

PATENT SPECIFICATION

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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO THE CRIMPING OF YARN

(71) We, JOSEPH BANCROFT & SONS Co., a corporation organised and existing under the laws of the State of Delaware, United States of America of Wilmington, Delaware, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to stuffer crimpers of the type wherein a yarn is fed between feed rolls into one end of a crimping chamber to form a core of crimped yarn which is advanced along the chamber by the pressure exerted by the incoming yarn.

A stuffer crimper of the invention is suitable for crimping yarn of large size, such as carpet size yarn.

According to one aspect of the present invention there is provided a method of crimping yarn in a stuffer crimper comprising feeding the yarn through feed rolls to a crimping chamber, crimping the yarn in the crimping chamber, passing the crimped yard in the form of a core into a heating chamber, subjecting the yarn in the heating chamber to the action of superheated steam heating the heating chamber to a temperature to maintain the steam therein in a superheated state, maintaining the pressure prevailing within the heating chamber substantially at atmospheric pressure, and introducing treating steam into the heating chamber at an elevated temperature and pressure to be superheated in a dry state when its pressure is reduced to atmospheric in said chamber to ensure that the steam can permeate the core of crimped yarn in the heating chamber in a superheated state without imparting moisture to the core.

According to a second aspect of the invention there is provided apparatus for carrying out the method of any one of the claims 1 to 3, comprising a crimping chamber, feed rolls disposed to feed yarn for crimping into one end of the crimping chamber, a housing forming a heating chamber registering with the

other end of the crimping chamber, treating steam inlet and outlet passages leading to the heating chamber, heating devices for heating the heating chamber to a temperature to maintain the steam therein in a superheated state, a support for holding a core of crimped yarn in the heating chamber spaced from the walls of the heating chamber means for introducing steam to said heating chamber at an elevated temperature and pressure to be superheated in a dry state when its pressure is reduced to atmospheric in said chamber, and a steam outlet connection from the heating chamber ensuring that the pressure of steam within the heating chamber is substantially at atmospheric pressure.

According to a third aspect of the invention there is provided yarn crimped by the above method or apparatus.

In order that the invention may be more readily understood, the following description is given, merely by way of example, with reference to the accompanying drawings, in which:—

FIGURE 1 is an end elevation with portions broken away of a stuffer crimper embodying the invention;

FIGURE 2 is a partial front elevation of the crimping apparatus on a larger scale than Figure 1;

FIGURE 3 is an enlarged elevation, partly in section, taken along the line 3—3 of Figure 2;

FIGURE 4 is a transverse section taken along the line 4—4 of Figure 1;

FIGURE 5 is a transverse section taken on the line 5—5 of Figure 1;

FIGURE 6 is a perspective view of the low friction chamber of the embodiment of the preceding Figures;

FIGURE 7 is a front elevation of the discharge end of the embodiment of the preceding Figures;

FIGURE 8 is a transverse section taken along the line 8—8 of Figure 7;

FIGURE 9 is a partial elevation similar to Figure 2 illustrating a yarn core choking de-

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vice of the apparatus of Figures 11 and 12;

FIGURE 10 is a section taken along the line 10—10 of Figure 9;

FIGURE 11 is a front elevation of a crimping apparatus with parts broken away illustrating a further embodiment of the invention;

FIGURE 12 is a transverse section taken along the line 12—12 of Figure 11;

FIGURE 13 is a side elevation, with parts in section, illustrating a modified form of crimping chamber; and

FIGURE 14 is a section taken on the line 14—14 of Figure 13.

Referring to Figures 1—8 in detail, there is shown a stuffer crimper having a split, rectangular crimping chamber 10 mounted in a support bracket 11 and shaped at its lower end to form a nosepiece conforming to the bite of a pair of feed rolls 12 and 13. The feed roll 12 is carried on a shaft 14 journaled in the bracket 11. The roll 13 is carried on a shaft 15 journaled in a bracket 16 which is pivoted to the bracket 11 and is biased into feeding engagement with the roll 12 by a rod 17 and a weight 18 interconnected through a pivoted bell crank lever 19. The shafts 14 and 15 are interconnected for driving at the same speed by spur gears 20 and 21. The shaft 14 is driven from a suitable source of power as by a belt 22 and a belt pulley 23.

Yarn 25 is fed to the bite of the feed rolls 12 and 13 through a traverse guide 26 sliding on rods 27 and having an arm 28 carrying a cam follower 29 riding in a closed helical groove 30 in a traverse roll 31.

The traverse guide 26 is offset from the bite of the feed rolls 12 and 13 so as to cause the yarn to lie on the surface of the feed roll 13 for a substantial distance as it is advanced to the bite. The grip of the feed roll on the yarn which is fed around a predetermined portion of its surface, for example, at least around an arc of 45°, serves to improve the feed and to relieve the strain which would otherwise be produced at the bite and which tends to cause breakage of the yarn, particularly when the yarn is rapidly traversed. The roll 31 is mounted on a shaft 32 and is driven from the shaft 14 through a set of reducing gears 36. The arrangement is such that the yarn is traversed along the bite of the feed rolls 12 and 13 as it is fed into the crimping chamber so as to provide a more uniform distribution of the yarn in the chamber.

A heating chamber comprising a block 40 is mounted on the bracket 11 above the crimping chamber 10. The block 40 carries heating rods 41 for maintaining the wall thereof at the desired temperature. A set of vertical rods 42 disposed in a rectangle and secured in upper, centre, and lower rectangular collars 43, 44 and 45 have curved inner surfaces disposed in alignment with the inner surface of the crimping chamber 10 to form a continuation thereof. The collars 43, 44 and 45 fit within

the walls of the block 40 and hold the rods 42 spaced therefrom. The lower collar 45 is centered with the chamber 10 by pin 47 carried by the collar 45 and entering a slot 48 in the wall of the chamber 10.

The arrangement is such that the core 50 of crimped yarn in the chamber 10 passes upwardly along the rods 42 and is supported thereby as it advances through the heating chamber.

A pair of yarn core choking members in the form of plates 51 of flexible metal are mounted on shafts 52 which are journaled in upstanding ears 53 on the walls of the chamber 10 with their axes parallel to the axes of the feed rolls 12 and 13. The plates 51 extend upwardly into the cage formed by the rods 42 in the heating zone and are biased toward the sides of the core 50 by a cord 55 carrying a weight 58. The cord 55 is fixed to a pulley 56 carried by one of the shafts 52. The cord 55 passes around a guide roller 59 and is attached to weight 58. Spur gears 57 cause the shafts 52 to turn at the same speed and maintain the two plates 51 symmetrically inclined with respect to the axis of the core 50.

The plates 51 compact the core which passes therebetween and impede the advance of the core so as to produce a back pressure at the bite of the feed rolls 12 and 13 which can be controlled by the weight 58.

A cooling cage 60 is formed by a set of rods 61 which are held in an upper collar 62 (Figure 7) and a lower collar 63 (Figure 1). The rods 61 register with the rods 42 and form a continuation thereof. The collar 43 carries positioning pins 64 entering holes in the collar 63 for holding the cooling cage in registration with the cage formed by the rods 42 in the heating chamber. The rods 61 and the collars 62 and 63 are similar in shape to the rods 42 and the collars 43 to 45.

A second yarn core choking device positioned in the cooling cage 60, comprises sets of fingers 66 carried on pins 67 journaled in a support bracket and biased towards the core 50 by weights 68 attached to the ends of rods 70 which are fixed to the pins 67.

The fingers 66 maintain the core under a predetermined pressure in the zone between the yarn core choking device of the heating chamber and that of the cooling chamber. This pressure is controlled by suitable selection of the weight 68.

The position and the pressure of the two yarn core choking devices are selected in accordance with the requirements of the particular yarn being processed. The back pressure produced by the first choking device affects the crimp leg length (crimping amplitude) and the pressure exerted by the second choking device affects the density of the core in the setting chamber which, in turn, affects the crimp angle which is set into the yarn. The location of the first choking device near the bite of

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the feed rolls in the crimping chamber makes it unnecessary to maintain a relatively high pressure on the core by the second choking device which would tend to cause the core of yarn to snake or otherwise distort and become jammed against or between the rods in the chamber thereby creating a non-uniform advancing of the core through the setting chamber and in some cases an actual stoppage completely of the advance thereof. In many instances, the second choking device may be omitted depending upon the desired characteristics of the crimp. The spacing of the outer surfaces of the rods 42 from the walls of the heating chamber permits circulation of heated air within the chamber and provides a more uniform heating for the core as it passes therethrough. A sensing device for the end of the core 50 comprises a collar 75 disposed to slide around the outer surfaces of the rods 61 and carrying a pair of inner rollers 76 which are in parallel spaced position and are disposed on opposite sides of the end rods 61 for guiding the collar as it rises and falls with the core. The rollers 76 rest on the top surface of the core and the crimped yarn 77 is extracted therebetween by delivery rolls or by a winder not shown. A pivoted bracket 78 includes arms 79 pivoted to the two sides of the collar 75 on opposite sides of the cage. The pivoted bracket 78 carries an arm 80 engaging a pin 81 extending from a sprocket 82 on a shaft 83 carrying a chain 84. The chain 84 engages a sprocket 85 carried on a shaft 86 of a potentiometer 87 which is adapted to vary the speed of a motor driving the feed rolls or a winder or other take up device in a sense to vary the rate of feed or extraction of the crimped yarn so as to maintain the end of the core at a substantially constant level.

Referring to the embodiment of Figures 9 to 12, the feed rolls, nosepiece, and heating and cooling cages are similar to those above described and have been given the same reference characters with the suffix "a." The heater housing is split and comprises a front part 90 and a rear part 91 which are hinged together and may be opened to provide access to the heating cage for cleaning. The collars 43a, 44a, and 45a fit within the bore of the housing and are secured therein by the housing walls when the parts are closed.

In this embodiment, means is provided for the admission of steam into the heating chamber in the space around the core of crimped yarn in the heating cage. For this purpose, a horizontal bore 92 is formed in each of the parts 90 and 91 to receive steam from an external source and to supply the same to horizontal slits 93 which extend through the walls of the housing parts at a point above the lower collar 45a. The steam, thus, envelops the core in the heating cage and permeates the crimped yarn. The lower collar 45a closes the space between the walls and the core to

prevent condensate from dripping onto the feed rolls. Any such condensate is absorbed by the core and passes upwardly therewith.

In order to minimize such condensation, heating rods 94 may be disposed in bores in the housing walls below and adjacent the inlet slits 93. Vertical grooves 95 are milled in the end walls of the housing, extending upwardly past the centre collar 44a and the upper collar 43a so as to allow the steam to contact the core in the space between the upper and lower collars and to escape into the atmosphere past the upper collar 43a.

The housing walls are heated by suitable means such as strip heaters 96 which may be temperature controlled by any suitable means. The parts 90 and 91 of the housing are formed with groove 97 and rib 98 which mesh for sealing the heating chamber against escape of steam.

Steam is supplied from an external source at, for example, pressure of 0.7 to 17.5 kilogrammes per square centimetre and at temperatures of from 116°C. to 210°C. depending upon the pressure. The chamber is maintained by the strip heaters at a temperature which is usually somewhat above the steam temperature, for example, at a temperature of from 121°C to 236°C. The required chamber temperature will depend upon the nature of the yarn and the rate at which the core passes through the chamber. The temperature must, of course, be below that at which degradation occurs. When the steam enters the heating chamber its pressure is reduced to substantially atmospheric pressure, owing to the fact that the chamber is vented to the atmosphere. Hence, the steam becomes super heated or dry steam as it contacts the core. Should any condensation occur owing to contact with the relatively cool core the condensate is re-vaporized by the heat supplied by the rods 94 and also due to the high temperature maintained in the chamber by the strip heaters 96.

The yarn is thus subjected to an atmosphere of steam in the heating chamber which is adapted to provide optimum setting conditions. As the yarn reaches the cooling zone the steam is immediately dissipated leaving the yarn in a dry state which is suitable for winding onto a package.

In this embodiment, the first yarn core choking device is shown as comprising a pair of choking elements 100 (Figures 9 and 10) journaled in the walls of the crimping chamber 10a. These choking elements 100 are formed with straight surfaces 101 which are offset from their centres and extend upwardly from such centres with top edges 102 which are adapted to be displaced inwardly toward the centre of the chamber as the choking elements are turned. In their retracted state, the straight surfaces 101 are disposed in recesses in the walls of the chamber 10a and are substantially coplanar therewith. The choking ele-

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ments 100 are geared together by spur gears 103 and are biased towards the centre of the chamber by a cord 104 and a weight 105.

5 The embodiment of Figures 9 and 10 has the advantage that the choking is effected at a point in the crimping chamber near the bite of the feed rolls whereas the choking step in the embodiment of Figures 1 to 8 is effected within the zone of the heating chamber. Such 10 a first choking device may be substituted in the embodiments of Figures 1 to 8, if desired. The arrangement selected will depend upon the characteristics of the yarn and the dimensions of the various parts. In any event, the 15 comparatively small area of contact between the sides of the core with the rods forming the heating and cooling cages produces a minimum of friction on the core, and the back pressure can be controlled by the arrangement of the two choking devices and by the pressures exerted thereby on the sides of the core as it advances. The sensing member shown 20 conforms to the average position of the top surface of the core and also forms a guide for the yarn which is extracted therefrom. 25

Referring to the form of Figures 13 and 14 the crimping apparatus is shown as comprising an outer housing 110 supported by suitable means, not shown, having a central 30 bore terminating in a bottom flange 111. A heater ring 112 is seated in said bore against the bottom flange 111 and is formed with a series of peripherally spaced holes adapted to receive heating elements not shown for heating 35 the crimping chamber.

The crimping chamber 113 is composed of a split cylindrical element seated within the heater member 112 and having a bottom 40 member 114 terminating in a central nosepiece 115 which is adapted to receive yarn for crimping from a pair of feed rolls 116 as in the embodiments of Figures 1 to 12.

A plurality of ribs 120, shown in the form of T bars are spaced around the periphery of 45 the chamber 113 with their crossheads 121 disposed in slots in the inner surface of the chamber wall. These ribs 120 may be secured to the bottom wall 114 by suitable means, for example soldering, and extend upwardly above 50 the top of the chamber 113 to form a cooling zone 122. The ribs are secured at their top ends to a ring 123 for rigidity.

Vertical grooves 124 are shown as formed in the outer surface of the chamber 113 opposite 55 the ribs 120 to provide air pockets for controlling the heat transfer from the heater ring to the chamber walls and thence to the ribs.

60 The inner edges 125 of the ribs 120 form a support for the core of crimped yarn as it advances along the crimping and heating chamber and along the cooling cage above such chamber where the crimp is set in the yarn. Since the ribs 120 contact the core of yarn 65 only at spaced points the friction which opposes

the advance of the core is reduced to a minimum.

A switch 127 may be mounted on a bracket 123a and actuated by feeler wire 128 which 70 extends between the bars 120 to rest upon the top of the core in the cooling zone. The switch 127 is connected to control the feed motor or the winder motor for maintaining the core at a constant level as described above in connection with Figures 1 to 12. While only so much 75 of the apparatus is shown in Figures 13 and 14 as is necessary for an understanding of the operation of this embodiment, it is to be understood that the remainder of the apparatus in this embodiment is similar to that described above. 80

The apparatus illustrated in the accompanying drawings is also described and claimed in our copending Patent Application No 2427/72 (Serial No. 1,285,970). 85

WHAT WE CLAIM IS:—

1. A method of crimping yarn in a stuffer crimper comprising feeding the yarn through feed rolls to a crimping chamber, crimping the yarn in the crimping chamber, passing the 85 crimped yarn in the form of a core into a heating chamber, subjecting the yarn in the heating chamber to the action of superheated steam, heating the heating chamber to a temperature to maintain the steam therein in a superheated state, maintaining the pressure prevailing within the heating chamber substantially at atmospheric pressure, and introducing treating steam into the heating chamber at an elevated temperature and pressure to be superheated in a dry state when its pressure is reduced to atmospheric in said chamber to ensure that the steam can permeate the core of crimped yarn in the heating chamber in a superheated state without imparting moisture 105 to the core.

2. A method according to claim 1 wherein the core is maintained spaced from the walls of the heating chamber, and wherein the steam is introduced into the space between the walls 110 of the heating chamber and the core of crimped yarn.

3. A method according to claim 1 or 2, wherein the pressure in the heating chamber is maintained substantially at atmospheric pressure by venting to atmosphere through 115 passages in the walls of said heating chamber.

4. Apparatus for carrying out the method of any one of the claims 1 to 3, comprising a crimping chamber, feed rolls disposed to feed yarn for crimping into one end of the crimping chamber, a housing forming a heating chamber registering with the other end of 120 the crimping chamber, treating steam inlet and outlet passages leading to the heating chamber, heating devices for heating the heating chamber to a temperature to maintain the steam therein in a superheated state, a support for holding a core of crimped yarn in the heating chamber spaced from the walls of the heat- 130



ments 100 are geared together by spur gears 103 and are biased towards the centre of the chamber by a cord 104 and a weight 105.

5 The embodiment of Figures 9 and 10 has the advantage that the choking is effected at a point in the crimping chamber near the bite of the feed rolls whereas the choking step in the embodiment of Figures 1 to 8 is effected within the zone of the heating chamber. Such
10 a first choking device may be substituted in the embodiments of Figures 1 to 8, if desired. The arrangement selected will depend upon the characteristics of the yarn and the dimensions of the various parts. In any event, the
15 comparatively small area of contact between the sides of the core with the rods forming the heating and cooling cages produces a minimum of friction on the core, and the back pressure can be controlled by the arrangement
20 of the two choking devices and by the pressures exerted thereby on the sides of the core as it advances. The sensing member shown conforms to the average position of the top surface of the core and also forms a guide
25 for the yarn which is extracted therefrom.

Referring to the form of Figures 13 and 14 the crimping apparatus is shown as comprising an outer housing 110 supported by
30 suitable means, not shown, having a central bore terminating in a bottom flange 111. A heater ring 112 is seated in said bore against the bottom flange 111 and is formed with a series of peripherally spaced holes adapted to receive heating elements not shown for heating
35 the crimping chamber.

The crimping chamber 113 is composed of a split cylindrical element seated within the heater member 112 and having a bottom
40 member 114 terminating in a central nosepiece 115 which is adapted to receive yarn for crimping from a pair of feed rolls 116 as in the embodiments of Figures 1 to 12.

A plurality of ribs 120, shown in the form of T bars are spaced around the periphery of
45 the chamber 113 with their crossheads 121 disposed in slots in the inner surface of the chamber wall. These ribs 120 may be secured to the bottom wall 114 by suitable means, for example soldering, and extend upwardly above
50 the top of the chamber 113 to form a cooling zone 122. The ribs are secured at their top ends to a ring 123 for rigidity.

Vertical grooves 124 are shown as formed in the outer surface of the chamber 113 opposite
55 the ribs 120 to provide air pockets for controlling the heat transfer from the heater ring to the chamber walls and thence to the ribs.

The inner edges 125 of the ribs 120 form
60 a support for the core of crimped yarn as it advances along the crimping and heating chamber and along the cooling cage above such chamber where the crimp is set in the yarn. Since the ribs 120 contact the core of yarn
65 only at spaced points the friction which opposes

the advance of the core is reduced to a minimum.

A switch 127 may be mounted on a bracket 123a and actuated by feeler wire 128 which
70 extends between the bars 120 to rest upon the top of the core in the cooling zone. The switch 127 is connected to control the feed motor or the winder motor for maintaining the core at
75 a constant level as described above in connection with Figures 1 to 12. While only so much of the apparatus is shown in Figures 13 and 14 as is necessary for an understanding of the operation of this embodiment, it is to be understood that the remainder of the apparatus
80 in this embodiment is similar to that described above.

The apparatus illustrated in the accompanying drawings is also described and claimed in our copending Patent Application No 2427/72
85 (Serial No. 1,285,970).

WHAT WE CLAIM IS:—

1. A method of crimping yarn in a stuffer
85 crimper comprising feeding the yarn through feed rolls to a crimping chamber, crimping the yarn in the crimping chamber, passing the crimped yarn in the form of a core into a heating chamber, subjecting the yarn in the heating chamber to the action of superheated steam, heating the heating chamber to a temperature to maintain the steam therein in a
95 superheated state, maintaining the pressure prevailing within the heating chamber substantially at atmospheric pressure, and introducing treating steam into the heating chamber at an elevated temperature and pressure to be superheated in a dry state when its pressure is reduced to atmospheric in said chamber to ensure that the steam can permeate the core of crimped yarn in the heating chamber in a
100 superheated state without imparting moisture to the core.

2. A method according to claim 1 wherein the core is maintained spaced from the walls of the heating chamber, and wherein the steam is introduced into the space between the walls
110 of the heating chamber and the core of crimped yarn.

3. A method according to claim 1 or 2, wherein the pressure in the heating chamber is maintained substantially at atmospheric
115 pressure by venting to atmosphere through passages in the walls of said heating chamber.

4. Apparatus for carrying out the method of any one of the claims 1 to 3, comprising
120 a crimping chamber, feed rolls disposed to feed yarn for crimping into one end of the crimping chamber, a housing forming a heating chamber registering with the other end of the crimping chamber, treating steam inlet and outlet passages leading to the heating chamber, heating devices for heating the heating
125 chamber to a temperature to maintain the steam therein in a superheated state, a support for holding a core of crimped yarn in the heating chamber spaced from the walls of the heat-
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ing chamber, means for introducing steam to said heating chamber at an elevated temperature and pressure to be superheated in a dry state when its pressure is reduced to atmospheric in said chamber, and a steam outlet connection from the heating chamber ensuring that the pressure of steam within the heating chamber is substantially at atmospheric pressure.

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5. Apparatus according to claim 4, and wherein said core support means comprise a cage formed by a plurality of spaced parallel rods disposed within said heating chamber housing with their inner surfaces forming a continuation of the walls of said crimping chamber, said rods extending throughout the length of said heating chamber effective to confine and guide a core of crimped yarn therethrough.

6. Apparatus according to claim 5, wherein said cage includes spacing members spacing the outer surfaces of said rods from said housing, effective to facilitate circulation of gas within said housing and around said cage.

7. Apparatus according to claim 5 or 6, further including collars having said rods secured therein and having outer surfaces fitting in said housing effective to facilitate removal of said cage.

8. Apparatus according to claim 5, 6 or 7, further including a cooling cage disposed in registration with said heating chamber cage, said cooling cage comprising a set of further rods registering with said heating chamber rods and means securing said further rods in spaced parallel positions effective to receive a core of crimped yarn therebetween and to guide said core to a discharge point.

9. Apparatus according to claim 8, further including yarn sensing means disposed in said cooling cage, said yarn sensing means comprising a collar adapted to extend around said rods, a pair of spaced rollers extending between opposite ends of said collar to rest upon the top of a core of crimped yarn in said cooling cage, a pivoted member having elements pivotally secured to opposite sides of said collar centrally of its ends, and means actuated by said pivoted member to vary the relative rates of feed and withdrawal of yarn, effective to maintain the core at a substantially constant level in said cooling cage.

10. Apparatus according to claim 9, further including a potentiometer connected to control said relative rates of feed and withdrawal, said pivoting member being connected to affect

said potentiometer upon a rise or fall of the level of said core in said cooling cage.

11. Apparatus according to any one of claims 4 to 10, wherein said steam introducing means comprise an inlet disposed in said walls; and wherein said heating means is disposed adjacent said inlet to prevent condensation of the steam entering the heating chamber.

12. Apparatus according to any one of claims 4 to 11, further including a traversing guide adapted to traverse yarn as it is passed to said feed rolls and displaced from said feed rolls, and effective to cause the yarn to engage one of said feed rolls tangentially and to extend around at least a 45° arc of the periphery thereof as it is passed to the zip of said feed rolls.

13. Apparatus according to claim 5, or any one of claims 6 to 12 when appendant thereto, and including means for choking said core upon exit from said crimping chamber.

14. Apparatus according to claim 13, wherein said choking means comprise yieldable choke members disposed to contact opposite sides of the crimped core, said choke members having surfaces adapted to register with the chamber walls when in a retracted position and being adapted to engage and compact said core when advanced; and including means biasing said members into compressive contact with said core.

15. Apparatus according to claim 14, wherein said choke members form a part of the walls of said crimping chamber when fully retracted.

16. Apparatus according to claim 14 or 15, wherein said choke members are mounted on shafts connected to turn oppositely through similar angles, and wherein biasing means is provided for urging said shafts for rotation in a sense extending said choke members into said heating chamber.

17. A method of crimping yarn, substantially as hereinbefore described with reference to the accompanying drawings.

18. Apparatus for crimping yarn, substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

19. Yarn when crimped by the method of any of claims 1 to 3 or 17, or by the apparatus of any of claims 4 to 16 or 18.

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