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APPARATUS FOR THE PRODUCTION OF ARTIFICIAL STRUCTURES

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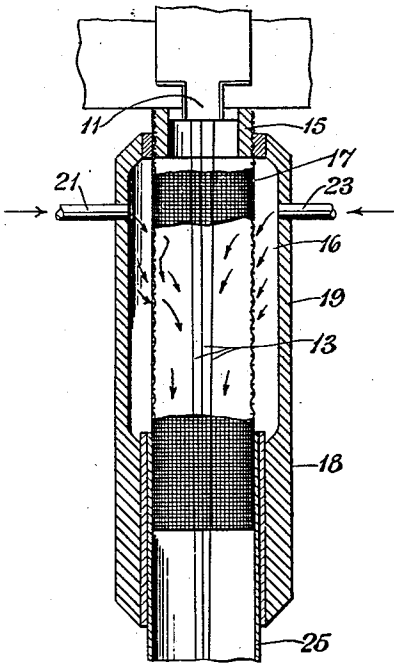


Fig. 1

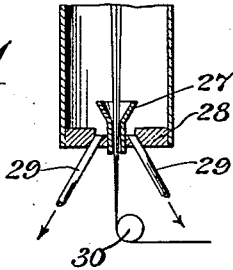


Fig. 2

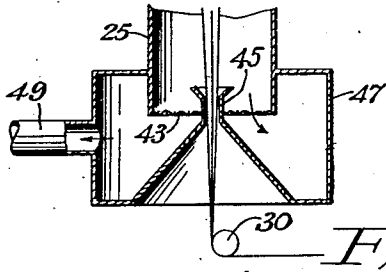
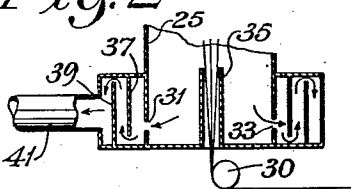


Fig. 3

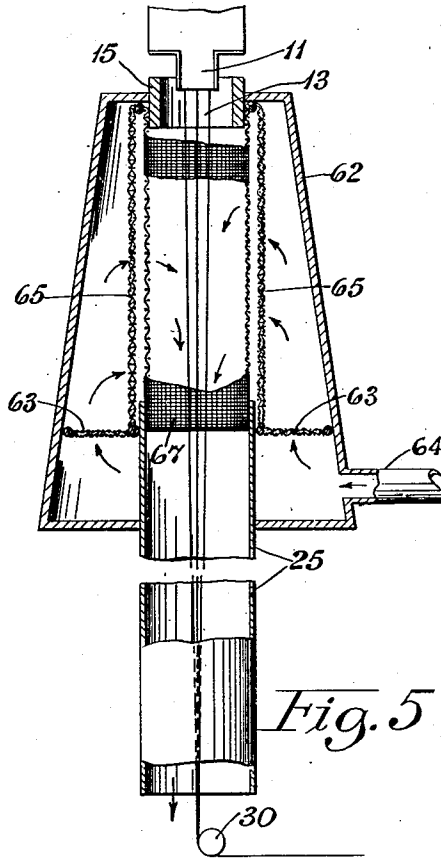


Fig. 5

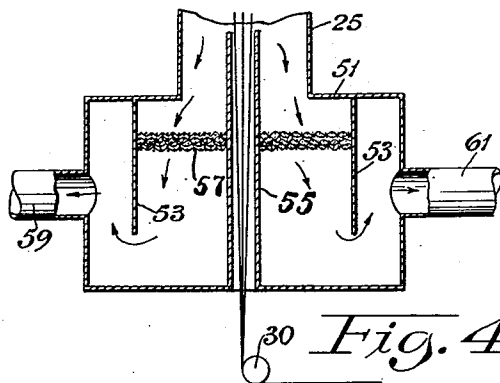


Fig. 4

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2,252,684

APPARATUS FOR THE PRODUCTION OF
ARTIFICIAL STRUCTURES

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1 Claim. (Cl. 18—8)

This invention relates to the spinning of molten organic filament-forming compositions for the production of filaments, yarns, ribbons and the like. More particularly, this invention relates to an improvement in method and apparatus for the spinning of such molten compositions whereby to obtain spun structures having greater uniformity of physical characteristics.

In the spinning of molten organic filament-forming compositions difficulty is experienced in obtaining yarns, filaments and like structures having a uniform denier throughout the length thereof. Such structures as have a non-uniform denier have been found to be non-uniform as to dyeing characteristics, drawability, etc. When molten organic filament-forming compositions are passed through the atmosphere slight air drafts and the like somewhat affect the spinning operation, and it has furthermore been found that the movement of the filaments or yarns sets up a turbulent air movement which also objectionably affects the uniformity of physical characteristics of the resultant product.

It is, therefore, an object of this invention to provide an improved method and apparatus for the spinning of molten organic filament-forming compositions to produce spun structures having a constant denier, and having uniform dyeing properties, along the length thereof.

It is a further object of the present invention to provide an improved method and apparatus for the rapid and uniform cooling of structures spun from molten organic filament-forming compositions.

It is a specific object of this invention to provide an improved method and apparatus for the spinning, at high rates of speed, of molten organic filament-forming compositions with a concurrently directed flow of a cooling medium whereby to produce spun products having a uniform denier and having a high tenacity.

Other objects of the invention will appear hereinafter.

The objects of this invention are accomplished, in general, by spinning the molten organic filament-forming composition through a cooling and solidification chamber in which a gaseous cooling medium such as air or other inert gas is passed, with a substantially straight-line flow, in a direction co-current with the movement of the spun structures. The air or other inert gas is preferably introduced at or in the top of the cooling chamber, in close proximity to the spinneret. The air or other inert gas is passed through a foraminous means of substantially the same diameter

as the cooling chamber, and is allowed to escape at the base of the cooling chamber through a diffusion cell, or through the open end of the chamber.

5 The nature of the invention will be more clearly apparent by reference to the following detailed description when taken in connection with the accompanying illustration, in which:

10 Figure 1 is a sectional view through a cooling and solidification chamber constructed in accordance with the invention.

Figure 2 is a detailed view, with parts shown in section, illustrating a diffusion cell constructed in accordance with the principles of the present invention.

15 Figure 3 is a detailed view, with parts shown in section, of a modified form of diffusion cell.

Figure 4 is a detailed view, with parts shown in section, of still another form of diffusion cell.

20 Figure 5 is a front elevational view, with parts shown in section, of a cooling and solidification chamber in which the cooling medium is introduced by means of pressure.

Referring to Figure 1 of the drawing, reference numeral 11 designates a spinneret containing a number of fine openings through which is extruded a molten organic filament-forming composition for the formation of a multi-filament yarn 13. The freshly extruded filaments which, as they emerge from the spinneret openings are in a molten state, are cooled and solidified in the cooling and solidification chamber generally designated by reference numeral 18. A heat insulating collar 15 is preferably provided around the spinneret to prevent heat conduction from the spinneret or the spinneret supporting means to the cooling chamber. A foraminous sleeve 17, which may be constructed of a fine mesh screen (16 to 100 meshes per inch) is positioned around the insulating sleeve 15. The sleeve 17 in the construction shown in Figure 1, comprises 6 layers of 16 x 16 mesh copper screen. A tube 25, constructed of any desired material, is positioned about the screen 17 in such a manner that about 4 3/4" of the screen separates the insulation sleeve 15 from the tube. The inner diameter of the screen in the present instance is approximately 1 3/4".

25 An annular member 19 is positioned around the screen in such a manner as to provide an annular chamber 16 on the outside of the screen sleeve 17. Openings 21 and 23 are provided for admission of a gaseous cooling medium into the annular chamber 16. The bottom of the tube 25 is closed by means of member 28. A small

funnel 27 is positioned substantially in the center of the closure member 28. One or more cooling medium exit means 29 are also provided in the closure member 28. The cooling medium, which may be air or other inert gas, is drawn through the cooling and solidification chamber by means of vacuum applied to the cooling medium exit means 29.

Referring to Figure 2 of the drawing, reference numeral 25 designates the lower end of the tube as shown in Figure 1, above described. A cooling medium diffusion cell surrounds the lower end of the tube so as to provide a means for the constant and uniform withdrawal of the cooling medium. The diffusion cell comprises an inwardly extending sleeve 35, a pair of annular baffles 37 and 39 and a withdrawal conduit 41. One or more small openings 31, 33 are provided in the lower portion of tube 25 for withdrawal of the cooling medium.

Referring to Figure 3 of the drawing, a modified form of diffusion cell is provided for the lower portion of the tube 25. This modified form of diffusion cell comprises a foraminous member 43 at the bottom of the tube 25 and an annular chamber 47 surrounding the external portion of the said tube 25. An extension sleeve 45 is preferably provided within the internal lower section of the tube. The chamber 47 is provided with an outlet means 49 for withdrawal of the cooling medium.

Referring to Figure 4 of the drawing, reference numeral 51 designates a small annular chamber surrounding the lower end of tube 25. The chamber 51 is provided with an annular baffle 53 projecting downwardly from the top surface thereof and an annular baffle 55 projecting upwardly from the bottom thereof. An annular foraminous means 57, comprising, for example, a plurality of screens, is positioned between the baffles 53 and 55. One or more outlets 59, 61 for withdrawal of the cooling medium may be connected to chamber 51. The annular baffle 55 constitutes a sleeve of small diameter which will surround the filaments and prevent substantial leakage of cooling medium from the end of the cooling chamber through which the filaments are withdrawn.

In the above-mentioned Figures 1, 2, and 3, the funnel 27, the extension sleeve 35, and the extension sleeve 45 also function in this manner to prevent substantial leakage from that section of the cooling chamber where the filaments are being withdrawn. In all of the figures, reference numeral 30 designates a guide provided to facilitate conduction of the spun filaments to a winding mechanism or the like.

Referring to Figure 5 of the drawing, a frusto-conical chamber 62 is positioned about a section of the cooling chamber comprising the cylindrical screens 65 and 67. Another annular foraminous means comprising screens 63 is provided at the bottom of the cylindrical screen 65. A cooling medium inlet means 64 is connected to the chamber 62 below the annular screens 63.

The apparatus illustrated in Figures 1, 2, 3, and 4 is designed to provide for draught of the cooling medium therethrough by application of a vacuum to exit means 29, 41, 49 or 59 and 61. Thus, referring to Figure 1, the cooling medium is drawn in through the openings 21 and 23 filling the chamber 16, whence it is drawn through the sleeve 17, flowing downwardly through the remainder of sleeve 17 and the tube 25 eventually being withdrawn through the exit means 29.

The apparatus illustrated by Figure 5 provides means whereby the cooling medium may be forced through the apparatus by admitting it under pressure. Thus, referring to Figure 5, the compressed cooling medium is admitted through the inlet 64, is forced upwardly through the annular screen 63, inwardly through the cylindrical screens 65 and 67 and downwardly on the inside of screen sleeve 67 and the tube 25, escaping freely through the open end thereof.

In the above-described modifications of the invention the air, or other cooling medium, enters adjacent the top of the cooling chamber within about 1" of the spinneret through a screen or other foraminous means. It emerges at the bottom of the cooling chamber approximately 24 to 30" below the top. In a properly constructed cooling chamber a straight-line flow is imparted to the cooling medium so that the filaments move very steadily without any appreciable fluttering during their entire travel from the face of the spinneret to the yarn guide at the base of the chamber. Uniform cooling brought about by the uniform straight-line air-flow, and the steady position assumed by the filaments enables one to spin very uniform yarn having uniform dyeing characteristics.

The preferred embodiment employs about 1" of insulation between the face of the spinneret and the first effective section of the screen through which the cooling medium enters the cooling chamber. This prevents undue cooling of the spinneret by the air entering the cooling chamber. However, the screen may be attached directly to the spinneret holder so that the air comes in around the face of the spinneret. On the other hand, as much as 4½" of space between the face of the spinneret and the first effective section of screen is permissible. A spacing greater than about 1" is undesirable because it results in greater compression of the filament bundle by the air entering the screen. If, for example, the yarn is spun from twenty holes located on a circle about ⅝" in diameter and about 4" intervenes between the face of the spinneret and the first effective edge of the screen, the filaments are blown in toward the center of the chamber and the filament bundle is compressed to a cylinder with a diameter of approximately ¼". Under these conditions the rate of cooling is much less satisfactory than when the filaments are separated to a greater degree. Since air-flow within the chamber is straight-line, there is very little mixing of the air transversely of the direction of its flow. Consequently, only the air within the immediate vicinity of the filaments is effective in bringing about their cooling.

Straight-line flow of the cooling medium which is necessary to bring about uniform cooling and to prevent fluttering of the filaments within the chamber can only be produced by bringing the air into the chamber through a foraminous means, i. e., through screens or numerous other fine openings uniformly distributed over the section through which the air is allowed to enter. This has been shown by numerous experiments in which smoke was introduced at various points into the chamber. If air is introduced through a large opening of any sort, turbulent flow is always encountered in the chamber. A wide variety of screens may be employed as the foraminous means. Thus, the screen employed in Example I, which is given below, comprises about six layers of 16 x 16 mesh copper screen. It is believed, however, that the best arrangement em-

plays a single layer of 50 mesh screen separated by a space of $\frac{1}{4}$ " or more from the supplementary screens or air distributing devices as illustrated in Figure 5. Such an arrangement invariably insures a steadier flow of filaments with a greater freedom from fluttering than one in which a series of 50 x 50 or 100 x 100 mesh screens are wrapped one on top of another. If desired, one or all of the layers of screens can be replaced by fabric or glass fabric, very porous paper or other similar foraminous materials.

Straight-line flow induced by the introduction of the air through a foraminous means generally does not persist beyond about two or three feet below the lower edge of the screen. Beyond this point the air becomes turbulent, the filaments begin to flutter and heat is transferred rapidly from the filaments and the air in their immediate vicinity to the rest of the air in the chamber and to the walls of the chamber. Unless a thread guide is used to bring the filaments together above this turbulent point and to keep the filament bundle from fluttering, poor denier control is obtained.

These considerations generally limit the length of the cooling chamber below the screen to about two or three feet. The walls of the chamber should be as smooth as possible and should have essentially the same diameter as the screen and should be of nearly uniform diameter throughout the entire length of the chamber. Slight contraction of the diameter of the chamber toward the lower end could probably be tolerated, but flaring out of the chamber at the lower end would be particularly undesirable.

The type of co-current cooling chamber operating on compressed air is preferred over that operating with vacuum because it is easier to thread up and because the pressure in the chamber is slightly above that in the surrounding atmosphere and, consequently, leaks do not tend to interfere with the straight-line flow as seriously as in the case of chambers operated with vacuum.

The length of screen through which the cooling medium is passed into the chamber is not very critical. It may be shortened to as little as 2", although the invention has been operated successfully with screens as long as about 18". However, the longer screens have the disadvantage that most of the air enters through the lower part of the screen and, consequently, much less rapid cooling is obtained. The use of long screens tends to produce yarn of lower tenacity. It is preferable to use a section of screen between about 4 and 6" in length. For each cooling chamber assembly there is an optimum air-flow which can readily be chosen by anyone skilled in the art. As the air-flow is increased a condition is reached at which the filaments exhibit almost no motion at all in a horizontal direction. This is the condition which gives the best denier control. As the air-flow is increased beyond this point, turbulence sets in and the filaments flutter more and more. This reduces the quality of denier control. In order to obtain the best results it has been found that the air-flow through the cooling chamber should preferably be maintained between 1 and 7.5 cubic feet per minute per square inch of cross-section of the chamber.

By blocking off areas on the screen, it is possible to influence the distribution of the filaments and the shape of the filament bundle. For example, when two $\frac{1}{2}$ " strips of tape are applied

to opposite sides of the screen on a 2" diameter chamber in such a manner that they block off an area $\frac{1}{2}$ " x 6" in a vertical position on each side of the screen, the filament bundle takes the form of an oval with its long dimension approaching that of the diameter of the chamber. Under these conditions much more rapid cooling of the filaments is obtained and there is not much loss in denier uniformity. The use of baffles in this manner is considered to be within the scope of this invention.

The following examples are given to illustrate specific details of the present invention, it being understood that the details as set forth in these examples are not to be considered limitative of the invention.

Example I

Polyhexamethylene adipamide having a melt viscosity of approximately 350 poises was melted and maintained at 285° C. in an atmosphere of nitrogen. The polymer was pumped by means of a gear pump and a metering pump through a filter pack comprising a large plurality of screens, and thence through a spinneret having a diameter of about 1" and perforated with about twenty holes having a diameter of 0.006". The holes are located on a circle having a diameter of $\frac{5}{8}$ ". A collar of magnesium carbonate insulation was fastened to the spinneret in the manner shown in Figure 1 of the drawing. The cooling chamber comprised 18" of glass tubing approximately $1\frac{3}{4}$ " in diameter. The screen comprised six layers of 16 x 16 mesh copper screen wrapped about the upper magnesium carbonate insulation and the glass tubing in such a manner that $4\frac{3}{4}$ " of the screen separated the insulation and the glass tubing. The spinneret was operated at about 270° C. The pump rate was 5.25 grams per minute and the wind-up speed 910 feet per minute. Six cubic feet of air per minute were drawn from the base of the cooling chamber through a stopper and glass tube assembly as shown in Figure 1 of the drawing. The yarn was withdrawn through a small glass funnel.

The denier uniformity of the yarn was evaluated by cutting pairs of 9 cm. lengths of yarn from each of twenty-five successive meter lengths of yarn. The denier calculated from the weight of these 9 cm. sections of yarn was averaged and a standard deviation calculated from the individual deviations. The standard deviation is the root mean square of the deviations from the mean. The standard deviation was divided by the average denier and expressed in per cent as the standard percentage deviation.

A bobbin of 170-denier 20-filament yarn was spun in this manner and sampled at five places within the bobbin. The standard percentage deviation of the deniers so determined was 1.0% and the average spread of deniers within any series amounted to 3.5%. The yarn had uniform dyeing characteristics.

When similar yarn was spun without a cooling chamber, the standard percentage deviation was 2.6% and the spreads averaged 10%. On other occasions the standard percentage deviation of the yarn spun without the aid of a cooling chamber was as high as 4% with correspondingly larger spreads. When undrawn yarn spun without a cooling chamber was knit into fabric on a single end Wildman knitting machine, fabric was obtained which gave very non-uniform dyeing, with bad streaks and bands running crosswise of the tubing. In many cases these streaks and

bands were visible before the yarn was dyed. They were apparently made visible by a variation in the luster of the yarn. On the other hand, yarn spun through the co-current flow cooling chamber dyed very evenly and did not show these luster differences.

Example II

Yarn of 160 denier and 20 filaments was spun in a manner similar to that described in the previous example. In this case a cooling chamber similar to that shown in Figure 5 of the drawing and operated on compressed air was employed. The internal diameter of the innermost screens in the diffusion cell and the internal diameter of the chamber was $1\frac{1}{4}$ ". The inner screen was 100-mesh and located with its upper effective end $2\frac{1}{2}$ " below the face of the spinneret. The chamber extended 20" below the lower edge of the screen and was open at the bottom. Air was blown into the diffusion cell at the rate of 2.2 cubic feet per minute. Under these conditions the filaments moved very steadily, approaching in steadiness the conditions obtained in the previous example. The standard deviations of the samples taken from this yarn averaged 1.4% and the spreads averaged 3.7%.

In the foregoing examples, the invention has been illustrated with specific reference to the spinning of polyhexamethylene adipamide, a synthetic linear polyamide, but the invention is not so limited.

This invention has particular utility for the spinning of molten organic filament-forming compositions which are crystalline in the solid state as evidenced by X-ray investigation. The synthetic linear polymers, to which class synthetic linear polyamides belong, exhibit this property. Other types of synthetic linear polymers are polyesters, polyethers, polyacetals, mixed polyester-polyamides, etc., such as may be prepared by a condensation reaction as described in U. S. Patent No. 2,071,250. Polymers prepared by the high pressure polymerization of ethylene, which are more fully described in the

copending application of Fawcett, Gibson and Perrin, Serial No. 123,722 filed February 2, 1937 also are crystalline in the solid state.

The invention is also applicable to the spinning of other molten organic filament-forming compositions such as the vinyl polymers, polystyrene and polyacrylic acid derivatives.

The filament-forming material used in the process of this invention may contain modifying agents, for example, luster-modifying agents, plasticizers, pigments and dyes, anti-oxidants, resins, etc.

Introduction of air or other gaseous cooling medium through the screen results in a straight-line flow of the cooling medium which assures steady travel of the filaments and affords uniform cooling conditions. This prevents stretching of the filaments caused by their fluttering in the air and also prevents oscillation of the freezing point thus giving constant denier yarn.

This invention can be used to secure denier control, to improve uniformity of dyeing, and to prevent luster differences caused by variable cooling.

Since it is obvious that many changes and modifications can be made in the details above described without departing from the nature and spirit of the invention, it is to be understood that the invention is not to be limited except as set forth in the appended claim.

I claim:

In an apparatus for the spinning of molten organic filament-forming compositions, means for forming a spun structure from said molten compositions, a chamber adjacent said means through which said spun structure is passed, a plurality of concentric cylindrical screens in said chamber adjacent said means for forming the spun structure, and means for forcing a gaseous cooling medium through said cylindrical screens and through said cooling and solidification chamber in a direction co-current with the passage of said structure.

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