Jan. 24, 1961 D. W. GROOMBRIDGE ET AL 2,968,834

MANUFACTURE OF VOLUMINOUS YARNS

Filed April 22, 1957

FIG. 1

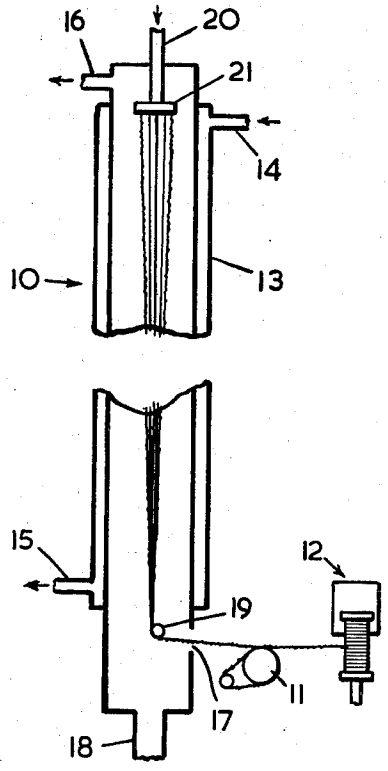


FIG. 2

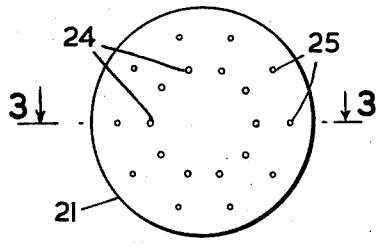


FIG. 3

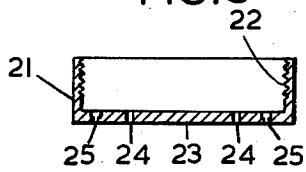
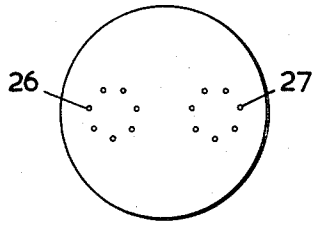


FIG. 4



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MANUFACTURE OF VOLUMINOUS YARNS

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4 Claims. (Cl. 18—8)

This invention relates to the manufacture of voluminous yarns, that is to say yarns having a high bulk in relation to their weight, and is an improvement in or modification of the invention described in our U.S. application Ser. No. 545,905, filed November 9, 1955, now Patent No. 2,904,953.

Various methods of making voluminous yarns are known, but for the most part these earlier methods have the disadvantage that if yarns produced thereby are temporarily subjected to tension, they suffer to some degree a permanent reduction in voluminosity.

U.S. application Ser. No. 545,905, filed November 9, 1955, describes the production of a new type of voluminous yarn by extruding a solution of a filament-forming substance in a volatile solvent (i.e. a solvent from which the said filament-forming substance can be dry spun) into an evaporative atmosphere at a high linear rate such that the filaments formed are crinkled, and doubling or combining the said crinkled filaments with a substantially uncrinkled support thread. Preferably the crinkled filaments are brought into contact with the support thread during their travel from the spinning jet by means of which they are formed and before they are collected or taken up, advantageously while they are still inside the spinning cell.

Two methods are described in U.S. application Ser. No. 545,905, filed November 9, 1955, for making the new voluminous yarns. In one of them the crinkled filaments and support thread are formed simultaneously in a single spinning cell by extruding a spinning solution, or two different spinning solutions, through two spinning jets at different extrusion rates, and in the other the crinkled filaments are formed in the spinning cell and while still passing through it are brought into contact with a pre-formed support thread which is drawn through the spinning cell at a suitable speed.

The present invention is concerned with another method of making voluminous yarns such as those described in the said U.S. application Ser. No. 545,905, filed November 9, 1955, which has the advantage that although the support thread and crinkled filaments are formed simultaneously, only a single spinning jet is employed.

According to the invention voluminous yarns are made by extruding a solution of a filament-forming substance in a volatile solvent into an evaporative atmosphere through two sets of orifices of differing dimensions in a single spinning jet, bringing the two sets of filaments formed respectively by the two sets of orifices together to form a single yarn after they have become substantially completely set, drawing the said yarn away, and winding it up, the dimensions of the orifices in one of the sets being so correlated with the rate at which the solution is supplied to the spinning jet and with the rate at which the yarn is drawn away that the linear rate of extrusion of the solution through them is at the most equal to the rate at which the yarn is drawn away so that substantially uncrinkled support filaments are formed thereby, and the dimensions of the orifices of the other

set being so correlated with the same factors that the linear rate of extrusion of the solution through them is above that at which the solution immediately after extrusion, and the filaments which it forms, will tend to travel through the cell under the influence of the various forces acting on them at any point up to and including that at which they come together with the support filaments to form a single yarn, so that crinkled filaments are formed thereby. Preferably the support filaments and crinkled filaments are brought together while still in the spinning cell.

It will be seen that the dimensions of the orifices of the two sets must be such that the spinning solution meets with less resistance when passing through the individual orifices of one set than when passing through those of the other. In the preferred form of the invention, the orifices which are to produce the support filaments are made considerably longer than those which are to produce the crinkled filaments; thus they should be at least twice as long and are preferably between about 5 and 30 times as long. By the "length" of a spinning orifice is meant the length of the channel passing through the end wall of the jet and issuing in, and of substantially the same diameter as, the hole in the face of the jet through which the solution emerges into the spinning cell. When the end wall of the jet is uniformly thick, as it will usually be, the lengths of the individual orifices can be varied by countersinking them to various depths, or by countersinking some and leaving the others untouched.

Preferably the two sets of orifices are grouped separately, and in the most advantageous arrangement they are grouped in two concentric circles differing in diameter by at least 5 mm., and preferably 8 mm. or more, e.g. 10–20 mm. When using an arrangement of this kind it is generally preferred that the orifices in the outer circle should form the crinkled filaments and those in the inner circle the support filaments. Other arrangements can however be used. For example the orifices of each set can be arranged in one or more compact groups, the spacing between groups at their nearest points being preferably at least 5 mm. and better 8 mm. or more. When the orifices of one set are too close to those of the other the crinkled and support filaments may come into contact while they are still soft or tacky, and such premature contact may result in interfusion or cohesion between the filaments of the two kinds.

The diameters and numbers of the orifices in the two sets will depend on the spinning conditions and the precise structure of the voluminous yarn which it is desired to make. As was explained in U.S. application Ser. No. 545,905, filed November 9, 1955, now Patent No. 2,904,953, the voluminosity of the yarn will vary with the ratio of the total denier of the crinkled filaments to the total denier of the support filaments, and also with the number of the crinkled filaments. High voluminosity results from a denier ratio equal to or greater than unity, and also from the use of a larger number of finer filaments rather than a smaller number of coarser filaments of similar total denier. Thus by suitably choosing the denier ratio and the number of the crinkled filaments it is possible to produce yarns of a wide range of voluminosity and general appearance.

Since in practice it is desirable that the support filaments should undergo some degree of draw-down in the spinning cell, which will of course reduce their denier, it is preferred that the orifices through which they are extruded should have a somewhat larger cross-sectional area than those used for forming the crinkled filaments, usually between about 1.25 and 3 times as large, with of course an appropriately greater length to ensure that the solution is extruded through them at a suitable relatively low speed.

The filament-forming material from which the voluminous yarns are made may with advantage be a lower fatty acid ester of cellulose, especially an acetone-soluble cellulose acetate or a cellulose triacetate, i.e. a cellulose acetate of acetyl value above 59% reckoned as acetic acid. (The term "lower fatty acid" is used here to denote acids containing up to 4 carbon atoms in the molecule.) However other materials from which filaments can be formed by dry spinning may be used, e.g. polymers and copolymers of acrylonitrile, vinyl chloride and other vinyl compounds.

In describing the invention in more detail it will be convenient to refer particularly to the production of voluminous yarns having a basis of an acetone-soluble cellulose acetate. Such yarns may be made by extruding an acetone solution of the cellulose acetate into an evaporative atmosphere, e.g. into a current of air travelling up or down a heated spinning cell in the known manner. It has been found that stronger yarns may be obtained if the spinning solution is heated, preferably to about 50°–80° C., before it is extruded, whether or not the incoming air or the spinning cell is also heated. The spinning solution may if desired contain an effect material, e.g. a finely divided white or coloured pigment or dyestuff.

The minimum linear rate at which the spinning solution must be extruded through the orifices which are to produce the crinkled filaments is as already stated substantially higher than the speed at which the solution immediately after extrusion, and the filaments which it forms, will tend to travel under the influence of the various forces acting on them at any point up to and including that at which they come into contact with the support filaments. The forces acting on the extruded solution and the filaments include the pull exerted on the filaments by the support filaments, friction with the evaporative atmosphere, and gravitation, and the effect of these forces, and with it the minimum useful rate of extrusion, will vary with inter alia the viscosity of the spinning solution and the diameter of the orifices. For example when a cellulose acetate of viscosity (measured in a solution of 6 grams of the cellulose acetate in 100 cc. of 95% aqueous acetone at 25° C.) between about 250 and 400 centipoises is to be spun and the concentration of the spinning solution is 20–30%, and especially between 25 and 27%, (corresponding to a spinning solution viscosity of say 800–900 poises at room temperature), the minimum linear rate of extrusion through orifices of diameter 0.03 mm. is about 150 meters per minute, and through orifices of diameter 0.05 mm. is about 650 meters per minute; for orifices of diameter 0.075 and 0.10 mm. the corresponding figures are in the neighbourhood of 850 and 1000 meters per minute. If a cellulose acetate of higher viscosity or a solution of higher concentration is used, so that the viscosity of the spinning solution is increased, the minimum extrusion rate will be somewhat lower.

It is usually preferable that the linear extrusion rate actually employed for a given spinning solution and orifices of a given diameter should not greatly exceed the minimum rate at which crinkled filaments are formed under these conditions, since considerably higher rates not only involve the use of spinning pressures that may be inconveniently high, but also give a less satisfactory product.

It is important that any tension applied to the crinkled filaments before they are combined with the support filaments should be very low, and it has been found advisable that the rate of travel of the support filaments when the crinkled filaments first make contact with them, and therefore the approximate rate at which the yarn is drawn from the spinning cell, should be less than about 0.8 times, and especially between 0.3 and 0.75 times, the linear rate of extrusion of the solution to form the crinkled filaments. Speeds below 0.3 times the linear rate of extrusion to form the crinkled filaments may be used if desired, but speeds above 0.8 times may result in the crinkled filaments being pulled out to some extent, and the voluminosity of the product then suffers.

If desired two or more ends of voluminous yarn may be made using a single spinning cell containing a plurality of the spinning jets having two sets of orifices.

The yarn is preferably simultaneously twisted and wound up outside the spinning cell, for example by means of a cap spinner or a ring spinner. The degree of twist inserted may be quite low, e.g. between about 1 and 5 turns per inch and especially 1–3.5 turns per inch. However when yarns of this general type are given higher twists, e.g. between 5 and 10 turns per inch, filament loops tend to form both in the surface and in the body of the yarn, so further increasing its bulk. Such twists may be imparted wholly before or when the yarn is first wound up, but it will often be more convenient to give the yarn a low degree of twist at the winding up stage, and to increase this, e.g. to a total twist between 5 and 10 turns per inch, in a subsequent operation.

The invention includes also the spinning jets used in carrying out the process described above, i.e. spinning jets in which the spinning orifices are of two types, those of the one type being at least twice as long, and preferably 5–30 times as long, as those of the other, and also of cross-sectional area such that they offer a higher resistance to the passage of a viscous liquid. While it is preferred that the orifices of the two types should be grouped separately in two concentric circles, other arrangements can be adopted, all as described above.

The invention is illustrated by the accompanying drawing, in which

Figure 1 represents a side view in section of a dry spinning cell,

Figure 2 is a plan view on an enlarged scale of the spinning jet in Figure 1, as seen from below,

Figure 3 is a section taken along the line 3—3 of Figure 2, and

Figure 4 is a plan view of a spinning jet of another form, as seen from below.

(For the sake of clarity, the lengths of the orifices in the jet are exaggerated in Figure 3.)

Referring now to the drawing, the apparatus as generally illustrated in Figure 1 comprises a dry spinning cell **10**, a feed roller **11** and a cap spinning device **12**. The spinning cell is provided with a heating jacket **13** with an inlet **14** for heating fluid at its upper end and an outlet **15** at its lower end. An air outlet **16** is provided at the upper end of the cell and communicates with a suction device (not shown) by means of which air can be drawn upwardly through and from the cell. The cell is provided near its lower end with a lateral opening **17**, and at its lower end with an air intake **18**, and contains a central yarn guide **19** at about the same level as the lateral opening **17**. A feed pipe **20** leads to a spinning jet **21** near the upper end of the cell.

The spinning jet **21** is illustrated in more detail in Figures 2 and 3. It comprises a cup-shaped member provided with an interior thread **22**, and its face **23** is pierced by orifices **24**, **25** arranged in an inner and outer circle respectively. The inner orifices extend at constant diameter through the whole of the thickness of the jet face **23**, while the outer orifices **25** are countersunk from the interior of the jet over the greater part of their length. The jet is screwed by means of the thread **22** onto a conventional mounting which is not separately shown.

An alternative type of spinning jet is illustrated in Figure 4. This is similar to that illustrated in Figures 2 and 3, except that the orifices **26** and **27** are arranged in two small circular groups, which may for example be about 10–12 mm. apart at their nearest points. The orifices **26** correspond to the orifices **24** (Figure 2) and extend through the whole thickness of the jet face, while

the orifices **27** are countersunk over the greater part of their length in the same way as the orifices **25**.

The invention is further illustrated by the following example, in which the apparatus illustrated in Figures 1–3 of the drawing was employed.

Example

A 26.2% solution of cellulose acetate in acetone at a temperature of 60° C. was fed to the spinning jet **21** by means of a gear wheel spinning pump in the usual way. The jet face was 42 mm. in diameter and the jet contained 20 orifices arranged in two circles of 10. The diameter of the outer circle was 34 mm., and the orifices **25** in it were 0.036 mm. in diameter and were so countersunk that their length was 0.030 mm. The diameter of the inner circle was 20 mm., and the orifices **24** in it were 0.055 mm. in diameter and 0.50 mm. long. The spinning cell was heated by means of the heating jacket **13** to a temperature which when spinning was in progress was 72° C. at the top and 28° C. at about the level of the lateral opening **17**, and air was drawn upwardly through the cell from the air intake **18** to the outlet **16**.

The spinning solution was fed to the jet **21** at a rate such that crinkled filaments were formed from the outer ring of orifices **25**, and substantially uncrinkled filaments from the inner ring of orifices **24**. Shortly before they reached the yarn guide **19** the two groups of filaments were combined, and the resulting voluminous yarn was drawn out of the cell through the lateral opening **17** by means of the feed roller **11** at a speed of 95 metres per minute, and wound up on the cap spinner **12** with a twist of 1.5 turns per inch. The total denier of the resulting voluminous yarn was 170, of which the crinkled filaments accounted for 96 and the support filaments for 74.

If the yarn was subsequently given a further twist of 7.5 turns per inch loops of filaments were formed, and the bulk of the yarn was still further increased.

Although in the process and the spinning jets as particularly described above circular spinning orifices of the usual kind are employed, orifices having other cross-sections, e.g. semi-circular, slot-like or crescent-shaped orifices, may be used if desired, especially for the production of the crinkled filaments. By this means voluminous yarns of characteristic appearance can be made, and their appearance can be modified by subsequently boiling them in water or aqueous solutions, e.g. aqueous soap solutions. Moreover further different effects may be obtained by combining the crinkled and support filaments with a separately produced support thread, which may be termed a binding support thread, and which preferably first comes into contact with the crinkled and support filaments at a point between that at which they are themselves combined into a single yarn and that at which the yarn is twisted and wound up. Such a binding support thread may be formed in the same cell as the crinkled and support filaments by means of a separate spinning jet, or it may be preformed, and combined with the yarn formed from the crinkled and support threads either inside or outside the spinning cell. It may be chemically similar to or different from the crinkled and support filaments; for example when the latter are of cellulose acetate a binding support thread may be a high tenacity regenerated cellulose thread or a polyamide or other synthetic polymer thread.

Having described our invention, what we desire to secure by Letters Patent is:

1. A multi-hole spinning jet in which some of the spinning orifices are of a first type and some of a second type, the length of the orifices of said first type in a direction at right angles to the face of said jet being greater than the corresponding length of the orifices of said second type and the cross section of the orifices of the second type being less than that of the cross section of the orifices of the first type.

2. A spinning jet according to claim 1, wherein the length of the orifices of the one type is 5–30 times that of the orifices of the other type.

3. A spinning jet according to claim 2, wherein the orifices of the two types are arranged respectively in concentric circles differing in diameter by at least 8 mm. the innermost circle consisting of orifices of the longer type and the outermost of orifices of the shorter type.

4. A spinning jet according to claim 2, wherein the orifices of the two types are arranged in two or more compact groups spaced from each other at their nearest points by at least 8 mm.

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