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W. L. WEBB ET AL
METHOD AND APPARATUS FOR SPINNING
ARTIFICIAL FIBERS
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2,465,408

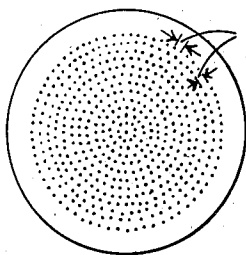


Fig. 1

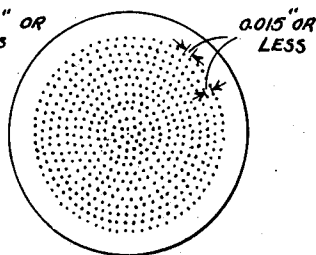


Fig. 2

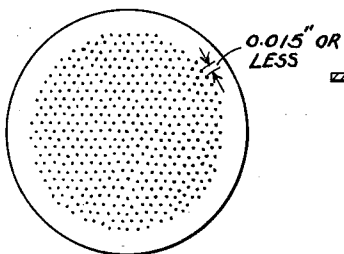


Fig. 3

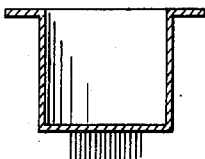


Fig. 4

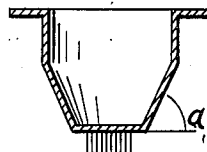


Fig. 5

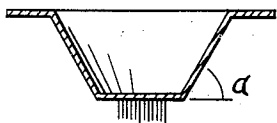


Fig. 6

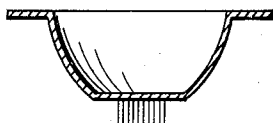


Fig. 7

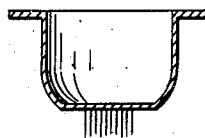


Fig. 8

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2,465,408

METHOD AND APPARATUS FOR SPINNING
ARTIFICIAL FIBERS

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15 Claims. (Cl. 18—8)

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This invention relates to methods and apparatus for spinning artificial fibers, and is more particularly concerned with improved spinnerets and improved methods of wet spinning which are accomplished by the utilization of such spinnerets.

Heretofore the general practise has been to space the orifices in spinnerets in circles with considerable distances of the order of 40 to 70 thousandths of an inch between the adjacent orifices. This wide spacing was a requisite to proper spinneret inspection by the conventional "thumb" method. In addition, to assure rapid and adequate penetration of the liquid coagulating medium through the outer shroud of filaments of the bundle, the large spaces between the orifices were considered essential. For the same general reason, a central area of the spinneret was generally left blank, so that all filaments would be placed nearer the outer shroud where they would be more immediately available to the coagulating medium.

Accordingly, the arrangement of orifices in the conventional spinneret heretofore used consists of an annulus of one or more circular rows of orifices with wide spaces between the rows and the orifices in the rows, the central portion of the spinneret being left blank. The only exception that may have occurred occasionally was in the type of spinneret which has been used for the production of filaments for conversion into staple fibers. In such production, it has been the practice to produce a much greater number of filaments from a single spinneret (generally well over twelve hundred holes per spinneret) and consequently the orifices have been crowded together to a greater extent than has been customary in the production of continuous filament products.

In accordance with the present invention, unexpectedly improved results have been obtained in the production from synthetic fiber-forming materials, such as viscose, of artificial filaments and staple fibers, especially those of high tenacity, when spinnerets having less than about twelve hundred orifices are used, provided the orifices are relatively closely spaced so that there is a distance of not over fifteen thousandths (0.015) of an inch and preferably not over ten thousandths (0.010) of an inch between adjacent circles and between adjacent orifices in a circle, provided that the distribution of the orifices extends throughout the area circumscribed by the outermost orifices so that no noticeably blank area is present therein centrally or eccentrically located. Preferably, though not necessarily the distribution is substantially uniform throughout the perforate area. The invention is of special advantage in the production of high tenacity filaments and staple fibers.

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The invention will be more particularly described with reference to the accompanying drawing, in which:

Figures 1 to 3 show face views of spinnerets having their orifices arranged in accordance with the present invention; and

Figures 4 to 8 are cross-sectional views showing various forms of spinnerets constructed in accordance with the present invention.

Examples of spinnerets within the scope of this invention include those having a central orifice and circular rows of orifices thereabout, the radius of the innermost circle being 0.015 inch or less and the radii of all circles differing by 0.015 or less, and the distance between orifices in a circle being 0.015 or less (see Fig. 1); those having no central orifice but an innermost circle having three orifices on the corners of an equilateral triangle 0.015 inch or less apart surrounded by a plurality of concentric circles having radii 0.015 inch or less greater in radius than the central circle, the orifices in the circles being 0.015 inch or less apart, (see Fig. 2); those in which the orifices are placed upon the corners of a network of equilateral triangles, the sides of which are 0.015 inch or less (see Fig. 3). Preferably in all of Figures 1 to 3, the distance between rows, circles, and between individual holes in the rows or circles is 0.010 of an inch or less.

The spinnerets may take any of the forms shown in Figures 4 to 8. Preferably, a type having a conical walled tip, such as those shown in Figures 5 and 6, in which the angle α is at least 45° and preferably 55 to 60°, is used. The steep slope of the wall of the spinneret streamlines the flow of the fiber-forming material within the spinneret and substantially avoids or reduces dead corners and stagnation or deposition of the material in the spinneret. In addition, the flow of the coagulating medium is streamlined by the conical tip as the medium approaches the filaments from the rear of the plane of the spinneret face.

Regardless of whether or not a cylindrical or conical walled tip form of spinneret is used, the face of the spinneret is preferably designed so that the outermost orifices are about 0.060 to 0.080 of an inch or more from the outer edge of the face, though a smaller band may surround the orifices with some sacrifice in spinning results.

Some of the surprising and unexpected results obtained from the closely spaced orifices are: less breakage of filaments at the spinneret, less clogging of the orifices, and consequent increase in efficiency, reduction of inspection attention by the operators, and improvement of quality of the products obtained. The improvement in these respects is the more noticeable as the ratio of rate of filament withdrawal from

the spinneret to the rate of extrusion through the orifices increases. This ratio commonly ranges from 2:1 (or even less than 1:1) to 5:1 and may be called the "jet stretch" ratio. In addition, it has been found that the close-spaced spinneret orifices as against the conventional spacing, other conditions being equal, make it possible to safely impart a higher degree of stretch to the filaments, and consequently to produce filaments having higher tenacities. For example, in producing high tenacity rayon from viscose in which the filaments while still plastic are stretched by 40% or more, the close-spaced orifice spinneret not only improves the spinability at the orifices, but the effect of the subsequent stretching of the filaments while still plastic is favorably influenced. The spinability has been found to reduce the inspection and attention required, in certain instances, to between one-half and one-fifth of that needed when the conventional spinnerets are used.

Besides these unexpected results, the close spacing of the orifices in accordance with the present invention reduces considerably the amount of metal needed for making the spinneret even when a streamlined form having the conical wall tip is desired. This is of special importance when the spinning conditions are such that the spinneret must be made of a noble metal, such as platinum alloy, or of other special alloys.

The explanation for the various improvements effected by the present invention is highly conjectural. One theory has it that the filaments are mutually supported in the liquid coagulating medium by virtue of the viscosity of the medium in combination with the close spacing of the orifices which permits this factor to come into play, thereby reducing the tendency of the filaments, and especially of the outer shroud of filaments which are particularly prone to breakage, to break at the spinneret face. A corresponding inner shroud of relatively unsupported filaments heretofore present in the annular band of orifices in conventional spinnerets is avoided by the present invention. However, it is not intended to limit the scope of the invention by any particular theory of operation.

The spinnerets and methods of improving spinning by using them may be applied to the wet spinning of artificial filaments from viscose, cuprammonium cellulose; cellulose esters, such as cellulose acetate, cellulose acetate propionate, and cellulose acetate butyrate; cellulose ethers, such as ethyl cellulose, benzyl cellulose; synthetic resins, such as polymers of vinyl chloride alone or copolymerized with vinyl acetate or with acrylonitrile; condensation polymers, such as nylon; proteins, such as casein and soya bean protein; and other fiber-forming materials. The spinnerets may likewise be used in dry-spinning or melt-spinning, though its advantages are most pronounced in wet-spinning and particularly in the production by the wet-spinning process of filaments and fibers of high tenacity in which at least 40% after-stretch is involved.

It is to be understood that changes and modifications may be made without departing from the invention as defined by the appended claims.

We claim:

1. A spinneret having a plurality of orifices, substantially all of the orifices being arranged in rows spaced apart by a distance of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, the distance between adjacent orifices

in the rows being of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, said orifices being distributed throughout the area within the periphery defined by the outermost orifices.

2. A spinneret having a plurality of orifices, substantially all of the orifices being arranged in rows spaced apart by a distance of approximately ten thousandths of an inch, the distance between adjacent orifices in the rows being approximately ten thousandths of an inch, said orifices being distributed throughout the area within the periphery defined by the outermost orifices.

3. A spinneret having less than twelve hundred orifices, substantially all of the orifices being arranged in rows spaced apart by a distance of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, the distance between adjacent orifices in the rows being of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, said orifices being distributed substantially uniformly throughout the area within the periphery defined by the outermost orifices.

4. A spinneret having less than twelve hundred orifices, substantially all of the orifices being arranged in rows spaced apart by a distance of approximately ten thousandths of an inch, the distance between adjacent orifices in the rows being approximately ten thousandths of an inch, said orifices being distributed substantially uniformly throughout the area within the periphery defined by the outermost orifices.

5. A spinneret having less than twelve hundred orifices, substantially all of the orifices being arranged in circular rows spaced apart by a distance of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, the distance between adjacent orifices in the rows being of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, said orifices being distributed throughout the area within the periphery defined by the outermost orifices.

6. A spinneret having less than twelve hundred orifices, substantially all of the orifices being arranged in circular rows spaced apart by a distance of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, a central orifice spaced a distance of the order of ten thousandths of an inch but not substantially over fifteen thousandths of an inch from the orifices in the innermost circular row, the distance between adjacent orifices in the rows being of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, said orifices being distributed substantially uniformly throughout the area within the periphery defined by the outermost orifices.

7. A spinneret having less than twelve hundred orifices, all of the orifices being arranged in circular rows spaced apart by a distance of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, the orifices in the innermost circular row being located substantially on the corners of an equilateral triangle having sides of a length of the order of ten thousandths of an inch, such length being at the most not over fifteen thousandths of an inch, the distance between adjacent orifices in the rows being of the order of ten thousandths of an inch, such distance being at the most not

stantially over fifteen thousandths of an inch, said orifices being distributed throughout the area within the periphery defined by the outermost orifices.

8. A spinneret having a plurality of orifices located on the points of intersection of three sets of parallel rows, the rows in each set making an angle of about 60° with those in each of the other sets, the distance between the rows of each set being such that the distance between adjacent orifices is of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, orifices being placed at all intersections within the area circumscribed by the outermost orifices.

9. A spinneret having less than twelve hundred orifices, substantially all of the orifices being arranged in rows spaced apart by a distance of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, the distance between adjacent orifices in the rows being of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, said orifices being distributed substantially uniformly throughout the area within the periphery defined by the outermost orifices, said spinneret comprising a streamlined peripheral wall portion having internal and external diameters gradually reducing in size to the plane of the spinneret face.

10. A spinneret having less than twelve hundred orifices, substantially all of the orifices being arranged in rows spaced apart by a distance of approximately ten thousandths of an inch, the distance between adjacent orifices in the rows being approximately ten thousandths of an inch, said orifices being distributed substantially uniformly throughout the area within the periphery defined by the outermost orifices, said spinneret comprising a streamlined peripheral wall portion of frusto-conical shape having internal and external diameters gradually reducing in size to the plane of the spinneret face, said wall portion being inclined at an angle greater than 45° to the plane of the spinneret face as measured outside the spinneret.

11. A spinneret having less than twelve hundred orifices, substantially all of the orifices being arranged in circular rows spaced apart by a distance of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, the distance between adjacent orifices in the rows being of the order of ten thousandths of an inch, such distance being at the most not over fifteen thousandths of an inch, said orifices being distributed throughout the area within the periphery defined by the outermost orifices, the perforate area of the spinneret face being surrounded by an imperforate annular band having a width of at least about sixty thousandths of an inch.

12. The method of spinning artificial fibers comprising extruding viscose at a jet stretch ratio between 2:1 to 5:1 to form a multiplicity of filaments flowing into a liquid coagulating medium as a compact bundle, each individual filament in which is spaced from its adjacent filaments by distances of the order of ten thousandths

of an inch, such distance being at the most not over fifteen thousandths of an inch at the plane of entry into the medium, the filaments being distributed in the bundle at its plane of entry into the medium throughout the area in that plane circumscribed by the outermost shroud of filaments in the bundle.

13. The method of spinning artificial fibers comprising extruding viscose to form a multiplicity of filaments flowing into a liquid coagulating medium as a compact bundle, each individual filament in which is spaced from its adjacent filaments by distances of the order of ten thousandths of an inch, such distances being at the most not over fifteen thousandths of an inch at the plane of entry into the medium, the filaments being distributed in the bundle at its plane of entry into the medium throughout the area in that plane circumscribed by the outermost shroud of filaments in the bundle, and stretching the filaments while still in plastic condition by at least 40%.

14. The method of spinning artificial fibers comprising extruding viscose at a jet stretch ratio between 2:1 to 5:1 to form a multiplicity of filaments flowing into a liquid coagulating medium as a compact bundle, each individual filament in which is spaced from its adjacent filaments by distances of the order of ten thousandths of an inch, such distances being at the most not over fifteen thousandths of an inch at the plane of entry into the medium, the filaments being distributed in the bundle at its plane of entry into the medium throughout the area in that plane circumscribed by the outermost shroud of filaments in the bundle, and stretching the filaments while still in plastic condition by at least 40%.

15. The method of spinning artificial fibers comprising extruding viscose at a jet stretch ratio between 2:1 to 5:1 as a multiplicity of filaments into an aqueous acid coagulating medium as a compact bundle, each individual filament in which is spaced from its adjacent filaments by distances of approximately ten thousandths of an inch at the plane of entry into the medium, and stretching the filaments while still in plastic condition by at least 40%.

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Certificate of Correction

Patent No. 2,465,408.

March 29, 1949.

WESLEY L. WEBB ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 1, line 15, after the word "filaments" insert *into the inner filaments*; column 4, line 69, claim 7, for "substantitally" read *substantially*; column 5, line 1, same claim, for "stantially" read *substantially*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of November, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.