Aug. 20, 1940. G. DE W. GRAVES 2,211,946

SPINNERETTE

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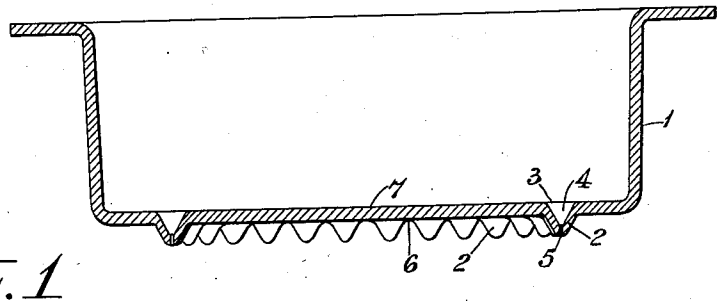


Fig. 1

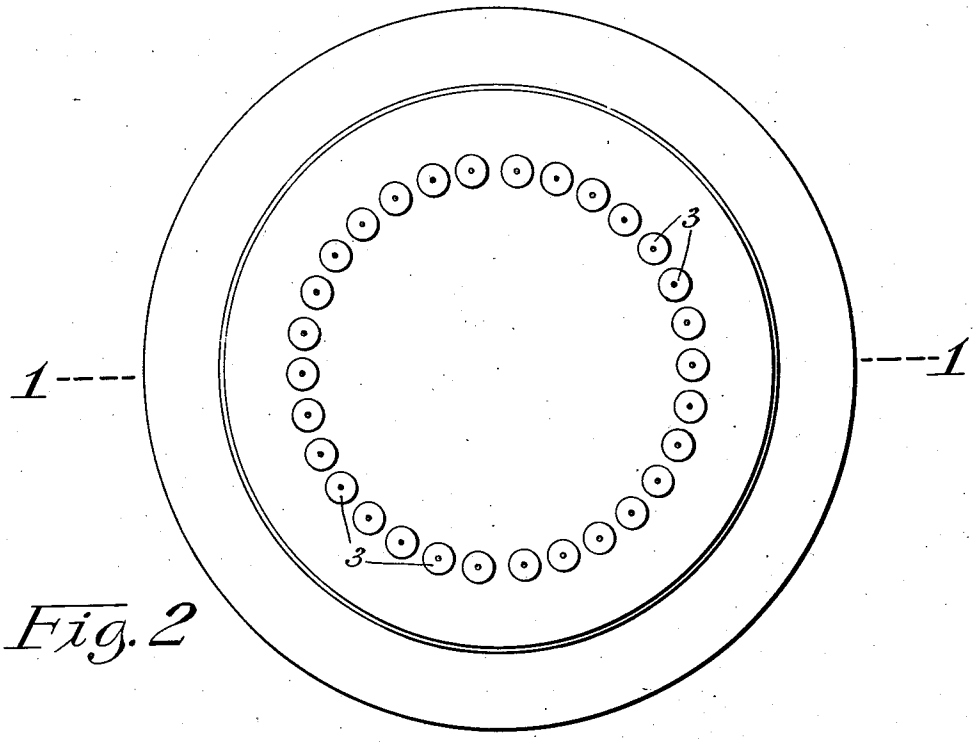


Fig. 2

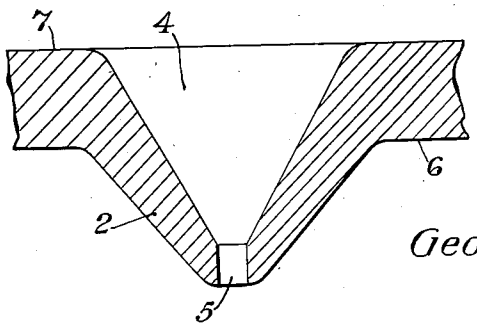


Fig. 3

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SPINNERETTE

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2 Claims. (Cl. 18—8)

This invention relates to the manufacture of artificial filaments and more particularly to new and improved spinnerettes.

This invention has as an object a spinnerette which may be used advantageously not only in the manufacture of filaments, yarns, etc. from filament-forming materials conventionally used in solution form but which may also be used successfully for the melt spinning of those filament-forming materials capable of being extruded in molten form. A further object is a spinnerette which is particularly adapted to the spinning of filaments from molten polyamides and which is capable of spinning filaments from such molten materials without the fouling that takes place with the known type of spinnerettes due to adherence of the molten material to the outside surface of the spinnerette nozzle. Further objects will appear hereinafter.

Artificial filaments are in general prepared by two methods: (1) by wet spinning, which consists in extruding a solution of the filament-forming material through small orifices, i. e., through a spinnerette, into a liquid coagulating bath, and (2) by dry spinning which consists in passing a solution of the filament-forming material through a spinnerette into a chamber in which the solvent is evaporated. In the application of these methods, the solution in the spinnerette is usually kept at ordinary or slightly elevated temperatures and due to the presence of the solvent, little difficulty is encountered in starting spinning and in obtaining a continuous stream of solution through the spinnerette orifices. The spinnerettes ordinarily employed for this purpose have a flat surface provided with orifices. These flat face spinnerettes are employed in the spinning of viscose, cuprammonium, and cellulose acetate yarns. Spinnerettes in which the outlets protrude from the face of the spinnerette have been described but these spinnerettes have found little application even in connection with commonly used filament-forming materials which are unsuited to melt spinning.

A spinnerette having conically shaped outlet members with large orifices (diameter above 1.5 mm. or 0.59 inch) having sharp cutter-like edges, cone height above 5 mm. or 0.2 inch, and a taper of 1 or more to 20, making the apex angle formed by extending the cone walls 5.7°, or more, has been recommended for high speed spinning of artificial silk solutions since this type of spinnerette is stated to prevent the spinning solution from adhering to the inside of the spinnerette outlet and to reduce the pressure on the spinning solution. However, the known spinnerettes having orifices at the end of cone-shaped outlets are poorly suited to melt spinning of filaments useful in the manufacture of fabrics. Moreover, spinnerettes in which the orifices are small and occupy the entire space of the conical outlet members are difficult to fabricate.

The spinning of artificial filaments by extruding the molten filament-forming material through a spinnerette, the type of spinning to which the present invention is particularly adapted, has found little application because until quite recently the only known filament-forming materials of good quality were too unstable to permit their spinning from melt. However, a new class of filament-forming materials, which are sufficiently stable for melt spinning, is described in U. S. Patents 2,071,250, 2,071,251, 2,071,252, and 2,071,253. These filament-forming materials are described as synthetic linear condensation superpolymers. While these synthetic linear condensation polymers can be spun from solution by conventional wet and dry methods, it is more economical to spin them directly from melt since this does not require the use of solvents and their subsequent removal. Furthermore, melt spinning can be carried out at a much greater rate of speed than spinning from solution by either the dry or wet method.

While the melt spinning referred to in the above mentioned patents has certain inherent advantages over other methods of spinning, it involves certain difficulties, particularly in the case of filament-forming materials having high melting points, as for instance melting points of from 175 to 300° C. In general, the spinning temperature is fairly critical; if the temperature is too high the material becomes so fluid that it does not set up properly on leaving the spinnerette and if the temperature is too low filaments of inferior quality are obtained. Furthermore, it is more difficult to start the spinning operation in melt spinning than in spinning from solution. In addition, molten polymer has a greater tendency to foul the spinnerette by flowing along the face of the spinnerette than in the case of solution spinning. In some cases the fouling occurs after spinning has started by a turning back of the filamentary stream of molten polymer onto the face of the spinnerette, a phenomenon referred to as "flicking." Although large filaments can frequently be spun without much trouble by extrusion of the molten polyamide through openings of the kind provided in spinnerettes used for spinning other types of fila-

ment-forming materials, the spinning of small filaments from molten polyamides is attended with much difficulty because it is difficult to start the spinning and much fouling of the spinnerette occurs. This outside fouling or "flicking" encountered in melt spinning causes very frequent interruptions in the spinning operation, particularly when spinning at low jet velocities. Owing to the high temperatures used in melt spinning it is not feasible to wipe off fouled spinnerettes as in the case of dry spinning. Such a procedure would cause the filament-forming material to freeze at the spinnerette. On the other hand, the molten materials show little tendency to adhere to the inside of the outlet.

I have now found that the use of a cone-type spinnerette constructed as described herein greatly facilitates the starting of spinning and reduces the tendency toward fouling encountered in melt spinning.

My improved spinnerette is illustrated in the accompanying drawing in which

Fig. 1 is a plan view of a spinnerette provided with spinning cones embodying the feature of my invention,

Fig. 2 is a section taken on the line A—A of Fig. 1, and

Fig. 3 is a full size sectional diagrammatic view of one of the spinning nozzles.

The cone-shaped protrusions or nozzles 2, which will be described in more detail below, extend outward from the lower face 6 or delivery side of the spinnerette 1. The circular openings 3 at the surface of the inner face 7 at the bottom of the spinnerette lead into the channels 4 which are preferably cone-shaped and which are formed in the truncated cones 2, and the lower end or apex of each of these channels lead into a fine conduit or base which passes through the wall of the smaller end of the truncated cone and terminates at its apex in a small hole 5.

It will be seen that while the cross sectional area of the small protruding end of each truncated cone is quite small (less than 0.002 square inch), the hole occupies but a small portion of this area. The diameter of the small end of the truncated cone will be at least 1.5 times the diameter of the hole but preferably less than 4 times the diameter of the hole.

The optimum results in melt spinning filaments of the sizes used in making fabrics are obtained when the angle made by the sides of the cone, that is when the apex angle, is between 20° and 90°, the preferred construction being that shown in detail in Fig. 3. The height of the cone, which should be not more than 0.17 inch, is at least 0.03 inch and is preferably from 0.06 inch to 0.12 inch. If the cones are too long the filament-forming materials tend to freeze at the small end. The diameter of the outlet or hole for the spinning of textile fibers is between 0.005 inch and 0.01 inch. For the spinning of bristles and the like larger holes may be used. In this connection it should be observed that the spinning of large filaments is less critical since they show less tendency to foul the spinnerette. It will be apparent that the spinnerettes may contain a single cone and hole or a plurality of cones. For the commercial production of filaments for use in fabrics and the like, spinnerettes containing a plurality of holes, e. g., 10 to 100 are used. In spinnerettes of this type it is essential that the cones be so spaced that the extruded filaments do not easily come in contact with each other. Furthermore, in melt spinning, it has been found that filaments of most uniform denier are obtained when the holes are spaced at an equal distance from the center of the spinnerette face, i. e., when the cones are located on a single circle centered in the spinnerette face. This arrangement gives the most uniform distribution of the molten filament-forming material to the various holes.

In the embodiment shown in the drawing, particular reference being had to Fig. 3, the walls of the conical-like protrusions are quite thick and the hole, which is of greater length than diameter, is practically a capillary through the protruding base or small end of the truncated cone rather than an orifice in the usual sense of the term.

The practice of this invention is illustrated by the following examples:

Example I

This experiment illustrates the spinning of polyhexamethylene adipamide, a synthetic linear condensation polyamide derived from hexamethylenediamine and adipic acid. This polymer melts at approximately 263° C. under oxygen-free conditions. The specific polymer used had an intrinsic viscosity of 0.9. It was spun from melt at 285° C. using a constant volume delivery pump. The spinnerette employed contained 30 holes each of 0.0088 inch diameter situated at the bottom of truncated cone-shaped protrusions extending outward from the delivery side of the spinnerette. Each cone-like protrusion had a depth of 0.063 inch and the sides of the cone formed an angle of 60°. The cones were distributed as indicated in the diagram. The surface of the spinnerette cones was coated with a film of polymerized isobutylene before spinning. Extruded filaments were collected on a motor driven drum. The spinning proceeded smoothly. The 30-filament yarn obtained in this way had a denier of approximately 200. The yarn was subsequently cold drawn to improve its quality.

Attempts to spin the polyamide under the same conditions using a flat face spinnerette resulted in much more frequent foulings.

Example II

Polydecamethylene adipamide, a polyamide derived from decamethylenediamine and adipic acid, was used as the filament-forming material in this example. The polyamide had a melting point of approximately 230° C. and an intrinsic viscosity of 0.76. It was spun from melt at approximately 260° C. under a pressure of 100 pounds per square inch applied with oxygen-free nitrogen using a 10-hole spinnerette of the truncated cone type, in which the height of the truncated cone was 0.125 inch and the angle made by the sides approximately 60°. Spinning proceeded smoothly for several hours at a rate of 1000 feet per minute.

Example III

Polymerized 6-aminocaproic acid, having an intrinsic viscosity of 0.72, was spun from melt at approximately 246° C. from a spinnerette of the type used in Example II. The spinnerette had been coated with polymerized isobutylene prior to spinning. The filaments were extruded under a pressure of 200 lb./sq. in. applied with oxygen-free nitrogen. The spinning rate was 750 feet per minute.

Example IV

The filament-forming material used in this example was ethyl cellulose admixed with 20% of dimethoxyethyl phthalate to lower its melting point. This composition was spun into filaments at a temperature of 210–215° C. from a spinnerette of the type described in Example II under 50 pounds nitrogen pressure. Spinning proceeded smoothly.

It will be apparent from the foregoing description and examples that truncated cone-type spinnerettes can be used to advantage in melt spinning any filament-forming material which is sufficiently stable to permit spinning from melt. Examples I–III illustrate the application of these spinnerettes to the melt spinning of synthetic linear condensation polyamides. These polyamides are members of a class of fiber-forming materials known as synthetic linear condensation polymers. Additional types of polymers falling within this class are polyesters, polyacetals, polyethers, and polyester-polyamide interpolymers, whose preparation is described in U. S. 2,071,250. Of the synthetic linear condensation polymers, however, the polyamides, and particularly those derived from diamines and dicarboxylic acids or amide-forming derivatives of dibasic carboxylic acids, yield the most valuable products. The spinnerettes of the present invention are particularly well adapted to the melt spinning of these polyamides. Owing to the fact that the polyamides are sensitive to oxygen at elevated temperature, the molten polymer which is fed to the spinnerette should be protected from oxygen.

As illustrated by Example IV, however, my new spinnerette is capable not only of improving the melt spinning of polyamide filaments but is also applicable to cellulose derivatives which can be melted without appreciable decomposition or which can be suitably plasticized to spin from melt. As examples of other cellulose derivatives which can be employed there may be mentioned cellulose acetate, cellulose propionate, cellulose acetate-propionate, and benzyl cellulose. Filament-forming resins, such as meta styrene, can also be melt spun to advantage through the spinnerettes herein described. Although my invention is designed chiefly to overcome difficulties incident to melt spinning, the spinnerette described herein is also useful for solution spinning.

As indicated above, the spinnerettes of this invention are particularly useful in the melt spinning of small filaments, i. e., of the type used in making fabrics. My improved spinnerette, however, with retention of novel and advantageous features, may be made with larger spinning holes for the spinning of large filaments, as for instance bristles.

This invention provides a spinnerette of useful design for the preparation of filaments and the like from molten filament-forming materials, particularly synthetic linear condensation polyamides. The spinnerette facilitates the starting of the spinning operation and greatly decreases fouling during spinning, thus overcoming the principal drawbacks of spinning molten filament-forming materials from spinnerettes of the ordinary or flat face variety. Another advantage of this spinnerette is that the protrusions it contains serve to cool the molten filament-forming material. This means that the temperature of the molten mass in the spinnerette cavity above the protrusions can be kept somewhat above the temperature of the mass as it leaves the holes in the bottoms of the conical protrusions. The higher temperature in the main spinnerette cavity increases the fluidity of the filament-forming mass and aids in its uniform flow to the various protruding outlets. In contrast to spinning from solution, melt spinning, which is made successful and practical through the use of the spinnerettes of this invention, is more economical since it does not require the use of a solvent and does not involve a solvent-removal operation.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments thereof except as defined in the appended claims.

I claim:

1. A spinnerette the delivery face of which is provided with at least one essentially truncated cone-shaped protrusion having a height of 0.03 to 0.17 inch, said protrusion containing a conical channel converging from the internal delivery face of the spinnerette to a straight-sided hole in the truncated end of the protrusion, the diameter of the external face of the truncated end of the protrusion being at least 1.5 times that of said straight-sided hole.

2. A spinnerette the delivery face of which is provided with at least one truncated cone-shaped protrusion having a like shaped channel of 0.03 to 0.17 inch length converging from an opening in the internal delivery face of the spinnerette to a straight-sided hole passing through the wall of the truncated end of the cone-shaped protrusion, the diameter of the external face of the truncated end of the protrusion being from 1.5 to 4 times that of said opening.

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