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SPINNING APPARATUS

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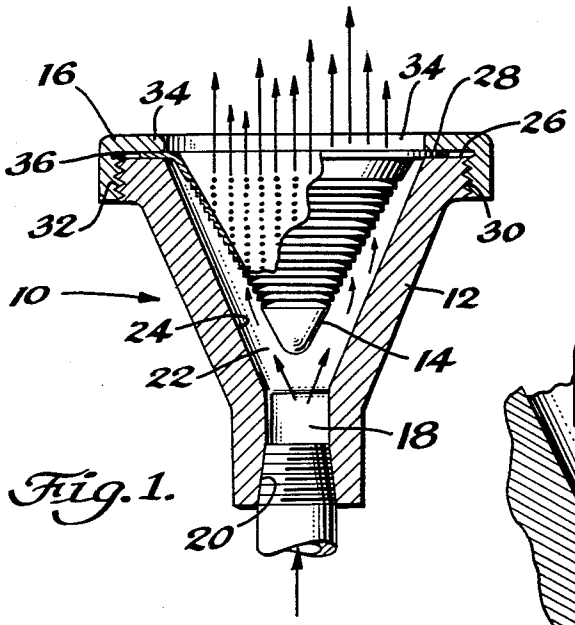


Fig. 1.

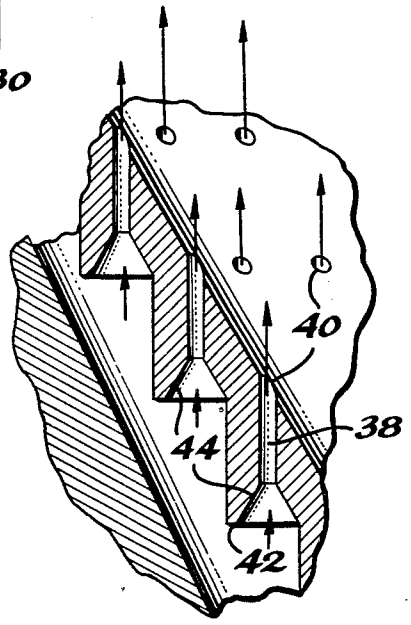


Fig. 2.

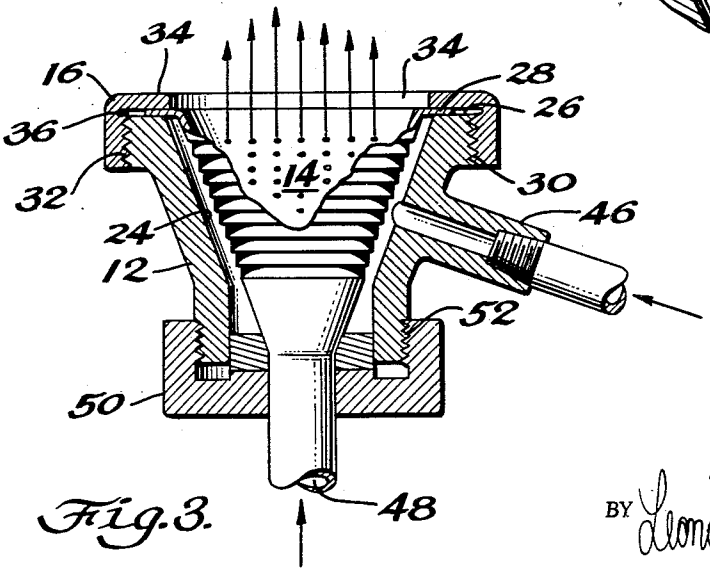


Fig. 3.

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SPINNING APPARATUS

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The present invention generally relates to spinning apparatus useful in the production of filaments by dry, wet, or melt spinning procedures, and more particularly to an improved spinneret design for utilization in carrying out such procedures.

In the latest methods for spinning filaments and fibers, particularly by the melt spinning and dry spinning methods, wherein filter packs of considerable density are employed upstream of the spinneret, it is necessary to have the spinneret made of a high load-bearing material of a sufficient thickness to withstand the considerable pressures encountered without experiencing buckling or other deformation. Consequently, the older methods of making spinnerets from thin metal blanks by simply punching out the extremely small diameter orifices desired, or by drilling with extremely small drills, can no longer be utilized to provide spinnerets suitable for use in high pressure applications.

Spinnerets which have been developed in response to these new requirements have been found to possess certain inherent deficiencies. The fabrication of the spinnerets generally involves removing part of the metal where the orifice is to be formed to thereby reduce the thickness of the spinneret blank at that point to a thinness capable of being punched or drilled to give the small diameter orifice in common usage. Such technique, as counterboring with a conical bit or by drilling step-wise with progressively smaller bits, or by drilling with one larger bit to reduce the thickness of the spinneret blank at the point desired and then making the small diameter orifice, all suffer from requirements that these counterbores must be sufficiently large to admit the bit holder or shank, or the punch holder or shank to the bottom of the bore in order to produce the small diameter orifice. On the other hand, the size of the counterbore cannot be made so large as to seriously reduce the load-bearing ability of the finished spinneret.

Another factor having significant bearing on the strength of the spinneret is the matter of orifice spacing, which becomes even more significant when orifices are formed in the above related manner. In the conventional disc-shaped spinneret blank, the minimum inter-orifice distance is, in part, limited by the size and number of the above mentioned counterbores. A spinneret design capable of providing sufficient distance between orifices without increasing the cross sectional area of the spinneret or decreasing the number of orifices is indicated.

Another problem encountered in the art of filamentary spinning has particular relation to that mode of spinning referred to as wet spinning, wherein the spinnable medium, commonly referred to as dope, is extruded through the spinneret, after which the medium comes in contact with a spin bath solution, which solution must be maintained highly uniform in the area immediately surrounding the spinneret face. This requirement creates problems in spin bath circulation which are amplified by the flat exterior face of the conventional spinneret. There has, therefore, been a long recognized need for a spinneret of such design as to aid rather than obstruct circulation of the spin bath solution in the vicinity of the face of the spinneret.

With the above problems and deficiencies in mind, it is an object of the present invention to provide an improved

spinners of such design as to offer maximum resistance to deformation by spinning pressures without increasing the thickness of the spinneret blank or necessitating the employment of involved machining operations. A further object of this invention is to provide a spinneret of such configuration as to maximize the orifice density per unit cross sectional area of the spinneret. Still another object of this invention is to provide a spinneret which will insure improved circulation of the spin bath solution across the face of the spinneret.

According to the present invention, the foregoing and other objects are obtained by providing a spinneret assembly comprising a substantially cone-shaped spinneret member which, by virtue of its configuration and the manner in which it is housed and supported, has a greatly increased resistance to deformation due to high spinning pressures, provides a greater orifice density per unit cross sectional area, and also provides increased circulation of the spin bath solution in the immediate vicinity of the down stream side of the spinneret. This is accomplished by forming along the external surface of the spinneret member axially spaced, circumferentially extending grooves or steps, a plurality of spinning orifices being formed at spaced intervals throughout the extremities of each such step or groove, which orifices preferably extend substantially parallel to the axis of symmetry of the cone-shaped spinneret. A variable feature of the instant spinneret assembly is the manner in which a spinnerable medium, and, in the case of wet spinning precedures, the spin bath solutions, are conveyed and circulated through the spinneret assembly. In one modification, the smaller end of the cone-shaped spinneret member terminates in an axially aligned passage through which the spin bath solution is conveyed to a point of contact with the interior surface of the spinneret to thereby increase the effectiveness of solution contact with the filaments immediately upon their extrusion.

Referring now to the drawing, wherein like reference numerals designate identical or corresponding parts throughout the several views:

FIG. 1 is an axially sectionalized view of one form of the spinneret assembly of the present invention showing the interrelationship of its various components;

FIG. 2 is a highly enlarged detail view of a typical cross-section through the wall of the spinneret shown in FIG. 1 indicating the spinneret passage configuration therethrough, and

FIG. 3 is an axially sectionalized view of another embodiment of this invention wherein the spin bath solution is fed through the rear or upstream end of the spinneret assembly.

Referring now in detail to the drawings and more particularly to FIG. 1, there is shown one possible embodiment of the present invention in the form of a spinneret assembly, generally indicated by the arrow **10**, having essentially three basic components, viz, an integral, flared spinneret housing **12**, a cone-shaped spinneret **14** mounted internally within said housing and a lock-ring **16** threadably engaged with the flared end of housing **12** in such a manner as to clamp the spinneret **14** in an operative position, wherein the walls of the spinneret are radially spaced from the interior surface of housing **12**. At the upstream or smaller end of the spinneret housing **12**, there is provided a supply duct **18** which may be provided with suitable internal threading **20** for engagement with a conduit to convey a spinnable medium, which may be in the form of a dope, to the interior of the spinneret housing **12**, whence it is extruded through spinneret pasages formed in the spinneret **14** to thereby form continuous

filaments. Preferably, the interior wall of spinneret housing **12** has a more gradual taper than that of the wall of the spinneret **14** to thereby provide a uniformly tapering, annularly-shaped plenum chamber **22** between the spinneret **14** and the interior wall **24** of spinneret housing **12**, whereby any tendency toward a pressure drop as one proceeds along the chamber toward the flared end of housing **12** is minimized. The flared end of housing **12** is seen to terminate in a substantially flat shoulder portion **26** upon which rests the integrally formed, radially outwardly extending flange portion **28** of the spinneret **14**. The flared end of housing **12** is also provided with external threading **30** which is engageable with the internal threading **32** of lock-ring **16**. Upon placing the spinneret **14** within housing **12** in a centered relationship, lock-ring **16** is engaged and turned down tightly by any suitable wrenching means to a point where the inwardly extending lip portion **34** of the lock ring clamps the flange portion **28** of spinneret **14** hard against the shoulder portion **26** of spinneret housing **12**, whereupon the spinneret **14** is rigidly maintained in its centered position preparatory to the commencement of a spinning operation. It may be found desirable to provide an annularly-shaped recess **36** in the lock-ring **16** for reception of a suitable sealing means, such as a conventional rubber O-ring, not shown. The degree of taper of the cone-shaped spinneret **14** and the interior wall **24** of housing **12** is not critical to the practice of the present invention and may vary over a wide range, the particular tapers chosen being dictated by considerations of space requirements, number of spinning orifices desired, spinning pressures anticipated to be encountered, and thickness of the spinneret wall.

With the above described assembly, it will be appreciated that there has been provided an apparatus of simple and rugged construction without sacrifice to quality of the end product and which may be easily and quickly assembled and disassembled for necessary maintenance and repair. It will also be appreciated that, by providing a cone-shaped configuration, it is possible to provide a greater number of spinneret orifices per unit of cross sectional area, which configuration inherently possesses significantly greater resistance to deformation due to high spinning pressures.

Another and concomitant advantage of this configuration and arrangement of parts is that of increased spin bath solution circulation and filament contact, where the present invention is employed in wet spinning type operations, in which case the spinneret assembly of FIG. 1 would be substantially submerged in a spin bath solution to allow such solution to be in intimate contact with the entire interior of spinneret **14**. Because of the tapered configuration, each spinning orifice will be served by a greater volume of the spin bath solution and the solution will be more efficiently agitated and circulated.

Referring now to FIG. 2, wherein there is depicted on a highly magnified scale a typical cross section through a wall portion of the spinneret cone **14**, showing the details of construction of the spinneret passages **38** and spinneret orifices **40**. Preliminary to forming such passages and orifices, a cone-shaped spinneret blank would be formed by any desirable metal-shaping technique, as by pressing or spinning from sheet stock. The spinneret blank is then turned on a lathe to form axially spaced, circumferential step **42**, the surfaces of which preferably extend in planes perpendicular to axis of symmetry of the spinneret cone **14**. These steps **42** are provided to facilitate later machining operations incidental to the forming of passages **38** and orifices **40**. The axial spacing of these steps along the exterior wall of the spinneret cone **14** will be varied according to the hole spacing desired which, in turn, will be prescribed by the mode and conditions of a particular spinning operation. Counterbores **44** are then formed in steps **42** to thereby facilitate entry of a suitable drilling tool to drill out the very small diameter spinneret passages **38**. Where other modes of metal forming are employed, such as by ultrasonic abrasion and chemical etching, the need for counterbores **44** is obviated, which is to emphasize that such counterbores have no functional significance other than with relation to one possible method of forming orifices passages **38**.

Reference will now be had to a modified form of the present invention illustrated in FIG. 3. As there shown, this modified form is in most respect similar to that illustrated in FIG. 1 save for the manner of access of the spin bath solution to the interior of the spinneret cone **14** and the point at which dope is supplied to interior of housing **12**. Initially, let it be pointed out that the laterally protruding supply duct **46** is not of critical location and such duct may be situated adjacent the rear portion of the spinneret housing **14**, as shown in FIG. 3, a location which has a particular advantage in larger spinnerets. As shown in FIG. 3, the spinneret cone of the modified embodiment differs from that shown in FIG. 1 in the provision of a flared open end **48**, which protrudes externally of the lower extension of housing **14**, as defined by positioning collar **50**, which collar is preferably engaged with the lower extension of housing **14** by suitable threading **52**. This collar **50** serves to position the lower extremity of the spinneret cone **14** in axial alignment with tapered housing **12** to assure dimensional integrity of the tapering, annularly-shaped plenum chamber **24**. In operation, the spinneret assembly of FIG. 3, which is particularly adaptable to wet spinning type operations, would be substantially submerged in a spin bath solution, whereupon dope is supplied to plenum chamber **24** to thence be extruded through the spinneret **14**. This extrusion action will serve to supplement any mechanical agitation or circulation imparted to the spin bath solution by exerting a jet-pump type action on such solution to urge it through the flared open end **48** to provide ready access to the interior of a spinneret cone **14** and then to be urged toward the down stream end of the spinneret assembly. It will be appreciated that the mode of spin bath solution circulation made possible by this unique spinneret configuration will result in a substantial increase in the degree and uniformity of solution contact with the dope as it is exhausted from the spinneret orifices **40** to result in a product of enhanced qualities as compared to those obtainable from more conventional apparatus.

It is to be understood that, though the above description has had primary reference to a spinneret having a linear taper in the fashion of a common cone, the inventive concept is not to be limited to such a configuration, but is intended to include any spinnerets of funnel-like configuration whose profile may describe a varying curvature at least to the extent that such curvature will accommodate a greater orifice density per unit cross sectional area as compared to disc-like spinnerets and, as a concomitant of such configuration, has greater resistance to deformation as compared to disc-like spinnerets.

Obviously numerous modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

I claim:

A spinneret assembly comprising in combination a housing and a spinneret means enclosed thereby and in spaced relationship thereto, said spinneret means having the general configuration of a hollow cone having an interior-convex surface and an exterior-concave surface, said convex surface having formed therealong a series of circumferentially extending, axially spaced steps, a plurality of circumferentially spaced, axially extending spinneret passages communicating between each of said steps and the concave surface of said spinneret means to thereby define a plurality of axially spaced, circumferentially extending rows of spinning orifices over a major portion of said concave surface, the smaller end of said spinneret means protruding from said housing and terminating in a

rearwardly opening, axially aligned port; the interior surface of said housing being that of a cone having a lesser degree of taper than that of said spinneret means to thereby define a tapered, annularly-shaped plenum chamber, a supply passage extending through the wall of said housing to communicate with said plenum chamber, an aligning collar threadedly engaging the smaller end of said housing and having a central aperture formed therein, the smaller, protruding end of said spinneret means extending through said aperture to be aligned by said collar within said housing.

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