

Aug. 12, 1969

R. S. HECKROTTE ET AL

3,460,199

SPINNERET ASSEMBLY

Filed Aug. 11, 1967

3 Sheets-Sheet 1

FIG. 1

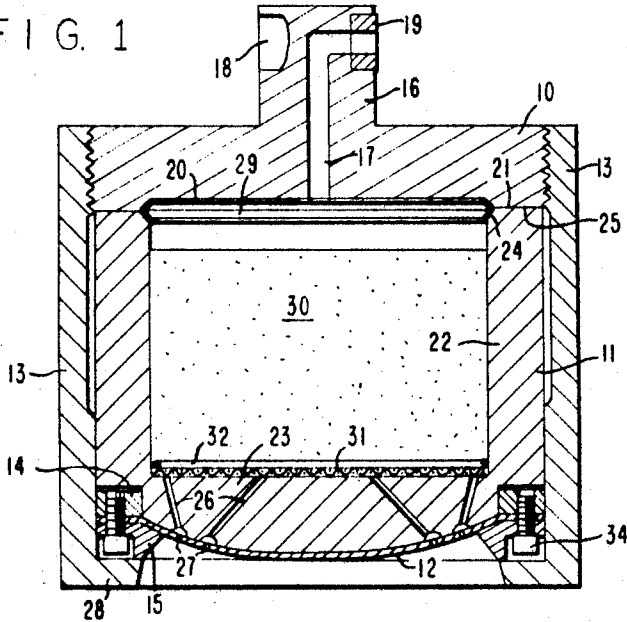


FIG. 2

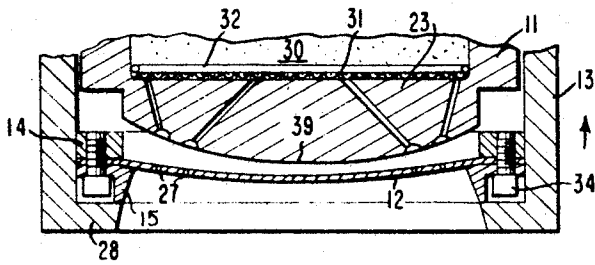


FIG. 3

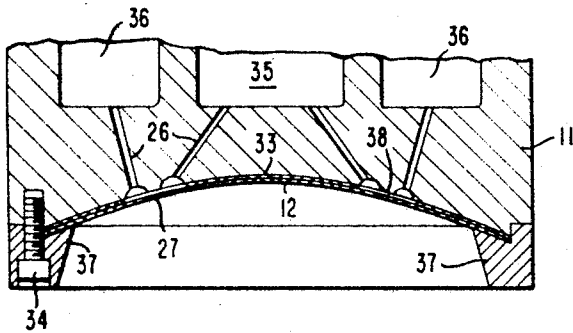
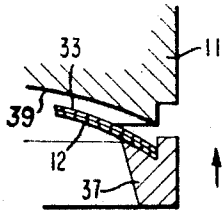


FIG. 4



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3 Sheets-Sheet 2

FIG. 5

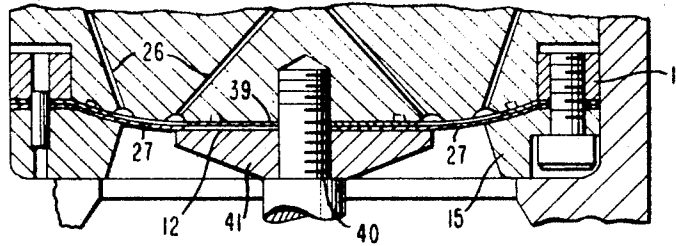


FIG. 6

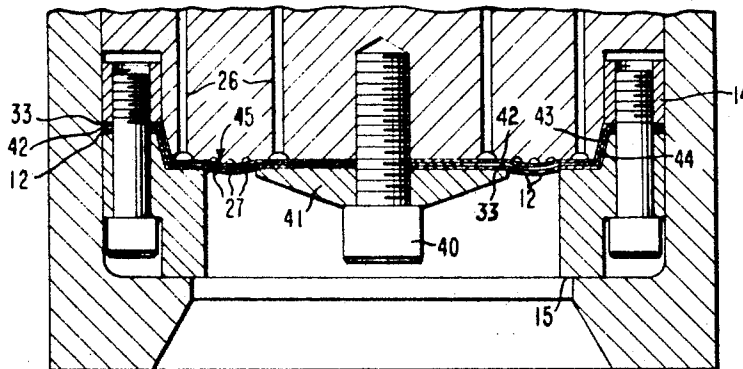
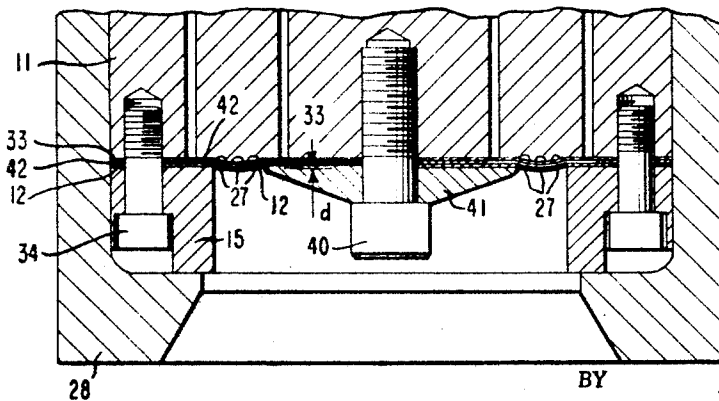


FIG. 7



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3 Sheets-Sheet 3

FIG. 8

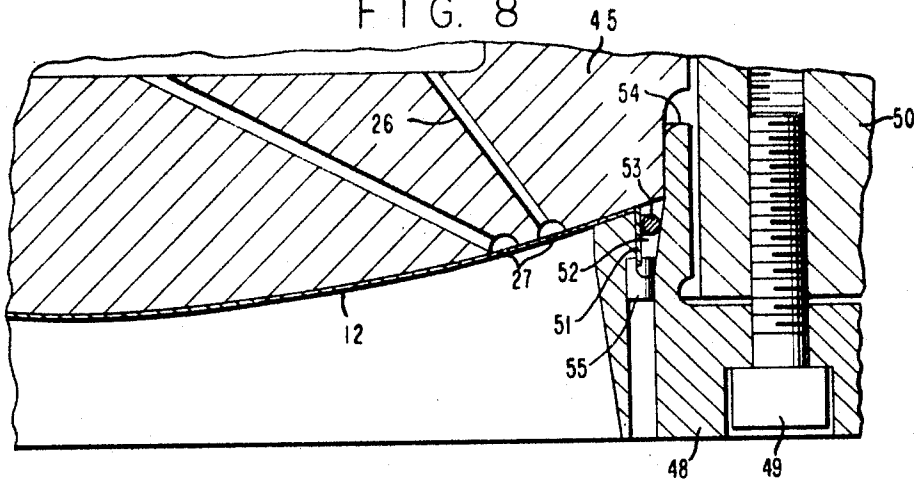
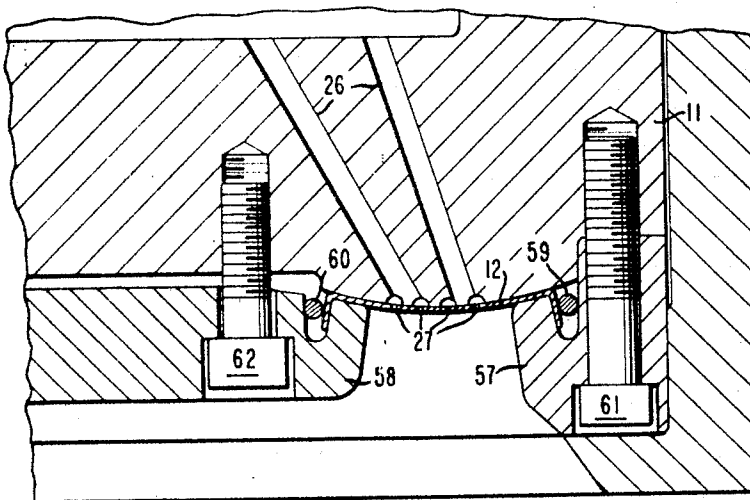


FIG. 9



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SPINNERET ASSEMBLY

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9 Claims

ABSTRACT OF THE DISCLOSURE

Spinneret assemblies are disclosed for thin spinnerets which are suitable for use at the relatively high pressures required in high speed spinning. The spinneret is clamped on a curved supporting member so that the spinneret is bent into a curve and preloaded under tensile or compressive stress to sustain the pressure of the material being spun without leakage. The supporting member may be the sand holder of a conventional filter pack, but modified to have a curved bottom and clamping members for mounting the spinneret. A disclosed advantage is the use of extremely thin spinnerets which are inexpensive to manufacture. Several embodiments of spinneret assemblies are illustrated.

SPECIFICATION

This invention relates to spinnerets useful in the production of synthetic filaments by dry-, wet-, or melt-spinning procedures, and more particularly to a spinneret assembly wherein the spinneret may be extremely thin.

In the latest methods for high-speed spinning of filaments, particularly by melt-spinning or dry-spinning methods, it has been necessary to have the spinneret made of a load-bearing metal of sufficient thickness to withstand considerable pressures without severe deformation, leakage or rupture. Consequently, the advantages of thin spinnerets, such as ease of manufacture by simply punching or drilling thin metal plates, have not been available, and new problems directly associated with use of thicker spinnerets have arisen.

In order to maintain rigidity of the thick spinnerets and yet allow passage of spinning fluid through their orifices at high speeds, it is customary in making them to remove part of the metal where the orifice is to be located, as by counterboring, and thereby reduce the thickness of the spinneret blank at that point to a thickness that can be punched or drilled to give the small-diameter orifice necessary for spinning. Such methods are expensive and suffer from the requirement that the counterbore must be sufficiently large to admit the bit of punch holder or shank to the bottom of the bore to produce the small-diameter orifice, and yet not so large as to excessively reduce the load-bearing strength of the spinneret. In addition, it is necessary to smooth the bores of these drilled holes, as well as the convergent sections, by coining or polishing operations. It is further necessary to maintain the lengths and diameters of the small orifices within the precise tolerance of ± 0.5 mil (± 12.7 microns). As a consequence of the special skills and tools required, the method is an involved and expensive procedure. Any slip in the production of a single orifice often spoils the whole spinneret, since repair of damage to these small-diameter orifices is often impossible.

In view of the evident economic advantage that would attend the use of thin spinnerets in modern high-speed production methods, such spinnerets not having to be counterbored, considerable research effort has been expended to obtain this end. However, the proposals of the

2

prior art are less than satisfactory, either because of the cost of fabrication or because they do not completely eliminate bulging or leakage in the spinning assembly.

It is an object of the present invention to provide an economical spinning assembly, having an extremely thin spinneret which is useful in modern, high-speed methods of filament manufacture without attendant leakage, rupture, or other drawbacks experienced in the art. Other objects and advantages will become apparent hereinafter.

The objects of this invention are accomplished by a spinneret assembly which differs from conventional construction in having a thin metal spinneret clamped in position under transverse tensile or compressive forces to sustain the pressure of material being spun without leakage. The spinneret is mounted on a filter holder body member having a curved spinneret-supporting surface and distribution passages for supplying polymer to the supporting surface. Spinneret-clamping means apply transverse forces, generally tangential to the curved surface, to conform the spinneret to the curvature of the supporting surface and prevent flow of polymer between the peripheral surfaces of the spinneret and supporting surface. Extremely thin spinnerets may be used, between 2 and 25 mils in thickness, which are economical to replace since they are not bonded to the support. Normal forces are produced by the application of transverse forces of from 10% to 99.5% of the yield strength of the spinneret metal thus urging the spinneret against the filter holder member as needed to withstand spinning pressures.

In the drawings, which illustrate several specific embodiments,

FIGURE 1 is a side sectional view of a preferred embodiment of the spinning assembly of the present invention, the section being taken along a plane through the central axis of the assembly;

FIGURE 2 is a partial side sectional view of the assembly of FIGURE 1 illustrating the spinneret in position for assembly on the supporting member, just prior to tensioning the spinneret;

FIGURE 3 is a partial side sectional view of a second embodiment of the present invention wherein the spinneret is subjected to transverse compressional forces;

FIGURE 4 is a side sectional view of a portion of the apparatus of FIGURE 3 illustrating the spinneret position just prior to compressing the spinneret.

FIGURE 5 is a partial side sectional view of a modification of the embodiment shown in FIGURE 1.

FIGURE 6 is a partial side sectional view of another modification employing different clamping means.

FIGURE 7 is a partial side sectional view of another modification in which tension is applied by central clamping.

FIGURE 8 is a partial side sectional view showing a modification of the clamping means of FIGURE 1.

FIGURE 9 is a partial side sectional view of another modification employing a toroidal spinneret.

In FIGURE 1 of the drawings, the major elements include a lid 10, a spinneret-supporting member consisting of a filter holder 11, a spinneret 12, and stress-inducing members which include a nut or collar 13 and upper and lower clamp rings 14 and 15, respectively.

The lid 10 is provided with an upstanding web 16 which has an L-shaped flow passage 17 extending through the lid. Opposite passage 17, web 16 has a depression 18 which accommodates a bolt or clamping lug (not shown) on the spinning machine by means of which the assembly is supported so that the passage 17, with its associated metallic gasket 19, is held against a mating port of the manifold (not shown) through which liquid polymer flows to the assembly. On the lower side thereof, lid 10 has a circular recess 20 and an annular surface 21.

Filter holder 11 has a cylindrical side wall 22 and an internal chamfer 24 which terminates in a surface 25 complementary to surface 21 on lid 10. The chamfer 24 forms a V-shaped groove with the similar formation on lid 10 when the surfaces 21, 25 are engaged. Bottom wall 23 has a plurality of distribution passages 26 extending therethrough.

Spinneret plate 12 is provided with orifices 27 through which liquid polymer is extruded to form filaments. The collar 13 is cylindrically shaped and provided at one end with an intumed flange 28 which engages lower clamp ring 15. At its opposite end, collar 13 is internally threaded for engagement with threads provided externally on lid 10.

The joint between surfaces 21, 25 is sealed by a band-shaped metallic gasket 29 which is seated between chamfer 24 and lid 10. Within the container 11 is body 30 of an inert filtering medium such as sand. The filtering medium 30 is supported and contained by a fine screen 31 which is held in place by a metallic ring 32.

The periphery of spinneret 12 is fastened between upper and lower clamp rings 14 and 15 by means of bolts 34. A foraminous member may, optionally, be sandwiched between plate 12 and holder 11.

In FIGURE 2, the numbers of which correspond to the elements of FIGURE 1, the spinneret 12 is shown fastened between upper and lower clamp rings 14 and 15 by tightening bolts 34, but this is only loosely housed in collar 13, prior to complete assembly. Transverse stress is applied to the spinneret by screwing collar 13 tightly onto lid 10 to move the collar upward in the direction of the arrow and secure the spinneret 12 in sealing engagement against its supporting member, which, in this case, is the filter holder 11. As shown, the plate is of lesser convexity than the filter-holder bottom 39 before it is positioned in sealing engagement with the filter holder. Thus, in the practice of the present embodiment, the spinneret 12 is stretched transversely when being mounted, causing a normal force to exist between the spinneret 12 and the filter holder bottom 39.

In the embodiment of FIGURE 3, spinneret 12 is curved inwardly in the assembly. In this case, the spinneret is subjected to transverse compressive forces by stress-inducing ring 37 and associated bolts 34. The mode of stress inducement is shown more particularly in FIGURE 4. As the spinneret 12 and its associated thin distribution plate 33 are brought into sealing engagement with the filter holder bottom 39 by tightening bolts 34, which in this embodiment engage the filter holder 11, compressive forces are produced in the spinneret. In this case the spinneret is of a greater degree of concavity, that is, the spinneret has a smaller radius than the supporting member prior to complete assembly. As shown in FIGURE 3, special use is made of the thin distribution plate 33 so that bicomponent fibers may be spun side-by-side. Here one polymer is fed to the center channel 35 and another polymer is fed to annular outer channel 36. The polymers flow through their respective distribution passages 26 of filter holder 11, then through narrow slots 38 provided in distribution plate 33 to merge at the orifice and flow therefrom in side-by-side adhering contact.

The embodiment shown in FIGURE 5 is a modification of the one shown in FIGURES 1 and 2. The central portion of the spinneret 12 is secured to the bottom 39 of the supporting member by central bolt 40 and washer 41. The spinning orifices 27 are arranged in a zone surrounding the washer which is curved to form a portion of a toroid. The outer edge of the spinneret is clamped to apply transverse stress to the toroidal zone. As shown, the washer 41 has a diameter nearly half that of the spinneret, but this can be varied as desired. The other details of this embodiment are similar to that of FIGURE 1 and are correspondingly numbered.

In the embodiment shown in FIGURE 6, the spin-

neret 12, the distribution plate 33 and an additional thin perforated plate 42 are all clamped between upper and lower clamp rings 14 and 15. The upper portion of clamp ring 15 is provided with a tapering or conical surface 43 (of about 40° included angle) which is complementary to surface 44 on the bottom of filter holder 11. The plates 33, 42 and the spinneret are likewise pre-shaped to conform generally to the conical surface 43; however, the size of the conical portion of these three thin plates is such that an interference results when they are positioned on the conical surface 44, so that tensile stress is induced in the lower portion of all of the plates when they are clamped tight. This stress is concentrated at the generally toroidal bulge 45 which contains the spinning orifices 27. A central bolt 40 and washer 41 clamp the plates taut around the inner portion of the toroidal surface.

FIGURE 7 shows another embodiment having the spinneret orifices located on a toroidal surface. The spinneret 12 and plates 33 and 42 are secured at their peripheral edges by clamp ring 15, which is bolted directly to their filter holder 11. Tensile stress is then applied to the spinneret and plates by tightening central bolt 40 to draw the washer 41 into a shallow central recess of depth *d* in the supporting member. Thus, the normal force is concentrated at the toroidal bulge.

The embodiment shown in FIGURE 8 differs from that of FIGURE 1 in the means for applying tension to the periphery of the spinneret.

The entire peripheral edge of the spinneret 12 is turned downward, forming a generally cylindrical wall or skirt 51 which is relatively short; e.g., in the order of 0.2 inch. The skirt 51 is secured in a groove 52 in the upper part of the ring 48, the inner wall of which is substantially cylindrical, being of a size to match the inside diameter of the skirt 51 which is engaged therewith; the outer wall of the groove 52 is tapered or conical thus forming a V having an included angle of about 10°. Within the V groove is a wedge wire 53 which extends essentially around the entire groove and serves to lock the spinneret 12 securely in place. At the outer boundary of the V groove 52 is a cylindrical rim 54 which engages a machined surface on the outer periphery of the filter holder 45, thus keeping the ring 48 and spinneret 12 concentric with the filter holder. A pin 55 in the ring 48 intersects the groove 52 as well as a notch in the lower skirt of the spinneret 12, serving to locate the parts circumferentially. A plurality of machine screws 49 pass through the ring 48 and engage the block 50 thereby serving to urge the ring 48 and spinneret 12 against the filter holder 45.

In a similar manner, a toroidal spinneret can be clamped and stressed as shown in FIGURE 9. This spinneret has a large central aperture which may be, for example, half the outside diameter of the spinneret. The annular spinneret has downturned edges which engage V grooves in clamping members 57 and 58. The outer edge is locked in the V groove of outer ring-shaped clamping member 57 by means of wedge wire 59, and the inner edge is locked in the V groove of inner clamping member 58 by means of wedge wire 60. The outer ring member is secured to the spinneret supporting member 11 by machine screws 61. The inner clamping member 58 is secured to filter holder 11 by machine screws 62. Tightening the machine screws draws the spinneret into conformity with the toroidal bulge on the supporting member.

It is preferable to preform the spinneret from its initial flat shape into a shape corresponding somewhat to the supporting member against which it is to be placed. This may be done by pressing the spinneret against a suitably shaped and smoothed anvil. The degree of permanent deformation produced must not be as great as the deformation which occurs in the operative mounting of the spinneret. A suitable degree of deformation is shown in FIGURE 2 wherein the spinneret is preshaped to conform partially to the geometry of the filter-holder bottom, but

yet has a lesser degree of convexity prior to its final assembly in FIGURE 1.

The spinneret-supporting member may be the filter holder illustrated in the accompanying drawings, but any suitable support may be used. The stress-inducing members, as shown in FIGURES 1 and 2, include upper and lower clamp rings 14 and 15 and nut or collar 13. In FIGURES 2 and 3 there is a single ring. Any means to produce transverse tensile or compressive forces may be used.

In order to achieve the benefit of the present invention, the spinneret in its final assembly in the spinning pack is subjected to transverse tensile or compressive forces of from 10% to 99.5% and preferably about 80% of the yield strength of the metal used, which, in the case of 17-4 PH steel, is from approximately 150,000 to 200,000 p.s.i. (10,575 to 14,100 kg./cm.²), and in the case of 301 hardened stainless steel, is from approximately 200,000 to 300,000 p.s.i. (14,100 to 21,150 kg./cm.²).

The metal of the spinneret may be any suitable metal conventionally used in spinneret manufacture.

Although it is not necessary for achieving the benefits of the present invention, a foraminous member or, as shown in FIGURE 6, a thin, perforated, backup plate may be sandwiched between the spinneret and the supporting member. A thin distribution plate or metering plate may be similarly sandwiched between the spinneret and its supporting member. A metering plate, such as that shown in FIGURE 3, is desirable for accurately metering two polymer components to form a bicomponent fiber.

The present invention has a great advantage of allowing use of extremely thin spinnerets without attendant leaks or bulging in spinning operations. The new spinnerets are preferably between 2 and 25 mils (50.8-635 microns) in thickness and, more preferably, between 5 and 12 mils (127-305 microns) in thickness. The use of such thin spinnerets allows highly sophisticated methods of producing orifices in them, such as by the photoetching process described in Mears et al. U.S. Patent No. 2,536,383, dated Jan. 2, 1951, or electron-discharge methods which are known in the art. Also, because no counterbore is necessary in the spinnerets, the orifices may be situated in close relationship to each other, and spinneret orifices of odd cross-sections may be readily produced.

A further advantage of the new assembly is the ease of cleaning. All of the parts are interchangeable and easily disassembled.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not

limited by the specific illustrations except to the extent defined in the following claims.

We claim:

1. A spinning assembly comprising a body member having a curved spinneret-supporting surface, distribution passages through the body member for supplying polymer to the supporting surface, a thin metal spinneret mounted on said supporting surface to form the operative face of the spinning assembly, and clamping means for securing the spinneret in position under transverse forces to conform the spinneret to the curvature of said supporting surface and for preventing flow of polymer between the edges of the spinneret and said supporting surface.

2. The spinning assembly defined in claim 1 wherein the spinneret is clamped under transverse forces of from 10% to 99.5% of the yield strength of the spinneret metal.

3. The spinning assembly defined in claim 1 wherein said supporting surface has a convex curvature and the clamping means subject the spinneret to transverse tensile forces.

4. The spinning assembly defined in claim 1 wherein said supporting surface has a concave curvature and the clamping means subject the spinneret to transverse compressive forces.

5. The spinning assembly defined in claim 1 wherein said clamping means comprises an edge-engaging ring, extending around the periphery of the spinneret, with bolts for securing the ring and spinneret in position on the body member.

6. The spinning assembly defined in claim 5 wherein the central portion of the spinneret is secured to said supporting surface by bolting means.

7. The spinning assembly defined in claim 6 wherein spinneret orifices surround the central bolting means in a zone which has a toroidal curvature.

8. The spinning assembly defined in claim 1 which includes a thin formaminous member sandwiched between the spinneret and said supporting surface.

9. The spinning assembly defined in claim 1 wherein said spinneret is between 2 and 25 mils thick.

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