

Dec. 23, 1969

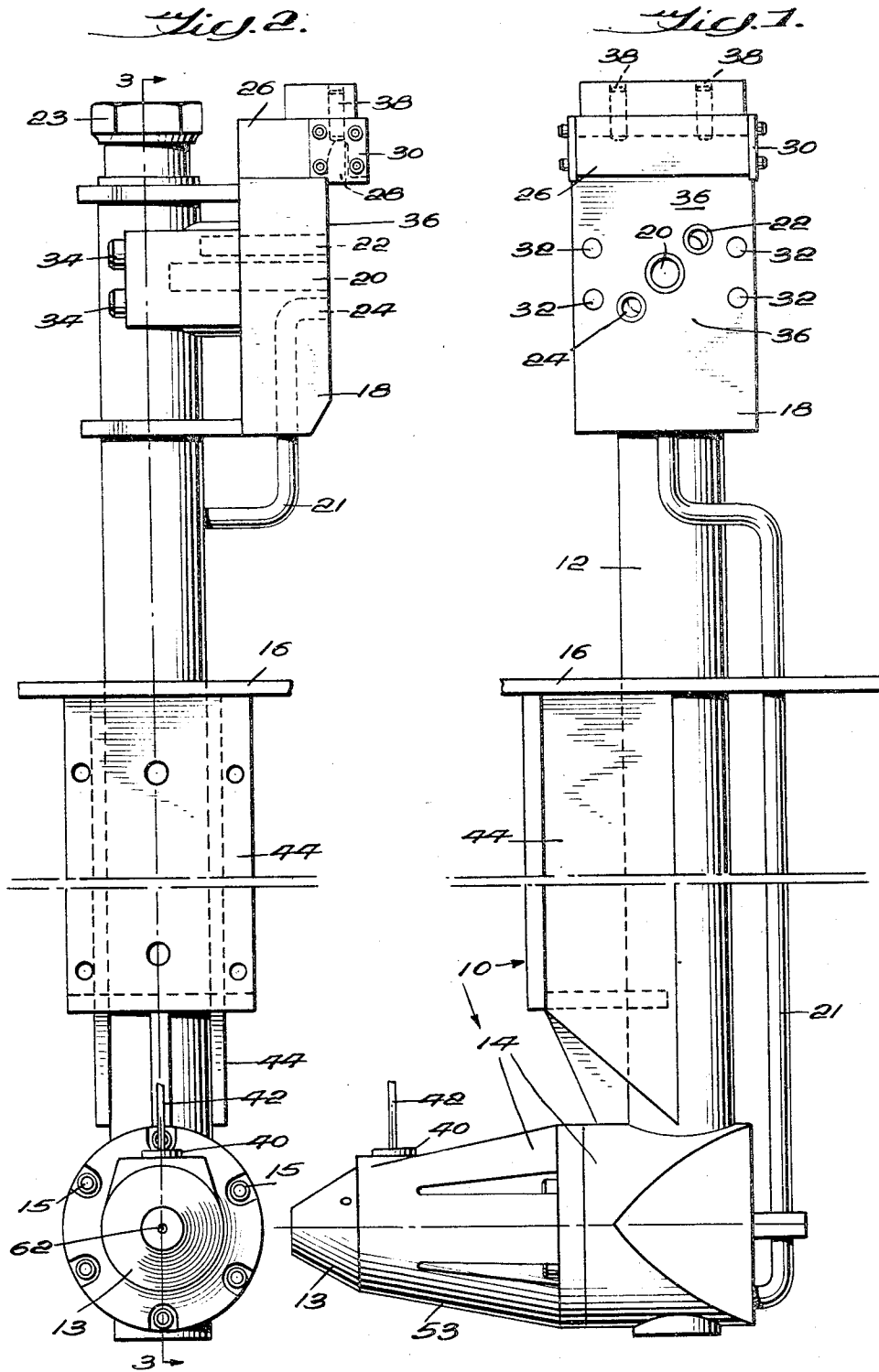
J. G. SMITH

3,484,899

SPINNERET PACK FOR FLASH EXTRUSION

Filed April 6, 1967

3 Sheets-Sheet 1



Dec. 23, 1969

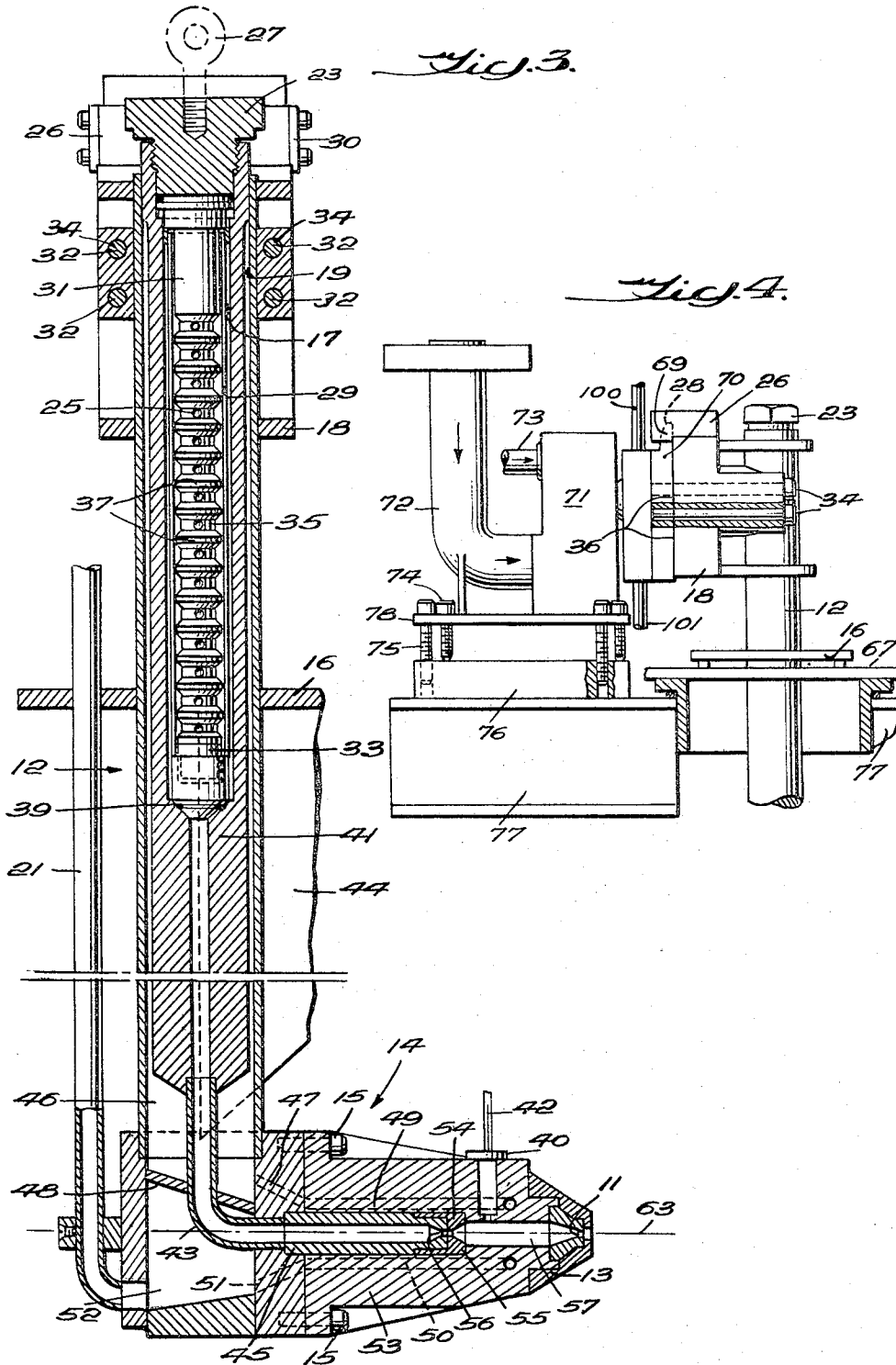
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3 Sheets-Sheet 2



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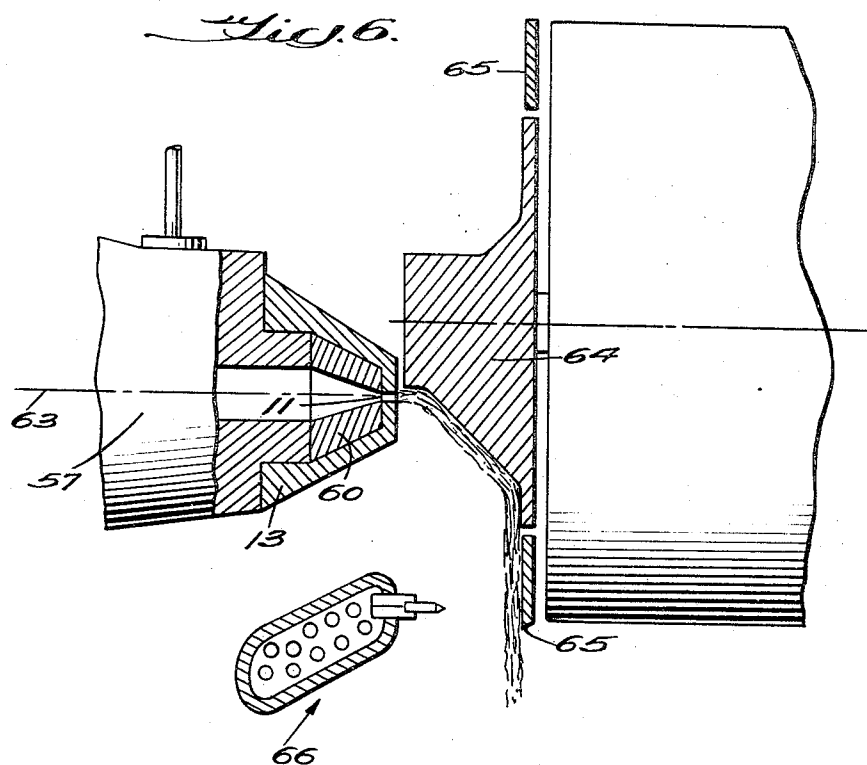
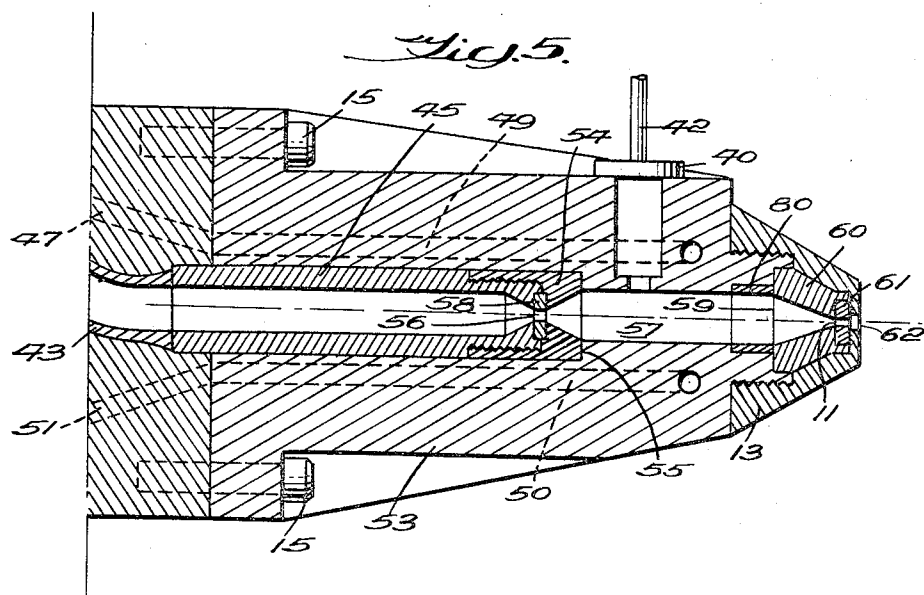
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3 Sheets-Sheet 3



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3,484,899

SPINNERET PACK FOR FLASH EXTRUSION
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Int. Cl. D01d 3/00

U.S. Cl. 18—8

6 Claims

ABSTRACT OF THE DISCLOSURE

A spinneret pack for flash-spinning including an L-shaped structure and an attachment block. Passageways for polymer solution and heating fluid are provided in the L-shaped structure and these communicate with ports in the attachment block, which in turn communicate with corresponding ports in a fixed mounting block. The pack can be accurately positioned in a spinning cell by aligning guides on the attachment and mounting blocks.

BACKGROUND OF THE INVENTION

The present invention is concerned with a spinneret pack for producing synthetic filamentary material and more particularly with a spinneret pack for flash-extruding a polymer solution to form a plexifilamentary strand. The art of flash-extruding or flash-spinning is described in U.S. Patent 3,081,519 to Blades and White. In essence, it comprises spinning a solution of polymer which is forwarded continuously to the spinneret at a temperature above the boiling point of the solvent. Preferably the temperature is near the critical temperature of the solvent. In the spinneret pack the solution is kept at a pressure considerably above the autogenous pressure, e.g. by mechanical means described in U.S. Patent 3,227,794 to Anderson and Romano. The pressurized hot solution is fed to an orifice which is much larger than the usual orifice for dry spinning or wet spinning. As the solution extrudes from the spinneret orifice, the solvent expands rapidly into a gas. Bubbles are formed which expand and grow while being cooled adiabatically. When the temperature of the spinning solution is sufficiently high and when the concentration is sufficiently low, the solvent gas expands sufficiently to rupture the bubbles and form a fibrillated strand which has been termed a plexifilament. The strand is composed of a 3-dimensional network of film-fibril elements which are connected at tie points along and across the strand. The film-fibril elements are less than 5 microns thick. In general, the spinnerets used for flash-spinning have a single large orifice. A multifibrous strand is thus obtained from a single orifice. It should be evident that spinnerets entirely different from those used in wet or dry spinning must be designed for flash-spinning. Some of the earlier spinnerets are described in the Blades and White patent.

Additional spinneret art is disclosed in U.S. Patent 3,169,899 to Steuber. This patent discloses spinnerets which are horizontally oriented and which direct the strand against an oscillating baffle, which, in turn, spreads the strand into a wide network which is deposited on a moving belt. A fibrous sheet is obtained having networks oriented in an overlapping multi-directional configuration. The fibrous sheet is useful for preparation of wall covering, book binding, soft textile like nonwovens, and as a substrate for various coatings, impregnants, and laminates.

In developing the flash spinning technology for preparation of nonwoven fibrous sheets, it has become obvious that improved spinnerets are needed. In particular, when a large number of spinnerets are used for deposit of the plexifilaments on a moving belt, these must be accurately positioned and coordinated to produce a uniform deposit.

2

In addition, it has been discovered that the solvent gases, which are volatilized almost explosively, create considerable turbulence in the flash spinning chamber. For this reason, the design of the entire apparatus must be directed toward streamlined flow.

SUMMARY OF THE INVENTION

According to this invention there is provided a spinneret pack for flash-extrusion of a polymer solution to form a plexifilamentary strand. The spinneret can be readily and accurately positioned in the ceiling of a flash spinning cell. It is simple to remove and replace in the cell and it minimizes the effect of gas turbulence within the cell. Reduced turbulence serves to reduce folding and entanglement of the plexifilament and accurate placement serves to give accurate regulation of the overlapping deposits on a moving belt.

The spinneret pack of this invention comprises an L-shaped solution supply tube having a vertical mounting arm and a tapered horizontal extrusion arm and having passageways for polymer solution and heat exchange fluid. An attachment block is rigidly mounted on the upper end of the vertical arm. The attachment block is provided with a port communicating with the passageway for polymer solution in the L-shaped tube and additional ports for heat exchange fluid inlet and outlet communicating with the passageway for heat exchange fluid in the L-shaped tube. All of the ports in the attachment block terminate in a common surface; the spinneret pack is mounted in the ceiling of a spinning cell by mating this surface of the attachment block with a similar surface of a rigid mounting block having corresponding ports for polymer solution and for heat exchange fluid inlet and outlet.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a side elevation showing the apparatus of the invention.

FIGURE 2 is an end view of the same apparatus.

FIGURE 3 is a cross-sectional view taken along the line 3—3 of FIGURE 2.

FIGURE 4 is a side elevation of a valve unit which serves as a mounting block to align the apparatus of FIGURES 1, 2, and 3.

FIGURE 5 is a cross-sectional elevation view of the spinning arm portion of the L-shaped solution supply tube.

FIGURE 6 is a diagram showing the positioning of the spinneret nose opposite a rotating baffle. The location of an ion gun for depositing an electrostatic charge is also shown.

DETAILED DESCRIPTION

Considering FIGURE 1, the flash-extrusion spinneret pack comprises an L-shaped solution supply tube 10 having vertical mounting arm 12 and a horizontal spinning arm 14. A plate 16 is provided on vertical arm 12; this plate rests lightly upon a gasket around a hole in a supporting plate. The supporting plate in turn rests on a gasket around a port hole in the ceiling of a spinning chamber. The entire unit is fastened and supported in precise spinning position by means of attachment block 18. The attachment block is provided with a solution inlet port 20, a steam inlet port 22, and a steam outlet port 24, all of these being gasketed.

The vertical location of the spinneret above the moving collection belt (not shown) is established by means of a carefully milled notch 28 shown in FIGURE 2 by means of dotted lines. The notch is located in block 26, which is bolted to attachment block 18. A matching lip is provided on the flange of a valve shown in FIGURE 4. The valve serves as a positive guide for locating the position of the spinneret pack over the collecting belt. Cover plates

30 in FIGURES 1, 2 and 3 are side guides which help to position the spinneret pack when it is lowered by crane onto the lip. The approximate location of the spinneret pack in the longitudinal direction along the collection belt is fixed by bolt holes 32 (FIGURES 1 and 3). Mounting bolts 34 (FIGURE 2) are screwed through these holes into the rigidly supported valve shown in FIGURE 4. The valve unit is steam cored. The solution inlet port 20 for the spinneret pack when mounted coincides with the solution outlet port of the valve (FIGURE 4). The steam inlet port 22 and steam outlet port 24 coincide with the corresponding steam lines in the valve. The three connections are gasketed by means of O rings not shown. The surface 36 of the spinneret pack assembly is machined to mate precisely with the flat face of the flange on the solution and steam supply valve.

During the mounting process the spinneret pack of FIGURE 2 is lowered in such a manner that the precise groove 28 falls over the top of the lip 69 of the valve shown in FIGURE 4. The top of the lip is carefully milled and permanently positioned so that it will be parallel to the surface of the moving belt. The top of the milled notch 28 in the attachment block 18 of FIGURE 2 is precisely parallel to the spinneret orifice axis 63. When the notch 28 of the spinneret pack assembly is precisely located on the lip of the mounting unit, the unit is properly oriented for spinning. The precise matching of the lip and the groove can be determined by means of feeler buttons 38 which are carefully machined. After properly orienting the pack, bolts 34 are passed through holes 32 and screwed into matching holes in the valve flange.

In the spinning arm 14 of FIG. 3 a fitting 40 is provided for measuring pressure in a chamber of the spinneret to be described. A flexible mercury capillary 42 transmits this pressure to a pressure transducer. The capillary is located in a flexible tube. Massive plates 44 which are welded to the solution supply tube are provided for stiffening the structure and may also be used for supporting deflector positioning equipment (not shown) which, in turn, supports a web deflector unit and web charging unit. The location of the deflector and charging units relative to the spinneret is shown in FIGURE 6. The complex positioning equipment is omitted for clarity; it is described in detail in the U.S. application of James Gerald Smith, Ser. No. 628,872, filed simultaneously herewith.

It should be noted that horizontal spinning arm 14 is tapered toward the spinneret orifice 11. Likewise, a tapered nose piece 13 is provided. As shown in FIGURE 2, the tapered spinning arm 14 has recesses for bolts 15. The tapered pieces are generally conical but could be wedge-shaped, if desired. The amount of interrupted surface should be minimized to promote streamlined flow.

Considering further the mounting system, FIGURE 2, shows by means of dotted lines the location of passageways in the attachment block 18: solution inlet port 20, steam inlet port 22, and steam outlet port 24. The main solution inlet 20 empties into an annular zone around a filter in the upper end of the vertical mounting arm 12. This solution entry point is indicated by the number 17 in FIGURE 3. The steam inlet 22 empties into a different annular area which is indicated in FIGURE 3 by the number 19. The steam outlet 24 of FIGURE 2 carries steam from pipe 21. The steam inflow and outflow passageways are connected to separate passageways in the valve which serves as mounting block for the spinneret pack.

In FIGURE 3 a cross-section is shown for the spinneret pack assembly. The exterior parts are the same as those in FIGURES 1 and 2. The view is from the reverse side compared to FIGURE 1. Cap 23 is the upper portion of a cylindrical solution filter 25 which screws into the end of vertical mounting arm 12. This cap is also provided with screw threads by which an eye bolt 27 may be attached for lifting the unit. Inside the cap 23 is a gasket for sealing the cap and filter. The filter comprises a

cylindrical screen 29, which is sealed to an upper cylinder 31, and a lower cylinder 33. A perforated cylinder 35 is attached and sealed to the upper cylinder 31. Stiffening rings 37 on the perforated cylinder prevent collapse of the screen when exposed to exterior pressure. The lower cylinder 33 of the filter is sealed to the perforated cylinder 35. The lower end of the filter unit when installed is sealed by gasket 39 to the pipe 41. Pipe 41 is constructed of very thick material to provide stiffness.

In operation of the apparatus solution is pumped from the inlet port 20 through annular space 17. It passes inward through screen 29 and perforated tube 35. The filtered solution then passes downward through pipe 41 to the tubular L-bend 43. The solution then passes to the tapered horizontal spinning arm 14 through approach insert 45.

The steam supply for the spinneret pack is provided through annular passage 19. It passes downward through the outside passageway to chamber 46 and into the horizontal spinning arm 14 through passageway 47. Chamber 46 because of sloping partition 48 permits condensed steam to be carried completely out of the vertical arm 12. The steam passes through passageway 49 in spinning arm 14, circles the arm near the nose of the spinneret and returns through passageways 50 and 51 into chamber 52 and eventually out through tube 21. Needle valves are used to allow a constant steam bleed through; the moving steam entrains the condensate and blows it upward through line 21 and out of the spin pack.

A very useful feature of the apparatus is its adaptability for spinning at a variety of flow rates. In the Anderson and Romano patent, referred to above, the importance of a pressure let-down chamber is indicated. Likewise, the residence time in this chamber is mentioned as an important process element. The assembly of inserts in the horizontal spinning arm 14 permits a variety of spinning rates to be used without changes in the spinneret exterior. Exterior changes must be minimized so that the stream-lined flow is maintained and so that the position of the tapered spinneret nose 13 opposite the web deflector will be maintained. The entire horizontal spinning arm 14 is mounted on the vertical mounting arm 12 by means of bolts 15, which pass through the main exterior piece 53. Approach insert 45 and retainer insert 54 together must fill the cavity between the shoulder 55 and the end of L-bend supply pipe 43. A let-down orifice 56 is provided between inserts 45 and 54.

A let-down chamber 57 following orifice 56 permits nucleation of the spinning solution as described in the Anderson and Romano patent referred to above. When the solution, for example, is 12.5% linear polyethylene in trichlorofluoromethane and is supplied to the let-down orifice 56 at 1600 p.s.i.g. (113 kg./cm.²), a single phase liquid is present upstream of the let-down orifice. The pressure in the chamber 57 is typically about 900 p.s.i.g. (63.4 kg./cm.²) and a two-liquid-phase dispersion exists downstream from orifice 56.

The spinning arm 14 is shown in somewhat greater detail in FIG. 5. It will be observed that supported between approach insert 45 and retainer insert 54 is a disc 58 having a hole which comprises let-down orifice 56. The solution (actually a two-liquid-phase dispersion) in let-down chamber 57 passes through screen insert 59, the screen being fused to the end of a cylindrical tube 80. A final orifice approach insert 60 conducts the solution to disc 61 having a hole comprising the exit orifice 11. Disc 61 is concentrically located relative to the conical taper of the approach insert 60.

Inserts 59, 60 and 61 are fastened into the horizontal spinning arm 14 by means of tapered nose piece 13. Nose piece 13 is threaded onto exterior piece 53. Nose piece 13 has a centrally drilled hole which serves as a tunnel 62 for the solution as it is spun. The final spinneret disc 61 must be carefully centered so that the orifice 11 is concentric with the cylindrical tunnel 62.

The solution is extruded from the final orifice 11 and the solvent evaporates spontaneously, resulting in precipitation of the polymer which expands and fills tunnel 62. As it issues from the tunnel, the polymer is in the form of a plexifilamentary strand. In FIGURE 6 this strand (not shown) is passed directly to a rotating lobed deflector 64. Because of the contours in the deflector surface the strand is directed alternately to the left and to the right as it descends to the moving belt not shown. Simultaneously, the strand is spread into a wide network. The network passes over a target plate 65 which is grounded. Ion gun 66 which is charged to a voltage of 30 to 70 kilovolts deposits a charge on the network causing it to remain in the spread-open configuration as it falls to a moving belt. The network is collected on the moving belt. Preferably, the belt is an electro-conductive material and is charged oppositely to the fibers.

By placing various combinations of insert pairs 45 and 54 in the nozzle a variety of flow rates may be used with a high degree of fibrillation being maintained in each case. For example, to use a higher flow rate a shorter approach insert 45 is used and a longer retainer insert 54 is used. In this way the let-down orifice is moved upstream and a larger let-down chamber is formed. The larger chamber compensates for higher flow rates. The exposure time in the let-down chamber may be thus adjusted to the same level for various flow rates. Of course, inserts 45 and 54 should be matched so that the cavity between shoulder 55 and the end of L-bend supply tube 43 will be properly filled and sealed. For convenience, it is usually preferred to assemble all of the parts of the horizontal spinning arm 14 first and then to mount these by means of bolts 15 in one operation. After this, the pressure sensor fitting 40 is installed and connected by capillary 42 to a transducer.

As stated above, the spinneret pack may be used as the support structure for a rotary web deflector and positioning equipment to accurately establish the relative locations of the web deflector centerline opposite the final orifice centerline. This equipment may be conveniently connected to the upper mounting arm of the spinneret pack assembly by attachment to bracket 44. When connected in this way, the spinneret pack assembly, the web deflector and positioning equipment may be removed from the ceiling of a spinning chamber in one simple operation.

The rapid removal of the spinneret pack is greatly facilitated by having all fluid conduits communicate with ports in the attachment block 18 which ports terminate in a common surface 36. As shown in FIGURE 4, the surface 36 mates with a similar surface of a mounting block 70 having corresponding ports. The ports are not shown in FIG. 4 but are aligned, for example, as shown in FIGS. 1-3. Bolts 34 extend through attachment block 18 and into the surface of mounting block 70. The spinneret pack can be removed from the spinning cell merely by removing bolts 34, then lifting by means of a hook not shown attached to plate 67 and located over the center of gravity of the pack-deflector unit (when the whole unit is to be removed) or attached to cap 23 (when the spinneret pack only is to be removed).

As shown in FIG. 4, mounting block 70 can be part of a heated valve unit. In the embodiment shown a jacketed line 72 supplies polymer solution to valve body 71. A primer such as nitrogen is introduced through line 73. Heat exchange fluid is supplied through line 100 and removed through line 101. A three-way valve in valve body 71 admits either nitrogen or polymer solution to the port 20 leading to the central conduit in the vertical arm 12 of the L-shaped solution supply tube 10 (FIG. 1). Use of nitrogen as a primer in starting up flash-extrusion operations is described and claimed in Gilardi U.S. application Ser. No. 607,304, filed Jan. 4, 1967. The valve body also contains passages (not shown) for circulation of heat exchange fluid, and the valve unit also includes in-

let and outlet lines (not shown) carrying heating fluid.

The valve unit is supported on plate 78 which is in turn supported through jack screws 74 on block 76. Position of the valve unit and associated mounting block is accurately adjusted by means of jack screws 74 and fastened by screws 75. Block 76 is supported upon ceiling structure 77 of the spinning cell.

Once the flash-spinning unit has been removed from the spinning chamber, it may be serviced in any way needed. It should be pointed out that the assembly which supports deflector 64 (FIG. 6) must be carefully positioned and rigidly supported opposite the spinneret orifice. If the deflector assembly is attached to the spinneret pack through massive plates 44 (FIGS 1 and 2) the latter may be disassembled without completely dismantling the former. Thus, as described in the Smith application Ser. No. 628,872, referred to above, the web deflector unit and positioning equipment can be separated from the spinneret pack by removal of bolts in bracket 44, and can be separately supported by structure connected to the supporting plate for the integral unit. The spinneret pack can then be lifted separately by a crane attached to an eye bolt 27 screwed into a threaded socket in cap 23.

The filter unit 25 may be removed without removing the various inserts in the horizontal arm. Likewise, the inserts defining the let-down chamber may be replaced without the necessity of removing the filter. It should be understood however that the most thorough procedure consists in removing and separating all of the parts in the vertical and horizontal arms of the spinneret pack assembly. The present invention provides rapid servicing and cleaning of all parts and minimizes the amount of effort which is needed for cleaning crevasses and hidden cavities.

I claim:

1. A spinneret pack for flash-extruding a polymer solution to form a plexifilamentary strand comprising an L-shaped solution supply tube having a vertical mounting arm and a horizontal extrusion arm, the vertical arm having a central conduit for polymer solution and an annular conduit for heat exchange fluid, the horizontal arm being rigidly mounted on the vertical arm but capable of being detached therefrom, the horizontal arm having a central conduit for polymer solution which communicates with the central conduit in the vertical arm and terminates in an extrusion orifice, and a separate conduit for heat exchange fluid which communicates with the annular conduit in the vertical arm, the central conduit in the horizontal arm containing a pair of removable sleeve inserts which hold in place between them a disc having a central hole, thereby dividing the central conduit into two chambers connected by an orifice, the exterior of the horizontal arm being tapered toward the extrusion orifice to minimize turbulence;

an attachment block rigidly mounted on the upper end of the vertical mounting arm and having a port communicating with the conduit for polymer solution and having additional ports for heat exchange fluid inlet and outlet communicating with the conduit for heat exchange fluid in the L-shaped solution supply tube, all of the ports terminating in a common surface on the attachment block, the pack being mountable in the ceiling of a spinning cell by mating that surface with a similar surface of a rigid mounting block having corresponding ports for polymer solution and for heat exchange fluid inlet and outlet.

2. A spinneret pack as defined in claim 1 wherein a pipe external to the L-shaped solution supply tube connects the conduit for heat exchange fluid in the horizontal arm with the outlet port for heat exchange fluid in the attachment block.

7

3. A spinneret pack as defined in claim 1 wherein the attachment block has a groove which is machined to mate precisely with a lip on the mounting block, the tops of both groove and lip being substantially parallel to a horizontal plane containing the longitudinal axis of the spinning arm, said groove and lip providing for exact positioning of the spinneret pack relative to the rigid mounting block.

4. A spinneret pack as defined in claim 3 wherein means are provided for rigidly attaching the spinneret pack to the mounting block.

5. A spinneret pack as defined in claim 2 wherein the attachment block has a groove which is machined to mate precisely with a lip on the mounting block, the tops of both groove and lip being substantially parallel to a horizontal plane containing the longitudinal axis of the spinning arm, said groove and lip providing for exact posi-

8

tioning of the spinneret pack relative to the rigid mounting block.

6. A spinneret pack as defined in claim 5 wherein means are provided for rigidly attaching the spinneret pack to the mounting block.

References Cited

UNITED STATES PATENTS

702,382	6/1902	Topham.
2,136,201	11/1938	Whitehead.
2,586,971	2/1952	McDermott.
2,821,743	2/1958	Kocay.
2,917,327	12/1959	McDermott et al.
3,176,345	4/1965	Powell.

WILLIAM J. STEPHENSON, Primary Examiner