Sept. 2, 1958 M. SONNINO 2,849,751

WET-SPINNING APPARATUS

Filed Sept. 26, 1955 2 Sheets-Sheet 1

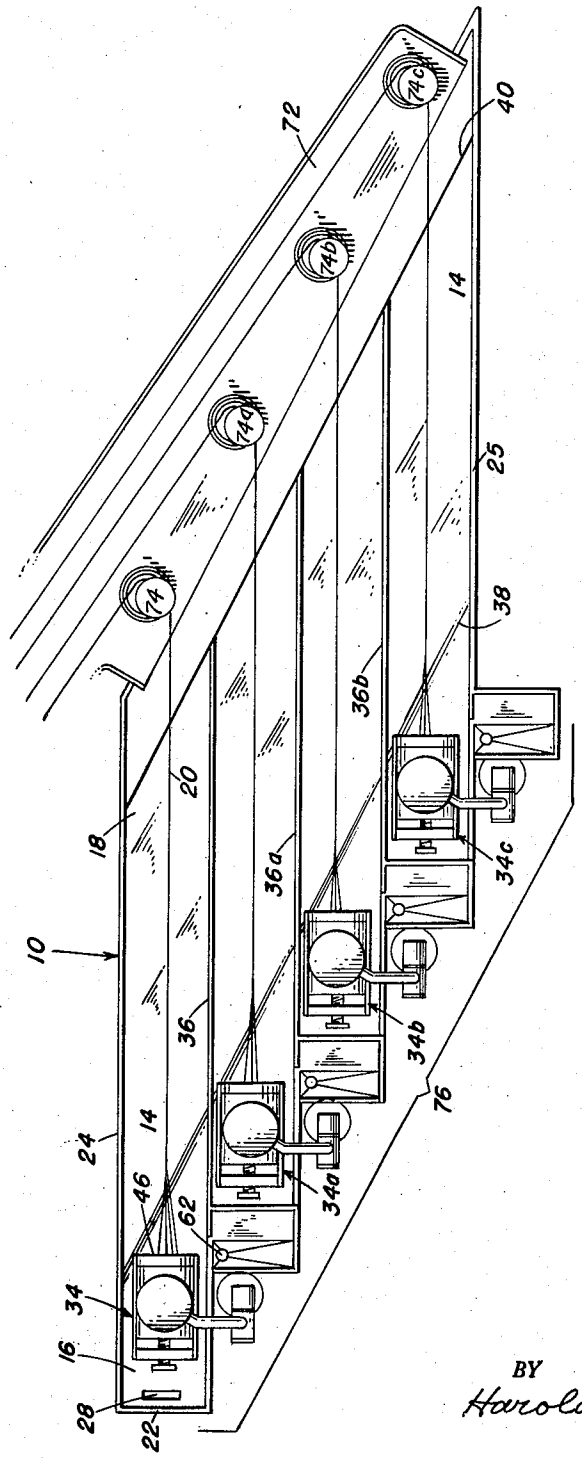

Fig. 1.

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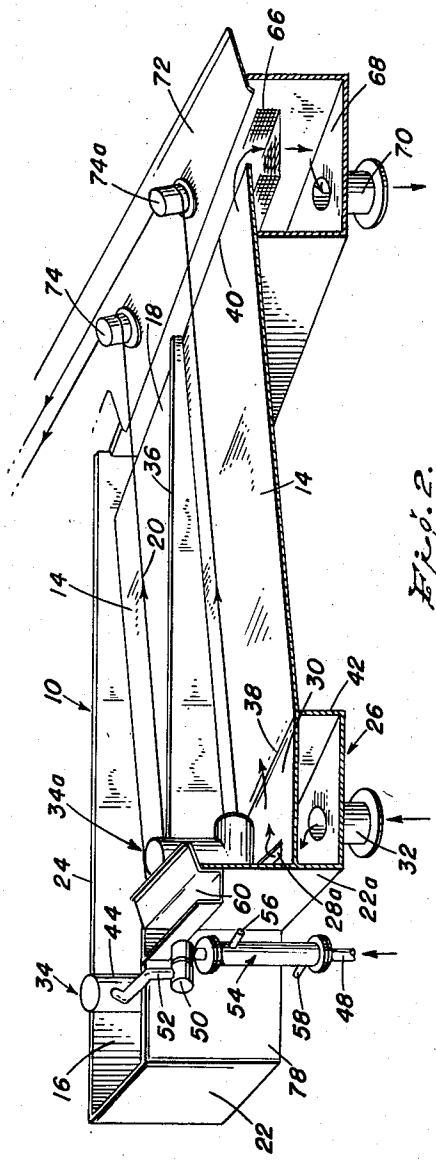

Fig. 2.

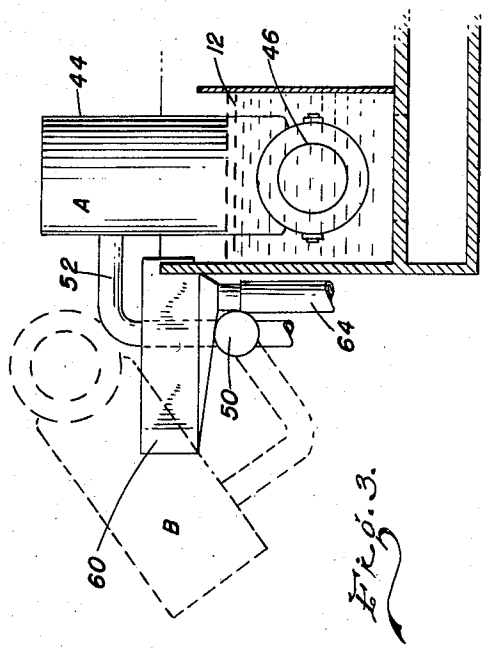

Fig. 3.

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WET-SPINNING APPARATUS

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Application September 26, 1955, Serial No. 536,479

5 Claims. (Cl. 18—8)

This invention relates to wet-spinning apparatus and, more particularly, to certain new and useful improvements in wet-spinning apparatus for use in producing synthetic filamentary material. The invention is especially concerned with such apparatus which is especially adapted for use in producing filamentary material formed of a polymer of acrylonitrile. The polymer of acrylonitrile may be either homopolymeric acrylonitrile or a copolymer of acrylonitrile containing a major proportion by weight of acrylonitrile combined in the polymer molecule.

Various methods of producing synthetic or artificial fibers in continuous filament, tow and staple form heretofore have been suggested or are in use, and involve the use of appartaus of various designs. In general, such methods involve the production of filaments by either the so-called dry-spinning or wet-spinning methods. The present invention is concerned with apparatus whereby synthetic filamentary material in the form of continuous filaments (mono- or multifilaments) or tow (rope or bundle of continuous filaments) is produced by a wet-spinning operation. The invention will be described with particular reference to the production of synthetic filaments of a polymer of acrylonitrile but is obviously not limited to the preparation of filamentary material only from such a polymer. For instance, it can be used in making filaments from regenerated cellulose (rayon) or from any other compositions that can be formed into filaments by extrusion through a spinneret into a suitable liquid coagulant.

In the wet-spinning method of producing filamentary material, e. g., polyacrylonitrile yarn or tow, a solution of the polyacrylonitrile is extruded through a perforated nozzle or jet, which is commonly known as a spinneret, into a bath composed of a liquid that will leach out the solvent from the polymer solution. As a result of thus extracting the solvent from the solution, the polymer is coagulated or precipitated from the solution. The coagulated yarn or filamentary material forms at the face of the spinneret and is carried through the bath for a sufficient distance and at a rate such as will cause solidification of the coagulated filamentary polymer to the desired extent. Thereafter the coagulated yarn is generally subjected to a stretching operation, usually while it is still in a gel state, in order to increase the tenacity as well as otherwise to improve the physical properties of the filaments. This improvement in properties results from orientation, along the fiber axis, of the polymer molecules of which the filaments are comprised. Other treating and processing steps then may be given the oriented filaments, such as, for example, washing, crimping, cutting into staple lengths (either before or after drying), etc.

It is a primary object of the present invention to provide wet-spinning apparatus, which includes the filament-forming portion thereof, and which is compact in its layout or arrangement and provides ready accessibility to the various elements thereof, from the operating face of the apparatus, for "thread-up," inspection, jet maintenance, etc.

Another object of the invention is to provide apparatus of the kind briefly described in the previous paragraph that is relatively simple and inexpense to construct and which can be operated with a minimum number of operators.

Another object of the invention is to provide wet-spinning apparatus that will provide maximum yield of product at minimum capital expenditure and utilizing a minimum of floor space.

A further object of the invention is to provide apparatus of the character described hereinbefore that will provide maximum yield of product at minimum cost from the standpoint of both maintenance and labor expenditures.

Still other objects of the invention will be apparent to those skilled in the art from the description which follows and the accompanying drawing.

The novel features of my invention are set forth in the appended claims. The invention itself, however, will best be understood from reference to the following more detailed description when considered in connection with the accompanying drawing, which is illustrative of a preferred embodiment of the invention, and wherein:

Fig. 1 is a plan view of wet-spinning apparatus embodying my invention;

Fig. 2 is a perspective view of a portion of the apparatus shown in Fig. 1; and

Fig. 3 is a side view of a portion of the apparatus shown in Figs. 1 and 2, more particularly the filament-forming assembly thereof in both its normal operating or spinning position and in its bleeding or dripping position.

Referring to the drawing there is shown in Figs. 1 and 2 wet-spinning apparatus for use in producing synthetic filamentary material comprising a container **10** for confining a liquid coagulant **12** (Fig. 3) therein. This liquid coagulant (taking the process described in Cresswell U. S. Patent No. 2,558,730, dated July 3, 1951, as illustrative of a wet-spinning process by which continuous filamentary material can be produced from a spinning solution or "dope," e. g., a solution of a polymer of acrylonitrile) advantageously may be water alone or an aqueous solution containing from 5 to 15% of a water-soluble thiocyanate such as sodium thiocyanate, and which is maintained at a temperature not exceeding +10° C., e. g., about 0° C. The container **10** advantageously may be formed of a synthetic material, e. g., unplasticized polyvinyl chloride, or of a laminate comprised of a combination of a polyester resin and glass fibers in fabric or other form. This container has a bottom wall **14** which is so sloped that when the apparatus is in use there is a greater depth of liquid coagulant in the filament-forming end-section **16** of the container than at the opposite end **18** where the coagulated filamentary material **20** leaves the container. In addition to the bottom wall **14**, the container **10** also is provided with end walls **22**, **22***a*, etc. (Figs. 1 and 2) and with parallel or approximately parallel side walls **24** and **25** (Fig. 1). When viewed in plan, the container has the general configuration of a trapezoid.

The liquid coagulant **12** is introduced into the end-section **16** of the container **10** by suitable means which include appropriate pumps (not shown) and a compartment **26** having openings **28** (Fig. 1), **28***a* (Fig. 2), etc., in its upper or top wall **30**. This upper wall **30** of the compartment **26** constitutes a portion of the bottom wall **14** of the container **10**. The liquid coagulant **12** is introduced into the compartment **26** through a suitable inlet conduit or conduits, e. g., inlet conduit **32** (Fig. 2) from a suitable supply source (not shown).

The openings **28**, **28***a*, etc., may be reduced in size when it is desired to restrict the volume of inflow of liquid coagulant to the container, or to a particular unit

thereof, merely by closing off a portion of the opening with a suitable plug or insert.

It is a particular advantage of my invention that, by means of the compartment and auxiliary parts embodied in the apparatus, turbulent flow of coagulant in the area adjacent to the spinneret face is obviated or minimized, thereby facilitating the formation of uniform, undamaged, gelled filaments.

When a plurality of filament-forming assemblies **34**, **34***a*, **34***b*, **34***c*, as shown in Figs. 1 and 2, is employed in producing a rope or bundle of filaments (that is, tow) then the compartment **26** is a manifold compartment or chamber having a plurality of openings **28**, **28***a*, etc., corresponding in number to the number of filament-forming assemblies. These openings are so located that each is closely adjacent to a single filament-forming assembly. By this construction and arrangement of the openings or orifices the flow of liquid coagulant to each filament-forming assembly, and more particularly to the spinneret thereof, is uniform. By thus maintaining a uniform flow of the liquid coagulant to the area adjacent the face of each spinneret of the filament-forming assemblies better assurance is provided that the coagulated filaments as they form at the face of the spinneret will be uniform in size and in degree of coagulation.

In the preferred embodiment of the invention the container **10** is provided with partitions or baffles **36**, **36***a*, **36***b*, which are parallel or approximately parallel to the side walls **24** and **25** of the container and whereby the liquid coagulant serving one filament-forming unit is prevented from intermingling with that which serves each adjacent unit. The advantages of having such partitions disposed in the container in order to separate each filament-forming assembly and coagulated tow are practical advantages that will be immediately apparent to those skilled in the art. These baffles may be formed of any suitable construction material, which is not affected by, nor will affect, the liquid coagulant, e. g., unplasticized polyvinyl chloride, Teflon, stainless steel, aluminum, etc.

In the preferred embodiment of the invention the bottom wall **14** begins an upward and rearward slope from the front edge **38** as shown in Figs. 1 and 2. It is not essential that the bottom wall begin to slope upwardly from this front edge and, if desired, the slope may begin at any other point which is closer to the end wall **22** (Figs. 1 and 2), **22***a* (Fig. 2), etc., or somewhat closer to the rear edge **40** of the bottom wall **14**. From the standpoint of simplicity and minimum cost of construction the bottom wall **14** advantageously may begin to slope upward from the front edge **38** as indicated. This edge **38** is in the same plane as the vertical side wall **42** of the compartment **26**.

By having the bottom wall slope upwardly toward the rear or discharge end of the container, the volume of the liquid coagulant in the container is substantially reduced, with important practical advantages. For example, this construction substantially reduces the volume of liquid coagulant to be recirculated in the process, as well as the volume of make-up coagulant to be added to the system. Also, when the process employed is of the type or kind described in the aforementioned Cresswell patent and wherein the liquid coagulant is refrigerated to maintain it at a low temperature, then the refrigeration requirements also are materially reduced, because there is a lesser total volume of coagulant to be refrigerated.

Another very important advantage of the use of the described sloping bottom is that the coagulating solution flows concurrent with the rope or tow of filamentary material; hence, since the rate of flow of liquid coagulant to the container is substantially constant, the solution increases in its velocity as it approaches the overflow point from the container and at which point the filamentary material is the strongest. It is well-known that freshly coagulated filamentary material is weakest at the face of the spinneret where it is first formed and that it gets stronger as it leaves the face of the spinneret. By the arrangement hereinbefore described and illustrated in the accompanying drawing, the tow, as it becomes increasingly stronger, is subjected to an increasingly greater action by the liquid coagulant (due to its aforementioned higher velocity) as they both approach the discharge end of the container. Also, the higher-velocity coagulant provides a better support for the tow. The gelled tow has sufficient tensile strength when it leaves the coagulating bath that it can be further handled and processed in gel state without any particular difficulty.

The filament-forming assemblies **34**, **34***a*, **34***b*, **34***c* are each comprised of a spinneret head **44** and a spinneret having a face indicated at **46** in Figs. 1 and 3. The spinneret is detachably mounted in the spinneret head **44** and is so positioned in the container **10** that the coagulated filamentary material leaving the face of the spinneret is approximately parallel to the walls defining the sides of the container.

The individual filament-forming assemblies **34**, **34***a*, **34***b*, **34***c* are each so pivotally mounted and the spinneret is so mounted in the spinneret head **44** that the assembly can be swung outside of the container from a spinning to a bleeding or dripping position as shown in Fig. 3, while the spinneret remains in the same plane. In Fig. 3 the spinneret is shown at A in the normal position in which it is employed during the spinning operation and at B in the position to which it is swung outside of the container when it is in a bleeding position.

The spinning solution is led to the individual filament-forming assembly by suitable means which preferably comprise, as shown in Fig. 2, a conduit **48**, a hollow trunnion **50** and a conduit **52** leading from this trunnion into the spinneret head **44**. En route to the trunnion **50** the spinning solution passes, if desired or required, through a heat exchanger **54**, wherein the solution is heated to the desired temperature by a suitable fluid medium such as steam, hot water, oil, etc. The hot fluid medium enters the heat exchanger **54** through the inlet conduit **56** and is discharged from the exchanger through the outlet conduit **58**. When it is desired to move the spinneret head **44** from a point within the container to a point outside the container or vice versa, this is done by merely swinging the head about the axis of the trunnion **50** as shown in Fig. 3.

When it is desired to place the head **44** in a bleeding position, the bleedings or drippings from the spinnert of an individual filament-forming assembly **34** are caught in the trough **60**, which is provided with a bottom that slopes toward the outlet **62** (Fig. 1) and thence through conduit **64** (Fig. 3) to a recovery system (not shown).

I prefer to use as the filament-forming assembly the device disclosed and claimed in the copending application of William N. Sellers and Mario Sonnino, Serial No. 536,700, filed concurrently herewith, and which has a filter unit embodied in the spinneret head. If a different device containing no such filter unit is used, then it is generally preferable to filter the spinning solution before it enters the heat exchanger **54**. This filter may be, for example, a candle filter that is positioned either before or after the pump or pumps that pump the spinning solution to the filament-forming assembly.

The liquid coagulant overflowing from the container **10** at the rear edge **40** first passes through a porous trough **66** (Fig. 2) and thence into the trough **68**. The porous trough **66** may be formed of any suitable material, such as wire screening, and in which any broken filaments or other filamentary waste material can be collected before the liquid coagulant passes into the trough **68**. The trough **68** is provided with suitable conduits, one of which is shown at **70** in Fig. 2, for withdrawing the liquid coagulant from the wet-spinning apparatus for recirculation in the system, generally with

the addition of a certain amount of make-up solution so that it will be of the same desired composition when it is re-used in the process.

The apparatus of this invention also includes an apron **72** which is spaced from the rear edge **40**. On this apron **72** are mounted the capstans **74**, **74***a*, **74***b*, **74***c*. If only a single filament-forming unit is to be used, then only a single capstan is required. The apron **72** slopes toward the trough **68** as indicated in Fig. 2. The capstan or capstans mounted on the apron serve to guide the coagulated filamentary material away from each of the filament-forming units of the wet-spinning apparatus.

A particular advantage of the construction of the wet-spinning apparatus of this invention is that not only the filament-forming assemblies **34**, **34***a*, **34***b*, **34***c*, etc., are accessible from the operating face **76** (Fig. 1) of the apparatus but the aforesaid capstans **74**, **74***a*, **74***b*, **74***c* are also accessible from this operating face. This is because of the size and arrangement of the apparatus as a whole, including the manner in which the end walls of the container are offset from each other as shown in Figs. 1 and 2, and more clearly in Fig. 2 where the end walls **22** and **22***a* are offset. These end walls **22** and **22***a* abut the wall **78** which forms all or part of one side of the filament-forming end-section **16**. The same general relationship exists between the other filament-forming units of the apparatus if there are more than 2 units, e. g., from 3 to 50.

I claim:

1. Wet-spinning apparatus adapted for use in producing synthetic filamentary material comprising a container capable of confining a liquid coagulant therein, said container having a bottom wall that slopes upwardly from the front portion of the container to the rear portion; a plurality of pivotally-mounted, filament-forming assemblies each comprising a spinneret head and a spinneret detachably mounted therein, said assemblies being positioned during spinning at the front portion of the container and with the spinneret so mounted in the spinneret head that the coagulated filamentary material leaving the face of the spinneret is approximately parallel to the walls defining the sides of the container, the individual assembly being adapted to be swung outside of said container from a spinning to a bleeding position while the spinneret face remains in the same vertical plane; an operating face comprised of a series of end walls and side walls defining the said front portion of the said container, the said end walls being offset from each other in a stepwise manner for a distance such that when the individual filament-forming assembly is swung out of the container and over the side wall that abuts the said next end wall it will be extrenal to the latter; means for charging spinning solution to the spinneret heads of the individual filament-forming assemblies; means for collecting waste spinning solution outside the said container when an individual filament-forming assembly is in a bleeding position; means for introducing liquid coagulant to the said front portion of the said container through a plurality of openings corresponding in number to the number of filament-forming assemblies and each opening being located closely adjacent to a single filament-forming assembly, each opening being so positioned with respect to the said assembly that a vertical line drawn through the edge of the said opening that is furthest from the vertical front wall of the front portion of the said container is rearward of a vertical line drawn through the face of the spinneret mounted in said assembly when it is in operating position; and means for removing the liquid coagulant from the said container at the said rear portion.

2. Wet-spinning apparatus as in claim 1 wherein the means for introducing liquid coagulant to the defined front portion of the container includes a manifold compartment positioned beneath the filament-forming assemblies, said compartment having an upper wall with a plurality of openings therein corresponding in number to the number of filament-forming assemblies and each opening being located as is set forth in claim 1.

3. Wet-spinning apparatus as in claim 1 wherein the means for removing the liquid coagulant from the container at the defined rear portion thereof are overflow means, and the apparatus additionally includes a trough beneath the rear edge of the container for receiving the overflowing liquid coagulant; an apron spaced from said rear edge and sloping toward said trough; and a plurality of capstans mounted on said apron for guiding the coagulated filamentary material away from each of the filament-forming units of the said wet-spinning apparatus, the said capstans being accessible from the said operating face.

4. Wet-spinning apparatus as in claim 1 wherein the means for collecting waste spinning solution outside the container when the individual filament-forming assembly is in a bleeding position includes a plurality of individual troughs located external to the container, each trough excepting the last being mounted on the off-set end walls of the container with its plurality of corresponding filament-forming assemblies therein, and the location of the individual trough on said end walls being such that it can receive the bleedings of the immediately preceding filament-forming assembly when the latter is in a bleeding position.

5. Wet-spinning apparatus as in claim 1 wherein the container has partitions therein which are approximately parallel to the side walls of the container and whereby the liquid coagulant serving one filament-forming unit is prevented from intermingling with that which serves each adjacent unit.

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CERTIFICATE OF CORRECTION

Patent No. 2,849,751 September 2, 1958

Mario Sonnino

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 3, for "inexpense" read -- inexpensive --; column 4, line 49, for "spinnert" read -- spinneret --; column 5, line 28, for "2 units" read -- 2 such units --; line 52, for "extrenal" read -- external --.

Signed and sealed this 3rd day of February 1959.

(SEAL)
Attest:

CARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents