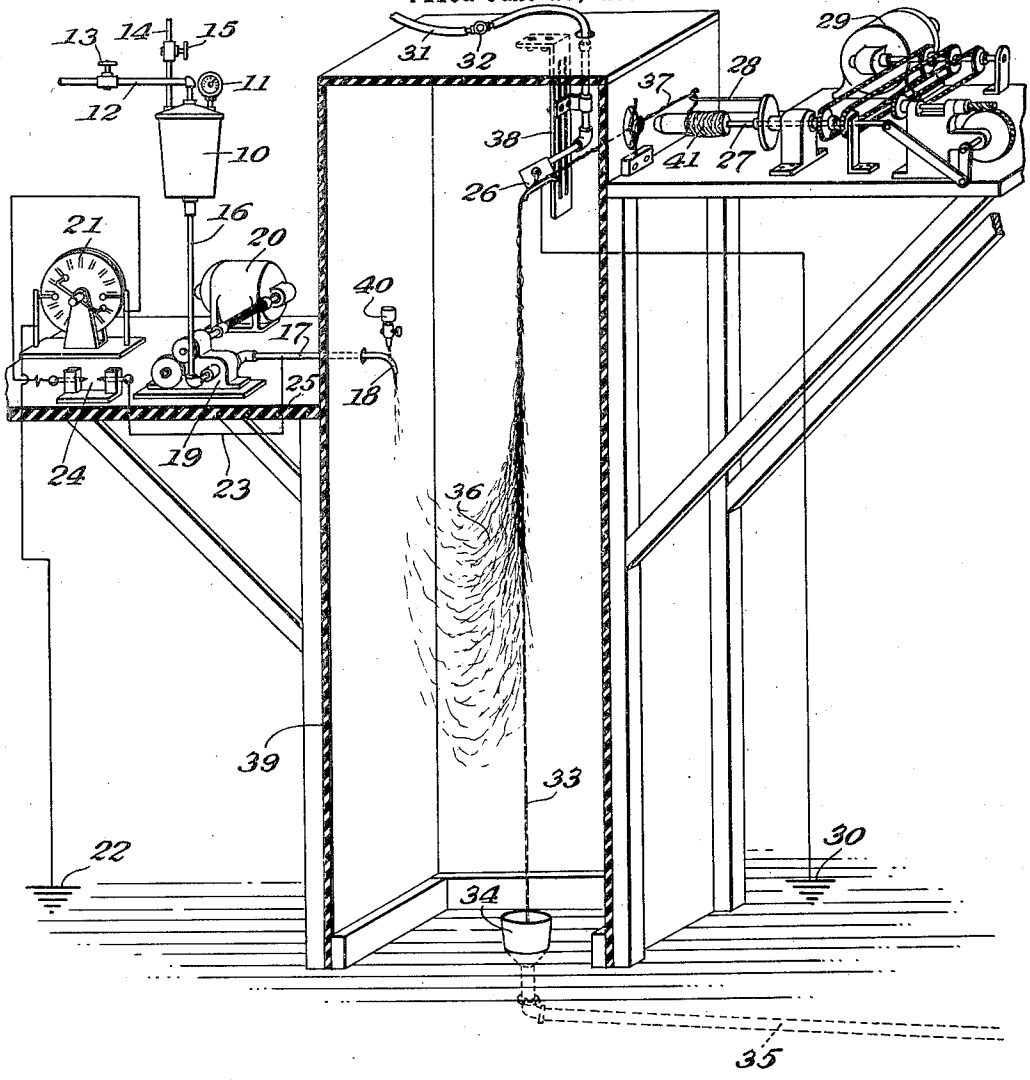
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METHOD OF AND APPARATUS FOR FORMING FIBROUS MATERIAL

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METHOD OF AND APPARATUS FOR FORMING FIBROUS MATERIAL

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11 Claims. (Cl. 18—8)

In another application, Serial No. 117,600, filed December 24, 1936, I have described a method and apparatus for producing a continuous length of fibrous material, for example, a roving, yarn, cord, or the like, from a succession of discontinuous artificial fibres by the electrostatic disruption into such fibres of a viscous liquid capable of rapid solidification, and the progressive withdrawal of the fibres, as they are formed, to a suitable collecting apparatus. As described in said application, the method includes electrifying the viscous liquid, for example, a solution of cellulose acetate in acetone, with an electrostatic charge while delivering the same from an orifice in a continuous stream, thereby causing the stream to be broken up and solidified into fibres in a region adjacent to but spaced from the point of delivery, collecting the fibres as they are formed on previously formed fibres in the form of a tail, and progressively withdrawing the tail, as it builds up, over a grounded support to form a sliver which may be led directly to a twisting and winding mechanism.

I have discovered that the practice of the above method can be greatly facilitated and the resulting product greatly improved by directing a stream of a suitable liquid, for example, cold water, over the grounded support and permitting the same to flow downwardly along the tail as the latter builds up and is withdrawn upwardly, or in opposition to the flow of the stream, over the support. By this practice several distinct and important advantages are obtained. Control of the temperature and humidity of the atmosphere in which the fibres are formed, heretofore essential, can be disregarded since the fibres are thoroughly wet and maintained approximately at the temperature of the stream in which they are formed and collected. Fibres solidified and collected in the water can be automatically delustred to any desired degree, the effect being similar to that of adding water to the solution, as described in my said prior application. The stroking or combing action of the stream as it flows downwardly over the tail causes the fibres to lie more nearly parallel, while its action in tending to draw out the tail downwardly and thereby lengthen the same produces a more even distribution of the fibres, both of which factors contribute to the evenness of the product. The liquid stream tends to wash out the solvent and precipitate the fibres at a low temperature, thereby increasing the strength of the product. The temperature of the water or other liquid constituting the stream should be low, preferably near the freezing point, for the above reason and also because it tends to prevent adhesion of the fibres, causes them to solidify faster, and permits a more rapid withdrawal of the fibrous strand without breaking, all of which contribute to the evenness, fineness and strength of the resulting yarn. The liquid constituting the stream need not be pure water or even water at all. Its only limitations are (1) that it be electrically conductive and (2) that it not be a solvent for the fibres. Consequently it may include a dye for coloring the fibres as they are formed, or any of the precipitating hardening, toughening, delustring, etc., agents known in the art for the purpose of accelerating the solidification of the fibres and improving their quality and appearance. The presence of a small quantity of calcium chloride in the liquid, or of mixtures of calcium chloride and sodium chloride, have been found to have a particularly beneficial effect in hardening and strengthening the fibres and improving their lustre. If water is used, it dissolves and carries off much of the acetone solvent which may be readily recovered.

The initial twisting action on the strand or sliver formed by progressively drawing the tail over the support takes place throughout that length thereof extending from the support to the twisting and winding apparatus, there being no twisting effect upon the depending tail, this being prevented by the support over which the sliver is drawn. It is found that the quality of the yarn, and particularly its fineness, can be improved by placing it under a substantial tension as it is twisted, that is to say, by applying as great a tension as possible within the tensile strength of the twisting sliver to the length above referred to. Such tension is applied by the effective weight of the depending tail, and its amount is determined by several factors, namely, the length and mass of the tail, the weight of the falling column of water, and the speed of withdrawal of the sliver by the winder. Consequently, in accordance with one feature of the invention, the support is located at as high an elevation with respect to the supply orifice, and the water supplied at as high a rate, as possible without causing rupture of the tail which should, of course, be maintained in a vertically depending, self-supporting condition.

The invention will best be understood from the following description of the arrangement and operation of an apparatus embodying the same and by which it may be practiced, as illustrated in the accompanying drawing, the particular ar-

rangement shown and the particular operations described having, however, been chosen for purposes of exemplification merely, as it will be obvious to those skilled in the art that the invention, as defined by the claims hereunto appended, may be otherwise embodied and practiced without departure from the spirit and scope thereof. It will also be understood that the theoretical statements herein contained as to the behavior of the materials, the effect of various factors involved, etc., are based on my present knowledge of these matters, and are for the purpose of giving the fullest possible information now available to me, but I do not limit myself to the particular theories advanced.

The drawing is a diagrammatic perspective view, partly broken away, of an arrangement of apparatus embodying and suitable for practicing the invention.

Except as hereinafter pointed out, the apparatus shown is similar to that described in my prior application, above referred to, and includes a reservoir 10 for the viscous liquid material of which the fibres are to be formed, for example a solution of cellulose acetate in acetone. Means are preferably provided for applying a light pressure, indicated by a gauge 11, to the material in the reservoir, as, for example, a pipe 12 leading from a source of air under pressure and controlled by a valve 13. A supply pipe 14 controlled by a valve 15 may also be provided for replenishing the solution in the reservoir from time to time as may be required. Leading from the reservoir 10 is a standpipe 16 communicating with a conduit 17 leading to a delivery spout or nozzle 18 having an unobstructed discharge orifice of substantial size, for example a diameter of the order of ⅛ of an inch, or greatly in excess of that of the fibres to be formed. At a suitable point in the system, for example at the junction of the standpipe 16 and conduit 17, there is preferably interposed a metering pump 19 driven by a suitable motor 20. The metering pump may in some cases be omitted, particularly if sufficient pressure be provided to insure the flow of the liquid from the reservoir to the discharge spout, but it is preferred in order to insure an even flow of the material. 21 denotes an electrostatic machine or other suitable source of electric potential one pole of which is grounded, as indicated at 22, and the other of which is connected with the conduit 17 or other part of the discharge system as indicated at 23, whereby the liquid, prior to and at the instant of its discharge, is electrified with an electrostatic charge of single polarity. As a convenient means for controlling the potential of the charge, the connection 23 may include a spark gap 24. The potential employed is susceptible of considerable variation in accordance with the length and fineness of the fibres desired. It should not be materially less than 6000 volts and is preferably of the order of from 10,000 to 15,000 volts. The electrified parts are all insulated from their support as indicated at 25.

Spaced from the discharge spout 18, and disposed at an elevation somewhat higher than the latter, is the collecting apparatus which, as shown, comprises a support 26 in the form of a short trough or guide and a suitable winding and twisting apparatus which, as shown, comprises a spindle 27 and flyer 28 operated by an electric motor 29 through suitable power transmitting connections adapted to rotate the spindle and flyer at different speeds and reciprocate the spindle slowly in a longitudinal direction. The support 26 is preferably grounded as indicated at 30. Leading from a suitable source of cold water, or other liquid of the character above referred to, is a pipe 31 arranged to discharge said liquid upon the support 26 under the control of a valve 32, the liquid so discharged falling in a stream 33 into a receptacle 34 from which it is conducted to a suitable point of disposal through a conduit 35.

With the apparatus arranged as above described, when the pump 19 and electrostatic machine 21 are started the material is discharged from the spout 18 in a highly electrified condition and is separated or disrupted into fine particles which are drawn out and solidified into discontinuous fibres in a region adjacent to but spaced from the spout 18, as indicated at 36. A leader of cotton string is attached to the spindle 27 and passed over the guide 26 and allowed to hang down in the water streams to serve as a start for the fibres to build on. Said fibres are collected in or by contact with the wet string and the liquid 33 which flows through said region, whence they may be progressively withdrawn from said region and from said stream of liquid upwardly, or in a direction opposite to the direction of flow of said stream, over the support 26, so that the continued formation of fibres in said region and stream causes them to be built up on the tail 36 of fibres previously formed, resulting in the production of a continuous sliver or length 37 of fibrous material. Due to the grounding of the support 26 and stream 33, in conjunction with the electrified discharge spout 18, said support and stream are electrified by a bound charge of opposite polarity and lower potential than that of the material when disrupted, so that the fibres, as they are brought into contact with said stream, are immediately discharged of their initial electrostatic charge and receive a light induced charge of opposite polarity, causing them to attract the newly formed fibres and progressively build up the tail 36. The water stream and whole collecting system may be insulated and charged from opposite pole of the electrostatic apparatus if desired.

The continuous sliver 37 formed by the progressive building up of the tail 36 in or adjacent to the stream 33 is withdrawn from the latter over the support, as above described, and led to the twisting and winding apparatus where it is twisted into a yarn. The twisting and winding apparatus is operated at a speed determined by the rate of formation of the fibres and the thickness of yarn desired. The twisting takes place throughout that length extending between the spindle 27 and the support 26 and it is desirable to apply a tension to said length, which tension is preferably made as great as possible within the tensile strength of the material. This tension is provided by the effective weight of the depending tail 36, and its amount is determined by the length and mass of the vertically depending tail itself, the weight of the falling column of liquid, and the speed of operation of the spindle. Consequently the apparatus is preferably so arranged and adjusted as to provide a length of tail and rate of discharge of liquid as great as possible without rupturing either the tail or the twisting sliver. The rate of discharge of the liquid is controlled by the valve 32, while the length of the tail can be determined to a certain extent by the height of the support 26 with respect to the discharge spout 18, and to this end said support is preferably carried by a bracket 38 upon which it is vertically adjustable.

The lustre and strength of the fibres are improved by causing the forming fibres to travel as long a path as possible between the supply spout 18 and the stream 33, as this affords greater opportunity for the evaporation of the solvent. It is found that the length of this path, as well as the length of the tail, can be considerably increased by directing the spout 18 downwardly, as shown in Fig. 1. Also the temperature of the liquid supplied through the pipe 31 affects the lustre and strength of the fibres, the fibres being strengthened and their lustre being increased and made more silky by lowering the temperature, so that it is preferred to supply said liquid at a temperature as near the freezing point as practicable.

In order to make possible the recovery of the solvent, as well as to shield the region of fibre formation from sudden air drafts which might disturb the operation, said region, together with the spout 18 and support 26, is preferably enclosed by a casing 39 which, in order to maintain the proper electrostatic condition, is composed of insulating material. The major portion of the solvent is carried off by the stream 33, the liquid of which may be conveyed through the conduit 35 to a suitable point of recovery, while the solvent vapors in the casing 39 may likewise be withdrawn for the same purpose by a suitable suction apparatus, not shown.

It is found that the smooth and even delivery of the viscous material from the spout 18 can be facilitated and insured by applying a small quantity of lubricant to said spout, as by means of an oil cup 40 adapted to drop oil thereon at the rate of a few drops per hour.

I claim:

1. In the art of forming a sliver of textile fibers, the method which comprises electrically disrupting a stream of liquid of a character adapted to form individual fibers when disrupted, providing a ground including a sliver wetted with a non-solvent electrically conductive liquid for attracting the disrupted fibers by electrostatic action and thereby causing them to attach themselves to one another and to the sliver to form the tail of the sliver, continuously wetting the sliver with said electrically conductive liquid, and progressively withdrawing the sliver from the field of sliver formation at a speed to render the sliver continuous.

2. In the art of forming a sliver of textile fibers, the method which comprises electrically disrupting a stream of liquid of a character adapted to form individual fibers when disrupted, providing a ground including a sliver wetted with a non-solvent electrically conductive liquid for attracting the disrupted fibers by electrostatic action and thereby causing them to attach themselves to one another and to the sliver to form the tail of the sliver, continuously wetting the sliver with said electrically conductive liqnid, and progressively withdrawing the sliver upwardly from the field of sliver formation at a speed to render the sliver continuous.

3. In the art of forming a sliver of textile fibers, the method which comprises electrically disrupting a stream of liquid of a character adapted to form individual fibers when disrupted, flowing a stream of electrically conductive liquid in the field of fiber formation, said second mentioned liquid being a non-solvent for the fibers and serving to form an electrical ground whereby the fibers are attracted to said stream of liquid and each fiber attaches itself to another fiber as it travels toward the liquid and forms a sliver, and progressively withdrawing the sliver from the field of sliver formation at a speed to render the sliver continuous.

4. In the art of forming a sliver of textile fibers, the method which comprises electrically disrupting a stream of liquid of a character adapted to form individual fibers when disrupted, flowing a stream of electrically conductive liquid in the field of fiber formation, said second mentioned liquid being a non-solvent for the fibers and serving to form an electrical ground whereby the fibers are attracted to said stream of liquid and each fiber attaches itself to another fiber as it travels toward the liquid and forms a sliver, and progressively withdrawing the sliver upwardly from the field of sliver formation counter to the flow of said stream of electrically conductive liquid at a speed to render the sliver continuous.

5. In the art of forming a sliver of textile fibers, the method which comprises electrically disrupting a stream of liquid of a character adapted to form individual fibers when disrupted, providing a ground including a sliver wetted with a non-solvent electrically conductive liquid for attracting the disrupted fibers by electrostatic action and thereby causing them to attach themselves to one another and to the sliver to form the tail of the sliver, directing over the sliver a falling stream of said electrically conductive liquid, and progressively withdrawing the sliver from the field of formation at a speed to render the sliver continuous.

6. In the art of forming a sliver of textile fibers, the method which comprises electrically disrupting a stream of liquid of a character adapted to form individual fibers when disrupted, providing a ground including a sliver wetted with a non-solvent electrically conductive liquid for attracting the disrupted fibers by electrostatic action and thereby causing them to attach themselves to one another and to the sliver to form the tail of the sliver, directing over the sliver a falling stream of non-solvent, electrically conductive liquid, and progressively withdrawing the sliver upwardly from the field of sliver formation through the falling stream at a speed to render the sliver continuous.

7. In the art of forming a sliver of textile fibers, the method which comprises electrically disrupting a stream of liquid of a character adapted to form individual fibers when disrupted, providing a ground including a sliver wetted with a non-solvent electrically conductive liquid for attracting the disrupted fibers by electrostatic action and thereby causing them to attach themselves to one another and to the sliver to form the tail of the sliver, directing over said tail a stream of said electrically conductive liquid, whereby the stream assists in forming an electrical ground as the fibers are attracted thereto and attach themselves to one another, and progressively withdrawing the sliver as it is formed at a speed to render the sliver continuous.

8. A method as specified in claim 7 in which the stream of electrically conductive liquid travels counter to the direction of travel of the sliver as it is withdrawn and in which the sliver is withdrawn upwardly.

9. An apparatus for forming a sliver of textile fibres comprising, in combination, means for disruting a spinning liquid into discontinuous fibres in a field of fibre formation, a grounded support, means for progressively withdrawing a sliver of said fibres over said support as it is built up by

the collection of successively formed fibres upon a tail of previously formed fibres depending from said support and sliver, and means for progressively wetting said tail with a non-solvent, electrically conductive liquid.

10. An apparatus for forming a sliver of textile fibres comprising, in combination, means for disrupting a spinning liquid into discontinuous fibres in a field of fibre formation, a grounded support above said region, means for progressively withdrawing a sliver of said fibres over said support as it is built up by the collection of successively formed fibres upon a tail of previously formed fibres depending from said support and sliver, and means for directing over said support, sliver and tail a stream of a non-solvent, electrically conductive liquid.

11. An apparatus for forming artificial fibrous material from a spinning liquid capable of electrostatic disruption comprising, in combination, a nozzle, means for delivering the liquid from said nozzle in the form of an electrified stream whereby said liquid, as it leaves said nozzle, is broken up and solidified into discontinuous fibres in a region adjacent to but spaced from said nozzle, a support above said region, means for progressively withdrawing the resulting material over said support in a continuous length as it is built up by the collection of successively formed fibres upon a tail of previously formed fibres depending from said support, and means for directing over said support and tail a falling stream of an electrically conductive liquid in which said fibres are insoluble.

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