

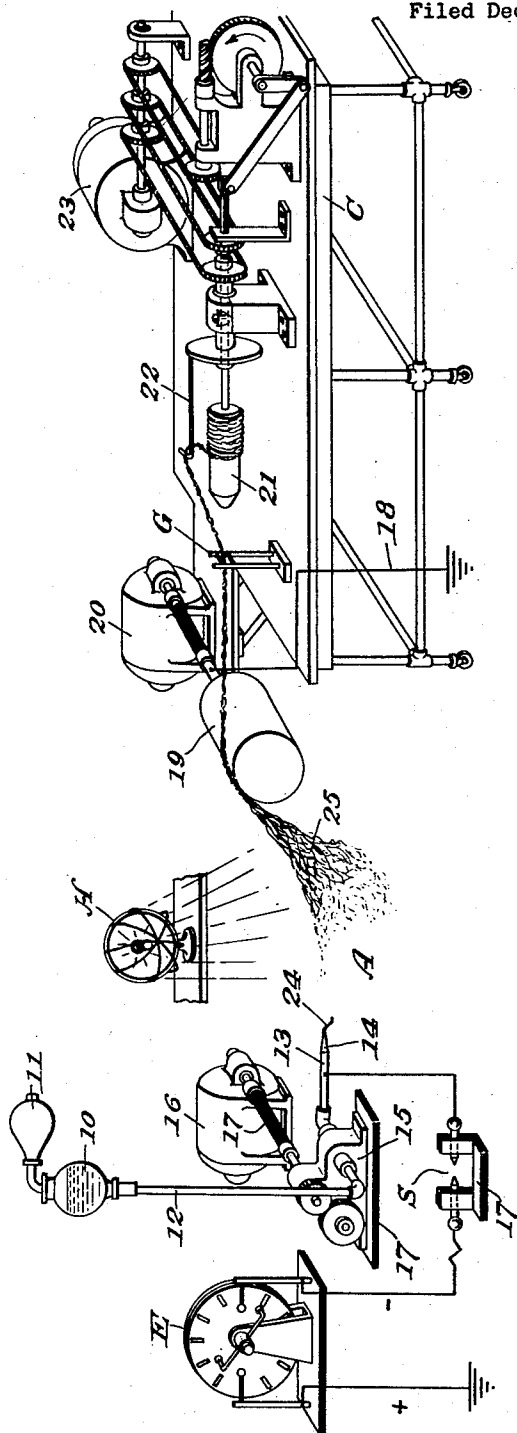
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METHOD AND APPARATUS FOR PRODUCING ARTIFICIAL FIBERS

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METHOD AND APPARATUS FOR PRODUCING
ARTIFICIAL FIBERS

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My present invention relates to the formation, by controlled electric discharges of high voltage, of fibers from various spinning liquids, i. e., liquids capable of electrostatic dispersion and rapid solidification into such fibers, and especially to the production of slivers, rovings, yarns and the like in continuous lengths from discontinuous or staple fibers of this character. The invention includes a novel process and a novel apparatus for practicing the process. While the primary utility of the invention lies in the manufacture of artificial textile fibers from cellulose acetate solutions, viscose and the like, it is also capable of use in the production of fibers from other materials, for example, molten rosin or glass, synthetic resins such as vinyl acetate or polyvinyl resin, and water solutions of glue, gelatine, sugar, sodium silicate and so forth. The invention will be described hereafter particularly in connection with the manufacture of textile fibers from cellulose acetate containing a suitable solvent.

The invention is of particular importance, because it produces yarns which closely approximate in quality and appearance yarns produced from well-known natural staple fibers, such as cotton and wool, and also because it affords means for regulating the particular quality. For instance, harsh, coarse, curly, crinkly fibers like carpet wools may be produced, likewise soft fibers like Shetland wools and straight or wavy fibers like cotton, silk and linen. The texture and quality of the fibers may be regulated, likewise their lustre, it being possible to produce a highly lustrous or glossy fiber or one which is dead and almost totally without lustre or sheen. Likewise the length of the staple and the size of the fiber may be controlled. My process makes it possible to produce such fibrous material directly in a continuous length in the form of a sliver or roving without the necessity of carding or combing, the yarn being produced directly from the sliver or roving.

I am aware that attempts have been made to produce textile fabrics by high-voltage discharges, but none of these attempts have been commercially successful in the direct production of yarns or slivers of even quality, size, strength and appearance.

For example, in the patents to Morton No. 705,691, July 29, 1902, and Formhals, No. 1,975,504, October 2, 1934, as well as in my own prior Patent No. 2,048,651, July 21, 1936, are described the production of fibers from viscous liquid by disrupting the liquid under the influence of an electrostatic charge of one polarity, but, in ac-

cordance with each of the methods described, the fibers are collected on an electrode of opposite polarity and equal potential, as has heretofore been considered necessary in order to control their travel and position. While these methods are successful to some degree in the formation of a heterogeneous mass of fibers, the collection of the fibers on an oppositely polarized object has not proved practical for the purpose of forming fibrous material in continuous lengths because of the difficulty of removing the fibers continuously from the collection electrode. In accordance with one modification of the invention described in the Morton patent, a continuous fiber is produced, but this comprises, not a sliver or roving of fibers formed by the electrostatic disruption of the material, but only a single fiber formed by flow, induced by electric potential, from a single capillary orifice.

In the patent of Cooley, No. 745,276, November 24, 1903, there is shown apparatus in which the viscous liquid is allowed to flow downward through an orifice into the field between two electrodes of opposite polarity, the material being then said to be broken up into fibers, after which the fibers are collected on a reel located beneath the electric field. There is also shown a modification of the apparatus in which the stream of viscous material is deposited directly on the point of one of the electrodes, being then broken up into fibers and thereafter collected on a reel located below the electrified field. In practice, I find that this apparatus is defective because, if the field is intense enough to produce fibers at all, these fibers stray in large quantities to all parts of the apparatus, to the walls of the room in which the work is done and even to the operator himself. Such stray fibers not only are wasted or lost, but interrupt the operation of the apparatus. This is due to the fact that the patentee made no adequate provision for supporting, collecting, and otherwise controlling the fibers in the region of their formation. Also, I have found that when the material is deposited upon an electrode, as distinguished from being electrified at or prior to the time when it is discharged, only an insignificant number of fibers are formed, and the electrode soon becomes coated with a mass of the material which impedes, and in some instances completely prevents, the further continuous formation of fibers.

I have discovered that if the viscous liquid is discharged through a nozzle while electrified by an electrostatic charge, and the intensity of the field thus formed is regulated properly with re-

spect to the nature and viscosity of the mixture and the temperature and humidity of the atmosphere, fibers will be formed in a region spaced by an air gap from the nozzle, which fibers tend to float or drift away from the nozzle and across said region. Under proper conditions the forward ends or portions of the fibers thus formed tend to contact with and adhere to fibers which have been previously formed, particularly if the previously formed fibers are withdrawn to a grounded support, or one electrified by a bound charge of opposite polarity but materially lower potential than that by which the liquid is electrified. I further find that by employing this method and arrangement I am able to produce a sliver or roving directly and that this sliver or roving may be wound on a spool or bobbin, or be twisted into a yarn, thus doing away altogether with the necessity of carding, combing or preparing the fiber for conversion into a sliver or roving.

The invention will best be understood from the following description of the arrangement and operation of apparatus embodying the same and by which it may be practiced, as illustrated in the accompanying drawing, this, however, having 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.

Said drawing is a diagrammatic view of apparatus arranged and operating in accordance with the invention.

The apparatus shown in the drawing includes a reservoir 10 for the material of which the fibers are to be formed, for example, a viscous solution of cellulose acetate in acetone and alcohol. The reservoir 10 is preferably provided with means, herein shown as a bulb 11, whereby a slight pressure may be applied to the material therein. Leading from the reservoir 10 is a standpipe 12 communicating with a conduit 13 leading to a nozzle 14, while at a suitable point in the system, preferably at the junction of the standpipe 12 and conduit 13, is a metering pump or feed controlling device 15 driven by a suitable motor 16. The pump 15 may be of the well known type employed in apparatus for the manufacture of rayon and similar artificial fiber by the extrusion method and serves to produce a regulated flow of the material from the reservoir 10 to the nozzle 14. The nozzle 14 is provided with a discharge orifice of appreciable size, as distinguished from the minute openings in the nozzles customarily employed for forming artificial fibers by extrusion, said orifice being preferably of a diameter of from .03 inch to .25 inch. Consequently, this nozzle does not produce a single fiber or a plurality of such fibers, but is of a size to produce a stream large enough to be broken up by electrostatic action into a considerable number of fine fibers of the general size of natural textile fibers. E denotes a source of electric potential, such as an electrostatic machine of any suitable and well known type, or a suitable high voltage transformer and current rectifier, one pole of which is grounded, and the other of which is connected with the nozzle 14, or with the conduit 13, whereby the liquid, prior to and at the instant of its discharge from the nozzle, is electrified with an electrostatic charge of single polarity. As a convenient means of controlling the potential of the charge, particularly when an electrostatic machine is used, the connection

between said machine and the nozzle or conduit may include a spark gap S between two pointed electrodes one of which is adjustable toward and from the other, whereby a regulated silent discharge between them is obtained. The electrified parts are all insulated from their support, as indicated at 17.

Spaced from the nozzle 14, and preferably disposed at an elevation somewhat above the latter, is the collecting apparatus which comprises a support in the form of a drum or cylinder 19 which is rotated by an electric motor 20, suitable guiding means generally indicated at G, and a suitable winding and twisting apparatus, which, as shown, comprises a spindle 21 and flyer 22 operated by another electric motor 23 through suitable power transmitting connections adapted to rotate the spindle and flyer at different speeds and to move the spindle slowly in a longitudinal direction. The support 19 is grounded, as indicated at 18, so that, in conjunction with the electrified nozzle, it is electrified by a bound charge of opposite polarity and lower potential than that of the nozzle and of the material discharged therefrom.

With the apparatus arranged as above described, when the pump 15 is started with the electrostatic machine E at rest the material merely drips from the nozzle 14, but when the electrostatic machine is likewise started, the material is discharged from the nozzle in the form of a tongue 24 in a state of rapid and violent agitation or vibration, closely resembling a snake's tongue. The material breaks up and is dispersed into fine particles which are at first almost invisible but which are drawn out and solidified into a wisp of fibers, somewhat repelled from one another, in a region spaced by an air gap A from the nozzle, as indicated at 25. If the forward ends of these fibers be drawn together and carried over the support 19, they may be progressively withdrawn from the region of their formation, so that the continued formation of fibers in said region causes them to be built up on the tail 25 of fibers previously formed, resulting in the production of a continuous sliver or length composed of a series of discontinuous fibers. Due to the grounding of the support 19, and its consequent bound charge, in conjunction with the air gap A intervening between the tongue 24 and tail 25, the fibers, as they engage the support 19, are immediately discharged of their initial electrostatic charge through the ground and, in the region of their formation, receive a light induced charge of opposite polarity, causing them to attract the newly formed fibers and to be mutually repelled to form the brush-like tail 25. This electrostatic action also causes the tail 25 to be directed toward the nozzle 14 and charged tongue 24, which, combined with the effect of gravity on the fibers supported at their forward ends by the support 19, causes the tail to float in the formation region in a position to be progressively built up by newly formed fibers as the previously formed fibers are progressively withdrawn in the form of a sliver from which and the support the tail depends. By maintaining the tail 25 in the region of fiber formation, and nearer to the nozzle than any other solid object, the fibers as they are formed tend to be attracted and adhere to it instead of to other objects, so that their travel and disposition are controlled, scattering and loss are prevented, and they can be progressively withdrawn in an orderly manner in the form of a sliver or

continuous length of fibrous material. The fibers when first formed are practically straight but on drying become crooked, crinkled and twisted. This action continues after the fibers are formed in the tail and causes an interlocking and weaving together of the fibers, adding strength to the sliver. Also, the somewhat eccentric position of the tail with respect to the forces by which it is supported causes it to have a tendency to rotate, thereby giving the sliver an initial twist.

The drum 19 may be held stationary or rotated by the motor 20 at a speed determined by the rate of discharge of the material from the nozzle 14 and consequent rate of formation of the fibers, and the resulting sliver is led to the spindle 21 where it is twisted into a yarn, dragging over the more slowly rotating drum, with tension if desired. If preferred, the spindle 21 may be omitted and the sliver wound directly on the drum 19, whence it may subsequently be unwound, as a sliver, and removed to separate spinning or other processing apparatus, or, by relatively moving the nozzle and support in a direction transverse to the direction of fiber formation, the material can be delivered in the form of a bat or web suitable for felting for which it is well adapted.

The length and relative fineness of the fibers formed is determined by the viscosity characteristic of the material, the nature and amount of solvent included, the electric potential employed, and the temperature and humidity of the atmosphere in which the formation takes place, and can be controlled by variation of these factors. The higher the viscosity of the material, the coarser will be the fibers formed. The electric potentials employed are capable of substantial variation, and the higher the potential the finer and shorter will be the fibers. It is preferred to use a potential of the order of 20,000 to 25,000 volts, although the apparatus can be successfully operated with substantially lower potentials. If materially higher potentials are used, the irregular dispersion of the fibers and the consequent difficulty of collection are increased. The temperature under which the process is carried out affects the viscosity of the material and consequently the fineness of the fibers produced, that is to say, the higher the temperature, the lower the viscosity and consequently the finer the fibers. Under one set of conditions, the diameter of fibers formed at a room temperature of 50° F. was found to be of the order of .002 inch, while that of fibers formed at 80° F., from material of the same original viscosity, and under the same conditions, was found to be of the order of .0005 inch. The humidity of the atmosphere affects the rate of evaporation of the solvent and consequently the length and diameter of the fibres formed. Increase of humidity delays evaporation and consequently results in the formation of coarser and longer fibers. It also reduces scattering and facilitates collection. It is found preferable to carry out the process in an atmosphere having a relative humidity of at least 75%.

I have also found that the cold resulting from the evaporation of the solvent in the fibers during their initial formation tends to delay the complete drying and solidification of the fibers, resulting in the semi-plastic or tacky condition above referred to. Under some conditions, this effect may be so pronounced as to cause the fibres to adhere to and merge with one another to an undesirable degree, and this can be avoided by providing a heater H, such as an electric heater,

so arranged as to project a beam of radiant heat upon the tail 25 as it is formed. To the same end the drum 19 may be heated and formed with perforations to constitute a drier.

I have further found that the arrangement of the fibers in the tail 25, and in the resulting sliver or web, depends upon the relationship of the distance of the support 19 from the nozzle 14 to other factors, especially the electric potential employed. For a given set of conditions (potential, viscosity, etc.) it is found that there is a certain distance at which the fibers tend to arrange themselves in parallelism, resulting in a particularly satisfactory sliver. This distance varies from 12 to 30 inches as the potential rises from 15,000 to 25,000 volts, also varying slightly with other factors. It is therefore desirable to make provision for adjusting this distance in accordance with the requirements, as by mounting the collecting apparatus on a movable carriage C, whereby it can be moved toward and from the nozzle 14 until the exact position is found wherein the desired effect is best obtained under the prevailing conditions.

I have still further found that, in the case of material such as cellulose acetate and the like, the presence of small amounts of water in the liquid mixture used has important effects on the fiber produced. For instance, when water up to about 3% and preferably about 1½%, is included in the mixture, the fiber produced is much softer in texture and is de-lustered, or of a milky translucency, having the texture of a fine Shetland wool and the general appearance of cotton. The addition of water also tends to reduce scattering of the fibers, so that a higher potential can be employed and consequently a finer fiber produced without sacrificing length. It also obviates the necessity of close humidity control of the atmosphere.

Similar results may be obtained by introducing into the liquid small quantities of some metallic salts or other electrically conducting materials. This, as also the addition of water, and the maintenance of a humid atmosphere to retard evaporation, tends to preserve the electric conductivity of the fibers and facilitates the dissipation of their electrostatic charge through the grounded support or collecting means.

If fused substances which become poorer conductors when cooled, such as glass and rosin, are used in my process, they should preferably not be cooled to such an extent as to become good insulators until they reach the drum 19 or other grounded support, although wetting the tail 25, as by means of a jet of steam or a drip of water, will serve to maintain its conductivity.

It will be understood that the theoretical statements herein contained as to the operation of the apparatus, the behavior of the material operated upon, the action and effect of the various forces and other factors involved, the exact results accomplished, etc., are based on my present knowledge of these matters, and are for the purpose of giving the fullest possible information in regard to the invention now available to me, but I do not limit myself to the particular theories stated.

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 for attracting the disrupted fibers by electrostatic action, sup-

porting the sliver so as to provide a freely depending tail thereon and cause the disrupted fibers to attach themselves endwise to the sliver tail to form part of the sliver and progressively withdrawing the 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 for attracting the disrupted fibers by electrostatic action, supporting the sliver so as to provide a freely depending tail thereon and cause the disrupted fibers to attach themselves endwise to the sliver tail to form part of the sliver, progressively withdrawing the sliver formation at a speed to render the sliver continuous, and twisting the sliver as it is withdrawn to form a continuous length of yarn.

3. An apparatus for forming a sliver of textile fibers comprising, in combination, a means for

electrostatically disrupting a spinning liquid into discontinuous fibers in a region of fiber formation by the action of an electrostatic charge, means including a grounded supporting member positioned entirely above said disrupting means and above said region for supporting a sliver having a tail freely dependent therefrom, whereby each fiber as it is formed has its electrostatic charge concentrated at its ends, one of said ends tending to attach itself endwise to the free end of the tail below said support and leave the remainder of the fiber free to be drawn into substantially parallel relationship with the other fibers, said tail being unsupported in the region the fibers attach themselves in endwise relation to the sliver, and means for progressively drawing said sliver upwardly over said supporting member as it is built up by the collection of successively formed fibers upon the tail of previously formed fibers.

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