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APPARATUS FOR THE PRODUCTION OF FILAMENTS, THREADS, AND THE LIKE

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FIG. 1.

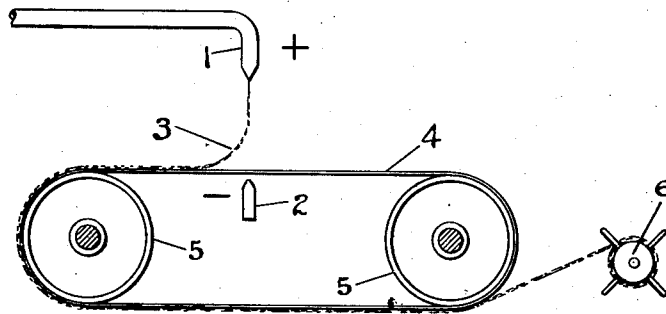


FIG. 2.

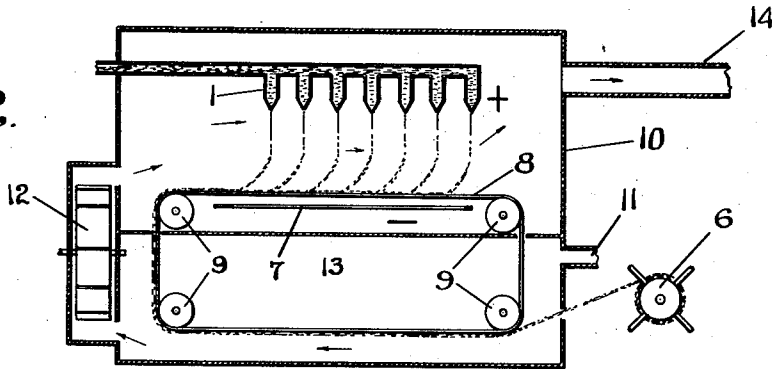
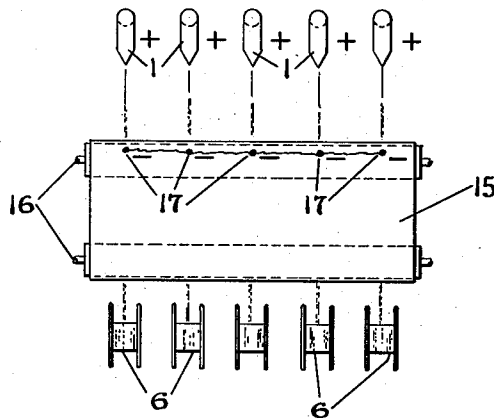


FIG. 3.



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APPARATUS FOR THE PRODUCTION OF
FILAMENTS, THREADS, AND THE LIKE

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4 Claims. (Cl. 18—8)

This invention relates to the electrical spinning of filaments, threads and the like, and in particular it relates to an electrical process for the production of filaments, threads and the like from cellulosic solutions.

It has been disclosed in Formhals U. S. Patent No. 1,975,504, issued October 2, 1934, that solutions of filament forming material, for example, solutions of cellulose acetate, may be spun into filaments by causing the spinning solution to be extruded in the form of a stream into an electrical field formed between two electrodes having opposite charges, one of the electrodes being the spinning jet, and the other electrode serving as the collector for the filaments, the last named electrode being movable. The electrostatic force in the electrical field tends to break up the spinning solution as it passes into the field and to produce a multiplicity of filaments or fibers by removal of the solvent.

It is an object of the present invention to devise a novel process for the electrical spinning of filaments. A further object of the invention resides in an improved electrical spinning process and apparatus for the production of staple fibers, i. e., short lengths or discontinuous fibers.

A further object pertains to improvements in the art of the electrical spinning of filaments which overcome difficulties inherent in prior art processes, and which effect an economical and efficient mode of spinning and collecting filaments. Other objects of the invention will become apparent hereinafter.

The objects of the present invention are accomplished in general by passing the spinning solution, i. e., a solution of filament forming material, into a high potential electrical field generated between two electrodes, both of the electrodes being stationary, the formed filaments being continuously collected by means of a movable collecting device, for example, a continuous belt composed of a material, for example, cotton, which is a non-conductor of electricity, which belt passes through the electrical field and between the electrodes and which continuously carries the filaments away in the form of a fiber or the like, the filaments being removed from the movable collector in any suitable way, for example, by being wound up on a reel.

My invention will be best understood by reference to the attached drawing in which Figure 1 is a diagrammatic showing of an apparatus adapted to the electrical spinning of filaments; Figure 2 is a diagrammatic sketch showing a

modified form of apparatus; Figure 3 is a view of another modified form of apparatus.

Referring to Figure 1, a spinning solution is extruded through nozzle 1 comprising an electrode designated by a plus sign indicating a positive charge, the nozzle directing the solutions towards a stationary electrode 2 designated with a minus symbol to indicate a negative charge. Electrodes 1 and 2 are connected to any suitable source of electrical power sufficient to establish a high potential electrostatic field between the electrodes. The spinning solution passing from the jet 1 in the direction of electrodes 2 is broken up under the influence of the electrostatic force, the solvent being simultaneously removed so as to form a mass of discontinuous filaments 3, which are collected on a traveling belt 4 of non-conducting material, for example a cotton belt, which is in driving contact with pulleys 5, either one or both of which may be driven, the filaments being taken off by any suitable means and at any desired point and collected on a reel 6.

Figure 2 illustrates the use of a plurality of nozzles 1 arranged in tandem, all of the nozzles together serving as one positive electrode and being designated with a plus sign, the other electrode being line electrode 7 which may be a wire or a metal conductor of any other suitable form and being designated minus to signify a minus charge. The sliver is collected on belt 8 which is in driving contact with pulleys 9, any or all of which may be driven, the sliver being collected on reel 6. The use of a plurality of electrodes arranged along a line parallel to belt 8, enables the filaments to be collected in the form of a sliver much larger than is obtained from a single electrode, thereby increasing the capacity of the machine without greatly increasing its cost.

Figure 2 further illustrates a solvent recovery system. The whole apparatus is enclosed as shown in a casing 10, air being admitted at 11 and being drawn by means of a pump 12 or the like through the lower part of the solvent recovery system which is separated from the upper part by partition 13, having openings therein to permit the passage of the belt and sliver, air and any solvent picked up in the lower portion passing through passage 12 into the upper portions of the casing and through exit passage 14 to a solvent recovery system.

Figure 3 illustrates multiple production by arranging several nozzles 1 side by side, the spacing of the nozzles being such that adjacent electrodes would not interfere with the formation of a separate sliver for each nozzle suitable for

stripping from the belt, and unwinding from the reel for subsequent processing. All slivers will preferably be collected on a single traveling belt 15 which is in driving contact with pulleys 16 and individually wound on reels 6 as shown in Figure 3. Negative electrodes 17 designated with a minus sign and electrically interconnected, are disposed below the belt 15, as shown.

It will be understood that instead of the single nozzles shown in Figure 3, there may be rows of nozzles of the type shown in Figure 2, each row being arranged in tandem, the individual rows serving as electrodes, and separately connected to a suitable source of power, this construction permitting the slivers to be collected as dense rope-like structures.

Briefly, the operation of the apparatus is as follows. The solution may be one of cellulose acetate dissolved in acetone, or in mixtures of acetone and alcohol or in other solvents, or other cellulose derivatives dissolved in suitable solvents can be used. For example, cellulose acetate having a combined acetic acid content of 54-55% is dissolved in acetone to make a solution containing 10-20%, and preferably 15% of solids. Other solvents or modifying agents may be added to the acetone to change the type and character of the solution and/or spinning qualities. Other materials such as plasticizers, softeners, etc., may be added to the solution in order to modify the spun cellulose acetate fibers, making them soft, harsh, flexible, strong, etc., as desired. The solution is extruded through the nozzle which is connected to the electrical potential supply to form one of the electrodes producing the electrical field. The other electrode, oppositely charged, may consist of a needle point, spherical surface, or be line-shaped as exemplified by a length of wire as shown in Figure 2. The latter example may be used, for instance, when it is desired to spin from a multiplicity of nozzles. The electrostatic field between the electrodes is obtained by means of a high potential produced in any desired way. It is preferred that an ordinary source of alternating current, for example 60 cycle, 120 volt current, be used as the source of electrical energy, the current being transformed to a high potential of say 5,000 to 10,000 volts, and being rectified to direct current by any suitable means. It is understood, however, that a frictional electrostatic machine may be used, and instead of direct current, the current between the electrodes may be alternating current. Where it is desired to change alternating current to direct current it may either be mechanically rectified according to methods known in the art, or vacuum tubes may be used.

The solution issuing from the nozzle electrode into the electrical field is split up into numerous fine filaments or fibers which are attracted to the electrode oppositely charged. Spaced between these two electrodes and preferably near the one opposite the nozzle is a moving electrically non-conducting belt, such as is illustrated in the drawing, which interrupts the passage of the fibers to the electrode opposite the nozzle. These collect on this moving belt and are carried out of the influence of the electrical field so that there is a continuous collection of fibers on the belt, which by its motion causes the fibers to lie practically parallel to each other.

It is preferred that the moving belt be made of electrically non-conducting material, i. e., a material which is a good dielectric or electrical insulator, which material is frictionally resistant so that the fibers are readily removed from the elec-

trostatic field. It is only necessary that the belt be so designed that the frictional resistance of the belt be greater than the tendency of the fibers to remain in place due to the attraction to the lower electrode. However, normally, this attraction is not sufficiently great to keep the fibers in place, and after the process is started, there is little difficulty in this regard.

After the belt has moved away from the influence of the electrical field, the fibers can be taken off it in a continuous length of rope sliver and wound onto a reel or any other suitable receiving device in such a manner that the sliver can be subsequently unwound for use in the spinning or fabrication of thread and the like.

While I prefer to make the spinning nozzles one of the electrodes, it is obvious of course that I need only to spin the solution into the electrical field and that it is only necessary to have one of the electrodes in the vicinity of the spinning nozzle. I have also described my invention in terms of cellulose acetate specifically and cellulose derivatives more generally. For example, instead of a solution of cellulose acetate, a solution of cellulose nitrate in a suitable organic solvent, or viscose, or aqueous alkaline solutions of lowly etherified or lowly esterified cellulose such as lowly etherified methyl, ethyl or glycol cellulose, or lowly esterified cellulose acetate may be used. The invention also comprehends in its broad scope the spinning of various other materials, for example, solutions of resins to form similar filamentary material. It is only necessary that the solution to be spun contain filament forming material dissolved in a solvent which is readily removed during the spinning operation.

Among the advantages of my invention is the provision of an apparatus and a process which lends itself admirably to the production of fibers and filaments which may be spun into threads. With respect to cellulose acetate and cellulose esters generally, it is known that those filaments which are produced by the ordinary dry spinning processes have so regular a contour that if the filaments are cut up into staple lengths, it is difficult to twist these staples into a spun thread. Attempts have been made to produce cellulose acetate filaments which would have a somewhat roughened contour and prevent slippage when the staples are spun into a thread. These attempts generally have not been successful. The fibers produced by my process are of variable deniers and of variable lengths and lend themselves admirably to the production of a spun thread. The provision of a process involving a moving belt and a stationary electrode is a contribution to the practical art because it makes possible for the first time an expedient method of producing this very desirable fiber, with an elimination of many of the mechanical and electrical difficulties encountered in the prior art. For example, by the use of stationary electrodes, it is unnecessary to regulate continuously the contact between the source of electrical power and the moving electrodes, and the mechanical difficulties incident to rotation or motion of the electrode are eliminated.

In addition, by the use of a moving belt which passes through the electrostatic field, the fibers, after being drawn out of the field, can be removed without any difficulty from the collector. On the contrary, where a movable electrode is used, the adhesion between the filaments and the electrode is so marked that removal of the filaments is rendered that much more difficult with

the concomitant danger of injury to the filaments.

Additional advantages comprise the use of a multiplicity of spinning jets forming simultaneously a multiplicity of slivers. The apparatus, furthermore, may be so designed as by virtue of the solvent recovery feature shown in Figure 2 as to eliminate fire hazard, where inflammable solvents are present. In addition, the recovery of the solvents adds greatly to the economy of operation.

It may be stated in passing that since both electrodes are stationary there is little danger of sparking and ignition of the volatile solvents, whereas on the contrary where moving electrodes are used, the sparking hazard may be present where there is an imperfect contact between the source of electrical power and the moving surface of the electrode, or alternatively, the electrode must be carefully shielded so as to eliminate any danger that might arise by virtue of sparking.

Since this invention is susceptible of considerable modification, it is intended that any variation from the above detailed description of the apparatus and process which conforms to the spirit of the invention, be included within the scope of the claims.

I claim:

1. In an apparatus for the electrical spinning of artificial fibers, in combination, oppositely charged stationary electrodes spaced from each other to create a high potential electrical field therebetween, means for passing a stream of spinning solution between said electrodes whereby said high potential field will cause said stream to break into a plurality of fine fibers and cause the same to be attracted towards one of said electrodes, and non-conducting means movably positioned between said electrodes adapted to collect said fibers and carry them from the field of electrical influence between said electrodes.

2. In an apparatus for the electrical spinning

of artificial fibers, in combination, oppositely charged stationary electrodes spaced from each other to create a high potential electrical field therebetween, means for passing a stream of spinning solution between said electrodes whereby said high potential field will cause said stream to break into a plurality of fine fibers and cause the same to be attracted towards one of said electrodes, and a continuous belt composed of non-conducting material movably positioned between said electrodes adapted to collect said fibers and carry them from the field of electrical influence between said electrodes.

3. In an apparatus for the electrical spinning of artificial fibers, in combination, oppositely charged stationary electrodes spaced from each other to create a high potential electrical field therebetween, means for passing a stream of spinning solution between said electrodes whereby said high potential field will cause said stream to break into a plurality of fine fibers and cause the same to be attracted towards one of said electrodes, and a non-conducting porous means movably positioned between said electrodes adapted to collect said fibers and carry them from the field of electrical influence between said electrodes.

4. In an apparatus for the electrical spinning of artificial fibers, in combination, oppositely charged stationary electrodes spaced from each other to create a high potential electrical field therebetween, means for passing a stream of spinning solution between said electrodes whereby said high potential field will cause said stream to break into a plurality of fine fibers and cause the same to be attracted towards one of said electrodes, and a non-conducting porous belt movably positioned between said electrodes adapted to collect said fibers and carry them from the field of electrical influence between said electrodes.

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