July 19, 1938. A. FORMHALS 2,123,992

METHOD AND APPARATUS FOR THE PRODUCTION OF FIBERS

Filed July 1, 1936 2 Sheets-Sheet 1

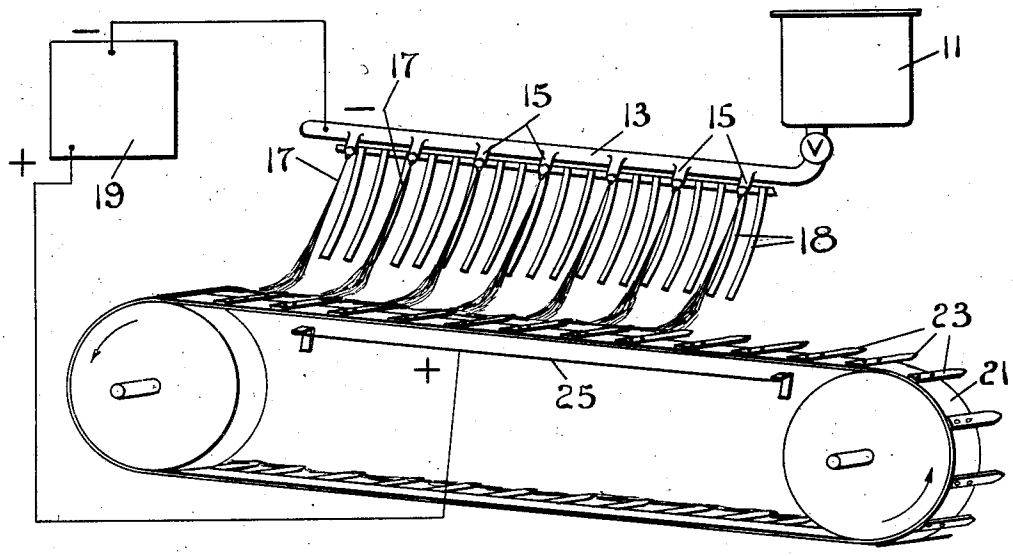

FIG. 1.

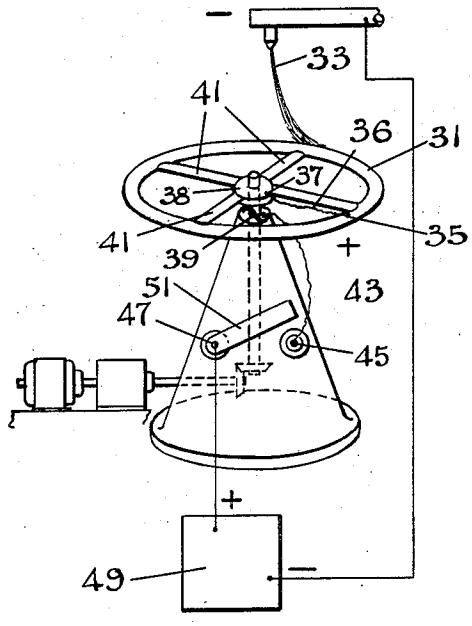

FIG. 2.

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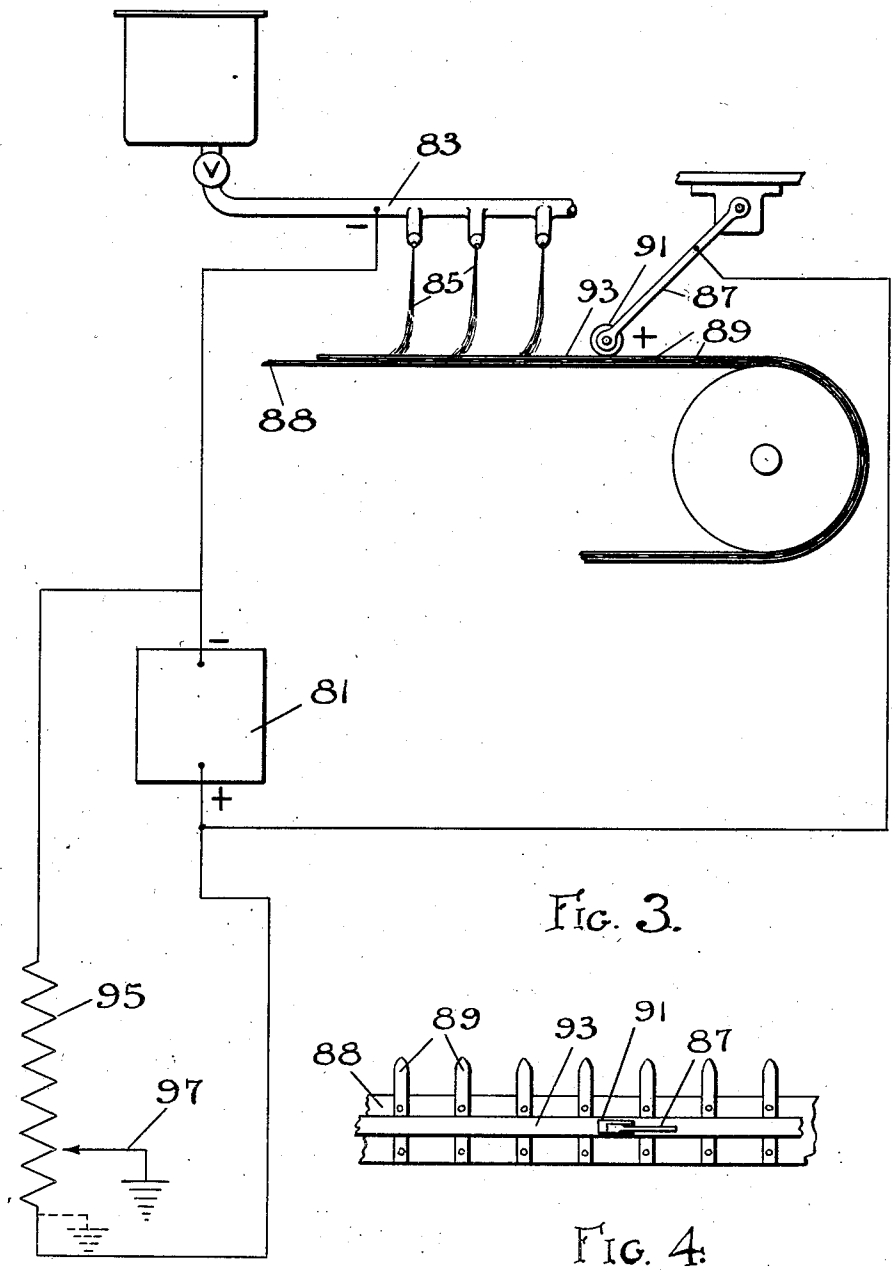

FIG. 3.

FIG. 4.

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UNITED STATES PATENT OFFICE

2,123,992

METHOD AND APPARATUS FOR THE PRODUCTION OF FIBERS

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Application July 1, 1936, Serial No. 88,431

11 Claims. (Cl. 18—8)

This invention relates to the spinning of filaments and fibers by imparting an electrical charge of high potential to a stream of spinning solution to disperse or shatter the same into a plurality of comparatively fine fibers, and collecting the said fibers on a moving electrode to which has been imparted an electrical charge of high potential of an opposite polarity to that imparted to the spinning solution. This method of spinning filaments and fibers will, for convenience, be hereinafter referred to as the "electrical spinning of fibers".

Reference is made to the applicant's copending applications, Serial No. 88,428, filed July 1, 1936, and Serial No. 88,429, filed July 1, 1936, relating respectively to new article textile structures, and a new method and apparatus for spinning artificial fibers.

In accordance with the electrical spinning of fibers as disclosed in U. S. patent to Formhals No. 1,975,504 of October 2, 1934, a spinning solution is introduced between a stationary electrode in the form of a serrated wheel immersed in a spinning solution, and an oppositely charged moving electrode which may be in the form of a revolving wheel, ring, belt, bobbin or drum. The high electric tension between the electrodes disperses or shatters the spinning solution into a plurality of fine filaments or fibers which are attracted to the moving electrode and temporarily collected thereon.

In the method and apparatus as disclosed by the said patent to Formhals, as well as other previously known procedures for the electrical spinning of fibers, opposite poles of a high potential producing electrical device were directly connected to the opposing electrodes between which the fibers were spun, thus maintaining high potential charges of equal potential and opposite polarity on said electrodes.

It has now been found that when the voltage of the two oppositely charged electrodes is substantially equal, unsatisfactory results will be forthcoming. The comparatively fine fibers into which the stream of spinning solution is dispersed or shattered will not all satisfactorily collect on the collecting electrodes but many fibers will fly off the collecting device or fail to reach the same and will therefore fly about between the two electrodes and into the spinning room causing a great waste of fibers.

When it is desired to form a continuous, compact, coherent fiber band composed of heterogeneous fibers arranged substantially parallel to each other, as described in the above mentioned copending application relating to new artificial textile structures, the use of high potential electrical charges of substantially equal potential on the nozzle and the collecting device not only has the disadvantage of causing many fibers to fly about but involves the following additional objectionable features. Many of the spun fibers after being attached to the collecting device will tend to stand out at right angles from the device. This action of the fibers is obviously objectionable in that it seriously interferes with the formation of good parallelism between fibers and creates an undesirable entanglement between fibers. If, in a collecting device, certain of the fibers are projecting therefrom at a substantial angle, it is difficult to get them back down into a parallel, free-drawing and untangled fiber band such as would otherwise be produced if the fibers were properly laid down during the spinning thereof. The fibers which fly about between the electrodes and into the spinning room tend to attach themselves to various parts of the spinning apparatus. The attaching of such fibers to certain sections of the spinning apparatus, such as the nozzles, interferes with the continuity of spinning, the continuity of spinning solution delivery and causes an undesirable entanglement of the flying fibers with the freshly spun fibers.

The above mentioned objections are primarily caused by the repelling effect of the high potential charge on the collecting device. A fiber leaving the spinning nozzle may be, for example, charged negatively. As it approaches the field of the collecting device it may be charged with a positive charge from the collecting device before it reaches the latter. In this case the positively charged fiber will be repelled by the positively charged collecting device and therefore never reach the collector. In other cases the fibers may temporarily adhere to the collector but due to the high potential thereon will be repelled and thrown back toward the nozzle. Other fibers after reaching the collecting device and partially adhering thereto are positively charged and ends thereof which have not had adequate opportunity to adhere to the collecting device are projected outwardly at an angle to the collector.

It is therefore an object of the present invention to electrically spin fibers between two members bearing charges of high potential of opposite polarity in which the fibers are substantially all collected on one of the said members in the form of a sliver which may be directly drawn and twisted into a thread.

It is another object of the invention to electrically spin fibers between two members bearing charges of high potential of opposite polarity and collecting the said fibers on one of said members without permitting the same to fly about between the said members and into the spinning room or permitting the said fibers to project outwardly from the collecting means.

It is a further object of this invention to prevent excess waste of fibers by preventing the flying of said fibers about in the spinning room.

It is yet another object of this invention to regulate to any desired degree the relative distribution of potential between the spinning means and the collecting means.

Other objects of the invention will appear hereinafter.

The objects of the invention may be accomplished in general by imparting an electrical charge of high potential to a stream of a spinning solution and collecting the said fibers on a moving electrode to which has been imparted a high potential of opposite polarity and in which the high potential on the collecting electrode is substantially lower than the potential imparted to the spinning solution.

The potential on the collecting electrode is made sufficiently lower than the potential imparted to the stream of spinning solution that the charge on the formed fibers will not be neutralized or discharged until they have actually reached and adhered to the collector and will not be repelled from the collector after their collection thereon.

In order to more clearly set forth the present invention reference is made to the following detailed description taken in connection with the accompanying illustrations, in which:

Figure 1 is a diagrammatic perspective view of an electrical spinning machine constructed in accordance with the present invention.

Figure 2 is a diagrammatic perspective view of a modified form of electrical spinning machine.

Figure 3 is a diagrammatic side elevational view of another modification of an electrical spinning machine.

Figure 4 is a top plan view of the collecting belt and current transmitting trolley shown in Figure 3.

Referring to the drawings, reference 11 designates a supply tank of a spinning solution. A header pipe 13 is connected to the supply tank 11, and a plurality of nozzles 15 are connected to the header pipe 13. The spinning solution is passed through the header pipe 13 and through the individual nozzles 15 from which it issues in fine streams 17. An electrical charge of high potential is transmitted to the streams 17 by means of an electrical device 19 which may be a transformer and rotary converter for changing ordinary line current, such as 110 volt, 60 cycle alternating electric current into a high voltage pulsating direct current. Any other source of high potential direct or pulsating direct current may be used; furthermore, for obtaining special effects for the shattering of a stream of spinning solution a high potential alternating current of any desired frequency or varying frequency may be used. The high potential charge may be transmitted to the stream by connecting the negative pole of the electrical device 19 to the metal conduit 13. The belt 21 may be constructed of any desired material; it is preferred, however, that it be made of a non-conducting material such as fiber, cloth, rubber, leather or the like. The belt 21 is continuously moved adjacent the plurality of spinnerets 15 and at a predetermined distance therefrom. The belt 21 is provided with a plurality of electrodes 23 which are preferably composed of metal and have a portion thereof projecting from the belt 21 in a direction towards the spinnerets 15. The members 23 are preferably pointed at the projecting portions thereof for reasons to be described hereinafter. An electrical charge of high potential, but a potential lower than the potential imparted to the spinning solution, is imparted to the electrodes 23. Electrodes 23 thereby serve as a means for attracting the fine fibers into which the streams 17 are shattered and for temporarily collecting the same substantially at the projecting portions thereof. The high potential electrical charge transmitted to the electrodes 23 is maintained at a considerably lower potential and of opposite polarity to that imparted to the streams 17. This may be accomplished in any desired manner. In Figure 1, for example, the conductor 25 positioned beneath the belt 21, but spaced at a short distance therefrom, is charged by connecting the same with the positive pole of the electrical device 19. The charge imparted to the conductor 25 is therefore substantially equal to the charge imparted to streams 17. The electrodes 23 obtain their charge through the air gap between the electrodes 23 and the conductor 25. The electrical charge from 25 will flow across the air gap between the conductor 25 and the electrodes 23 and thereby charge the latter. Therefore, the electrical potential on electrodes 23 will be considerably lower than that imparted to streams 17 due to the electrical resistance offered by the air gap. The substantially lower potential of the electrodes 23 will be sufficient to attract and collect the fibers but will be insufficient to charge and repel the fibers and thereby cause them to be thrown about in the spinning room or to cause them to project from the electrodes.

It is preferred that a means be provided for imparting the desired size, shape, position and/or intensity to the electric field between the spinning nozzles and the collecting device. To this end a shield 18 constructed of a plurality of prongs composed of a conducting material is positioned behind said nozzles. The shield 18 is provided with a high electrical potential of the same polarity as that of the streams 17.

Referring to Figure 2 of the drawings, the collecting wheel rim 31 is charged with high potential electricity of a polarity opposite to that imparted to the stream 33. The spokes 41 of the wheel rim 31 are made of a non-conducting material such as resinous condensation products, hard rubber or the like. The rim 31 is electrically connected to a source of high potential at point 35 with the wire 36. The wire 36 is connected at point 37 to a disc collector 38. A brush 39 is stationarily positioned so as to be electrically connected to disc 38 and thereby maintain the said disc 38 electrically connected with wire 43. The wire 43 is connected to the insulator 45. A similar insulator 47 is directly connected to a source of high electrical potential 49. An air gap is maintained between an adjustable conductor 51, connected to 47, and the insulator 45 so that the high potential electrical charge must flow across an air gap between 51 and 45. The stream of spinning solution 33 ob-

tains its high potential electrical charge by direct connection to the opposite pole of the source of high electrical potential **49** in the same manner as above described with reference to Figure 1. It is therefore clear that the high potential electrical charge on rim **31** is considerably lower than the high potential imparted to the stream of spinning solution **33**.

Referring to the modification shown in Figures 3 and 4 of the drawings, reference numeral **81** designates a source of a high electrical potential. The negative pole of the electrical source **81** is directly connected to the conduit **83** and the streams of spinning solution **85**. The positive pole of the electrical source **81** is directly connected to trolley arm **87** and to the individual electrodes **89** on the belt **88** by means of the trolley **91** and the conductor **93**. Connected to the negative and positive lead wires is a very high resistance **95** which is provided with an adjustable grounding mechanism **97**. By the adjustable grounding mechanism **97** the potential of the electrical charge which is transmitted respectively to the streams of spinning solution **85** and the electrode **89** can be adjusted in any desired manner. The point at which the resistance **95** is grounded will be at zero potential and will determine the potential to which the streams of spinning solution **85** and electrodes **89** respectively will be charged. As shown in Figure 3, a considerable reduction of voltage will take place from the positive terminal, whereas a much smaller reduction will take place from the negative terminal. Therefore the individual electrodes **89** will bear a much smaller potential than the streams of spinning solution.

If desired the collecting electrodes **89** may be maintained at zero potential by grounding the same. This may be accomplished by moving the grounding mechanism **97** to the bottom of the resistance **95** as illustrated by dotted lines in Figure 3.

By the electrical spinning of fibers in accordance with the process and apparatus of the present invention the streams of spinning solution are continuously and uniformly shattered or dispersed into fine fibers which will be collected on the projecting portions of the spaced collecting electrodes in compact, coherent fiber bands in which the fibers are substantially parallel to each other, which fiber band may be directly drawn and twisted into a thread or yarn. The projection of fibers from the collecting electrodes and the flying about of fibers between the electrodes and into the spinning room will be substantially eliminated. Due to the elimination of the flying about of fibers a great improvement in continuity of spinning and delivery of spinning solution will be realized.

The present invention is found to have particular utility when combined with means for controlling the size, shape, position and/or intensity of the electric field between the spinning nozzles and the collecting device as disclosed in the copending application, Serial No. 88,430, above referred to.

Obviously many changes and modifications may be made in the processes and apparatus above described without departing from the nature and spirit of the invention. It is therefore to be understood that the invention is not to be limited except as set forth in the appended claims.

I claim:

1. In a method for the electrical spinning of fibers, the steps comprising dispersing a stream of spinning solution into fibers by imparting a high potential electric charge to said stream of solution, and collecting said fibers on a collecting device which is maintained between zero potential and a potential lower than the potential imparted to said stream of solution and of polarity opposite thereto.

2. In a method for the electrical spinning of fibers and the collection thereof on a collecting device, the steps comprising dispersing a stream of spinning solution into fibers by directly connecting said stream of solution to one pole of a source of high electrical potential, and directly connecting a conducting medium which is spaced from said fiber collecting device to the opposite pole of said source of high electrical potential whereby to charge the fiber collecting device with a lower electrical potential of opposite polarity than the potential with which the stream of solution is charged.

3. The method for the electrical spinning of fibers and the collection thereof on a collecting device, the steps comprising dispersing a stream of spinning solution into fibers by imparting a high potential electric charge to said stream of solution, and collecting said fibers on said collecting device which is maintained at zero potential by grounding the same.

4. In an apparatus for the electrical spinning of fibers, means for forming a stream of spinning solution, means for imparting a high potential electrical charge to said stream of solution whereby to disperse the same into fibers, a moving collecting device for collecting said fibers, and means for maintaining said collecting device between zero potential and a potential lower than the potential imparted to said stream of solution and of polarity opposite thereto.

5. In an apparatus for the electrical spinning of fibers, means for forming a stream of spinning solution, means for imparting a high potential electrical charge to said stream of solution whereby to disperse the same into fibers, a moving collecting device for collecting said fibers, and means for imparting a high potential electrical charge of polarity opposite to said first named charge to said collecting device, resistance means for maintaining the charge on said collecting device at a lower potential than the charge on said stream of solution.

6. In an apparatus for the electrical spinning of fibers, means for forming a stream of spinning solution, means for imparting a high potential electrical charge to said stream of solution whereby to disperse the same into fibers, a moving collecting device for collecting said fibers, and means for imparting a high potential electrical charge of polarity opposite to said first named charge to said collecting device, and air gap means for maintaining the charge on said collecting device at a lower potential than the charge on said stream of solution.

7. In an apparatus for the electrical spinning of fibers, means for forming a stream of spinning solution, means for imparting a high potential electrical charge to said stream of solution whereby to disperse the same into fibers, a moving collecting device for collecting said fibers, and means for grounding said collecting device to maintain the said collecting device at zero potential.

8. In a method for the electrical spinning of fibers, the steps comprising dispersing into fibers a stream of spinning solution formed by a solution feeding device by imparting a high poten-

tial electric charge to said stream of solution, collecting said fibers on a fiber collecting device which is maintained between zero potential and a potential lower than the potential imparted to said stream of solution and of polarity opposite thereto, said high potential electric charge exerting a directing force on said stream and fibers, and placing an electrically charged fiber influencing means of constant polarity in proximity to said high potential electric charge on said stream of solution in such a manner as to cause said stream and fibers to be directed along a path between said devices other than the path taken thereby in the absence of said influencing means.

9. In a method for the electrical spinning of fibers, the steps comprising dispersing into fibers a stream of spinning solution formed by a solution feeding device by imparting a high potential electric charge to said stream of solution, collecting said fibers on a fiber collecting device which is maintained between zero potential and a potential lower than the potential imparted to said stream of solution and of polarity opposite thereto, said high potential electric charge exerting a directing force on said stream and fibers, and placing an electrically charged fiber influencing means of high potential and of constant polarity in proximity to said high potential electric charge on said stream of solution in such a manner as to cause said stream and fibers to be directed along a path between said devices other than the path taken thereby in the absence of said influencing means.

10. In an apparatus for the electrical spinning of fibers, a solution feeding device for forming a stream of spinning solution, means for imparting a high potential electrical charge to said stream of solution, a moving fiber collecting device, means for maintaining said collecting device between zero potential and a potential lower than the potential imparted to said stream of solution and of polarity opposite thereto, said high potential electric charge exerting a directing force on said stream and fibers, and electrically charged fiber influencing means of constant polarity positioned in proximity to said high potential electric charge on said stream of solution in such a manner as to cause said stream and fibers to be directed along a path between said devices other than the path taken thereby in the absence of said influencing force.

11. In an apparatus for the electrical spinning of fibers, a solution feeding device for forming a stream of spinning solution, means for imparting a high potential electrical charge to said stream of solution, a moving fiber collecting device, means for maintaining said collecting device between zero potential and a potential lower than the potential imparted to said stream of solution and of polarity opposite thereto, said high potential electric charge exerting a directing force on said stream and fibers, and a high potential electrically charged fiber influencing means of constant polarity positioned in proximity to said high potential electric charge on said stream of solution in such a manner as to cause said stream and fibers to be directed along a path between said devices other than the path taken thereby in the absence of said influencing means.

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