July 15, 1969 C. W. KILBY ET AL 3,456,156

APPARATUS FOR APPLYING AN ELECTROSTATIC CHARGE TO FIBROUS MATERIAL

Filed April 6, 1967 4 Sheets-Sheet 1

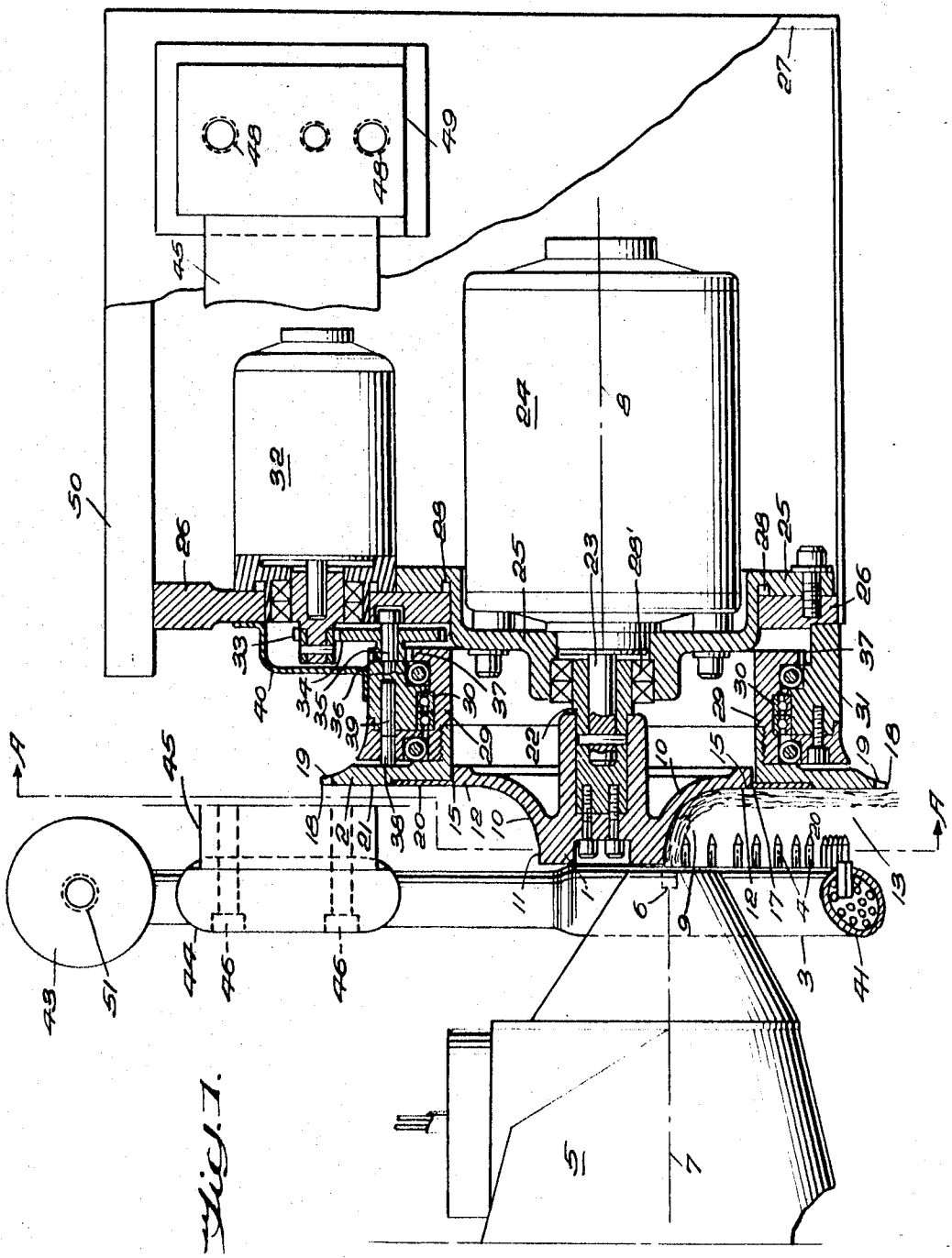


Fig. 1.

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APPARATUS FOR APPLYING AN ELECTROSTATIC CHARGE TO FIBROUS MATERIAL

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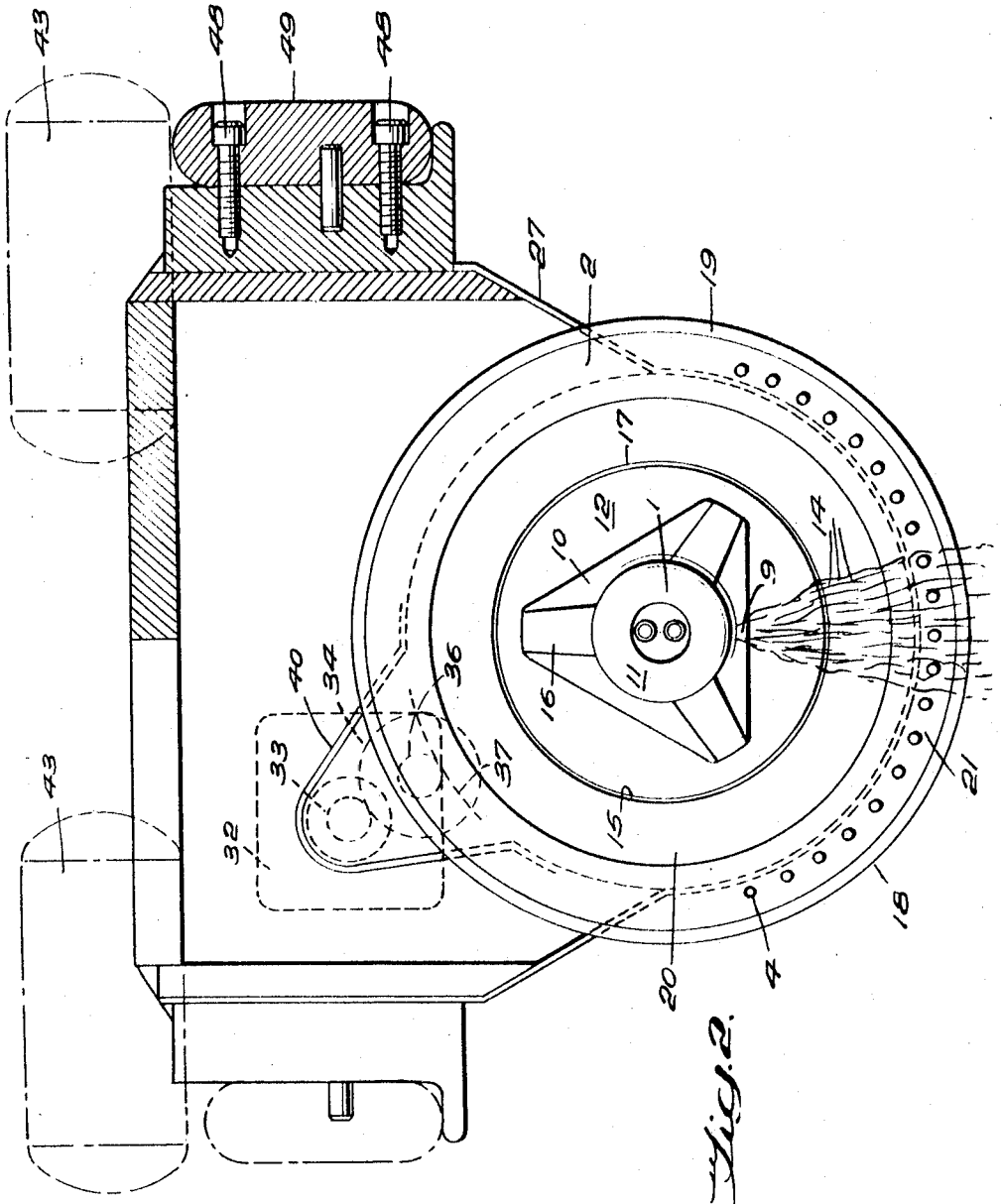


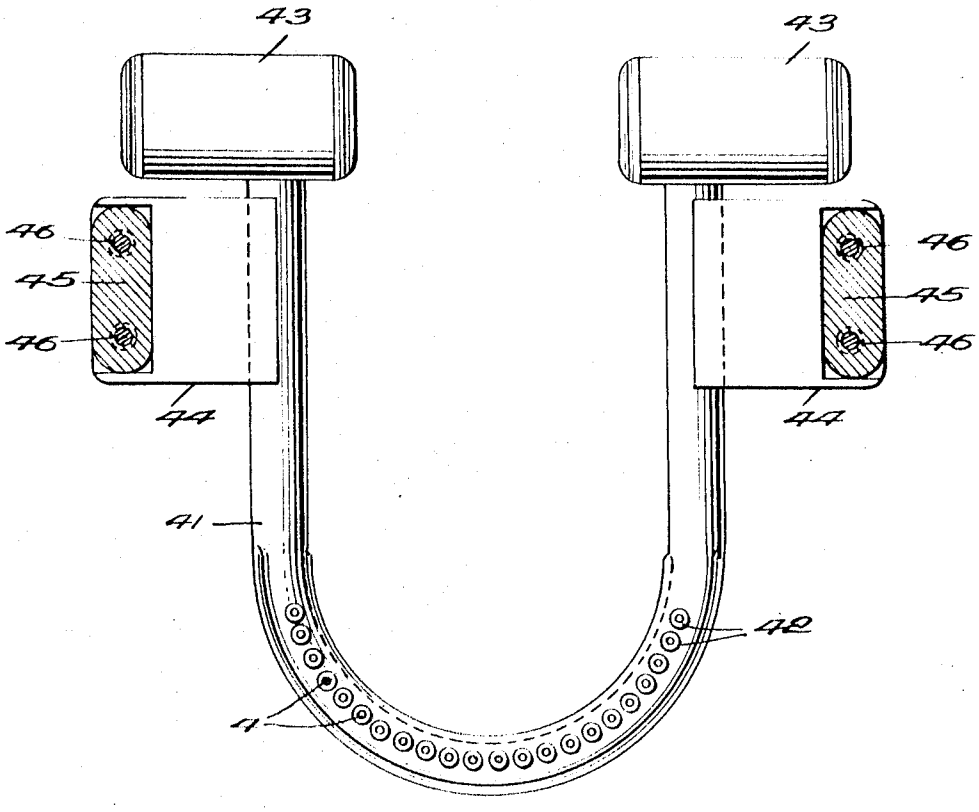

Fig. 2.

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APPARATUS FOR APPLYING AN ELECTROSTATIC CHARGE TO FIBROUS MATERIAL

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Fig. 3.



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APPARATUS FOR APPLYING AN ELECTROSTATIC CHARGE TO FIBROUS MATERIAL

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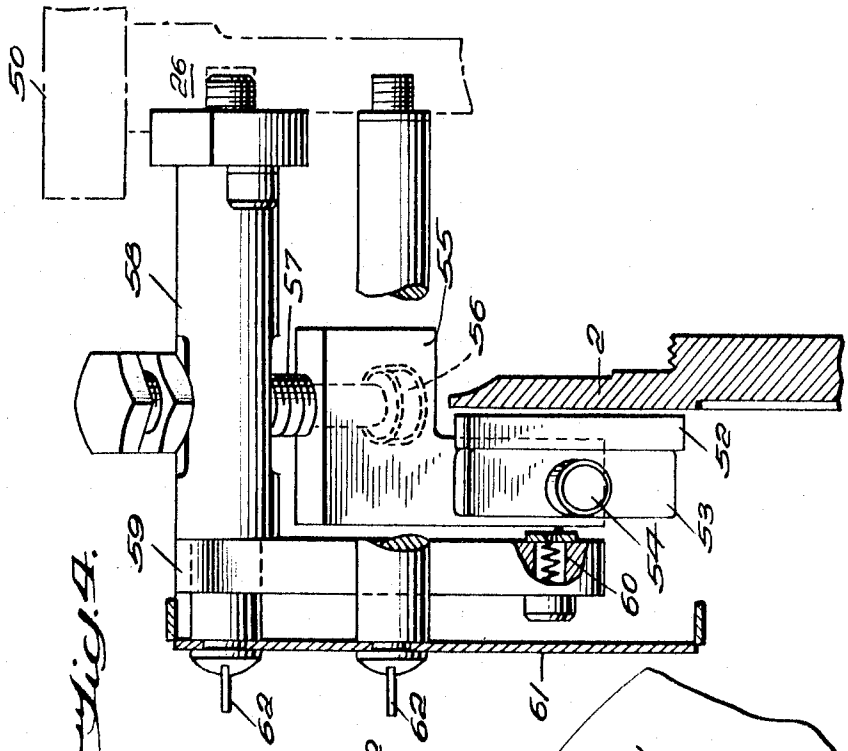



Fig. 4.

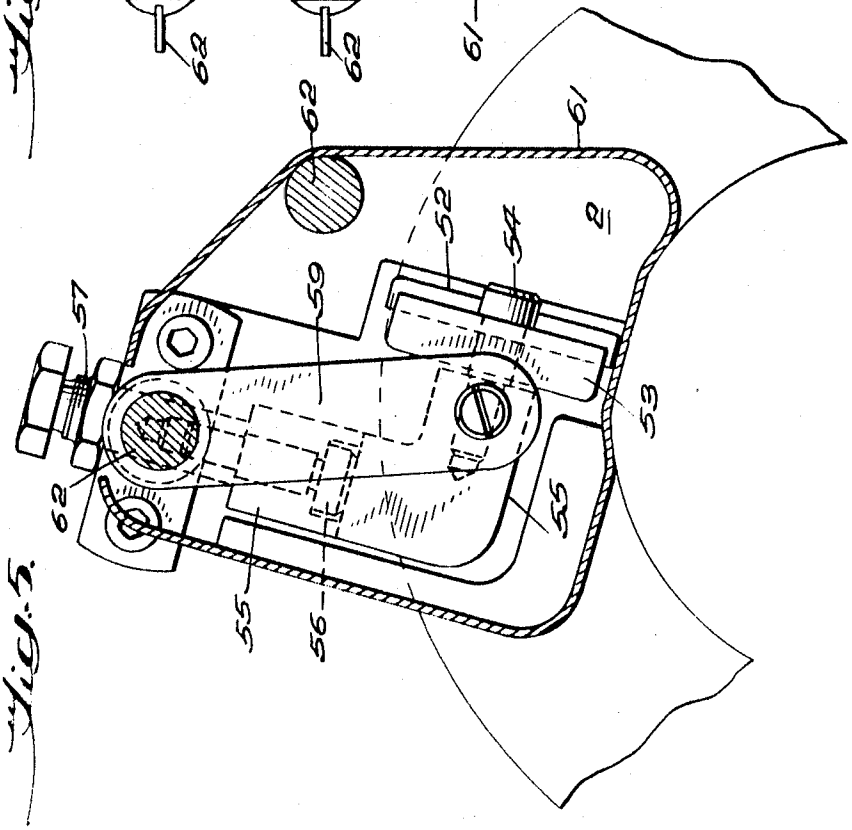



Fig. 5.

United States Patent Office

3,456,156

Patented July 15, 1969



3,456,156

# APPARATUS FOR APPLYING AN ELECTROSTATIC CHARGE TO FIBROUS MATERIAL

Claude William Kilby, Chester, Va., and James Gerald Smith, Newark, Del., assignors to E. I. du Pont de Nemours and Company, Wilmington, Del., a corporation of Delaware

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Int. Cl. H05f 3/06, 1/00

U.S. Cl. 317—4

14 Claims

## ABSTRACT OF THE DISCLOSURE

An apparatus for applying an electrostatic charge to fibrous material moving in a planar path. An annular disc target electrode is located on one side of the path and a multi-needle ion gun is positioned on the opposite side of the path. The needles of the ion gun are aimed at a portion of the target electrode to provide a corona discharge zone. The target electrode is rotatable so that that portion of its surface outside the corona discharge zone can be cleaned during operation.

## Background of the invention

This invention concerns an apparatus for applying an electrostatic charge to fibrous material moving in a planar path. It is more particularly concerned with an apparatus for applying a charge to a fibrous web, thereby preventing the web from collapsing and providing an electrostatic force to promote controlled deposit of the web on an oppositely charged moving belt or roll.

In U.S. Patent 3,081,519 to Blades and White a flash-extrusion method is described for preparing fibrillated strands. These strands are composed of three-dimensional networks of extremely fine film-fibrils. The network structure is particularly useful in preparation of nonwoven fibrous sheets, these having been described in Steuber U.S. Patent 3,169,899. In further development of this technology an apparatus has been developed wherein the network passes from a curved baffle opposite the spinneret hole to the center of a rectangular flat target plate electrode. The network then is carried along the flat surface and leaves the electrode by passage over a straight trailing edge. The target plate is electrically grounded. A second electrode, termed an ion gun, which is a corona charging electrode, is used to deposit an electrostatic charge on the open network as it passes along the surface of the target plate. The charged network is then deposited on an oppositely charged belt or roll. In this process it has been found that residues of polymer, fibrils or other substances have tended to collect on the target plate surface principally by electrostatic precipitation. The residues cause a reduction in the charging efficiency with a resulting deterioration in the collected sheet. As a consequence, interruption of the process is required while the target is cleaned or replaced. This, of course, is a disadvantage resulting in costly loss of production time.

In U.S. application of Pollock and Smith Ser. No. 628,871, filed simultaneously herewith, there is described a new type of rotating web deflector which spreads a plexifilamentary strand into a web and causes the web to oscillate as it leaves the deflector by means of surface contours. This deflector is capable of oscillating the web through large angles. Consequently the straight-edge target plate is not completely satisfactory. In particular, the use of a straight-edge target plate requires that the strand traverse a much larger portion of the target plate when it is at its maximum point of oscillation.



## Summary of the invention

In accordance with this invention there is provided an apparatus for applying an electrostatic charge to fibrous material moving in a planar path. The apparatus comprises an ion gun and an annular flat disc target electrode. The ion gun is located in proximity to the path and has a multiplicity of needles, each connected to a source of high voltage, disposed across the width of the path and pointed toward the path, the points of the needles being located in a plane generally parallel to the path. On the opposite side of the path from the ion gun the target electrode is positioned so that its face is aligned in a plane generally parallel to the plane of the needle points and extends across the width of the path. The needles of the ion gun are aimed at a portion of the electrode so as to provide a corona discharge zone between that portion of the electrode and the needles. The apparatus further comprises a bearing for supporting the electrode for rotation in a plane generally parallel to the path. The electrode is rotatable so that a clean portion can be rotated into the corona discharge zone during operation.

## Brief description of the drawings

FIGURE 1 is a cross-sectional side view of the apparatus of the invention.

FIGURE 2 is a front view, partly in cross-section, of the apparatus of the invention.

FIGURE 3 is a front view of a U-shaped, multi-needle ion gun suitable for use in the apparatus of this invention.

FIGURE 4 is a side view of a scraper for continuously cleaning a rotating target electrode.

FIGURE 5 is a front view of the scraper of FIGURE 4.

## Preferred embodiments

In the preferred embodiment the target electrode is continuously rotatable and continuously cleaned during operation. The preferred cleaning means is a scraper assembly comprising a scraper blade and means for urging the blade against the face of the electrode as it rotates. The scraper assembly is surrounded by a housing connected to a vacuum line for collecting and removing debris cleaned from the electrode.

The needles of the ion gun are preferably disposed along the arc of a circle which is concentric with the target electrode. The diameter of the circle must, of course, be greater than the inside diameter but less than the outside diameter of the target electrode. Generally the needles will be disposed over approximately a semicircle and will be aimed at the lower portion of the target electrode. The scraper, or other means of cleaning the electrode, will then be located at the upper portion of the electrode.

The apparatus of the invention is especially designed for use in combination with a circular rotatable baffle and means for rotating the baffle. The baffle diameter is slightly less than the inside diameter of the target electrode. The baffle is positioned so that it is concentric with the target electrode and so that the surface of the baffle at its periphery is aligned in the same plane as the surface of the target electrode. The surface of the baffle is contoured to receive a fibrous strand moving in a generally horizontal direction on to deflect the strand into a generally vertical plane downward toward a collecting surface. At the same time the baffle spreads the strand into a flattened web and causes the web to oscillate in a generally vertical plane. As the web is deflected downward, it passes through the corona discharge zone between the ion gun and the target electrode. With the annular target electrode and with the ion gun needles arranged on the arc of a circle, the area of the dis-

charge zone through which the web must pass is equal at all points of oscillation.

FIGURE 1 shows a preferred embodiment of the apparatus of the invention comprising a rotatable strand deflector 1, an annular, flat-surfaced target electrode 2, and a multi-needle ion gun 3. Deflector 1 and target plate 2 are also shown in the front view of the apparatus, FIGURE 2. Location of the needles 4 of ion gun 3 are also indicated in FIGURE 2. Ion gun 3 is shown in FIG. 3.

In FIGURE 1 there is also shown a spinneret nozzle 5 terminating in exit orifice 6. Axis 7 of orifice 6 is parallel to axis 8 of deflector 1. Both axes are horizontal. In operation of this embodiment, a polymer solution under high temperature and pressure is extruded through orifice 6. Immediately upon extrusion, the solvent evaporates and the polymer solidifies, forming what has come to be known as a plexifilamentary strand 9. This strand impinges upon the fillet portion 10 between hub portion 11 and disc portion 12 of deflector 1. The strand 9 approaches the deflector 1 in a direction substantially parallel to the axis 8. Deflector 1 diverts the strand downward through the area 13 between the needles 4 of ion gun 3 and target electrode 2. Expansion of the vaporized solvent against the hub of the rotating deflector causes the strand to be spread into a planar web 14 which increases in width as it passes through area 13, as indicated in FIGURE 2. It is in the area 13 that an electrostatic charge is applied to the fibrous web by corona discharge between needles 4 and target electrode 2. This electrostatic charge prevents the web 14 from collapsing and also aids in collecting and pinning the web on a surface, e.g. an oppositely charged moving belt, located below the spinning unit.

Spinneret nozzle 5 is preferably the horizontal arm of a spinneret pack comprising an L-shaped solution supply tube. The pack is adapted for mounting in the ceiling of a closed spinning cell above an oppositely charged surface. The spinneret pack is further described and claimed in U.S. application of James G. Smith Ser. No. 628,888, filed simultaneously herewith. For further details on the spinneret pack, reference should be made to the Smith application, the entire disclosure of which is hereby incorporated.

Considering FIGURE 2, the preferred deflector 1 is a one piece structure having a hub portion 11 and a flat disc portion 12, the disc portion having a circular trailing edge 15. Hub portion 11 and disc portion 12 are integrally connected by means of a fillet 10 having lobes 16. There should be one or more (preferably 2–4) lobes 16 in the fillet portion 10, the embodiment shown in FIGURES 1 and 2 having three. The presence of lobes 16 in fillet portion 10 cause the web to oscillate from side to side (as viewed in FIGURE 2) as deflector 1 rotates. By proper design of the deflector web oscillation amplitudes as high as about ±55 degrees can be obtained. The preferred deflector design is further described and claimed in U.S. application of Pollock and Smith, Ser. No. 628,871, filed simultaneously herewith. The entire disclosure of said application is hereby incorporated by reference.

As the network 14 leaves the circular trailing edge 15 of the rotating strand deflector 1 it passes directly to the flat surface of the annular electrode 2. This surface should be in substantially the same plane as the top surface of disc portion 12 of deflector 1 or set back slightly therefrom. This permits the fibrous web to cross the circular trailing edge 15 of deflector 1 and over the circular leading edge 17 of target electrode 2 without gathering into clumps. The circles defining the edges (17 and 18) of target electrode 2 are concentric with the circle defining the trailing edge 15 of deflector 1. The web then passes across the surface of the flat target electrode 2. As it approaches the circular trailing edge 18 of target electrode 2 it passes through the corona discharge zone 13 between needles 4 of ion gun 3 and target electrode 2 where an electrostatic charge is placed on the web. The charged web leaves the trailing edge 18 of electrode 2 and is deposited in overlapping, multidirectional layers on a moving, oppositely charged, belt (not shown). It should be noted that in this circular type of target electrode the fibers are carried approximately the same distance across the surface regardless of orientation of the deflector at any particular moment. In older fiber target electrodes, particularly those having a straight trailing edge, the fiber at the end of the oscillation stroke had farther to travel than at the center of stroke and tended to lose momentum and to clump on the surface of the target electrode.

In the embodiment of FIGURES 1 and 2, a rim 19 of epoxy resin or other insulating material is provided on the circular trailing edge 18 of target electrode 2. The purpose of this rim is to avoid secondary ionization at the edge 18. In addition an inlaid ring 20 of epoxy material may be provided to reduce the amount of conducting material surface, thereby reducing the amount of surface to be cleaned and providing a more uniformly concentrated field. The ring 20 is inset to provide a smooth transition of the fiber from the deflector 1 to the conducting portion 21 of the surface of target electrode 2.

As shown in FIGURE 1, deflector 1 is mounted on an extension 22 of shaft 23 of motor 24 to provide for rotation thereof. Motor 24 is mounted on flange 25 which is in turn mounted on plate 26. Plate 26 is welded to housing 27. An O ring seal 28 is provided between flange 25 and plate 26 and seal members 28′ are provided around shaft extension 22 to prevent entry of fluids to motor 24 or to the interior of housing 27.

The support means for annular target electrode 2 includes means for rotating the electrode during spinning so that a fresh surface may be presented as needed to the corona charging area 13. Electrode 2 rotates independently of and much slower than deflector 1. Thus when residues form on the target electrode 2 or when deposited there by electrostatic attraction, a fresh surface may be provided by rotation of the target electrode. The residues are thereby carried out of the charging area 13 and may be removed from the surface of electrode 2 by means which will be discussed hereinafter.

Referring to FIGURE 1, the target plate 2 is rotatably mounted on a tubular shaft 29 which is carried in ball bearings 30 which, in turn, are mounted inside the stationary ring 31. The ring 31 extends outwardly from the housing 27 and is being secured to the plate 26. Inside the housing 27 is a small slow-speed motor 32 which is secured to the plate 26; the motor body and the shaft are sealed in respect to the housing 27 in the same manner as the motor 24; the motor 32 carries a small pinion 33 which meshes with a gear 34 on stationary jackshaft 35. Secured to the gear 34 is a small pinion 36 which meshes with a large gear 37 secured to the rearward end of the tubular shaft 29. From this it will be seen that the motor 32 will drive the target plate 2 at a very low rate, for example at 2 revolutions per minute. To assure electrical grounding of the target plate 2, a carbon brush 38 is urged against the back of the plate 2 by a spring 39 and both are mounted in a hole in the stationary ring 31. A sheet metal guard 40 covers the gear train. Target plate 2 is threadedly engaged in the tubular shaft 29 and consequently may be removed without the necessity for disassembling any other members.

Multi-needle ion gun 3 is situated in proximity to the spinneret orifice 6 and the target plate 2. As shown in FIGURE 3 the ion gun is U-shaped and carries a number of needles 4 provided with a high voltage power supply to promote corona discharge between the needles 4 and the annular target plate 2. The ion gun comprises a tubular conductive sheath 41 with numerous ports 42 along its length. At each end of the tubular material

is a cylindrical sheathed resistor housing **43** made of electroconductive material. The entire structure is supported by support arms **44** which are composed of insulating material and are cemented to the sheath **41**.

The lower portion of the U-shaped sheath **41** is fabricated from aluminum having an oval cross-section as shown in FIGURE 1.

In the lower portion of the sheath **41**, shown in FIGURE 3, spaced from each other with a chordal distance of about 0.965 cm. (or 7°10′ angular spacing), are holes **42′** each occupied by an insulative tubular insert. Extending through the center of each insulative insert is a corona generating needle **4** which is connected to a separate insulated wire conductor. Each wire conductor is connected to a separate resistor located in resistor housing **43**. The needles **4** are adjusted, so that their sharp, conical ends are equidistant from the surface of the target plate **2** being spaced therefrom by about 0.62 inch (1.6 cm.). The ion gun is oriented so that the points are aimed at an imaginary curve (a semi-circle) situated about 1.3 cm. from the edge **18** of the target plate. The entire interior of the sheath **41** is filled with epoxy resin (Armstrong EC–001, R. Hardener) to retain the inserts and for other purposes described further below.

Each wire conductor is insulated along its length from the corona generating point to the resistor. The wires pass upwardly through the legs of the tube **41** into the confines of one of the aluminum resistor housings **43** where each wire is joined to one terminal of its respective resistor, the resistance of these being substantially equal and being in the range of 10 to 1000 megohm. The resistor housing **43**, as shown in FIGURE 1, is provided with a threaded hole **51** to receive a jack for supplying high voltage direct current to the gun. The conductive sheath is electrically connected to the power source and in addition each needle is connected through a resistor to this source.

Considering FIGURE 3, the ion gun is supported and electrically insulated from the remaining parts of the apparatus by insulative support arms **44**, which are in turn attached to the ion gun by an epoxy cement. Nonconductive bolts **46** are used to attach insulated support arms **44**, to insulated rigid supports **45** as shown in FIGURE 1, the support **45** being shown partially cut away. Supports **45** are in turn attached at the opposite ends through insulator **49** to housing **27** by means of bolts **48** shown at the right side of FIGURE 1 and also in FIGURE 2.

In operation the annular target plate is grounded and the distance between the points and the target together with the voltage are adjusted to promote corona discharge, this being readily apparent from a glow in the dark. The voltage betwen the power source at jack hole **51** and the grounded target electrodes is usually between 50 and 150 kilovolts.

The protective tubular shield on the ion gun has a beneficial effect in extending the life of the ion gun. The voltage drop from the bus bar in the resistor housing to the corona generation points is typically only 3 to 5 kilovolts. The voltage drop between the tubular shield and the wires leading to the corona generating points is likewise only 3 to 5 kilovolts.

The flow of solvent gases tends to aspirate additional gases over the tubular portion of the ion gun **3** on the side nearest the spinneret **5**. It is to be noted that the inner surface of the ion gun **3** is conical and generally concentric with the conical surface of the spinneret housing Thus there is smooth flow of the atmospheric gases over the U-shaped ion gun **3** into the flow line provided by the solvent escaping from the orifice **6**. In a similar manner, gas is aspirated along the bottom surface of the target assembly, and is carried toward and past the back surface of the thin outer epoxy-covered edge **19** of the annular target plate **2**. Because of the aerodynamic design, turbulence is minimized and the formation of the low pressure area along the face of the target plate is maximized. This permits the web to ride close to the target electrode surface in a zone of high voltage gradient and maximum charging efficiency.

In general, to minimize resistance to gas flow, the ion gun **3** should have a small frontal area in a plane perpendicular to the axes of the needles **4**.

In fabricating the apparatus of this invention the flat surface of the target electrode **2** should be aligned with the flat surface of the deflector **1** at its trailing edge **15**. However, the deflector **1** may, in an alternate embodiment, have a flat conical surface near its trailing edge **15** provided that the angle between the hub **11** and the disc **12** is between 90 and 120 degrees. When this angle is 90° the surface of the target plate **2** should preferably be planar to provide the best alignment with the deflector. When the angle between the hub **11** and the trailing edge **15** of the deflector **1** is other than 90°, the target electrode **2** should have a flattened conical shape.

It should also be noted at this point that the target electrode **2** may be offset slightly, being slightly below the level of the strand deflector **1**. This permits flow of the web over the deflector **1** onto the target electrode **2** without entanglement or pile up. Generally this offset is between 0.12 and 0.38 mm.

In construction of the annular target plate **2** certain aerodynamic principles should be observed. In particular, the trailing edge **18** of the annular target electrode should be very thin, i.e., less than 5 mm. in thickness, and should permit streamlined flow of gases within the spinning cell over the back side of the trailing edge as well as over the front side. In FIGURE 1 it will be noted that the target electrode has a faired edge (smoothly curved) which permits smooth flow of aspirated vapors along the motor casing to the backside of the annular electrode. Eddy currents at the trailing edge are thereby minimized.

The preferred ion gun for use in the apparatus of this invention is more fully described and claimed in the U.S. application of Rapp Wallace Crook III, Ser. No. 628,983, filed simultaneously herewith.

The bearings for the annular electrode **2** are protected from the corrosive atmosphere by means of O-ring seals which may be made, for example, of neoprene.

In a preferred form of the invention, the annular target plate **2** is continually cleaned at a point outside of the area of electrostatic influence. For example, a scraper as shown in FIGURES 4 and 5 may be used.

Referring to FIGURES 4 and 5, the target plate scraper comprises a sharp edge blade **52**, of tungsten carbide, which is secured to a holder **53** which is pivotally mounted on a shoulder bolt **54**; the latter engages an L-shaped member **55** having a rearward projecting lug which is suspended by a shoulder bolt **56** from an adjusting screw **57**. The screw **57** is supported by a cantilever arm **58** which is secured to plate **26** of the housing **27**. At the end of the cantilever arm **58** is a fixed bracket **59** the lower end of which carries a small spring **60** which urges the blade **52** edge against the face of the target plate **2** by pivoting the L-shaped member **55** about the axis of the shoulder bolt **56**; consequently the blade edge always rests in contiguity with the face of the target plate **2**. The entire scraper assembly is surrounded by a housing **61**, the interior of which collects debris; the housing **61** may be removed periodically for cleaning by removal of thumb screws **62**.

The scraper embodiment shown in FIGURES 4 and 5 may be conveniently modified by connection of a vacuum tube or hose to a port in the collection box **61** so that the collected debris may be removed. A vent may be provided to allow air to sweep through the box into the vacuum line.

In another variation tension for the scraper of FIGURE 4 may be provided by means of pneumatic pressure supplied through a tube to a piston and cylinder which replace tension spring **60**. Tension on the scraper may be

adjusted remotely in this embodiment of the invention without opening the spinning chamber. This is accomplished simply by increasing or decreasing the pneumatic pressure.

While the invention has been illustrated by using separate baffle and target electrode pieces, it is possible that a single piece may serve the same purpose. However, in developing a high-speed laydown process the requirements for oscillation of the baffle and for renewal of the target electrode are different, and it is preferred then to have two separately moving pieces. In a single piece baffle/target the ion gun should be aimed near the edge of the piece which, of course, should be well grounded.

In operation of the invention a solution of about 14% linear polyethylene in trichlorofluoromethane is typically spun from a spinneret at the rate of approximately 16 kg./hour. It is intercepted immediately by a rotating contoured deflector preferably of trilobal design. The rotating deflector turns at the rate of 500 to 2000 revolutions per minute (25 to 100 strand oscillation cycles per second). The deflected stand passes then over the annular target plate. The annular target plate is rotated through the cleaning area with scraper at the rate of about 1 to 10 revolutions per minute. It is important to avoid excessive speed of the target electrode or of the rotating strand deflector since this may create an aerodynamic disturbance, which will upset the theadline. The multiple needles of the ion gun should be aimed at a line upstream of the trailing edge of the target electrode so that the edge of the corona field is upstream of the trailing edge and secondary ionization from the edge is minimized. Obviously, the needles of the ion gun must be arranged in a semi-circle having a radius smaller than that of the trailing edge of the target plate. In order to promote uniform corona discharge from each of the multiple parallel points, the points should be in series with elements of high resistance, for example, in the range of 200 to 600 megohms.

In operation of the charging apparatus, a corona current at each needle from about 5 to about 30 microamps is adequate; between 10 and 20 microamps per needle is preferred for charging a plexifilamentary web. At these low currents of 5 to 30 microamperes per needle and in the absence of the resistors the effect of fluctuations in dynamic resistance between electrodes would be magnified. The ion gun described herein, however, provides a high impedance circuit to each point so that normal fluctuations in the effective dynamic resistance of corona discharge have little effect on emitted current. This is done by using a resistance of sufficient magnitude in series with each point to provide a voltage drop at least about 3,000 volts. In a typical ion gun target configuration the effective dynamic resistance of corona discharge is about 60 megohms, whereas the resistance placed in series with each point to provide a corona current at each point of at least 5 microamps is typically 600 megohms and for 12 to 20 microamps is typically 270 megohms. Use of the resistors makes the needle-to-needle current variations much less sensitive to such factors as point/target spacing.

The position of corona generating points 4 with reference to target plate 2 is important for efficient operation. It will be apparent that the clearance between the needle points 4 and plate 2 should be as small as efficient operation will permit. Generally a clearance of from about 1 cm. to about 2.5 cm. is satisfactory although this will vary with the design and capacity of the particular equipment.

It should be noted that as the distance between the needle points 4 and the target electrode 2 is reduced, the total applied voltage across the resistor and the gap should be reduced to keep the current per point in the 5–30 microampere range. In addition, as the needle point-to-electrode distance is decreased, it is desirable to increase the number of points per inch in order to deposit a uniform charge on all parts of the web. On the other hand, when increasing the distance between the needle points and the target electrode the voltage should be increased and/or the number of points per cm. decreased. For optimum operation, the points should be equally spaced along the tubular shield. It has been found convenient in developing dimensions for the ion gun and target plate to create a carbon black deposit on target plate 2 by spraying powdered carbon black into the operating area between the plate and the gun. An oval pattern is outlined by carbon deposits opposite each needle indicating the area of electrostatic influence of each needle under the particular conditions employed. The patterns laid down by single points are centered approximately the same distance apart as the needles. The shape and size of the oval varies depending on needle-to-target spacing. The arrangement of the ion gun 3 opposite the annular target plate 2 is shown in FIGURES 1 and 2. The rotary deflector 1 is shown at the center. Smooth operation of the equipment with uniform laydown generally occurs when the outside diameter of the target plate is 19 cm. and the diameter of the semi-circular ring of needles 4 in the ion gun is 16.5 cm. Making the circle diameter for the needles smaller can cause pinning or clinging of the web to the target plate. This results in bunching for an instant, an uneven discharge across the web width, and a falling free of the bunched web which contributes to sheet non-uniformity. In addition, use of a small diameter circle as the locus of the needles 4 results in a very abrupt web charge curve, making the process more difficult to control. On the other hand, if the ion gun is aimed too near the outer edge of the target plate, secondary ionization will develop at the edge of the target plate generating ion of opposite polarity which will tend to discharge the web.

While the ion gun and target plate are shown in connection with flash spinning, the combination obviously is useful for a wide variety of purposes, such as for applying a charge to fibers in melt spinning, dry spinning, or in control of fluff or short staple fibers.

By use of the apparatus of the invention continuous spinning operations may be maintained in a closed cell with a much reduced frequency of shut-down. Because of the continuous cleaning or the continuous provisions for new target electrode surface afforded by the present invention, atmospheric conditions within the cell may be controlled more effectively so as to promote more uniform charging. The invention also has an important advantage in that no replaceable fibers, sheets, or discardable materials are used. The use of such materials, although very effective under certain circumstances, still requires interruption of the process from time to time. Changes in the quality of such materials greatly affect the charging efficiency. These problems are largely eliminated by the apparatus of this invention.

The ion gun 3, deflector 1, and target electrode 2 assembly are suspended through upper flat plate 50 welded to housing 27. This assembly may be supported independently of spinneret 5. In the preferred embodiment however spinneret 5 is part of a spinneret pack comprising an L-shaped solution supply tube and the gun-deflector-electrode assembly is supported through structure secured to the vertical arm of the spinneret pack. This arrangement provides a modular unit which facilitates placement in and removal from the ceiling structure of a closed-cell spinning chamber. The gun-deflector-electrode assembly may be rigidly mounted in a fixed position, or it may be mounted through intermediate structure providing for longitudinal, vertical, and/or transverse motion relative to the horizontal axis 7 of spinneret 5. An arrangement of the latter type is described and claimed in U.S. application of James G. Smith, Ser. No. 628,872, filed simultaneously herewith, the disclosure of which is hereby incorporated.

As stated above, the deflected, charged web, as it

leaves the target electrode 2 is deposited, along with similar webs from the other spinneret positions, in overlapping multi-directional layers on an oppositely charged moving belt. A suitable charged frame and belt laydown machine is described in U.S. application of J. E. Owens and S. P. Scheinberg, Ser. No. 628,870, filed simultaneously herewith. The entire disclosure of the Owens and Scheinberg application is also incorporated herein.

We claim:

1. An apparatus for applying an electrostatic charge to fibrous material moving in a planar path, said apparatus comprising:

an ion gun located in proximity to the path and having a multiplicity of needles disposed across the width of the path and pointed toward the path, the points of the needles being located in a plane generally parallel to the planar path;

an annular flat disc target electrode located on the opposite side of the path, extending across the width of the path, aligned in a plane parallel to the plane of the needle points, and positioned so that the needles of the ion gun are aimed at a portion of the electrode, whereby there is provided a corona discharge zone between that portion of the electrode and the needles when a direct current source of high voltage is applied to the needles;

a bearing for supporting the electrode for rotation in a plane generally parallel to the path whereby a clean portion of the electrode can be rotated into the corona discharge zone.

2. An apparatus as defined in claim 1 which comprises, in addition, means located outside the corona discharge zone for cleaning the face of the electrode.

3. An apparatus as defined in claim 2 which comprises, in addition, means for collecting and removing debris cleaned from the electrode.

4. An apparatus as defined in claim 2 including means for continuously rotating the electrode.

5. An apparatus as defined in claim 2 wherein the means for cleaning the electrode is a scraper assembly comprising a scraper blade and means for urging the blade against the face of the electrode as it rotates.

6. An apparatus as defined in claim 5 wherein a remotely operated pneumatic system urges the blade against the face of the electrode.

7. An apparatus as defined in claim 3 wherein the means for collecting and removing the debris comprises a housing around the scraper assembly and a vacuum line connected to the housing.

8. An apparatus as defined in claim 4 wherein the means for rotating the target electrode comprises a ring gear concentric with the target electrode and connected to and extending from the rear side of the target electrode, a pinion positioned to mesh with the ring gear and mounted on a shaft, and means for rotating the shaft.

9. An apparatus as defined in claim 8 wherein the target electrode threadedly engages a concentric tubular shaft extending from the rear side of the target electrode, the tubular shaft being integral with the ring gear.

10. An apparatus as defined in claim 1 wherein the needles of the ion gun are disposed along an arc of a circle, the circle being concentric with the target electrode and having a diameter greater than the inside diameter and less than the outside diameter of the target electrode.

11. An apparatus as defined in claim 10 wherein the arc is an approximate semi-circle, the needles are aimed at the lower portion of the target electrode, and the means for cleaning the electrode is located at the upper portion of the electrode.

12. An apparatus as defined in claim 11 wherein the means for cleaning the electrode is a scraper assembly comprising a scraper blade and means for urging the blade against the face of the electrode as it rotates.

13. An apparatus as defined in claim 10 which includes a separate circular, rotatable baffle and means for rotating the baffle, the baffle having a diameter slightly less than the inside diameter of the target electrode, the baffle being concentric with the target electrode, the surface of the baffle at its periphery being aligned in the same plane as the surface of the target electrode, and the surface of the baffle being contoured to receive a fibrous strand moving in a generally horizontal direction and deflect it into a generally vertical plane downward toward a collecting surface, while simultaneously causing it to oscillate in the generally vertical plane.

14. An apparatus as defined in claim 1 wherein a rim of insulating material is provided on the outer edge of the annular disc electrode.

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JOHN F. COUCH, Primary Examiner

D. HARNISH, Assistant Examiner

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