

Jan. 20, 1970

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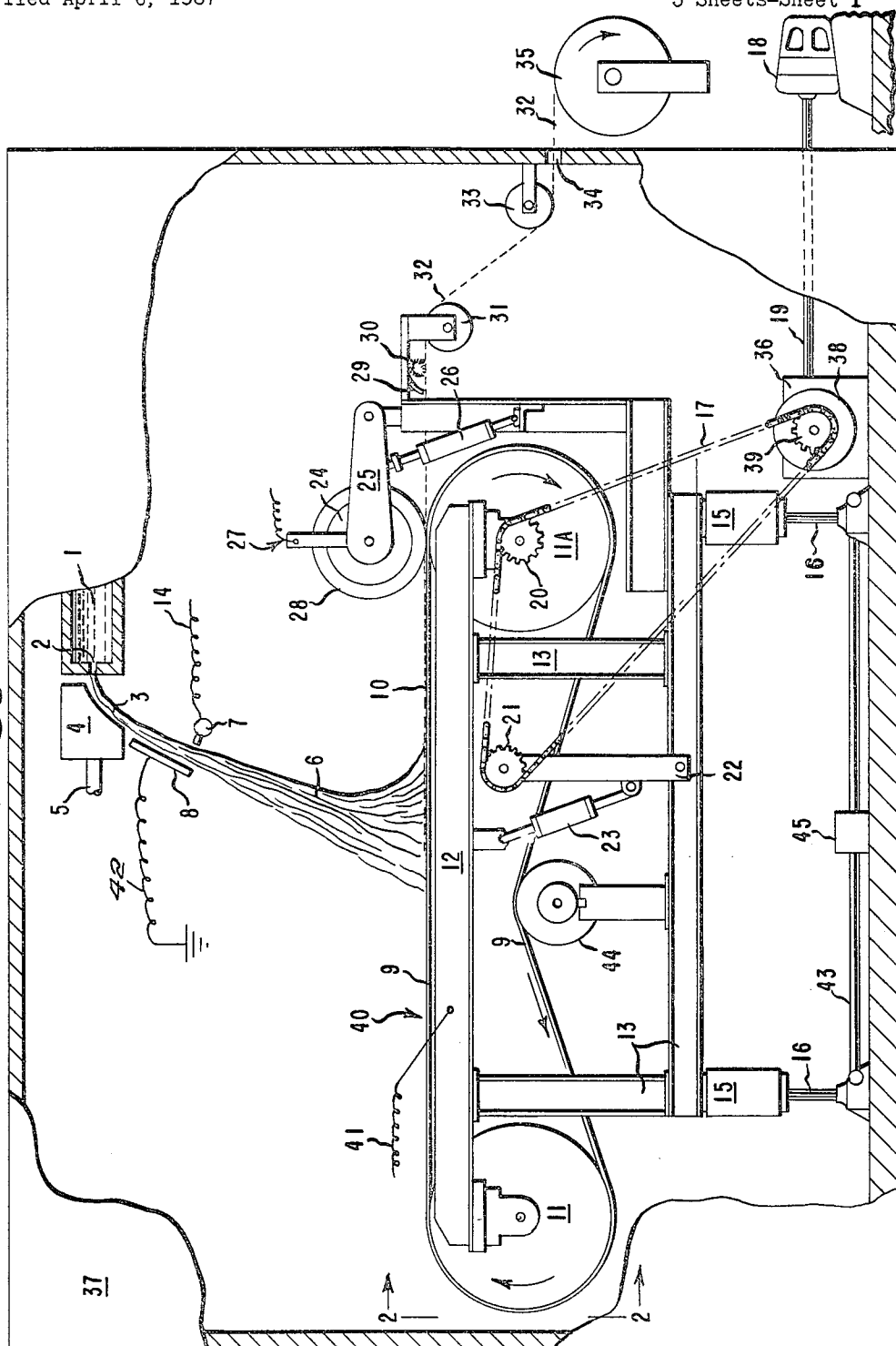
3,490,115

APPARATUS FOR COLLECTING CHARGED FIBROUS MATERIAL IN SHEET FORM

Filed April 6, 1967

3 Sheets-Sheet 1

FIG. 1



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FIG. 2

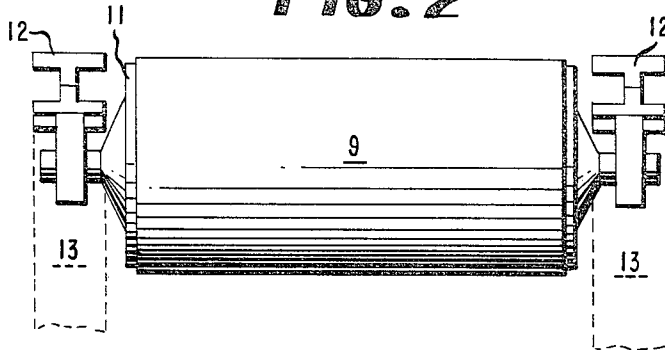


FIG. 3

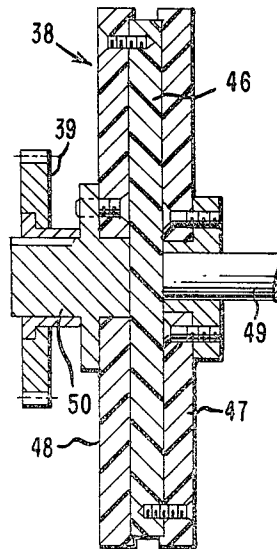


FIG. 7

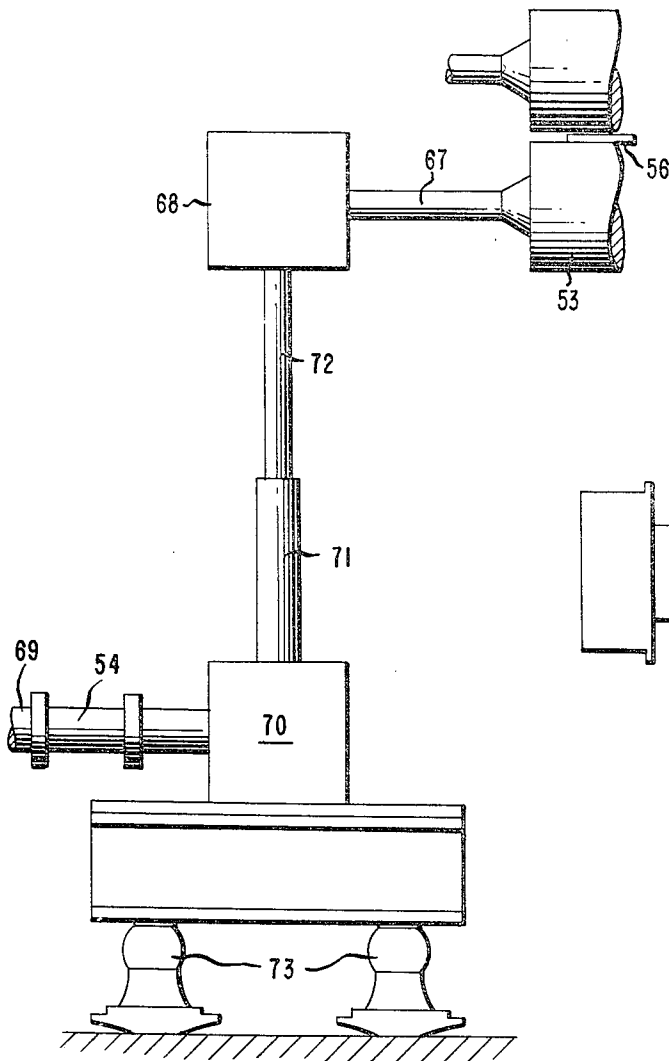
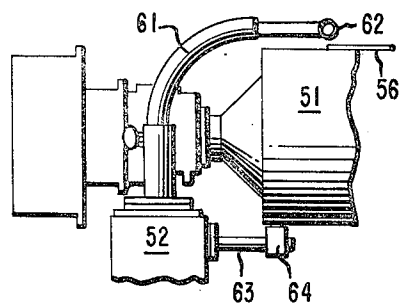


FIG. 6



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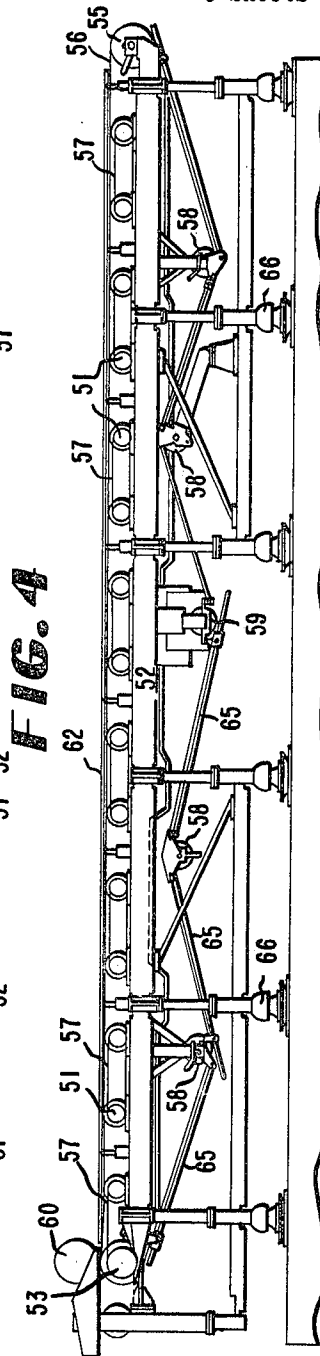
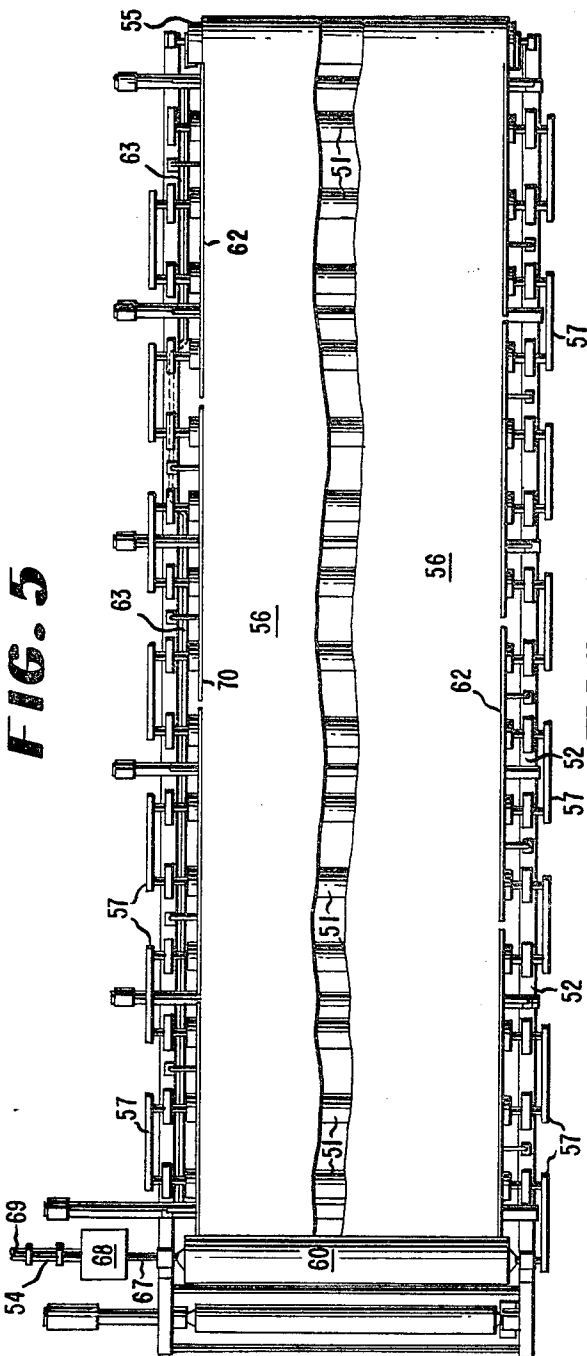
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APPARATUS FOR COLLECTING CHARGED FIBROUS MATERIAL IN SHEET FORM

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4 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus for forming a nonwoven sheet from filamentary material, having a depositing electrode and a collecting electrode. Both of said electrodes have a voltage different from that of ground. A conductive endless belt is trained to run about rolls mounted in a conductive frame. The belt, rolls, and frame are electrostatically charged. The frame is supported on insulators which are in turn supported on jacks for adjusting the height of the frame, rolls and belt. A motor is positioned to drive one roll through an insulated coupling. The frame includes corona shielding structure for deterring loss of charge from points or edges.

BACKGROUND OF THE INVENTION

This invention relates to a web laydown device for collecting spun and electrostatically charged filamentary material as a nonwoven fibrous sheet.

Various electrostatic devices and procedures employing such are known for control of fiber deposition in the preparation of a fibrous web or sheet. For example, the collection of flash-spun sheets from plexifilaments is described in Steuber U.S. 3,169,899. In one embodiment of the Steuber procedure several spinnerets are used simultaneously to produce strands of proximity to one another. Each of the strands as it forms at the spinneret is intercepted by an oscillating baffle and is thereby spread and directed downwardly onto a moving belt to form a sheet. The distribution of fibers within a small section of the sheet can be adjusted by changing the slope and frequency of oscillation of the baffles.

The present invention provides an improvement whereby the dispersion of fibers and uniformity of the sheet can be adjusted by raising or lowering the level of the collecting belt relative to the oscillating baffles. In conjunction with this feature of belt adjustability, certain additional features are also provided to avoid changes in the distribution of electrostatic charges in the collecting chamber to thereby obtain a uniform laydown of fibers on the moving belt. For example, without these additional features, the raising or lowering of the belt would tend to change the relative positioning of the thin edges of the belt with respect to grounded articles nearby. This, in turn, could cause excessive corona discharge from the belt edges and instability in the electrostatic supply which provides the high potential field necessary for proper guidance and pinning of webs to the belt.

SUMMARY OF THE INVENTION

This invention is an apparatus for forming a nonwoven sheet from filamentary material. The apparatus has a depositing electrode and a collecting electrode, both of which have a voltage different from that of ground. It comprises

- (a) A conductive frame,
- (b) At least two spaced-apart parallel conductive rolls mounted for rotation on said frame,
- (c) A conductive endless belt trained to run about

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said rolls and providing a horizontal surface for receiving said charged filamentary material thereon,

(d) Corona shielding structuring for deterring loss of charge from points or edges,

(e) Charging means for applying to said frame, belt and corona shielding structure a high voltage electrostatic charge opposite to that of the charged filamentary material,

(f) Electrical insulators supporting the weight of said frame and associated structure,

(g) Jack means supporting said insulators for raising or lowering said frame and associated structure to vary the spacing between said belt and said spinneret,

(h) A motor mounted in a fixed position remote from said frame structure, and

(i) Structure defining an electrically insulated drive connection between said motor and one of said rolls, said structure including means of operatively adjusting the connection upon raising or lowering of said frame upon said jack means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a schematic elevation view showing one embodiment of the apparatus of the invention in a closed spinning cell, the sides of the cell being cut away to show the machine within the cell.

FIGURE 2 is a schematic end view of the charged frame apparatus taken along the line 2—2 of FIGURE 1.

FIGURE 3 is a section view showing details of the insulated coupling in the drive mechanism for the apparatus of FIGS. 1 and 2.

FIGURE 4 is a schematic elevation view of an alternate embodiment of the apparatus of the invention showing the frame, rolls, belt, insulators, and corona guards arrangement.

FIGURE 5 is a schematic plan view of the apparatus of FIGURE 4.

FIGURE 6 is a schematic view of the mounting arrangement for the corona shielding structure for the top edge of the belt.

FIGURE 7 is a schematic elevation view of the drive mechanism for the apparatus of FIGS. 4 and 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Considering the embodiment of FIGURE 1 in detail, the apparatus of the invention when used for flash spinning is advantageously enclosed in a chamber. FIGURE 1 shows the walls 37 of the chamber cut away. The enclosure permits recovery of substantially 100% spinning solvent and also provides better electrostatic control by isolating the system from atmospheric changes in temperature or humidity. While FIGURE 1 shows the apparatus as it is used for flash spinning, it will be understood that the device can also be used for laydown of fibers produced by other methods. In FIGURE 1 a solution 1 is provided through a spinneret orifice 2. In flash spinning the solution is provided at a temperature far above the boiling point of the solvent and at a pressure usually near the critical pressure of the solvent. As the solution passes into the spinning cell which is at substantially atmospheric pressure, the solvent evaporates instantly and forms a plexifilamentary strand 3. The strand meets curved baffle or other web deflector 4 which directs it towards the collecting apparatus in the form of a much wider network 6. Oscillation of the baffle is afforded through baffle support 5. This oscillation causes the web 6 to deposit at various points across the width of the collecting device 40. Usually, several spinning units are provided and the networks from each of these are dispersed and deposited in overlapping multidirectional layers on the collecting machine.

During spinning the plexifilamentary strand 3 is carried forward by means of the expanding solvent gas along the curved surface of baffle 4 and across target plate 8 which is electrically grounded. The solvent gas during operation fills spinning cell 37 and may be recovered.

Direct current is provided to ion gun 7 by means of a high voltage source connected to cable 14. The voltage required must be high enough to promote ionization of the gas between the ion gun needle points and the target plate, thus creating a corona current flow from the ion gun to the target plate sufficiently high to deposit a high charge upon the moving web 6. The voltage applied is dependent upon the ion gun-to-target plate distance, the quantity of web flowing across the target plate in pounds/hour/inch of active charging width, and the dielectric strength of the atmosphere within the spinning chamber. For example, in a 95 to 100% trichlorofluoromethane atmosphere with an ion gun point-to-target plate distance of $\frac{3}{4}$ inch for a 35-lb./hr. flow of polyethylene web spread over an approximately 8-inch wide charging zone, an ion gun potential of 45 to 70 kv. is required to provide a corona current flow from the ion gun to the target plate of 8 to 17 microamperes per charging point. This will deposit an electrostatic charge of 6 to 9 microcoulombs per gram of web when the center-to-center distance between ion gun points is $\frac{3}{8}$ ".

The expanding plexifilamentary web 6 carrying an electrostatic charge passes continuously then to a conducting belt 9 which is charged oppositely. The fibrous network is deposited in a multi-directional overlapping arrangement to form a sheet 10. The belt 9 is a metallic mesh such as a Fourdrinier machine belt used in papermaking. The wire belt is supported by idler roll 11 and drive roll 11A and these in turn are supported by journals in upper frame-work 12. The rolls are charged to the same potential as the entire framework. Both the rolls and the framework are free from sharp edges or points which would otherwise act as points of voltage stress concentration and cause corona discharge to nearby grounded objects.

A meter relay (not shown) may be used to measure target plate current to ground in conductor 42 and to control the voltage applied to ion gun 7.

The entire collecting device is supported on insulators 15 which are mounted on hydraulic jacks 16. The latter permit the entire framework to be raised or lowered as needed for control of web laydown. The hydraulic jacks are controlled by pumping oil through pipe lines 43 from pump and equalizer 45. The entire framework above the insulators is charged to between 50 and 150 kilovolts D.C. potential by means of a high voltage source connected to cable 41, and is insulated from ground potential by means of the insulators 15. These must be strong enough to hold the entire weight of the machine and must be made of a material which will be inert to the solvent atmosphere. When the solvent is trichlorofluoromethane, these insulators are advantageously made of "Delrin" polyoxymethylene or ceramic material. The jacks 16 for reasons of safety are remotely controlled. They may be hydraulic jacks, pneumatic pistons, mechanical linkages such as worm-screw drives or other suitable mechanisms.

An important consideration in the design of the machine is the structural arrangement and location of the upper framework 12 which in this embodiment acts as a corona shield. Because of the proximity of the equipment supporting the spinneret, baffle, and web charging device, the upper framework must be in the near proximity to, parallel to, and in the same plane as, or slightly above, the conducting belt 9. This is shown more clearly in FIGURE 2. The purpose of this arrangement is to avoid corona discharge from the sharp edges of the conducting belt to nearby grounded equipment. Corona discharge from the lower edge of the belt may be effectively

prevented by large masses of equally charged machinery adjacent to the belt edges and mounted on the charged machine frame. The exact nature of the structure can vary quite widely depending upon the type of frame employed. Discharge is prevented at the rolls 11 and 11A, because of the massive nature of the drive rolls and the nearby frame-work.

Tracking of the collecting belt 9 (FIGURE 1) may be controlled by moving one end of roll 44 backward or forward in the direction of belt travel by means not shown. The collected web 10 is carried under roll 24 which is covered with a non-conductive material 28 (such as a hexafluoropropylene and vinylidene fluoride copolymer). An auxiliary charging device 27 may be optionally provided to deposit a charge on the non-conductive roll covering 28, which is the same polarity as the charge on sheet 10. In one embodiment of this invention the pressure for consolidating the sheet is adjusted by means of piston 26 operating on pivotally mounted lever arm 25.

Drive motor 18 located outside the cell is connected through shaft 19 to a standard right angle gear mechanism 36. The terminal end of the shaft from the gear mechanism 36 is connected through insulated coupling 38 to sprocket 39. The coupling and sprocket assembly is shown in detail in FIG. 3. Chain 17, which is corona shielded by means not shown, passes around sprockets 39 and 20, then passes to idler sprocket 21 mounted on arm 22, which is in turn connected to piston 23. The latter arrangement holds the chain drive 17 snugly against sprockets 39 and 20 over a large range of belt heights. It will be apparent that this drive mechanism may take many other forms.

After consolidation, the sheet passes under an induction neutralizing device 30 which neutralizes any residual charge on the sheet, thus preventing spark discharge at the surface of the sheet. Such discharge could physically damage the sheet by burning it or by initiating free radical sites for future oxidative degradation. This neutralizing device is shielded by means of a curved metal plate 29 between the neutralizer 30 and roll 24. This plate prevents neutralization of charges on the roll cover 28 by the neutralizer 30. In the embodiment shown the induction neutralizer is merely a wire brush extending across the width of the sheet. Both the neutralizer and the curved metal shield are connected to and charged to the same potential as the machine frame. In this embodiment of the invention, compacted sheet 32 passes over idler rolls 31 and 33 and out through slit 34 in the end of the cell. The compacted sheet 32 may then undergo further treatment outside the cell or may be wound on roll 35.

FIGURE 3 shows in detail the insulated coupling and sprocket assembly. Shaft 49 from gear mechanism 36 (shown in FIG. 1) terminates in coupling 38 composed of solid disc 46 and annular discs 47 and 48. Discs 46, 47 and 48 are all made of a suitable non-conductive material such as polyoxymethylene. Sprocket 39 fits on a shaft extension which is attached to the opposite side of the couplings 38.

In the operation of the device of FIGURES 1 to 3, the arc swept by fibrous web 6 is determined by the angle slope and frequency of oscillation of baffle 4. In one form of the invention there are several such spinnerets and baffles. The overlap of webs may be controlled to obtain a uniform weight distribution across the sheet. Raising the laydown frame and belt serves to narrow the swath width and reduce overlapping of the separate webs and gives greater web control and improved small scale random uniformity. Lowering the frame and belt has an opposite effect, i.e. improves the cross-direction or profile uniformity at the expense of the small scale uniformity. The adjustable height of the laydown table, therefore, provides a means for achieving the best balance between profile (cross-directional uniformity) and small-scale random uniformity. Minor changes in the weight per

square yard may also be made by raising or lowering the frame and belt. With lower positioning of the frame and belt, a web of lower weight per square yard is obtained over a larger area. On the other hand, raising the collecting device causes webs of higher weight per square yard to be prepared. Obviously, the width of the sheet varies under the two circumstances. However, ordinarily the outside edges of the sheet are removed by trimming so that no significant problem is encountered.

In an alternate embodiment of the invention, as shown in FIGURES 4, 5, 6 and 7 the upper frame is not in sufficiently close proximity to the edges of the belt and a separate corona shield is therefore added. Likewise, the edges of the belt in the lower portion of its loop are also shielded since they, too, may be close to nearby grounded objects. In this embodiment the shields are round or tubular bars mounted upon an extension of the frame.

Referring to FIGURES 4, 5, 6 and 7 in detail, a large number of secondary drive rolls 51 are supported by the upper portion of frame 52. A main drive roll 53, also supported on the frame, is located at the wind-up end of the machine and is connected through an insulating coupling 54 to a drive motor, not shown. At the opposite end of the machine is a non-driven, rotatably mounted roll 55. Conductive belt 56, shown in FIGURE 4, is carried along the top of secondary drive rolls 51. Motor power transmitted to main drive roll 53 is transmitted to each of the smaller drive rolls 51 through belts 57 between successive pairs of rolls. These are located alternately on first one side and then the other side of the machine as shown in FIGURE 5. It is important that the belts 57 be constructed either of non-conductive materials or that they be properly shielded to avoid corona discharge from conductive points.

The collecting belt loop 56 in its upper horizontal level is carried toward roll 53 and then returns in its lower level over a series of idler rolls 58 to the feed end of the machine. An alignment adjusting roll 59 provides proper tracking of the belt to keep it centered. This roll is guided by automatic equipment of the well known type which moves one end of the roll axis in response to sensors along the edges of belt 56. In FIGURE 5 a center portion of belt 56 is shown cut away along its entire length to afford better visibility. At the wind-up end of the machine, the belt passes under consolidation roll 60 which compresses the fibrous sheet to form a coherent structure for wind-up by means not shown.

The entire machine is charged to a potential of 50 to 150 kv. by means not shown and is insulated from ground potential by support insulators 66. The insulators are supported upon jacks, not shown, for adjusting the height of the machine. For flash-spinning, the machine is suitably located within a closed cell to permit solvent recovery. Use of a solvent such as trichlorofluoromethane having a high dielectric strength permits charging the machine to a higher voltage than would be practical in an air atmosphere, since the solvent atmosphere has a higher dielectric strength than air. The spinnerets, baffles, and target plates, not shown, are located within the cell and above the machine in a manner similar to that depicted in FIG. 1.

Referring to FIGS. 5 and 7, the drive mechanism comprises a shaft 67 connecting drive roll 53 and gear mechanism 68. A fixed motor not shown drives shaft 69. A portion of shaft 69 is made up of a non-conductive material such as "Delrin" polyoxymethylene to provide an insulating coupling 54. Power is transmitted from shaft 69 through gear mechanism 70 to shaft 71, thence to shaft 72. Shaft 72 slides vertically inside shaft 71 to allow raising and lowering the machine but is provided with a spline (not shown) to provide a positive drive mechanism at any height. The drive mechanism is supported upon insulators 73 which are in turn supported by a floor or other fixed support. Shafts 67, 72 and 71 and

gear mechanisms 68 and 70 are thus charged to the same potential as the frame.

It will be apparent that other types of drive mechanism can be used. A flexible drive belt may be used as illustrated in FIG. 1; however, this should preferably be non-conductive or should be shielded to prevent corona discharge from sharp points or edges.

Corona shielding for the apparatus of FIGURES 4 and 5 is provided by means of conductive tubing having a diameter of about 1 1/4 inches. This shielding is particularly needed with this embodiment of the invention since the upper framework 52 is not close enough to the thin edge of the belt to prevent corona discharge to nearby grounded objects such as the spinning and baffle equipment above the belt. The upper belt edge shielding structure is provided in alignment with the belt edges. This structure is supported by standards 61 which are firmly connected electrically to the framework of the machine 52 as shown in FIGURE 6. As may be seen from FIGURE 6, belt 56 is adequately shielded without the special structure as it passes immediately over a drive roll 51, but will be inadequately shielded between roll 51 and the next unless shielding is provided. For this reason the corona shield 62 becomes necessary. In FIGURE 6 a conductor 63 and brush 64 are also shown. This is an optional feature which is needed on massive machinery of high voltage when rollers are supported on bearings where oils or other insulating materials are present which would otherwise prevent adequate equalization of potential from one edge of the machine to the other. A connective portion of this conductor 63 is shown also in FIGURE 5 running the complete length of the machine.

Considering now FIGURE 4, shielding may also be provided along the return path of belt 56 as indicated by similar tubing 65. An alternate way of shielding this portion of the equipment is to provide a massive vertically standing plate which is electrically connected to the framework parallel to the edge of the machine.

It will be apparent that a variety of structural arrangements will provide adequate shielding. In simplest form, the shielding is provided by the framework itself, as in FIGS. 1 and 2, or by conductive tubing electrically attached to the framework, as in FIGS. 4-6. Alternatively, the shielding may be separate from the framework, in which case it must be charged by other means to the same potential as the framework. In any case the shielding means must be positioned to prevent corona discharge regardless of belt height. Massive current losses due to corona discharge place a large drain on the electrostatic power supply which provides the high DC potential to the belt and frame, causing it to become too low for adequate pinning of the fiber to the belt. In addition the power supply may become unstable and provide a fluctuating potential to the laydown belt. In this case fibers will not be attracted uniformly at all points in time and they will tend to lift from the surface of the belt or to be attracted non-uniformly to it.

Corona shielding can also be provided around the drive mechanism as needed.

We claim:

1. An apparatus for forming a nonwoven sheet from filamentary material, having a depositing electrode and a collecting electrode, both of said electrodes having a voltage different from that of ground, said apparatus further comprising

- (a) a conductive frame,
- (b) at least two spaced-apart parallel conductive rolls mounted for rotation on said frame,
- (c) a conductive endless belt trained to run about said rolls and providing a substantially horizontal surface for receiving said charged filamentary material thereon,
- (d) a corona shielding structure separate from said frame and comprising elongate means substantially

- parallel to the edges of said belt and spaced therefrom,
- (e) charging means for applying to said frame, belt and corona shielding structure a high voltage electrostatic charge opposite to that of the charged filamentary material,
- (f) electrical insulators supporting the weight of said frame and associated structure,
- (g) jack means supporting said insulators for raising or lowering said frame and associated structure to vary the spacing between said belt and said spinneret,
- (h) a motor mounted in a fixed position remote from said frame structure, and
- (i) structure defining an electrically insulated drive connection between said motor and one of said rolls, said structure including means of operatively adjusting connection upon raising or lowering of said frame upon said jack means.
2. Apparatus of claim 1 wherein the shielding structure comprises conductive round bars or tubing in alignment with belt edges and in near proximity to the belt.

3. Apparatus of claim 1 wherein the shielding structure is electrically connected to the charged frame to promote equal electric potential between the shield and frame.

4. Apparatus of claim 1 wherein conductive brushes are provided between the rolls and the frame to promote equal electric potential across the width of the rolls.

References Cited

UNITED STATES PATENTS

2,466,906 4/1949 Miller 156—380 XR
2,538,972 1/1951 Magnani.

FOREIGN PATENTS

631,925 11/1961 Canada.

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U.S. Cl. X.R.

19—155; 117—17, 93.4; 118—621; 156—62.2, 380; 264—24