Dec. 2, 1969 J. E. OWENS ET AL 3,481,005

MACHINE FOR FORMING NONWOVEN WEBS

Filed Nov. 21, 1967 2 Sheets-Sheet 1.

Fig. 1.

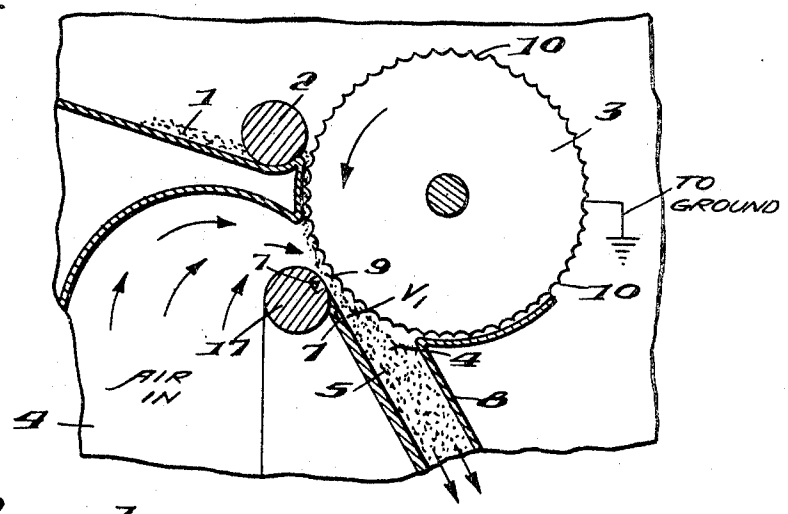


Fig. 2.

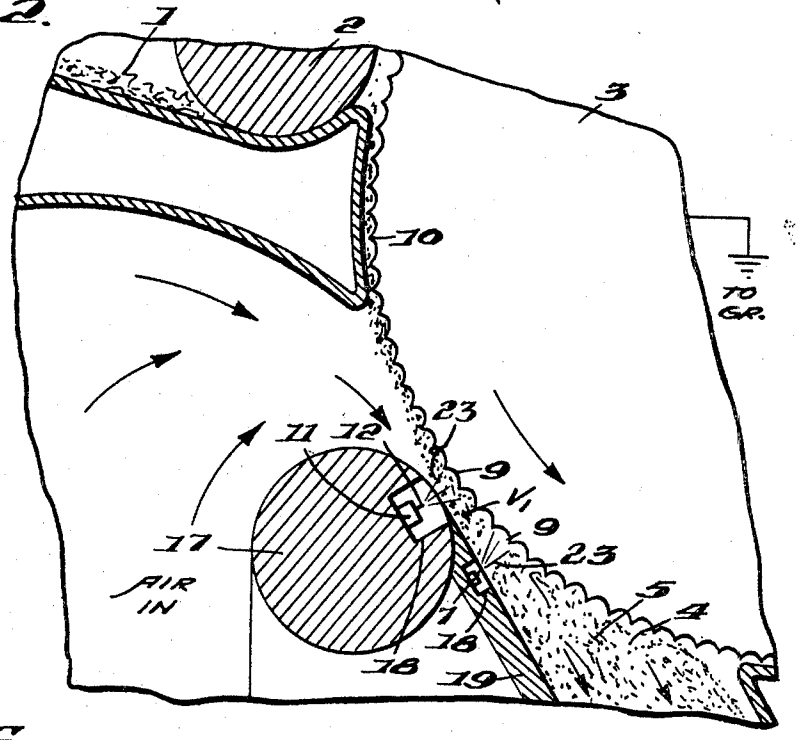
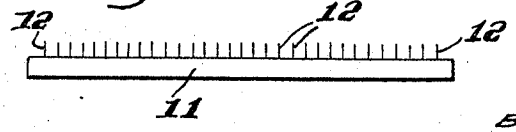


Fig. 5



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Fig. 3.

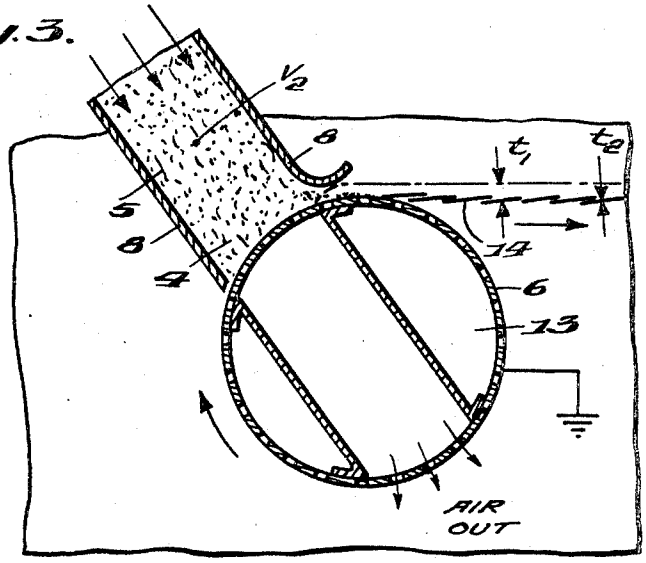
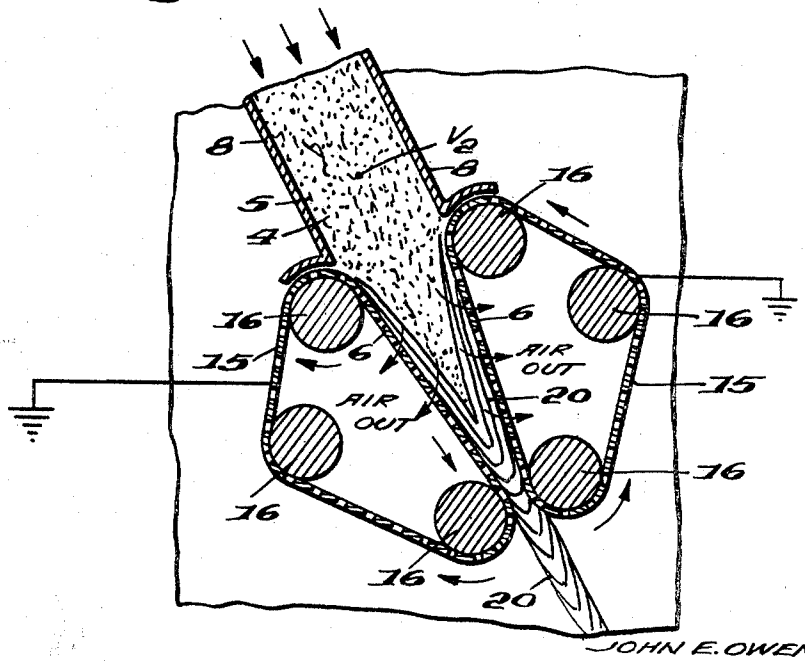


Fig. 4.



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3,481,005

MACHINE FOR FORMING NONWOVEN WEBS

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U.S. Cl. 19—156.4 6 Claims

ABSTRACT OF THE DISCLOSURE

A machine is disclosed for forming random fiber webs comprising: (1) a disperser roll; (2) a feed device for feeding fibers to the disperser roll; (3) a foraminous condenser roll; (4) a duct extending from the disperser roll to the condenser roll, the duct containing an air stream; and (5) a corona discharge system for imparting a uniform electrical charge to the fibers after they have been randomly dispersed into the air stream by the disperser roll.

BACKGROUND OF THE INVENTION

Field

This invention relates to an improved random fiber nonwoven web forming machine.

Description of the prior art

The principle of forming random nonwoven webs by dispersing loose textile fibers into an air stream and subsequently condensing the fibers onto a foraminous surface to form a batt is well known. There are several commercial machines employing this principle, some of which are described by F. M. Buresh at page 13–21 of Nonwoven Fabrics, Reinhold Publishing Corp., 1962. Of the commercial machines, the most common is sold by the Curlator Corporation under the name Rando-Webber. Rando-Webbers are described in the patent literature in the following patents: U.S. 2,451,915, issued Oct. 19, 1948; U.S. 2,700,188, issued Jan. 25, 1955; U.S. 2,703,441, issued Mar. 8, 1955; U.S. 2,744,294, issued May 8, 1956; and U.S. 2,890,497, issued June 16, 1959.

A problem with the presently known machines has been to maintain a random distribution of the fibers in the air stream before the fibers are condensed. This problem is particularly aggravated when the fibers pick up nonuniform static electrical charges from triboelectric or other effects. This problem usually manifests itself in the condensing zone, where the air velocity is lower than it is in the dispersing zone. As the air speed is lowered to permit the fibers to condense, tufting of the fibers occurs which seriously detracts from web uniformness and quality. Unless the fibers can be maintained in random distribution, capacity of the machines is severely lowered. In the past, this fiber distribution problem in the air stream has been a limiting factor upon capacity.

SUMMARY OF THE INVENTION

According to this invention, there is provided a machine for forming random fiber webs by dispersing the fibers in a gaseous medium and subsequently condensing the fibers onto a foraminous surface. This machine comprises, in combination:

(a) means for dispersing the fibers in the gaseous medium;
(b) means for supplying the gaseous medium;
(c) means for feeding the fibers to the dispersing means;
(d) means for condensing the fibers from the gaseous medium;

(e) a duct connecting the dispersing means to the condensing means, the duct containing the gaseous medium; and
(f) a corona discharge system located at a point beyond where the fibers are dispersed in the gaseous medium.

The corona discharge system comprises, in combination: (1) an ion emitting electrode; (2) a target electrode oppositely positioned across the path of the fibers in the gaseous medium, the target electrode being connected to ground; (3) a source of electrical current and voltage; and (4) means connecting the ion emitting electrode to the source of electrical current and voltage.

A process is also provided for forming a random fiber nonwoven web. This process comprises:

(a) feeding fibers to a dispersing zone;
(b) dispersing said fibers into a gaseous medium at the dispersing zone;
(c) imparting a uniform electrical charge to said dispersed fibers in the gaseous medium;
(d) conveying said dispersed fibers in the gaseous medium to a condensing zone; and
(e) condensing said dispersed fibers from the gaseous medium onto a foraminous surface in the condensing zone.

An advantage of the machine and process of this invention is that an improvement in maintaining the random distribution of dispersed fibers in the gaseous medium is realized due to the uniform electrical charge on the fibers. Another advantage is that the fibers are maintained in an open position, i.e.—they are not doubled over, during conveyance from the dispersing zone to the condensing zone. These advantages permit nonwoven web forming machines to be run at higher capacities while producing webs of a uniformness and quality which is comparable to those formed at lower capacities by prior art machines.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a cross-sectional view of fiber dispersing-fiber charging apparatus.

FIGURE 2 is a blown up cross-sectional view of the fiber dispersing-fiber charging system shown in FIGURE 1 which illustrates the corona discharge system in greater detail.

FIGURE 3 is a cross-sectional view of single condenser apparatus.

FIGURE 4 is a cross-sectional view of a dual condenser apparatus.

FIGURE 5 is a front view of one of the corona discharge electrodes shown in FIGURE 2.

DESCRIPTION OF THE INVENTION

The elements of an ordinary, commercial air laydown nonwoven web forming system are shown in the figures. FIG. 1 illustrates a feed fiber stock **1** which can be of many forms, i.e.—opened, raw, carded, loose, in batt form, etc., and which is fed through a feeding system of feeding device **2** which can vary in form, shape and size, to a disperser or lickerin roll **3**, which revolves at high speeds and breaks away small fiber groups from the feed to throw them into a gaseous medium **4**. The disperser roll **3** is normally covered with card clothing, usually of the garnett type and generally has protruding teeth **10**. Finally, the gaseous medium **4** which is commonly an air stream, carries the dispersed fibers **5** through a duct **8** to a condensation zone (illustrated in FIGURES 3 and 4) where the fibers are condensed onto a foraminous or perforated, vacuum backed moving surface **6**.

In addition to having the elements of prior nonwoven web forming machines, the machines of this invention

have a corona discharge system located at a point in the apparatus after the fibers have been distributed by the disperser roll **3**. The corona discharge system is made up of: (1) an ion emitting electrode **7** commonly having one or more needle points **12**, the ion emitting electrode being connected to a source of electrical current and voltage; and (2) a target electrode **9** which is connected to ground. As has been pointed out, imparting a uniform charge onto the fibers as they pass through the ion flow created by the corona discharge system helps to maintain good fiber distribution in the gaseous medium and consequently reduces the tendency of fibers to form tufts before and during the time they are condensed.

FIGURE 2 is a blown up view of the corona discharge system shown in FIGURE 1. In this view, it can be seen that the ion emitting electrode **7** is made up of a conductive base **11** and one or more conductive needle-shaped points **12**. These needle points allow a sufficient build up of current density at the needle tips to cause a corona discharge to occur thereby setting up a flow of ions **23** from the ion emitting electrode **7** to the grounded target electrode **9**.

The duct **8**, which carries the charged fibers **5** from the dispersing roll **3** to the condensation zone, normally is expanded toward the condenser end, thus creating a venturi effect within the duct. Because of this, the gaseous medium **4** has a higher velocity, V_1, near the point at which the fibers are dispersed or venturi throat than the gas velocity, V_2, near the condenser apparatus. The lower velocity V_2 facilitates the condensation of fibers from the gaseous medium **4**.

FIGURE 3 illustrates a single condenser apparatus which comprises the duct **8** which conveys the charged fibers **5** dispersed in a gaseous medium **4** to a foraminous condenser roll **13**. The gaseous medium **4** may pass through the foraminous roll and is either recirculated through the system or expelled. Nonwoven web material **14** is collected from the condenser roll **13**, which is grounded to remove the charge from the fibers.

A desirable secondary effect obtained by uniformly charging the fibers can be observed in the web material collected from the condenser roll **13**. When the corona discharge system is not in use, the collected web material **14** is thicker and more non-uniform at its surface than with an operating corona system. In FIGURE 3, web material produced without the use of corona discharge has a thickness t_1. In contrast, the charged fibers form a much thinner web due to electrostatic pinning and a more uniform web illustrated in FIGURE 3 as having a thickness t_2.

FIGURE 4 illustrates another possible embodiment of a condenser system. A dual condenser system is shown comprised of two foraminous grounded belts **15** driven by a series of drive rolls **16**. The belts are angled so that the condensed fibers are conveyed in a converging pattern thereby forming chevrons **20** from the fibers. A desirable secondary effect of uniformly charging the fibers is evidenced in a dual condenser apparatus by the length of the chevrons **20**, which are formed from the fibers converging from the sides at an angle to form a V shape. When the corona discharge system is not used, the chevrons **20** are much shorter than when the corona discharge system is turned on due to the electrostatic pinning effect. In general, longer chevrons in a dual condenser system such as that illustrated in FIGURE 4 mean the nonwoven web produced will be stronger than a web produced where the chevrons are shorter. The web produced with charging is also more uniform.

The increased strength and uniformity of webs produced according to this invention can be explained in terms of three effects produced by uniformly charging the fibers. First, the good initial distribution of fibers is maintained. Secondly, the fibers are electrostatically pinned to the condensing surface resulting in thinner webs (single condenser) or longer chevrons (dual condenser). Thirdly, since the fibers are well pinned on the condensing surface, they are not disturbed as the web is conveyed away from the condensing zone. The first and third effects increase the uniformity of webs while the second results in increased web strength.

The first reason for tuft formation is simple overcrowding. At 5 lbs. of fibers/in. of width/hour, for example, there are approximately 250,000–1 denier per filament (d.p.f.), 1 inch staple fibers per inch of machine width per second. For 1½ d.p.f., 1½ inch staple, this figure is still over 100,000. With all these fibers flying about, it is very likely that, unless they are somehow made to repel each other, they will entangle and group into fiber tufts. This tendency is, of course, increased by air turbulence and disturbances in the system.

The tuft forming tendency is also reinforced by electrostatic attraction of fibers for each other, especially under conditions of low relative humidity in the atmosphere. The primary source of this attraction is random triboelectric charges imparted to the system before or at the feed point. Conditions met by the fiber, prior to being separated into small fiber groups and gas borne, are such as to impart nonuniform charges, not only of different intensity but also of different polarity from fiber-to-fiber. When atmospheric humidity is high, the fiber may lose most or all of these charges to the disperser roll or the feed device prior to being gas borne, since under such conditions, its surface conductivity is high.

Because of tufting, web quality has not been sufficient with commercially available machines at high rates, i.e.—2–3 lbs. fibers/in. of width/hour. At these rates, the tufts which form at the fiber deceleration zone, even though they are under favorable humidity conditions, are too large to form an acceptable quality product.

For this reason, the corona charging system was set up, to apply uniform electrostatic charges to all fibers, immediately after they are separated into small groups or individual fibers, so that they will subsequently repel each other, and retain the initial good fiber openness and distribution, until they are deposited on the condensing surface.

The point where the fibers are charged must be after they have been dispersed into the gaseous medium, and is preferably immediately adjacent to the point of dispersion. This point is preferred because: (1) the fiber is at its best separated state, either fiber-by-fiber or in very small groups; (2) the fibers have just lost contact with the disperser roll and are gas borne which means that they will retain the charges transmitted to them, even though the relative humidity is high; (3) the fibers are close to an ideal target electrode at this point since the smaller the distance from the target, the more efficient is the charging; (4) due to the good separation by the disperser, fibers fly along a single surface and there is essentially only one fiber in the path between the ion emitting electrode and target electrode thereby assuring that the fibers are charged efficiently; and (5) the proximity of the fiber stream to the grounded target permits the use of practically any ion emitting electrode to target spacing desired to fit optimum conditions as dictated by factors such as the disperser roll clothing, voltage levels permissible, polarity and stability desired, etc.

Commercially known air laydown nonwoven web forming machines can be suitably modified to provide the machines of this invention. As mentioned above, the most commonly known machine is sold under the name Rando-Webber by Curlator Corp. The patents incorporated by reference above disclose many embodiments of the Rando-Webber which can be modified to include a corona discharge system to uniformly charge the fibers subsequent to their distribution into a gaseous medium. The incorporated references are also relied upon for their disclosure of web forming machines suitable for modification according to the principles of this invention.

Two relatively simple modifications which can be made to Rando-Webbers to provide them with a suitable corona discharge system are shown in FIGURES 1 and 2.

The first merely involves redesigning the removable saber tube **17** so that it supports an ion emitting electrode **7** within a recessed area **18**. If desired, the saber tube **17** can be partially or completely constructed of an electrical insulating material. When the ion emitting electrode **7** is properly mounted in the saber tube **17**, the tube is replaced in the Rando-Webber and positioned so that the needle tips **12** of the electrode **7** are located at a point where the fibers **5** have been dispersed into the gaseous medium **4**, which in the case of a Rando-Webber is an air stream. To complete the corona discharge system, the disperser roll **3** is connected to ground and the ion emitting electrode **7** is connected to a source of electrical power. This is a particularly preferred embodiment of the invention because charging takes place very close to the point where the fibers leave the disperser roll **3** and because the required modifications to the saber tube **17** can be made quickly and inexpensively.

A second relatively simple modification can be made to a Rando-Webber by cutting out a recessed area **18** in the machine's interior housing **19** at a point close to where the fibers **5** leave the disperser roll **3** to become airborne and then mounting an ion emitting electrode **7** in the recessed area **18**. The disperser roll **3** can again be grounded and act as the target electrode.

As shown in FIGURES 1 and 2, a Rando-Webber can be modified to be equipped with two corona discharge systems, one being located in the saber tube **17** and the other being located in the machine's interior housing **19**. Other locations are also possible. The advantage to multiple corona discharge systems is that they can be turned on singly, simultaneously, consecutively, in various combinations, or they can all be turned off. Their mere presence, as long as the ion emitting electrode **7** is recessed, does not adversely affect web characteristics.

Fiber stock **1** is fed to the disperser roll **3** by feeding means which can be simple or complex. Simple feeding means include a feed roll **2**, conveyor, shute, etc. More complicated feeding means include mechanisms such as Rando-Feeders, sold by the Curlator Corp. One typical Rand-Feeder is described in detail in Buresh et al., U.S. Patent 2,744,294, issued May 3, 1956.

Apparatus for creating a corona discharge system is also well known in the art. In general, an apparatus is used utilizing an electrically charged ion emitting electrode **7**, preferably negatively charged, having at least one and preferably more needle points **12** disposed in line and spaced apart from a cylindrical target electrode **9** which is grounded. A shaped, intense electrical field is established between the electrodes containing a region of high and substantially unipolar ion charge density in proximity to the surface of the target electrode **9** through which region the dispersed gas borne fibers **5** are passed.

The corona discharge is believed to operate on the following principle. When an electric field is established between a negative point and some target or ground with an intervening air gap, generally in that air gap there are many free ions due to the action of normal background radiation. As the electric field intensity is increased, the free positive ions move under the influence of the field and are accelerated toward the negative point electrode. Upon colliding with that electrode, the ion transfers sufficient kinetic energy to the electrode to overcome the surface work function and, as a result, several electrons are emitted from the electrode. The emitted electrons acquire kinetic energy from the field, and collide with atoms in the air. These collisions cause further ionization and the process avalanches. Thus, near the point the electron avalanches produce an ion space charge, and at some distance from the point, the field strength, becomes low enough for the electrons to attach to neutral atoms through electron sharing, and form negative ions which move under the influence of the field toward ground. The process is regenerative and since charge carriers of both signs are generated, eventually the air gap zone stabilizes into three regions. Close to the negative point electrode there is a region which is termed bipolar flow. It contains positive ions moving toward the point electrode and a greater number of electrons moving in the direction of the ground. Farther away from the point electrode and beyond or in the region of electron attachment there is a region which is termed that of the bipolar cloud, since it contains charge carriers of both signs and is made up of electrons and air atoms which, of course, are mainly nitrogen and oxygen which have either gained or lost an electron. The region between the cloud and the ground plane or target is termed the region of unipolar flow. It is substantially comprised of negative ions moving toward the ground plane with perhaps very few electrons contributing to flow in this region.

Since a large number of fibers are to be charged, it is desirable to use an ion emitting electrode **7** with many needle points **12** spaced transversely across the electrode base **11** as shown in FIGURE 5. The spacing depends upon the amount of fibers to be charged and other factors. Preferably, the spacing is about every ⅛" to about every ¼" across the electrode base **11**.

The ion emitting electrode is connected to an electrical source of power. Direct current is preferable because there is a direct relationship between the current level and charge level, thereby making it desirable to use a very constant amount of current. The power source should be capable of supplying from about 5 to about 100 kilovolts to the ion-emitting electrode **7** and preferably should supply from about 10 to about 50 kilovolts.

The amount of current required depends upon the number and spacing of the needle points **12** on the ion emitting electrode base **11**. For a needle point spacing of ⅛–½ inch, an amount of current should be supplied by the power source to provide a current at the needle points **12** of from about 1 to about 30 microamps and preferably from about 5 to about 20 microamps. In any case, the charge imparted to the gas borne fibers **5** should be from about 0.1 to about 10 microcoulombs per gram of fibers and is preferably from about 0.5 to about 5 microcoulombs per gram of fibers. The preferred voltage, current and charge density ranges have been found to help insure that initial fiber distribution is maintained until the fibers are condensed. Of course, the power source is connected to the ion emitting electrode with electrical wiring.

Some examples of suitable power sources for this invention include: (1) Models DU–60 and 2040 manufactured by Spellman High Voltage Co., New York, N.Y.; (2) Model PSC–30–5–1 manufactured by Del Electronics Corporation, Mount Vernon, N.Y.; and (3) Model 230–6P manufactured by Sorenson Co., South Norwalk, Conn.

For a more detailed description of corona discharge systems considered suitable for use with the present invention, see the following United States patents, all of which are herein incorporated by reference for their descriptions of such systems: Di Sabato et al., U.S. 3,163,753, issued Dec. 29, 1964; and Owens, U.S. 3,340,-429, issued Sept. 5, 1967.

Any gaseous medium capable of being ionized is suitable for use with this invention. Of course, each gaseous medium will have its own ionization characteristics, and accordingly, adjustments in physical and electrical parameters will have to be made. Air is the preferred gaseous medium because it is inexpensive, readily available and easily ionized. An air flow can be very simply provided by a fan system, as is used in Rando-Webbers. When an air stream is used, the air velocity V_1 should be from zero to about 30,000 feet per minute. A preferable air

velocity V_1 is in the range of from about 1000 to about 10,000 ft. per minute because at such rates very uniform nonwoven webs can be formed.

Any type of fiber, natural or synthetic, can be used with the machine of this invention as long as it is capable of holding an electrical charge. Some examples of suitable fibers include: (1) ¾–1 inch, 1½ denier per filament (d.p.f.) viscose rayon staple; (2) 1½–2 inch, 1½ d.p.f. "Dacron" fiber with mechanical crimping; (3) ¼–2 inch, 3 d.p.f. "Dacron" fiber with no crimping or with mechanical or spiral crimping; (4) ¾–2 inch, 3 d.p.f. nylon fiber with mechanical crimping; (5) ½–2 inch, 1½ d.p.f. acetate fibers; and (6) a blend of 20–80% ¼–¾ inch, 1½ d.p.f. acetate rayon, crimped or uncrimped, with 20–80% 1–2 inch, 1½ d.p.f. "Orlon" fiber, crimped or uncrimped. "Dacron" and "Orlon" are registered trademarks of E. I. du Pont de Nemours & Co. for polyester and acrylic fibers, respectively.

The machine and process of this invention are useful for forming random nonwoven web material from fibers. Nonwoven web material, in turn, has many of the same utilities of woven webs. In particular, nonwoven webs are used to make fabrics for women's dresses, to make tent fabric, as substrates for linoleum coverings, as substrates in fabric composites and as interlinings on men's and women's suits and dresses. Nonwoven webs are generally more economical than comparable woven web materials and often can be made stronger per equivalent weight.

The following examples illustrate the invention. All parts and percentages are by weight unless otherwise specified.

Examples 1–19

These examples were performed on a modified 40 inch wide Rando-Webber type 40B. A model 40B type Rando-Feeder was used to feed the web forming machine. Rando-Webber and Rando-Feeders are trade names for machines built and sold by Curlator Corp., East Rochester, N.Y.

The disperser roll was grounded and covered with garnett type card clothing with 40 teeth/in.^{2} with a 3/16 in. tooth height. Normal operating speed of the roll was 2500 r.p.m. (9" roll size) or approximately 6,000 surface feet per minute.

The air system of the Rando-Webber consists of dual blowers located inside the machine. Air from a plenum chamber, supplied by the outlet of the blowers, passes through a venturi formed by the saber tube and the lickerin cylinder. As the fibers are doffed, the air transports the fibers to the condensing roll where the web is formed. The air passes through the perforated condenser and returns to the inlet of the blowers. The air system is controlled by means of dampers located at the outlets of the blowers.

The following modifications were made to the Rando-Webber:

(1) Two corona ion emitting electrodes, each connected to a Spellman Model DU–60 power source, were installed on the machine. One was embedded in the saber tube and one was located in the lower plate of the air chamber. To eliminate fiber hangups on the grounded metal surface, the lower plate of the air duct and the metal doff bar were changed to "Lucite." The saber tube was also changed to "Delrin" to accommodate the corona electrode. "Lucite" and "Delrin" are trademarks of the E. I. du Pont de Nemours & Co. for acrylic resins and acetal resins, respectively;

(2) A minor modification was made to the duct shape to eliminate a low pressure zone in the area of the feed device by inserting a small triangular piece of material to the interior housing of the machine immediately above the saber tube.

The fibers used were one inch long rayon staple, sold by American Viscose. Approximate air velocity during these examples was 8500 ft./min. at the saber tube venturi

TABLE I

	Example No.																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Rate, lbs./in./hr.	.5	1.0	1.0	1.5	1.5	2.0	2.0	2.5	3	4	1.0	1.0	1.5	1.5	2.0	2.0	2.5	3.0	4.0
Basis wt., oz./yd.^{2}	1.0	1.0	2.0	1.0	2.0	1.0	1.0	2.0	20	2.0	1.0	2.0	1.0	2.0	1.0	2.0	2.0	2.0	2.0
Web speed, ft./min.	14	29	14.5	43	21.5	57	28.5	35.7	43	57	28.6	14.0	4.3	21.5	57	28.5	35.7	43.0	57.0
Feed speed, ft./min.	1.8	3.6	3.6	5.4	5.4	7.2	7.2	9.0	10.8	14.2	3.6	3.6	5.4	5.4	7.2	7.2	9.0	10.8	14.2
Lickerin, r.p.m.	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Relative humidity, percent	55	62	62	62	62	62	62	62	62	62	60	60	60	60	60	60	60	60	60
Air setting, percent open	75	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Saber Corona, voltage kv.	0	0	0	0	0	0	0	0	0	0	−27	−27	−27	−27	−27	−27	−27	−27	−27
Saber Corona, current, μA/in.	0	0	0	0	0	0	0	0	0	0	20	20	20	20	20	20	20	20	20
Plate Corona, voltage kv.	0	0	0	0	0	0	0	0	0	0	−24	−24	−24	−24	−24	−24	−24	−24	−14
Plate Corona, current μA/in.	0	0	0	0	0	0	0	0	0	0	20	20	20	20	20	20	20	20	20
Quality of web	(1)	(2)	(3)	(4)	(5)	(6)	(6)	(6)	(6)	(6)	(7)	(8)	(7)	(8)	(10)	(11)	(11)	(12)	(6)

[1] Very high quality.
[2] Almost acceptable quality, blotchy but uniform.
[3] Good but heavy, blotchy but uniform.
[4] Not acceptable, blotchy and badly distributed.
[5] Average, blotchy but uniform.
[6] Blotchy, badly distributed and pieces of feed in product.
[7] Better than No. 2.
[8] Good.
[9] Acceptable, blotchy but uniform.
[10] Better than No. 2, blotchy and badly distributed.
[11] Blotchy and badly distributed.
[12] Blotchy but uniform.

throat (V_1) and 1000 ft./min. in the condensation zone (V_2).

In an effort to see the full effect of the charging system at rates with very low and difficult to achieve basis weights, web samples, usually of 1 oz./yd.² nominal basis weight, were collected at different rates, usually 1, 1½, 2½, 3 and 4 lbs./in. width/hour, at each machine setting, and visually compared for blotchiness and relative uniformity to standard web samples. Test results are given in Table I above.

Examples Nos. 1 and 10 in Table I were made as a reference set with the unmodified Rando-Webber. Example No. 1 at 0.5 lb./in./hr. is identical to the best of what is being produced presently by this machine. Uusually a quality between that of Example No. 1 and Example No. 2 (between 0.5 and 1 lb./in./hr.) is acceptable. Consequently, any example better than Example No. 2 was considered acceptable.

The 2 oz./yd.² examples included in Table I were made to demonstrate the relative ease of producing 2 oz./yd.² rather than 1 oz./yd.² examples. Blotches and basis weight nonuniformities tend to become masked. The web is also easier to handle.

Immediately over 1 lb./in./hr. (Examples 4 and over) quality drops below the acceptable limit. First blotches set in, and then gradually basis weight nonuniformities become more pronounced. Finally over 2.5 lb./in./hr., fiber chunks from the feed start escaping into the web, and the product becomes totally unacceptable.

Examples 11 through 19 in Table I were made under identical conditions as those of Examples 1–10, but with the electrostatic modifications. In this particular experiment both Corona wands were kept active, since this appeared to be slightly better than activating either wand by itself. The voltage-amperage settings used here were chosen for optimum performance.

As shown in Table I electrostatics raised the productivity to the range between 1.0 and 1.5 lb./in./hr. Example 15 made at 2 lbs./in./hr., is still better than Example 2 made at 1 lb./in./hr. by the unmodified machine, but not as good as Example 1 made at 0.5 lb./in./hr.

Examples 20–41

These examples were carried out on a 40 inch wide Rando-Webber with a 5½ feet long by 40 inch wide "Lucite" duct and dual screen condenser. "Lucite" is a registered trademark of E. I. du Pont de Nemours & Co. for acrylic resins. The ion emitting electrode was mounted in a "Delrin" housing section to ensure that the shortest path to ground was via the disperser roll. The "Delrin" section was mounted at a point in the duct immediately below the saber tube. "Delrin" is a registered trademark of E. I. du Pont de Nemours & Co. for acetal resins. The ion emitting electrode was positioned so that the shortest path to ground was to the disperser roll at a point where virtually all of the fiber was airborne. A Del Electronics Model PSC–30–5–1 high voltage DC power supply was connected to the ion emititng electrode. For these examples, "Dacron" polyester fiber of 1.85 and 2.75 d.p.f., 1.5 inches long. "Dacron" is also a registered trademark of E. I. du Pont de Nemours & Company for polyester fiber.

The operating conditions were:

Feed condenser vacuum	0.8–1.1" of H_2O.
Feed roll speed	15.8–20.7 ft./min.
Lickerin roll speed	1900–2800 r.p.m. (9" dia.).
Air flow	2000–2700 c.f.m.
Relative humidity	45–70% at 70–80° F.
Batt weight	15–25 oz./yd.².
Fiber flow rate	2–2.5 lb./in./hr.

Test parameters for these examples are given in Table 2.

TABLE 2

	Corona Kv.	Corona Milliamps	Duct R.H. percent	Lickerin Roll, r.p.m.	DPF
Example:					
20	−35	1.5	35	2,800	2.75
21	−24.5	0.5	35	2,800	2.75
22	−29	1.0	35	2,800	2.75
23	−36.5	1.75	35	2,800	2.75
24	−40	2.0	35	2,800	2.75
25	−38	1.5	45	1,800	2.75
26	−35	1.0	45	1,800	2.75
27	−36	1.5	66	1,800	2.75
28	−28	0.5	66	1,800	2.75
29	−40	1.9	66	1,800	2.75
30	+29	0.5	45	1,800	2.75
31	+34.5	1.0	45	1,800	2.75
32	−35	1.5	47	1,800	2.75
33	−37.5	2.0	47	1,800	2.75
34	−29	0.5	47	1,800	2.75
35	−34	1.0	53	2,800	1.85
36	−36.5	1.25	53	2,800	1.85
37	−35	1.0	60	1,900	1.85
38	−40	2.0	60	1,900	1.85
39	−36	1.5	50	1,900	1.85
40	−38	1.5	70	1,900	1.85
41	−37	1.0	75	1,900	1.85

The chevron length of Examples 40 and 41 were compared to similar runs with the corona system shut off. The operating conditions varied slightly from those set out above, and the changed parameters are noted below:

	Example 40	Example 41
Batt weight, oz./yd.²	15–16	24.7
Fiber flow rate, lbs./in./hr	2	3
Chevron length, no charge, inches	3	4¼
Chevron length, with charge, inches	6	6½

Several effects were visible with the corona system in use as compared to runs without use of the corona system. The chevron changed dramatically in that it became much longer and sharper. The amount of fiber movement on the screens and the amount of bare screen were both visibly reduced. No fiber hangup on the duct or machine parts was observed.

Chevron length was marked by the insertion of black fiber at the feed roll and increased by as much as 100% from 3" to 6". This increase was less dramatic at high air flow rates but was at least 20% under all conditions. In all cases, the chevron became sharper going from U shaped or a short v shape to a longer, more pronounced V shape.

In all cases, fiber does move as it deposits on the bare screen or on other fibers; however, the amount of movement was visibly reduced when electrostatic charging was used. There also was visible evidence of an attraction of the fiber to the bare screen. With electrostatic charging, the fibers deposited closer to the leading edge of the dual condenser screens.

The insertion of black fiber to define the chevron length also revealed that the transverse direction and graded density distribution of the black fiber were more uniform with electrostatic charging than without.

These effects were reproducible and observable for the ranges of fiber flow rates, batt weights, air flows, lickerin roll speeds, relative humidities and fiber deniers previously listed.

Both positive and negative charging were effective. However, the negative charging is, in general, more stable and, therefore, preferred. The current and voltage levels did not seem to have much effect once they were above certain minimum levels. Typical effective operating conditions for the 37" long charging electrode were −30 to −40 kv. at 1 to 2 milliamps.

What is claimed is:

1. A machine for forming random fiber nonwoven webs by dispersing fibers in a gaseous medium and sub-

sequently condensing said fibers onto a foraminous surface, comprising, in combination:

(a) means including a disperser roll for dispersing said fibers in said gaseous medium;

(b) means for supplying said gaseous medium;

(c) means for feeding said fibers to said dispersing means;

(d) means for condensing said fibers from the gaseous medium;

(e) a duct connecting the dispersing means to the condensing means, said duct containing the gaseous medium; and

(f) a corona discharge system located at a point beyond where the fibers are dispersed into the gaseous medium said corona discharge system comprising, in combination,

(1) an ion emitting electrode comprised of a plurality of conducting needles fixed rigidly in a lateral spacial relationship arranged transverse to and completely across said fiber path with the points of the said needles facing said target electrode;

(2) a target electrode oppositely positioned across the path of the fibers in the gaseous medium said target electrode comprising said disperser roll and being connected to ground;

(3) a source of electrical current and voltage sufficient to provide a corona discharge from said ion emitting electrode; and

(4) means connecting said ion emitting electrode to the source of electrical current and voltage.

2. A machine of claim **1** wherein said gaseous medium comprises an air stream flowing in the duct from the disperser roll to the condensing means.

3. A machine of claim **2** wherein the means for feeding said fibers to the dispersing roll comprises at least one feed roll.

4. A machine of claim **3** wherein said means for condensing said dispersed fibers comprises a foraminous condenser roll.

5. A machine of claim **3** wherein said means for condensing said dispersed fibers comprises at least one foraminous conveyor belt.

6. A machine of claim **3** wherein said means for condensing said dispersed fibers comprises two foraminous conveyor belts angularly arranged in a converging configuation.

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