

[54] **METHOD FOR MANUFACTURING
NON-WOVEN TEXTILE ARTICLES**

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1967, Pat. No. 3,535,187.

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[51] Int. Cl. **B32b 19/00**

[58] Field of Search. **156/62.2, 62.4, 62.8,
156/166, 180, 181, 296, 501**

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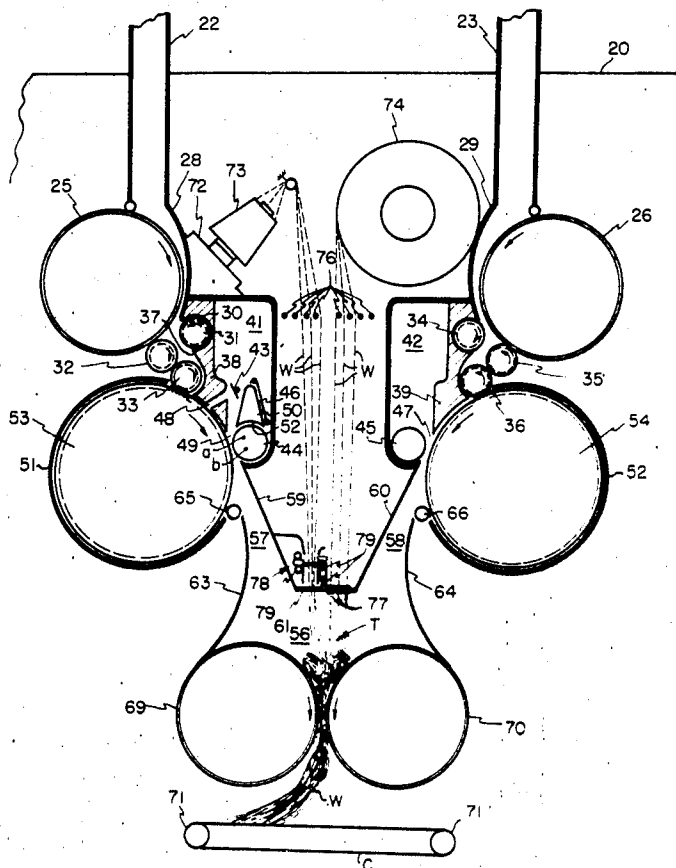
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[57] **ABSTRACT**

In this process various materials are fed into a condensing chamber between two rotary condensers to form a composite nonwoven product. Staple fibers may be formed into two separated mats from which the fibers are combed by lickerins into two separate air streams for delivery to the condensing chamber; and continuous filaments may be fed between the fibers to the condensers, and intermingled, in the nip between the condensers, with the staple fibers to form a non-woven and continuous filament composite; or a powdered binder may be fed into the condensing chamber to form a two-type non-woven and powdered-binder composite; or staple fibers may be fed by three separate air streams into the nip between the condensers to form a three-type non-woven product.

8 Claims, 8 Drawing Figures



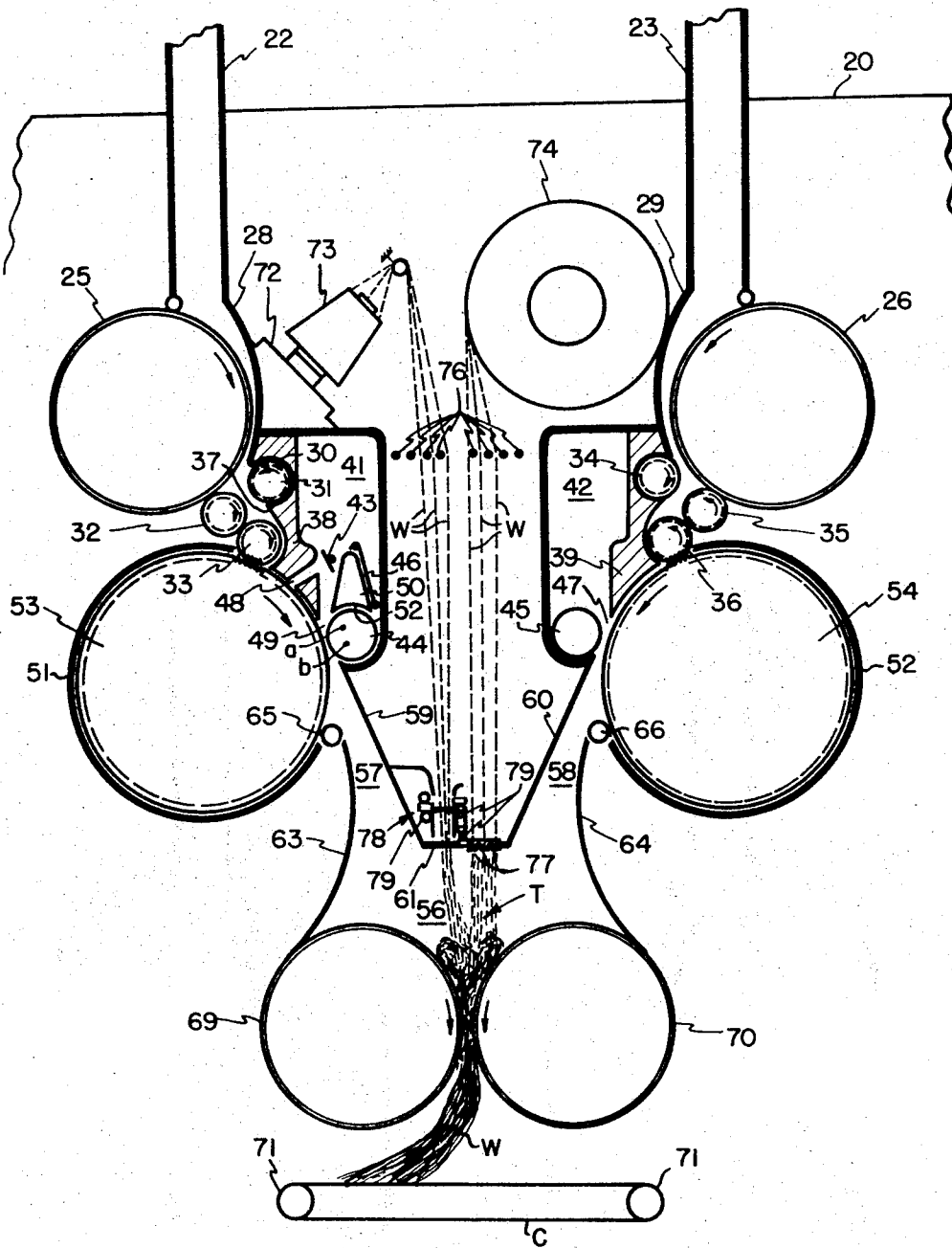


FIG. 1

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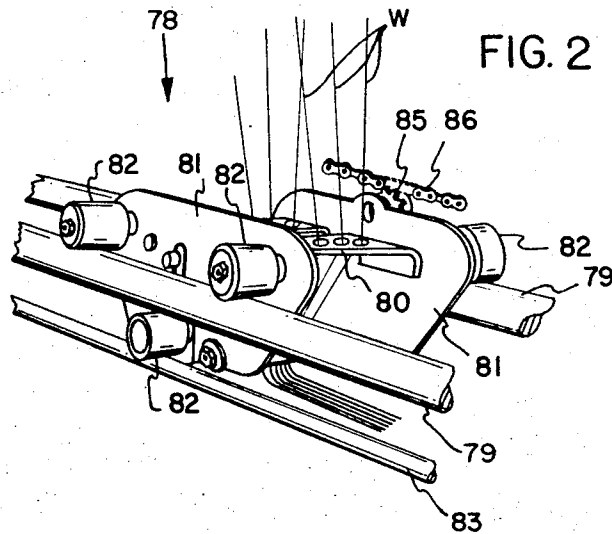


FIG. 2

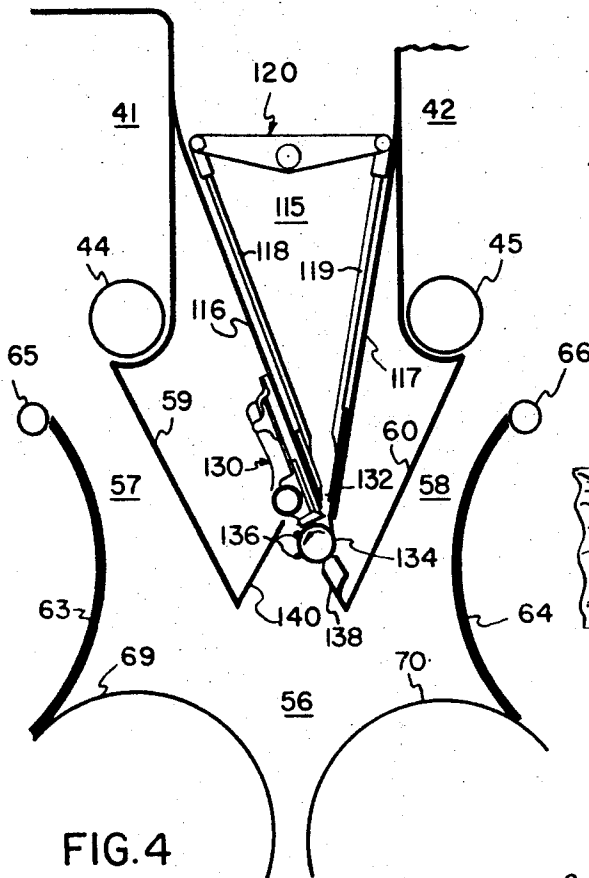


FIG. 4

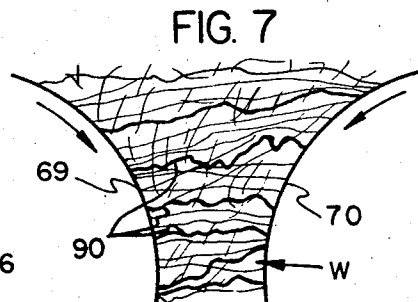


FIG. 7

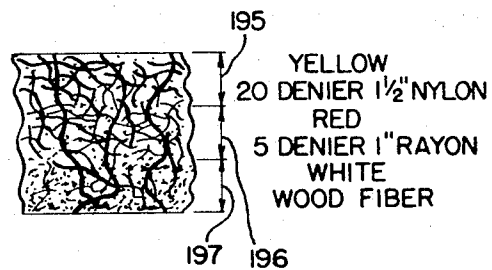
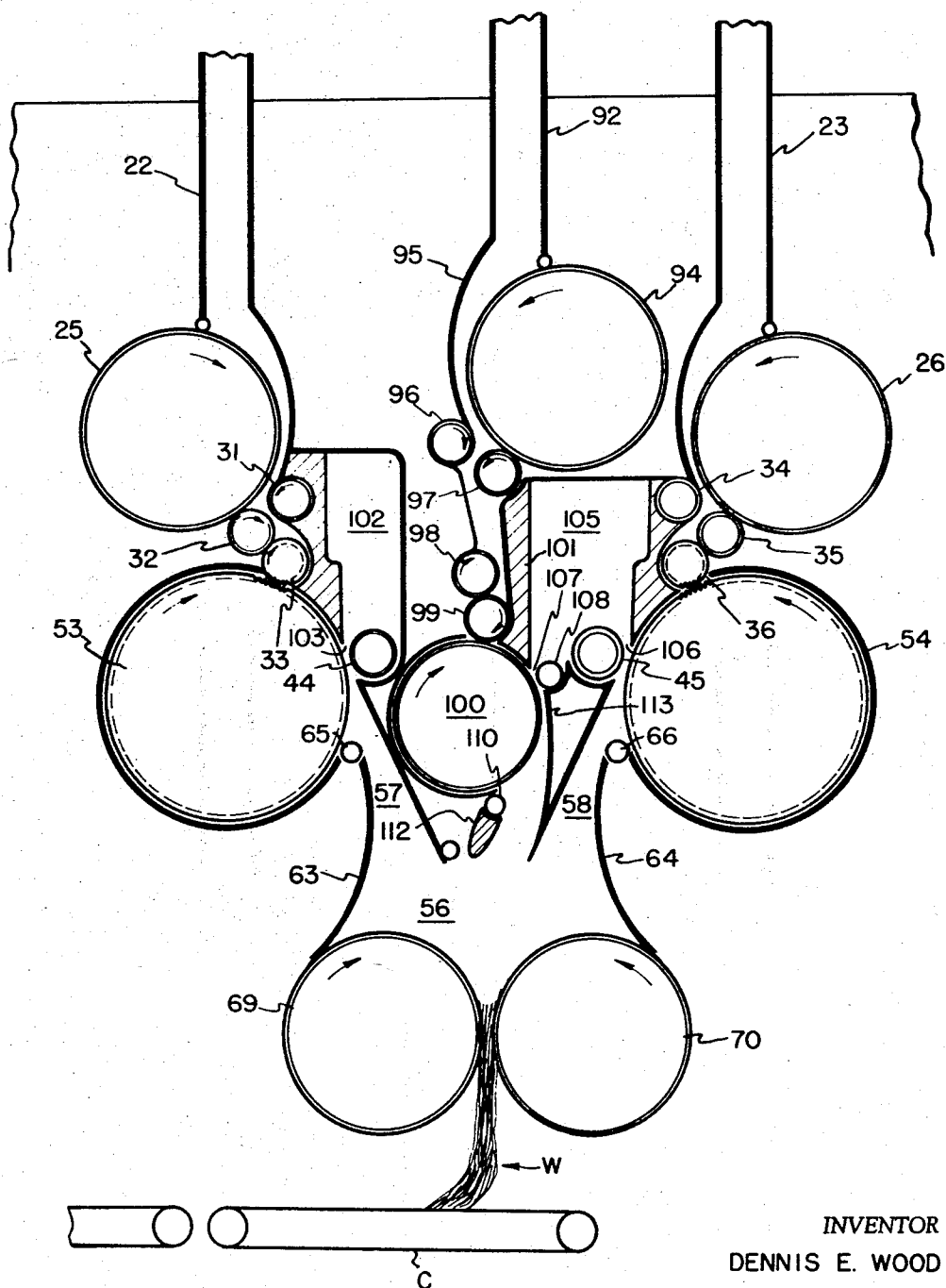


FIG. 8

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METHOD FOR MANUFACTURING NON-WOVEN TEXTILE ARTICLES

This application is a division of my application Ser. No. 691,544, filed Dec. 18, 1967, now U.S. Pat. No. 3,535,187 issued Oct. 20, 1970 and a continuation of my application Ser. No. 47,029, filed June 17, 1970, now abandoned.

This invention relates to a method for producing non-woven textile articles, that is, textile articles produced without spinning, weaving or knitting operations.

There are several known methods of preparing non-woven textile products.

One object of the present invention is to produce non-woven materials superior to those produced heretofore.

A further object of this invention is to provide an improved, non-woven textile material. To this end, another object of this invention is to provide a process which eliminates the formation of objectionable lumps of fibers in the finished, non-woven web.

A more particular object of this invention is to provide a process for combining continuous and non-continuous textile filaments into a textile web, which will exhibit physical properties equivalent to similar woven or knitted fabrics.

Still another object of the invention is to produce a nonwoven product stronger than present day nonwoven webs.

Other objects of the invention will be apparent hereinafter from the specification and from the recital of the appended claims, particularly when read in conjunction with the accompanying drawings.

In the drawings:

FIG. 1 is a somewhat diagrammatic, fragmentary sectional view in a vertical plane through web forming apparatus made in accordance with this invention and illustrating the process of the invention;

FIG. 2 is a fragmentary perspective view of a weft laying unit;

FIG. 3 is a fragmentary sectional view similar to FIG. 1, but showing another manner of practicing the invention;

FIGS. 4 to 6 illustrate schematically and fragmentarily three additional modifications of the invention;

FIG. 7 is an enlarged, fragmentary sectional view of the throat between the rotating condensers of the apparatus, and illustrating diagrammatically how the fibers are laid down in the formation of a non-woven web according to the invention; and

FIG. 8 is a section through a web made according to one embodiment of this invention.

In recent years there has been much work on monocryalline, monofilament, and like fibers made in continuous lengths. Most of these fibers, in particular monocryalline types, have the greatest strength of any textile materials made today.

The heart of all nonwoven production is the web formation process, whether this process be by conventional textile machines, such as cards or garnetts, which produce a web with a predominant fiber orientation, or by machines which use a stream of gas or air to lay down, on a moving condenser, a web in which the fibers have a random arrangement.

This invention, in one aspect, consists in combining continuous length fibers with a weaker nonwoven fiber mass to create a whole new generation of composites stronger than present day nonwoven products. It has

been found that a nonwoven web, made by combining the two types of fibers mentioned into a composite, retains the advantages of its constituents and is superior to webs made by present day processes. Moreover, the combination yields a nonwoven material which has characteristics greater than those of the constituents alone.

The continuous material may be extruded filaments, bundles of aligned fibers, strands, threads, yarns, and the like.

The invention, however, is not restricted to the production of nonwoven textile articles from a mixture of fibers of staple, or indiscriminate lengths and/or continuous filaments. In certain aspects, the invention relates to formation of nonwoven webs from different types of staple or indiscriminate fibers, and also to instances in which such fibers are bonded together with thermoplastic resins.

Referring now to the drawings by numerals of reference, and first to FIG. 1, 20 denotes a part of the frame of a machine for practicing this invention. Mounted on this frame are two spaced, parallel, vertically disposed chutes 22 and 23, each of which is adapted to receive textile fibers transported, for example, by pneumatic conveying ducts, for instance, such as shown in U.S. Pat. No. 3,326,609, granted June 20, 1967.

Rotatably mounted beneath the lower ends of the chutes 22 and 23, respectively, are two spaced, parallel condensers 25 and 26, which are of conventional construction and may comprise rotary screens surrounding fixed diametral ducts or rotary screens surrounding a slotted duct through which air is sucked to one or both ends of the condenser. The condensers 25 and 26 are disposed beneath the lower, open ends of the chutes 22 and 23, and confront curved meter plates 28 and 29, respectively, which constitute extensions of walls of the chutes 22 and 23, respectively. These plates converge downwardly toward the peripheries of the two condensers so that the space between the plates and their respective associated condensers gradually narrows downwardly.

Mounted below plate 22 in proximity thereto is a rotary feed roll 31. Mounted beneath condenser 25 is substantial contiguity therewith is a rotary feed roller 32. Feed roller 31 rotates in a pocket or recess 30 in a feed plate 38. Mounted in substantial contiguity with roller 32 but spaced slightly from the arcuately curved surface 37 of plate 38 is a rotary feed roller 33. Similarly mounted at the opposite side of the machine are three, spaced, parallel feed rolls 34, 35 and 36, respectively. Roller 36 is adapted to cooperate with feed plate 39.

Plates 38 and 39 constitute the outside walls of chambers 41 and 42, respectively.

Mounted in the lower ends of the chambers 41 and 42, respectively, adjacent the lower ends of the feed plates 38 and 39, respectively, are saber tubes 44 and 45, respectively. The right hand chamber 42 has an outlet 47 in its lower end between the saber 45 and the adjacent feed plate 39. At the opposite side of the machine, the chamber 41 has in its lower end a first outlet 48 formed by an elongate slot in the feed plate 38, and a second outlet 49 formed between the feed plate 38 and the saber tube 44. A pivoted damper 43 in chamber 41 is used to control the flow of air from this chamber through the outlets 48 and 49.

The saber 44 has a triangularly shaped extension 50 by which it is pivotally mounted in chamber 41. A leaf spring 43 serves resiliently to press saber 44 clockwise about its pivot.

It is to be understood, that, if desired, the chambers 41 and 42 at opposite sides of the machine may be constructed identically — i.e. both may be like chamber 41, or both like chamber 42.

Mounted to rotate beneath the feed rolls 33 and 36, and adjacent the outlets of the chambers 41 and 42, respectively, are two conventional lickerins or swifts 53 and 54, respectively. Guards 51 and 55 extend around the greater portions of these lickerins.

The pneumatically-carried fibers are delivered by chutes 22 and 23 to the condensers 25, 26, respectively; and as the condensers rotate, and air is sucked through them by a suction fan or fans (not shown), the condensers and the meter plates 28, 29 cooperate to collect, condense and from the fibers into laps. The laps are doffed from the condensers by doffing rolls 32 and 35, respectively, and guided between rolls 32 and 31 and roll 33 and feed plate 38 on the one hand, and between rolls 34 and 35 and roll 36 and feed plate 39 on the other hand and thereby compacted into fiber mats. The mats are fed over the noses of the feed plates 38 and 39 by feed rollers 33 and 36, respectively, into contiguity with the lickerins 53, 54, respectively. The fibers are combed from the respective laps by the rotating lickerins.

The rolls 31, 32, 34, 35 may be plain or knurled. The feed rolls 33 and 36 are metallic-clothed with a tooth arrangement reversed with respect to the teeth of the lickerins.

Mounted beneath and between the lickerins 53 and 54 is a condensing chamber 54 to which the combed fibers are delivered through spaced ducts 57 and 58 which open at their upper ends on the peripheral surfaces of the lickerins 53 and 54, respectively. These ducts are defined by inner or upper walls 59 and 60, respectively, and by outer walls 63 and 64. Upper walls 59 and 60 extend from the lower ends of the chambers 41 and 42, respectively, downwardly and inwardly toward one another, and are connected at their lower ends by a horizontal plate 61 that extends transversely across the upper end of chamber 56.

The opposed, outer walls 63 and 64 of these ducts are spaced and curved covers which maybe made of "Plexiglas," or the like. These covers may extend around lickerins 53 and the integral with guards 51 and 55 or be hinged thereto. The lower ends of the covers 63 and 64 terminate in approximate contiguity with spaced, parallel, rotary condensers 69 and 70, which are adjustably mounted on the frame of the machine for lateral movement toward and away from one another to adjust the width of the throat T or space formed between the confronting peripheries of these condensers.

The condensers 69 and 70 are disposed slightly above a conventional endless conveyor belt C that is adapted to be mounted beneath the condensers 69 and 70 to travel over pulleys 71.

The center zone or section of the machine is disposed between the chutes 22 and 23. Mounted in the upper end of this section in the embodiment of the invention illustrated in FIG. 1 are means for supplying continuous filamentary material. This supply may be from creels 72, only one of which is shown, but which are disposed

in spaced relation widthwise of the machine, and each of which holds a plurality of bobbins 73 (only one of which is illustrated), or in the form of a warp beam or beams 74 extending across the width of the machine and mounted to rotate parallel to the condensers 25 and 26, or both creels and warp beams may be employed. In the drawings (FIG. 1) a creel is shown at one side of the machine, and a warp beam at the other side.

As shown by broken lines in FIG. 1, the continuous filaments or warps F from the rotating bobbins 73 and/or beams 74, which are driven in conventional manner, are guided by spaced rods 76, preferably made of glass, downwardly through the center of the machine between the chambers 41 and 42, into the condensing chamber 56. Some of the filaments or warps may be guided into the chamber 56 through nozzles 77 that are formed in plate 61 adjacent one side (the right side in FIG. 1) of the machine. Others of these filaments may be threaded through a weft laying unit 78 of conventional construction, which is mounted to reciprocate on guide rods 79 between opposite ends of the machine above plate 61.

As shown more clearly in FIG. 2, the weft laying unit 78 may comprise one or more perforated bars 80 that are mounted on a carriage 81, which rolls through rollers 82 on rods 79. A sprocket wheel 85 rotatably mounted on one side of the carriage 81 may be driven in conventional manner by a chain 86, and through a conventional drive (not illustrated), may transmit its rotation to one or more of the rollers 82, thereby to move the unit 78 in opposite directions depending upon the direction of movement of the chain 86.

In use, non-continuous filament or staple fibers are fed by the chutes 22 and 23 to and deposited on the condensers 25 and 26 and compacted between the condensers and the meter plates 28 and 29 into laps which are fed by rolls 31, 32, 33, and 34, 35, 36, respectively, to the lickerins 53 and 54, as in conventional machines for forming random fiber webs. The lickerins, which rotate at high speed, comb individual fibers from the mats. These fibers are doffed from the lickerins into chamber 56 by centrifugal force and by the velocity of the air streams flowing over the lickerins toward the condensers 69 and 70, respectively.

In forming a composite nonwoven web W, the fibers of indiscriminate and/or staple lengths are, under the influence of the turbulence existing in the atomization or condensing chamber 56, augmented by the presence of the continuous filaments. The fibers are deposited in a haphazard manner on the condenser screens with the continuous filaments. In such as assembled mass, many of the fibers extend from one major face of the web to the other and from one continuous filament to the next. The fibers that extend through the web and between the continuous filaments provide a direct tie so that the web becomes an integrated structure from the upper to the lower surface. The shorter, staple fibers collect in part on the surfaces of the condensers 69 and 70, and in part in the throat T (see FIG. 7) between the condensers, and around the vertically disposed continuous filaments F. Moreover, many of the staple fibers operate as linking fibers 90, each of which has one end thereof embedded in the layer of fibers formed on the surface of the condenser 69, and has its opposite end embedded in the fiber layer formed on the surface of the condenser 70. These linking fibers 90 extend transversely across the throat T, and to opposite faces of the

web W formed by the fibers upon passing downwardly through the throat T. The linking fibers 90 prevent opposite faces of the web from separating, and as a result produce a single web W, which is a composite of the fibers fed into chamber 56. Web W thus created is fed downwardly into, and is conveyed away by the conveyor C.

It is essential in order to provide a satisfactory web W, that there be a continuous, uniform supply of fiber to each side of the machine, and ultimately to the condenser chamber 56. It is important, too, that a uniform rectangular cross-section of material be presented to each swift or lickerin. The lickerins comb individual fibers into the condensing chamber. The uniform rectangular feed sheets, which have been formed by the action of the condensers 25, 26, the meter plates 28, 29 and the feed rolls 31, 33, 34, 36 supply the fibers in an alignment which increases the uniformity, across the width of the condensing chamber and the venturi sections, of the fibers deposited in the air streams and increase the consistency of the distribution of the fibers from top to bottom of the air stream by increasing the consistency of the rate at which the fibers are removed from the laps by the combing action of the lickerins.

Air is forced axially through the openings in the chambers 41, 42 by the exhaust from the recirculation fans for condensers 25, 26 which are connected at one end to ducts that are connected at their other ends to chambers 41, 42. Preferably the axial velocity of the air at the point where it passes between the surfaces of plates 38 and 39 and the lickerins is greater than the peripheral speeds of the lickerins. This avoids windage drag on the fibers being carried partly on the teeth of the lickerins and partly in the bound layers around the lickerins, and causes each individual fiber to be encapsulated by the air. This encapsulation is important since it reduces frictional resistances and the possibility of coagulation of the fibers.

To assure uniform fiber supply, the chambers 41 and 42 are supplied with air under pressure in conventional manner from the recirculating fans, or the like, and function as expansion chambers for incoming air, so that as the air enters these chambers, from the smaller cross-sectional area ducts it expands. Thus the air will have a relatively high velocity in the inlet ducts leading into chambers 41 and 42, and a relatively low velocity in these chambers themselves. This produces an aerodynamic turbulence in the form of a cylindrical rolling motion of the air across the width of the machine.

The amplitude of this transverse cycloidal motion can be regulated by changing the suction velocities of the fans. This rolling motion of the air tends to result in axial air flow which is of average uniformity across the machine and prevents laminations of the flow at the velocities used.

Having obtained uniformity across the widths of the chambers 41 and 42 by expansion of the air, which results in reduced air velocity, the velocity of the air, which is to be expelled from the chambers, must be increased. The slots formed between the undersides of the feed plates 38, 39 and the saber tubes 44, 45, respectively, are accordingly made of reduced rectangular cross section. This causes acceleration of the air, which enters at points where the fibers are fed into the venturi sections which have rectangular cross sections less than those of the acceleration slots. This reduction in depth of the condensing chambers and increase in

velocity of the air stream reduces the magnitude of the transverse movements which are induced by turbulence, thus, in effect compressing the large movements of air into a number of small amplitude movements and causing a more uniform axial movement of the air and fiber mixture.

The air mixture is introduced at a zone of uniform flow achieved by the small lateral turbulence and high velocity, namely in zones, such as bounded by lines a and b for saber 44-lickerin 53. Thereafter the air and its suspended fibers travel uniformly as regards the width of the condensing chamber and the fibers are deposited uniformly across the widths of the condensing screens 69, 70.

It has been found that if a change is made in the raw material, as for example, length and/or denier of the stock, or if a change is desired in the weight of the non-woven web to be produced, the velocity of the air should be changed correspondingly. Should the air velocity be too high, the impact of the fibers on the condensing screens 69, 70 would be too severe; and should the air velocity be too low, coagulation of the fibers would occur due to the fibers not being encapsulated correctly. Therefore, a balance must be achieved in the air velocity in the condensing chamber such that individual fibers have just enough kinetic energy to deposit themselves in an isotropic web formation. The required variation of air can be achieved by balancing the air flow through the fans and so into the expansion chambers 41, 42, and by adjusting the positions of the sabers 44, 45 thus adjusting the acceleration slots.

It has been found that certain fibrous materials tend to accumulate or "ball up" between the feed rolls 33, 36, and their associated lickerins 53, 54, on the downstream side of the tangent point of a feed roll and lickerin, or just below where the fibers are removed from a feed lap. This is most undesirable, since the accumulated fibers will eventually escape from this zone, and will cause an uneven discharge into the condensing chamber 56. The outlet 48 is provided to obviate this "balling up." The outlet 48 creates an air current or turbulence immediately adjacent the point where the fibers tend to accumulate, and as a consequence prevents accumulation.

The theoretical or ideal amount of air required for air-layed random webs is that amount which is necessary to open the lap feed into individual fibers, and to encapsulate each fiber in a sphere of air, and then to pass these air encapsulated fibers upon the rotating condensing screens 69 and 70 so that no fiber touches or joins its neighbor en route.

For example, if the material to be processed is cotton fiber of 1 inch staple length and a denier of $1\frac{1}{2}$ inches with a specific gravity of 1.53, then there will be 6,696,250 fibers per oz. Therefore, the required air to encapsulate 1 oz. of the cotton fiber is 2,290 cubic feet. If the machine output is only a modest 80 lbs./hr. then the air requirement would be 48,853 cubic feet per minute. This is not practicable, so a compromise is made such that a dilution factor is used to maintain as nearly as possible these ideal conditions wherein coagulation and frictional resistance are kept to a minimum. It has been found that the required air may be calculated from the formula $810 \cdot P \cdot L^2 / D \cdot k$

where P = Production rate of the machine is lbs./hr.

L = Fiber length in inches

D = Denier

k = Dilution factor

The above formula is empirical.

In the apparatus shown in FIG. 1, three separate feed zones are employed: two at opposite sides of the machine as represented by the chutes 22 and 23, and a third in the center of the machine as represented by the creel 72 and warp beam 74. The center zone provides the continuous filaments, which are blended in the space between the condensers 69 and 70 with the non-continuous fibers, which are fed into the condenser 56 from the two outer zones. By modifying the center zone, the structure of the resultant nonwoven web may be altered.

For example, in the modification illustrated in FIG. 3, wherein like numerals are used to designate elements similar to those employed in the first-described embodiment, it will be noted that although the two outer feed zones are substantially the same as in the machine of FIG. 1, the creel 72 and warp beam 74 of the inner zone have been replaced by means for supplying non-continuous filament or staple fiber.

In this second embodiment a chute 92 in the center of the machine feeds fibers to a condenser 94 that is located between and parallel to the condensers 25 and 26. A lap is developed in the usual manner between condenser 94 and adjacent meter plate 95, and is fed downwardly by a plurality of plain or knurled feeder rolls 96, 97, 98 and 99 and over a feed plate 101 to a lickerin or swift 100 that is located in the center of the machine above condensing chamber 56. The saber 44 is mounted in the lower end of a chamber 102, which is similar to the chamber 42 in the first embodiment, and which has a single outlet 103 adjacent the saber to assist in delivering fibers to the condenser inlet 57 as they are removed from the lap by the lickerin 53.

Similarly, the saber 45 is located in the lower end of a chamber 105 having a first outlet 106 adjacent the lickerin 54 to assist in delivering fibers to the condenser inlet 58, and a second outlet 107, which is located between the lickerin 100 and another saber 108 mounted in the lower end of the chamber 105 adjacent lickerin 100. Mounted beneath the lickerin 100 is a rotatable doffing bar or roll 110, and an adjustable deflection unit 112, which cooperates with a stationary plate 113 that extends downwardly beneath saber 108 to direct fibers from the lickerin 100 into chamber 56. This plate, in effect, is the fiber attenuating duct floor and upper section for the adjacent web formation units.

It will be appreciated that with the machine illustrated in FIG. 3, three completely different varieties of materials may be manufactured into a web W. For example, cotton fibers could be fed to chute 22, metallic fibers to center chute 92, and manmade or synthetic fibers to chute 23. The resultant web will have three different materials combined into an integrated web.

In the embodiment illustrated in FIG. 4 the center zone comprises a bin 115 adapted to hold a powdered binder, such as a phenolic resin. This bin extends across the machine between chambers 41 and 42, and has sidewalls 116 and 117 that are secured at their upper ends to the inner walls of chambers 41 and 42, respectively, and that converge downwardly. Mounted in the bin 115 is a conventional breaker rod assembly 120 for agitating the contents of the bin. This comprises a twin set of breaker arms 118, 119 which may be driven independently to feed the granular or powdered material in the hopper to the discharge port.

Mounted on the outside of plate 116 at the bottom of bin 115 is a conventional vibrating gage knife assembly 130, which is set to control the flow of the contents of the bin 115 out of the port 132 in the lower end of the bin onto a dispensing or feed roller 134, which is mounted beneath port 132 to rotate parallel to the condensers 69 and 70.

In use, a powdered or granular binder such as a phenolic resin, or the like, is placed in the bin 115 and fed continuously and at a predetermined rate, by the vibrating gage knife assembly 130, onto the roller 134 for distribution thereby into the upper end of the condensing chamber 56. For certain types of powder it has been found necessary to incorporate vibrating dispersion wires 36 adjacent to and around the roll 134 to loosen any particles that may tend to compact on the surface of this roll.

An important feature is that bin 115 is positioned just above the condensers 69 and 70; and the plates 138 and 140 are disposed to extend, respectively, between the feed roller 134 and the floor plate 60, and between the vibrating knife assembly 130 and the floor plate 59, thereby to prevent any powder or other granular material, that is fed out of bin 115, from being recirculated through the upper working parts of the machine, where it might cause blockages, or contaminate the bearings of the many rotating elements of the machine. The air flowing through the ducts 57 and 58 into the condensing chamber 56 distributes the powder, that is fed into the chamber by the roller 134, equally throughout the twin web or matrix being formed on the condensers 69 and 70.

In the embodiment illustrated in FIG. 5 the two outer zones are the same as in the embodiment illustrated in FIG. 4, but the center zone is modified to include a forehearth furnace 142 for supplying molten glass to spinnerets 144 connected at the bottom of the furnace. The spinnerets from spun glass filaments F and deliver them to an enclosure 146 in which a lubricant is applied to the filaments. They then pass through a cooler 148 to the upper end of a hollow forming hood 150. Hood 150 extends downwardly between the ducts 41 and 42, and opens on the upper end of the condensing chamber 56 between the lower edges of the floor plates 59 and 60.

The continuous glass filaments enter the upper end of chamber 56 and are guided by the hood 150 directly downwardly into the nip between the condensers 69 and 70, where they are stretched and formed, together with the fibers entering the inlets 57 and 58 into a web W in a manner similar to that described above.

Instead of producing glass filaments, the apparatus illustrated in the center zone of FIG. 5 may also be utilized to produce other types of man-made filaments or fibers such as cellulose acetate fibers or nylon filaments. Heated air may be forced through the forming hood 150 to remove undesirable quantities of volatile dope, which may be present on the fibers or filaments.

In FIG. 6 a further modification of the process has been illustrated, which is achieved by modifying the center zone of the machine to feed continuous filaments or yarns which are taken from creels and/or warp beams mounted in the top of the machine as, for example, in FIG. 1, and which are coated with a natural or synthetic type foam material. The foam material may be a thermoplastic such as ethylene, styrene, ure-

thane, a plastic resin, or a dispersion of a natural or artificial foam rubber.

By projecting these tacky, foam-coated continuous filaments into the matrix or web, it will be seen that the fibrous material formed constitutes an extremely novel resilient and lofty material wherein there are continuous foam rubber filaments running throughout the length, depth and width of the nonwoven web so that the fibrous materials, which are trapped between the foam castings, form links such that the fibrous material will be bonded between adjacent coated continuous filaments giving the web high resilience and loft.

In FIG. 6 continuous filaments 150 are fed downwardly through the center zone of the machine, where they are guided by glass rods 156 around one side of a doctor roll 158, which is mounted to rotate adjacent the upper end of floor plate 60 parallel to the condensers 69 and 70. The bottom of the doctor roll 158 extends into a tank 160, which is secured to the inside of plate 60 beneath the roll 158. The tank 160 contains a tacky material such as, for example, a natural or synthetic foam rubber, or any foamable thermoplastic substance, or thermosetting resin. The rotating doctor roll 158 picks up the foam from the tank 160 and applies it to the continuous filaments that extend over, or engage one side of the roll. This provides tacky, foam-coated continuous filaments that are guided downwardly into chamber 56. As these coated filaments extend downwardly into the throat T between the condensers 69 and 70, the fibrous material entering the ducts 57 and 58 is blended with these filaments to form, in a manner similar to that above-described, a web W.

FIG. 7 is a diagrammatic section showing the matrix bridge between condensers 69 and 70 during formation of a film web comprising short fibers and longer fibers or continuous filaments. The longer fibers 90, which extend from the matrix surface of one condenser to the matrix surface of the other condenser, are in such position that when the web is fully formed, they constitute a bridge or link across and between the upper and lower surfaces of the web.

The truly isotropic zoned or composite nonwoven webs, which are processed to form the products of this invention, may contain natural or synthetic, vegetable, animal or mineral fibers such as: cotton, silk, wool, hogs hair, sisal; synthetic or man-made fibers such as the cellulosic fibers, notably viscose, or regenerated cellulose fibers, cellulose ester fibers such as cellulose acetate and cellulose triacetate; the polyamide family of fibers such as nylon 6, nylon 66 and nylon 610; protein fibers such as "Vicara," halogenated hydro carbon fibers such as "Teflon" (polytetrafluoroethylene); hydrocarbon fibers such as polyethylene, polypropylene, and polyisobutylene; polyester fibers such as Kodel, Tereylene; vinyl fibers such as Vinyon and saran; acrylic fibers such as "Dynel," "Verel," "Orlon," "Acrilan," "Creslan;" mineral fibers such as glass, aluminum oxide, graphite, silicone carbide, silicone nitride, tantalum carbide, etc; thermoplastic or thermosetting extrusions, such as polymeric amides, vinylidene chloride, quartz and acetone solutions, protein base minerals, and petroleum derivatives.

As previously indicated, the air depression at the confronting condenser surfaces is just sufficient for the individual fibers to have enough kinetic energy to displace themselves in a truly isotropic nonwoven web whose upper and lower surfaces are of the same config-

uration. This contrasts with the prior art since heretofore the upper and lower surfaces of nonwoven random fiber webs have varied from one another because one surface would have a large percentage of fibrous material with a low mass while the other surface would have an excess percentage of fibrous material with a high mass.

Also nonwoven webs as heretofore formed have had an undesirable shingle effect or diagonal layering from the top surface to the lower surface. This is because the condenser surface is a continuously moving surface and the air-borne fibers tend to be attracted to the uncovered or least covered portions of this surface, the line of least resistance, which is continuously being rotated into the web-formation chamber so that the matrix is first formed on the area of the condenser screen entering that chamber. Thus, build-up of the fibers has two component motions, one circular and one rectilinear. The resultant motion of the matrix surface formed is that of a helix. The amount of material and the surface speed of the condenser allow the continuously moving surface of the matrix to be formed until the required weight or depth of material is obtained.

In forming a web in such a manner, the suction or depression at the condenser surface is diminished as the thickness of the web increases. Therefore discrimination of individual fibers is caused giving rise to the difference in upper and lower surface configuration, and to the shingle effect.

By contrast, a nonwoven web formed according to the present invention may have upper and lower surfaces of the same configuration by feeding like materials through the two outer ducts 22 and 23 (FIG. 1) of the machine, for instance. Should the materials fed into the two outer sections of the machine differ greatly from one another in length, denier, color, type, etc., however, the top and bottom surfaces of the finished web obviously will be of different texture and/or appearance. By adjustment of the twin condensers 69, 70 relative to each other, the matrix formation bridge moreover, may be reduced or increased, and the longer fibers locked through the nonwoven web. The web may be truly isotropic the fibrous material being randomly arranged in all directions throughout the width, length, and depth of the web. There are innumerable fibers which extend transversely throughout the depth of the web; and these fibers aid in tying the web into and integral structure, and impart to the web increased strength, resilience, and loft.

The absence of suction or of reduced pressure at the condenser surfaces allows the web to emerge from between the condensers in a continuous integrated web in a thickness determined by the quantity of fibrous material introduced, the resilient expandability of the material, and the spacing between the condenser cylinders.

Instead of feeding continuous filaments in the center section of the web as illustrated in FIG. 1, the continuous material may be cut film, that is, rolls of plastic film can be substituted for warp beam 74 and run over a series of closely-spaced cutting heads so that thinly-cut strips are formed to be incorporated in the nonwoven web in such a manner similar to the filaments F of FIG. 1.

With the present invention, moreover, three layered webs of different materials can readily be produced. FIG. 8 shows one such web. Here the top portion 195 of the web may be of 20 denier ½ inch nylon fibers, for

instance, the middle portion 196 may be of 5 denier 1 inch rayon, for instance, and the bottom portion 197 may be made of wood fibers. Moreover, the different layers may be of differently colored material. Top portion 95, for instance, may be made from nylon dyed yellow; middle portion 96 may be made from red-dyed rayon; and bottom portion 97 may be made of white bleached wood pulp fibers. It is to be noted that in the web illustrated in FIG. 8 some of the longer fibers are locked through the web and extend from top to bottom of the web.

The layers of the web, however, obviously may be all of the same color and may differ only in denier. For instance, the top layer may be of 5 denier, the middle layer of 3 denier, and the bottom layer of 1 denier. The web may also be made from two different materials, with top and bottom layers the same. Thus, the top and bottom layers may be of acrylic fibers; and the middle layer may be made of polypropylene. On the contrary all three layers of a web may be made of the same basic material, but in different fiber lengths and/or colors. Thus, all three layers may be made of rayon, the upper layer being made from red rayon whose fibers are ½ inch in length, the middle layer being made from white rayon, whose fibers are 1 inch in length, and the bottom layer being like the top layer in that it is made from red rayon fibers but these fibers being on the other hand 2 inches in length. Another example of the possibilities achievable with the machine of this invention is a web made of three different materials, as, for example, nylon, wool, and dacron, the three different materials being laid down in substantially three different layers.

The web formed in any event may be drafted to the take-off conveyor C (FIG. 1) and delivered to any desired subsequent process.

Having thus described my invention, what I claim is:

1. The method of manufacturing a non-woven textile web comprising conveying the fibers by two separate spaced air streams into a common enclosed chamber and into the nip between two oppositely rotating foraminous condensers so that the fibers of the two streams are intermingled and arranged in random manner, and simultaneously delivering to the condensers into said chamber and into said nip between the fibers a material different from the fibers which are carried by

the two air streams, so that the condensers form between them a nonwoven random fiber web composed of at least two different materials.

2. The method according to claim 1, wherein said different material comprises continuous filaments.

3. The method according to claim 2, wherein said continuous filaments are spun fibers selected from the group consisting of plastic fibers and glass fibers.

4. The method according to claim 1, wherein said different material is allowed to fall by gravity into said nip, and the condensers are so disposed that individual fibers delivered into the nip between the condensers are of sufficient length to extend across said nip from one condenser to the other.

5. The method according to claim 1 wherein said different material is a fibrous material, and the fibers carried by the two air streams are staple fibers.

6. The method according to claim 2, wherein the continuous filaments are coated with a tacky substance and then fed to the condensers.

7. The method according to claim 2, wherein some of the filaments are guided into the chamber into said nip to form warp threads in said web and other filaments are guided and laid down transversely of the first-named filaments to form weft threads in said web.

8. The method of manufacturing a nonwoven textile web comprising preforming fibrous material into two separate feed mats, combing fibers from the two separate fiber mats by two separate lickerins rotating at high speed about separate axes, doffing centrifugal fibers from the lickerins by centrifugal force, due to the high speed rotation of the lickerins, and by two separate air streams flowing past the two lickerins, and conveying the fibers by the two separate spaced air streams into a common enclosed chamber and into the nip between two oppositely rotating foraminous condensers so that the fibers of the two streams are intermingled and arranged in random manner, and simultaneously delivering to the condensers into said common chamber and into said nip and between the fibers a material different from the fibers which are carried by the two air streams, so that the condensers form between them a nonwoven random fiber web composed of at least two different materials.

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