

Oct. 4, 1955

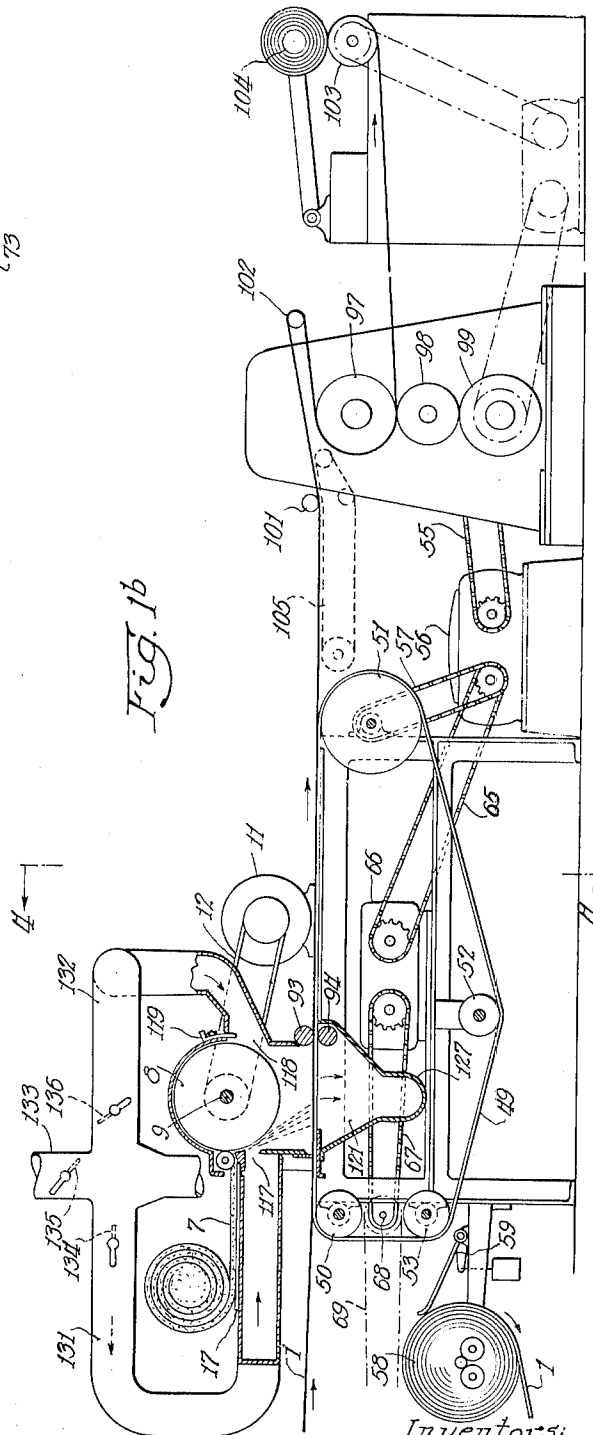
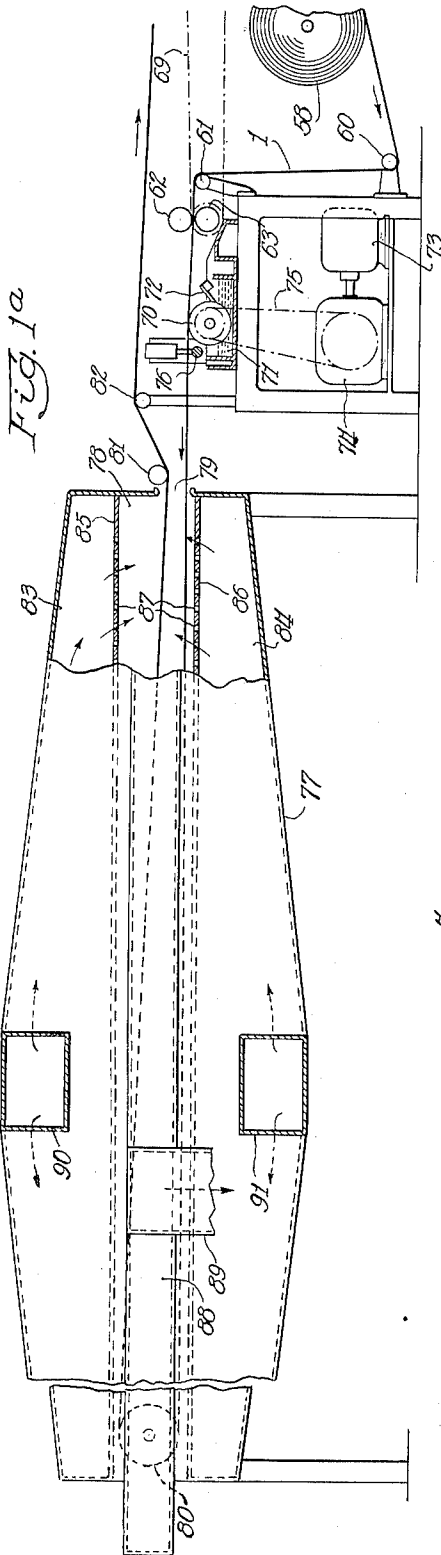
K. J. HARWOOD ET AL

2,719,337

METHOD OF MAKING NON-WOVEN FABRIC

Filed May 28, 1949

6 Sheets-Sheet 1



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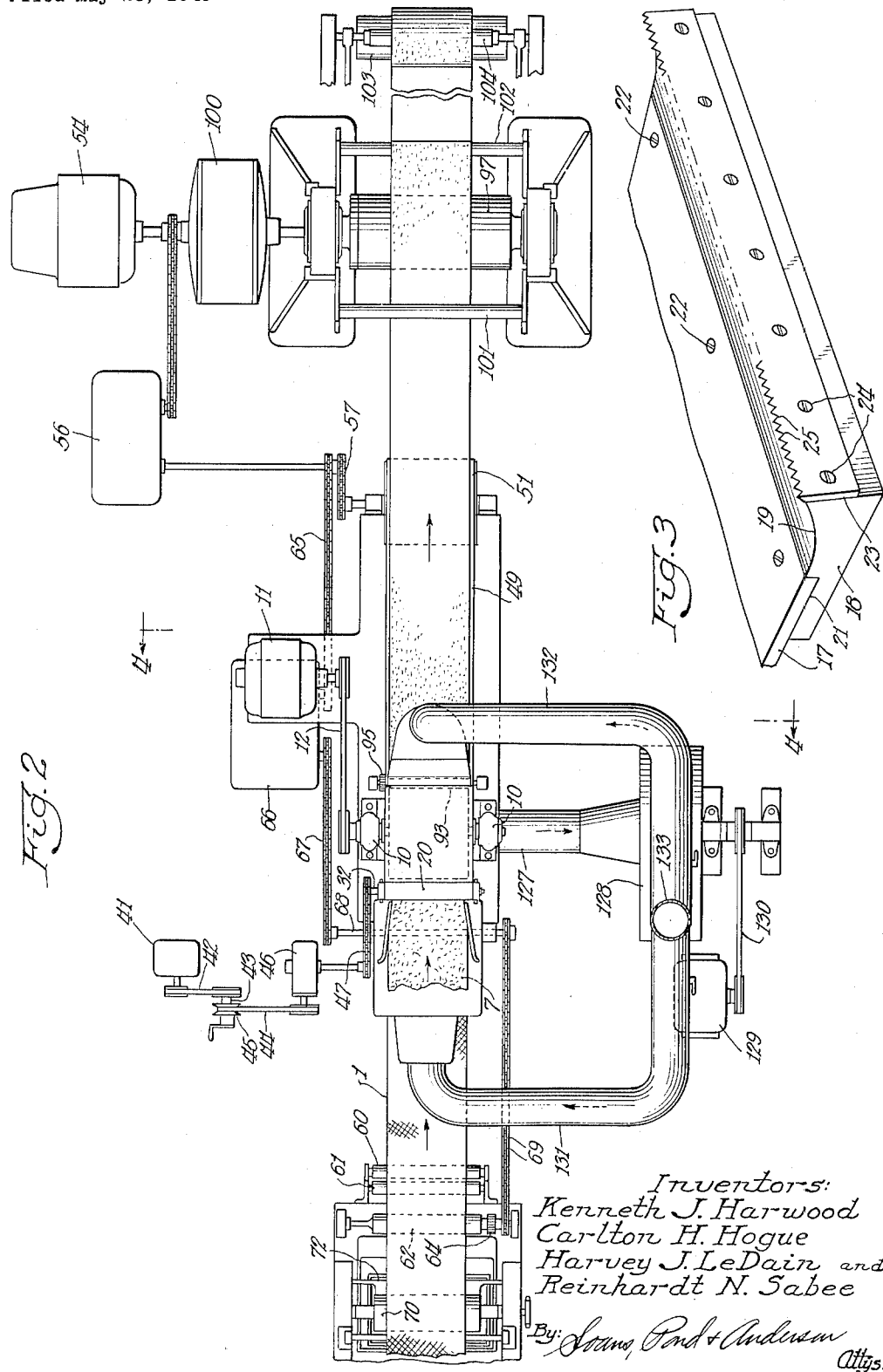
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6 Sheets-Sheet 3

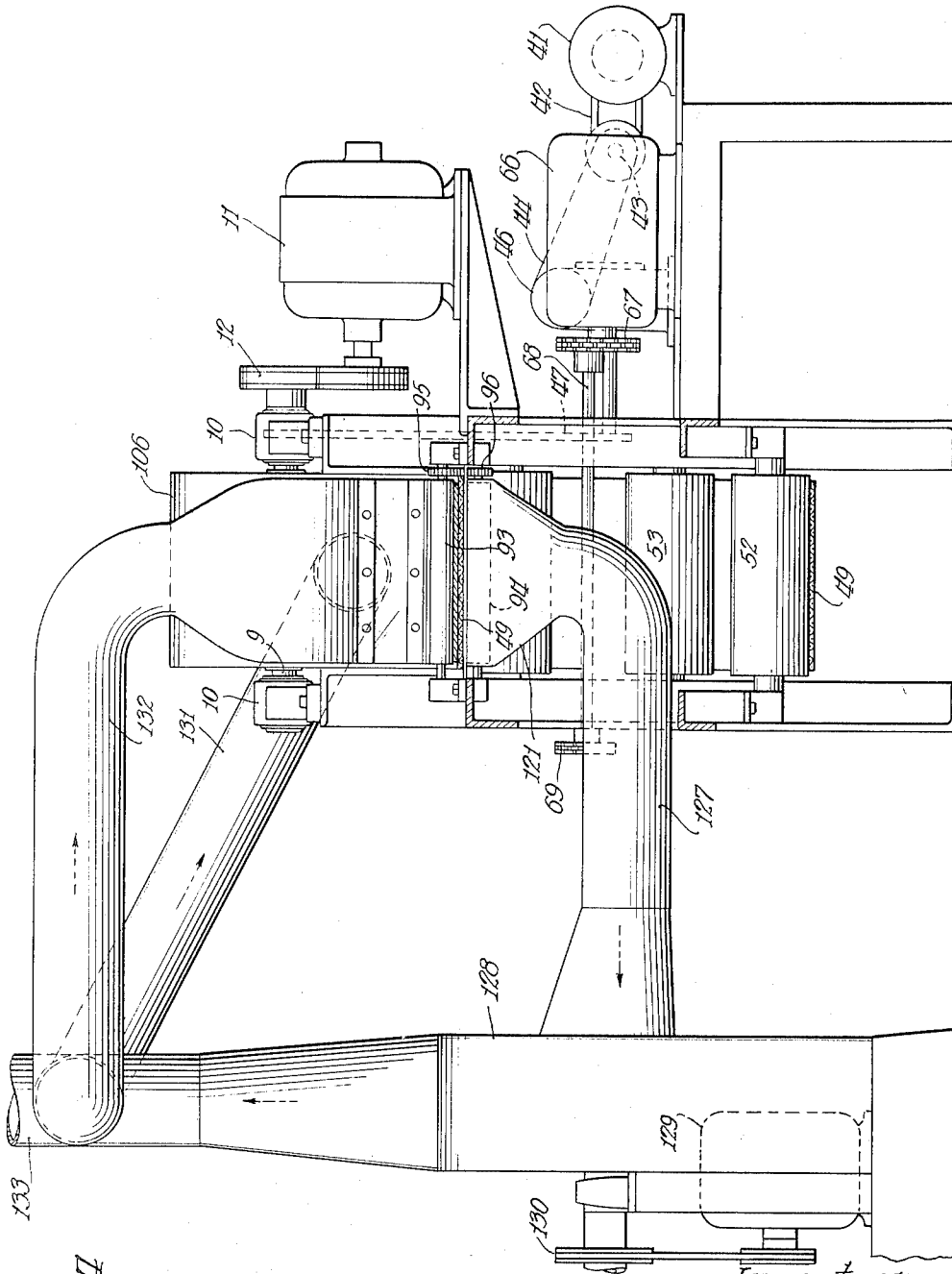


Fig. II

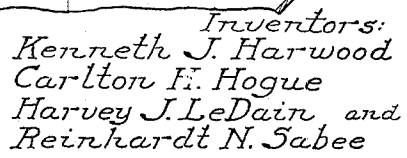
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METHOD OF MAKING NON-WOVEN FABRIC

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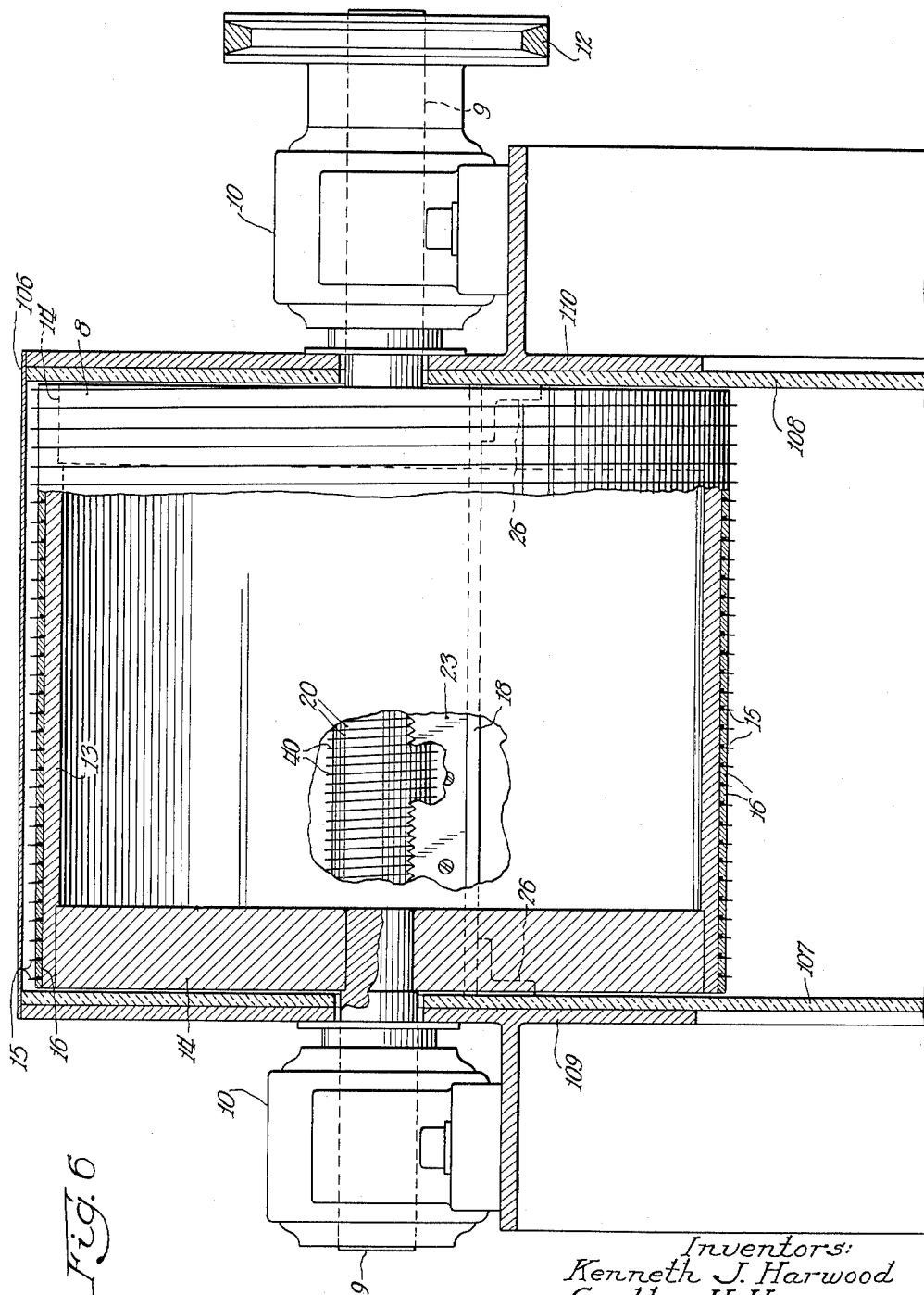
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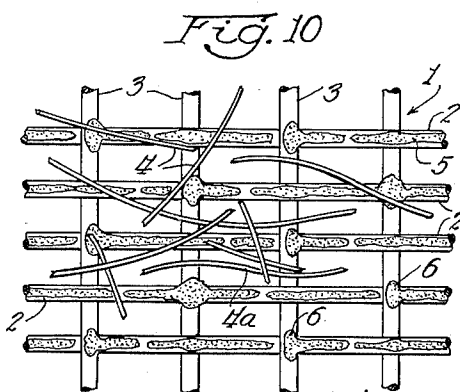
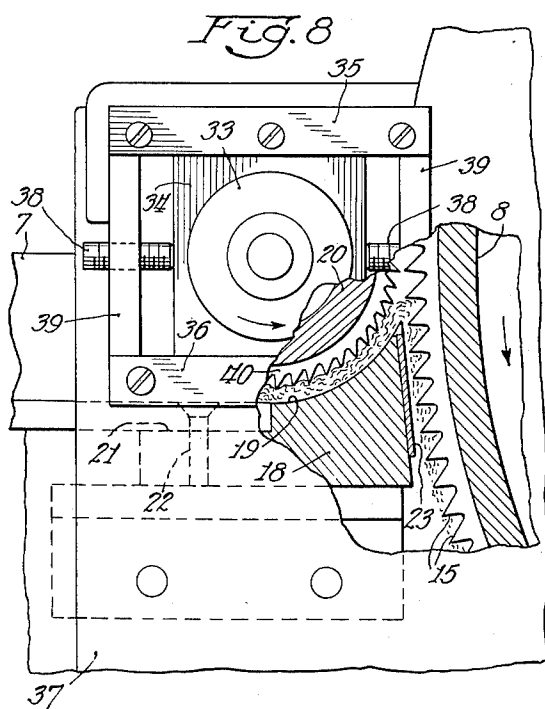
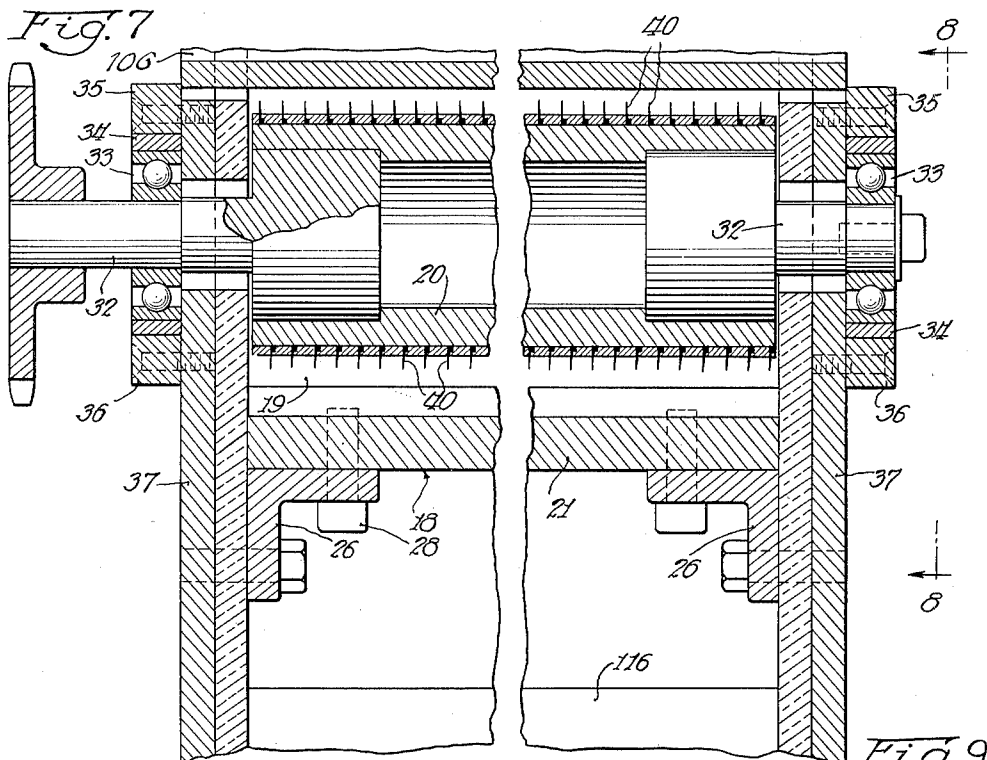
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6 Sheets-Sheet 6



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2,719,337

METHOD OF MAKING NON-WOVEN FABRIC

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Application May 28, 1949, Serial No. 96,006

13 Claims. (Cl. 19—156)

This invention relates to the production of textile fabric wholly or partially of nonwoven fibers. Fabric made partially of nonwoven fibers according to the present invention comprises a supporting web or backing of woven material such as gauze, or of a plurality of threads of fibrous material usually extending lengthwise of the fabric as produced. The backing may also consist of other forms of sheeting having characteristics required in the finished product, tensile strength for example, which characteristics might not be present in the nonwoven component of the fabric. To such a backing sheet, whatever its character, a layer or facing of nonwoven fiber is applied and bonded.

Nonwoven fabric made wholly of nonwoven fibers according to the present invention contemplates a web of material formed by bonding together fibers deposited in the form of a layer of desired thickness and density, the fibers being natural or synthetic fibers selected to provide in the finished product the desired characteristics such as smoothness, softness, flexibility, etc., mixtures of various kinds of fibers being sometimes used in order to obtain some of the properties of each kind of fiber used in the finished product.

The main objects of the invention are to provide a method and apparatus whereby fabrics of the character indicated may be produced at a high rate of speed and at low cost; to provide such a method and apparatus which will be dependable and efficient in operation and which will afford effective control of the weight or density of fiber deposited per unit of area of the finished web and which will also facilitate control of the relationship of the fibers to each other.

Other objects and advantages of the invention will be understood by reference to the following specification and accompanying drawings (6 sheets) in which there is illustrated a selected embodiment of apparatus for producing a textile fabric web embodying nonwoven fiber, with or without a backing sheet, and also one modification of such apparatus.

In the drawings:

Figs. 1a and 1b are side elevations of the left-hand and right-hand portions of the apparatus, certain portions being shown in section to clarify the disclosure;

Fig. 2 is a plan of that portion of the apparatus shown in Fig. 1b;

Fig. 3 is a perspective illustrating a detail of the apparatus which appears also in Figs. 4, 5, and 7 of the drawings;

Fig. 4 is a cross section on the line 4—4 of Figs. 1b and 2;

Fig. 5 is a cross section corresponding to a portion of Fig. 1b but on a greatly enlarged scale so as to more clearly illustrate some of the important details of the structure;

Figs. 6 and 7 are cross sections, respectively, on the lines 6—6 and 7—7 of Fig. 5;

Fig. 8 is a fragmentary view corresponding in part to a portion of Fig. 5 but showing other parts in elevation;

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Fig. 9 is a fragmentary perspective of a detail of construction;

Fig. 10 is a more or less schematic illustration on an enlarged scale of composite nonwoven and woven material fabric which may be produced by the apparatus shown in the other figures.

The material shown in Fig. 10 has a woven gauze backing sheet 1 which comprises lengthwise-extending threads 2 and cross threads 3 interwoven in the usual manner to form a gauze web. Nonwoven fibers are represented at 4, these fibers being deposited, in the illustrated example, in a haphazard manner on one face of the backing sheet, some of these fibers being adhesively bonded to the gauze and some, such as the one indicated at 4a being free of adhesive attachment but held to the gauze by one or more other fibers which are adhesively attached to the gauze and which overlie said fiber 4a. Adhesive is applied to the gauze so as to occur more or less continuously, as represented at 5, along the lengths of the lengthwise-extending threads 2 and in small accumulations or blobs 6 which occur at alternate intersections of the lengthwise and crosswise threads of the backing sheet. Fabric embodying these details of construction is the subject matter of copending application Serial No. 71,904 filed January 21, 1949.

In some instances, the application of adhesive by coating the gauze may be replaced by incorporating in the gauze some threads of thermoplastic material, or by incorporating in some of the threads of the gauze, fibers of thermoplastic material. Also, the stock of fibers deposited on the web may contain at least some thermoplastic fibers. Heat, or pressure, or both, or treatment with solvents or other agents, may be employed to cause the thermoplastic content of the gauze or fiber stock to adhesively bond the applique of nonwoven fibers to the gauze.

For some purposes the fibers 4 may be formed into a layer on a forming screen or belt or other surface in the absence of a backing element and the fibers adhesively bonded to one another. Adhesive bonding of fibers to one another may be effected by applying adhesive in discrete particles or otherwise to some or all of the fibers as by spraying suitable adhesive material on and into the fiber layer. Such bonding may also be effected by employing a predetermined amount of fibers of thermoplastic material in the fiber stock and subjecting the fiber layer to heat or pressure or both, or to treatment with solvents to activate the thermoplastic material. In fiber mixtures of this kind, the thermoplastic fibers constitute both a fiber and an adhesive component of the web. The web may, of course, be made entirely of thermoplastic fibers, but for many purposes, a mixture of cotton or other non-thermoplastic fibers with a small proportion of thermoplastic fibers is more desirable.

Fiber to be formed into a layer of the required density and thickness may advantageously be supplied to the apparatus in the form of a fairly dense, self-sustaining bat 7, usually in roll form as shown in Fig. 1b. This bat is fed into a divellicating or similar mechanism which will tear the fibers one by one from the end of the bat and effect deposition of the fibers in the desired layer form on a backing web such as the gauze backing 1 or directly on a forming member from which the fiber layer may later be stripped as an integrated web.

The divellicating apparatus shown best in Figs. 5 to 8, inclusive, comprises a roll 8 carried by a shaft 9 which is rotatably supported in bearings 10 mounted on a suitable supporting frame. The shaft 9 and the roll 8 are driven at high speed with reference to the speed at which the bat of fibers is fed to the roll. In one instance, an electric motor 11 acting through a belt 12 and suitable

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pulleys on the motor shaft and on the shaft 9 drive the roll 8 at a peripheral speed of 6,000 ft. per minute. This, and other speeds of operation herein mentioned may vary considerably, depending upon the kind of fiber being used, the weight of product desired, and other factors.

The roll 8 may be of hollow construction as shown in Figs. 5 and 6, embodying a cylindrical tubular body 13 and end plates such as represented at 14 fixedly seated in the ends of the cylindrical body 13. The shaft 9 is preferably composed of separate sections respectively secured to the end plates 14 and projecting outwardly therefrom into the supporting bearings 10 as illustrated in Fig. 6.

The cylindrical outer surface of the member 13 is provided with clothing 15 which may be formed by spirally winding a saw-tooth strip about the roll, one form of such strip being represented in Fig. 9. This clothing is anchored securely to the surface of the roll by means of an anchoring strip 16 which is wound on the roll intermediate the coils of the clothing, the ends of said strip and intermediate portions thereof being suitably fastened to the roll. This clothing 15 provides a multiplicity of sharp teeth on the roll 8, the sharpened ends or points of the teeth being located accurately at a uniform distance from the axis of rotation so that the points of said teeth lie in a substantially true cylinder about the axis of rotation of the roll 8.

The bat 7 of fiber material is fed toward the roll 8 over a normally stationary supporting table 17 which is suitably mounted on the framework of the apparatus. At the delivery end of said table there is provided an end member 18 which has an arcuate upper surface 19 substantially concentric with the axis of rotation of a feed roll 20. Said member 18 is provided with a ledge 21 to which the delivery end portion of the table plate 17 is suitably attached as by means of fastening screws represented at 22. At its free end the member 18 is provided with a comb 23 which is attached to the member 18 by means of screws 24 or the like as represented in Fig. 3. Said screws have their heads countersunk into the comb 23 so that they will not project from the free face of the comb into the path of the teeth of the clothing 15 on the roll 8. The teeth 25 of the comb project upwardly in continuation of the normal plane of the body of the comb.

The end member 18 is so adjusted as to bring the free face of the comb plate 23 about as close to the points of the clothing 15 as is possible without having actual contact with said points. To permit such adjustment, the member 18 is supported on brackets such as represented at 26 (Figs. 5 and 7), said brackets being bolted to up-standing frame parts or side plates forming part of the mechanism. Said brackets are preferably provided with horizontally elongated slots represented at 27 to permit a certain amount of horizontal adjustment of the position of the brackets relative to the supporting plates and relative to the toothed drum 8. The member 18 is in turn secured to the brackets 26 by means of bolts represented at 28 which extend upwardly through horizontally elongated slots 29 in the brackets and into threaded holes provided in the member 18. By providing the elongated slots 29, horizontal adjustment of the member 18 is permitted, the bolts 28 being adapted to be tightened to lock the member 18 in selected position of adjustment.

To facilitate very fine or micro-adjustment of the member 18 toward and from the tooth drum 8, an adjusting means is provided in the form of screws 30 which are threaded into suitably tapped openings in the ledge portion of the member 18 and rotatably but axially immovably anchored in ears such as indicated at 31 which project upwardly from the respective brackets 26. By turning the screws 30, the member 18 together with the table plate 17 and the comb 23 will be adjusted toward or from the toothed drum 8.

The feed roll 20 is, in this instance, of hollow construction having stub shafts 32 (Fig. 7) anchored in and projecting from the opposite ends of the roll and journaled

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in suitable anti-friction bearings such as shown at 33 which are supported in bearing blocks 34 (Figs. 7 and 8). The bearing blocks 34 are horizontally, adjustably, slidably mounted in upper and lower ways 35 and 36 which are screwed or otherwise secured to the frame side plates 37 which also support said brackets 26. The bearing blocks 34 are adapted to be adjusted toward and from the tooth drum 8 by means of adjusting screws such as represented at 38 which are threaded through fixed members 39 into engagement with the respectively adjacent edges of said bearing blocks 34. By appropriately adjusting the said screws 38, the bearing blocks 34 and the feed roll 20 may be minutely and accurately adjusted toward and from said drum 8.

The feed roll 20 is provided with clothing 40 on its surface, this clothing being of the same character as the clothing 15 on the drum 8 but of somewhat smaller tooth formation as best shown in Fig. 8. The teeth of the feed roll 20 are preferably faced oppositely to the direction in which the fiber bat is fed. A longitudinally fluted feed roll may be substituted for the toothed feed roll described, the important consideration being that of providing a feed which will positively control the advance of the bat toward the roll 8. When a fluted feed roll is used, it is preferable that it be spring biased toward the feed table so as to maintain effective control of the bat 7 being fed to the roll 8.

The feed roll 20 is driven at a relatively slow and carefully controlled rate of speed so as to effectively control the rate at which the bat 7 of fibers is fed to the divellicating roll 15, thereby to present to the clothing of said roll 8, end portions of the bat of about fiber thickness, said drum 8 being thereby enabled to tear individual fibers from the bat rather than chunks containing a plurality of fibers.

The feed roll 20 may be driven in various ways, and in this instance, it is shown (Fig. 2) as being driven by an electric motor 41, a belt 42 engaging pulleys on the driven shaft of the motor and on the shaft of a speed jack 43, a belt 44 which is driven by a variable diameter pulley 45 of the speed jack and engages a pulley on the input shaft of a speed-reducing drive unit 46, the output shaft of which is provided with a sprocket for driving a chain 47 which engages a sprocket on one of the shafts 32 of the feed roll.

The toothed feed roll 20 is operative in cooperation with the delivery end of the table 17 and the arcuate surface 19, as indicated in Figs. 5 to 8 to compress the bat 7 of fibrous material to a small fraction of its initial, normal thickness and to feed said compressed bat upwardly over the teeth of the comb 23. Immediately above the comb 23, the compressed fiber material tends to expand so that the end portion of the bat which is engaged by the teeth 15 of the roll 8 is relatively loosely matted; divellication of the bat, fiber by fiber, by the action of the toothed drum 8 is thereby facilitated. The fiber-pulling action of the toothed roll 8 also effects pulling of the approaching end portion of the compressed bat downwardly over the teeth 25 of said comb so that the teeth of the comb more or less impale the end portion of the bat. Breaking of chunks of the bat from the end portion thereof is thereby effectively prevented, and the separation of single fibers substantially assured. The teeth of the feed roll 20 are preferably disposed at an angle such as illustrated so that they will tend to resist pulling of the bat 7 forwardly past the feed roll which, therefore, exercises effective control of the advance of the bat toward the comb 23 and the roll 8.

In one operative arrangement, the drum 8 is driven at a peripheral speed of around 6,000 feet per minute, while the feed roll 20 is driven at a peripheral speed of about 2 feet per minute. The comb 23 is adjusted relative to the drum 8 to provide a clearance of about only .008 inch between the toothed edge of the comb and the ends of the teeth of the roll 8. Similar clearances may be main-

tained between the teeth of the drum 8 and the teeth of the feed roll 20.

Under conditions which will presently be explained, the individual fibers separated from the bat 7 by the roll 8 are discharged in a stream 48 (Fig. 5) to a forming wire or to a gauze or other backing sheet depending upon the type of fabric to be produced. The fibers are discharged from the teeth of the roll 8, at least in part, by centrifugal force developed by the rotation of the roll. This fiber discharge may also be more or less effected or aided by air currents which are produced as hereinafter explained and which flow more or less over the surface of the roll in such directions that they may tend to strip the fibers from the roll.

By advancing the bat 7 very slowly by the described slow rotation of the feed roll 20, and by rotating the divellicating roll 8 at said high speed, a low density fiber stream is produced. This low density stream, and the high speed travel thereof incident to the centrifugal force with which the fibers are discharged from the roll 8, and the implementing of said travel by air currents as mentioned, are very helpful in attaining uniform fiber distribution in the layer or web 1 of nonwoven fiber and also freedom from fiber clots or bunches in said web. Low density in the stream permits the fibers to remain separated during their travel in the stream from the roll 8 to the intercepting foraminous member 49 on which the fibers are collected in said layer or web form, and the forced or fast movement of the fibers in the stream tends to prevent straying or migration of the fibers from the stream, such straying being also resisted by said air currents as hereinafter explained.

In Fig. 5, a gauze backing web 1 is illustrated as being propelled by means of a supporting screen or wire 49 transversely, diagonally across the path of the fiber stream 48 so that the fibers are deposited on said gauze backing web. The fibers in the stream 48 are forcefully propelled at high speed directly to said screen 49 or to the web 1 on said screen. The centrifugal force with which the fibers are discharged from said roll 8, and the windage developed by the rotation of said roll as aforesaid produce force which is capable of so delivering the fibers to the screen. These forces may be supplemented and strengthened, as above indicated, by other air currents which are produced as hereinafter described. The gauze web is, in this instance, preliminarily provided with thermoplastic adhesive material; this adhesive material is largely set but nevertheless retains at least slight surface wetness or tackiness when it passes through the fiber stream so that the fibers will become almost immediately adhesively secured to said backing web upon contact therewith. For most purposes the adhesive attachment so obtained is not secure enough and the backing web together with the fiber facing thereon is subjected to further operations to improve or perfect said adhesive bonding.

When the fiber is to be applied to a gauze or other web to form a facing on such web, the web is propelled transversely of, i.e. across the path of the stream 48 of fibers by means of the supporting screen 49 which is in the form of an endless belt trained around and supported and guided by suitably journaled rollers 50, 51, 52, and 53 (Fig. 1b). One of these rollers, for example, the roller 52 may be vertically, adjustably mounted so as to constitute a belt-tensioning roll arranged to maintain the upper, operative reach of the belt in the desired degree of tautness. The roller 51 may be positively driven, preferably by means of adjustable speed driving mechanism so that the speed of travel of the belt 49 may be gradually adjusted through a suitable range of speeds.

In this instance, the pulley or roller 51 is shown as being driven by an electric motor 54 (Fig. 2), through a chain drive 55 to a variable speed drive unit 56 and a chain drive 57 (see also Fig. 1b).

The web 1 has driving engagement with substantially the entire length of the upper reach of said screen belt

49 whereby said belt will have sufficient tractive force on the web to insure travel of the web and belt as a unit through the fiber-laying chamber. Suitable other drives applied to the web 1 before it enters the fiber-laying chamber and after it leaves the same also aid in propelling the web.

The web 1 may be drawn from a supply roll 58 suitably rotatably supported as indicated in Fig. 1b, a weighted brake arrangement 59 being provided to prevent unwinding of the roll as the result of momentum when positive web-propelling forces are stopped. The web is guided from the roll 58 around suitably supported guide rolls 60 and 61 (Fig. 1a), and between a pair of cooperating web feed rolls 62 and 63. The feed rolls 62 and 63 are geared together as indicated at 64 (Fig. 2) and the feed roll 63 is illustrated as being positively driven by the motor 54 through the speed changer 56, a chain drive 65, a second variable speed drive 66, a chain drive 67, shaft 68, and a chain drive 69. The rolls 62 and 63 cooperate to pull the web 1 from the supply roll 58, and from said feed rolls the web is guided over adhesive-applying mechanism.

The adhesive-applying mechanism may be of any suitable character, it being represented in this instance as consisting of an applicator roll 70 (Fig. 1a) which rotates in a bath 71 of adhesive material, the amount of adhesive carried by the roll 70 being governed by a doctor blade 72. The adhesive applicator should, of course, be selected to suit the particular kind of adhesive being applied. In this instance, it is contemplated that the adhesive be of a thermoplastic character and of such consistency that when applied by the roll 70 it will not soak into the web but will remain substantially on the surface of the web 1 or on the surface of the threads of the web if the latter is made of threads. The adhesive is, also, for most purposes, preferably of a permanently flexible type so that it will not seriously impair the normal softness and flexibility of the web to which it is applied. The adhesive material is, of course, to be selected with due regard for the purpose to which the finished material is to be applied.

The adhesive-applying roll 70 may be positively driven by any suitable means such as an electric motor 73 operating through a speed-reducing unit 74 and a chain drive 75 to said roll. An independent drive is provided for the applicator roll 70 so that the latter may be maintained in rotation when the remainder of the apparatus is stopped so as to prevent setting of the adhesive on the exposed part of the applicator roll. Suitable gauze-lifting mechanism 76 is also provided for lifting the gauze from the roll 70 during any period in which the feed of the web is stopped. This lifting mechanism 76 may be automatically, electrically actuated by suitable connections to the controls whereby the other parts of the apparatus are stopped. The details of this web lifting mechanism form no part of the present invention, wherefore the same are not shown.

When the adhesive is of thermoplastic character, it is preferably at least partially dried before the fiber is deposited on the web, and to that end the adhesive bearing web is guided through drying mechanism 77. This drying mechanism comprises a central, elongated chamber 78 having an opening 79 at one end and a roll 80 journaled therein adjacent its other end. The web 1 enters the chamber 78 through the opening 79, traverses the length of said chamber and is trained around said roll 80 and again traverses the length of said chamber but in the reverse direction and thence under a guide roll 81 at the mouth of the chamber. From the guide roll 81 the web passes over a guide roll 82 to the screen belt 49 as will be apparent from an inspection of Figs. 1a and 1b.

The drying chamber has associated with it, upper and lower manifolds 83 and 84, respectively, (Fig. 1a) which have bottom and top walls 85 and 86, respectively, provided with a multiplicity of perforations 87 to permit air

to flow from the respective manifolds into said drying chamber 78. The perforated walls 85 and 86 serve to effect substantially uniform distribution of air flow from the manifolds to the respectively adjacent lengths of the web 1 during its travel through the drying chamber. Air is exhausted from the drying chamber by means of an exhaust manifold 88 which extends along the side of the drying chamber, and has connection ports suitably distributed along the length of the drying chamber. A conduit 89 may connect the exhaust manifold 88 to an exhaust fan which may discharge the exhausted air into the atmosphere or into heating or cooling means from which the air may be returned to the manifolds 83 and 84 through suitable ducts 90 and 91. To effect setting of thermoplastic adhesive, air at atmospheric temperature may be circulated or, if preferred, suitably cooled air may be circulated. Similarly, dried or heated air may be circulated, depending upon the kind of adhesive employed and the kind of drying effect desired.

After the fiber facing has been deposited on a carrier web or after a fiber web has been deposited directly on the foraminous belt 49, it is subjected to further treatment to improve the bonding between the fibers and between the fibers and the carrier web, after which the fiber web or the fiber-faced carrier web may be rolled on itself into supply rolls for subsequent use.

The carrier web with the fiber facing deposited on the web in the chamber 92, or the unbacked non-woven fiber formed on the wire 49 in said chamber, emerges from said chamber by passing between a pair of rubber covered rolls 93 and 94 (see Fig. 5). These rolls are interconnected by gears 95 and 96 for simultaneous rotation, and they may be driven by suitable connections to the driven pulley 51 or merely by friction from the forming wire 49 as shown in this instance. These rolls 93 and 94 may be spring loaded, or the weight alone of the upper roll may be relied upon, to urge the rolls together with sufficient force to cause said rolls to press together the fibers, or the fibers and carrier web, so as to cause a physical inter-attachment of said fibers or of said fibers and gauze. Inter-attachment so effected is sufficient to render the web self-sustaining to an extent which permits the web to travel without breaking, through mechanism for improving or perfecting the bonding of the fibers to each other and to a backing web, if present.

The mechanism for improving or perfecting said bonding comprises a calendar stack having an upper vertically movably mounted hard roll 97 which is preferably heated to a predetermined temperature, a cooperating calendar roll 98 and a backing or supporting roll 99. The roll 99 may be water cooled so as to be adapted to prevent over-heating of the roll 98 which, in some instances and for certain purposes may be constructed of material which may be injured by excessive heating. The rolls 97, 98 and 99 are yieldingly urged together under considerable pressure so that the fibers in the facing web, and said fibers and backing web if present, will be pressed tightly together in the presence of heat whereby thermoplastic adhesive on the backing web, or thermoplastic fibers or adhesive in the layer of fibers, will be softened and caused to adhesively bond the components of the web being made.

The rolls 97, 98, and 99 may be suitably driven from the motor 54 through a speed-reducer 100 (Fig. 2) which is preferably connected directly to the lower roll 99. The frictional contact between the cooperating calendar stack rolls serves, of course, to cause the rolls 97 and 98 to be driven from the roll 99. As shown in Fig. 1b, the web is guided from the foraminous belt 49 under a guide roll 101 and around a guide roll 102, and thence around the calendar roll 97. The web is thereby maintained in engagement with the surface of the heated roll 97 about half way around the circumference thereof whereby adequate heating is assured to soften the thermoplastic before pressure is applied between the rolls 97 and

98. This insures adequate heating of thermoplastic components of the web to produce the desired effective bonding. From the calendar stack the web is carried around the drive roll 103 of a winding mechanism and around a reel core 104 on which it is wound. In some instances, particularly when making wholly non-woven fiber webbing, a transfer conveyor 105 may be interposed between the web forming mechanism and the calendar stack for supporting the relatively weak web.

In the arrangement shown (Fig. 5), the roll 8 and feed roll 20 are enclosed in a housing comprising an approximately semi-cylindrical cover 106 which extends between and over upstanding end wall plates 107 and 108, respectively, (Fig. 6), which are suitably supported by attachment to rigid frame-supported end wall members 109 and 110, respectively. The end plates 107 and 108 may advantageously be formed of transparent plastic sheeting (such as typified by Lucite) which has a very smooth polished surface to which the fibers will not readily cling. The feed roll 20 (Fig. 5) is, in effect, housed by a cover 111 which overlies said feed roll and extends into engagement with the adjacent marginal portion of the cover 106. At the opposite edge of the feed roll cover 111, it is provided with a down-turned flange-like portion 111a to which is secured an apron 112. Said apron 112 has its lower portion curved to approximately concentric relationship to the feed roll and it extends downwardly to such extent that its lower edge bears against the fiber bat 7, to thereby produce a seal against the passage of an excessive amount of air into the housing at the point of entrance of the fiber batting.

To complete the housing, front and back baffle-plates 113 and 114 (Fig. 5) are provided more or less in extension of the cover 106 on the inlet and outlet sides, respectively, of the web forming chamber. The front baffle-plate 113 may be supported by suitably adjustably attaching its ends, as indicated at 115, to the opposite end plates 107 and 108, so as to permit adjustment of said baffle inwardly and outwardly of said forming chamber 92. Said plate 113 is preferably provided at its upper edge with a vertically adjustable lip 116, whereby the opening permitted to remain between the baffle 116 and the overlying portion of the feed structure may be adjusted to thereby control the flow of air into the housing through the opening indicated at 117. A strip 113a is mounted on the lower marginal portion of the baffle 113, so as to be adjustable toward and from the forming wire 49. This provides an adjustable seal between the forming wire 49 or backing web 1 thereon, and the baffle 113. The rear wall or baffle 114 may be mounted by attachment at its opposite ends to the side plates 107 and 108 in fixed relation to the roll 93, the upper edge of said baffle being spaced from the adjacent edge of the cover 106 to provide an air inlet opening 118. A plate 119 is adjustably mounted on the overlying marginal portion of the cover 106 for the purpose of adjusting the width of the opening between the edge of the cover and the upper edge of the baffle 114. Suitable locking means such as indicated at 120 is provided for holding the plate 119 in selected position of adjustment.

A suction box 121 is provided under that portion of the screen belt 49 which forms the bottom of the housing or forming chamber, and the effective length of said suction box may be adjusted by means of a top plate 122 which is horizontally slidably adjustably mounted on the upper end of the suction box 121. Said plate 122 may be adjusted inwardly and outwardly to vary the size of the effective opening remaining between the forward edge 124 of the plate 122 and the opposite edge 125 of the suction box.

The suction box 121 is connected by a suitable conduit 127 to the intake port of a suction fan or blower 128 which is suitably driven by an electric motor 129 (Figs. 2 and 4) and a belt drive 130. The discharge port of

the blower 128 is connected by suitable ducts 131 and 132 to the front and rear sides respectively of the forming chamber. An exhaust pipe 133 (see Fig. 1b) is also provided to permit discharge to the atmosphere of some of the air drawn from the suction box 121 to thereby facilitate regulation of the air pressure developed in the indicated air-circulating system. Dampers such as represented at 134, 135 and 136 may be provided in the respective ducts to regulate the air currents flowing there-through.

In the arrangement shown, it will be seen that air is caused to flow through the foraminous carrier web 1 and the foraminous supporting belt 49 to thereby effect fairly strong, frictional attachment of the fibers to the backing web, if used, and to each other, whether deposited on a backing web or directly on the forming screen wire 49. Some or all of the air exhausted from the forming chamber by the suction box may be recirculated by being reintroduced to said chamber through the inlet openings 117 and 118 in proportions determined by the selected settings of the dampers 134, 135 and 136, and by the settings of the front and rear baffle members 116 and 119. Air currents, within the chamber, which result from the delivery of air through said openings 117 and 118, flow against or toward the front and rear sides respectively of the stream 48 of fibers and in the direction of said stream and appear to have the effect of confining the separated fibers in a fairly well defined stream.

By adjusting these respective air currents, the position of the stream and its width (front to rear) at the screen may be controlled with considerable effectiveness. These air currents are discharged from the chamber through the forming screen (including the carrier web if present) into the suction box 121, and some of the air from said air streams flows through the web formed on said screen and thereby tends to increase the matting of the fibers in the web, whereby initial web strength is somewhat improved. These air currents also serve to prevent the accumulation of stray fibers in the corners of the chamber. A current of air similarly flows into the suction box 121 through the opening indicated at 137 outwardly of the rear wall 114 of the chamber and outwardly of the rolls 93 and 94. The latter current of air serves to strip from the upper seal roll 93 any fiber which tends to cling to such roll and also tends to settle into the fiber layer or web, any fibers remaining loose on the fiber layer or on the carrier web after passage thereof between the rolls 93 and 94. Also the extension of the suction box to a point outside of the seal rolls 93 and 94 and beyond the web delivery portion of the forming chamber, serves to provide air flow through the fiber layer portion in and adjacent to said web delivery portion of the forming chamber. Such air flow serves to hold the fibers in place in the web against forces which tend to displace the fibers in said fiber layer portion. Such fiber displacing forces appear to arise mainly as an incident to air movements within said chamber especially but not exclusively when sub-atmospheric pressure is maintained in the chamber.

The lower end of the rear baffle plate 114 is provided with a rearwardly or outwardly extending sealing flange 138 which, with suitable packing material 139, forms a substantially air-tight seal between the baffle 114 and the surface of the roll 93. The rolls 93 and 94, in addition to serving the purpose of initially pressing the fibers together, constitute an air seal to prevent or at least restrict the flow of air into the forming chamber where the web emerges from the chamber, and thereby help to avoid disturbance of the selected fiber laying air flow within the chamber, particularly when web formation is being effected with less than atmospheric pressure in the chamber. This condition may be brought about by proper setting of the dampers 134, 135 and 136, and especially by eliminating all recirculation of air. The air inlet opening 137 previously mentioned aids in this latter matter

by relieving the normal atmospheric pressure immediately outwardly of the rolls 93 and 94.

We have found that air streams entering the housing or forming chamber 92 through inlet openings such as 117 and 118, and withdrawn through the suction box 121, produce good results in respect of the control of the stream 48 of fibers and the laying of said fibers on the forming surface whether it be a backing web or the forming wire belt 49. Recirculation of air is not necessary, but some benefits are attained by it. When recirculation is employed, good results are obtained when the dampers 135, 134, and 136, and the inlet openings 117 and 118 are so regulated that air pressure above atmospheric pressure is maintained in the forming chamber and the recirculated air enters through the openings 117 and 118 respectively in the proportion of about three to one. However, even without recirculation, air streams formed by air drawn into the forming chamber through the openings 117 and 118 provide a desirable control on the fiber stream, this control being variable by adjustment of the members 116 and 119, and also the suction box gate plate 124. These air currents may advantageously be varied from time to time, apparently depending upon the particular kind and the type of fibrous material being formed into a web.

By maintaining air pressure in the forming chamber slightly above atmospheric pressure, and maintaining sub-atmospheric pressure in the suction box 121, entrance of stray or unwanted air currents into the housing above the forming surface may effectively be prevented. These pressures may be, for example, about $\frac{1}{2}$ inch of water in the housing and minus one inch in the suction box.

The described apparatus may be employed to form nonwoven fiber webs (with or without a backing sheet) of a wide range of thicknesses. The thickness of the formed web may, of course, be controlled largely by the speed at which the forming surface is propelled through the forming chamber. The apparatus has been found especially adaptable to the forming of very lightweight nonwoven fiber webs such as, for example, a nonwoven web of as little as 1.5 grams per square yard and up to 8 grams per square yard. These weights are not to be regarded as minimum or maximum limits, but they merely represent a range of web weights which is very difficult to produce with conventional carding and ginning equipment, but which may readily be produced with the described equipment. The lighter weights of nonwoven fiber web are, of course, very flimsy and have but little tensile strength even if the fibers are well bonded to each other; the lighter webs are therefore usually made on gauze or other backing sheets which supply desired tensile strength. However, the very uniform distribution of fiber obtained by the described apparatus facilitates the production of correspondingly well distributed bonding, so that even the flimsiest webs may be made unusually strong, with substantially uniform strength throughout the area of the webbing.

Light weight webs of the indicated order may be made at very high speed, i. e. while driving the forming belt or web at high speeds while the bat of fibers is fed forwardly at a very slow rate. For example, a web of cotton fiber weighing 5.8 grams per square yard may be made by feeding a cotton bat weighing 600 grams per square yard, at the rate of about 2 feet per minute, with the forming surface travelling at the rate of about 200 feet per minute, and the delivelling roll travelling at a peripheral speed of about 6000 feet per minute, the roll 8 being of the order of 13" in diameter, and the feed roll 20 of the order of 2" in diameter in this example.

When nonwoven fabric is to be made without a backing sheet, several methods may be employed for effecting bonding of the fibers to each other. For example, the web may be sprayed with a fine mixture of thermoplastic or other adhesive material, or it may have incorporated some thermoplastic fibers which, when subjected to

the heat of the calender stack, will be made tacky and caused to be adhesively united to the other fibers; also various applications of suitable adhesive either all-over or in printed-on stripes, dots, or other patterns may be employed, the patterns being selected to provide bonding distributed over the area of the web in such a manner that practically every fiber will have at least one point of bonding to another fiber, or in such a manner that some lesser or greater amount of bonding will occur.

Various changes in the described method and apparatus may be made while retaining the principles of the same as referred to in the following claims.

We claim:

1. The method of forming a non-woven layer of fibers which comprises the steps of propelling a foraminous member along a predetermined path, forcefully propelling a stream of fibers directly to said foraminous member so as to cause the latter to intercept the fibers and collect the same in layer form on said member, and causing air currents to flow simultaneously at selected flow rates obliquely against opposite sides of and in the direction of flow of said fiber stream to thereby control the position and width of said stream.

2. The method of forming a non-woven layer of fibers which comprises the steps of propelling a foraminous member along a predetermined path, forcefully propelling a stream of fibers directly to said foraminous member so as to cause the latter to intercept the fibers and collect the same in layer form on said member, and causing air currents to flow simultaneously at selected flow rates partially in the direction of flow of said fiber stream and, respectively, partially in and counter to the direction of travel of said foraminous member and against opposite sides of said fiber stream to thereby control the position and width of said stream.

3. The method of forming a non-woven layer of fibers which comprises the steps of propelling a foraminous member along a predetermined path, forcefully propelling a stream of fibers directly to said foraminous member so as to cause the latter to intercept and collect the fibers in layer form on said member and carry such layer rearwardly from said stream of fibers, and causing air currents to flow simultaneously partially in the direction of said fiber stream and, respectively, in and counter to the direction of travel of said foraminous member at relatively high and low flow rates against opposite sides of said fiber stream to thereby control the position and width of said stream.

4. The method of forming a non-woven layer of fibers which comprises the steps of propelling a foraminous member along a predetermined path transversely of and in communication with a chamber, producing a stream of separated fibers which is forcefully propelled through said chamber directly to said foraminous member so as to cause the latter to intercept the fibers and collect the same in web form on said member, causing air currents to flow simultaneously in such chamber at selected flow rates against opposite sides of and in the direction of flow of said fiber stream to control the position and width of said stream, and maintaining over-atmospheric pressure in said chamber on the fiber receiving side of said member and lower pressure on the opposite side thereof, said over-atmospheric pressure serving to resist the development and flow of air currents into said chamber over the surface of the formed fiber layer incident to the existence of said lower pressure.

5. The method of forming a non-woven layer of fibers which comprises the steps of rotating a fiber bat divelliating roll at high speed within a chamber, slowly advancing a bat of fiber material against a portion of said roll in said chamber to thereby cause a low density, diverging stream of fibers to be formed and forcefully propelled at high speed through said chamber, propelling a foraminous member along a predetermined path spaced from said divelliating roll and transversely of said cham-

ber and the path of high speed movement of said stream of fibers so as to cause the fibers to be collected in a layer and carried from said chamber, and causing air currents to flow simultaneously into said chamber at selected flow rates respectively in and counter to the direction of travel of said foraminous member from in front of and in back of said stream of fibers and into engagement therewith to resist straying of fibers from said stream to thereby produce a fiber layer having a high degree of uniformity of fiber distribution in the layer.

6. The method of forming a non-woven layer of fibers which comprises the steps of rotating a fiber bat divelliating roll at high speed within a chamber, propelling a foraminous member along a predetermined path transversely of said chamber, slowly advancing a bat of fiber material against said roll to thereby cause a low density, diverging stream of fibers to be discharged from said roll and forcefully propelled directly to said foraminous member so as to cause the latter to intercept the fibers and collect the same in a layer on said member, and causing air currents to flow simultaneously into said chamber respectively in and counter to the direction of travel of said foraminous member and at relative high and low flow rates respectively into engagement with opposite sides of said fiber stream to resist straying of fibers from said stream and to control the path of travel thereof to said foraminous member, thereby facilitating attainment of a high degree of uniformity of fiber distribution in the collected layer of fibers.

7. The method of forming a non-woven layer of fibers which comprises the steps of rotating a fiber bat divelliating roll at high speed within a chamber, propelling a foraminous member along a predetermined path transversely of said chamber in communication therewith, slowly advancing a bat of fiber material against said roll to thereby cause a low density, diverging stream of fibers to be discharged from said roll and forcefully propelled directly to said foraminous member so as to cause the latter to intercept the fibers, collect the same in a layer on said member, and carry said fiber layer rearwardly from said chamber, causing air currents to flow simultaneously into said chamber at selected flow rates in and counter to the direction of travel of said foraminous member from in front of and in back of said fiber stream into engagement therewith to resist straying of fibers from said stream, thereby facilitating attainment of a high degree of uniformity of fiber distribution in the collected layer of fibers, and maintaining over-atmospheric pressure in said chamber on the fiber receiving side of said foraminous member to thereby resist the development and flow of air currents into said chamber along the surface of said fiber layer.

8. The method of forming a non-woven layer of fibers, which comprises the steps of rotating a fiber bat divelliating roll at high speed within a chamber, propelling a foraminous member along a predetermined path transversely of said chamber and in communication therewith, slowly advancing a bat of fiber material against said roll to thereby cause a low density, diverging stream of fibers to be discharged from said roll and forcefully propelled directly to said foraminous member so as to cause the latter to intercept the fibers, collect the same in a layer on said member, and carry said fiber layer rearwardly from said chamber, causing air currents to flow simultaneously into said chamber at selected flow rates in and counter to the direction of travel of said foraminous member from in front of and in back of said fiber stream into engagement therewith to resist straying of fibers from said stream, thereby facilitating attainment of a high degree of uniformity of fiber distribution in the collected layer of fibers, maintaining over-atmospheric pressure in said chamber on the fiber receiving side of said foraminous member to thereby resist the development and flow of air currents into said chamber along the surface of said

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fiber layer, and maintaining sub-atmospheric pressure on the other side of said foraminous member in the area in which fiber is collected thereon as aforesaid to thereby promote the flow of said fiber stream and said air currents toward said foraminous member.

9. The method of forming a non-woven layer of fibers which comprises the steps of rotating a fiber bat divellicating roll at high speed within a chamber, propelling a foraminous member along a predetermined path transversely of said chamber and in communication therewith, slowly advancing a bat of fiber material against said roll to thereby cause a low density, diverging stream of fibers to be discharged from said roll and forcefully propelled directly to said foraminous member so as to cause the latter to intercept the fibers, collect the same in a layer on said member, and carry said fiber layer rearwardly from said chamber, causing air currents to flow simultaneously into said chamber at selected flow rates in and counter to the direction of travel of said foraminous member from in front of and in back of said fiber stream into engagement therewith to resist straying of fibers from said stream, thereby facilitating attainment of a high degree of uniformity of fiber distribution in the collected layers of fibers, maintaining over-atmospheric pressure in said chamber on the fiber receiving side of said foraminous member to thereby resist the development and flow of air currents into said chamber along the surface of said fiber layer, and maintaining sub-atmospheric pressure on the other side of said foraminous member in the area in which fiber is collected thereon as aforesaid and rearwardly thereof to a point outside of said chamber portion where said foraminous member and fiber layer leave said chamber, thereby to promote the flow of said fiber stream and said air currents toward said foraminous member and to further resist the development and flow of air currents into the chamber along the surface of said fiber layer.

10. The method of forming a non-woven layer of fibers which comprises the steps of rotating a fiber bat divellicating roll at high speed within a chamber, propelling a foraminous member along a predetermined path spaced from said divellicating roll and transversely of said chamber, slowly advancing a bat of fiber material against a portion of said roll in said chamber to thereby cause a low density, diverging stream of fibers to be formed and forcefully propelled at high speed through said chamber and to said foraminous member so as to cause the fibers to be collected in a layer on one side of said foraminous member and thereby carried from said chamber, maintaining sub-atmospheric pressure on the other side of said foraminous member in the area in which fiber is collected, and maintaining sub-atmospheric pressure on said other side of said foraminous member outside of said chamber adjacent to the portion thereof from which said foraminous member and fiber layer leave said chamber.

11. The method of forming a non-woven layer of fibers which comprises the steps of rotating a fiber bat divellicating roll at high speed within a chamber, propelling a foraminous member along a predetermined path spaced from said divellicating roll and transversely of said chamber, slowly advancing a bat of fiber material against a portion of said roll in said chamber to thereby cause a low density, diverging stream of fibers to be formed and forcefully propelled at high speed through said chamber and to said foraminous member so as to cause the fibers to be collected in a layer on one side of said foraminous member and thereby carried from said chamber, maintaining sub-atmospheric pressure on the other side of said foraminous member in the area in which fiber is collected thereon as aforesaid to promote the flow of said stream of fibers toward said foraminous

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member, and maintaining said sub-atmospheric pressure continuously from said area to a point outside of the portion of said chamber from which said foraminous member and fiber layer leave said chamber, thereby to hold the fibers in place in said layer against forces which tend to disturb the lay of fibers in the fiber layer portion in and adjacent to said portion of the chamber.

12. The method of forming a non-woven layer of fibers which comprises the steps of rotating a fiber bat divellicating roll at high speed within a chamber, slowly advancing a bat of fiber material against a portion of said roll in said chamber to thereby cause a low density, diverging stream of fibers to be formed and forcefully propelled approximately tangentially from said roll at high speed through said chamber, propelling a foraminous member along a predetermined path spaced from said divellicating roll and transversely of said chamber and the path of said stream of fibers in such proximity to said divellicating roll as to cause the fibers in said stream to be intercepted while moving at high speed as a part of said forcefully propelled stream and thereby collected in a layer and carried from said chamber, causing an air current to flow toward said stream across the portion of the surface of said divellicating roll which is moving away from said stream to aid stripping of the fibers from said roll and to provide an air cushion against said side of the fiber stream to control the position of said side, and causing another air current to flow toward the other side of said stream at a point adjacent the beginning of the formation of said fiber stream and along said other side of the stream to control the position of said other side of said stream.

13. The method of forming a non-woven layer of fibers which comprises the steps of rotating a fiber bat divellicating roll at high speed within a chamber, slowly advancing a bat of fiber material against a portion of said roll in said chamber to thereby cause a low density, diverging stream of fibers to be formed and forcefully propelled approximately tangentially from said roll at high speed through said chamber, propelling a foraminous member along a predetermined path spaced from said divellicating roll and transversely of said chamber and the path of said stream of fibers in such proximity to said divellicating roll as to cause the fibers in said stream to be intercepted while moving at high speed as a part of said forcefully propelled stream and thereby collected in a layer and carried from said chamber, causing an air current to flow toward said stream across the portion of the surface of said divellicating roll which is moving away from said stream to aid stripping of the fibers from said roll and to provide an air cushion against said side of the fiber stream to control the position of said side, and causing another air current to flow at higher velocity than said first mentioned air current and toward the other side of said stream at a point adjacent the beginning of the formation of said fiber stream and along said other side of the stream to control the position of said other side of said stream.

References Cited in the file of this patent

UNITED STATES PATENTS

1,761,493	Rogers	June 3, 1930
1,810,675	Nuttall et al.	June 16, 1931
1,961,272	Williams	June 5, 1934
2,062,626	Williams et al.	Dec. 1, 1936
2,317,895	Drill	Apr. 27, 1943
2,319,666	Drill	May 18, 1943
2,451,915	Buresh	Oct. 19, 1948
2,477,675	Wilson et al.	Aug. 2, 1949
2,478,148	Wilson et al.	Aug. 2, 1949
2,589,008	Lannan	Mar. 11, 1952