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Kamp

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[54] **METHOD FOR THE HIGH SPEED PRODUCTION OF NON-WOVEN FABRICS**

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[73] Assignee: **Union Carbide Corporation**, New York, N.Y.

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Related U.S. Application Data

[62] Division of Ser. No. 51,967, July 2, 1970.

[52] **U.S. Cl.** **264/91;** 19/156.3; 156/74; 264/114; 264/121; 425/224; 425/464

[51] **Int. Cl.** **B29d 23/03;** D04h 1/00

[58] **Field of Search** 264/91, 114, 121, 309, 264/311; 19/156.4, 156.3

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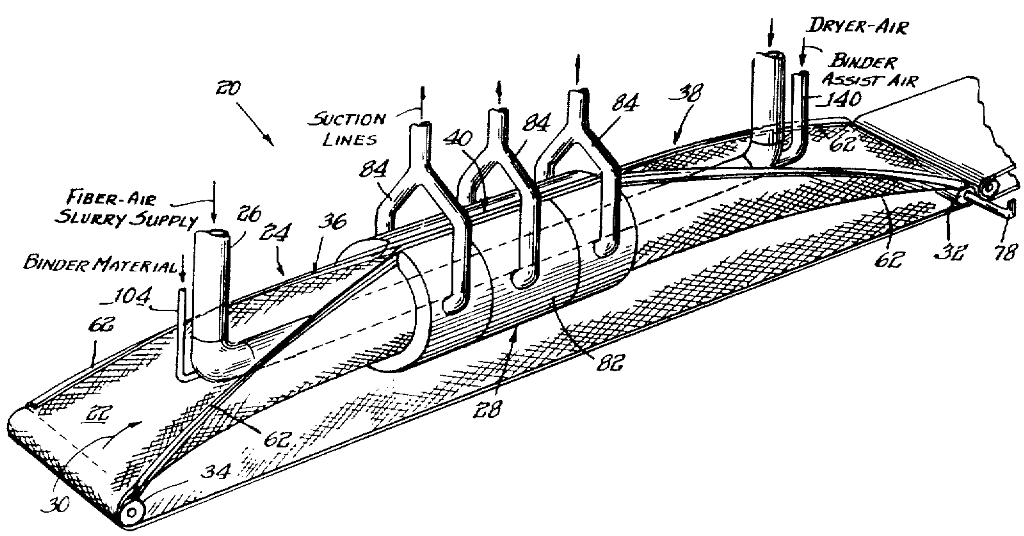
Attorney, Agent, or Firm—Olson, Trexler, Wolters, Bushnell & Fosse

[57] **ABSTRACT**

A method of making a non-woven fibrous web comprises providing a fluid stream, incorporating fibers in that stream, continuously directing the stream into a centrifugal flow, and collecting the fibers from the flow as a substantially endless web.

9 Claims, 18 Drawing Figures



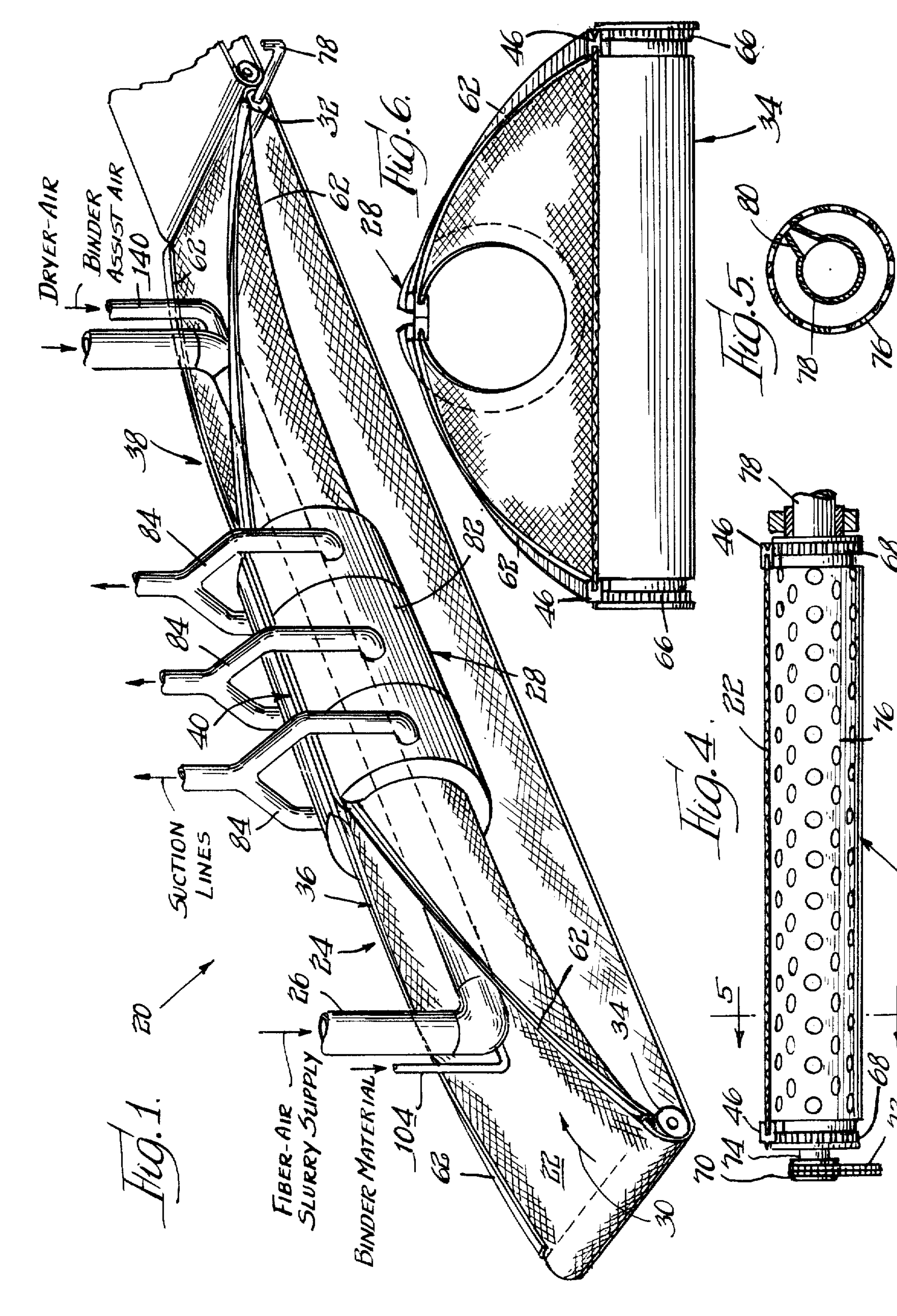
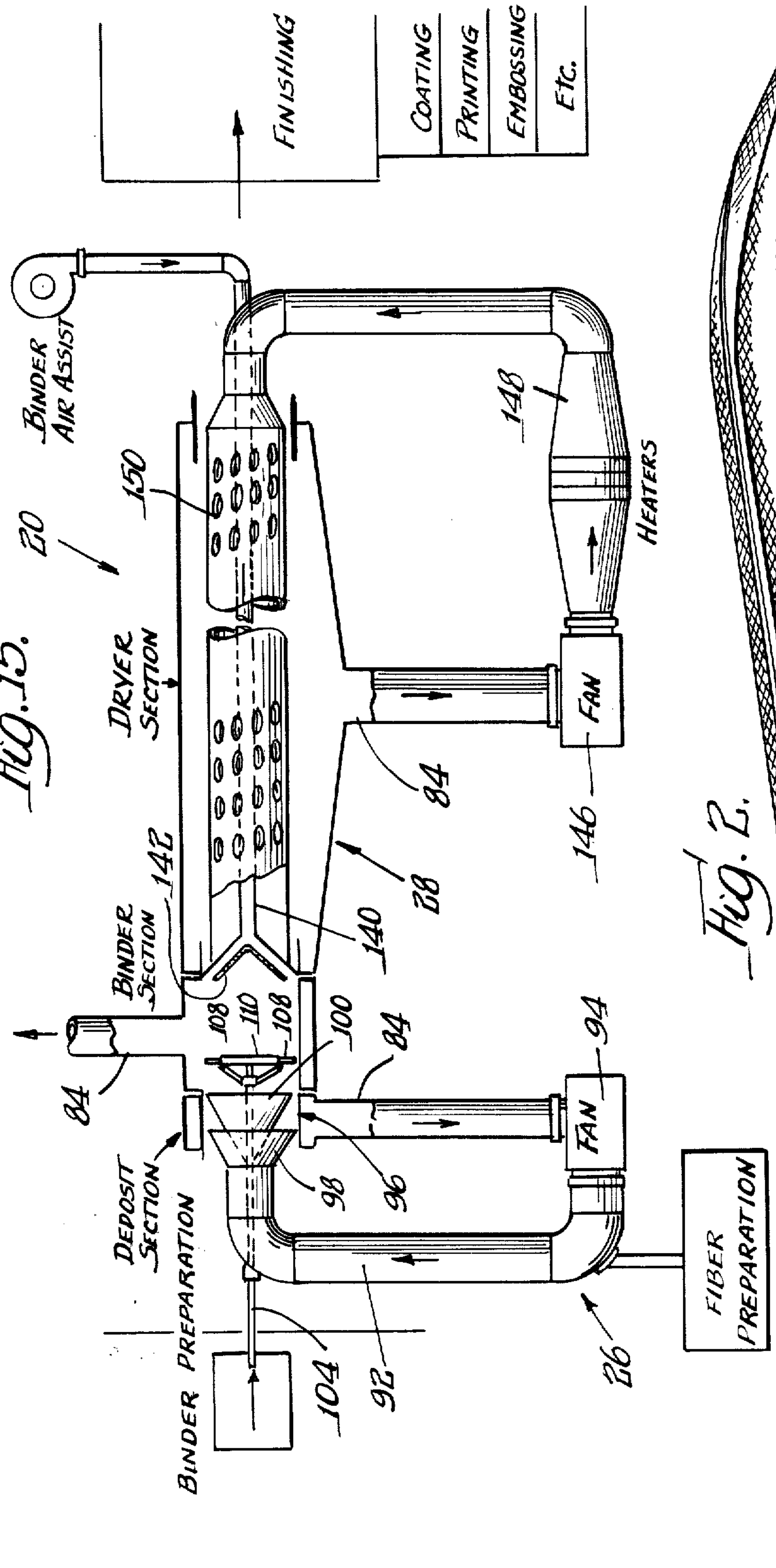


Fig. 1.
Fig. 4
Fig. 5.
Fig. 6.
DRYER-AIR
BINDER ASSIST AIR
SUCTION LINES
FIBER-AIR SLURRY SUPPLY
BINDER MATERIAL

Fig. 15.


FINISHING
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BINDER AIR ASSIST
DRYER SECTION
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DEPOSIT SECTION
HEATERS
FAN
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FIBER PREPARATION
BINDER PREPARATION
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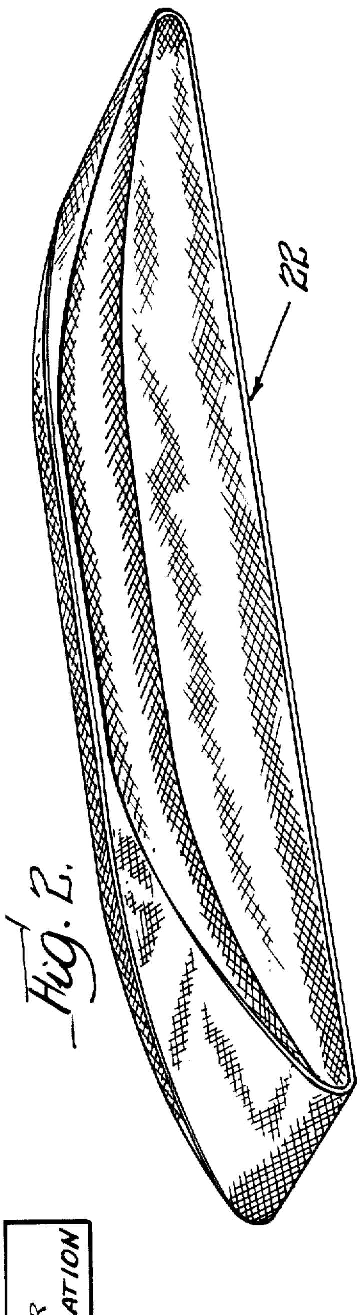
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Fig. 2.

Fig. 3.

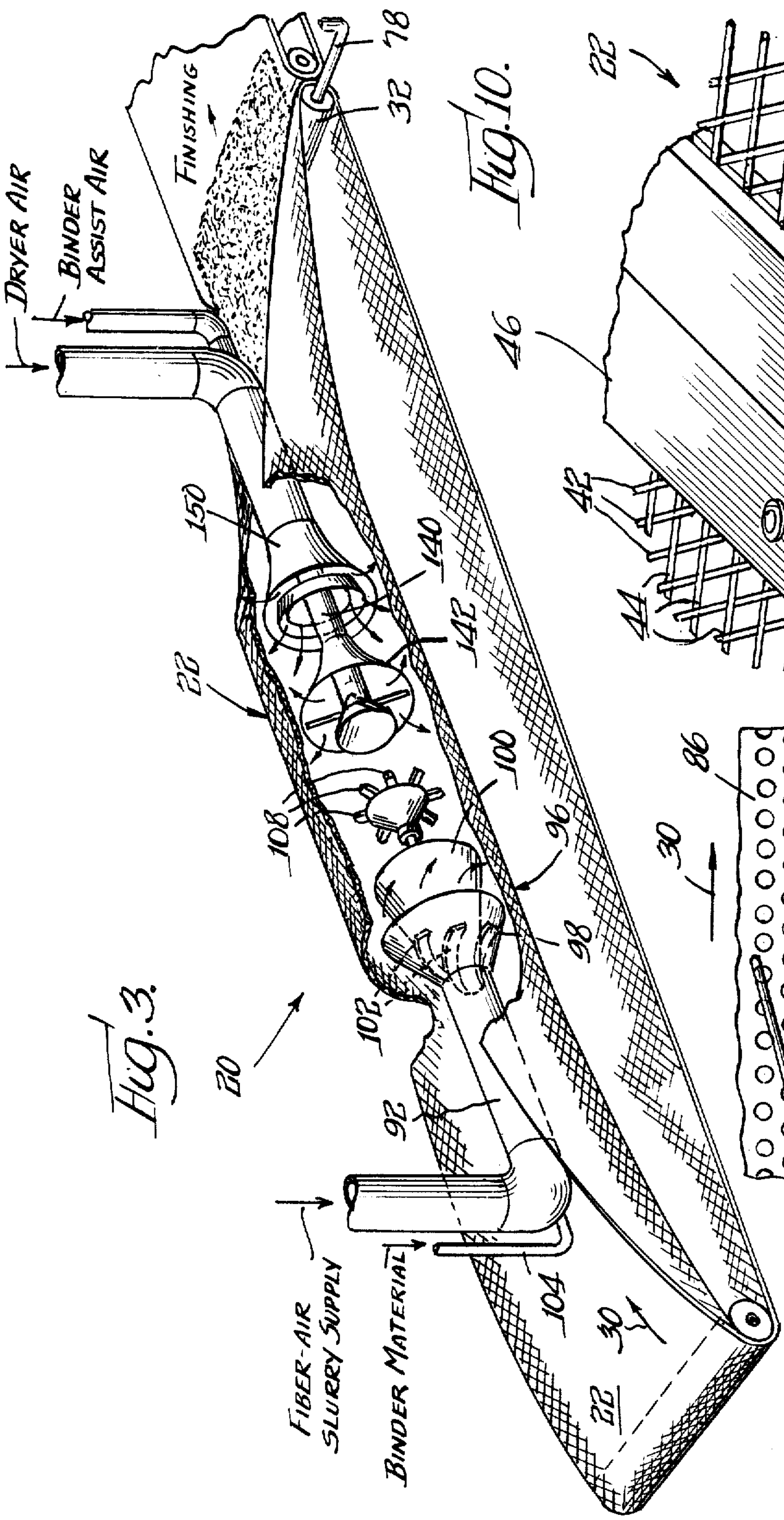
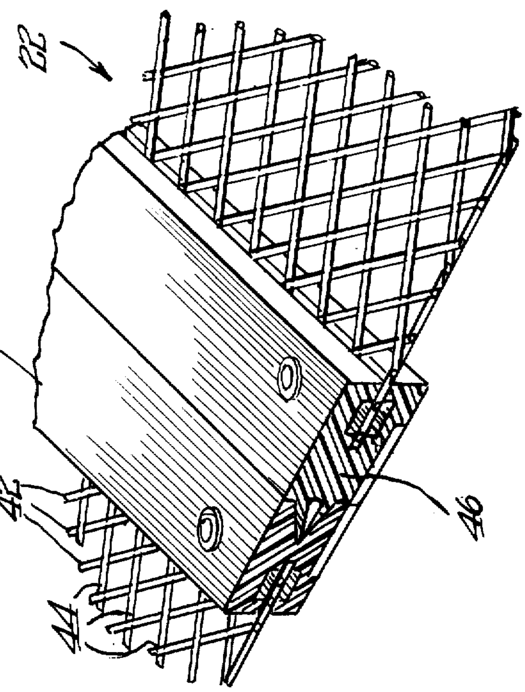


Fig. 10.



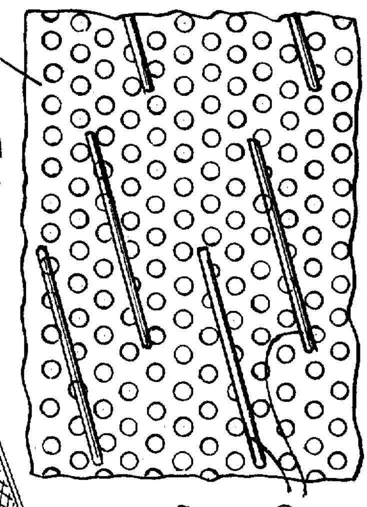


Fig. 9.

Fig. 7.

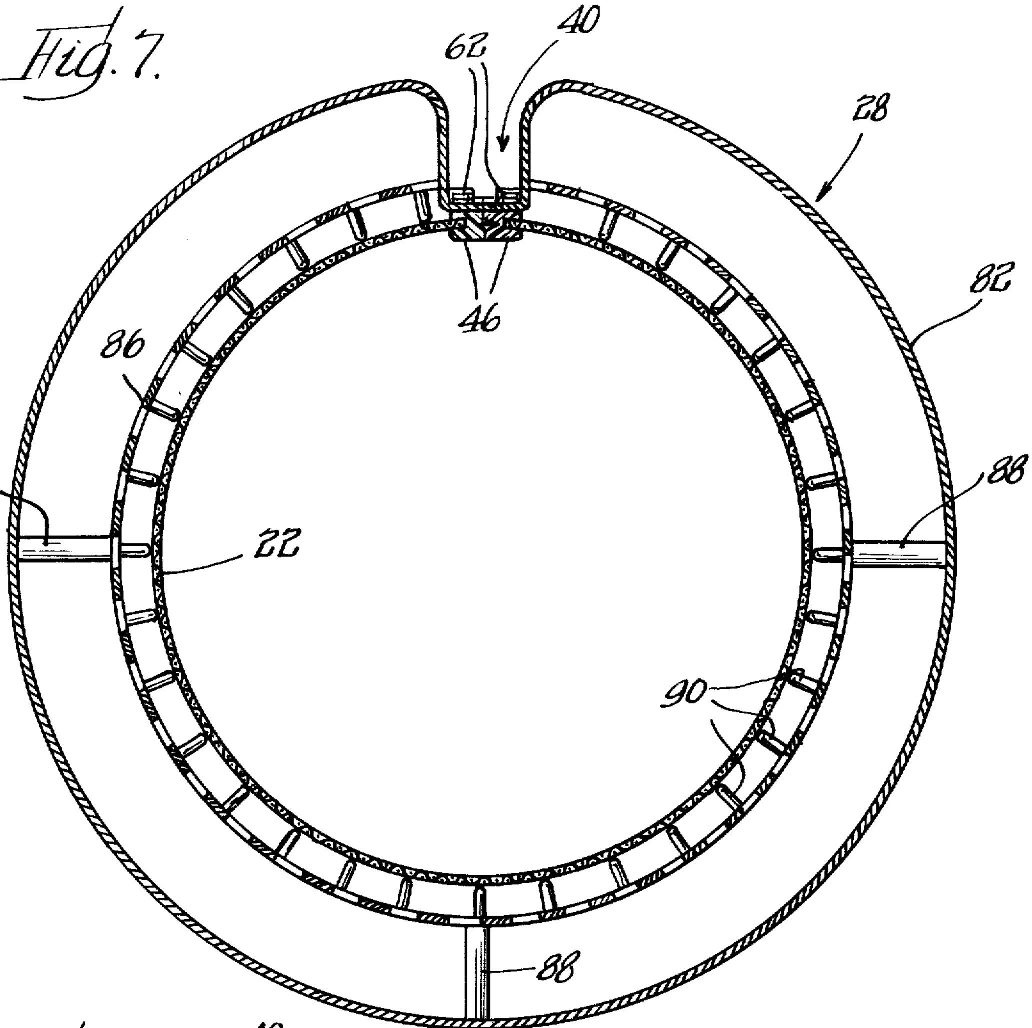

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Fig. 8.

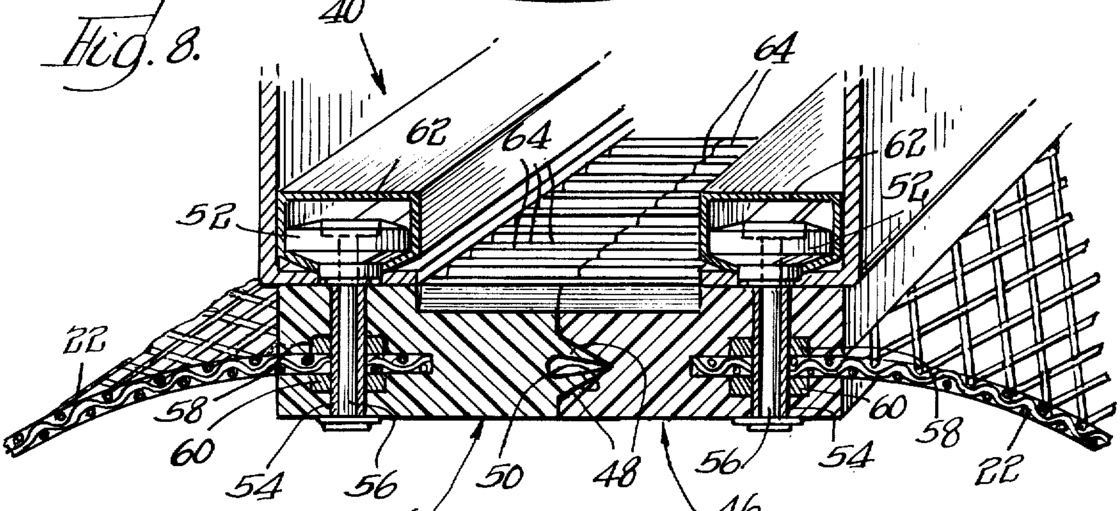
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Fig. 12.

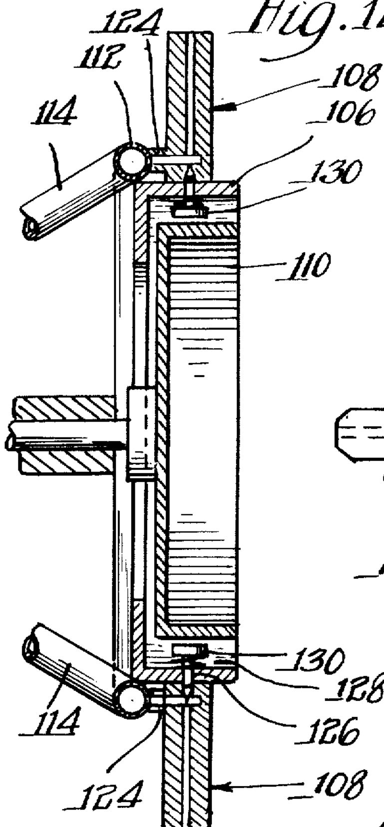


Fig. 11.

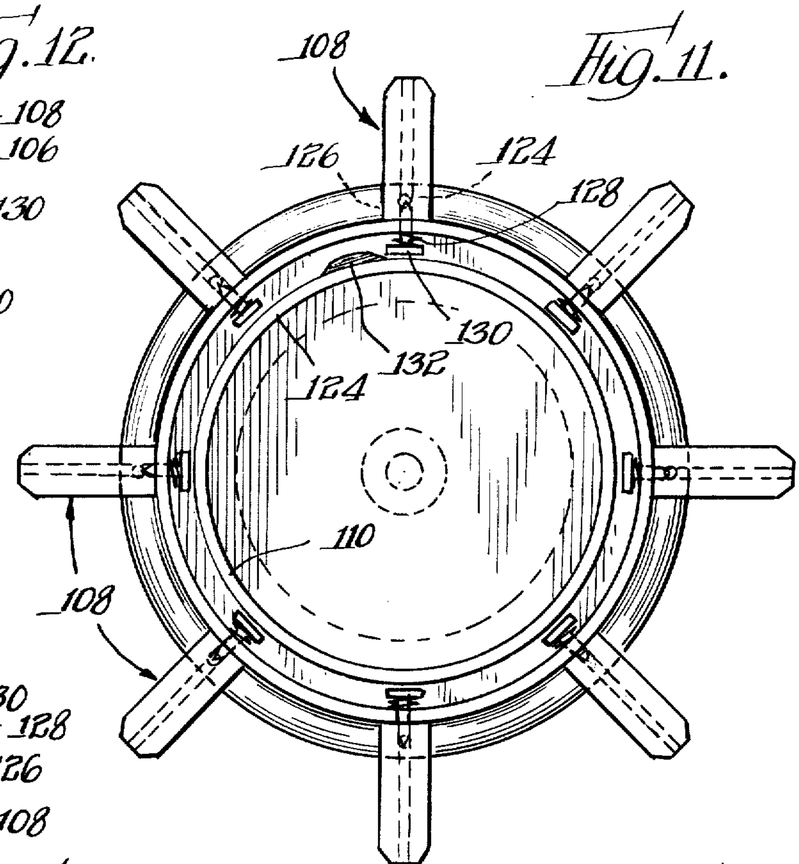
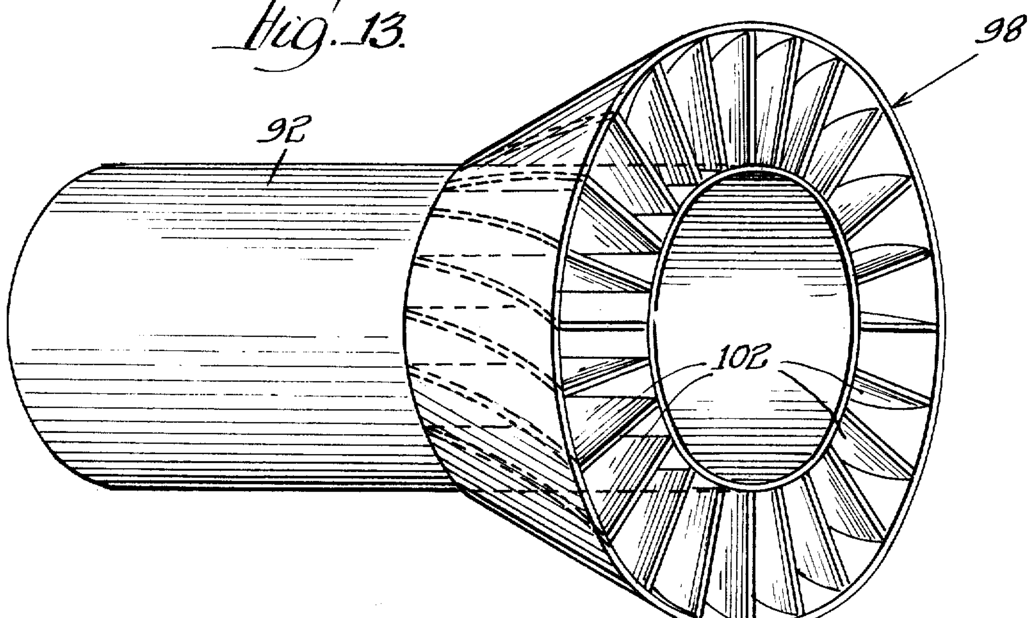


Fig. 13.



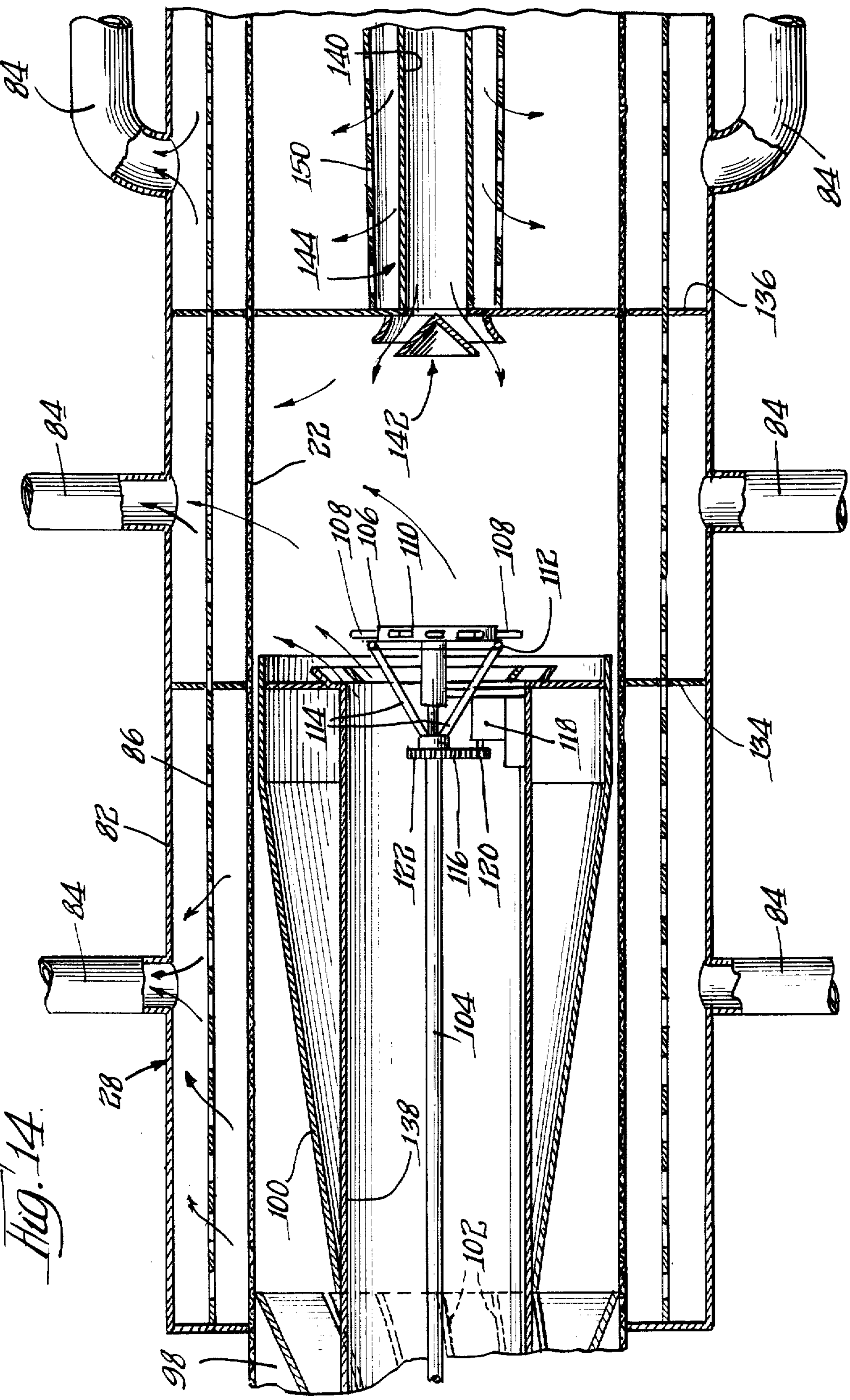

84
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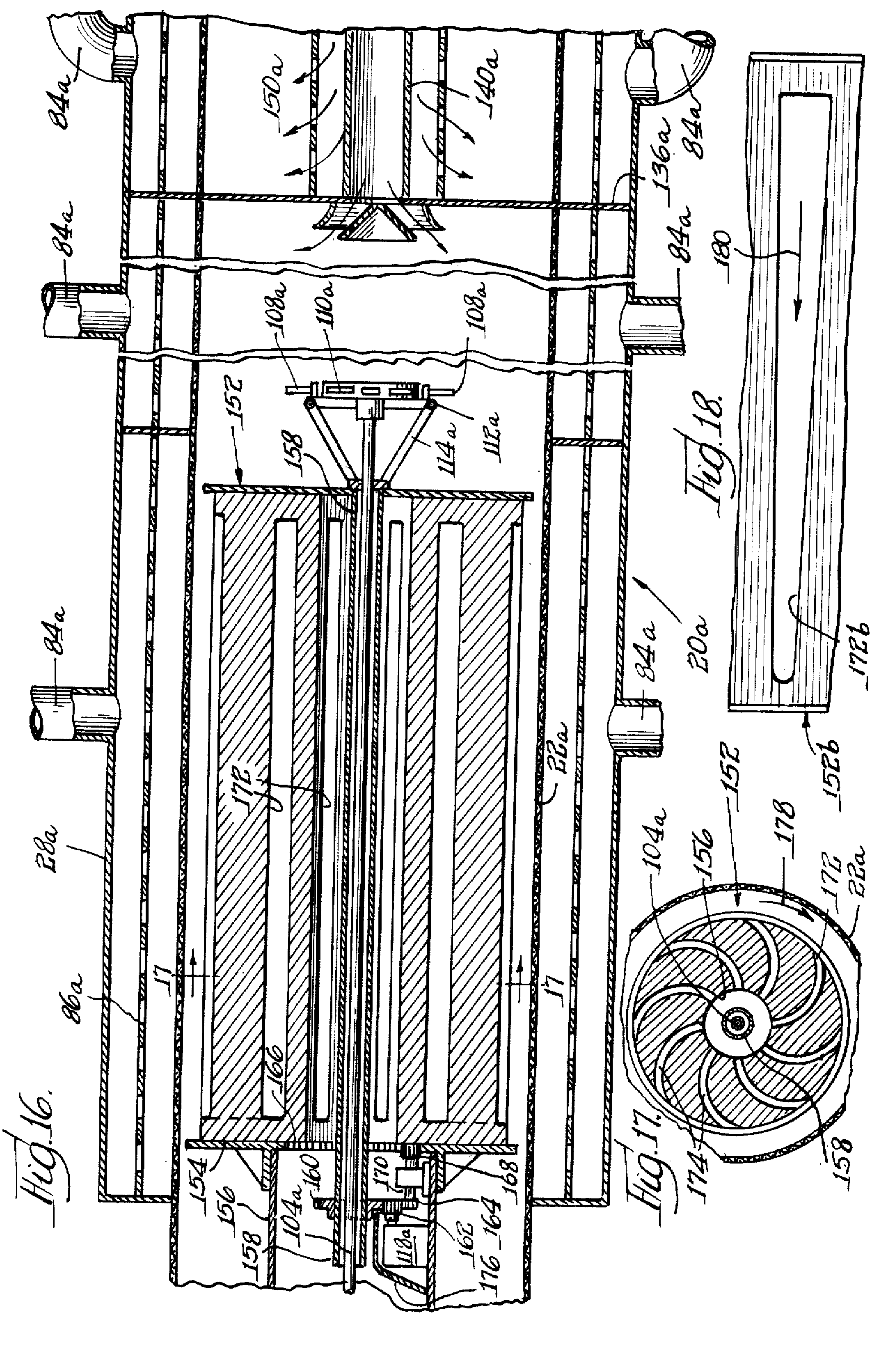
Fig. 14



METHOD FOR THE HIGH SPEED PRODUCTION OF NON-WOVEN FABRICS

This application is a division of copending application Ser. No. 51,967 filed July 2, 1970.

This invention relates generally to the manufacture of non-woven fabrics and more particularly to the manufacture of such products by substantially dry procedures.

Non-woven fabrics pose the potential of supplying the need for disposable bedsheets; but heretofore, machinery has not been available for producing such fabrics in sufficient width for use as sheeting and with sufficient speed to achieve necessary economy. For example, carding machines operate too slowly, require relatively long staple fiber and are restricted in practical width. Rando-Webber machines are capable of handling inexpensive, short-staple fibers but are limited in width.

Therefore, an important object of the present invention is to provide methods of producing a non-woven fibrous web at high speeds and in substantial width.

A more general object of the invention is to provide new and improved methods of producing a non-woven fibrous web.

These and other objects and features of the invention will become more apparent from a consideration of the following descriptions.

The invention will be better understood by reference to the following disclosure and drawings forming a part thereof, wherein:

FIG. **1** is a diagrammatic perspective view of apparatus for use in the practice of the method of the present invention;

FIG. **2** is a view similar to the showing of FIG. **1** but with the suction plenum and other equipment removed to show the tubularization of the fiber collecting belt;

FIG. **3** is a view similar to the showing of FIG. **1** but with the suction plenum removed and a portion of the belt broken away to show the fiber spray nozzle arrangement, the binder spray nozzle and the complementary air flow system;

FIG. **4** is an elevational view of the head pulley used in the apparatus of FIG. **1**;

FIG. **5** is a cross-sectional view taken along the line **5—5** of FIG. **4** with the fiber-collecting belt removed;

FIG. **6** is an elevational view of the tail pulley used in the apparatus of FIG. **1**;

FIG. **7** is an enlarged cross-sectional view taken through the exhaust plenum;

FIG. **8** is a further enlarged cross-sectional view showing the channels used in tubularizing the travelling belt;

FIG. **9** is an enlarged fragmentary view showing the interior of the exhaust plenum and details of its construction;

FIG. **10** is a fragmentary perspective view showing details of the construction of the travelling belt;

FIG. **11** is an enlarged elevational view of the binder spray nozzle used in the apparatus of FIG. **1**;

FIG. **12** is a central cross-sectional view of the binder spray nozzle of FIG. **11**;

FIG. **13** is an enlarged perspective view of a part of the fiber distributing unit used in the apparatus of FIG. **1**;

FIG. **14** is an enlarged longitudinal sectional view taken through the exhaust plenum;

FIG. **15** is a diagrammatic view relating to the process of the present invention;

FIG. **16** is a view similar to the showing of FIG. **14** but illustrating a modified embodiment of the invention;

FIG. **17** is a cross-sectional view taken substantially along the line **17—17** of FIG. **16**; and

FIG. **18** is a fragmentary elevational view of a further modified embodiment.

The present invention contemplates injecting a fiber-air suspension onto the inside of a porous tube formed by curling a section of a foraminous belt and subsequently flattening out the blet so that the formed and finished web may be lifted off and transferred to subsequent processing stations. This arrangement facilitates uniform distribution of the fibers and promotes application of bonding agents in liquid form.

Referring now in detail to the drawings, specifically to FIG. **1**, apparatus for producing a non-woven fibrous web in practicing the method of the invention is indicated by the reference numeral **20**; and the apparatus **20** broadly comprises a flexible, endless foraminous belt **22**, a guide unit **24**, a fiber suspension supply arrangement **26** and an air exhaust plenum system **28.** A drive arrangement which will be described more fully hereinafter, caused continuous, longitudinal movement of the belt **22** in the direction of arrow **30** and between a head pulley **32** and a tail pulley **34.**

The guide unit **24** includes a fore section **36** which tubularizes the foraminous belt and an aft section **38** which de-tubularizes the belt. The guide unit **24** additionally includes an intermediate guide section **40** which corresponds with the tubularized length of the belt. Turning now to FIG. **10** for a description of the foraminous belt **22,** it will be appreciated that the edges of the belt traverse a greater distance in forming the tubularized section than does the center line of the belt. While these different amounts of movement may be accommodated by means of crowned pulleys or "bent" pulleys, in accordance with the present invention they are accommodated by means of bias woven strands **42** and **44,** strands **42** running at a 45° angle to the center line of the belt in one direction and strands **44** running at a 45° angle in the opposite direction so that the respective sets of strands cross each other at right angles. Thus, local changes in the bias angles permit the belt to flex internally and accommodate the differential movements. Flexible edge strips **46** are secured to the cut ends of the woven strands to complete the assembly. Various materials can be used for the strands **42** and **44** including matallic wire and such synthetic materials as nylon and polyester resins. With reference to FIG. **8,** the edge strips **46** are provided with mutually interengageable aligning means comprising a pair of spaced, resiliently convergible blades **48** fashioned on one edge strip and a mating groove **50** fashioned in the opposite edge strip. Upon the two edge strips being brought forcibly together, the blades **48** wedge into the groove **50** and provide alignment and a seal. Carrier elements are mounted on the edge strips **46** for use in directing the foraminous belt in its tubularizing and detubularizing movements. Specifically, button rollers **52** are affixed to the edge strips **46** at spaced intervals by means of a bushing **54** and a rivet **56.** Reinforcing bands **58** and **60** are situated within the edge strips on opposite sides of the belt **22** in the vicinity of the rivets **56.** The button rollers **52** travel in inverted channel members or rails **62** forming the respective sections of the guide unit.

In order to drive the foraminous belt longitudinally, gear teeth **64** are fashioned on appropriate surfaces of the flexible edge strips **46**; and turning to FIG. **6**, the tail pulley **34** includes a pair of spur gears **66** which meshably engage the gear teeth of the respective edge strips **46**. Similarly, and with reference to FIG. **4**, the head pulley **32** includes a pair of spur gears **68** which mesh with the gear teeth **64**. Power is supplied to the drive arrangement by means of a sprocket **70** and a drive chain **72**, sprocket **70** being attached to the head pulley **32** by means of a shaft **74** and the chain **72** being drivingly connected with a suitable motor, now shown.

It is advantageous to lift the fibrous web from the foraminous belt **22** at the end of belt travel in the machine direction; and for this purpose, head pulley **32** comprises a perforated metal drum **76** that is arranged coaxially with an air duct **78**. As will be seen in FIG. **5**, the duct **78** includes a central cylindrical portion and a radially extending vent portion **80** which communicates the central portion with the perforated surface of drum **76**. If desired, the duct **78** may be arranged to be rotated to position the vent portion **80** for maximum effectiveness.

In order to promote efficiency in the deposit of fibers on the tubularized section of the foraminous belt, suction is applied by means of the exhaust plenum **28**; and with reference to FIG. **1**, the plenum **28** comprises an outer shell **82** and a suitable number of suction lines **84**. Turning to a consideration of FIG. **7** in conjunction with FIG. **9**, the exhaust plenum **28** additionally comprises a cylindrical perforated inner shell **86** which is spaced apart from the outer shell **82** by ribs **88**. In order to minimize the frictional attack on the foraminous belt, rectangular spacer bars **90** with rounded, smoothly polished edges are secured to the inner shell **86** to extend radially inwardly toward the belt **22**. In addition, the bars **90** are hardened or hard-coated. As is best seen in FIG. **9**, the spacer bars **90** are situated at a shallow angle with respect to the direction of belt travel **30** in order to avoid bland spots in the fiber deposit; and the bars **90** on opposite sides of the shell **86** are oppositely angled to avoid inducing rotation of the belt.

Turning to FIG. **3** for a description of the fiber delivery system and related equipment, a conduit **92** delivers a suspension of suitably opened fibers to the tubularized section of the foraminous belt. Numerous types of fibers may be employed in the invention, such as wood, synthetic cellulose, cotton, synthetic polymers, asbestos and glass; and these fibers are opened to the point where each fiber is detached from the others and becomes a separate entity. Long staple can be fluffed up and separated by well known devices such as opening pickers, cards and garnetts while wood cellulose is generally provided in sheet form that can be fluffed up by equipment such as hammer mills, special cards arranged for that purpose, and disc grinders. After opening, the fibers are mixed with flowing air delivered by a fan **94** shown in FIG. **15**.

Continuing with reference to FIG. **15** together with FIG. **3**, the fiber supply conduit **92** terminates at the tubularized section of the foraminous belt in a nozzle arrangement **96** which releases the suspension into a tapering angular chamber defined between an upstream conical member **98** and a downstream conical member **100**. A series of deflector vanes **102** are mounted between the conical members **98** and **100** to produce a swirl flow in a substantially tangential direction alone the inside of the foraminous belt. The shaping of the vanes **102** is shown in greater detail in FIG. **13**.

It is oftentimes advantageous to provide at least preliminary bonding of the non-woven web before it exits from the tubularized section of the foraminous belt. For this purpose, a binder supply conduit **104** for liquid binder material is arranged coaxially with the fiber supply conduit **92**. As is shown in FIGS. **11, 12** and **14**, a rotating nozzle ring **106** carries a suitable number of radially disposed spray nozzles **108** and surrounds a stationary ring **110**. Liquid binder material flows from the conduit **104** to a rotating toroidal manifold **112** through a suitable number of flaring pipes **114** which also serve as the mechanical connection between ring **106** and a swivel joint **116**. A suitably energized drive motor **118** is provided with a spur gear **120** on its output shaft, and the spur gear **120** meshes with a second spur gear **122** mounted on the swivel joint **116**. In addition, the swivel joint **116** includes a rotary liquid coupling to make a leaktight seal between the conduit **104** and the pipes **114**.

With reference to FIGS. **11** and **12**, each of the binder spray nozzles **108** communicates with the manifold **112** through a stub conduit **124**, and a shut-off needle **126** is slidably disposed in a nozzle bore intercepting the conduit **124** at right angles thereto. A spring **128** biases the needle generally away from the stub conduit. The needle **126** terminates in the radially inward direction in a heel plate **130** which is positioned to engage a stationary cam **132** on the ring **110** once each revolution. Thus, the nozzles are shut off periodically; and this has been found to create surge loads having a tendency to clear the nozzles of incipient coagulants. The narrow region where no spray occurs is advantageously arranged to coincide with the united edge strips **46** in the tubularized section of the foraminous belt, shown for example in FIG. **7**. It will be appreciated that no substantial fiber deposit occurs on these edge strips because there is no suction behind them. Thus, the fibrous web is formed initially with a longitudinal discontinuity which permits flattening without cutting.

Returning to FIG. **14**, the exhaust plenum **28** is advantageously divided into three separate sections by means of annular bulkheads **134** and **136**. When these bulkheads are positioned as shown, the leading section becomes a fiber air return; the intermediate section, a binder air return; and the trailing section, a dryer air return. Furthermore, an imperforate tubular chamber **138** desirably penetrates the first section of the exhaust plenum so that an air stream may be injected generally in the direction of belt travel. In addition, the upstream section of the exhaust plenum is advantageously penetrated by a tubular duct **140** so that an air stream may be injected in the downstream direction generally opposite the stream delivered through the tube **138**. A diffuser unit **142** is secured to the bulkhead **136** in alignment with the duct **140** to direct the air stream in a generally outward direction. The two air streams that are injected into the intermediate exhaust plenum section cooperate both in directing binder material away from the bulkheads and other structures and in carrying the bonding liquid deep into the fibrous structures carried on the foraminous belt.

Since it is frequently desirable to distribute heated air over the fibrous web, as for example to evaporate water, extract solvents, fuse binder material or foam a binder material, means are provided in the present invention for supplying heated air to the final section of the exhaust plenum. Specifically, an annular chamber **144,** shown in FIG. **14,** is arranged to receive a supply of heated air from a fan **146** and heaters **148,** shown in FIG. **115,** the annular chamber **144** being defined by a perforated metal tube **150** and the duct **140.** Electromagnetic drying may be used in place of heated air, and the cylindrical shape of the tubularized section of belt **22** presents an ideal configuration for radio frequency drying.

With respect to the operational characteristics of the described apparatus and considering FIG. **15,** fibers are introduced into the inlet fiber supply conduit **92** by suspending them uniformly in a moving air stream. The resultant suspension is a function of the nature of the fiber or fibers involved, a high density, thick fiber generally requiring more air than a light, thin and irregularly shaped fiber. However, in general, best results are obtained if the suspension has a density of not less than 30 cubic feet of air per pound of fiber, preferably between 50 and 200 cubic feet of air per pound of fiber. The velocity to which the suspension is adjusted is also a function of fiber characteristics. The minimum suspension velocity to maintain the fibers in suspension and prevent any undesirable degree of fiber agglomeration is approximately 1,500 feet per minute and preferably in the range of about 3,000 to about 5,000 feet per minute. The suspension is directed toward the moving foraminous felt **22** in a centrifugal flow by the nozzle arrangement **96,** the suspension being volumetrically expanded in a substantially uniform manner until its average velocity at right angles through the belt is less than about 1,000 feet per minute and preferably less than about 300 feet per minute. The vanes **102** act to direct the suspension in successive streams whereby to provide commingling layers of deposited fibers. Suction from the exhaust plenum **28** cooperates in the volumetric expansion of the suspension flow and promotes uniformity in the fiber deposit by tending to draw more fiber toward thin areas than those where the deposit is thicker. Belt speed, suspension density and suspension velocity determine the weight of the deposited web.

After the fibers have been deposited, binder is sprayed onto the resultant web by means of the spinning nozzles **108** while the web and the foraminous belt are still in tubularized form, air assist from both the upstream and the downstream direction promoting rapid efficient binder deposition. Thereafter, and in continued tubularization of the foraminous belt, heated air from the fan **146** is delivered to the dryer section through the perforated drum **150** for curing the binder material.

After exiting from the final section of the exhaust plenum **28,** the foraminous belt **22** is de-tubularized by the channels **62** of aft guide section **38,** and the bonded fibrous web is lifted from the head pulley **32** by air from the duct **78,** as is shown in FIG. **3,** for such finishing operations as additional bonding, coating, printing and embossing. After it has passed from the head pulley **32,** the belt **22** may be backwashed with air, scrubbed with solvent, brushed and dried, during its return trip to tail pulley **34.**

While a particular embodiment of the invention has been thus far shown and described, it should be understood, of course, that the invention is not limited thereto since many modifications may be made. In order to enhance the understanding of the invention, one such modified form of the invention has been illustrated in FIGS. **16** and **17.** Since many of the elements of this modified embodiment are similar to those shown and described with reference to FIGS. **1–15,** like parts have been identified with like numerals, the suffix letter "a"being employed to distinguish those elements associated with the embodiment of FIGS. **16** and **17.**

The embodiment of FIGS. **16** and **17** is distinguished by the manner in which the fiber suspension is directed toward the foraminous belt. More specifically, a plurality of fiber dispensing nozzles are focused toward the foraminous belt and are continuously directed in a path of movement generally away from the point of instantaneous impingement at the belt. Structurally, a nozzle unit **152** is disposed within the tubularized section of the foraminous belt coaxially therewith, the nozzle unit **152** being provided with an upstream collar **154** which fits rotatably over a suspension delivery conduit **156.** The collar **154** supports the nozzle unit **152** from the conduit **158** and establishes an end seal therewith.

In order that the motor **118*a*** may drive both the nozzle unit **152** and the rotary binder spray arrangement, motor **118*a*** is displaced upstream from the nozzle unit **152**; and the swivel joint **116*a*** is replaced by a simple support ring which is connected to a drive sleeve **158.** A spur gear **160** is mounted on the sleeve **158** to be drivingly coupled to the motor **118*a*** through a meshing pinion gear **162.** Rotary motion is imparted to the nozzle unit **152** by means of a pinion gear **164** which meshes with the pinion gear **162** and which powers the nozzle unit by means of a ring gear **166** fashioned on the nozzle unit and a pinion gear **168** carried on a common, journaled shaft **170.**

The nozzle unit **152** is provided with a suitable number of discharge orifices **172** which open to the delivery conduit **156** through respective, arcuate channels **174.** An aerodynamic shroud **176** is located upstream from the drive motor **118*a*** to minimize distrubances in the fiber suspension movement which might otherwise be caused by the drive arrangement; and in order to promote uniform volumetric expansion of the fiber suspension, the nozzle unit **152** is rotated in the direction of arrow **178** generally in a direction opposite to the tangential velocity vector of the individual exiting streams. Spin rates on the order of 1,500 r.p.m. have proved useful in a specific embodiment of the invention where the tubularized section of the belt took a diameter of one foot. Slower spin rates have proved useful with larger diameter sections.

Air supply for the binder is provided exclusively from the tubular conduit **140*a*** . In addition, the discahrge from nozzle unit **152** is substantially radial whereas the discharge from nozzle arrangement **96** is more nearly a downstream divergent, hollow, conical flow. In other respects, the apparatus of FIGS. **16** and **17** is constructed and operates similarly to the apparatus of FIGS. **1–15.**

A modified form of rotating discharge member is shown in FIG. **18** where slots **172*b*** of nozzle unit **152*b*** are flared in the upstream direction in order to level fiber discharge, the general direction of air travel being shown by arrow **180.**

An electrostatic field may be included in the apparatus of the invention for enhancing fiber deposit and is of special advantage in that it will permit electrostatic flocking at high machine speed and accomplish flocking with long staple fibers.

The specific embodiments herein shown and described are to be considered as being primarily illustrative. Various changes beyond those described will, no doubt, occur to those skilled in the art; and such changes are to be understood as forming a part of this invention insofar as they fall within the spirit and scope of the appended claims. The invention is claimed as follows:

1. The method of making a non-woven fibrous web comprising the steps of: providing a gaseous stream; incorporating discrete fibers in said stream; continuously directing said stream into a centrifugal flow; collecting said fibers from said flow as a substantially longitudinally endless tubular web; and de-tubularizing and flattening said web.

2. The method according to claim **1** wherein said method comprises the additional step of adding binder to said fibers.

3. The method according to claim **2** wherein said binder is added to said fibers after they have been formed into said tubular web.

4. The method according to claim **1** wherein said fibers are collected from said flow using suction.

5. The method according to claim **1** wherein said flow is a dowstream diverging, hollow, generally conical flow.

6. The method according to claim **1** wherein said flow is a substantially radial flow.

7. The method according to claim **1** wherein said tubular web is formed initially with a longitudinal discontinuity whereby to facilitate flattening.

8. The method of making an agglomerated web comprising the steps of: providing a gaseous stream having particulate fibrous matter incorporated therein; continuously directing said stream into a centrifugal flow; and collecting said particulate matter from said flow as a substantially longitudinally endless web.

9. The method according to claim **8** wherein said stream is collected on a foraminous member and wherein said stream is continuously directed into a centrifugal flow which is caused to move relatively generally away from the point of instantaneous impingement at said member.

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