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Dilo

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[45] **Sept. 18, 1973**

[54] **METHOD OF MAKING A TUBULAR NEEDLED WEB**

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[22] Filed: **Feb. 17, 1971**

[21] Appl. No.: **116,030**

Related U.S. Application Data

[60] Continuation-in-part of Ser. No. 882,391, Jan. 7, 1970, which is a division of Ser. No. 741,492, July 1, 1969, Pat. No. 3,530,557.

[52] **U.S. Cl.** ..... **28/72.2 R,** 156/149

[51] **Int. Cl.** **D04h 18/00**

[58] **Field of Search** ..... 28/72.2 R, 72.2 F, 28/4 R, 4 N; 156/149

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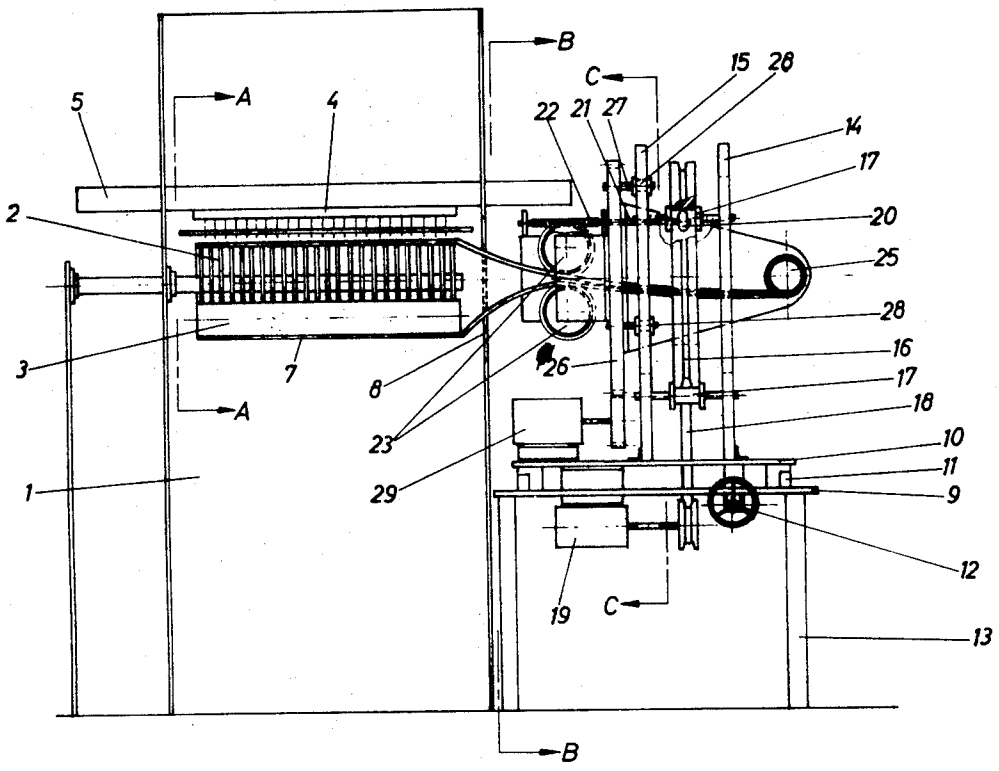
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Primary Examiner—Robert R. Mackey
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[57] **ABSTRACT**

A continuous fabric tubing is prepared by helically winding non-woven webs on a rotating drum in partly overlapping relationship, stitching the partly superimposed turns to each other by needling, and axially pulling the tubing so formed from the drum. The take-up mechanism, which pulls the tubing from the drum, rotates with the drum, and an automatic cut-off mechanism may be provided for automatically cutting the continuous tubing to uniform, adjustable lengths. The tubing may consist entirely of monofilaments and other smooth fibers not capable of normal felting.

1 Claim, 11 Drawing Figures

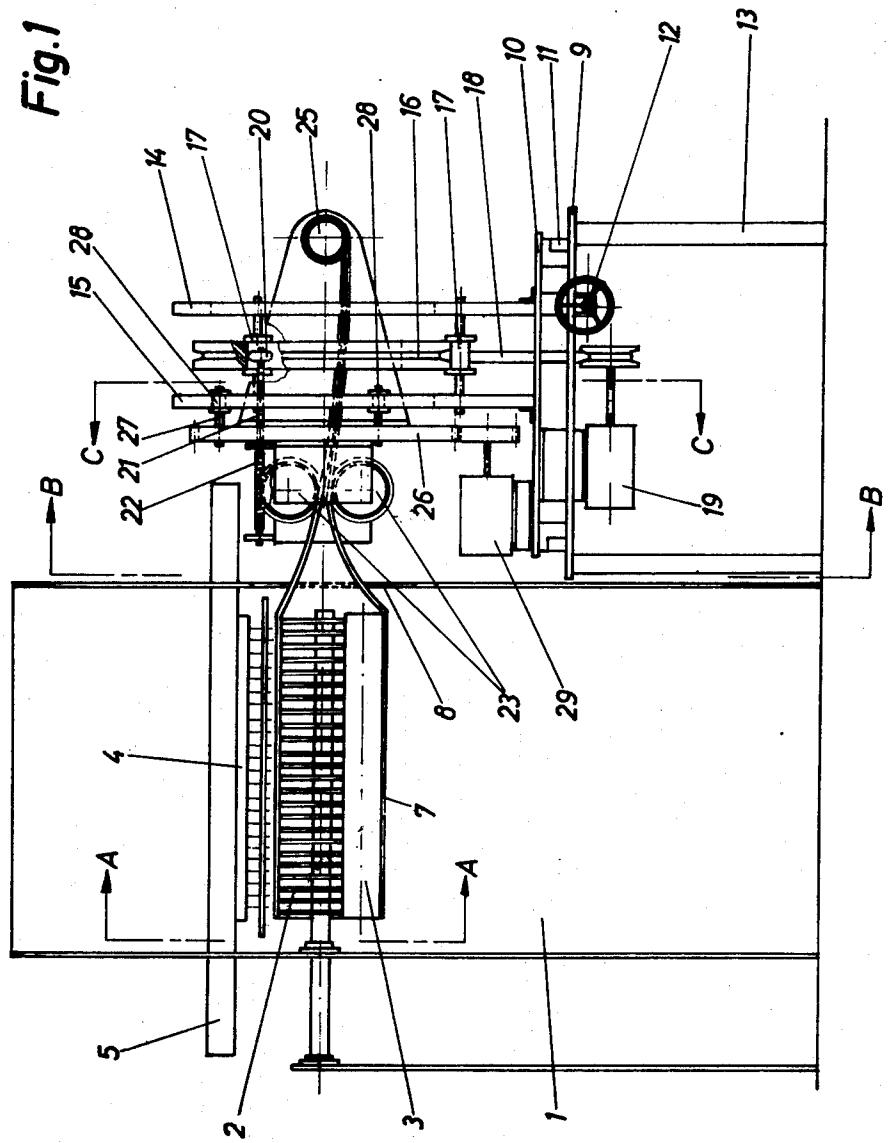


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SHEET 1 OF 7

Fig.1



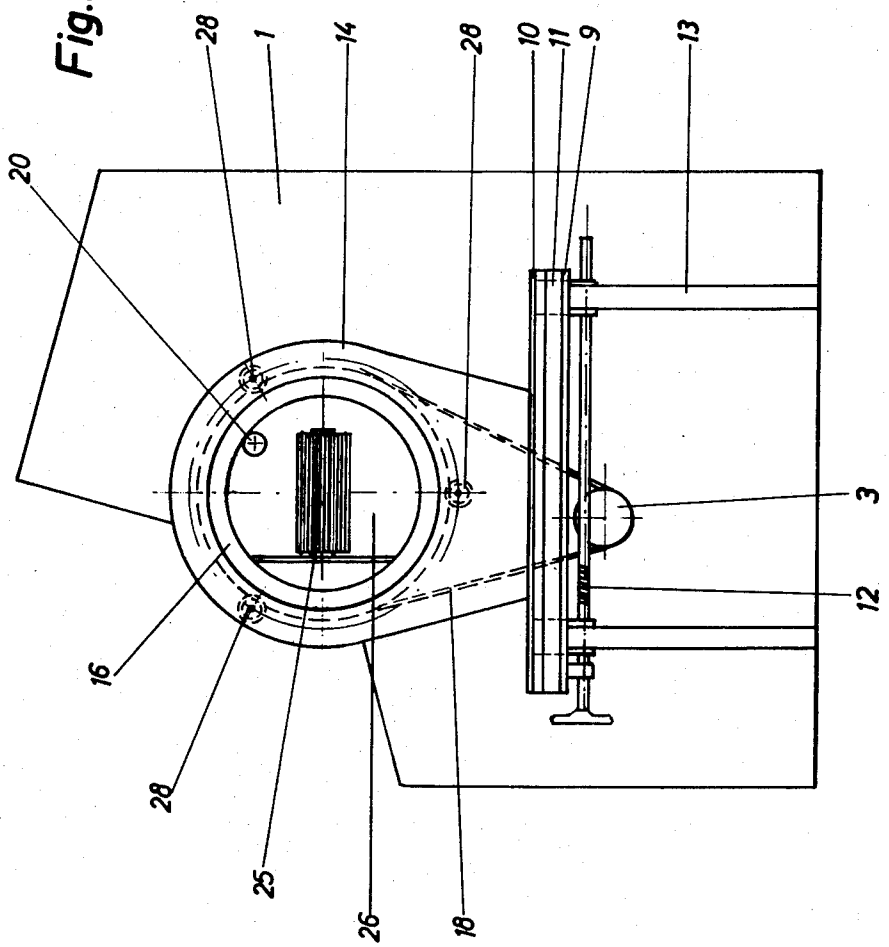
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Fig.2



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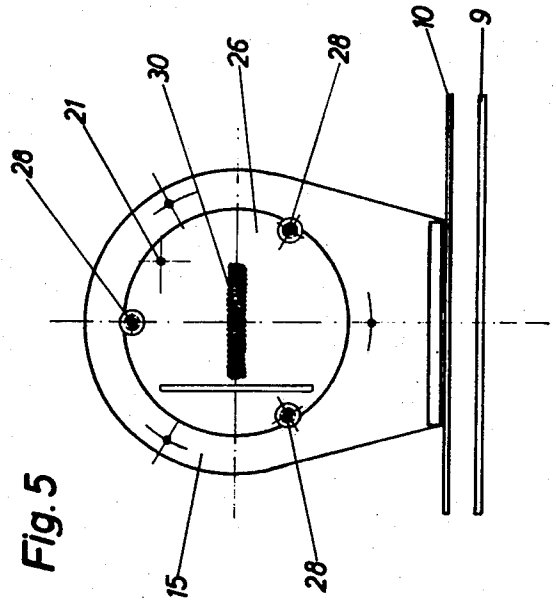


Fig. 5

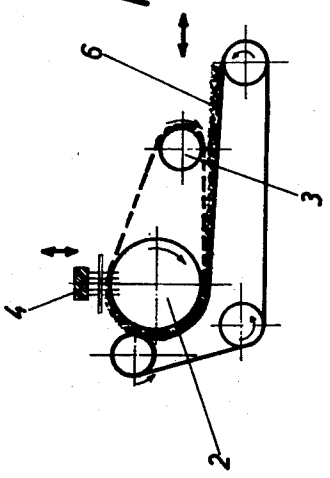


Fig. 3

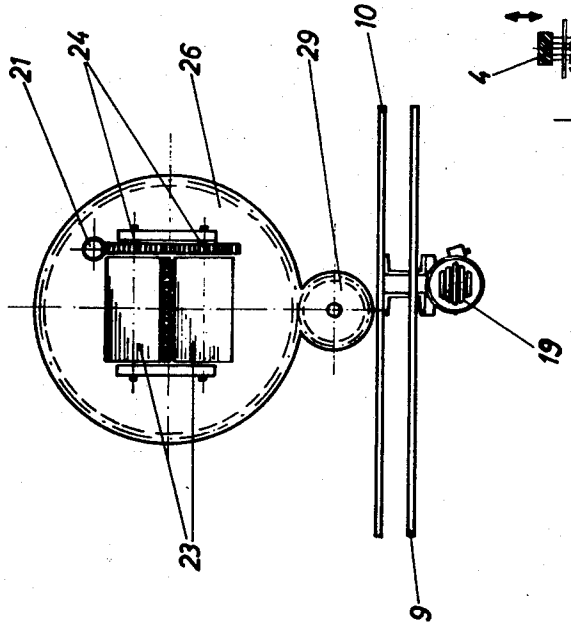


Fig. 4

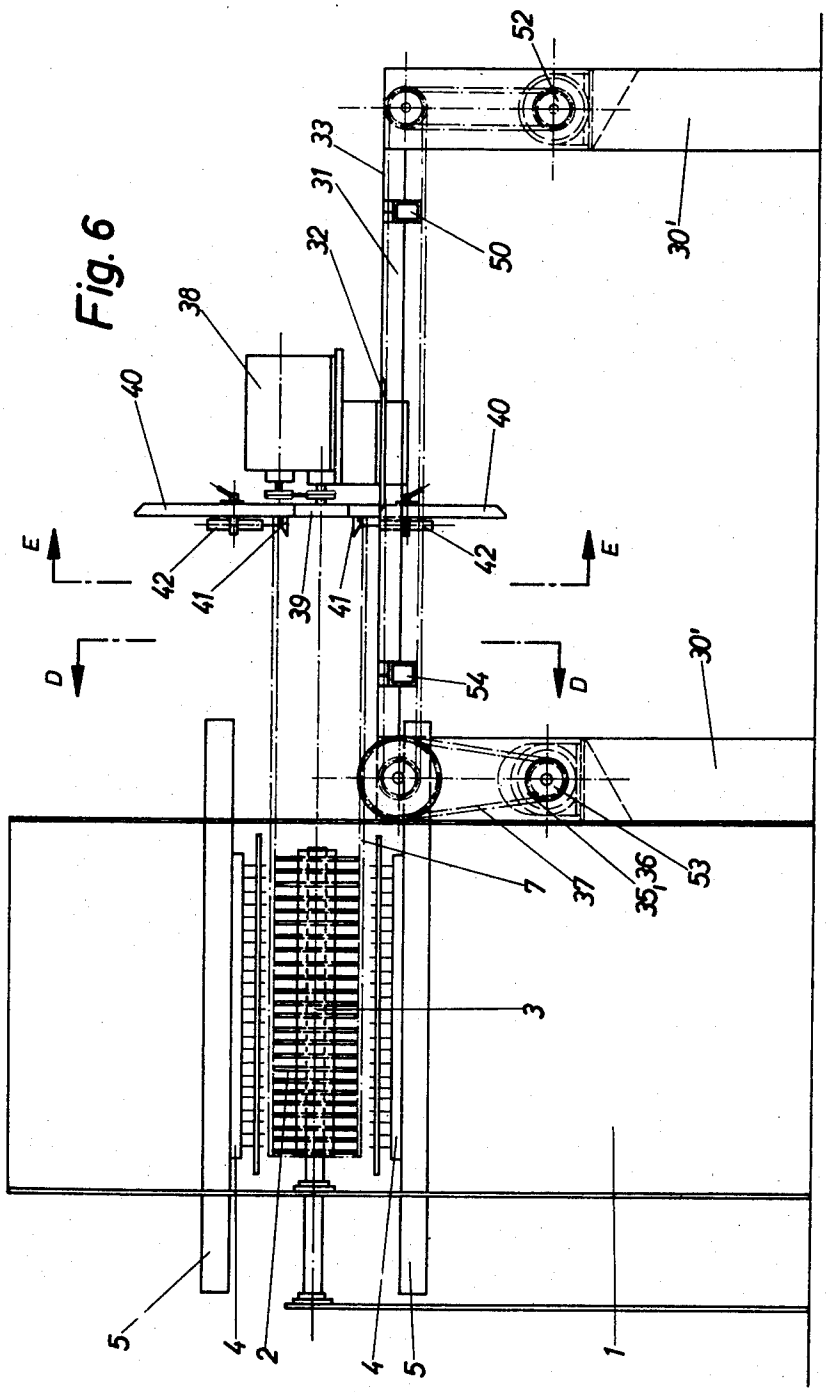
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Fig. 6



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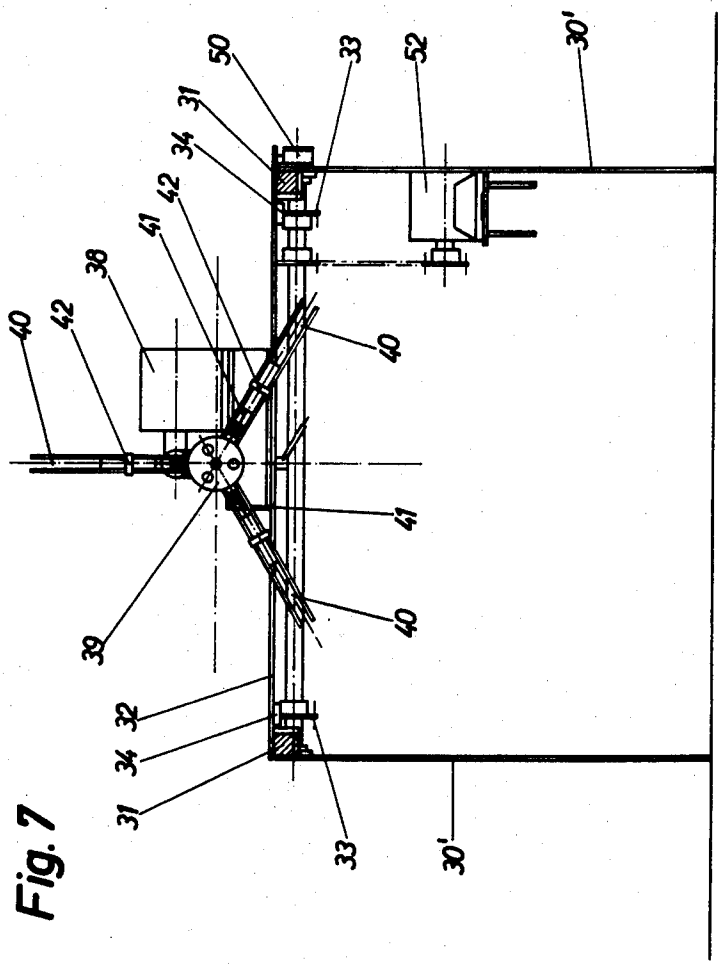


Fig. 7

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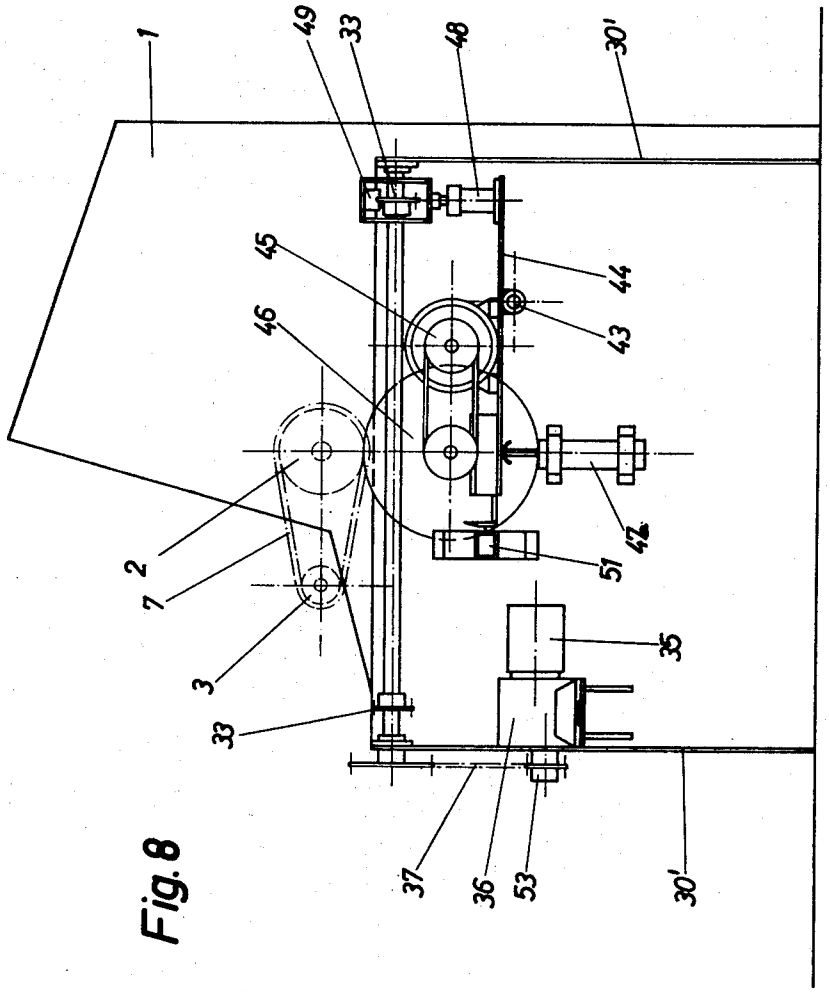


Fig. 8

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Fig. 9

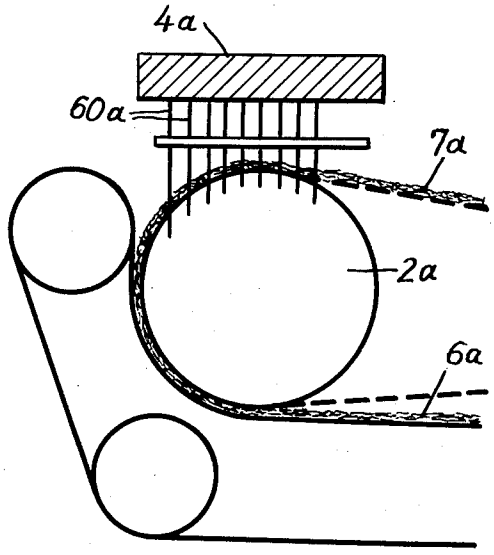


Fig. 10

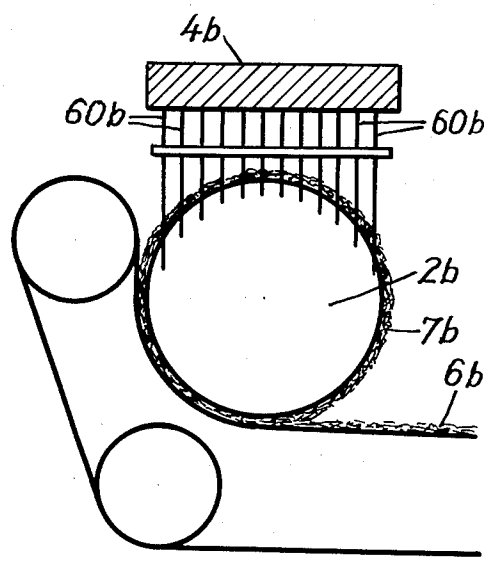
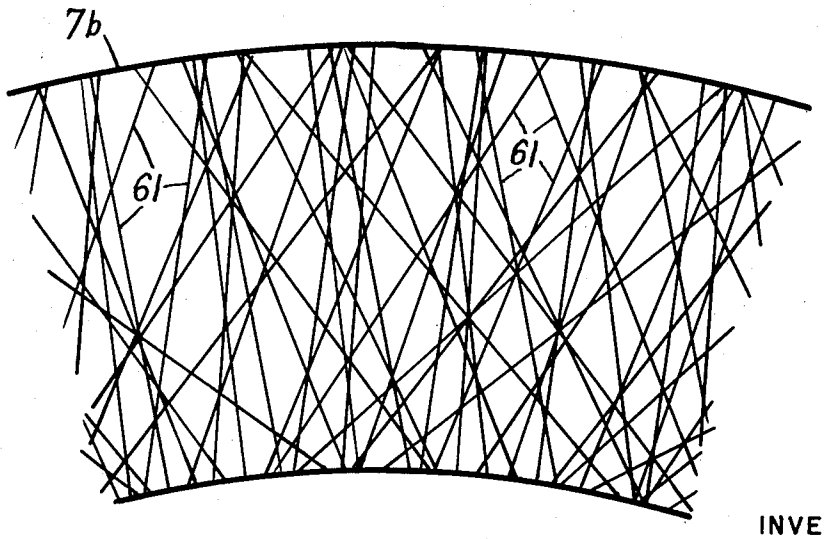


Fig. 11



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METHOD OF MAKING A TUBULAR NEEDLED WEB

This application is a continuation-in-part of copending application Ser. No. 882,391, filed Jan. 7, 1970, now abandoned which is a division of parent application Ser. No. 741,492, filed July 1, 1968, now U.S. Pat. No. 3,530,557, dated Sept. 29, 1970.

BACKGROUND OF THE INVENTION

This invention relates to non-woven textiles, and particularly to tubing essentially consisting of helically wound turns of a non-woven fibrous web, to a method of producing such tubing, and to an apparatus for performing the method.

Sleeves of felt and similar non-woven textile material find many applications in industry, such as surface layers on rollers in processing equipment and the like. The range of fibrous materials capable of being converted into felts having the necessary mechanical strength is quite narrow because smooth fibers do not engage each other with sufficient friction to provide a felt made therefrom with adequate cohesive strength. The fibers which are converted to felts by fulling or other conventional methods must contain a sizable percentage of wool for adequate strength of the tubing to be prepared therefrom. Wool, however, is sensitive to acid and particularly to alkali, and quickly deteriorates when used with these and many other chemicals.

An object of the invention is the provision of non-woven textile tubing whose mechanical strength does not depend on a specific configuration of the fibers employed, and is thus capable of being prepared from synthetic fibers of all types, including monofilaments, and from inorganic fibers which may have completely smooth surfaces.

Concomitant objects of the invention are a method of producing such non-woven tubing, and apparatus for performing the method.

SUMMARY OF THE INVENTION

In one of its aspects, the invention therefore resides mainly in tubing essentially consisting of a plurality of helically wound, coaxial turns of at least one fibrous web of non-woven fabric, each turn overlapping at least one preceding turn and being overlapped by at least one succeeding turn. A plurality of fibers integral with each other extend angularly from that turn inward through at least one subjacent turn, the turns being fastened to each other by the angularly extending fibers.

In the method of making continuous tubing of the aforedescribed type, at least one non-woven fibrous web is wound in a plurality of coaxial helical turns at such a helix angle that each turn axially overlaps at least one preceding turn and is itself overlapped by at least one succeeding turn. A multiplicity of needles is passed inwardly through the overlapping turns until fibers from an outer turn are drawn inwardly through at least one subjacent turn, whereby the turns are fastened to each other. The needles are then withdrawn from the tubing so formed in an outward direction.

The web may be fed continuously to a drum member in a tangential direction while the drum member rotates about its axis, and the turns so formed are axially drawn from the drum. The turns are fastened to each other by the aforementioned needles while supported on the drum.

More specifically, the apparatus employed may mainly consist of a drum arrangement which tapers in the direction of its axis of rotation (not shown in the drawings), a feeding mechanism for continuously feeding a web of non-woven material to an axial portion of the drum arrangement in a direction substantially tangential relative to the axis of rotation, a needling mechanism for needle stitching consecutive turns of the web wound on the drum arrangement and a take-up mechanism for axially moving the turns on the drum arrangement. By the simultaneous rotation of the drum arrangement and the axial motion imparted by the take-up mechanism, the turns of web material form a helix of partly radially superimposed turns when the velocity of axial movement does not exceed a predetermined velocity. The several turns are thus stitched to each other in the form of continuous tubing, and the tubing is drawn from the drum arrangement by the take-up mechanism.

Other features, additional objects and many of the attendant advantages of this invention will be readily understood by reference to the following detailed description of a preferred embodiment when considered in connection with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 shows an apparatus of the invention for the continuous production of non-woven textile tubing in side elevation;

FIG. 2 shows the apparatus of FIG. 1 in front elevation;

FIGS. 3 to 5 show the apparatus of FIG. 1 in sections on the lines A—A, B—B and C—C, respectively;

FIG. 6 illustrates a modified apparatus of the invention in side elevation;

FIGS. 7 and 8 show the apparatus of FIG. 6 in sections on the lines E—E and D—D, respectively;

FIG. 9 is a transverse section, similar to FIG. 3, illustrating the use of a set of needles spanning about one-half of the diameter of the mandril;

FIG. 10 is a similar transverse section illustrating the needles applied to a cylindrical product and extending across the entire diameter of the mandril; and

FIG. 11 is a diagrammatic view of a portion of the needled web on a greatly enlarged scale illustrating the various angular paths of the needles through the web.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings in detail, and initially to FIGS. 1 and 2, there is seen a machine frame 1 which supports an elongated drum 2 of circular cross section. The drum 2 tapers slightly from the left toward the right (not shown in the drawings), as viewed in FIG. 1, and has a multiplicity of circumferential grooves. For the sake of convenient pictorial representation, relatively few grooves have been shown in FIG. 1, and their axial width has been exaggerated. The drum 2 is mounted on a shaft which is driven at a constant speed by a non-illustrated electric motor, whenever the machine operates.

A thin cylindrical roller 3 is journaled in a non-illustrated bearing on the frame 1 below the drum 2, and the bearing is adjustable on the frame to vary the axial spacing of the drum 2 and the roller 3, the respective axes being parallel.

A plate 4 carrying a multiplicity of needles is mounted above the drum 2 on a carrier 5. The carrier is vertically slidable on the frame 1 and is reciprocated by the drive motor of the drum 2 so that the needles on the plate 4 are inserted into the grooves of the drum 2 and withdrawn at a speed which can be adjusted by a variable transmission, not shown, which is interposed between the non-illustrated drive motor and the carrier 5.

As is seen in FIG. 3, a narrow fibrous web 6 of non-woven fabric is fed by an endless conveyor to the drum 2 and the roller 3, and is initially wound in a continuous loop over the drum and the roller. The several layers of fibrous material superimposed during the joint rotation of the drum and the roller, the latter being turned by the fibrous material, are continuously interlaced by the reciprocating needles on the board 4 in a manner conventional in the manufacture of non-woven fabrics. When the starting loop reaches the desired thickness, it is pulled manually along the drum 2 from the wide toward the narrow axial end at a rate to maintain the desired thickness in the multilayered, helically wound tube 7 of needled non-woven fabric which is thereafter produced. The end of the tube is ultimately drawn from the drum 2 and pulled through an opening 8 in the frame 1 to a take-up mechanism which thereafter collects the tubular material at a rate to provide the desired overlapping of sequential turns of the web 6.

The take-up mechanism is mounted on a carriage 10 which travels on rails 11 on the table 9, a spindle 12 equipped with a handwheel being journaled on the table 9 and engaging a threaded sleeve on the carriage 10 to move the carriage horizontally at right angles to the axis of the drum 2. The table 9 is mounted on legs 13 which are hydraulic cylinders containing pistons attached to the table 9, but not visible in the retracted position shown in the drawing. The take-up mechanism may thus be shifted in two directions to accommodate tubes 7 of different width, as determined by the radial spacing of the drum 2 and roller 3.

Two annular upright plates 14, 15 are mounted on the carrier 10 in such a manner that the axes of their openings coincide and are parallel to the axis of the drum 2. A flat annular pulley 16 is supported between the plates 14, 15 on rollers 17 which engage the outer circumference of the pulley and whose shafts connect the plates 14, 15. A V-belt 18 is trained over the pulley 16 and over the drive pulley of a variable-speed electric motor 19 mounted on the frame 1.

A friction roller 20 engages the inner circumference of the pulley 16, and drives a shaft 21 which passes freely through the central opening in the plate 15. The shaft 21 carries a worm 22 which meshes with a gear 24 on one of two take-up rolls 23 drivingly connected by the gears 24.

During operation of the illustrated apparatus, the tube 7 is flattened and pulled through the opening 8 in the frame 1 by the take-up rolls 23 driven by gears 24. It is stored on a wind-up reel 25 driven by its own non-illustrated electric motor equipped with a slip clutch to maintain the necessary slight tension in the flattened tube.

The tube 7 rotates about its axis as it is discharged from the drum 2 and roller 3, and the entire take-up mechanism turns with it. A spur gear 26 is rotatably mounted on the plate 15 by means of circumferentially distributed stub shafts 27 on the gear 26, which carry V-notched rollers 28. The rollers 28 travel on the rim of the plate 15 around the central opening of the plate so that the gear 26 rotates coaxially with the pulley 16. The gear 26 is driven by a pinion on the output shaft of a variable-speed electric motor 29 at the same surface speed as the drum 2. As is best seen in FIG. 5, the flattened tube 7 passes through a diametrical slot 30 in the gear 26.

The aforementioned shaft 21, which connects the worm 22 to the friction roller 20, is journaled in the gear 26. The take-up rollers 23 driven by gears 24, the wind-up reel 25, and the non-illustrated drive motor of the latter are mounted on a sheet metal bracket fixedly attached to the gear 26 and extending through the central openings in the plates 14, 15.

Typically, the drum 2 and the roller 3 in the apparatus shown in FIGS. 1 to 5 may be set to produce helically wound, needle-stitched, non-woven fabric tubing 4 to 12 cm. in diameter. The needle plate 4 may carry about 1300 needles arranged in 13 rows extending axially of the drum 2, one needle of each row being aligned with a groove in the drum 2 and with one row of needles passing through the center line of the drum in a radial direction while the other rows are spaced from the center line in parallel planes. Depending on the requirements, the needle plate carrier 5 may be reciprocated approximately 100 to 1000 times per minute. The thickness of the tube 7 depends on the characteristics of the web 6 and on the pitch of the helix in which the web is wound over the drum 2 and the roller 3. The helix pitch is determined by the rotary speed of the take-up roll 25 at fixed rotary speed of the drum 2, and thus by the relationship of the speeds of the motors 19 and 29 which can be adjusted in a non-illustrated conventional manner.

The tubing produced on the aforementioned apparatus is being used successfully as a surface cover on cylindrical rollers employed in the paper industry and on tannery equipment. It can also be used as a filter medium on drum filters and, generally, where felt sleeves are presently used.

Conventional felt sleeves are prepared from woven fabrics or by fulling. In order to possess the required mechanical strength, they must contain an adequate amount of wool and have, therefore, limited resistance to acids, and particularly to alkaline liquids. The apparatus described above produces strong tubing from all types of fibers including smooth fibers which cannot be felted by fulling or other conventional methods. I have successfully prepared felt-like tubes from all commonly available synthetic fibers, but also from inorganic fibers, such as metal, glass and asbestos fibers, without the admixture of wool. All conventional textile materials, including wool, can of course be converted to tubing on the illustrated apparatus.

When the tubing made according to this invention includes thermoplastic fibers, such as fibers of po'yesters, polyamides, polypropylene, or acrylics, they may be subjected to a thermal aftertreatment. Typically, they may be subjected to infra-red radiation from the outside or the inside to soften and fuse as much of the fibrous material as is desired. Depending on the readily controlled input of thermal energy, the tubing may be converted to a continuous, homogeneous structure, to an otherwise continuous film tube having pores of controlled size, or to a material of recognizable fiber struc-

ture in which the fibers are partly bonded to each other by heat sealing.

Bonding of the fibers to each other with or without thermal sealing may also be achieved by conventional admixtures to the initial web **6**, such as elastomers (natural or synthetic rubber), and thermoplastic resins or thermosetting resins in the uncured condition, particularly phenol-formaldehyde and amine-formaldehyde resins, and by subsequently setting the adhesive. Other bonding materials suitable for use in preparing webs **6** include starch, starch ethers or esters, glues and adhesives of animal or plant origin (alginates, caseinates), also cellulose derivatives (cellulose esters, cellulose ethers, viscose) and vinyl alcohol.

Adhesives or bonding agents which have been used with particular success on the illustrated apparatus include a latex of butadiene-styrene elastomer, a latex of butadiene-acrylonitrile copolymer, and natural rubber latex. These bonding agents are set by heating the tube until the water is substantially completely evaporated. The configuration of the pores in the non-woven fabric tube so obtained can be controlled precisely and reproducibly by selecting the setting conditions. The bonding agent, while still fluid, tends to migrate toward the source of heat, and the pores thus are smaller on the side of the tubing from which the heat is applied.

Other bonding agents which have been used successfully in webs **6** fed to the apparatus of FIGS. **1** to **5** are aqueous dispersions of plasticized vinyl ester polymers, such as polymers and copolymers of vinyl acetate and vinyl chloride.

The modified apparatus shown in FIGS. **6** to **8** operates in substantially the same manner as that described hereinabove to produce corresponding products from non-woven webs with or without bonding agents.

Referring initially to FIG. **6**, there are seen a frame **1**, a drum **2**, and a roller **3**, identical with the corresponding elements shown in FIG. **1**, and two needle-studded plates **4** on respective carriers **5** which move radially toward and away from the drum **2** in opposite directions for needle-stitching a tube **7** formed on the drum in the general manner described above with reference to FIGS. **1** to **5**. The modified apparatus is capable of producing tubing **7** of a diameter selected by varying the spacing of the drum **2** and of the roller **3**.

The take-up mechanism best seen in FIGS. **6** and **7** is mounted on a support **30'** by means of rails **31** elongated axially of the drum **2** and a carrier plate longitudinally guided on the rails **31**. The plate **32** is moved by continuous drive chains **33** attached to lateral lugs **34** of the plate. The chains are trained over sprockets of which one is driven by an electric motor **35** equipped with an infinitely adjustable variable-speed transmission **36**, and connected to the driven sprocket by an overriding clutch **53**, pulleys and a belt **37**.

An electric motor **38** is mounted on the plate **32** for turning the hub **39** of a tube gripping mechanism about the axis of the drum **2** through a variable speed transmission which permits the rotary speed of the hub **39** to be adjusted to the rotary speed at which the drum **2** is turned by its non-illustrated drive motor.

Three pairs of guide channels **40** equiangularly radiate from the hub **39**. The opposite grooves of each pair hold a pneumatically operated clamping mechanism in a radially adjustable position. Each mechanism consists of a cylinder **42** carrying an anvil **41** in radially inwardly spaced relationship, and a spring-loaded plunger in the cylinder **42** which moves toward and away from the anvil **41** when the cylinder **42** is supplied with operating fluid from compressed air line and vented through a solenoid valve in a conventional manner, not explicitly illustrated in the drawing.

The modified apparatus also is equipped with a cut-off mechanism which has been omitted for the sake of clarity from FIG. **6**, where it would be largely obscured by the motor **35**, and associated elements of the drive mechanism for the chains **33**, but is shown in FIG. **8**. The cutting mechanism is mounted on the frame **1** by means of a shaft **43** and a rocker plate **44** movable on the shaft **43**. The portion of the rocker plate to the left of the shaft **43**, as viewed in FIG. **8**, carries an electric motor **45** connected by a belt drive to a circular cutting blade **46** mounted on the rocker plate **44** to the left of the motor. A pneumatically operated cylinder **47** is attached to the frame **1** under the portion of the plate **44** which carries the shaft of the blade **46**. Another pneumatically operated cylinder **48** attached to the plate **44** carries a coupling clamp **49** which permits the plate **44** to be coupled to one of the drive chains **33** for axial movement thereby on the shaft **43**.

The apparatus shown in FIGS. **6** to **8** automatically produces cut lengths of non-woven fabric tubing in the following manner:

At the start of each operating cycle, the carrier plate **32** is located at the left end of the support **30'**, as viewed in FIG. **6**, and the leading circular edge of the tube **7** is located between the anvils **41** and the retracted plungers of the clamping mechanism. As the plungers are expelled from the cylinders **42** by compressed air, they clamp the tube **7** to the take-up mechanism while the hub **39** turns in unison with the drum **2** and the roller **3**. The carrier plate **32** is moved toward the right by the chains **33** at a rate which determines the helix angle of the web which is being wound on the drum **2** and the cylinder **3** while the several layers of the tube **7** formed thereby are stitched to each other by the needles on the needle plates **4**.

The carrier plate **32** is moved toward the right until it abuts against a limit switch **50** which may be shifted on the support **30** according to the length of the tubing pieces which it is desired to produce. The switch **50** controls admission of compressed air to the cylinder **47** through a non-illustrated solenoid valve which also provides air for the coupling cylinder **48**. The rocker plate **44** is tilted clockwise, as viewed in FIG. **8**, so that the rotating blade **46** cuts the tube **7** while the plate **44** is moved by the chains **33** on the shaft **43** in unison with the take-up mechanism. The front end of the tube **7** is severed from the remainder of the tube after one revolution of the hub **39**, and upward pivoting of the plate **44** by cylinder **47** and drops from the machine while the rocker plate **44** hits another limit switch **51** on the frame **1**, which shifts the aforementioned non-illustrated solenoid switch to vent the cylinders **47**, **48** and energizes another motor **52** connected to sprockets for the chains **33**.

A non-illustrated return spring moves the rocker plate **44** on the shaft **43** into its starting position, and the motor **52** shifts the carrier plate toward the left, as viewed in FIG. **6**, until the clamping mechanism **41**, **42** grasps the freshly cut leading edge of the tube **7**, and a new operating cycle is started by abutting engagement of the carrier plate **32** with yet another limit switch **54** on the frame **1**. The switch **54** deenergizes

the motor 52 and actuates the clamping mechanisms 41, 42. The latter are released by a non-illustrated solenoid valve when the limit switch 50 is operated. The overriding clutch 53 permits the carrier plate 32 to be returned to its starting position by the motor 52 while the motor 35 is energized.

The relays which connect the limit switches 50, 51, 54 with the pneumatic circuit of the machine and with the associated electric motors, and the pneumatic circuit itself have not been shown since they are conventional and obvious to those skilled in the art from the above description of their mode of operation.

The tubing 7 produced on the apparatus shown in FIGS. 6 to 8 is indistinguishable from that made on the apparatus of FIGS. 1 to 5. As released from the illustrated machines, it consists essentially of a helically wound fibrous web, each helical turn axially overlapping at least one axially preceding turn and being itself overlapped by an axially succeeding turn, the several superimposed turns being connected by fibers of an outer web extending partly radially inwardly through the inner layers, as is inherent in the needling operation by which the several layers are firmly anchored to each other.

While it is preferred to equip the apparatus of the invention with an auxiliary roller 3 to permit the diameter of the tubing to be changed as needed, the slightly tapering drum 2 alone is sufficient if long lengths of tubing of uniform diameter are to be made. It will further be appreciated that more than one web 6 may be fed simultaneously to the same drum 2 if so desired.

In the embodiment of FIG. 9, the mandril 2*a*, web 6*a*, and corresponding parts are given the same reference numbers as in FIGS. 1 to 8 and are similar to that above described. In this form the needle bar 4*a* is substantially wider than the needle bar 4 of FIG. 3 and contains nine longitudinal rows of needles 60*a*.

It will be noted that these rows of needles 60*a* extend from about the center of the mandril to the periphery thereof and have their points disposed in an arc corresponding to the periphery of the mandril 2*a*. The needles at the center line of the mandril enter the web 6*a* radially, that is, they extend through the finished web substantially transversely. The needles in the outer row of the periphery of the mandril extend through the web substantially tangentially, that is, substantially longitudinally of the finished web. The intermediate needles extend through the web on the mandril at various angles from transverse to longitudinal. Hence, the fibers are displaced at random angles across the web.

As the mandril rotates a slight amount between needle strokes, the angles of the needles in the web are varied as the web advances, thus producing a web wherein the displacement of the fibers in each part of the web lie at various random angles.

As further layers of the web are laid on the mandril and the needling continues, additional fibers are displaced in each layer and through adjacent layers to bind the layers together so that the felted web in the final product possesses a substantial amount of tensile strength anc can be reduced to a semi-rigid state.

FIG. 10 illustrates a further embodiment which is similar to that above described except that the idler roll 3 is omitted and the web 6*b* is wound in a cylindrical form on the mandril 2*b*. In this form the needle bar 4*b* is of sufficient width to carry sets of needles which extend across substantially the entire diameter of the mandril. In the form shown there are twelve parallel sets of needles 60*b*, having their joints disposed in an arc corresponding to the periphery of the mandril 2*b*. The central rows of needles extend substantially radially through the web and the outer rows of needles extend substantially tangentially therethrough. The intermediate rows extend at various angles therebetween as in the form of FIG. 9. The product of FIG. 10 differs from that of FIG. 9 in that the angles vary through substantially 180° across the web, whereas in FIG. 9 the variation is approximately 90°. As the mandril 2*b* rotates a slight amount, such as an amount comparable to the needle spacing between succssive needle strokes, the fibers in each area of the web are displaced at various angles within a substantially 180° range.

The product obtained by the needle arrangement of FIG. 10 may be made relatively hard and stiff so that when applied to a roll of a paper making machine it will have a long life.

Since the points of the needles in FIGS. 9 and 10 are arranged on an arcuate line conforming generally to the periphery of the mandril, each needle penetrates the entire thickness of the web but does not extend substantially therebeyond. Of course the needles may be disposed to extend only partly through the web, if desired, depending upon the arrangement and upon the needle stroke. It will be noted that the needles displace the fibers between the layers so that the various layers of web are securely bound together by the displaced fibers and in the product the separate layers are substantially indistinguishable.

FIG. 11 illustrates diagrammatically the various angular paths of the needles. In this Figure the paths of the needles and consequently the displacement of the fibers in one layer of web is indicated by transverse angular lines 61. It will be apparent from this Figure that the web can be subjected to a large number of needle strokes in any one area and that the random displacement of the fibers extends throughout the various areas of the web and through and between the layers, although only a single layer is shown in FIG. 11 for purposes of clarity.

FIGS. 1 to 8 show the unfelted web as being wound spirally on the mandril 2 to produce a continuous tubular product. It is to be understood that the unfelted web may be made the full axial length of the mandril and may be wrapped successively around the mandril to build up a tubular product of the desired thickness, in which case the axial length of the tubular product will correspond to the width of the unfelted web. Various other arrangements will be apparent to a person skilled in the art.

I claim:

1. The method of felting an endless web of unfelted fibers which comprises spirally winding a web of such unfelted fibers over a mandril in a plurality of successive partially overlapped layers, needling each layer and the underlying layers as the web is wrapped around said mandril by causing a set of parallel needles which are displaced diametrically across the width of said mandril to advance as a unit in parallel paths and to penetrate said web at a plurality of peripherally spaced points, said needles penetrating the web at increasing angles to the surface of the web as the points of penetration progress from the center to the periphery of said mandril on which the web is wrapped and displacing said web both peripherally and axially of said mandril step by step at each successive penetration of said needles so that the fibers are displaced in and through said webs at various angles for firmly interfelting the webs.

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