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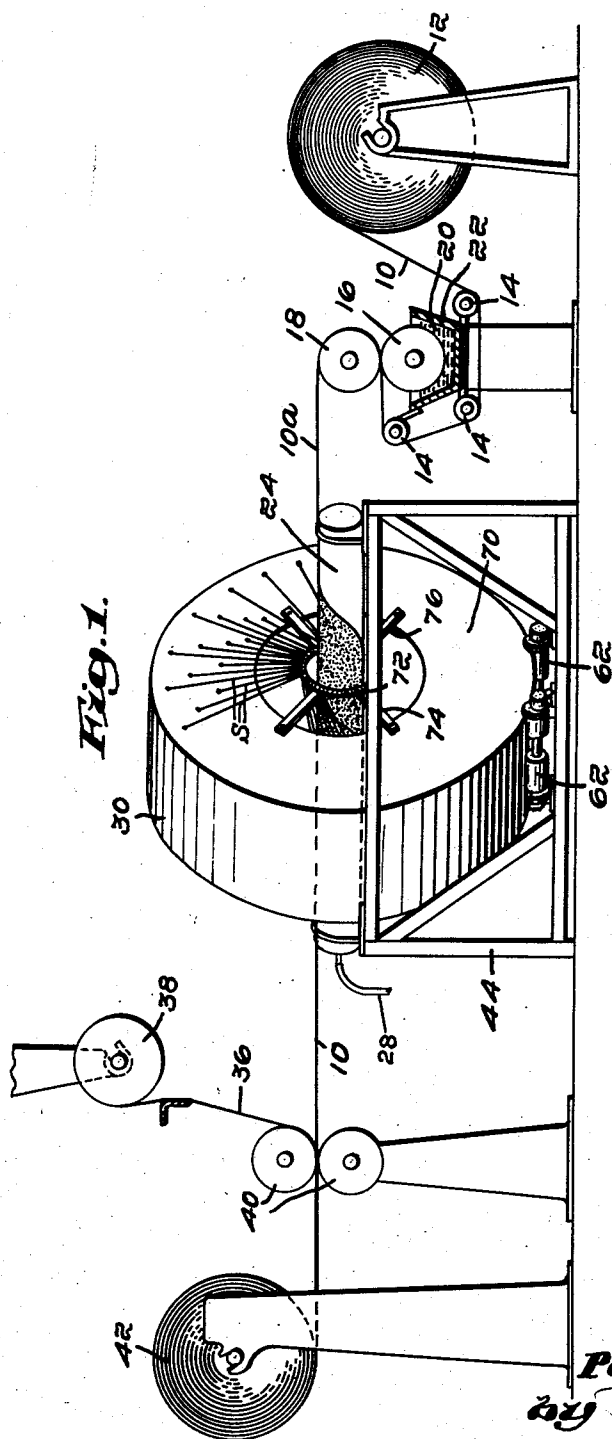
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WEB REINFORCING METHOD AND APPARATUS

Filed Jan. 24, 1952

4 Sheets-Sheet 1



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WEB REINFORCING METHOD AND APPARATUS

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4 Sheets-Sheet 2

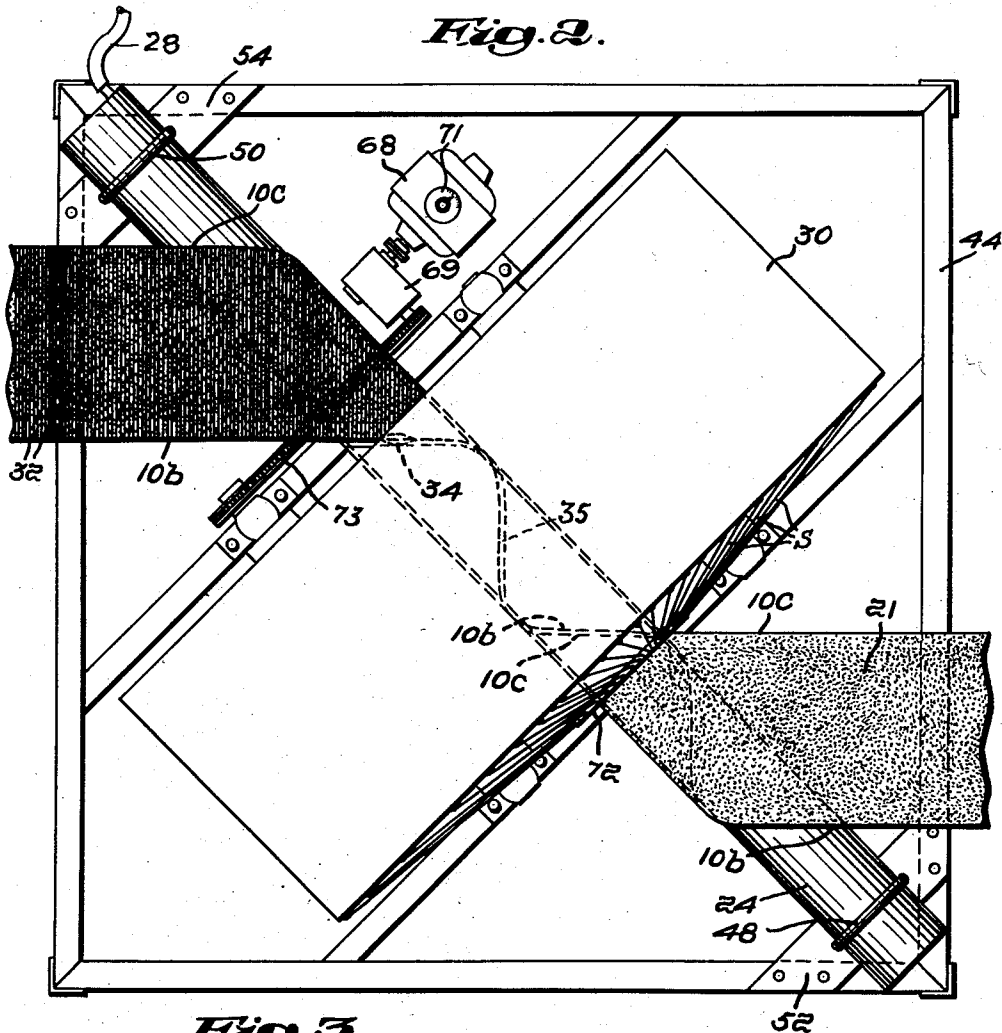
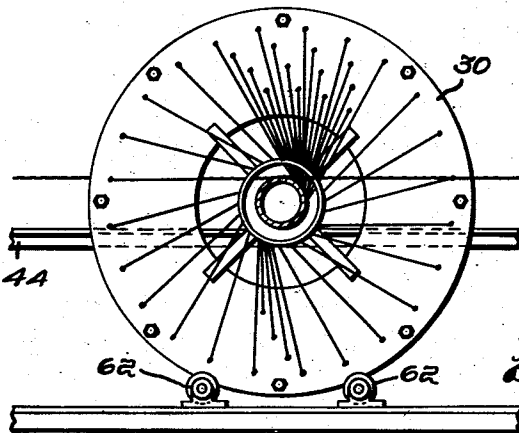


**Fig. 3.**



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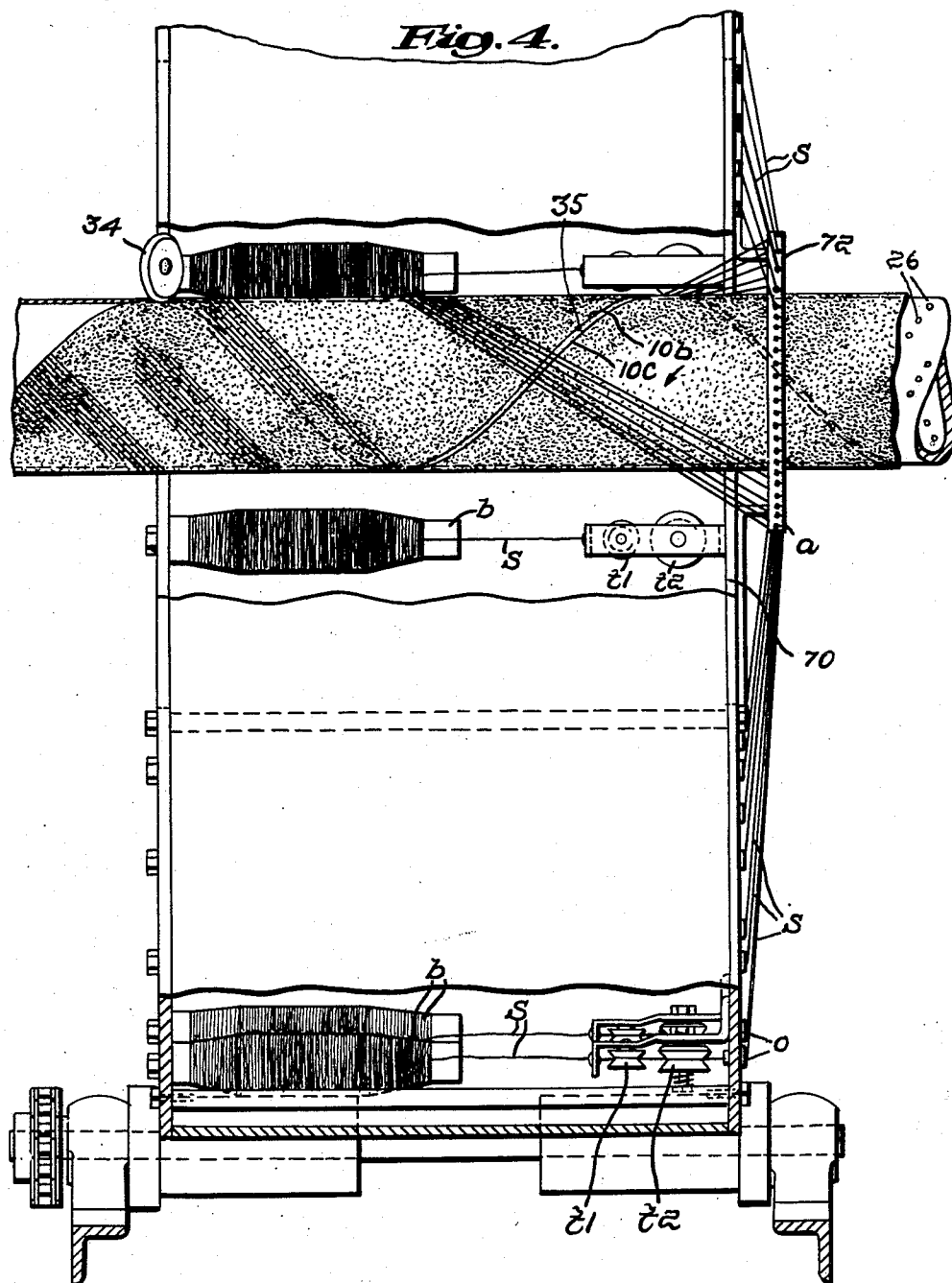
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# WEB REINFORCING METHOD AND APPARATUS

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4 Sheets-Sheet 3



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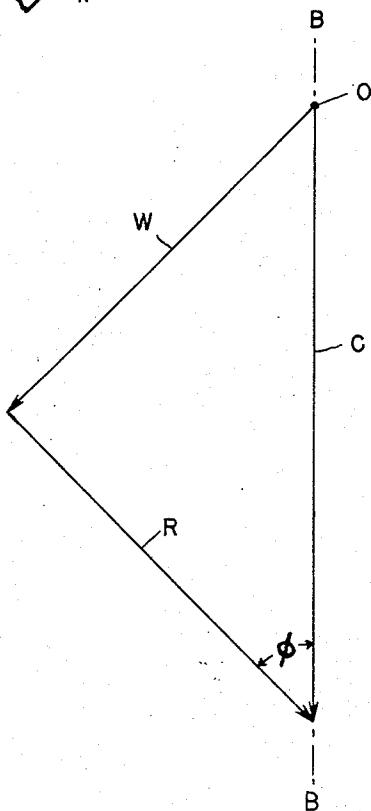
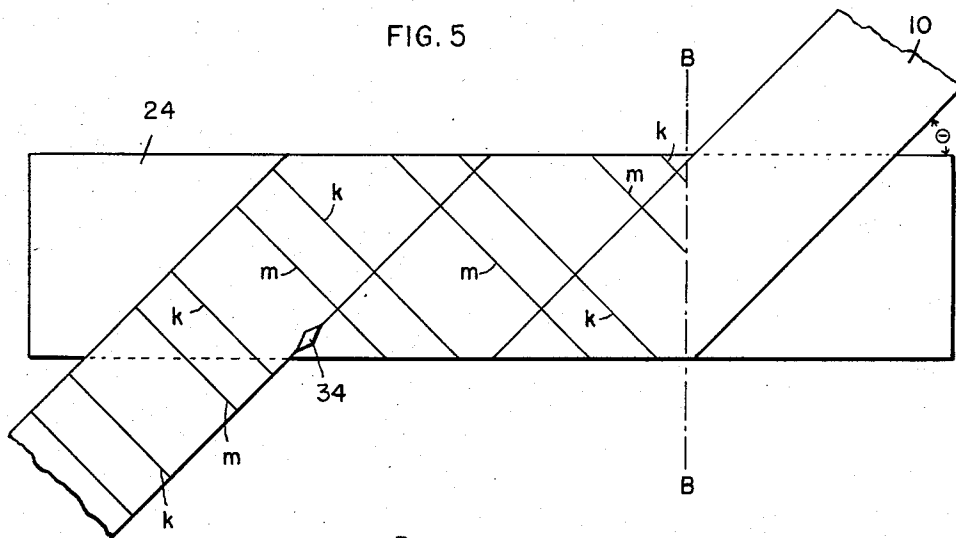
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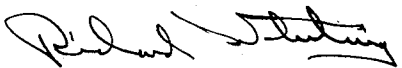
WEB REINFORCING METHOD AND APPARATUS

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4 Sheets-Sheet 4



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## WEB REINFORCING METHOD AND APPARATUS

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Application January 24, 1952, Serial No. 268,038

10 Claims. (Cl. 154—1.76)

This invention relates to the manufacture of reinforced webs by the deposit of reinforcing fibers transversely of a web while the web is moving continuously in a lengthwise direction. The primary object of the invention is to provide novel method and apparatus by which fibers may be deposited transversely of the web axis directly from a continuous fiber supply without the necessity of severing the fibers before depositing them, and by which the fibers may be deposited on the web at precisely right angles to the direction of web advance or at a different angle if desired.

A further object of this invention is to provide method and apparatus adapted for use with a range of sizes of transverse reinforcing fibers, including the very slender synthetic fibers.

There have been a number of proposals for obviating the need, as in present day commercial practice, of severing the transverse fibers before depositing them. Such prior proposals have included the suggestion that the web be fed helically about a mandrel which is done according to the preferred embodiment of the present invention. But such proposals have made little if any impression on the practical art, and have not adequately dealt with the problem of depositing fibers in directions precisely normal to the direction of web travel. By the present invention feeding movements of the web and the fibers may be so correlated as to speed and direction, that this desired result is accomplished in a way that is novel and commercially practicable. The invention also affords adjustability, if desired, in the operation of the machine by which, for example, a variation in the angle of fiber deposit from less than a right angle to greater than a right angle may be effected.

In the drawings:

Fig. 1 is a side elevation view of one form of apparatus embodying the present invention;

Fig. 2 is a plan view showing the creel and associated mechanisms;

Fig. 3 is a side elevation view of the creel, as viewed along its axis;

Fig. 4 is an enlarged vertical section of the creel, partly broken away;

Fig. 5 is a diagram illustrating a certain mode of operation of the machine; and

Fig. 6 is a vector diagram illustrating the effect of creel and web velocities.

Referring to Fig. 1, the web 10 to be transversely reinforced is drawn from a supply 12 around guide rolls 14 and thence between roll 16 and the back-up roll 18 so that one surface of the web is coated with adhesive 20 from the tank 22 in which roll 16 is immersed.

After leaving the roll 18, the web 10, with its adhesive coated surface 10a uppermost, passes tangentially of a mandrel 24 which the web approaches, in the embodiment illustrated, at an inclination of 45° to the mandrel axis as viewed in plan (Fig. 2). The web is wrapped helically about the mandrel twice in a constant direction so that the edges of adjoining convolutions lie closely adjacent each other and extend in parallel directions.

In Fig. 2 the left and right hand edges of the web, 10b and 10c respectively, have been indicated on the portion of the web approaching the mandrel and again on the portion leaving the mandrel. The closely adjacent edges 10b and 10c of successive convolutions intermediate the entering and leaving portions of the web are also indicated.

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The mandrel 24 is securely mounted against rotation on frame 44 by straps 48 and 50, securing opposite ends of the mandrel to opposite cross members 52, 54 of the frame. The motion of the web around the mandrel is a sliding motion around the rigidly fixed mandrel so that as the web moves through the course shown in Fig. 2 it holds its position lengthwise of the mandrel and does not travel down the mandrel toward strap 48 as it would if the mandrel rotated.

The speed of advance of the web may be varied, for example, by suitable variation in the speed of the web driving rolls 16, 18 and 40.

It is desirable that the web convolutions on the mandrel lie fairly close to each other. If spaced apart from each other very widely, some fiber waste will result since the fibers extend from one convolution to the next. For adjacent web convolutions to lie precisely in edgewise abutment, the approach angle ( $\theta$ ), the width of the web ( $F$ ) and the diameter of the mandrel ( $D$ ) must satisfy the equation  $F = \pi D \cos \theta$ . With varying paper widths, the appropriate relation between convolutions may be achieved by either varying the approach angle ( $\theta$ ) or using a mandrel of different diameter ( $D$ ).

When wider webs are accommodated either by a more acute approach angle ( $\theta$ ) or by a larger diametered mandrel, a greater length of web, as well as a greater width, contacts the mandrel to form the convolutions. This results in increased surface friction between the stationary mandrel and the convoluted portions of the web, and may impede the smooth travel of the web, particularly on starting. However, such surface friction may be very substantially decreased by interposing a film of air between the surface of the mandrel and the superposed convolutions of the web. To accomplish this the mandrel is made hollow, closed at both ends, and with apertures 26 (Fig. 4) passing through that surface area of the side wall of the mandrel over which the web travels. Compressed air introduced through pipe 28 into the bore of the mandrel and conducted through the apertures effectively lubricates, as it were, the web by supporting it on an air film as it passes around the mandrel.

Transverse reinforcing fibers are applied to the web from the rotating creel 30 as the web passes through the creel. The creel is in the form of a cylindrical drum mounted coaxially with the cylindrical mandrel for rotation thereabout. The weight of the creel 30 is carried by the cradle formed by the rollers 62 (Figs. 1 and 3). The creel is power rotated, as indicated, by variable speed motor 68 connected through reduction gearing 69 to a sprocket chain 73 which drives one or more of the rolls 62. Rheostat 71 on motor 68 is manually adjustable to vary the speed of the motor 68 and thereby vary the speed of the creel 30.

The transverse reinforcing fibers are supplied from a plurality of bobbins  $b$  suitably mounted on the creel, as shown in Fig. 4. A fiber  $s$  withdrawn from each bobbin  $b$  passes through two pairs of tension rings  $t_1$  and  $t_2$  and thence through an orifice  $o$  suitably formed in the side plate 70 of the creel and through an aperture  $a$  in ring 72 carried by the creel to rotate therewith by suitable cross brackets 74, 76 (Fig. 1). The ring 72 is coaxial with the mandrel and somewhat larger in diameter.

In starting the machine, a length of web drawn around guide rolls 14 and through the adhesive application rolls 16, 18, is wound on the mandrel through the creel and delivered through the take-up rolls 40 in combination with upper web 36. Lengths of fibers threaded through the apertured ring 72 are manually drawn out and deposited on that portion of the adhesive coated web 10 which is inside the creel. Motor 68 is operated to drive the creel in the same sense of rotation about the mandrel as the sense of rotation of the web helix about the mandrel, and the motor is adjusted by rheostat 71 to drive the creel at a linear velocity bearing a predetermined relation to the speed of the web. Due to these relative velocities, the fibers are drawn out parallel with each other across the web. The motion of the web around the mandrel, traveling away from the apertured ring 72, while the ring rotates in a plane normal to the mandrel axis at a certain speed greater than that of the

web, causes the bobbins to be advanced away from the portions of the fibers adhered to the web so that the fibers are withdrawn from the creel and deposited on the web.

The speeds of the creel and of the web have a predetermined relationship which is to be observed if desired results are to be obtained. For convenience, the creel speed may be considered as the linear speed of any portion of the creel projected to the web surface, since this is the effective speed of the fiber supply. If it is desired to deposit fibers at  $90^\circ$  to the web axis, the creel speed must be sufficiently greater than the web speed so that the web and creel have no relative movement lengthwise of the web and the only relative movement is transverse of the web. But this angle of fiber deposit can be made greater or less than  $90^\circ$  by suitable variations of these relative speeds.

Fig. 5 is a developed diagrammatic view of the mandrel with the web convoluted thereon showing the arrangement of the continuous fibers laid normal to the web axis. The plane of the fiber guide ring 72 is represented by line B—B. The disposition of the fibers about the mandrel is illustrated by two typical fibers *k* and *m* which extend continuously around the mandrel in the direction in which they were laid, until cut by knife 34 just before the web is conveyed away from the mandrel.

Fig. 6 is a vector diagram of the velocities at a typical point O on the mandrel surface in the plane B—B. The linear velocity of the creel at point O is represented by the vector C. The velocity of the web 10 is represented by the vector W. The relationship between vectors C and W is indicated by vector R which represents the velocity of the creel relative to the web, i. e., the velocity of the creel minus the velocity of the web. The web and the fiber supply are therefore moving apart along the direction of vector R.

By properly relating the magnitudes of vectors C and W, the vector R may be directed exactly at right angles to the vector W of the web 10 as shown in Fig. 6 so that the fibers are laid exactly perpendicularly to the axis of the web. Under these conditions the angle  $\phi$  between vectors C and R will be the same as the approach angle  $\theta$  (Fig. 5). It is apparent that to achieve this condition, the component of vector C in the direction of vector W must be equal in magnitude to vector W. Thus, for a given angle ( $\theta$ ) between the approaching web and the mandrel axis, the magnitude of C must be equal to the magnitude of W multiplied by the cosecant of the angle ( $\theta$ ) if the fibers are to be laid transversely of the web, perpendicular to its axis.

By changing the velocity of the creel or of the web, thereby varying vector C from the relation  $C=W \csc \theta$ , the direction of the vector R may be changed so that the fibers are laid on the web at angles more or less than  $90^\circ$  to the web axis. When the speed of the creel is increased relative to the web speed, the result is that as the fibers are laid they are slanted in the direction of web travel, and the fibers are spaced closer together. If the speed of the creel is reduced or the speed of the web increased so that vector C is less than  $W \csc \theta$ , the fibers are slanted in the opposite direction and the spacing between the fibers is increased.

The spacing of the fibers may be increased or decreased independently of creel or web speeds, and independently of the angle of deposit, by increasing or decreasing respectively the number of fiber ends guided to the web from the bobbins. Usually the fibers are threaded through apertures *a* in ring 72 at equal intervals around the ring. The pattern of the orifices *o* in the side wall 70 of the creel (of which some have been omitted for clarity in Fig. 3) is such as to permit a large number of fibers *s* to be delivered from the creel to ring 72 without interfering with each other.

As mentioned above, when apparatus of this invention is used for depositing fibers normal to the web axis, the preferred approach angle between the web axis and the mandrel axis is  $45^\circ$ . For other operations, however, a different approach angle often may be more desirable or in some instances even necessary.

Because of the flexible relationship between web and creel speeds, apparatus embodying the principle of this invention is readily adaptable to a variety of operations. For example, a web may be reenforced by two sets of fibers crossing the web in different diagonal positions by passing a web successively through two of my machines with appropriately different creel speeds and with the

apertured ring 72 of the faster creel leading fewer fibers to the web than the slower creel so that the fiber spacing as between oppositely slanting fibers will be uniform.

Unwoven fabrics formed only of adhered crossing fibers, for example, may be produced by replacing the paper web with a continuous band of longitudinal fibers and following known practices for the application of adhesive. The fibers may be natural, or synthetic, multi- or mono-filament, twisted, spun or unspun; and I use the term "fiber" generically to include all such variants.

I claim:

1. The method of depositing fibers transversely of a moving web, which comprises forming the moving web into helical convolutions, moving a supply of fibers in a circular course in a plane perpendicular to the axis of the web helix and about a center which lies in said axis with one component of the movement of the fiber supply extending in the helical direction of movement of the web and another component of the movement of the fiber supply extending normal to the direction of web movement so that the web and the fiber supply move apart as the fiber supply moves around the web helix, the speeds of advance of the web and of the fiber supply being so relatively predetermined as to deposit the fibers at a desired angle relative to the web axis.

2. The method of depositing fibers transversely of a moving web, which comprises convoluting the moving web into a helix, moving a supply of fibers in a circular course outside the web helix in a plane perpendicular to the axis of the web helix and about a center which lies in said axis, the movement of the fiber supply having a component in the helical direction of web advance so that, as the web moves away from the fiber supply and the fiber supply moves around the web helix, the fibers may be laid across the web, the speeds of advance of the web and of the fiber supply being so relatively predetermined as to deposit the fibers at a desired angle relative to the web axis.

3. The method of depositing fibers transversely of a moving web which includes the steps of advancing the web from a web supply toward a fixed mandrel at a predetermined acute angle with reference to the mandrel axis, winding the web about the mandrel in helical convolutions, advancing a fiber supply in a circular course about a center which lies in the axis of the mandrel, the plane of the circular course being normal to the mandrel axis so that the movements of the web and of the fiber supply diverge from each other, adhering the fibers to the web so that the movement of the web away from the fiber supply is effective to withdraw the fibers from their supply, the component of the movement of the fiber supply in the helical direction of the web movement being so predetermined as to dispose the fibers at the desired angle transversely of the web axis.

4. The method of depositing fibers transversely of a moving web which includes the steps of helically convoluting a continuously advancing web and advancing a fiber supply in a circular course around the web convolutions in a plane perpendicular to the axis of said helical convolutions, and at such a speed relative to the web speed that the sole relative motion between the fiber supply and the moving web is in a direction transverse of the web perpendicularly to the web axis so that the fibers are laid perpendicularly to the web axis.

5. The method of depositing fibers from a continuous fiber supply of indeterminate length transversely of a moving web of predetermined width which includes the steps of convoluting the advancing web about a mandrel with adjacent convolutions disposed in edgewise proximity to each other, advancing a creel of continuous fibers around said web convolutions in a circular course in a direction diverging at an acute angle from the direction of advance of the web, adhering the fibers to the web so that the movement of the web away from the fiber supply withdraws the fibers from the supply, and severing the fibers of the web extending from one edge to another edge in proximity thereto so that the fiber length is approximately commensurate with the web width.

6. A machine for depositing continuous reenforcing fibers substantially transversely of a moving web consisting of an annular creel containing a supply of fibers, means for rotating the creel, a stationary mandrel extending through the creel coaxially therewith so that the

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plane of rotation of the creel is normal to the mandrel axis, means for moving the web through the machine, and guide means for directing the movement of the web from a supply around the mandrel and through the creel in helical convolutions of predetermined acute angle inclination relative to the direction of rotation of the creel, and thence away from the mandrel.

7. A machine for depositing continuous reenforcing fibers substantially transversely of a moving web consisting of an annular creel containing a supply of fibers, means for rotating the creel, a stationary mandrel extending through the creel coaxially therewith so that the plane of rotation of the creel is normal to the mandrel axis, means for moving the web through the machine, guide means for directing the movement of the web from a supply around the mandrel and through the creel in helical convolutions of predetermined acute angle inclination relative to the direction of rotation of the creel, and thence away from the mandrel means for applying adhesive to that surface of the web which is outermost as the web passes around the mandrel, and guides directing the fibers into contact with the adhesive coated web surface so that the fibers adhere to an initial convolution of the web as the web passes through the creel.

8. A machine for depositing continuous reenforcing fibers substantially transversely of a moving web consisting of an annular creel containing a supply of fibers, means for rotating the creel, a stationary mandrel extending through the creel coaxially therewith so that the plane of rotation of the creel is normal to the mandrel axis, means for moving the web through the machine, guide means for directing the movement of the web from a supply around the mandrel and through the creel in helical convolutions of predetermined inclination relative to the direction of rotation of the creel, and thence away from the mandrel, means for applying adhesive to that surface of the web which is outermost as the web passes around the mandrel, guides directing the

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fibers into contact with the adhesive coated web surface so that the fibers adhere to an initial convolution of the web as the web passes through the creel, and a knife adjacent the mandrel surface in position to sever fibers extending between two successive convolutions of the web.

9. The method of depositing fibers from a supply transversely of a moving web which comprises advancing the web in a path defining a cylindrical helix, rotating the fiber supply around the web in a circular course in a plane perpendicular to the axis of the web helix and about a center which lies in said axis, and advancing in the same sense of rotation as the advance of the web through its helical course, the rotational course of the fiber supply being at an acute angle to the direction of advance of the web, so that the motion of the fiber supply has a component which extends in the direction of the web motion, and correlating the speed of the fiber supply with the speed of the web so that the fibers are deposited at a desired angle relative to the web axis, securing to the web the fibers so deposited, and severing the fibers between adjoining convolutions of the web helix.

10. The method as defined in claim 9 in which the speed of the fiber supply is correlated with the speed of the web to make the said component of the motion of the fiber supply substantially equal to the speed of the web, so that substantially the only relative motion between the fiber supply and the web is at right angles to the web, whereby the fibers are deposited in a direction substantially normal to the web axis.

#### References Cited in the file of this patent

#### UNITED STATES PATENTS

| Number    | Name          | Date          |
|-----------|---------------|---------------|
| 1,192,017 | Subers .....  | July 25, 1916 |
| 1,332,534 | Angier .....  | Mar. 2, 1920  |
| 2,575,666 | Knudson ..... | Nov. 20, 1951 |