July 3, 1962 R. W. KING 3,042,567

METHOD AND APPARATUS FOR DEPOSITING CONTINUOUS ROVING

Filed April 18, 1960 3 Sheets-Sheet 1

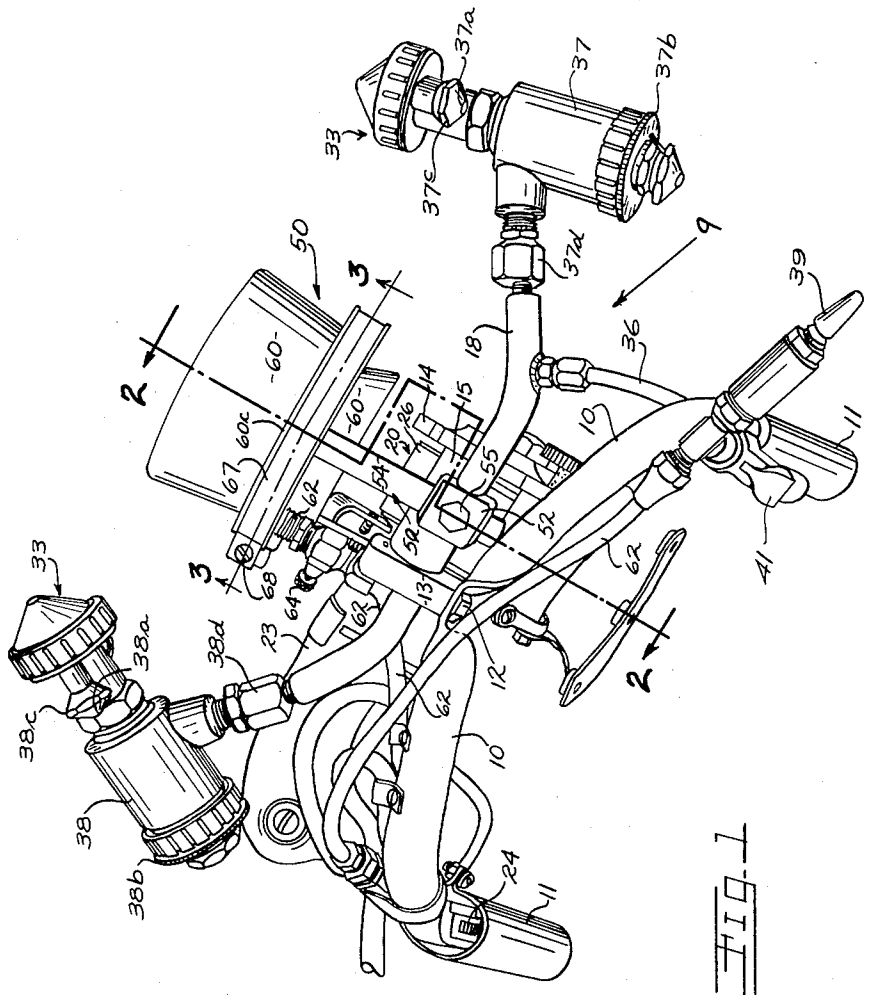


FIG. 1

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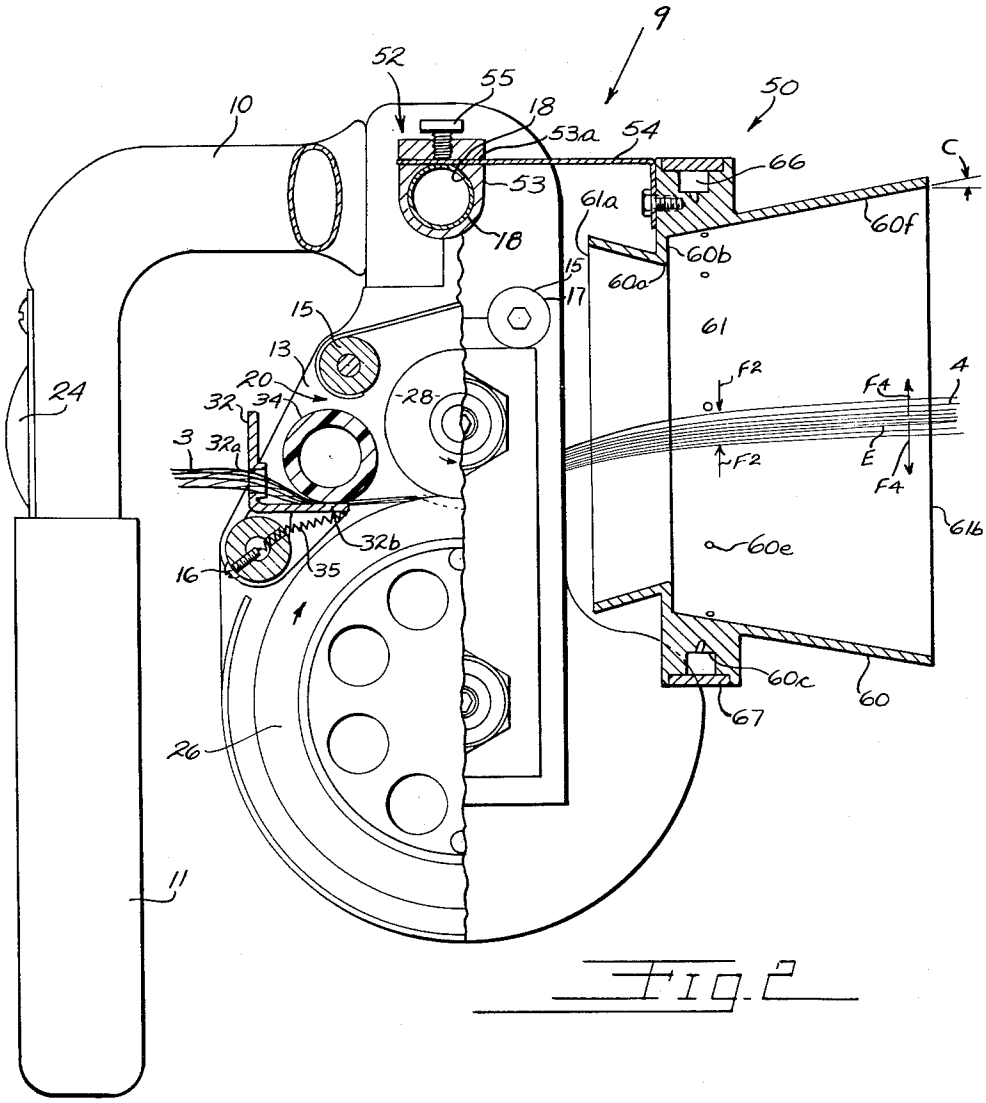


FIG. 2

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Filed April 18, 1960 3 Sheets-Sheet 3

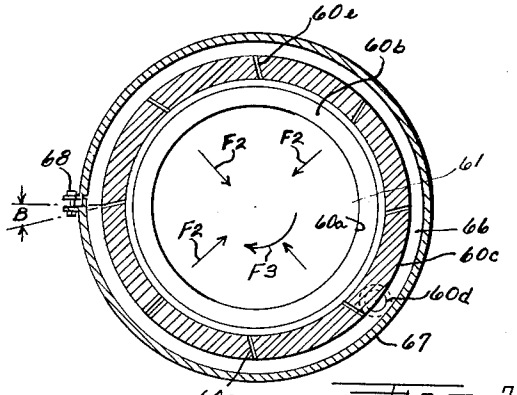


FIG. 8

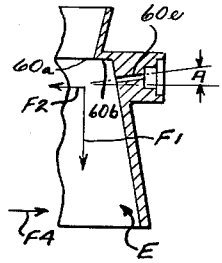


FIG 4

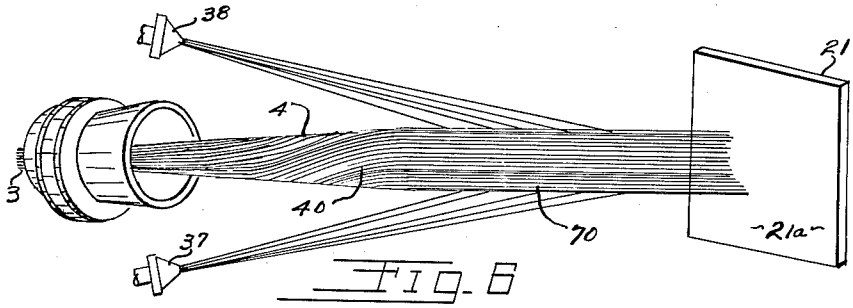


FIG. 6

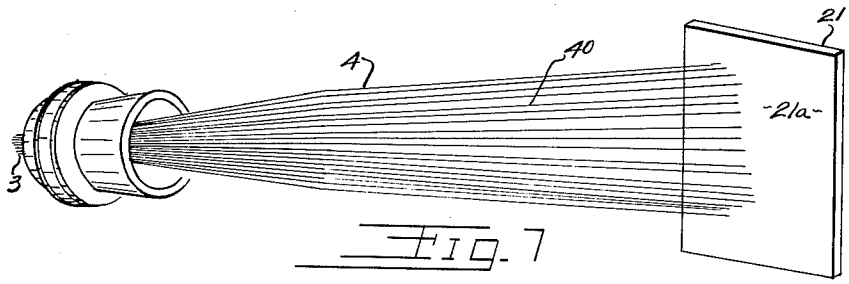


FIG. 7



FIG. 5A



FIG. 5B

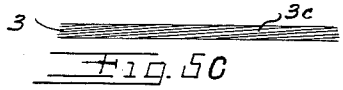


FIG. 5C

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United States Patent Office

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METHOD AND APPARATUS FOR DEPOSITING CONTINUOUS ROVING

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Filed Apr. 18, 1960, Ser. No. 22,774
4 Claims. (Cl. 156—38)

This invention relates to improvements in fiber depositor apparatus and more particularly to such apparatus for making a reinforced plastic laminate by depositing on a surface with liquid plastic a continuous roving having a plurality of fiber strands.

One of the objects of the present invention is to provide a fiber depositor apparatus having feeding rolls for feeding continuous roving toward a surface, and suitable directional means for keeping the roving directed toward this surface and for keeping the roving from following the periphery of one of these rolls.

A further object of the present invention is to provide a fiber depositor apparatus for feeding toward a surface continuous roving having a plurality of fiber strands wherein the apparatus includes suitable means for applying a turning force to the strands of the roving, includes suitable means for applying a lateral dispersing force by fluid to said strands, or includes both of these aforementioned means for depositing the roving in any desired pattern over the surface.

A further object of the present invention is to provide a fiber depositor apparatus characterized by its structural simplicity, economy of manufacture, multiplicity of operating features, and feature of depositing continuous roving in a desired pattern on a surface.

Other features of this invention reside in the arrangement and design of the parts for carrying out their appropriate functions.

Other objects and advantages of this invention will be apparent from the accompanying drawings and description and the essential features will be set forth in the appended claims.

In the drawings.

FIG. 1 is a perspective view of the fiber depositor apparatus;

FIG. 2 is a vertical, longitudinal sectional view taken generally along the line **2—2** in FIG. 1;

FIG. 3 is a transverse sectional view taken along the line **3—3** in FIG. 1;

FIG. 4 is an enlargement of a portion of FIG. 2;

FIGS. *5a*, *5b*, and *5c* illustrate three different types of continuous roving adapted to be handled as incoming roving by this apparatus; while

FIGS. 6 and 7 illustrate some of the different type dispensed fiber patterns obtainable with the fiber strand directional means supplied respectively with a small amount or a large amount of air.

Before the apparatus here illustrated is specifically described, it is to be understood that the invention here involved is not limited to the structural details, arrangement of parts, or method step here shown or described since an apparatus, structure, or method embodying the present invention may take various forms. It is also to be understood that the phraseology or terminology herein employed is for purposes of description and not of limitation since the scope of the present invention is denoted by the appended claims.

Apparatus **9** is disclosed herein as a fiber depositor gun or apparatus **9** for making a reinforced plastic laminate by depositing a dispensed continuous roving on a surface **21***a* with liquid plastic in a suitable pattern, such as shown in FIG. 6 or 7, as a dispensed continuous roving **4**. This roving **4**, when received by the gun as incoming roving (shown generally as roving **3**), has a plurality of fiber strands arranged in any suitable pattern, such as twisted roving **3***a* or **3***c* shown in FIG. *5a* or *5c* or straight roving **3***b* shown in FIG. *5b*.

This apparatus is especially designed to replace the hand lay-up method of making glass fiber reinforced plastic products.

Satisfactory results have been obtained with fiber glass roving **3** having approximately 60 fibers, fiber strands or ends with each of these strands having approximately 202 filaments each having a diameter of approximately 0.00039 inch. The strands and fibers extend generally longitudinally in the continuous roving. It is desirable that each strand have good "integrity" so as to hold its filaments in a single strand. Integrity depends upon the finish on the filaments and strands. Good strand integrity is desirable for many purposes. Good strand integrity may be defined as the finish on the fibers and filaments resisting wetting. The incoming continuous roving **3** received by the apparatus may have its strands twisted into twisted roving **3***a* or **3***c* in FIG. *5a* or *5c* or may have generally straight strands shown as straight roving **3***b* in FIG. *5b*. The helix formed by the twisted strands in roving **3***a* or **3***c* may be of any suitable pitch. Good results have been obtained with a twist of one twist per one foot length of roving.

It should be apparent that not only fiber glassfibers but also any other suitable fibers may be used in apparatus **9**.

The apparatus **9** has a frame in FIGS. 1 and 2. Tubular handle **10**, having handle grips **11** secured to its opposite end, is secured at its mid-portion by screws **12** to left side wall **13** of the frame. Right side wall **14** is secured in parallel relationship to wall **13** by suitable spacers **15**, **15** and **16** in FIG. 2 detachably secured at opposite ends to these walls by screws **17**. Spray nozzle manifold tube **18** is clamped intermediate its ends in wall **13** by screw **12**.

Apparatus **9** has a feeding unit **20** for feeding continuous fibers toward surface **21***a* on article **21** to be coated, as shown in FIGS. 6 and 7. Electric motor **23**, either a constant speed motor or an adjustable and variable speed motor, whichever is preferred, is mounted in FIG. 1 on wall **13** and is controlled by electric switch **24** on handle **11**. Switch **24** may be of the two position, on-off type or may be a variable speed control switch for controlling the speed of motor **23**. Motor **23** is drivingly connected to and rotates smooth metal drum **28** in FIG. 2, which drum rotates rubber sleeve **26** by peripheral contact friction. These feed rolls **26** and **28**, rotatably supported on parallel shafts between walls **13** and **14**, feed through their bight roving **3** toward surface **21***a*. Continuous fiber glass roving **3** is fed in FIG. 2 into the apparatus by having this continuous roving, either twisted roving **3***a* or **3***c* in FIG. *5a* or *5c* or straight roving **3***b* in FIG. *5b*, threaded through one or more guide holes **32***a* in roving guide shoe plate **32** pivotally carried on spacer **16**; then between rubber sleeve **34**, rotatably mounted between walls **13** and **14**, and portion **32***b* of plate **32** biased counterclockwise in FIG. 2 into tangential contact with sleeve **34** by tension spring **35**, secured at opposite ends to portion **32***b* and spacer **16**, to provide frictional drag on the roving; and then between feed rolls **26** and **28**. As motor **23** is driven, feed rolls **26** and **28** rotate in the direction of the arrows in FIG. 2 to draw roving **3** therebetween to feed the fibers toward the right in FIG. 2.

Although feed rolls **26** and **28** are specifically disclosed herein for feeding the roving, it should be readily apparent that any suitable feeding means may be provided for feeding the continuous roving toward surface **21***a*.

Spray unit **33** is provided in apparatus **9** in FIG. 1.

Air tube 18 supplies air from a source through line 39, valve 41 and line 36 to spray heads 37 and 38 for dispersing respectively accelerated resin and catalyzed resin, which comprises the plastic compound or liquid plastic flowing under pressure from resin sources through inlets 37*a* and 38*a* with the discharge rates of these heads controlled by adjustable fluid controls 37*b* and 38*b* to correspond with the amount of fibers deposited. Control of spray air to these heads is obtained by on-off air valve 41, normally spring biased to off position, located between lines 36 and 39. Spray heads 37 and 38 have adjustable air throttle valves 37*c* and 38*c* respectively to regulate the amount of air from line 18 for breaking up the fluid in each head into droplets.

In operation, the operator supports the fiber depositor apparatus 9 by hand grips 11 and depresses switch 24 and valve 41 to lay up a reinforced plastic laminate on surface 21*a*. The liquid fluid streams, fed from heads 37 and 38, converge in FIG. 6 on travel path 40 of the fiber strands of the dispensed continuous roving 4, and then the wetted fibers thereof are deposited in a desired pattern, by suitable movement of gun 9, over surface 21*a* in a fiber-resin laminate with the fibers embedded therein for making a reinforced plastic laminate. Spray heads 37 and 38 have been omitted in FIG. 7 and fibers 4 have been shown in FIGS. 6 and 7 as only approaching, but not on, surface 21*a* to simplify the illustration. After each layer is deposited on article 21, it is rolled down by hand to make an air free laminate. Continuous roving produces finished parts with higher flexural modulus, structural bursting strength, and flexural strength then chopped fibers.

Spray heads 37 and 38 are mounted by ball and socket joints 37*d* and 38*d* to opposite ends of tube 18 so that the angle of the heads may be adjusted to suit the shape of travel path 40 followed by the fibers of dispensed continuous roving 4.

Of course, if desired, the fibers of continuous roving 4 may be deposited by gun 9 on a previously or subsequently wetted surface 21*a* without using spray heads 37 and 38 by keeping valve 41 in off position.

When continuous roving 3 is fed through feed rolls, such as rolls 26 and 28, toward a surface, such as surface 21*a*, depositor apparatus 9 will operate satisfactorily on most occasions. However, on other occasions, continuous roving 3 may wind itself around the periphery of one or the other of the feed rolls, instead of being dispensed properly, so as to entangle the continuous fibers in the apparatus and to force shut down of the fiber dispensing operation. It is believed that this problem is caused by some conditions of humidity, electrostatic charge, surface finish on the fibers or strands (strand integrity), temperature and direction of travel of the continuous roving strands along path 40. For example, if path 40 is horizontal so as to feed the fibers horizontally against a vertical surface 21*a*, the problem is more likely to occur then if path 40 is vertical for feeding the fibers downwardly against a horizontal surface. Any suitable directional means may be provided for keeping the roving directed toward the liquid plastic convergence zone 70 in FIG. 6 and toward surface 21*a*, and for keeping dispensed roving 4 from following the periphery of one of the rolls 26 or 28.

The specific directional means disclosed herein on apparatus 9 is shown as directional means or unit 50. This unit 50 includes a member 60 detachably secured by clamp 52 to air manifold tube 18. Clamp 52 has a bracket 53 with a slot 53*a* extending therethrough within which one end of strap 54 is clamped by screw 55 threaded in bracket 53. The other end of strap 54 is welded or otherwise secured to a portion of member 60. Member 60 forms a conduit, having a through bore 61 therein, located between the bight of feed rolls 26 and 28 and surface 21*a*, through which dispensed roving 4 passes.

A fluid stream is directed into conduit bore 61 tending to center the fibers of dispensed continuous roving 4 therein. This fluid, such as air, is supplied from a pressure source 39 in FIG. 1 and line 62 having a controlling needle valve 64 for adjusting the fluid pressure from the source to jet ports 60*e* in member 60 in FIGS. 2 and 3. This fluid travels from valve 64 through hole 60*d* in member 60, through an annular header 66 formed by peripheral groove 60*c* in member 60 surrounded by band 67 clamped around member 60 by the screw and nut connection 68, and inwardly through the equally spaced ports 60*e* providing fluid injection jets directing the fluid into conduit bore 61. These ports 60*e* are located downstream from shoulder 60*b*. Each port 60*e* is inclined in the downstream direction toward the center of the passageway at an angle A in FIG. 4 and is inclined at an angle B in FIG. 3 to a radius of bore 61 to be generally tangential to a circle located in bore 61 transverse to path 40 of fiber travel. It has been found that satisfactory results are obtained with the following approximate dimensions: $A=9–11°$, $B=15–17°$, $C=9–11°$, and the diameter of each port 60*e* being 0.03125 inch to 0.0625 inch. Angle C is the angular relationship of the frustoconical surface 60*f* of bore 61 in member 60 gradually increasing in diameter in the downstream direction from the jet forming ports 60*e* to form a gradual expansion from the venturi in bore 61. This venturi is formed by a venturi throat 60*a* and an annular shoulder 60*b* at the throat of the venturi to provide a sudden increase in the transverse dimension of bore 61 on the downstream side of throat 60*a* before surface 60*f* diverges into an expansion zone E.

The air emerging from jet ports 60*e* exerts several force components on the fibers in roving 4 including: (1) an axial force component F1 in FIG. 4 (caused by angle A, the forward expansion of air in bore 61, and the velocity caused by the venturi action at throat 60*a*) pushing the fibers of continuous roving 4 toward surface 21*a* and pulling them away from the surfaces of feed rolls 26 and 28; (2) radially inward forces F2 in FIGS. 2, 3, and 4 near the throat of the venturi tending to center the fibers of roving 4 in bore 61 by the fluid streams inwardly directed through jet ports 60*e* spaced around bore 61 in FIG. 3; (3) a turning force F3, created by angles B, tending to turn the strands of roving 4 about the central longitudinal axis of path 40 in a vortex action; and (4) an outward force F4 in expansion zone E, as the injected air expands in this zone E, for dispersing the fibers outwardly.

Force F1 has several components. The venturi, provided by venturi throat 60*a* in FIG. 2, is especially adapted to exert a component of force F1 for continually pulling roving 4 away from feed rolls 26 and 28 so that the aforedescribed problems will not occur. Shoulder 60*b* provides a step in bore 61 to reduce the tendency for any of the air injected through port 60*e* from traveling back upstream in the left-hand direction in FIG. 2 so that air expansion within bore 61 is generally toward the right to help exert a component of force F1. The venturi throat 60*a*, located on the upstream side of jets 60*e*, increases the velocity of the air flowing through bore 61 to produce an induced flow for sweeping the strands of roving 4 forwardly by a component of force F1 toward the right in FIG. 2 toward surface 21*a* and to minimize backflow.

However, the axial air flow producing any components of force F1 is not great enough to disturb the desired fiber pattern being laid on surface 21*a*. Also, this expansion zone E of the venturi slows down the speed of the air traveling forwardly and axially through bore 61 so that high speed air doesn't disturb the desired distribution of the fibers on surface 21*a*.

Although a specific directional unit 50 is disclosed herein, it should readily be understood that this directional means may take other forms for solving this problem. For example, it has been found that air passing into a

conduit, receiving the strands of roving 4 from feed rolls 26 and 28, will solve these aforementioned problems and provide the aforementioned functions if the air is directed therein so as to provide only forces F1 and F2, and their funuctions mentioned heretofore. However, in the illustrated construction, the air flow in member 60 also provides vortex action force F3 and outward force F4 to be considered later herein.

The air flow within bore 61 will also effect the distribution pattern of the strands of roving 4 along path 40 and upon surface 21*a*. Compare FIG. 6 having little air injected through ports 60*e* with FIG. 7 having a large supply of air so injected. The differences in pattern may give a greater strength in localized zones, a directional strength characteristic caused by the directional orientation of the fiber strands, generally uniform strength by a uniform spread of the fibers in a homogeneous manner over surface 21*a*, or some other differences. Two distinct actions are believed to take place within bore 61. First, suitable fluid actuated, strand dispersing means exerts an outward force by a fluid on the fiber strands for increasing the lateral dispersion between the strands of dispensed roving 4 as they travel from the bight of feeding rolls 26 and 28 toward surface 21*a*. This lateral dispersing action is believed to be caused: (1) by the venturi having an expansion zone E on the opposite side of venturi throat 60*a* from feeding rolls 26 and 28 so that the injected air, expanding in this zone E, will exert an outward force F4 in FIG. 2 for outwardly dispersing the fibers; and (2) by the agitating action of vortex type turning force F3 tending to turn the strands of roving 4 about the central longitudinal axis of path 40 as the air is injected inwardly through ports 40*e* of a vortex means surrounding roving 4 and located between throat 60*a* and expansion zone E. Second, this vortex means, including inwardly directed jets from ports 60*e* surrounding roving 4, applies turning force F3 to the strands of roving 4. This force F3 is applied around an axis, formed by the direction of travel of roving 4 along path 40, before roving 4 is deposited on surface 21*a*. This turning force F3 is believed to change the helical twist of the fibers about this path as these fibers travel from feed rolls 26 and 28 through bore 61 toward surface 21*a*. If roving 4 was straight roving 3*b*, this turning force F3 may tend to put a helical twist in the strands to make them dispensed twisting roving. If incoming roving 3 were twisted roving 3*a* or 3*c* having a helical twist advancing in a given turning direction, this force F3 may exert a turning force on roving 3 either in a direction opposite to this given turning direction or in the same as this given direction. This depends upon which roving 3*a* or 3*c* is fed through bore 61 and on the direction of inclination of angle B controlling the direction of turning force F3 in FIG. 3. This turning force may provide in roving 4, received on surface 21*a*, a tight helix maintaining the fibers bunched close together in a rope-like pattern, a laterally dispersed pattern of fibers wherein the roving was dispersed by untwisting it and loosening the helix, or other suitable pattern.

The strand and roving pattern on surface 21*a* may be changed by suitable adjustment of apparatus 9. First, adjustment of air valve 64 will change the quantity and velocity of the air emerging from ports 60*e* so as to change the magnitude of forces F1, F2, F3 and F4. More air causes wider lateral dispersion of the strands. Compare FIGS. 6 and 7. Second, strap 54 may be adjusted in bracket 53 in FIG. 2 so that the distance between the bight of feed rolls 26 and 28 and venturi throat 60*a* is changed. This second adjustment will change the relationship between the transverse location and effective diameter of the rotating fluid stream vortex from ports 60*e* with respect to any given diameter of the dispensed continuous roving 4 after the strands of this roving had been previously pinched together by the bight of feed rolls 26 and 28.

Suitable changes in construction are submitted as being within the scope of the present invention. First, motor 23 and switch 24 may, if desired, be respectively an air motor and throttle valve with this valve connected between source line 39 and the air motor for varying the air pressure to the air motor for controlling the speed of this motor and rate of dispensing of fibers 4. Second, motor driven feed roll 28 and idler, rubber feed roll 26 may be replaced respectively for feeding continuous roving by a knurled, power driven, metal feed roll and an idler, metal feed roll. The advantage in making the idler roll of metal instead of rubber is that the rubber roll may become tacky in continuous operation for the following reasons: (1) for a mechanized operation, the rubber can become worn and tacky, and (2) there is also a tackiness that develops from the binder on glass fiber roving 3 when the friction with the rubber roll causes an increase in temperature. Third, one side wall, such as side wall 14 in FIG. 1 may be eliminated of the pair of side walls 13 and 14 straddling the pair of feed rolls so that the feed rolls are mounted in cantilever relationship to the remaining side wall 13. Now, it is easier to place the fed roving 3 into the bight between the rolls by movement of the roving along the axes of the rolls instead of requiring that roving 3 be fed in the direction of roving feed through the bight of the rolls during loading of the apparatus.

Various changes in details and arrangement of parts can be made by one skilled in the art without departing from either the spirit of this invention or the scope of the appended claims.

What is claimed is:

1. A fiber depositor apparatus for making a reinforced plastic laminate by depositing on a surface with liquid plastic a continuous roving having a plurality of fiber strands, comprising a frame, feeding means for feeding the continuous roving toward said surface, and fluid actuated dispersing means including a vortex means surrounding said fed continuous roving for exerting a force by a fluid on said fiber strands for increasing the lateral dispersion between the strands of the roving as they travel from the feeding means toward the surface.

2. A fiber depositor apparatus, as set forth in claim 1, with said dispersing means including a venturi receiving said fed strands and having an expansion zone on the opposite side of the venturi throat from said feeding means with said vortex means located between said venturi throat and expansion zone.

3. A fiber depositor apparatus for making a reinforced plastic laminate by depositing on a surface with liquid plastic a continuous roving having a plurality of fiber strands, comprising a frame, feeding means for feeding the continuous roving toward said surface, and vortex means surrounding said roving for turning the fiber strands about the path of said roving to change the helical twist of the fiber strands about this path as these fibers travel from the feeding means toward the surface.

4. A method of laying up a reinforced plastic laminate on a surface, including the steps of feeding a continuous roving of fiber strands toward said surface, applying a turning force to the strands of said roving around the direction of travel of said roving as an axis before depositing said continuous roving in a desired pattern over the surface, and feeding liquid plastic on said roving to form the reinforced plastic laminate with the roving strands embedded therein.

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