Sept. 13, 1966 W. J. DENNIS 3,271,825

METHOD OF CONDITIONING GLASS FIBER STRANDS

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FIG. 1

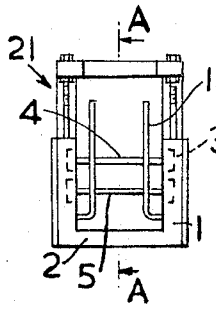


FIG. 2

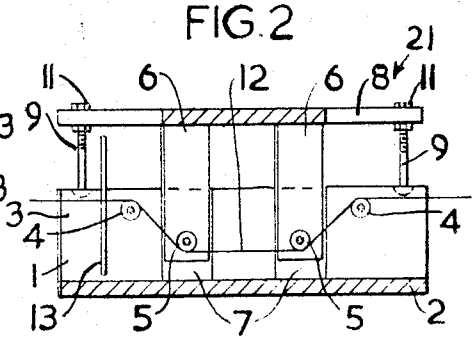


FIG. 3

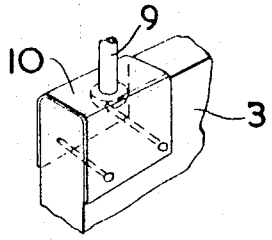
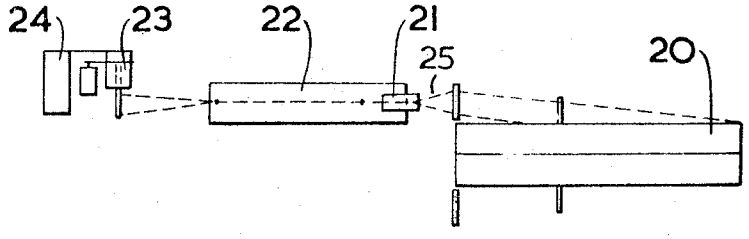


FIG. 4



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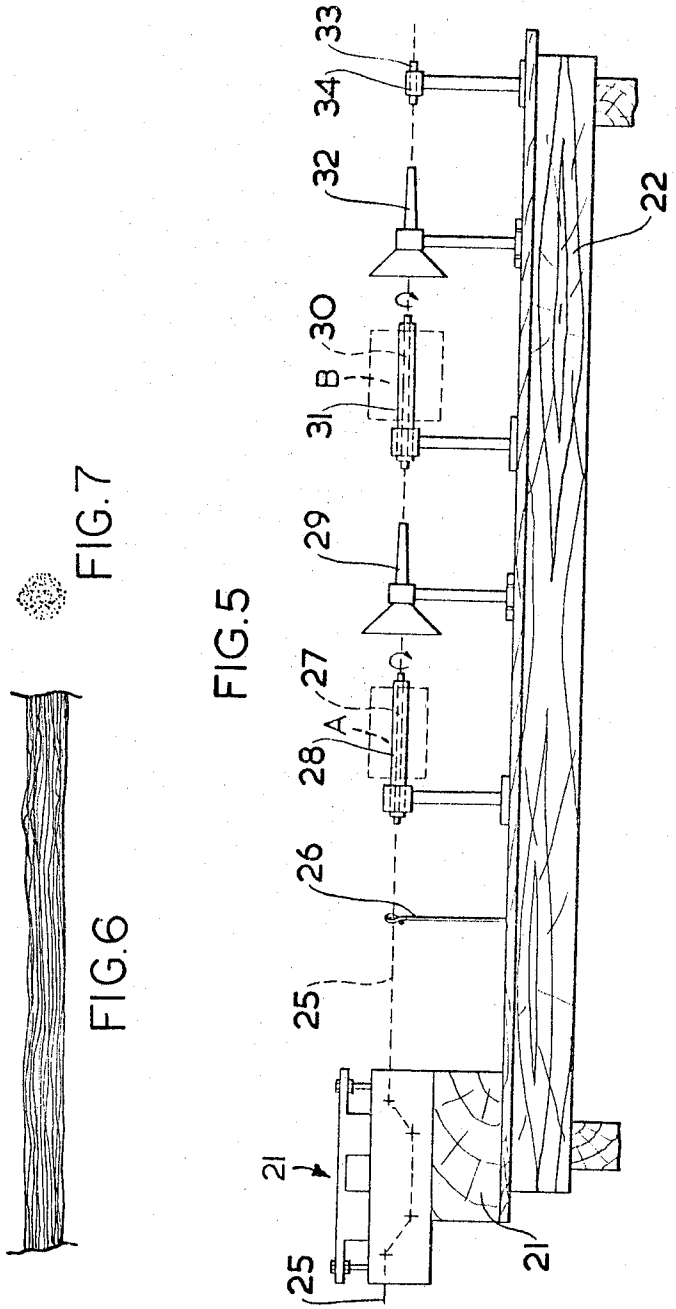


FIG.5

FIG.6

FIG.7



FIG.8

FIG.9

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Fig. 10.

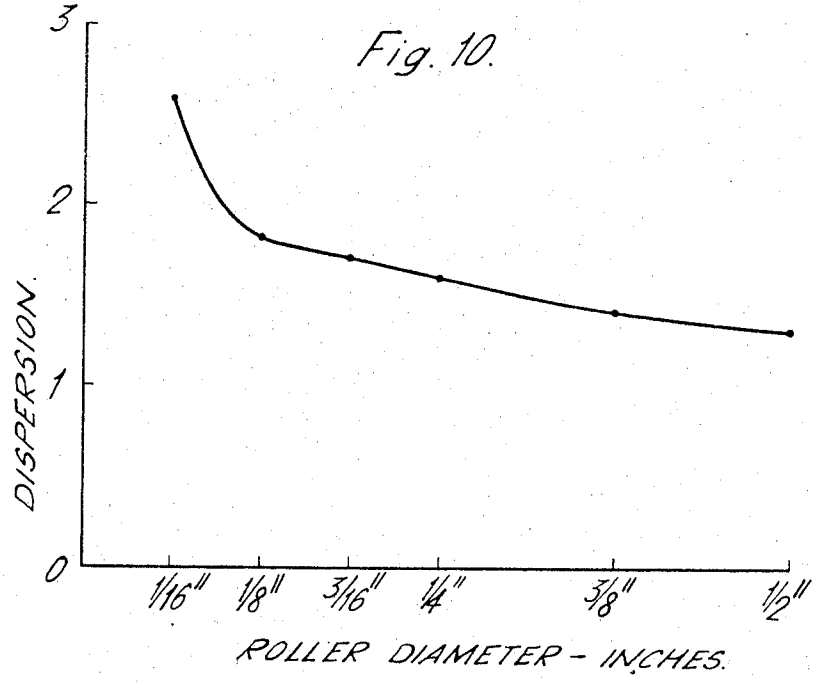
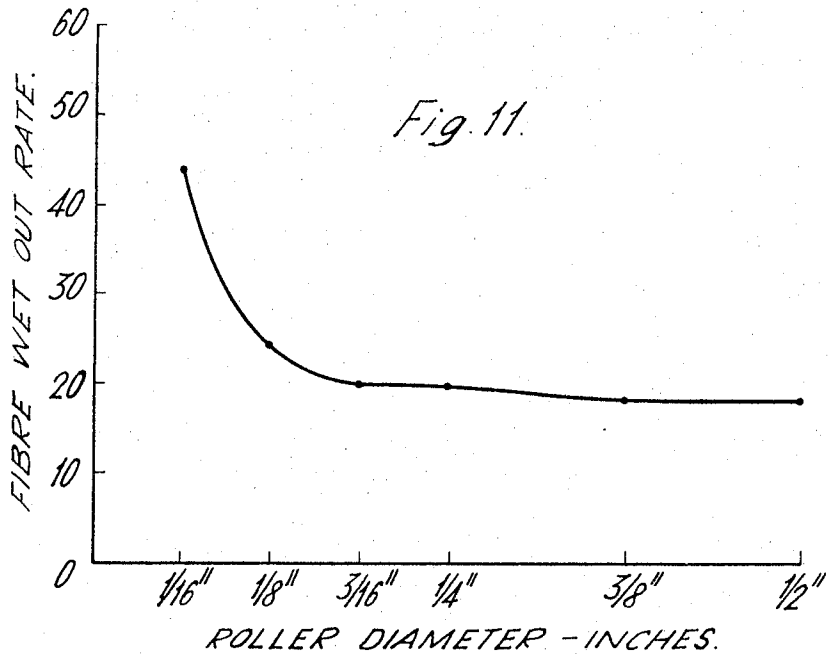


Fig. 11.



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METHOD OF CONDITIONING GLASS FIBER STRANDS

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6 Claims. (Cl. 19—65)

This application is a continuation-in-part of Serial No. 90,423 filed on February 20, 1961, now abandoned.

This invention relates to a method for the conditioning of a strand or a plurality of strands of a filamentary material. It relates particularly to a method for the conditioning of a strand or a plurality of strands such as a roving of sized glass fibers and will be described primarily with reference thereto. It can however be usefully applied to the conditioning of any linear material composed of one or more sized strands such as yarn or cord.

In the production of reinforced Fiberglas materials the use of a roving of Fiberglas strands is known. In order to obtain satisfactory performance of the roving in weaving Fiberglas fabrics and in subsequent impregnation of the fabric with resins such as polyesters it is desirable that all strands in the roving have certain characteristics. These include satisfactory permeability of the roving to a polyester resin, and substantially uniform tension. The strands should be under uniform tension since loose strands can give rise to a lowering of the tensile strength of the roving and can lead to snarling on guide eyes during subsequent processing of the roving. A number of ends (for example from 15 to 180 ends) of sized glass strands can be formed into a roving and the roving can then be wound to form roving packages for use in weaving operations, or chopped into staple.

With such roving packages and chopped roving being intended for various purposes, it is necessary to produce a fairly large variety of rovings having differing physical properties. The physical properties referred to are those determined by the nature and physical character of the coating of size on the glass fibers. The sizes used on glass fibers usually contain an organo-silane and a film-forming agent, which is commonly polyvinyl acetate. The composition of the size helps to determine the degree of stiffness of the resultant roving or bundle of the strands, (i.e. whether the roving is "hard" or "soft"), a decisive factor in this connection being the proportion of the film-forming agent in the size.

Furthermore, when a roving is to be formed into a package by means of a winding operation it is necessary that tension be imparted to the strands before they are delivered to the winding machine. Tensioning devices for this purpose are available but many known devices of this kind subject the strands to rather harsh treatment and cause an undesirably high degree of strand breakage due to abrasion. This is especially so when a bundle of glass strands is being taken from a creel and delivered to a winding machine. Whereas the strands should preferably be taken from the creel under minimum tension, tension must be imparted to them prior to the winding machine if a tight package, which will withstand subsequent handling, is to be produced. Since glass strands are readily susceptible to breakage, the provision of a satisfactory tensioning device offers some difficulty.

One well known device for winding of glass strands in roving packages is an apparatus consisting of a number of ½ to 1 inch diameter parallel brass bars mounted in a horizontal plane. All strands pass over and under as many bars as are required for attaining a desired tension. While this prior art unit may achieve some spreading of the filaments it also creates considerable

friction (unlike the present freely rotating rollers) and thereby adds heat to the strands. This causes the binder (such as polyvinyl acetate) to soften and causes some rebonding of the filaments.

It is very important that the Fiberglas strands and the rovings and fabrics produced therefrom should have maximum permeability to subsequently applied liquid material, in particular polyester laminated resins. In testing these materials this will be reflected in a property called the "wet out" rate.

The present invention therefore provides a method of conditioning a strand or a plurality of strands such as a roving of filamentary material in order to attain a physical separation of the filaments.

The present invention further provides a method for the conditioning of sized strands or rovings of glass fibers by effecting a separation of the filaments in the strands, whereby to improve the wetting-out property.

The invention further provides a method of modifying the properties of sized strands of glass fibers which comprises passing the strands in an angular pattern about a smooth faced cylindrical surface having a diameter in contact with the strand of between 1/16 to 3/16 of an inch.

The invention further provides a method of modifying the properties of sized strands of glass fibers which comprises passing the strands in an angular path about a freely rotatable smooth faced roller having a diameter between about 1/16 to 3/16 of an inch.

It has been found that conditioning strands of sized glass fibers in accordance with the methods of the present invention effects significant alterations to the properties of the strand or roving and to fabrics or laminates incorporating the conditioned strands therein. The major objective in applying this treatment is to achieve physical separation of the filaments in the strand so that as much as possible of the glass surface area of each filament is exposed for contacting with subsequently applied materials, in particular, polyester laminated resins. It is found that passing these strands about small rollers is effective in spreading the fibers laterally.

The separation of the filaments achieved by the process of the present invention improves the wetting-out of the strands when they are used for reinforcement of moulding resins.

In treating strands or rovings according to the methods of the present invention, it is found that other changes are effected in the properties of the strand besides the improved characteristics outlined above. These changes are variable and are determined by the dimensions of the particular apparatus and method used.

The method according to the present invention provides means to impart tension to a strand or roving without subjecting it to undue abrasion. It also provides a means for equalizing the tension of all strands in a roving, thereby reducing or eliminating the difficulties caused by the presence of loose strands with their resulting lowering of the strand is effected by conditioning according to the during subsequent processing.

Furthermore, with any given dimensions of the glass filaments and rollers, a given composition of size and a given sizing procedure there may be produced by means of the method of the invention, a range of strands or rovings having differing characteristics. When flexing of the strand is effected by conditioning according to the invention the hardness is immediately reduced and continues to be further reduced as the degree of flexing is increased. Eventually, a point is reached at which the flexing is so extreme as to cause excessive breakage of the filaments and this serves to limit the range within which the hardness of the strand can be adjusted. Since the limiting angle of flexing depends on the various

parameters mentioned above, it is not possible to give a general limiting value for the angle of flexing. Normally however, the flexing angle is obtuse if only because this is most convenient for practical purposes. The degree of modification of the hardness of the roving may be varied quite extensively by operating with a flexing angle of between 90 and 180.

In the practice of the present invention it is preferred to make use of a series of rollers instead of only one or two rollers. It appears to be more effective to flex the roving through two separate obtuse angles than through one acute angle which represents an identical degree of angular deviation of the roving. For example, it is preferred to flex the strand twice through an obtuse angle of 150 degrees rather than once through an angle of 60 degrees. Such double flexing can be employed to give two angular deviations in opposite senses to return the strand to a path parallel with its original path, or a plurality of double flexes can permit the strand to proceed after flexing on a path co-linear with its original path.

Other improvements in the properties of the strands are also found upon incorporation thereof into polyester laminates.

With the present invention it is possible to achieve laminate flexurals of the order of 15 to 25% better than obtained with the normal unflexed rovings.

It is observed that the present conditioning process results in improved separation from one another of the glass filaments within each strand. With greater flexing these effects are increased to give a roving that is softer and has improved wetting-out properties.

It has been found that the diameter of the roller or rollers employed is critical. If the roller has too large a diameter there is achieved little spreading out of the strand and a correspondingly small improvement of the wetting-out properties. With too small a roller diameter on the other hand, breakage of filaments becomes a problem and the process becomes impractical to operate. The specified range of from one-sixteenth to three-sixteenths of an inch is the effective practical range of the roller diameter. The best value within this range for a particular application of the process of the invention depends on the conditions involved, on filament diameter, type and thickness of the size coating on the strands and so on. For most purposes, rollers of about one-eighth of an inch in diameter have been found to be suitable for use in conditioning glass strands and rovings of all types and it is only necessary to depart from the use of such rollers when special considerations are involved.

It was attempted to replace the freely-rotatable rollers by stationary rods but was found that flexing a strand about such rods resulted in a sharp reduction in the quality thereof, becaues of filament breakage. It is therefore very preferable to use rollers which are freely rotatable. The actual construction of these rollers is not critical although it has been found advantageous to use rollers mounted on needle bearings.

The rollers employed in the present process must have a smooth surface. This is entirely different from the pairs of corrugated rollers which have been used in the past for crimping or otherwise deforming glass filaments.

The invention will now be described by way of illustration without limitation with reference to the accompanying drawing in which:

FIGURE 1 is a side view of a preferred strand conditioning device adapted to the present process;

FIGURE 2 is a section along the line A—A of FIGURE 1;

FIGURE 3 shows a detail of the conditioning device of FIGURE 1;

FIGURE 4 is a plan view of an arrangement for producing packaged roving;

FIGURE 5 shows part of the arrangement of FIGURE 4;

FIGURES 6 to 9 show a glass strand before and after treatment according to the method of the present invention.

FIGURE 10 shows the effect of variation of the roller diameter on dispersion of the filaments; and

FIGURE 11 shows the effect of variation of the roller diameter on the wet-out rate.

The conditioning device shown in FIGURE 1 comprises a wooden channel member 1 having a base 2 and sides 3. Within the channel member 1 there are mounted rollers 4 supported on the sides 3 in needle bearings. A further pair of rollers 5 are supported in needle bearings on wooden arms 6 which extend into cutaway portions 7 of the sides 3. The arms 6 depend from a wooden framework 8 which is supported at its four corners by means of posts 9. The posts 9 are secured to the sides 3 by means of saddles 10 as shown in FIGURE 3. The posts 9 are threaded at their upper portion and the height of the framework 8 above the sides 3 can be adjusted by movement of locknuts 11 along the threaded portions of the posts 9. The degree of adjustment which can be effected by movement of the locknuts 11 is sufficient to move the arms 6 in a vertical direction between a position in which the rollers 5 are in the same straight line as the rollers 4 and a position in which the arms 6 are in contact with the base 2. Thus, by adjustment of the locknuts 11 it is possible to effect variation of the total angular deviation to which a strand or roving is subjected when it is passed about all of the rollers 4 and 5. The manner in which a strand is passed about these rollers can be seen from FIGURE 2 in which a strand 12 is shown in the path it follows when passing through the conditioning device.

The conditioning device is provided adjacent the point of entry of the strand to be flexed with rod-like guides 13 fixed to the sides 3. The guides 13 merely serve to confine the strand to the middle of the flexing device and reduce the possibility of snagging.

FIGURE 4 shows an arrangement for the production of strands of rovings which incorporates the conditioning device of FIGURES 1–3. A two-sided creel 20 delivers the required number of glass strands, duly collected, to the flexing device 21 which is positioned at the end of a flex table 22. From the flex table 22 the roving is delivered to a standard type of winder 23 having a drive 24 which ensures constant winding speed together with constant positive feed at a set linear rate.

FIGURE 5 shows the arrangement of parts on the flexible table. The conditioning device 21 is identical with that described with reference to FIGURES 1–3. A roving 25 delivered from the creel 20 is subjected to an appropriate degree of flexing in the conditioning device 21. It passes therefrom through a pigtail 26 and then successively through the bore of a glass tube 27 mounted inside a copper tube 28. A glass funnel 29, the bore of a second glass tube 30 mounted inside a copper tube 31, a second glass funnel 32 and a further glass tube 33 also mounted in a copper tube 34. From the glass tube 33, the roving passes to the winding device 23. When producing single-ply rovings the equipment situated between the conditioning device 21 and the winding device 23 serves merely as a succession of guides. However, if it is desired to produce two-ply rovings copper tubes 28 and 31 serve as supports for additional apparatus units shown in dotted lines in FIGURE 5 and designated as package A and package B, respectively. The strands from package A are tied into the roving between package A and the funnel 29. When package A is almost used up it is broken out of the roving and package B is tied into the roving between package B and the funnel 32.

The conditioning device 21 also serves to impart optimum tension to the strands prior to their delivery to the winding device 23. Optimum tensioning can be achieved by adjusting the angle of flex, the freedom of rotation of the rollers 5 (which may vary with the viscosity of the oil in the roller bearings) and the inertia (which

depends on the weight and dimensions of the rollers). The tensioning is achieved with minimum abrasion, in contrast with the harsh treatment imparted by most conventional tensioning devices, such as those of the disc or gate type, on glass strands.

The individual strands from the creel **20** run through the conditioning device **21** in a fairly segregated state and by the time they emerge therefrom any looseness in any of the strands has been substantially dissipated so that the individual strands are evened out before delivery to the winding device **23**.

The desired degree of hardness of the strands can also be achieved by appropriately adjusting the amount of flexing to which they are subjected during passage through the conditioning device **21**. It will be appreciated that the number of rollers may be increased at will to modify the manner in which the strands are conditioned.

Obviously the design of the conditioning device depends on the needs of a particular case. In some instances a conditioning device subjecting the strands to a fixed total angular deviation may be satisfactory and it will then be unnecessary to provide for adjustment of total angular deviation. The rollers can then all be mounted in fixed relationship to one another.

In FIGURES 6 and 7 a sized glass strand is shown semi-schematically in elevation and cross section before treatment by the claimed conditioning method.

In FIGURES 8 and 9 the same strand is shown after passage through the conditioning apparatus shown in FIGURES 1 to 5 in accordance with a preferred embodiment of the method of the present invention. FIGURES 8 and 9 illustrate clearly the subdividing or spreading action resulting in the separation of filaments in the glass fiber strands.

Each glass strand can be comprised of a large number of filaments, for example, in this case, **204**, which are laid parallel to one another and held together by the sizing materials. The shape, or form of the glass strand prior to conditioning is more or less round, or cylindrical. On passing through the conditioner, the glass strand is caused to bend sharply and is pressurized, through tensioning, against supporting members. The stress so created on the glass strand causes the round (or cylindrical) bundle of filaments, to flatten out to a more or less ribbon-like state. The transition from the round to the flattened state causes the glass filaments to displace, in effect debounding from one another and resulting in much greater exposure of each filament.

The stresses that arise from flexing of the strand comprise one stress which is longitudinal or in the direction of the run of the strand, and another stress which is exerted laterally, or across the glass strand. It is believed to be this lateral stress which opens up the filament bundle and causes the exposure of the filament surfaces.

The present invention is particularly directed to the treatment of sized strands of fiber, as opposed to cotated strands. Sizing content of glass strands is normally around 0.7% by weight. To coat the filaments, so that there is continuity of coating, would require a much higher content, usually a minimum of approximately 5%. Glass fiber sizing is generally not of a continuous nature, because insufficient solids are applied to the glass strands.

Controlled experimental tests and actual practice show that the wet out rate of glass strands is increased as the diameter of the rollers is reduced through several steps from ½" to ⅛".

For example, FIGURES 10 and 11 show the results achieved by applying the present invention to sized glass strands as hereinbefore described. These procedures consisted essentially of passing the sized strands, 15 in number, through a roller flexer box approximately as shown in FIGS. 1–3, with 1¼" spacing between rolls. Six separate set-ups were made in which roller diameters were (a) ½", (b) ⅜", (c) ¼", (d) 5/16", (e) ⅛", (f) 1/16".

These tests were observed for their effect on the dispersion (filament separation) and wet out rate of the resulting strands.

The dispersion is measured as follows. A set of standards consisting of specimen fibers for varying degrees of fiber separation and numbered accordingly have been prepared. Samples to be tested are compared with these fixed standards and assigned a value which varies from 1 to 3.

This subjective test as it is presently constituted is useful for comparison of various products but it gives only relative results.

The Wet Out Rate is determined by ascertaining the comparative light transmission of chopped strand samples in contact with liquid polyester resins for five minutes. This test has been standardized but it also gives only relative results. These tests are useful for comparing the effects of varying different factors in the formation of strands of material. Materials which have a high dispersion and high wet out rate are found to give superior results in industrial applications.

I claim:

1. A method of tensioning and spreading filaments of a sized glass fiber strand to improve permeability thereof for subsequently applied liquid material, said method comprising the steps of feeding the strand under tension along a first linear path, deviating said strand from said first linear path into a second linear path by moving said strand in a first arcuate path ⅛ to 3/16 inch in diameter and engaging said strand along said first arcuate path with a smooth continuous surface, deviating said strand from said second linear path into a third linear path by moving said strand in a second arcuate path ⅛ to 3/16 inch in diameter and engaging said strand along said second arcuate path with a smooth continuous surface, moving said surfaces at the same speed as said strand to avoid creation of excess heat and thereby effecting a separation of the filaments in the strand to obtain maximum permeability therein.

2. A method as set forth in claim **1** wherein each step of deviating changes each linear path through an angle greater than 0° but less than 90°, one leg of said angle being the imaginary extension of each path and the other leg of said angle being the path immediately subsequent to said path.

3. A method as set forth in claim **1** wherein each deviating step changes the linear path through an angle greater than 20° but less than 90°, one leg of said angle being the imaginary extension of each path and the other leg of said angle being the path immediately subsequent to said path.

4. A method as set forth in claim **1** wherein said deviating steps change the linear paths through equal angles in opposite senses whereby said third linear path is parallel to said first linear path.

5. A method as set forth in claim **1** wherein there are more than two of said deviating steps, but the last linear path is parallel to said first linear path.

6. A method as set forth in claim **5** wherein the last linear path is colinear with said first linear path.

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