FLUID FLOW METHOD AND APPARATUS FOR APPLYING TWIST TO STRAND MATERIAL

This invention relates to tufting, and more particularly, to the use of bulky and/or low-strength filamentary material as the tuft forming components of pile fabrics.

In the tufting machines that have been used extensively in recent years for commercially producing pile fabrics, the introduction of the pile tufts is accomplished through the interaction of needle and looper components disposed on opposite sides of the path of the backing to which the tufts are to be applied. Each of the needles has an eye near the end thereof disposed closest to the path of the backing, and a pile strand is threaded through such eye.

When a threaded needle is reciprocated to project its end through the backing, the eye carries a loop of the pile strand through the backing into a position where the loop may be engaged by the looper element. After the looper element has engaged the loop, the needle is withdrawn from the fabric.

During these manipulations, the pile strands are subjected to stresses of some severity. Abrading forces of substantial magnitudes are applied to the strands when they are rubbed against the edges of the openings formed by the needles as they move through the backing. The tensions in the pile strands vary greatly in different portions of the machine cycle. At times large tensioning forces are applied to the strands. At other times the strands passing to the needles are slack. In a typical yardage machine where hundreds of pile strands pass to the needles in side by side relation, this irregularity in tension sometimes gives rise to entanglement of adjacent strands and similar problems that adversely affect performance of the equipment.

The range of fabric products that could be manufactured by conventional tufting procedures also was limited, particularly in connection with the strands from which the pile tufts are formed. For example, it was not feasible to employ pile strands that did not have substantial tensile strength, and the products produced heretofore have incorporated twisted yarns or assemblies of continuous filaments as the pile strands.

The present invention seeks to minimize these limitations and difficulties. One of its objects is to provide new fabrics having distinctive pile surfaces. Another object is to provide improved tufting apparatus and methods that will permit more effective handling of the pile strands during tufting.

An example of a fabric embodying principles of the invention is a tufted pile fabric in which the pile tufts are formed from generally untwisted yarns having low tensile strength. Such a yarn can comprise yarns as weak as roping or roving or a weak synthetic yarn. The term "roping" is commonly used to define the sliver delivered by the roving condenser at the front of a wool card. Roving is wound on jack spools which go directly to the spinning machine. The term "roving" is commonly used to define the continuous, soft, slightly twisted strand of fibers, as of cotton, rayon staple, etc., the product of a roving frame. Roving is made from sliver or other roving and usually used to produce yarn. The amount of twist imparted to roving is usually just enough to permit it to be withdrawn from a package and supplied to a spinning machine where it is made into yarn. The soft bulky texture of the weaker, untwisted yarns, especially roping and roving, gives the fabric pleasing surface characteristics not possessed by the tufted pile fabrics known heretofore.

Moreover, the low tensile strengths of the weaker yarns make a fabric of this type particularly suitable for later napping operations, and it is contemplated that the fabric may be an intermediate product in the manufacture of napped articles such as blankets.

The methods of this invention are characterized in general by the application of yielding twisting forces to the pile strands during tufting. In one embodiment, each of the pile strands is fed to a hollow tufting needle in which air is caused to flow spirally about the axis of the strand. The forces applied to the strands by the air streams tend to twist the strands and also to deliver the strands from the discharge ends of the needles.

A more complete understanding of the invention will be gained from a consideration of the accompanying drawings, in which:

FIGURE 1 is a diagrammatic view of a tufting machine constructed in accordance with the invention;

FIGURE 2 is a fragmentary detail view of a portion of the top of the needle carrier of the machine depicted in FIGURE 1, the view being taken along the lines 2—2 in FIGURE 1;

FIGURE 3 is an enlarged vertical cross sectional view illustrating the construction of one of the tufting needles and its relation to the needle carrier;

FIGURE 4 is an enlarged horizontal cross sectional view of one of the tufting needles, the view being taken along the line 4—4 in FIGURE 3;

FIGURES 5 and 6 are schematic views illustrating the effects produced by applying twisting forces in accordance with the invention to a pair of pile strands that pass together through a single tufting needle; and

FIGURE 7 is a schematic view illustrating the twist effects that result from use of the invention in making cut pile fabrics.

The frame of the machine illustrated in FIGURE 1 includes a base portion 2 and an upper housing unit 4 extending from one side of the machine to the other. Uprights 6 located at the ends of the machine support the upper housing unit 4 in spaced relation to the base portion 2 of the frame, and suitable fabric feeding and guiding means, including sets of rollers 8 and 10, advance a backing 12 across the base portion 2 in the zone between the uprights 6 in a conventional manner.

As the backing 12 is advanced, it moves through a tufting zone where pile loops 14 are inserted therethrough. In this zone, the backing 12 is supported from below by a plurality of thin metal strips or lines 16 secured to the base portion 2 of the machine, and it is held against substantial upward movements by a presser member or foot 18 carried by bracket means 20 secured to the upper housing 4. The presser member 18 is provided with openings 22 in vertical alignment with the spaces between adjacent ones of the lines 16 and also in vertical alignment with the needles 24 of the machine.

The needles 24 are hollow and are mounted on a needle carrier 26 which is moved up and down cyclically to periodically project the lower end portions of the needles 24 through the backing 12. The drive for the needle carrier 26 may include an eccentric 28 rotatable with a driven shaft 30 within a bearing member 32. The bearing member 32 is pivotally connected at 34 to the upper end of a push rod 36 mounted for vertical sliding movement in a bearing sleeve 38 carried by the upper housing unit 4 of the machine. The lower end of the push rod 36 is connected rigidly to the needle carrier 26 so that the
needle carrier 26 will reciprocate vertically as the eccentric 28 rotates about the axis of the shaft 30. Since the needle carrier 26 extends across the entire width of the tufting zone, it may require support at a number of points along its length. To this end, the machine may be provided with as many eccentrics 28, push rods 36, and associated parts, as may be necessary.

Pile strands 40 for forming the loops 14 may be supplied from any suitable source, such as a conventional creel 42 illustrated schematically in FIGURE 1. The movement of the pile strands 40 from the strand passages 44 on the creel 42 to the tufting needles 24 must be controlled, and such control may be exercised by any one of many types of mechanisms. Where it is desired to make a fabric in which all of the pile loops 14 are of the same height or length, it is sufficient to provide the machine with a single set of driven feed rollers 46 for drawing all of the strands 40 from the creel 42 and releasing them in a controlled manner to the needles 24. Where complex patterns of high and low pile loops are desired, it is necessary to provide a more elaborate mechanism such as a notched bar feed for controlling the advance of the pile strands 40. These mechanisms are well known in the art and they need not be described here in detail.

The needle carrier 26 is a hollow structure having an air chamber 48 on the interior thereof. Pressurized air from a suitable source, represented diagrammatically by the tank 50 in FIGURE 1, is supplied to the chamber 48 through flexible hose means 52 connected to suitable fittings 54 and 56 on the tank 50 and the needle carrier 26, respectively. In machines of substantial width, it is preferred that there be a plurality of flexible hoses 52 spaced at intervals along across the width of the machine in order to keep the air pressure in the chamber 48 will be generally the same along its entire length.

As shown best in FIGURE 3, each of the tufting needles 24 extends vertically through the needle carrier 26, so that the central portions of all the needles are exposed to the high pressure existing in the chamber 48. Each of the needles 24 is so shaped that it may be inserted through the top wall 58 of the needle carrier 26. After insertion, it is held in place by a suitable set screw means 60 bearing against a flat 62 milled on an upper portion of its surface. Flexible O-ring seals 64 and 66 are provided for preventing the escape of air between the top wall 58 and the needle carrier 26 and the exterior surfaces of the needles 24 where the needles pass through these walls.

It will be observed that each of the needles 24 has two of the flats 62 milled on its upper end portion. In installations where adjacent ones of the needles 24 are quite close together, it is sometimes desirable that the set screws 60 for alternate ones of the needles pass through the top wall 58 of the needle carrier from the front edge thereof rather than from the rear edge. Such an arrangement is suggested in FIGURE 2 for purposes of illustration even though the needles there shown are not particularly close together.

The yarn passageway through the shaft of the needle 24 is designated generally by the reference numeral 70. It extends vertically through the entire length of the needle. Air is admitted to an intermediate portion of the yarn passageway 70 through small passages 72 each of which has an inlet opening 74 in communication with the air chamber 48 in the needle carrier 26 and an outlet opening 76 in communication with the yarn passageway 70.

The outlet opening 76 of each air passage 72 is located below the inlet opening 74 and is also displaced about the axis of the yarn passageway 70 from the inlet opening 74. Hence, it will be seen that the air passages 72 are directed downwardly and circumferentially with respect to the yarn passageway 70. Air flowing from the high pressure air chamber 48 through the passages 72 attains a high velocity and issues from the outlet openings 76 in the form of jets directed spirally about the axis of the yarn passageway 70. When a pile strand 40 is located in the passageway 70 of a needle 24, the swirling air flow downwardly through the yarn passageway 70 tends to twist the strand about its axis and also feed the strand out of the lower end of the needle 24. The operation of the tufting machine is cyclical. During one cycle, the backing 12 advances through a distance corresponding to the longitudinal spacing between adjacent points where the pile loops 14 project through the backing 12, the needle carrier 26 goes through a complete reciprocation, and the peripheries of the strand feeding rollers 46 move through a distance equal the length of pile strand in a single stitch. When the needles 24 move downwardly to penetrate the backing 12, the lower ends of the yarn passageways 70 in the needles are exposed below the lower surface of the backing 12 and the air streams flowing through these yarn passageways 70 feed the pile strands 40 downwardly to form the loops 14.

The air streams will operate to deliver from a yarn passageway 70 the entire length of pile strand 40 made available to the needle during that portion of the machine cycle when the lower end of the passageway 70 is in fluid communication with the underside of the backing 12. Hence, the height of a loop 14 is controlled by the movements of the feed rollers 46 rather than by the depth of penetration of the needle 24. Although satisfactory results can be achieved where the rate of movement of the feed rollers 46 is uniform throughout a machine cycle, it is evident that these rollers may be advanced at different rates during different parts of the cycle if desired. For example, where long pile loops are to be formed, it may be desirable to impart an irregular motion to the feed rollers 46 so that the end of the strand length delivered to the needle during a cycle will be made available during that portion of the cycle when the tip of the needle is below the backing 12. It is feasible also to vary the rate at which air is supplied to the chamber 48 in the needle carrier 26, if desired. Since the projection of loops 14 through the backing occurs during only a portion of the machine cycle, the flow air through the passageways 70 in the needles 24 may be restricted substantially to this portion of the cycle.

The effects produced by the twisting forces applied to the strands by the swirling air flow are indicated in the diagrams designated FIGURES 5, 6 and 7. The reference characters applied to the components illustrated schematically in these views are the same as the reference numerals applied to the corresponding parts in FIGURE 1, except that the letter “a” has been added. Thus, the reference characters 44a are applied to strand packages, 46a to strand feed rollers, 42a to tufting needles of the type shown in FIGURE 3, and 12a to a backing.

FIGURES 5 and 6 relate to the making of a fabric in which two pile strands 78 and 80 run together through each of the tufting needles for simultaneous insertion through the backing so as to form pairs of pile loops of the same height at each point of penetration of the needles. A floor covering fabric of this general construction, wherein the strands 78 and 80 are yarns of different colors, has an attractive surface appearance. For example, the use of black and white yarns in combination gives the fabric a surface which is pleasing to the eye. Similar fabrics made by conventional techniques have been sold in large quantities in recent years.

The procedure used commercially prior to the present invention in producing such fabrics involved a backing operation prior to tufting. The pile strands were prepared by passing the yarns of different colors through suitable twisting apparatus for forming a lightly twisted two-ply yarn, and then this ply yarn was supplied to the tufting machine. The present invention makes the doubling operation entirely unnecessary. The swirling
air stream in the tufting needle 24a twists the two strands 78 and 80 together so that they will pass to the needle in the form of a unitary body.

It should be noted also that the twisting action of the air stream is a "false" twisting action. As is well known, the application of twisting forces to the middle of a length of yarn does not impart permanent twist to the yarn. This is ideal for the operation suggested in FIGURES 5 and 6. It is desirable that the two yarns 78 and 80 be twisted together to a very substantial degree in the zone between the feed rollers 46a and the tufting needles 24a, but they should not be twisted tightly together in the tufted product. In the product itself, two distinct loops 14a should be present at each point where a needle penetrates the backing 12a.

The twist conditions suggested in FIGURES 5 and 6 are those that exist after the machine has been in operation for a few cycles. When twisting forces are initially applied to strand material extending from the feed rollers 46a to the backing 12a, the material will be twisted in opposite directions on different sides of the zone of application of the twisting forces. However, after a few cycles of the machine, the twist in the portion of the strand below the zone of application of the twisting forces will have been relieved or taken up, so that the only substantial twist remaining in the strand is that which runs back from the needle 24a to the feed rollers 46a.

The false twisting effects which result from the application of swirling air streams to the pile strands during the manufacture of loop pile products are, of course, of interest in connection with the manufacture of products other than ones having groups of differently colored pile yarns. Such other embodiments have been illustrated in FIGURES 5 and 6 merely by way of example. The twisting forces may be applied advantageously in the manufacture of novel products which cannot be made on the conventional tufting machines in commercial use prior to the present invention.

Such novel products include a loop pile fabric in which the pile loops are formed from roving or roping, as previously described. Ordinarily, the stresses applied to pile yarns in conventional tufting operations have been so great that it has not been possible to use roping or any weaker yarn, as the pile strands. However, where air streams are employed to feed the pile strands through hollow needles into the desired positional relationships with respect to a backing, the pile strands are handled gently. Any strand that has sufficient tensile strength to permit its being withdrawn from a package by feed means should not break during the tufting operation. Usually these low-strength strands may be handled by tufting needles that have air passages for directing fluid along the strands without any pronounced swirling motion. That is to say, the inlet and outlet openings of the air passages may be located in the same vertical planes. However, many of these low-strength strands have substantial bulk, so that the application of twisting forces may provide definite advantages as far as the delivery of these strands to the needles is concerned.

An example of a loop pile fabric in accordance with this invention is a fabric in which the pile is formed from rovings of staple cotton staple fibers. In this embodiment, the fibers are formed from a polymer of acrylonitrile containing at least 80% by weight of acrylonitrile in the polymer molecule. Such fibers are available commercially under the designation "Acrilan." The individual fibers have deniers in the range of from 2.5 to 3.0, and their staple lengths are approximately 1.81 inches.

The roving has a twist of about three-quarters of a turn per inch, and a 727 yard length thereof weighs approximately one pound (.886 hank roving in the cotton system). There are approximately six rows of pile loops per inch across the width of the fabric and about six pile loops per inch along each of the rows. The pile loops themselves extend from the backing about five-sixteenths of an inch. This fabric has a soft luxurious pile surface. It is pleasing to the sense of touch and it is attractive in appearance. This novel texture opens up new fields for the utilization of tufted fabric products.

Loop pile fabrics embodying low-strength pile strands may also be used as intermediate products in the manufacture of other types of fabrics. In this connection, attention is invited to United States Patent No. 3,034,194 granted to Priest et al., which patent relates to napped tufted fabrics. Where the pile surface is made up of rovings, the napping operations required for products of this type may be carried out with a minimum expenditure of energy and without subjecting the fibers to unnecessarily high stresses.

Although the swirling air streams in the needles 24a apply false twist to the pile strands when pile loops are being formed, these air streams may apply real or permanent twist to the pile strands during the formation of cut pile fabrics. This change in the action of the air streams is suggested in FIGURE 7. This view shows a needle 24a at a point in the cycle when the tip of the needle is exposed below the backing 12a. It also indicates that the pile loop extending from the needle has just been cut, leaving an end 82 of the pile yarn in alignment with the yarn passageway through the needle. After a loop has been cut, the cut end of the pile strand is free to rotate in response to the forces applied by the swirling air streams. As indicated in FIGURE 7, the twist in the pile strand 84 will run all the way from the rollers 46a to the end 82, and the twist will be of the same direction throughout the twisted length. When tufting operations are carried out in accordance with this embodiment of the invention, it may be possible to eliminate some of the yarn processing steps that have been required heretofore in the preparation of tufting yarns.

The foregoing description of various embodiments of the invention is exemplary only. Still other variations and modification will be apparent to persons skilled in the art. It is intended, therefore, that the scope of the invention be ascertained from the following claims.

I claim:

1. An axially elongated hollow tufting needle terminating at its lower end in a tip portion adapted to penetrate a backing and having an axial strand passageway of substantially circular cross-section extending from the upper end of the needle to the tip portion, said needle being provided with a plurality of angularly spaced straight air passages through the wall thereof above the tip portion, each of said air passages having a diameter less than that of said strand passageway and being inclined downwardly and circumferentially with respect to said strand passageway.

2. In a method of tufting in which strand material extending along a path from a source to a backing is fed through said path and is inserted at intervals through said backing, the improvement which comprises applying spiral fluid flow to said strand material to twist said strand material while it moves through the backing.

3. A method of tufting which comprises moving a needle having a passageway therein back and forth to project an end thereof through a backing and to withdraw said end from said backing, feeding a predetermed length of strand material to said passageway in said needle, and flowing fluid along and circumferentially around the axis of the strand material in said passageway to feed and impart a twist to said strand material.

4. A method of making a loop pile fabric having a plurality of pile strands of different appearance passing together along a backing and passing together through the same openings in the backing at intervals to form pile loops, which method comprises feeding said plurality of pile strands at the same rate as separate strands, passing said strands together through a single passageway in a hollow tufting needle, flowing fluid circumferentially
around the axis of said passageway to apply twisting forces to said strands causing the portions of said strands extending to the needle to be twisted about each other, and moving the needle back and forth to project an end thereof through the backing at spaced locations to form pile loops.

5. A tufting needle which comprises a needle shaft defining therein a passage for transmitting a strand of material to be tufted, said passage having an open outlet, means for flowing fluid in said passage circumferentially around the axis thereof and axially toward said outlet to simultaneously impart a twist to the strand and feed it toward said outlet.

6. A tufting needle according to claim 5 wherein said fluid flowing means comprises at least one fluid passageway terminating in an outlet directed circumferentially into said strand passage.

7. A tufting needle according to claim 6 wherein said strand passage extends longitudinally through said needle shaft and said fluid passageway extends through the wall of said shaft intermediate the length of said strand passage.

8. A tufting needle according to claim 7 wherein said fluid passageway is also directed axially into said strand passage.

9. A tufting needle according to claim 8 comprising a plurality of said circumferentially and axially directed fluid passageways spaced around the circumference of said shaft.

10. A tufting apparatus comprising a tufting needle having a tip, means for moving said needle cyclically back and forth to project the tip through a backing and withdraw said tip from the backing, means for releasing strand material to said needle during a cycle of movement thereof, said needle having a passage therein for receiving said strand material, and means for directing fluid in a spiral path within and along said passage for applying twisting forces to and feeding said strand material.

11. A tufting apparatus as recited in claim 10 wherein said fluid directing means comprises at least one fluid passageway terminating in an outlet directed circumferentially into said strand passage.

12. A multiple needle tufting machine comprising means for advancing a backing, a needle carrier extending across the path of the backing, a plurality of tufting needles mounted on said carrier and having tip portions projecting therefrom toward the backing, each of said needles having therein a strand passageway terminating in an outlet adjacent its respective tip portion, means for moving said carrier toward and away from said backing cyclically to insert the tip portions of said needles through and withdraw them from the backing at intervals, means for supplying predetermined lengths of strand material to said strand passageways, and means for flowing fluid during at least a portion of each cycle in each of said passageways circumferentially around the axis thereof and axially toward the outlet thereof to feed and impart a twist to the strand material.

13. A tufting machine as recited in claim 12 wherein said fluid flowing means comprises at least one fluid passageway for each of said needles terminating in an outlet directed circumferentially into the strand passage of the respective needle.

14. A tufting machine as recited in claim 13 wherein each of said strand passageways extends longitudinally through its respective needle and each of said fluid passageways extends through the wall of its respective needle.

15. A tufting machine as recited in claim 14 wherein each of said needles has a plurality of said fluid passageways spaced therearound and directed axially as well as circumferentially into their respective strand passageways.

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