March 12, 1968 J. A. WILLIAMS ETAL 3,372,447

PROCESS AND APPARATUS FOR NEEDLE FELTING NON-WOVEN FABRICS

Filed Feb. 28, 1966 4 Sheets-Sheet 1

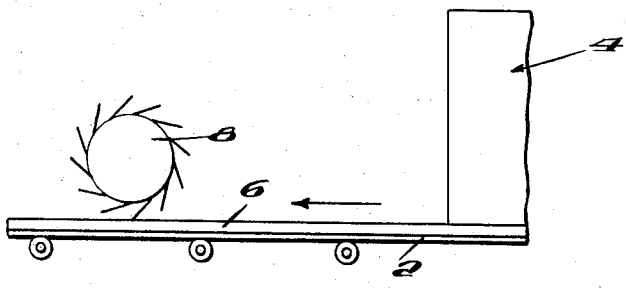

Fig. 1.

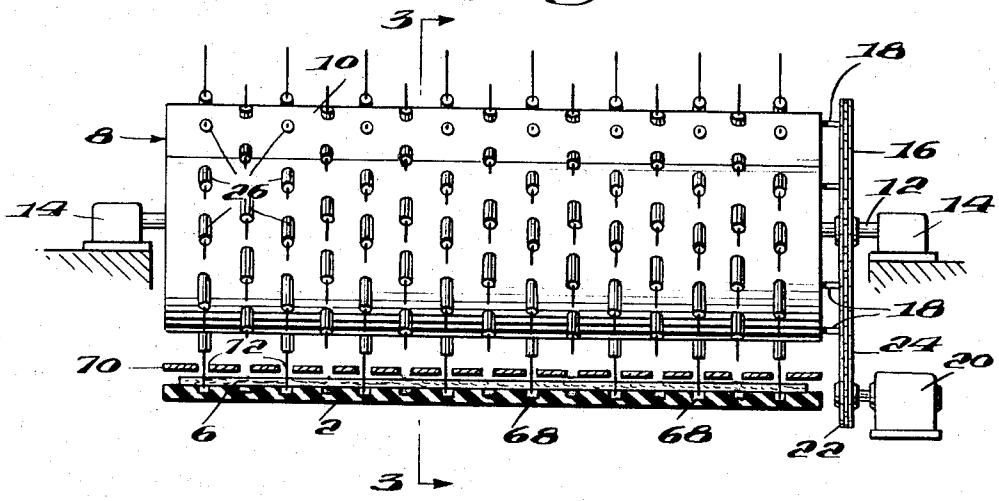

Fig. 2.

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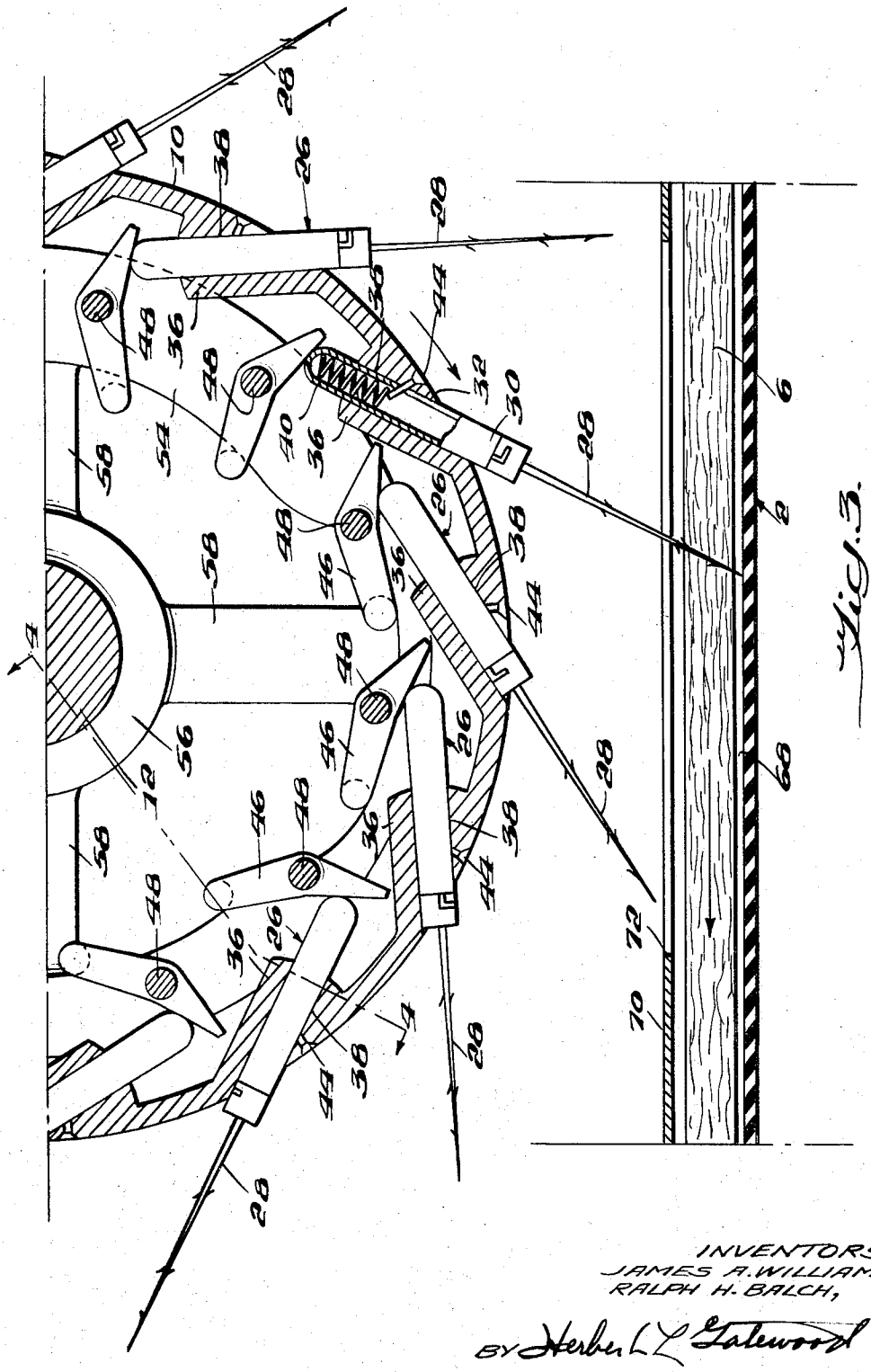

Fig. 3.

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Fig. 4.

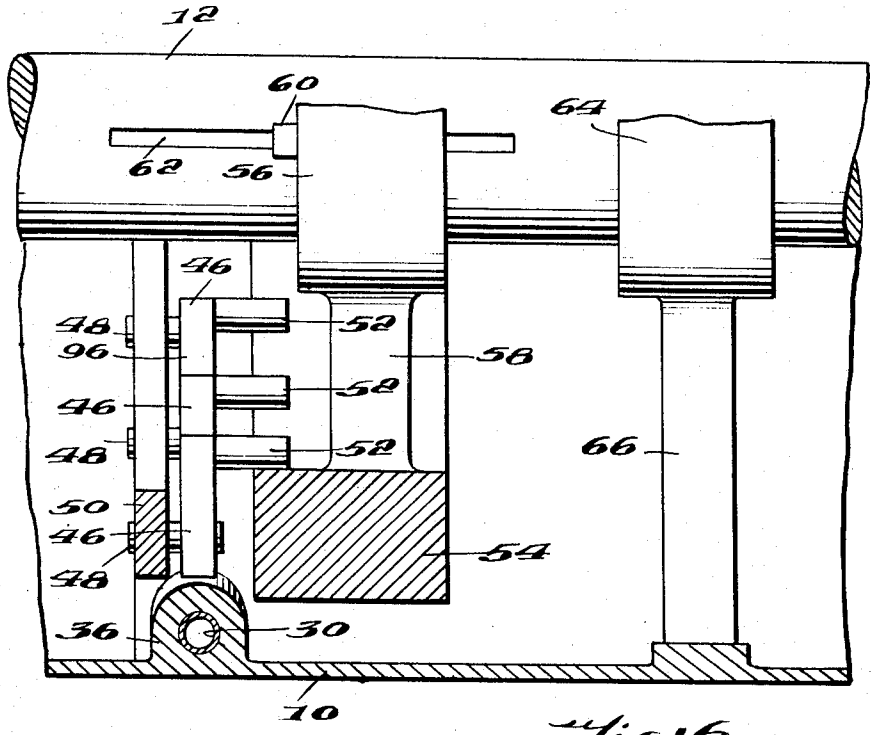
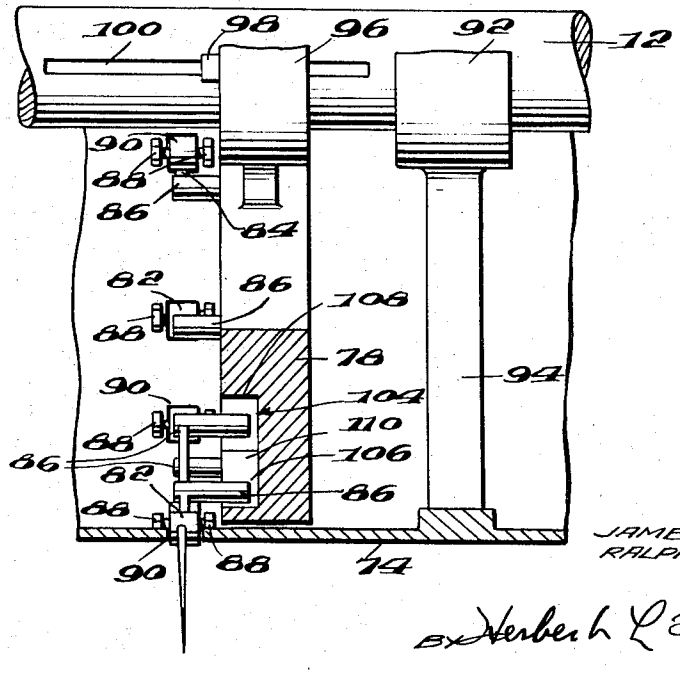


Fig. 6.



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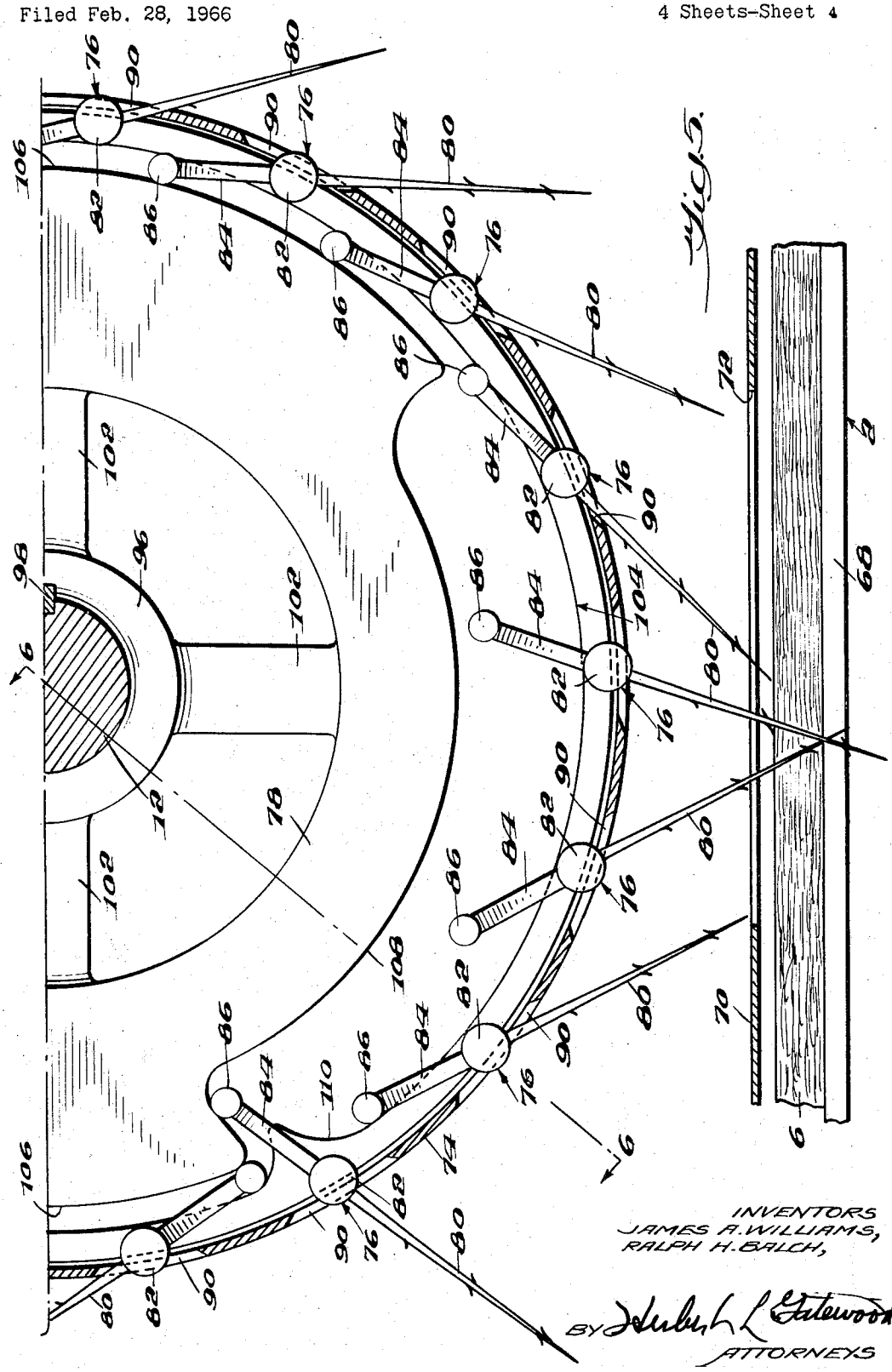

Fig. 5.

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United States Patent Office 3,372,447
Patented Mar. 12, 1968

3,372,447

PROCESS AND APPARATUS FOR NEEDLE FELTING NON-WOVEN FABRICS

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Filed Feb. 28, 1966, Ser. No. 530,446
16 Claims. (Cl. 28—4)

ABSTRACT OF THE DISCLOSURE

Non-woven fabrics are needle punched in a continuous manner by a plurality of needles mounted on a revolving drum. The needles enter the moving non-woven fabric at an angle less than 90° with respect to the fabric and are withdrawn from the fabric in a substantially longitudinal motion.

This invention relates to needle felting, and more particularly, to a method and apparatus for increasing the cohesion between the fibers in a non-woven fabric or mat by needling.

Non-woven fabrics can be produced by depositing a mat of fibers on a conveyor. The fibers are deposited individually on the conveyor by fiber distributing apparatus and a mat is built upon the conveyor of many fibers laid on top of each other. Very few of the fibers extend vertically through the mat and, as a result, there is practically no cohesion between the fibers in the mat. The loose mat is not self-sustaining and would disintegrate if it were removed from the conveyor. One method of improving the structural integrity of the mat is to pierce the mat with a plurality of needles. Usually, the needles have barbs and when they are forced through the mat, the barbs catch some of the fibers and draw them downward through the mat, so that the fibers become entangled with other fibers across the thickness of the mat.

In conventional needling apparatus, the needles are mounted in a frame which reciprocates vertically with respect to a horizontally moving mat. The progress of the mat is stopped while the needles are lowered into the mat and the mat is started again after the needles have been withdrawn from the mat. This step motion of the conveyor is necessary because the needle frame is not mounted for movement along with the conveyor. The step motion of the conveyor necessarily limits the rate of production of non-woven fabrics. Another deficiency of the reciprocating needle arrangement is that the needles enter the fabric substantially perpendicularly and thus engage only the fibers that are directly in the path of the needles. In order to get maximum entanglement of the fibers by the needling process, therefore, it is necessary to utilize a great many needles closely spaced together. This greatly increases the cost of the apparatus, if close entanglement of fibers is desired.

Accordingly, it is an object of this invention to provide an improved needling process and apparatus.

It is a further object of this invention to provide a method and apparatus for needling non-woven fabrics or mats on a conveyor while continuously advancing the conveyor.

It is a still further object of this invention to provide a method and apparatus for causing maximum entanglement of fibers in non-woven fabrics or mats.

These objects are accomplished in accordance with the preferred embodiment of the invention by mounting a plurality of needles on a revolving drum and changing the positions of the needles with respect to the non-woven mat as the needles approach and move away from the mat. In one embodiment, the needles are offset with respect to the axis of rotation of the drum and are quickly withdrawn from the mat by longitudinal motion of the needles. The motion of the needles is controlled in such a manner that the needles penetrate the mat and are quickly withdrawn while the drum is rotating and the mat is moving continuously under the drum. In another embodiment of the invention, the needles are mounted for swinging motion in radial planes with respect to the drum. The positions of the needles are controlled so that they point toward the mat as they approach the mat, but the mat moves at a slower speed than the drum, which causes the needles to swing rearwardly prior to being withdrawn from the mat. Thus, the needles are withdrawn approximately longitudinally to produce maximum entanglement of the fibers. The needles are barbed for catching fibers upon movement into the mat and also upon movement back out of the mat. In this second embodiment of the invention, a greater degree of entanglement of fibers is produced at the center of the mat than at the surface of the mat.

These preferred embodiments of the invention are illustrated in the accompanying drawings, in which:

FIGURE 1 is a schematic view of the needling apparatus of this invention;

FIGURE 2 is a front elevational view of the needling drum;

FIGURE 3 is a cross sectional view of the drum along the line 3—3 in FIGURE 2;

FIGURE 4 is a cross sectional view of the drum along the line 4—4 in FIGURE 3;

FIGURE 5 is a cross sectional view as in FIGURE 3, but of a modified form of the invention; and

FIGURE 6 is a cross sectional view of the modified drum along the line 6—6 in FIGURE 5.

Non-woven fabrics are made up of loose fibers that are joined together by random entanglement rather than weaving. One method of producing non-woven fabrics is to deposit the fibers on a moving conveyor **2**, as shown in FIGURE 1. The fibers may be deposited on the conveyor **2** as it passes through a chamber **4**. The fibers are laid on top of each other to form a mat **6** on the conveyor **2**. A revolving drum **8** is mounted over the conveyor **2** and extends transversely across the mat **6**.

The drum **8**, as shown in FIGURE 2, includes an outer cylinder **10** which is mounted for rotation on a stationary, non-rotating shaft **12**. The shaft is supported on mounting blocks **14** at its opposite ends which prevent rotation of the shaft **12**. A sprocket wheel **16** is mounted on one end of the cylinder **10** by means of spacer bolts **18** and a motor **20** is mounted adjacent the wheel **16**. The motor **20** has a sprocket wheel **22** which is connected with the wheel **16** by means of a sprocket chain **24** for turning the cylinder **10** relative to the stationary shaft **12**.

A plurality of needle assemblies **26** are arranged in rows extending around the circumference of the cylinder **10** and the rows of needle assemblies **26** are spaced apart uniformly along the length of the cylinder **10**. The spac-

ing between the rows of needle assemblies **26**, as shown in FIGURE 2, is merely illustrative. The needle assemblies may be positioned closer together or further apart, as required. Preferably, the needle assemblies in adjacent rows are staggered.

Referring to FIGURE 3, the needle assemblies **26** include a barbed needle **28** and a needle holder **30**. The needles have barbs pointing in opposite directions. In each assembly **26**, the base of the needle **28** is secured in a plug or cap **32**. The needle holder **30** is in the form of a hollow tube and the cap **32** is secured on the end of the tube by a conventional bayonet fastener **34**, or any other suitable means. The cylinder **10** has a plurality of internal bosses **36**, each of which has a tangential bore **38** in which the holder **30** is mounted. The needles **28** are pointed in the direction of rotation of the cylinder **10**. The central axis of each needle is positioned at approximately right angles to a radius of the cylinder **10**. With this orientation, the needles enter the mat at an angle less than 90° with respect to the mat surface. Preferably, the angle of entry is between 30° and 60°.

The holders **30** are received in the respective bores **38** and each of the holders is spring-biased toward movement inwardly with respect to the cylinder **10**. A spring **40** is mounted in each of the holders adjacent the closed end and the holders have a longitudinal slot **42** through which a screw **44** extends. The screw **44** is threaded into a hole in the cylinder **10** and the slot **32** allows the holder to move longitudinally relative to the screw **44**. The screw compresses the spring **40** against the closed end of the needle holder **30**. Thus, the spring **40** urges the holder inwardly with respect to the cylinder **10**.

The positions of the needle holders **30** with respect to the cylinder **10** are controlled by cam followers **46**. As shown in FIGS. 3 and 4, the cam followers **46** are mounted for swinging movement about a pivot pin **48** which is rigidly supported by a ring **50** extending radially around the interior of the cylinder **10**. The ring **50** is welded or otherwise secured to the interior surface of the cylinder **10** and rotates with the cylinder. Each of the cam followers **46** has an arm **52** which bears against a stationary annular cam **54**. The cam **54** is supported by a hub **56** with radial spokes **58** interconnecting the hub and the cam. The hub **56** is rigidly secured to the stationary shaft **12** by means of a key **60** which is received in a key slot **62** in the shaft **12**. Preferably, each of the rows of needle assemblies has a separate cam **54**.

The cylinder **10** is mounted on the shaft **12** for rotation relative to the shaft. The mounting for the cylinder includes a hub **64** and radial spokes **66** between the hub and the cylinder. The hub **64** turns freely about the shaft **12**. Preferably, a plurality of hubs and spokes are spaced along the length of the cylinder **10**. In order to provide staggered rows of needle assemblies, the hubs **56** are angularly offset from the hubs **56** of adjacent needle cam assemblies in such a manner that the path of the needles in each of the cam assemblies is substantially the same with respect to the mat **6**.

The profile of the cam surface is shown in FIGURE 3. The cam follower arms **52** are urged against the surface of the stationary cam **54** by the springs **40** in each of the needle holders **30**. As the needle assemblies move clockwise with the cylinder **10**, as viewed in FIGURE 3, the needle holders **30** are fully extended with respect to the cylinder **10** as they approach the mat **6**. As the needles enter the mat **6**, the respective cam followers approach the fall portion of the cam **54** which causes the followers **46** to swing about the pivot pin **48**. As the cam follower arm **52** passes over the fall portion of the cam, the follower **46** swings to its lowermost position on the cam, allowing the needle holder **30** to be retracted rapidly into the cylinder **10** by the spring **40**. This movement causes the needle to be withdrawn from the mat **6** in a substantially longitudinal motion. Then, after the needle **28** has moved clear of the mat **6**, the cam follower is pivoted by the rise portion of the stationary cam back to the extended position where it remains until the needle assembly again approaches the mat **6**.

Preferably, the needles **28** are sufficiently long to pierce the full depth of the mat and project a short distance below the mat, as shown in FIG. 3. In order to prevent interference between the needles and the conveyor **2**, grooves **68** may be provided in the conveyor **2**. Also, since barbs on the needle **28** engage the fibers in the mat to draw them transversely along the direction of movement of the needles, there may be a tendency for some of the fibers to remain on the needles when the needles are withdrawn from the mat. Accordingly, it may be necessary to provide a stripper plate **70** above the mat **6**. The plate **70** has longitudinal slots **72** through which the needles pass. The slots **72** are preferably narrow, so that they will pull off any fibers that are retained on the needles as they are withdrawn from the mat.

In operation, the speed of the conveyor **2** is adjusted to advance the mat **6** at a uniform speed under the drum **8**. The drum has approximately the same surface speed or a slower surface speed than the mat **6**. The clockwise rotation of the cylinder **10**, as viewed in FIGURE 3, advances the needles **28** sequentially into the mat. When the needles have pierced the mat **6**, they are immediately retracted by swinging movement of the cam followers **46** in moving through the fall portion of the cam **54**. The spring loaded needle holders are urged inwardly with respect to the cylinder **10** by the internal springs **40** as they reach the point of maximum penetration of the mat. Then after the needles **28** have been withdrawn from the mat **6**, the cam followers **46** rotate to move the needles **28** toward the outermost position where they remain until they engage the mat again.

A modified form of the invention is shown in FIGURES 5 and 6. The drum **8**, as shown in FIGURES 1, 2 and 3, is modified to include a cylinder **74**, on which are mounted needle assemblies **76** that are arranged in substantially the same manner as the needle assemblies **26**, shown in FIGURE 2. The needle assemblies **76** are mounted for swinging movement relative to the cylinder **74** and the positions of the needles are controlled by a stationary cam **78** inside the cylinder **74**.

Each needle assembly **76** includes a needle **80** which has its base mounted in a hub **82** and an arm **84** which projects outwardly on the opposite side of the hub. On the end of the arm **84**, there is a cam follower **86** which projects laterally from the arm **84**. The hubs **82** are mounted for swinging movement relative to the cylinder **74** by bearing blocks **88** on opposite sides of the hubs. Openings **90** are provided in the cylinder **74** for receiving the respective hubs **82**. Of course, other suitable arrangements may be provided for mounting the hubs **82** for pivoting movement relative to the cylinder **74**.

As shown in FIG. 6, the cylinder **74** is mounted for rotation on the shaft **12** by means of a hub **92** with radial spokes **94** extending between the hub **92** and the cylinder **74**. The stationary cam **78** is also supported on the shaft **12** by means of a hub **96**. The hub **96** is prevented from rotating relative to the shaft **12** by a conventional key **98** which is received in a key slot **100**. Spokes **102** project outwardly from the hubs **96** for supporting the stationary cam **78**.

The cam **78** has an annular groove **104** in the side adjacent the needle assemblies **76**. The groove **104** includes a narrow portion **106** and a wide portion **108** interconnecting the ends of the narrow portion **106**. The narrow portion **106** of the groove **104** is slightly wider than the diameter of the cam followers **86**, while the wide portion **108** is sufficiently wide to allow the arms **84** to swing freely about the hubs **82**. At the junction of the wide portion **108** and the narrow portion **106**, the side of the groove **108** forms a rise cam surface **110** which swings the needle around to point in the opposite direction and

guides the follower 86 into the narrow portion 106 of the groove.

As the cylinder 74 rotates, the needles 80 are guided into the mat 6, but while the cam follower is in the wide portion 108 of the groove 104, the needle is free to turn about the hub 82. The movement of the cylinder 74 at a greater surface speed than the mat 6 causes the needle to swing from a forwardly pointing direction to a rearwardly pointing direction, as shown in FIG. 5. Withdrawal of the needle occurs while the needle is pointing in a rearwardly direction. When the relative speeds of the cylinder 74 and the mat 6 are properly adjusted, the needles pierce the mat by substantially longitudinal movement of the needles relative to the mat. The needles are also withdrawn by substantially longitudinal movement of the needles and during such movement the barbs on the needles catch some of the fibers in the mat and draw them along the direction of movement of the needles. The needles have barbs pointing in opposite directions to catch the fibers as the needles pass into and back out of the mat 6.

The belt conveyor 2 under the mat 6 may be in the form of a plurality of individual belts 68 which are spaced apart sufficiently to allow the needles 80 to pass between the belts. The gaps between the belts should be aligned with the rows of needle assemblies 76 on the surface of the drum. Also, a stripper plate 70 is preferably positioned above the mat to remove the fibers remaining on the needles after they have been withdrawn from the mat.

In operation, the speed of the mat 6 is adjusted to be slower than the surface speed of the cylinder 74. As the needle assemblies 76 approach the mat 6, the needles 80 are guided by the cam groove 104 to point toward the mat as shown in FIG. 5. The relative distance between the cylinder 74 and the mat 6 is adjusted, so that the pointed end of the needle 80 enters the mat as the corresponding follower 86 enters the wide portion 108 of the cam groove 104. While the needle is in engagement with the mat, it swings to a rearwardly pointing position. After the needle has been withdrawn from the mat, the cam follower 86 of the needle assembly engages the rise portion 110 of the cam groove 104 to swing the needle 80 around so that it is in a forwardly pointing position before entering the narrow portion 106 of the groove 104.

The path of motion of the needles 80, as shown in FIGURE 5, causes a high degree of entanglement of fibers at the center of the mat adjacent the point about which the needles swing. At the surfaces of the mat, the needle moves transversely relative to the mat, causing a loose entanglement of fibers at the surfaces of the mat. The resulting mat resembles a napped woven fabric. This structure of the mat is desirable because of its good drape qualities and raised or napped surface.

It is apparent that the needles 28 and 80 of the apparatus of this invention enter the mat and remain in the mat for a considerably shorter duration than would be possible if merely radial needles were provided on the surface of the cylinder of the drum 8. Also, instead of sweeping through the mat, the needles penetrate the mat primarily in a longitudinal motion. Accordingly, the mat produced by the apparatus of this invention has a plurality of fibers that are drawn generally perpendicular to the direction of motion of the mat and are entangled with the adjacent fibers in the mat and the result is that the strength of the mat has been considerably increased. Furthermore, since the mat moves continuously during the needling operation, the apparatus achieves a high production rate and there is no need to provide for intermittent motion of the mat as is necessary with reciprocating type needling devices.

It is desirable for the points at which the needles penetrate the mat to be close together in order to obtain maximum entanglement of the fibers. As previously stated, the needle assemblies in adjacent rows may be staggered for this purpose. Another alternative is to provide a series of staggered drums 8 along the length of the mat 6 with the drums rotating in fixed angular relations with each other. Thus, the needles of the subsequent drums would penetrate the mat at points between the penetration points of the needles in preceding drums.

While this invention has been illustrated and described in several embodiments, it is recognized that variations and changes may be made therein without departing from the invention as set forth in the claims.

We claim:

1. A method of needle felting a non-woven fabric comprising effecting continuous motion of said fabric along a substantially straight path, piercing said fabric with needles, and withdrawing said needles from the fabric in a substantially longitudinal motion.

2. A method of needle felting a non-woven fabric according to claim 1 including moving said needles in an arcuate path.

3. A method of needle felting a non-woven fabric according to claim 2 including changing the position of said needles relative to said arcuate path while said needles are in engagement with said fabric.

4. A method of needle felting a non-woven fabric according to claim 1 including changing the orientation of said needles relative to said fabric while piercing said fabric.

5. A method of needle felting a non-woven fabric according to claim 4 including moving said needles and said fabric in substantially the same direction, said needles moving at a greater speed than said fabric.

6. Apparatus for needle felting non-woven fabrics comprising a plurality of needles, means for moving said needles in an arcuate path and means for changing the position of said needles relative to said path, whereby the needles are withdrawn from the fabric in a substantially longitudinal motion.

7. Apparatus for needle felting according to claim 6 wherein said moving means includes a drum, said needles being mounted in said drum, and means for rotating said drum.

8. Apparatus for needle felting according to claim 7 wherein said drum includes a cylinder and cam means, means mounting said needles in said cylinder, means for rotating said cylinder relative to said cam means, and means on said needless for engaging said cam means, whereby said cam means controls the position of said needles relative to said cylinder.

9. Apparatus for needle felting according to claim 7 wherein said needles are positioned generally tangentially of said cylinder.

10. Apparatus for needle felting according to claim 9 wherein said needle mounting means includes means cooperating with said cam means for individually displacing said needles longitudinally.

11. Apparatus for needle felting according to claim 8 wherein said needles are mounted for swinging movement relative to said cylinder, said cam means restricting swinging movement of said needles during a portion of each revolution of said cylinder and releasing said needles for swinging movement during another portion of each revolution.

12. In needle felting apparatus of the type having a movable conveyor on which non-woven fabrics are supported, a needle felting drum, a plurality of needles projecting outwardly from said drum, means for rotating said drum, said fabrics being in position on said conveyor to be pierced by said needles, and means for withdrawing said needles from the fabric by substantially longitudinal movement of said needles relative to said conveyor, said drum rotating continuously and said conveyor moving continuously relative to the drum.

13. The apparatus according to claim 12 wherein said conveyor supports said fabric on a substantially planar surface parallel to the central axis of said drum.

14. The apparatus according to claim 13 including means for guiding said needles into said fabric, said

needles engaging said fabric while inclined relative to the plane of said fabric and pointing in the direction of rotation of said drum.

15. The apparatus according to claim 14 wherein said needles are mounted for swinging movement while in engagement with said fabric, said conveyor moving said fabric at a slower surface speed than that of said needles, whereby the fabric causes the needles to swing from forwardly inclined to rearwardly inclined positions.

16. Apparatus for needle felting according to claim 6 wherein said needles have barbs projecting in opposite longitudinal directions.

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