March 14, 1961 J. L. HOLLOWELL 2,974,393

APPARATUS FOR NEEDLE PUNCHING SHEET MATERIALS

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FIG. 2

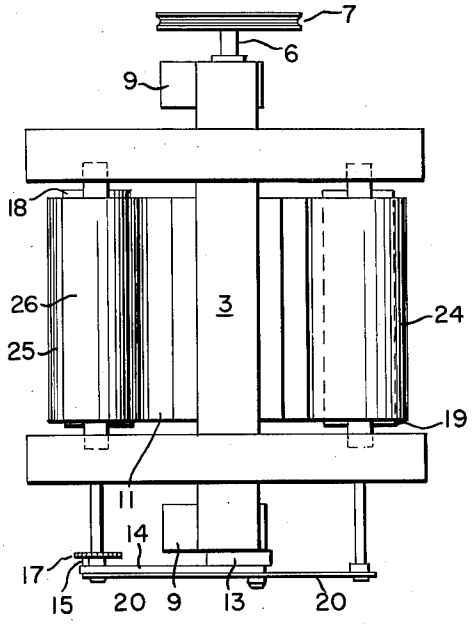
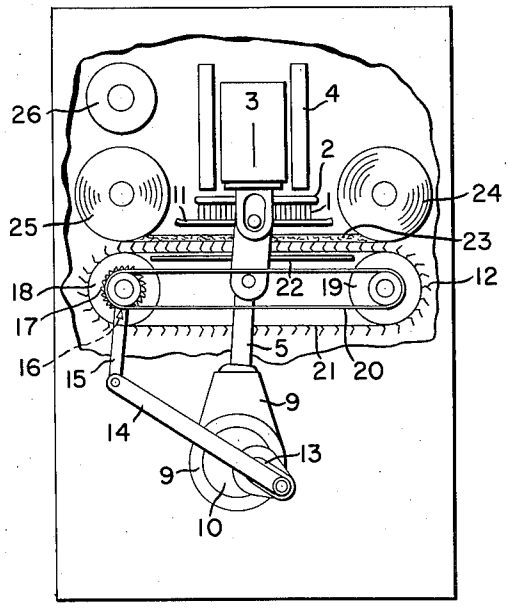


FIG. 1



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FIG. 3

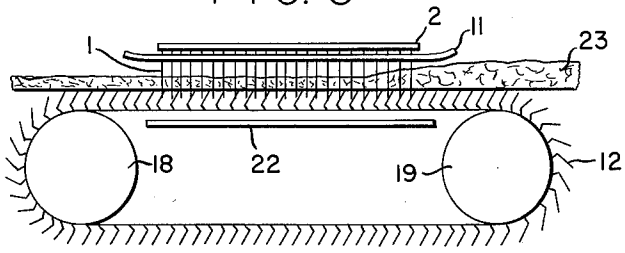


FIG. 4

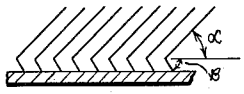


FIG. 5

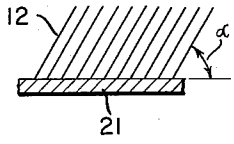


FIG. 6

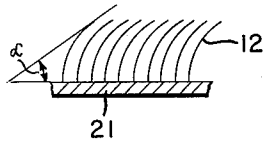
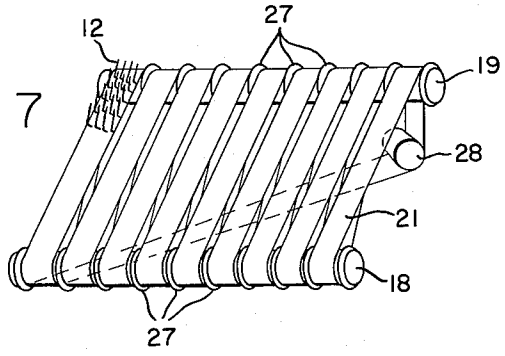


FIG. 7



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United States Patent Office 2,974,393 Patented Mar. 14, 1961

2,974,393

APPARATUS FOR NEEDLE PUNCHING SHEET MATERIALS

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Filed Jan. 8, 1959, Ser. No. 785,657

3 Claims. (Cl. 28—4)

This invention relates to needle punching and more particularly to an improved process and apparatus for needle punching sheet materials, especially unwoven batts of fibers.

Felt-like sheet materials have been prepared for many years in the textile industry by needle punching batts of carded or similarly oriented natural fibers of materials such as, for example, hair, jute and sisal. These punched felt-like materials have been used, for example, as carpet linings, insulating felts, slicker felts, cartridge wadding and the like. Recently, felt-like sheet materials have been prepared for unwoven batts of synthetic fibers.

Basically, needle punching comprises piercing an unwoven batt of fibers with a plurality of needles to orient individual or small groups of fibers subtantially perpendicular to the plane of the batt thereby giving added strength to the unwoven structure. In its crudest form, this process can comprise punching the batt with a hand-operated instrument comprising a substrate to which are fixed a plurality of needles. Usually, however, this operation is performed on a needle loom which basically comprises a large number of closely spaced needles supported in position to be moved, and usually reciprocated, into and out of the batt of fibers.

In order to take full advantage of the needle punching operation and to orient fibers throughout the thickness of the batt substantially perpendicular to the plane of the batt, the needles must pass through the batt. Conventionally, a batt of unwoven fibers in a needle loom is supported on a plate called a bedplate which has a plurality of holes in its surface. During needle punching, the needles in the needle loom pass through the batt of unwoven fibers and through the holes in the bedplate, then are withdrawn from the batt as the batt moves forward through the loom. This type of structure inherently has several disadvantages. First, the needles in the needle loom must be positioned to reciprocate into and out of the holes in the bedplate. Thus, if one or more of the needles become bent or are deflected by heavy fibers in the batt being punched, the needles strike the edge of the holes in the bedplate and are broken. Secondly, this structure inherently limits the needle density, that is, the number of needles per unit area in the punching surface, for, obviously, there is a limit after which there is no more bedplate through which to drill holes. Necessarily, this limitation in needle density also limits the number of punches per square inch per stroke which can be made in the batt. Consequently, batts of unwoven fibers must either be run through the needle loom several times or they must be run very slowly therethrough. Thirdly, it is very difficult to punch very thin batts of fibers, particularly synthetic fibers such as polytetrafluoroethylene, in a needle loom. Conventional needle looms greatly distort and stretch batts of synthetic fibers which have a low coefficient of friction and slide easily over one another and thus yield products with an uneven surface and density.

Since the aformentioned problems in needle-punching

solved by this invention are most acute when unwoven batts of fibers are punched, the following discussion deals primarily with such sheet materials; however, the following discussion applies equally well to the needle punching of sheet materials generally such as, for example, knitted fabrics, woven fabrics, coated fabrics, polymeric films and the like.

I have discovered an improved method and apparatus for needle punching sheet materials, particularly unwoven batts of fibers. This method and apparatus make it possible to use a very high needle density and, consequently, make it possible to punch sheet materials at a much higher rate than that obtained by conventional methods and apparatuses. This method and apparatus also eliminate the need for precise alignment of the needles in a loom with the holes in a bedplate. Also, certain embodiments of this invention are particularly suited for punching thin batts of fibers, including synthetic fibers.

The improved process of this invention comprises supporting a sheet material on a plurality of closely spaced, resilient, rod-like elements and moving a plurality of needles into and out of the sheet material. The improved apparatus of this invention comprises a needle loom for punching sheet materials which loom comprises a plurality of closely spaced needles, means to move the needles into and out of the sheet materials and a plurality of closely spaced, resilient rod-like elements positioned to support the sheet materials as the needles pass therethrough.

The improved apparatus of this invention is described in detail hereinafter by reference to a preferred embodiment shown in the accompanying drawings wherein:

Figure 1 is a partial section in side elevation of an improved needle loom of this invention;

Figure 2 is a plan view of the needle loom shown in Figure 1;

Figure 3 is an enlarged cross-section of the punching area in the needle loom shown in Figure 1;

Figures 4, 5 and 6 are side elevations of representative cross-sections of supporting members bearing a plurality of closely-spaced, resilient, rod-like elements; and

Figure 7 is a schematic drawing of a spirally wrapped flexible belt bearing a plurality of closely spaced, resilient rod-like elements.

The projected height of the rod-like elements which support the unwoven batts is at least about equal to the maximum distance which the tips of the needles move below the surface of the unwoven batts being punched. Usually, the rod-like elements are about from 1 to 10, and preferably 1 to 2 times this length. The cross-sectional configuration of the rod-like elements can be, for example, elliptical, square, triangular, round, oval or the like. Round or elliptical rod-like elements are usually used and are preferred. The average diameter of the elements usually decreases with the size of the fibers in the batts being punched; it also decreases as the inherent resiliency of the materials from which the elements are formed increases. Usually elements having an average diameter of 0.01 to 0.05 inch, and preferably 0.01 to 0.02 inch are used. The density of the rod-like elements, that is, elements per unit area, varies with the size of the fibers being needle punched and depends upon whether or not the unwoven batts are fed on a carrier such as, for example, a thin flexible film of polyvinyl chloride, polyethylene terephthalate, or similar polymeric materials, a woven fabric or the like. When a carrier is used, in which case the needles pass through the batt, the carrier and then between the rod-like elements, densities on the order of 10 elements per square inch can be used. With short fibers of small denier, densities on the order of 300 or more elements per square inch are desirable.

Preferably about from 100 to 300 elements per square inch are used.

As shown in Figures 4, 5 and 6, the rod-like elements can have a variety of shapes, that is, vertical configurations. The elements can be, for example, "kneed," straight or curved. When the rod-like elements have rounded points or a carrier is fed with the batt, particularly when high densities of the elements are used, the angle between the elements and the plane of the batts can approach 90°. In needle looms such as the preferred embodiments shown in the drawings in which the rod-like elements are pulled through the loom along with the non-woven batt as described hereinafter, the rod-like elements preferably project backward toward the feed side of the loom at an angle α of about from 20 to 80°. (See Figures 4, 5 and 6.) This configuration reduces distortion in the batts. "Kneed" rod-like elements such as those shown in Figure 4, the major portion of which project backward and upward at an angle α of about 20 to 80° and a lower minor portion of which project forward and upward at an angle β of about 20 to 90° are particularly preferred because they have outstanding strength and resiliency. In the punching area, the batts and the substrate bearing the rod-like elements are substantially parallel. Thus, for simplicity, in Figures 4, 5 and 6, the angles α and β are shown with respect to such substrates.

The rod-like elements can be formed from any of a wide variety of resilient materials such as, for example, steel and steel alloys, copper-beryllium alloys, tungsten or even rod-like resilient fibers of polymers such as polyamides, polyethylene terephthalate, cellulose acetate or polyformaldehyde. Elements of steel and steel alloys are preferred.

The rod-like elements may be fixed to any of a wide variety of substrates. For hand punching, or even in needle looms, the elements may be fixed to a rigid substrate such as, for example, fabric and fabric laminates impregnated with phenol-formaldehyde, melamine-formaldehyde and urea formaldehyde resins and substrates of, for example, steel, copper, brass, bronze, aluminum, tungsten and wood or the like. The rod-like elements can also be fixed to the bedplate or a needle loom. They can also be fixed to flexible substrates supported on one of the aforementioned rigid substrates. Preferably, as shown in the drawings, the rod-like elements are fixed to flexible belt which moves through the loom with the non-woven batts being punched. Examples of flexible substrates are those of leather, fabrics coated with rubber, both natural and synthetic, or any of the wide variety of other conventional coating materials such as, for example, vinyl chloride homopolymers and copolymers, polyurethanes, vinyl acetate homopolymers and copolymers, nitrocellulose, polytetrafluoroethylene, cellulose acetate butyrate, polyethylene or the like; unsupported sheets and films of the aforementioned or other polymeric materials or even wire screens or belts to which the rod-like projections are affixed.

Turning now to the drawings, the needle loom depicted in Figures 1, 2 and 3 consists of needles **1**, held in a needle board **2**, which in turn is fastened to a top beam **3**. The needle assembly consisting of needles **1**, needle board **2**, and top beam **3** is reciprocated substantially vertically between top beam guides **4** by connecting rods **5** which are connected to drive shaft **6** through eccentric straps **9** and eccentrics **10**. As the drive shaft **6** is turned by a suitable prime mover (not shown) through pulley **7**, eccentrics **10** rotate within the eccentric straps **9** which move the connecting rods **5** and the needle assembly. As the needles reciprocate, they pass downwardly through the holes in the stationary stripper plate **11**. Figure 1 shows the position of the needles **1** as they begin their downward stroke. Figure 3 shows the needles after they have passed through the stripper plate **11**, the unwoven batt of fibers **23** and between the rod-like elements **12**.

As shown in Figure 1, feed crank **13** fastened to eccentric **10** is rotatably connected to clutch lever **14** which is also rotatably connected to clutch pitman **15**. When the drive shaft **6** and eccentric **10** turn, clutch lever **14** causes clutch pitman **15** to oscillate back and forth. Ratchet **16** attached to clutch pitman **15** engages gear **17** and intermittently rotates rear draw roll **18**. Rear draw roll **18** intermittently rotates forward feed roll **19** through chain drive **20**. Thus, the needle assembly, the feed mechanism and rear draw roll **18** are all driven from eccentric **10**. In the embodiment shown in Figures 1, 2 and 3, the rod-like elements **12** are fixed to an endless belt **21** which passes around and is driven by friction contact with draw roll **18** and feed roll **19**. In the punching area underneath needles **1**, the endless belt **21** is supported by bedplate **22**.

In operation, the loose unwoven batt of fibers **23** fed from roller **24** is deposited on the tips of rod-like elements **12** which bear the batt into and through the punching area beneath needles **1**. As the batt passes beneath the needles **1** they reciprocate passing downwardly through the batt **23** and among the rod-like elements **12**, then upwardly back through the batt. The vertical movement of the batt **23** is limited by bedplate **22** and stripper plate **11**. Stripper plate **11** can be a drilled or slotted plate, a tensioned wire grid or the like; the bedplate **22** can be any substantially rigid supporting member. After being punched by the reciprocating needles **1**, the batt **23** is carried to and wound on roll **25**. If the batt is fed on a carrier, the carrier can be stripped from the batt and wound on roll **26** as the batt is wound on roll **25**.

Figure 7 shows a variation in the manner in which the rod-like elements **12** can be positioned in the needle loom. In Figure 7, the rod-like elements **12** (for clarity, shown only in part) are supported on an endless belt **21** which is spirally wrapped around draw roll **18** and feed roll **19**. Individual spirals are held in position and in close proximity with each other by thin ridges **27** on the rolls **18** and **19**. Roller **28** is used to feed and position the endless belt **21** as it runs from draw roll **18** back to the feed roll **19** on the other side of the punching area. Roller **28** or another roller can also be used to regulate the tension in the endless belt **21**. This embodiment shown in Figure 7 is particularly preferred because it helps keep the tension in the endless belt **21** equal throughout the width of the punching area.

The improved method and apparatus of this invention eliminate the necessity of precisely positioning needles, make it possible to needle punch sheet materials more quickly than with known methods and apparatuses and produce less distortion in the sheet being needle punched. With the improved method and apparatus of this invention, it is possible to use needle densities of 100 or even higher needles per square inch as compared with conventional apparatuses which, for example, usually have densities of less than about 5 to 10 needles per square inch. Also, with the process and apparatus of this invention, it is possible to punch very thin batts, for example, 1/16 inch or less formed from fibers as fine as 0.1 denier or less. The apparatus and process of this invention can be used with any of a wide variety of fibers, both natural and synthetic, and is particularly suited for synthetic fibers such as, for example, those of polytetrafluoroethylene, rayon, polyacrylonitrile, polyethylene terephthalate, nylon and the like.

The following example is intended to illustrate the utility of this invention and is not intended to limit it in any way.

Example

A loose batt comprising 10% by weight of 1.5 denier and 90% by weight of 0.5 denier polyethylene terephthalate staple fibers, 1½ inches long is carded and crosslapped into a non-woven batt of about 48 slivers weighing about 9.2 ounces per square yard. The loose batt is then fed on a polymeric film about 1 mil thick to a needle loom substantially similar to that shown in Figures 1

and 2 equipped with an endless, flexible, spirally wrapped belt bearing rod-like elements as shown in Figure 7. The rod-like elements are steel and of the "kneed" type such as those shown in Figure 4 having a diameter of about 0.014 inch. The elements project upward and forward at an angle β of about 70° about ⅛ inch, then upward and backward at an angle α of about 60° about ¾ inch. The density of the elements is about 208 elements per square inch.

The unwoven batt is punched about 3,000 times per square inch with 40 gauge single-barbed steel felting needles to yield a product about 35 mils thick weighing about 4.1 ounces per square yard and having a tensile strength of 5.3 pounds per linear inch in the machine direction and about 2.5 pounds per linear inch in the cross-machine direction. The product is substantially uniform throughout and free from uneven stretching and distortion.

I claim:

1. In a needle loom for punching sheet materials which loom comprises a plurality of closely spaced needles and means to move said needles into and out of said sheet materials, the improvement which comprises an endless flexible carrier belt and means to draw said belt through said loom, said belt bearing a plurality of closely spaced, resilient, rod-like elements positioned to bear said sheet materials through said loom and to support said sheet

materials as said needles pass therethrough, the upper major portion of said rod-like elements projecting upwardly and backwardly toward the feed side of said loom at an angle of about 20 to 80° with the plane of said sheet materials and the lower minor portion of said rod-like elements projecting upwardly and forwardly at an angle of about 20 to 90° with the plane of said sheet materials.

2. An apparatus of claim 1 wherein said rod-like elements have an average diameter of about 0.01 to 0.05 inch and a density of about from 100 to 300 elements per square inch.

3. In a needle loom for punching sheet materials, which loom comprises a plurality of closely spaced needles and means to move said needles into and out of said sheet materials, the improvement which comprises an endless flexible carrier belt spirally wrapped around feed and draw rolls for said loom, said endless flexible carrier belt bearing a plurality of closely spaced rod-like elements positioned to support said sheet materials as said needles pass therethrough.

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