June 13, 1967 C. J. SCHMIDT ETAL 3,325,324

PROCESS FOR PREPARING BONDED BIAXIALLY COMPRESSED FIBROUS BLOCKS

Filed Nov. 10, 1964 2 Sheets-Sheet 1

Fig. 2.

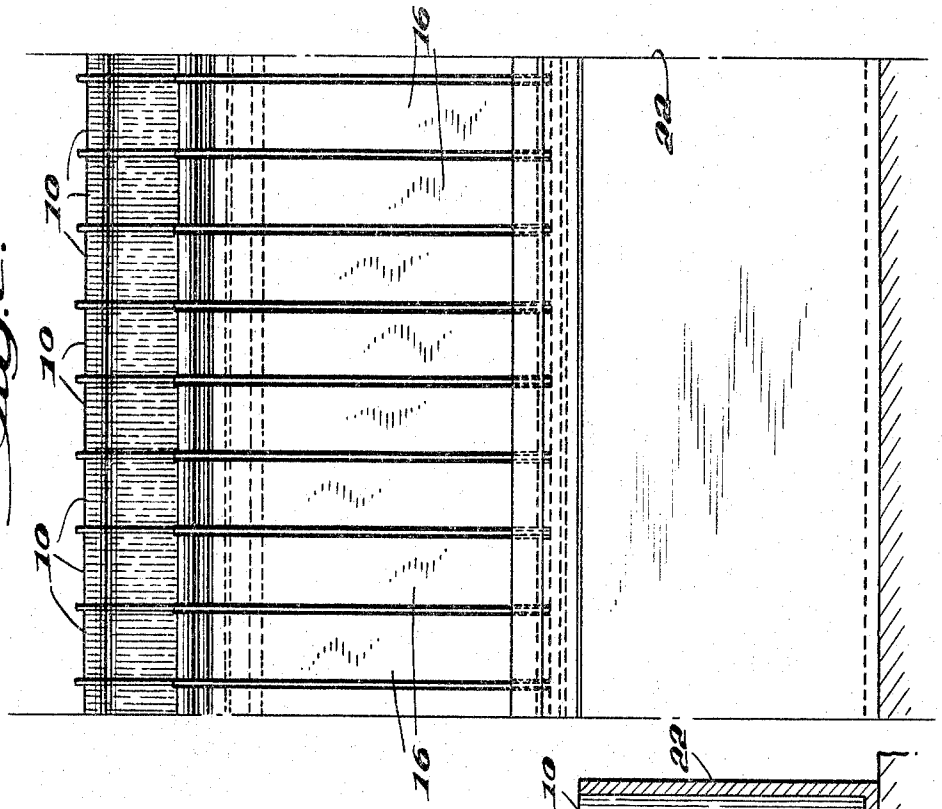

Fig. 1.

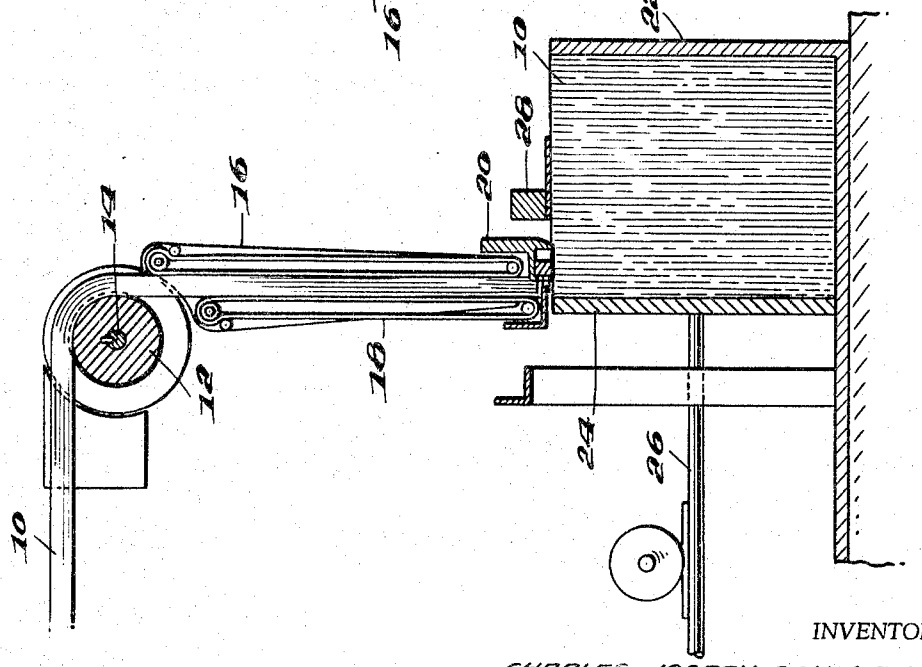

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Fig. 3.

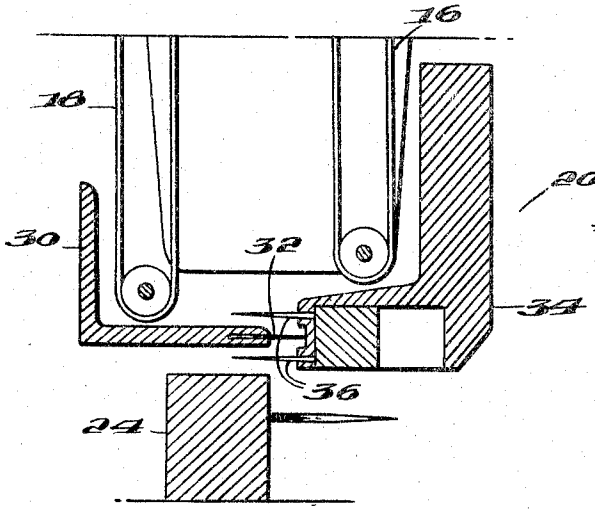


Fig. 4.

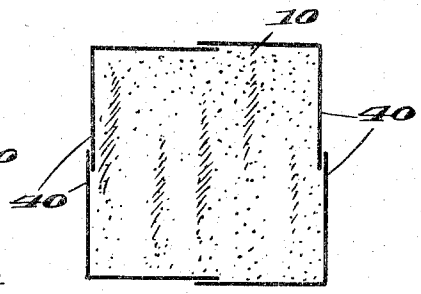


Fig. 5.

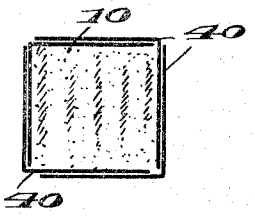


Fig. 6.

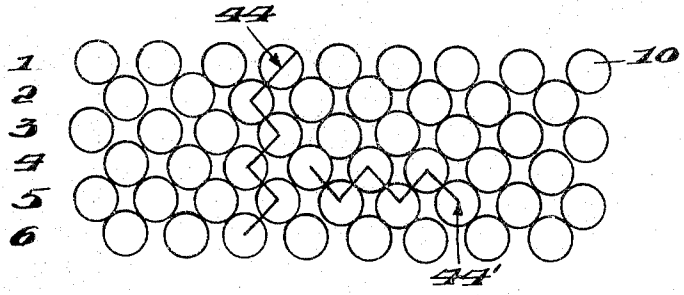


Fig. 7.

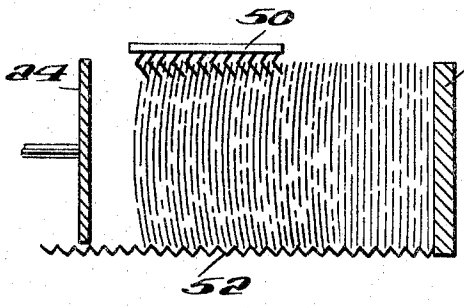
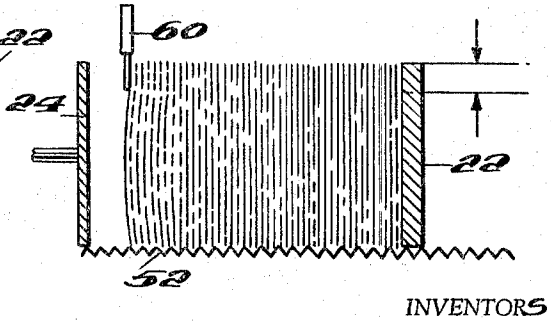


Fig. 8.



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United States Patent Office 3,325,324 Patented June 13, 1967

3,325,324

PROCESS FOR PREPARING BONDED BIAXIALLY COMPRESSED FIBROUS BLOCKS

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Filed Nov. 10, 1964, Ser. No. 410,192
3 Claims. (Cl. 156—72)

This invention relates to an improved process for making porous bonded blocks composed of bulky fibrous materials.

U.S. Patent No. 3,085,922 discloses methods for feeding parallelized fibers to a mold, attaching the fibers at spaced contact points to form a block and then cutting the block transverse to the direction of the aligned fibers to form a porous self-supporting fibrous sheet material. Sheets sliced from the blocks prepared by feeding cut sections of carded webs sometime tend to exhibit areas of high and low fiber density when the blocks or sheet is bent. These density non-uniformities often show up as separations or cleavage lines where the layers of carded web were pressed together.

An object of this invention is to provide an improved process to reduce non-uniformities and density variations in sheets and laminates made from porous bonded fibrous blocks. Other objects will appear from the description hereinafter.

The objects of this invention are accomplished in a process for preparing porous, bonded fibrous blocks by packing parallel rows of bulky fibrous elements having a fiber orientation predominantly in the longitudinal direction of the bulky fibrous elements to form a fibrous body and attaching the fibrous body at spaced contact points throughout the three dimensions of the fibrous body, the improvement comprising packing each adjacent row of bulky fibrous elements in a staggered relationship to form a fibrous body of relatively low density and thereafter compressing said fibrous body at least along an axis substantially perpendicular to said parallel rows of sliver sections with a compression ratio in the range of from about 2.0 to about 8.0 and to a final density in the range of from about 0.2 pound per cubic foot to about 5.0 pounds per cubic foot, with the proviso that when the final density is in the range of from about 0.5 pound per cubic foot to about 5.0 pounds per cubic foot, the compression ratio is in the range of from about 3.5 to about 8.0 and said fibrous body is biaxially compressed. "Density" as used herein means fiber density.

In the preferred embodiment, the novel process of this invention consists of the improvement comprising packing each adjacent row of sliver sections in a staggered relationship to form a fibrous body of relatively low density and thereafter biaxially compressing said fibrous body with a compression ratio in the range of from about 3.5 to about 8.0 to a final density in the range of from about 0.5 pound per cubic foot to about 5.0 pounds per cubic foot.

The term "biaxially compressing" is meant to define a relationship whereby one component of the compression is along an axis substantially perpendicular to the parallel rows of sliver sections and the other component of the compression is along an axis which is substantially perpendicular to the first axis. The sequence in which the two components of compression are carried out is not critical, the sole criteria being that each component provides at least 25% of the increase in density from the relatively low density of the fibrous body to the final density of the fiber block. Although it is preferred to have each component of compression consist of opposing forces on each respective side of the fibrous body, the forces are sufficient if provided only on two sides.

The term "compression ratio" is meant to define the ratio of the final density to the initial density, i.e., the relatively low density to which the parallel rows of sliver sections are initially packed.

In general, when the final block density is in the range of from about 0.2 pound per cubic foot to about 0.5 pound per cubic foot, packing the rows of sliver sections in a staggered relationship results in a fibrous block of good uniformity so that compressing along only one axis is required. When the final block density is desired to be in the range of from about 0.5 pound per cubic foot to about 5.0 pounds per cubic foot, compressing along only one axis results in excessive compression lines and biaxial compression is required to achieve a fibrous block having exceptional uniformity. For a final block density of 0.2 to 0.5 pound/ft.^{3} it is necessary to use a compression ratio of 2.0 to 3.5.

The embodiments of this invention and their advantages can be more readily understood fy referring to the accompanying drawings.

FIGURE 1 is a side elevation view of apparatus suitable for carrying out the novel process of this invention.

FIGURE 2 is a front elevation view of the apparatus illustrated in FIGURE 1.

FIGURE 3 is a detail view of the cutting mechanism illustrated in FIGURE 1.

FIGURE 4 is a diagrammatic view of a porous fibrous block having low density.

FIGURE 5 is a diagrammatic view of the porous fibrous block of FIGURE 4 which has been biaxially compressed.

FIGURE 6 is a diagrammatic view illustrating a porous fibrous block having adjacent rows staggered both longitudinally and latitudinally, and

FIGURES 7 and 8 are diagrammatic views illustrating holding devices for the mold used in the process of this invention.

With reference to FIGURE 1, there is shown a side elevation view of apparatus suitable for carrying out the novel process of this invention. Slivers **10** from sources not shown are passed over feed roll **12** which is mounted on spline **14**. Conveyors **16** and **18** are disposed on each side of slivers **10**. Cutting assembly **20** is located adjacent the bottom ends of conveyors **16** and **18**. Correspondingly, mold **22** is disposed below conveyors **16** and **18** and adapted to accept a row of sliver sections **10**. Ram **24** is connected to drive means not shown through shaft **26**. Holding member **28** is adapted to retain rows of sliver sections **10** in an upright position in mold **22** by contacting the upper ends of slivers **10**. FIGURE 2 shows a front elevation of the apparatus illustrated in FIGURE 1. Each continuous sliver **10** is guided by an individual conveyor **16** into mold **22**. FIGURE 3 illustrates a detail view of cutting assembly **20** shown in FIGURE 1. Cutting assembly **20** comprises angle iron **30** having cutter **32** mounted thereon and member **34** has combs **36** mounted therein. Ram **24** is shown in an intermediate position.

With respect to FIGURES 4 and 5, there is shown a porous fibrous block having low density (FIGURE 4) and a porous fibrous block which has been biaxially compressed (FIGURE 5). In FIGURE 4, rows of sliver sections **10** are shown loosely packed in collapsing mold **40**. In FIGURE 5, rows of sliver sections **10** have been biaxially compressed in collapsing mold **40** to the desired density.

Referring to FIGURE 6 there is shown a diagrammatic view of one embodiment in which adjacent rows of sliver section **10** are staggered. Lines **44** and **44'** are the index lines for illustrating the staggering between adjacent

longitudinal as well as latitudinal rows. As can be seen, the row designated as **2** is offset approximately ½ the distance between centers of adjacent sliver sections **10** to the left of row **1**. Row **3** is similarly offset ½ the center distance to the right of row **2**. Row **4** is then offset ½ the center distance to the left of row **3**. Row **5** is offset ½ the center distance to the right of row **4**. The positioning of row **6** with reference to row **5** is the same as the positioning of row **2** in reference to row **1**.

FIGURES 7 and 8 illustrate alternative means that can be used to hold the sliver sections of parallelized crimped fibrous elements in the mold. In FIGURE 7, the parallelized crimped fibrous elements are retained in an upright position in mold **22** by card clothing **50**, the bottom of the mold being corrugated, as shown by numeral **52**, to prevent the sliver sections from slipping. In FIGURE 8, rake **60** holds the parallelized crimped fibrous elements in mold **22**.

One typical operation is described hereinafter. Crimped staple fibers are processed by conventional means on a worsted card, which in turn is gathered into the form of a bulky sliver composed of a plurality of generally parallelized crimped fibers. A typical bulky sliver may have a weight of 200 grains per yard. In order to form a block of slivers in a mold, a creel is set up to provide the desired number of slivers. The slivers are then fed forward horizontally and are arranged in a parallel spaced relationship to each other so as to curve about a feed roll and then descend in the form similar to a waterfall vertically into the cavity of a horizontal mold. The mold is equipped with a chain drive to move the mold gradually in a horizontal direction away from the sliver feed as subsequent rows of sliver sections are packed into the mold. When the proper length of slivers has been advanced into the mold, the sliver is cut and the ram moves forward horizontally to place and compress the row of slivers in the mold. Between each stroke of the ram the feed roll is laterally displaced a distance approximately ½ the distance between centers of adjacent sliver sections. The feed roll is preferably mounted on a spline and the lateral movement can be conveniently accomplished by means of an air cylinder. As each row is packed into the mold, the mold is moved away from the ram horizontally a distance equivalent to the uncompressed sliver diameter. Packing is continued until a sufficient number of parallel staggered rows of sliver have been packed into the mold. The collapsing mold then biaxially compresses the block to the desired final density. This can be accomplished by any suitable means such as, for example, pneumatic cylinders adapted to compress the sides of the mold.

The mold of parallelized crimped fibrous elements are then transferred to a dipping tank containing a solution of resinous binder dissolved in a solvent and the mold is immersed completely so as to impregnate all three dimensions of the porous fibrous block with the binder solution. The mold is then raised from the dipping tank and allowed to drain, preferably at a 45° angle, so that all excess binder drains from the block by gravity. The mold is then placed in an oven which has hot air circulating through the interstices of the porous fibrous block in order to evaporate the remaining solvent and cure and/or solidify the resinous binder depending upon whether the resin is thermosetting or thermoplastic. The dry bonded fiber block is then removed from the mold and at this stage is self-supporting. This block may then be sliced with a sharp knife in a direction transverse to the fiber orientation to produce a thin porous flexible self-supporting sheet of appropriate thickness. This thin fibrous sheeting may then be attached to a backing, such as a woven scrim fabric, by spraying a thin layer of a suitable adhesive over the face of the sheet and then pressing the sheet to the scrim fabric to secure the two together.

The bulky fibrous elements for use as feed material to the mold are preferably in the form of relatively open slivers condensed from standard carded webs of crimped staple fibers. However, in place of these relatively open slivers there may be used other bulky relatively open forms of staple fibers and/or continuous filaments which have been gathered together in parallelized relationship, such as wound sliver batts, rolled webs, tow and the like. The bulky fibrous element should be composed of a multiplicity of fibers or filaments which have a large number of touching or interference points and it is recognized there will be a greater number of contact points as the fibers are crimped, even though they have been directionalized or parallelized or aligned in essentially the same direction.

The staple fibers or continuous filaments for preparing the bulky sliver elements may be composed of a number of different compositions, for example, the fibrous material may be made of synthetic organic polymeric composition such as polyamides, e.g., poly(hexamethylene adipamide), poly(metaphenylene isophthalamide), poly(hexamethylene sebacamide), polybenzimidazole, polycaproamide, copolyamides and irradiation grafted polyamides, polyesters and copolyesters, such as condensation products of ethylene glycol with terephthalic/isophthalic acids, ethylene glycol with a 98/2 mixture (by weight) of terephthalic/5-(sodium sulfo)-isophthalic acids, and trans-p-hexahydroxylylene glycol with terephthalic acid, self-elongating ethylene terephthalate polymers, polyacrylonitrile, copolymers of acrylonitrile with other monomers such as vinyl acetate, vinyl chloride, methyl acrylate, vinyl pyridine, sodium styrene sulfonate, terpolymers of acrylonitrile/methylacrylate/sodium styrene sulfonate prepared in accordance with U.S. Patent No. 2,837,501, vinyl and vinylidene polymers and copolymers, polycarbonates, polyacetals, polyethers, polyurethanes such as segmented polymers described in U.S. Patent Nos. 2,957,-852 and 2,929,804, polyesteramides, polysulfonamides, polyethylenes, polypropylenes, fluorinated and/or chlorinated ethylene polymers and copolymers (e.g., polytetrafluoroethylene, polytrifluorochloroethylene), certain cellulose derivatives, such as cellulose acetate, cellulose triacetate, composite filaments such as, for example, a sheath of polyamide around a core of polyester as described in U.S. Patent No. 3,038,236 and self-crimped composite filaments, such as, two acrylonitrile polymers differing in ionizable group content cospun side-by-side as described in U.S. Patent No. 3,038,237 and the like. Mixtures of synthetic organic polymer fibers with natural fibers such as regenerated cellulose, cotton, wool, mohair and the like can often be used to advantage. Blends of two or more synthetic organic fibers, may also be employed in making the feed sliver used herein.

The fibers or filaments should be crimped so as to provide maximum interference with each other upon packing in the mold. The crimp may be a regular zigzag or stuffer box crimp or a three-dimensional crimp. Typical examples of suitable three-dimensionally crimped fibers include the random curvilinear described in Belgian Patent No. 573,-230, the helical crimp described in U.S. Patent No. 3,050,-821, and the S-type crimp described in U.S. Patent No. 3,038,237. The denier of the fibers may vary from about 1 to 50 denier per filament. The fibers used as raw material, in addition to being crimped, such as by mechanical, chemical, heat or steaming methods, may also be selected to have one or more different cross-sections, such as round, trilobal (e.g., U.S. Patent No. 2,939,201 or U.S. Patent No. 2,939,202), tetralobal, and the like, or they may be selected to have one or more variations in denier along the lengths of mixtures of different lengths.

The individual bulky fibrous elements such as slivers, used in this invention may be identical, or they may be selected to have two or more different colors, different deniers, or weights, or other variations from one bulky element to another in order to build either specific repetitive designs or other variations into the block, or on the other hand to place designs or other variations in a completely random pattern in the block. In other words, the present process is particularly advantageous for creating

a wide variety of different styles in building the fibrous blocks, which in turn is useful for producing sheets and laminated pile fabrics in different styles of color, design and the like.

Normally a resinous binder will be useful for attaching the fibers together within the block. This binder composition may be chosen to be either soluble or insoluble and it may be thermoplastic or thermosetting. Suitable organic-soluble binders include natural rubber or synthetic elastomers (e.g., chloroprene, butadiene-styrene copolymers, butadiene-acrylonitrile copolymers), which may be used in the form of a latex dispersion or emulsion or in the form of a solution, vinyl acetate polymers and copolymers, acrylic polymers and copolymers such as ethyl acrylate, methyl acrylate, butyl acrylate, methyl methacrylate, acrylic acid/acrylic and methacrylic ester copolymers, cellulose nitrate, cellulose acetate, cellulose triacetate, poyester resins such as ethylene terephthalate/ethylene isophthalate copolymers, polyurethanes such as the polymer from piperazine and ethylene bis-chloroformate, polyamide polymers and copolymers, methoxymethyl polyamides, vinyl chloride polymers and copolymers such as vinyl chloride/vinylidene chloride copolymer latices. Alcohol soluble polyamide resins are also suitable organic-soluble binders. Suitable water-soluble binders include materials such as polyvinyl alcohol, sodium alginate, acrylic acid polymers and copolymers such as polyacrylic acid, carboxymethyl cellulose, hydroxyethyl cellulose, dextrins, animal glue, soybean glue and sodium silicate. Suitable binders which are insoluble in organic solvents include polytetrafluoroethylene and urea-formaldehyde resin latices.

Additional suitable binder compositions include chlorosulfonated polyethylene; butyl rubbers, such as isobutylene/isoprene copolymers; polyhydrocarbons, such as polyethylene, polypropylene and the like and copolymers thereof; high molecular weight polyethylene glycols sold under the trade name of Polyox; epoxide resins, such as the diepoxide of bisphenols; polystyrene; alkyd resins, such as polyesters of glycerol with phthalic or maleic acid; polyester resins such as from propylene glycol-maleic anhydride-styrene; phenol-formaldehyde resins; resorcinol-formaldehyde resins; polyvinyl acetals, such as polyvinyl butyral and polyvinyl formal; polyvinyl ethers, such as polyvinyl isobutyl ether; starch, zein, casein, gelatine, methyl cellulose, ethyl cellulose, polyvinyl fluoride, natural gums, polyisobutylene, shellac, terpene resins and rosin soaps. Segmented polymers, such as spandex polymers, polyether amides, polyether urethanes (e.g., those in U.S. Patent No. 2,929,800) and polyester/urethanes are also suitable.

The binder composition may be applied to the fibers by means of dipping, spraying, and other known means provided the binder composition is used sparingly to attach fibers together at spaced contact points throughout the three dimensions of the block. In place of using resinous binders for attachment of fibers there may be used fiber solvents or partial solvents for point welding the fibers together, various heating means such as ultra-high frequency may be used to point weld the fiber together, as well as other known methods, for example, including a binder fiber of lower softening point than the structural fiber within the feed material to the block, and then heating the block to soften the binder fiber and attach the structural fibers together at a temperature above the softening point of the binder fiber, but below the softening point of the structural fiber.

The following example is illustrative of the invention but not in limitation thereof. All parts and percentages are by weight unless otherwise indicated.

EXAMPLE I

A fiber blend of polyethylene terephthalate fibers, composed of 60 parts of 4 denier per filament, 2 inch long staple fibers having a three-dimensional curvilinear crimp and 40 parts of 1.5 denier per filament, 1.5 inch long staple fibers having a stuffer-box type of crimp, were carded into a web which was sprayed uniformly with a fine mist of a solution of 2.5 weight percent of binder coposition dissolved in methylene chloride. The binder composition was a copolyester of ethylene terephthalate/ethylene isophthalate (79/21 molar ratio) having a relative viscosity of 29. The sprayed web after evaporation of the solvent was found to contain 10% copolyester binder by weight. The sprayed web was recarded and then fed to a doffing cylinder which was 30 inches in diameter and 60 inches long. The doffing cylinder was taped the full width with a commercial polytetrafluoroethylene tape which had a pressure-sensitive adhesive on one side and was 2 inches wide. Three sections of the periphery of the doffing cylinder were covered with the plastic tape in order to separate three separate sections of carded web each measuring 60 inches by 24 inches, so that the three web sections could be removed for each complete rotation of the doffer cylinder. The fiber direction was along the 24 inch dimension of the card web. Each web section, weighing 250 grains per yard, containing essentially uniform density throughout the dimensions of the web, was rolled into a sliver measuring approximately 24 inches long in the direction of the fiber orientation and 3 inches in diameter. This rolled sliver was cut into four sections perpendicular to the fiber directions to make smaller rolled slivers measuring 6 inches long and 3 inches in diameter. Each sliver had essentially uniform fiber density along the length of the slivers, as well as through the diameter of the slivers. The 6 inch by 3 inch rolled slivers were fed to two different steel molds, A and B.

Preparation of Block A

The mold for Block A measured 18 inches by 68 inches by 6 inches deep and was built with overlapping and removable sides around the width and length dimensions so that either one dimension or both dimensions could be compressed if desired as illustrated in FIGURES 4 and 5. The rolled slivers were fed to mold A so as to stand vertically in the 6 inch deep dimension with the fiber orientation in the vertical direction. The slivers were hand packed in the mold in staggered rows as illustrated by the pattern shown in FIGURE 6. The initial fiber density of the sliver before packing was approximately 0.23 pound per cubic foot. After the mold was filled with slivers, the mold was closed and compression was applied in a direction perpendicular to the fiber orientation and parallel to the two sides of the mold measuring 68 inches in order to compress the slivers in the block from 68 inches down to 18 inches and produce a block measuring 18 inches in width and 18 inches in length. This compression in one dimension of the block to a final fiber density of 0.88 pound per cubic foot amounted to a compression ratio of approximately 3.8. The compressed block was heated in an oven at 425° F. (218° C.) for 5 minutes in order to fuse the copolyester binder particles on the fibers and bond together the fiber network to form a porous, bonded fiber block.

Preparation of Block B

The same type of mold as used in the preparation of Block A was built to measure 51 inches by 34 inches by 6 inches deep. The rolled slivers prepared in essentially the same manner as described for Block A and measuring 6 inches long in the fiber direction and 3 inches in diameter had an initial fiber desity before packing in the mold of approximately 0.18 pound per cubic foot. The mold was packed with these slivers standing vertically in the mold in the same manner as described above in staggered rows as shown in FIGURE 6. When the mold was filled and closed compression was applied perpendicular to the fiber direction and parallel to the sides of the mold measuring 34 inches in order to compress this dimension to 18 inches. At this stage the fiber density of the block was 0.34 pound per cubic foot. Then compression was applied

perpendicular to the fiber direction and parallel to the sides of the block measuring 51 inches in order to compress this dimension to 18 inches. This additional step of compression in a second direction increased the fiber density of the block from 0.34 to 0.95 pound per cubic foot. The block which had been compressed in two different directions was heated in an oven under the same conditions as hereinbefore described for Block A in order to fuse the binder particles and produce a porous, bonded fiber block.

Blocks A and B were removed from their respective molds and thin fiber sheets were cut using a band knife slitter perpendicular to the fiber direction to produce sheets 0.156 inch thick. Thin sheets A and B were placed against a black background and the surface uniformity of the two sheets was visually compared. Sheet B showed a highly uniform surface having acceptable uniformity with no visible individual slivers, no visible voids, and no visible high density lines or patterns of high and low density. Therefore, sheet B was judged as having very acceptable uniformity. Sheet A showed no visible individual slivers and no visible voids, with scarcely any gross areas of high and low fiber density. However, sheet A had one nonuniformity which made it unacceptable for many applications in that it exhibited lines of high fiber density running in one direction of the sheet, which indicated that the block density or compression ratio was too high for only one-way compression.

Although the description has hereinbefore been restricted to sources of sliver of indefinite length, it should be obvious that it is not necessary to supply continuous length sliver. The sliver could conveniently be cut to the desired length before it is forwarded to the mold. Also, carded web sections of a finite length having the fibers oriented predominantly in one direction could be formed into a rolled sliver by directing one longitudinal edge of the carded web section upwardly, contacting the upwardly directed longitudinal edge to roll the web section upon itself while meanwhile vibrating the web section throughout the rolling in a direction substantially perpendicular to the axis of hte rolling web section.

A typical sized porous block for use in the process to produce, a full-size blanket for example, would be one measuring 94 inches x 112 inches x 18 inches. The 18 inch dimension is in the direction of fiber alignment.

With respect to the density, the fibrous block can be packed initially to a relatively low density, i.e., in the range of from about 0.10 pound per cubic foot to about 1.0 pound per cubic foot. The exact initial sliver section density depends upon the end-use density that is required.

The sequence in which the fibrous block is compressed to the final density is not critical. It is generally preferred to first compress in the direction in which the rows of sliver sections were packed and then compressing in a transverse direction. However, these compression steps can be reversed or done simultaneously if desired. The sole criteria are that the compression ratio be maintained within the proper range and that each compression step must provide at least 25% of the increase in density.

As hereinbefore explained, it is preferred to stagger adjacent rows approximately ½ the distance between centers of adjacent sliver sections. However, the particular pattern utilized to accomplish the staggering of adjacent rows is not critical. The sole criteria is that adjacent rows of sliver sections be in fact staggered, i.e., that adjacent rows are not directly aligned. It should also be apparent that, although adjacent rows of sliver sections are staggered in a direction transverse to the usual direction of packing, the effect is to create a staggered relationship

with respect to both the longitudinal and latitudinal dimensions. Moreover, although the embodiment illustrated used an air cylinder to laterally index the feed roll, it should be obvious that this can be accomplished by any convenient means. For example, the mold could be laterally displaced to effect a staggering between adjacent rows.

The present invention provides a useful process for the preparation of porous self-supporting bonded fibrous blocks of different shapes and sizes, in which parallelized crimped fibers are attached at a plurality of contact points throughout the three dimensions of the porous block. These porous blocks are useful in preparing self-supporting sheet materials by slicing various thicknesses of sheets transversely to the direction of fiber orientation in the porous block. The self-supporting sheet materials in turn can advantageously be utilized for laminating to various backing materials to produce a wide variety of products such as pile fabrics, blankets, apparel fabrics, robes, bedspreads, bath mats, garment innerlinings, pile outerwear fabrics, carpets, cleaning and polishing materials, liquid and gas filters, weather stripping, sound, thermal and electrical insulation, and the like.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not to be limited except to the extent defined in the following claims.

We claim:

1. In a process for preparing porous, bonded fibrous blocks by packing parallel rows of bulky fibrous elements each having a fiber orientation predominantly in the longitudinal direction of the bulky fibrous elements to form a fibrous body and attaching the fibrous body at spaced contact points throughout the three dimensions of the fibrous body, the improvement which comprises packing each adjacent row of bulky fibrous elements in a staggered relationship to form a fibrous body of relatively low density and thereafter compressing said fibrous body at least along an axis substantially perpendicular to said parallel rows of bulky fibrous elements with a compression ratio in the range of from about 2.0 to about 8.0 and to a final density in the range of from about 0.2 pound per cubic foot to about 5.0 pounds per cubic foot, with the proviso that when the final density is in the range of from about 0.5 pound per cubic foot to about 5.0 pounds per cubic foot, the compression ratio is in the range of from about 3.5 to about 8.0 and said fibrous body is biaxially compressed.

2. In a process for preparing porous, bonded fibrous blocks by packing parallel rows of sliver sections each having a fiber orientation predominantly in the longitudinal direction of the sliver sections to form a fibrous body and attaching the fibrous body at spaced contact points throughout the three dimensions of the fibrous body, the improvement which comprises packing each adjacent row of sliver sections in a staggered relationship to form a fibrous body of relatively low density and thereafter biaxially compressing said fibrous body with a compression ratio in the range of from about 3.5 to about 8.0 to a final density in the range of from about 0.5 pound per cubic foot to about 5.0 pounds per cubic foot.

3. The process of claim 2 wherein the staggered relationship is such that said adjacent rows are offset with respect to each other a distance of approximately ½ the distance between centers of adjacent sliver sections.

No references cited.

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