

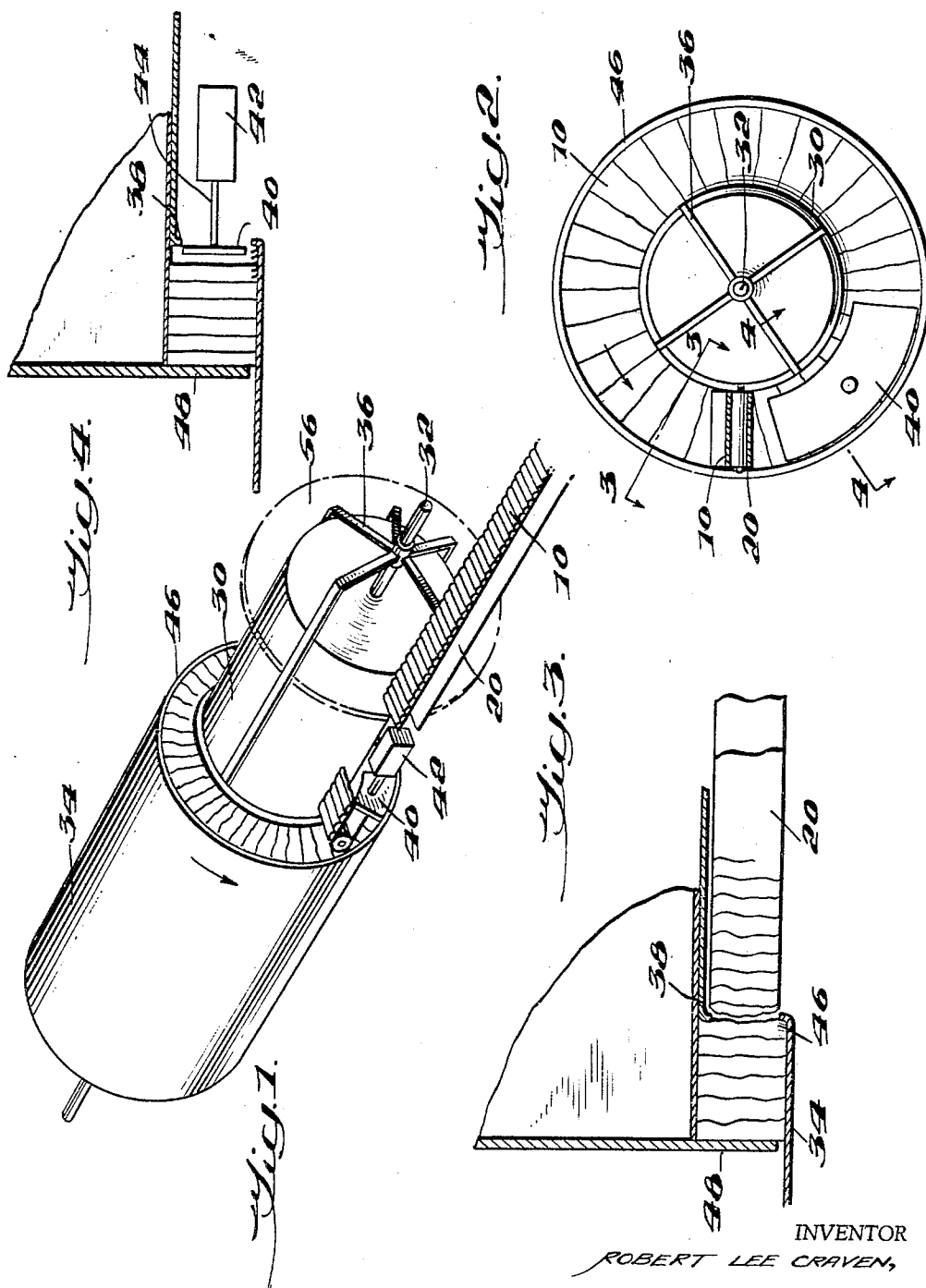
Dec. 23, 1969

R. L. CRAVEN
METHOD AND APPARATUS FOR FORMING A FIBER
PACK FROM BULKY FIBROUS ELEMENTS

3,485,693

Filed July 2, 1968

2 Sheets-Sheet 1



BY Gordon R. Coons

AGENT

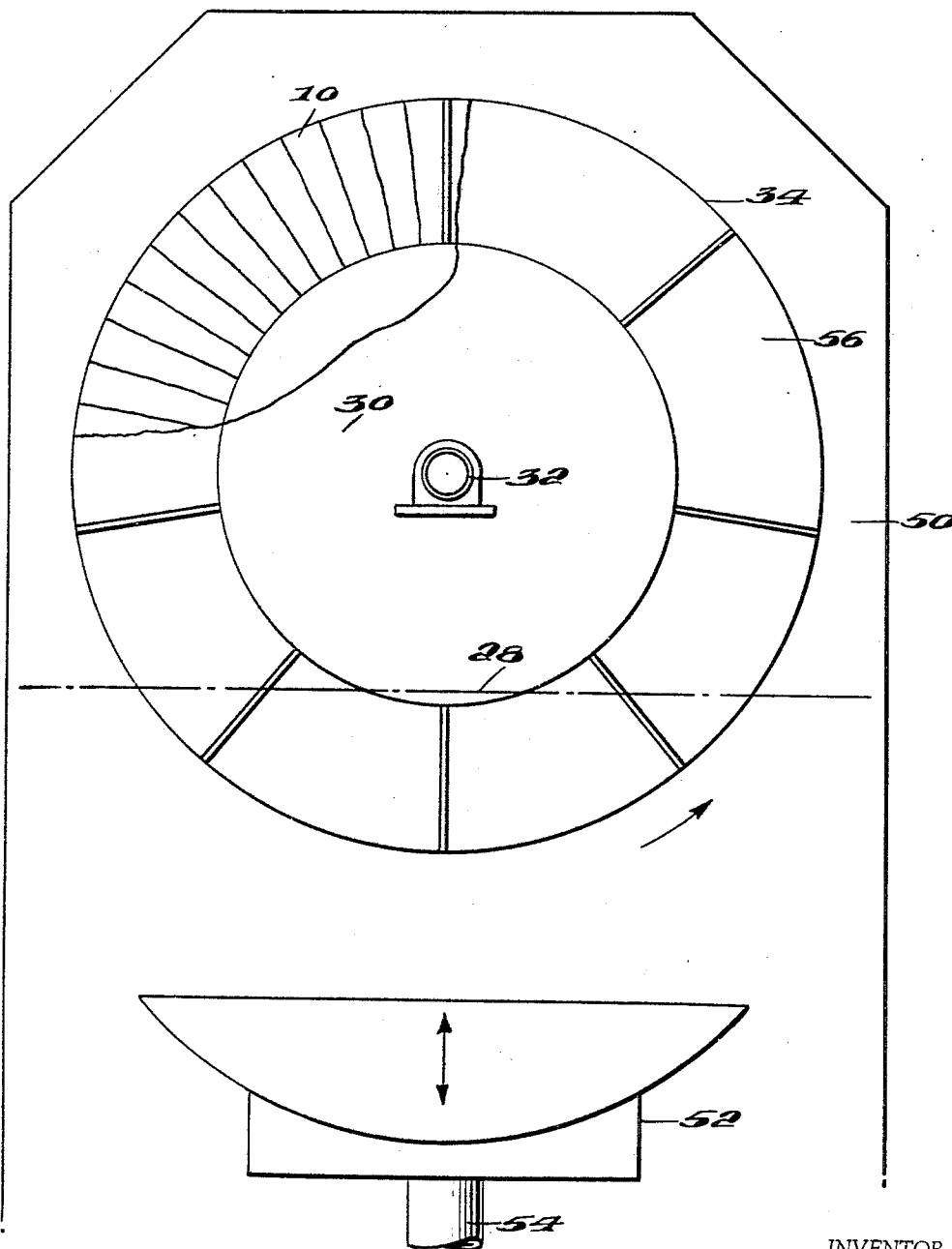
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Fig. 5.

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3,485,693

METHOD AND APPARATUS FOR FORMING A FIBER PACK FROM BULKY FIBROUS ELEMENTS

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Continuation-in-part of abandoned application Ser. No. 454,301, May 10, 1965. This application July 2, 1968, Ser. No. 742,976

Int. Cl. D04h 1/58, 1/70

U.S. Cl. 156—175

11 Claims

ABSTRACT OF THE DISCLOSURE

A self-supporting annular pack of parallelized, crimped, bonded fibers positioned radially with respect to the axis of the annulus is produced by positioning the fibers in a rotating receiving member which holds the fibers in an annular space to form indexed rows of the fibers, and thereafter bonding the fibers. The fiber pack can be cut to form seamless self-supporting fiber sheet material, which has numerous use, e.g., as blankets and apparel linings.

This application is a continuation-in-part of my co-pending application Ser. No. 454,301, filed May 10, 1965, now abandoned.

This invention relates to a self-supporting fiber pack and to a process and apparatus for producing such a fiber pack.

U.S. Patent No. 3,085,922 discloses certain porous self-supporting sheet material composed of parallelized crimped fibers attached to each other and to a novel process for producing this sheet material. However, when commercial yardages of a large size sheet are to be prepared, it is necessary to piece, bond or otherwise attach several sheets together either in the transverse or longitudinal direction. Such piecing together results in visible seams or weld joints in the final fabric.

Accordingly, an object of this invention is to provide a self-supporting fiber pack which can be utilized to produce continuous commercial yardages of seamless self-supporting fiber sheet material. Another object is to provide a method and means for producing a self-supporting fiber pack. Other objects will appear hereinafter.

The objects of this invention are accomplished by providing a self-supporting fiber pack which comprises an annulus of parallelized crimped fibers positioned normally with respect to the longitudinal axis of said annulus, said fibers being attached at a plurality of contact points substantially uniformly spaced throughout the three dimensions of said annulus, the density of said fibers in the longitudinal direction of said annulus being substantially constant and the density in the radial direction decreasing gradually towards the periphery of said annulus by no greater than about 25%. It is preferred for many uses that the fiber density be substantially constant or decrease gradually in a radial direction towards the periphery of said annulus by an amount no greater than about 10% (i.e., 0 to about 10%). Preferably, the attachment between fibers in the self-supporting fiber pack is in the form of a polymeric binder.

The term "substantially uniformly spaced" is merely means to define a spacing such that there are no localized areas of contact points which would result in visible seams or weld joints.

The term "self-supporting" is used to characterize the fiber pack's ability to maintain its integrity while being worked. In other words, the fiber pack maintains its points of fiber attachment and does not disintegrate e.g. while

being cut into the form of thin sheets, which similarly are self-supporting.

The novel apparatus for forming the fiber pack from bulky fibrous elements comprises, in general, a rotatable receiving means comprising an outer shell and a cylindrical core member, said outer shell and said cylindrical core member defining an annular space, said outer shell and said cylindrical core member having holding means positioned to receive the ends of said bulky fibrous elements, means rotating said receiving means, feeding means positioning finite bulky fibrous elements of parallelized fibers having orientation predominantly in one direction in the annular space with the fiber orientation being normal to the core member, the feeding means being adapted to position said bulky fibrous elements in timed relationship with said rotating receiving means to form a row of said elements about the periphery of the core member when the rotating receiving means has completed one revolution and means indexing the row of bulky fibrous elements in the annular space a predetermined distance as the receiving means makes one revolution. In the preferred embodiment, the means indexing the row of bulky fibrous elements continuously indexes so that the predetermined distance is reached simultaneously with the completion of a row.

The novel method for forming the fiber pack from bulky fibrous elements comprises, in general, providing a receiving member having an outer shell and a cylindrical core member which define an annular space, said outer shell and said cylindrical core member having holding means positioned to receive the ends of said bulky fibrous elements, rotating the receiving member, positioning bulky fibrous elements of parallelized fibers having orientation predominantly in one direction in the annular space with the fiber orientation being normal to the axis of the core, in timed relationship with the rotating receiving member to form a row of the bulky fibrous elements about the periphery of the core member when the rotating receiving member has completed one revolution and indexing the row of elements in the annular space a predetermined distance as the receiving member makes one revolution. To make the fiber pack self-supporting, the parallelized fibers are bonded, as hereinafter described, at a plurality of contact points throughout the three dimensions of the annulus.

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

FIGURE 1 is a perspective view of one embodiment of this invention,

FIGURE 2 is a front elevational view of the embodiment shown in FIGURE 1,

FIGURE 3 is a cross-sectional view taken along lines 3—3 of FIGURE 2,

FIGURE 4 is a cross-sectional view taken along lines 4—4 of FIGURE 2, and

FIGURE 5 is a schematic front elevation of the fiber pack after it has been packed in the embodiment of FIGURE 1, and is ready for application of binder.

Referring to FIGURES 1 and 2, there is shown a perspective view of one embodiment of this invention. Sliver 10 from a supply source not shown is forwarded by means of feed conveyor 20. Positioned adjacent feed conveyor 20, upon which slivers 10 are forwarded, is cylindrical core 30 which has a perforated surface and is mounted on axis roll 32. Perforated outer shell 34 is positioned concentric with cylindrical core 30 to form an annular space for receiving slivers 10. Cylindrical core 30 and perforated outer shell 34 are driven by a synchronous motor, not shown, so that there will be no relative rotation between the two. Support arms 36 are

connected to axis roll 32 and support flange 38. Ram 40 is positioned adjacent the annular space defined by the area between perforated outer shell 34 and cylindrical core 30 and is adapted to pack slivers 10 into the annular space. Pneumatic cylinder 42 is connected to ram 40 by means of connecting arm 44 to provide the motive force for ram 40. Referring to FIGURE 3, flange 38 serves to retain slivers 10 in a normal position with respect to cylindrical core 30. Also, holding means (not shown), such as card clothing is disposed around the periphery of cylindrical core 30 to retain slivers 10 in a normal position. Similarly, card clothing ring 46 is disposed inside the inner surface of perforated outer shell 34 to maintain the relative position of the outer ends of slivers 10. End flange 48 serves as a back support member while the fiber pack is being formed. FIGURE 4 illustrates a forward position of ram 40.

FIGURE 5 schematically illustrates one embodiment of apparatus suitable for applying the binder solution to the pack by a dipping operation and then heating to evaporate the solvent and bond the fibers in the pack. Referring to FIGURE 5, a section of the end flange 56 has been removed to expose the radial placement of slivers 10. To apply the binder solution by dipping, tank 52 is raised into position by ram 54. Binder solution is then pumped slowly into the tank 52. A suitable level for the solution is indicated by line 28. The pack is rotated slowly through one revolution and the solution then pumped out of tank 52. The tank is then lowered to its original position. The pack continues to rotate. The doors (not shown) of enclosure 50 are then closed and air is blown into the center of axis roll 32 and out through the pack radially and then exhausted from enclosure 50. The heating is continued to evaporate the solvent, heat the pack to bonding temperature and maintain the pack at temperature to complete the bonding. The hot air is then stopped, and cooling air is blown through the pack to cool it to permit a subsequent cutting operation. The doors of enclosure 50 are folded back, the end flanges 56, and 48 and the outer shell 34 are removed. The pack is now self-supporting and ready for cutting into continuous sheets of any desired thickness.

The operation of one embodiment of this invention is as follows. The parallelized fibers, preferably in the form of a sliver, are conveyed to the annular space defined by the area between the cylindrical core and the concentric outer shell. As each sliver is positioned, it becomes attached to the card clothing which forms a ring around the cylindrical core with a diameter equal to that of the cylindrical core plus the length of the sliver. Also the surface of the cylinder is covered with metallic card clothing of large teeth on 0.5 inch centers which holds the bottom of the sliver. Thus the sliver is positioned in the annular space normally with respect to the axis of the cylindrical core. The reciprocating ram disposed below and adjacent the feed conveyor completes the positioning of the sliver behind the card clothing ring and the card clothing on the core. As the slivers are being positioned, the core rotates thereby placing successive slivers adjacent to each other and normally with respect to the cylindrical core, thereby forming a row. After one complete revolution, the feed conveyor and the outer shell are indexed longitudinally along the cylindrical core an amount equal to the compressed thickness of the layer of sliver. Packing is continued in this manner until the surface of the cylindrical core is surrounded by fibers having the desired fiber density. In a preferred embodiment, the longitudinal indexing is done in timed relationship with the formation of the sliver row so that the completion of the row coincides with the completion of the desired longitudinal indexing. Due to the rotation of the cylindrical core and the longitudinal indexing, the slivers are positioned around the periphery of the cylindrical core in the form of a helix. The pitch of the helix is dependent upon such factors as the fiber density desired for the pack

and the number, size and fiber density of the slivers. After the ram completes the positioning, the helical arrangement is not noticeable. A segment of an end flange at the feed end is installed with the outer edge being behind the card clothing ring. Each of the segments is installed and the ring of the card clothing and the feed conveyor are then withdrawn. The outer shell is then fastened into position and the fiber pack is then ready for application of the binder solution. As shown in FIGURE 5, the tank for the binder solution is raised into position and filled with sufficient binder solution to cover the slivers positioned in the annular space on the bottom of part of the cylindrical core. The door of the enclosure is shut and the exhaust fan started. The fiber pack is then rotated at an exterior surface speed which is generally in the range of from about 12 to about 24 inches per minute, the exact speed being that required by the diameter-thickness ratio (i.e., the ratio between the diameter of the cylindrical core and the thickness of the annulus). After one revolution, the excess binder solution is pumped to a storage container and the tank lowered to its original position. With the fiber pack rotating, heated air or inert gas is blown into the center of the cylindrical core and out radially through the fiber pack to remove the solvent and heat the pack to bond the fibers. After sufficient time, the heat is removed, and air at room temperature is blown through the pack for a few minutes to cool it sufficiently for further processing. The doors of the enclosure are then opened and folded out of the way. The external shell and the end flanges are then removed and the bonded fiber pack is now self-supporting. Although the cylindrical core may also be removed, it is preferred not to do so, in that the core aids in the maintenance of the annular shape of the fiber pack, which is particularly desirable in larger packs. Relatively large (e.g., 30 ft., outside diameter, 28 ft., inside diameter) fiber packs, although self-supporting (as defined previously), may require external support to maintain their annular shape, e.g., while being cut. To form self-supporting sheets of any desired thickness, a band knife cutter can then be positioned against the outside surface of the pack and locked in position. The cylindrical core and the pack can then be rotated while the cutter continuously moves in toward the core as the wafer (self-supporting sheet) is cut continuously from the self-supporting fiber pack. Generally, the speed should be proportional to the rotation of the pack. As the wafer is cut, it can be conveyed to a wind-up station for accumulation on a roll.

In an alternative embodiment of this invention the binder may be sprayed onto carded webs of the fibers before forming the slivers. It is then unnecessary to use the step of dipping the formed pack in binder solution as described above. After forming the pack in the alternative embodiment, it is then heated to activate the binder and bond the fibers, and then cooled for the cutting process.

When it is desired to produce a fiber pack wherein the outer shell diameter exceeds the cylindrical core diameter by more than about 10%, sliver batts composed of rolled slivers or other forms of slivers having a variable longitudinal fiber density from one end of the sliver to the other are normally utilized as the starting material in order to produce packs of substantially constant fiber density and, correspondingly, self-supporting sheet materials of acceptable density uniformity. Such starting materials can be made by cutting a carded web in a zigzag fashion to form physically tapered web sections. A rolled sliver having a variable longitudinal fiber density (i.e., a density varying from one end to the other in the direction of fiber orientation) can then be formed by forwarding the physically tapered web sections in the direction of fiber orientation, directing on longitudinal edge of the physically tapered web section upwardly, contacting the upwardly directed longitudinal edge to roll the physically tapered web section upon itself and vibrat-

ing the physically tapered web section throughout the rolling in a direction substantially perpendicular to the axis of the rolling tapered web section.

When the outer shell diameter does not exceed the cylindrical core diameter by more than 10% the bulky fibrous elements, such as sliver batts, will normally have a uniform longitudinal fiber density from one end of the element to the other.

The fibers used to prepare the self-supporting fiber pack may be provided in a number of different forms of bulky fibrous elements. For example, carded webs, sliver, sliver batts, roving, tow, yarns and the like may be advantageously utilized. It is preferred to have the bulky fibrous elements in the form of slivers or sliver batts. They may be staple fibers of any desired length (e.g., 1.5 to 3 inches) or continuous filaments cut to equal lengths, dependent upon the desired size of the fiber pack. Regardless of the form of the fibers, they should be aligned substantially in the same direction and should be in units of the same length, either singly or collectively. In addition, the fibers should be crimped so as to provide maximum interference with each other upon packing. The crimp may be a regular zigzag or stuffer-box crimp or a three-dimensional crimp or blends of different crimps. Typical examples of suitable three-dimensionally crimped fibers include the random curvilinear described in Belgian Patent No. 573,230, the helical crimp described in Kilian, U.S. Patent No. 3,050,821 and the S-type crimp described in Taylor, 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 be bulked or unbulkied or drawn or undrawn. As hereinbefore described, another variation in the fiber raw material being fed to the fiber pack apparatus is the degree of uniformity of fiber weight from one end to the other of the length of the fibers being fed. If fibers of uniform denier or groups of fibers such as sliver whose fiber weight is substantially constant from one end of the sliver to the other is fed to the annular space, the fiber pack produced will contain a fiber density variation, and the continuous sheeting sliced from that pack will likewise contain a fiber density variation which is proportional to the ratio of the outside diameter to the inside diameter of the pack. It is preferred in the present invention to prepare the pack from sliver or other units of fiber whose fiber weight varies from one end to the other of the length of the unit such that said variation is the same as the ratio of the outside and inside diameters of the pack. This preferred fiber feed material will produce a pack and continuous sheeting cut therefrom having a uniform fiber density throughout.

A variety of different fibrous materials may be used as the feed material in making the self-supporting fiber pack of this invention. Typical of the fibers and filaments which may be employed are those made of polyamides, such as poly(hexamethylene adipamide), poly(metaphenylene isophthalamide), poly(hexamethylene sebacamide), polybenzimidazole, polycaprolactam, copolyamides and irradiation grafted polyamides, polyesters including homo- and co-polyesters such as condensation products of ethylene glycol with terephthalic/isophthalic acids, ethylene glycol with a 98/2 mixture of terephthalic/5-(sodium sulfo)isophthalic acids, and trans-p-hexahydroxylylene glycol with terephthalic acid, self-elongating ethyleneterephthalate polymers, polymerized hydroxypivalic acid as described in U.S. Patent 2,658,055, polyacrylics including polyacrylonitrile and 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 made in accordance with U.S. Patent 2,837,501, vinyl and vinylidene polymers and copolymers (e.g., vinyl chloride, vinylidene chloride, vinyl chloride/acetate copolymers), polycar-

bonates, polyacetals, polyethers, polyurethanes such as segmented polymers described in U.S. Patents Nos. 2,957,852 and 2,929,804, polyesteramides, polysulfonamides, polyethylenes, polypropylenes, fluorinated and/or chlorinated ethylene polymers and copolymers (e.g., polytetrafluoroethylene, polytrifluorochloroethylene), cellulose derivatives such as cellulose acetate, cellulose triacetate, ethyl cellulose, regenerated cellulose, composite filaments such as, for example, a sheath of polyamide around a core of polyester as described in U.S. Patent 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, cotton, wool, mohair, asbestos, glass, metal, ceramic and the like. Mixtures or blends of synthetic fibers with natural fibers may also be advantageously utilized for some applications. Blends of two or more synthetic organic fibers may likewise be utilized.

Normally a resinous binder will be useful for attaching the fibers together within the fiber pack. 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 those of ethyl acrylate, methyl acrylate, butyl acrylate, methyl methacrylate, acrylic acid/acrylic and methacrylic ester copolymers, cellulose nitrate, cellulose acetate, cellulose triacetate, polyester 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, dextrans, animal glue, soybean glue and sodium silicate. Suitable binders which are insoluble in organic solvents include polytetrafluoroethylene and ureaformaldehyde resins.

Additional suitable binder compositions include chlorosulfonated polyethylene; butyl rubbers, such as isobutylene/isoprene copolymers; polyhydrocarbons, such as polyethylene, polypropylene, and copolymers thereof; high molecular weight polyethylene glycols sold under the trade name of Polyox; epoxide resins; 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 selected for attaching the fibers together within the pack may be either permanent or fugitive. Thus, if the pack is to be used to prepare thin fibrous sheeting and laminates thereof to a stable backing material, the binder composition used for preparing the pack may be chosen so that it can be washed out of the pile layer after the fibrous sheeting is adhered to a permanent backing material. These products from which the binder has been removed from the pile layer are useful as artificial furs. One particularly suitable binder composition which is fugitive for the above purposes is a co-

polymer of methacrylic acid with other polymerizable monomer, as well as the sodium salt thereof. These polymeric binders are interchangeably soluble in organic media, such as trichloroethylene and in aqueous media.

The following examples will serve to illustrate the invention but are not intended to be in limitation thereof.

EXAMPLE I

A fiber pack was prepared starting with a blend of crimped staple fibers of polyethylene terephthalate. The blend was composed of 60 parts of 4 denier per filament, 2 inch (5.1 cm.) long staple fibers having a three-dimensional curvilinear crimp and 40 parts of 1.5 denier per filament, 1.5 inch (3.81 cm.) long staple fibers having a stuffer-box type of crimp, the blend being carded to form a 250 grains per yard (17.7 gm./m.) sliver. The sliver was cut into uniform 6 inch (15.2 cm.) long segments. The sliver segments were hand packed in parallelized relationship around the outer surface of the cylindrical core shown in FIGURE 1 to a fiber density of 1.0 pound per cubic foot (16.0 kg./cu. m.). The axis of the cylinder during hand packing was in a vertical position and a cardboard outer shell was used to retain the fibers in a radial relationship with respect to the axis of the cylinder during packing. After packing the cardboard was removed and a wire mesh screen was wrapped around the pack to provide support for the fibers during the dipping operation. The size of the fiber pack in the form of an annulus was 4 feet (121.5 cm.) in length (parallel to the cylindrical axis) and 6 inches (15.2 cm.) thick. The outside diameter of the fiber pack mounted on the cylinder was 5 feet (152.4 cm.). The cylindrical core containing the fiber pack was lowered into a dipping tank containing a solution of binder, with the axis of the cylindrical core in a horizontal position so that the cylindrical core penetrated the binder solution to a depth of 8 inches (20.3 cm.). To saturate the fiber pack with binder solution the cylindrical core was rotated about its axis through the solution at a rate of about 18 inches (45.1 cm.) of pack circumference per minute. The binder solution consisted of a 3.5% by weight solution in trichloroethylene solvent of a heat curable polyurethane formed of 2,4-toluene diisocyanate and the polyester of ethylene glycol with adipic acid. After rotating the pack through the binder solution for one complete revolution, the solution was then pumped out of the dipping tank at a rate of 1 inch (2.5 cm.) per minute, and the fiber pack was held suspended in air to allow excess binder to drain for one hour. The cylindrical core was rotated continuously during draining. The drained fiber pack was placed in an air oven for 4 hours at 121° C., in order to cure the polyurethane binder. Continuous lengths of thin unsupported fiber sheeting were then cut from the fiber pack by peeling as the fiber pack was rotated against a rotating band knife the length of the fiber pack. In this manner a sample of unsupported sheeting 175 feet (53.4 m.) long was peeled from the fiber pack with the knife being adjusted to cut sheeting thicknesses of 1/8 inch (3.1 mm.), 1/4 inch (6.3 mm.) and 3/8 inch (9.4 mm.). This experiment demonstrated that no collapse of the fiber pack occurred during dipping in binder solution even though the rate of rotation of the pack was as high as 18 inches (45.7 cm.) per minute. Also, it was possible to easily peel long continuous lengths of seamless fiber sheeting from the circular fiber pack, and the uniformity of the continuous sheeting was quite satisfactory. Some of the sheeting was laminated with suitable adhesive to a fabric backing and the resulting pile fabric laminates possessed excellent bulk and aesthetics for use as a blanket, a pile innerlining for garments and as a bed spread. The pile surface of these laminates was soft luxurious, and appealing to the eye.

EXAMPLE II

Polyhexamethylene adipamide crimped stable fibers (3 d.p.f. and 2 inches long) were carded to form a 250 grain/

yd. (17.7 gm./m.) sliver. The sliver was cut into uniform 6 inch (15.2 cm.) long segments. The sliver segments were hand packed in parallelized relationship around the outer surface of the cylindrical core shown in FIGURE 1 to a fiber density of 1.0 pound per cubic foot (16.0 kg./cu. m.). The axis of the cylinder during hand packing was in a vertical position and a cardboard outer shell was used to retain the fibers in a radial relationship with respect to the axis of the cylinder during packing. After packing, a wire mesh screen was wrapped around the sleeve to provide a support for the fibers as the cardboard was removed and during the dipping operation. The size of the fiber sleeves in the form of an annulus was 4 feet (121.5 cm.) in length (parallel to the cylindrical axis) and 6 inches (15.2 cm.) thick. The outside diameter of the fiber sleeve mounted on the cylinder was 5 feet (152.4 cm.). The cylindrical core containing the fiber sleeve was lowered into a dipping tank containing a solution of binder, with the axis of the cylindrical core in a horizontal position so that the cylindrical core penetrated the binder solution to a depth of 8 inches (20.3 cm.). To saturate the fiber sleeve with binder solution the cylindrical core was rotated about its axis through the solution at a rate of about 18 inches (45.1 cm.) of sleeve circumference per minute. The binder was a terpolymer formed by condensing together caprolactam, hexamethylene diamine, adipic acid and sebacic acid such that there were substantially equal proportions of polycaprolactam, polyhexamethylene adipamide and polyhexamethylene sebacamide in the terpolymer. After rotating the sleeve through the binder solution for one complete revolution, the solution was then pumped out of the dipping tank at a rate of 1 inch (2.5 cm.) per minute, and the fiber sleeve was held suspended in air to allow excess binder to drain for one hour. The cylindrical core was rotated continuously during draining. The drained fiber sleeve was placed in an air oven at 212° F. until all the volatiles were removed. Continuous lengths of thin, unsupported fiber sheeting were then cut from the fiber sleeve by peeling as the fiber sleeve was rotated against a rotating band knife the length of the fiber sleeve. In this manner a sample of self-supporting sheeting was peeled from the fiber sleeve with the knife descending at a rate to cut sheeting 1/4 inch thick (6.3 cm.). The sheet was attached on one side only to a woven fabric by applying a layer of neoprene based adhesive to one face of the self-supporting sheet and one face of the backing fabric. The binder holding the fibers of the sheet together was then removed with an ethanol/water (80/20) mixture.

EXAMPLE III

Biocomponent polyacrylonitrile staple fibers prepared according to U.S. Patent 3,038,237 having a 2 1/2 inch staple length and 3 denier/filament were treated in hot water (190 F.) for 15 minutes and dried at 120° F. in a tumble dryer. These fibers having a crimp index of 24% and a crimp frequency of 11 crimps/inch were carded to form a 250 gr./yd. (17.7 gm./m.) sliver. The sliver was cut into uniform 6 inch (15.2 cm.) long segments. The sliver segments were hand packed in parallelized relationship around the outer surface of the cylindrical core shown in FIGURE 1 to a fiber density of 1.0 pound per cubic foot (16.0 kg./cu. m.). The axis of the cylinder during hand packing was in a vertical position and a cardboard outer shell was used to retain the fibers in a radial relationship with respect to the axis of the cylinder during packing. After packing the cardboard was removed and a wire mesh screen was wrapped around the sleeve to provide support for the fibers during the dipping operation. The size of the fiber sleeve in the form of an annulus was 4 feet (121.5 cm.) in length (parallel to the cylindrical axis) and 6 inches (15.2 cm.) thick. The outside diameter of the fiber sleeve was lowered into a dipping tank containing a solution of binder, with the axis of the cylindrical core in a horizontal position so that the cylindrical

core penetrated the binder solution to a depth of 8 inches (20.3 cm.). To saturate the fiber pack with binder solution the cylindrical core was rotated about its axis through the solution at a rate of about 18 inches (45.1 cm.) of sleeve circumference per minute. The binder solution consisted of a 6% solution of polyacrylic acid dissolved in an acetone/water mixture (3/1 ratio by volume). After rotating the sleeve through the binder solution for one complete revolution, the solution was then pumped out of the dipping tank at a rate of 1 inch (2.5 cm.) per minute, and the fiber sleeve was held suspended in air to allow excess binder to drain for one hour. The cylindrical core was rotated continuously during draining. The drained fiber sleeve was placed in an air oven at 220° F. to remove the solvent and solidify the binder. Continuous lengths of thin unsupported fiber sheeting were then cut from the fiber sleeve by peeling as the fiber sleeve was rotated against a rotating band knife the length of the fiber sleeve and adjusted to cut a sheeting thickness of 1/4 inch.

One surface of this sheet was spray coated with a polyurethane adhesive and then bonded to a woven cotton fabric. The assembly was wound under tension and heated (240° F. for 30 minutes) to bond the fiber ends in one face of the sheet to the cotton backing. The binder was washed out of the pile layer and a soft bulky fabric suitable for use as a pile lining for garments was obtained.

EXAMPLE IV

A fiber pack similar to the one described in Example I was prepared utilizing the general procedure and the same type of fibers and binder, except the method of packing the fibers into the annular space was varied. In this example the cut sliver sections of equal length were fed at a predetermined speed to the annular space between the outer surface of the cylindrical core and the outer shell as shown in FIGURE 1, the feed speed of the sliver sections being adjusted to equal the speed of the average circumference of the pack. The conveying means for the cut sliver was a horizontally traveling belt, and a reciprocating ram packed the sliver sections into the annular space while the cylinder unit was rotating. The fiber density of the pack formed in the above manner was approximately 1.0 pound per cubic foot (16.0 kg./cu. m.). This pack was dipped in the same binder solution as indicated in Example I and after draining, the pack was cured in an oven for 7.5 hours at 115.5° C. Continuous sheeting was cut and peeled from the rotating pack at a speed of about 100 feet per minute (30.5 meters/minute). The uniformity of the sheeting, which was 0.25 inch (6.3 mm.) thick, was acceptable and samples of the sheeting laminated with an adhesive to various fabric backings produced laminated pile fabrics having pleasing aesthetics which were useful as bathrobes and other pile outerwear fabrics, as well as pile inner-linings for various garments.

The receiving means has been described as defining a circular annular space which is capable of receiving bulky fibrous elements. However, it is unnecessary to have circular surfaces since the receiving means may define an annular space having shapes other than circular, such as elliptical.

The relative speed of rotation for the receiving means may be maintained at any desirable rate. However, such speeds will generally be in the range of from about 2 revolutions per minute to about 4 revolutions per minute. Similarly, the relative speed of the feed means is usually maintained at about 150 feet/minute (45.72 meters/minute) when the sliver batt has only one layer of sliver sections. With the increase in layers the speed should be correspondingly diminished. The only requirement is that the speeds be adjusted in such a manner that there is no relative motion between the sliver batt ends and the cylindrical core member of the receiving means. Any such relative motion would cause the sliver batts to be distorted from their desired positioning normal to the core.

With respect to the means for packing sliver batts into the annular space, means other than the reciprocating ram may, of course, be utilized. When the ram is used, it is preferred to mount it in such a manner that it will rotate with the receiving means for part of a revolution and at the same speed. This results in the minimum distortion of the sliver batts from their position normal to the core.

As to the indexing after a row of sliver batts have been positioned, it should be apparent that this may be accomplished by indexing either the outer shell or the cylindrical core in a longitudinal direction. In other words, the fiber pack may be formed by moving the outer shell, the card clothing and feed conveyor in the direction of the feed supply, or the cylindrical core may be indexed in the opposite direction.

It will be obvious that the fiber density in the pack may be altered to some extent by changing the packing and loading pressure applied to the sliver batts. However, the fiber density desired is, of course, primarily determined by the amount of each longitudinal indexing.

In place of using a binder solution for attaching the fibers together in the fiber pack, other means of fiber attachment may be employed. For example, the fibers may be sprayed with liquid polymerizable binder or with a solution or dispersion of binder or a binder may be applied to the fiber feed material by a melt spraying technique, such as by using a flame spraying gun. Alternatively, a binder fiber may be blended with the structural fibers in different amounts as the feed material before entering the annular space. The binder fiber is normally selected to have a melting, softening, or tacky point below that of the structural fiber so that the structural fibers will be bonded together by heat treating the total pack assembly at a temperature which will soften the binder fibers, but not affect the structural fibers. In some instances it may be desirable to thoroughly melt the binder fiber in the heat treating step so that it forms globules of resin binder which act to attached neighboring structural fibers together in the pack. Another method is to apply powdered binder to the fibers and then heat the assembly to fuse the powder and attach structural fibers together at their touching points. Another method for attaching the fibers is to apply a latent fiber solvent, in liquid solution or mist form, to the structural fibers, then activate the latent fiber solvent at the proper time to make it an active solvent for the structural fibers in order to weld fibers together at their touching points. Another method for attaching the fibers together within the pack is to employ steam, radiant or induction heating for welding the fibers together. One or more applications of binder may be made to the structural fibers if found desirable.

One further convenient method for attaching the fibers in the pack is to pass a continuous stream of hot air into the axis of the rotating cylinder and out through the annular space as the sliver sections are being fed to the annular space to build the self-supporting pack.

The self-supporting fiber pack of this invention permits the peeling of long lengths (e.g., 400 yards, i.e., 365.4 meters, or more) of continuous self-supporting fibrous sheets in any desired width to accommodate a variety of products useful in the apparel and industrial textile markets. It is preferred that the thickness of the sheets be less than about 1/4 inch (6.3 mm.) for many preferred end uses, e.g., blankets or apparel linings. Also, the self-supporting fiber pack provides continuous sheeting having high uniformity and freedom from visible seams or weld lines which can be used for a variety of products either with or without laminating to various backing materials. Typical of the products which may be made are carpets, tiles, bath mats, and other floor covering materials, upholstery and slipcover backing, sound, thermal and electrical insulation, washing, cleaning, dusting,

polishing and buffing materials, liquid and gas filters, felts, rug pads, paint rollers, weather stripping, blankets, bedspreads, pile innerlinings for various types of garments, pile outerwear fabrics, sweaters, bathrobes, dresses, work clothes, uniforms, infant sleepers, ski jackets and pants, glove and boot liners, and the like. The fiber pack is itself useful as a polishing, buffing, cleaning or grinding wheel, paint roller, brush, and the like.

What is claimed is:

1. A method for forming a fiber pack from bulky fibrous elements which comprises providing a receiving member having an outer shell and a cylindrical core member which define an annular space, said outer shell and said cylindrical core member having holding means positioned to receive the ends of said bulky fibrous elements, rotating said receiving member, positioning said bulky fibrous elements of parallelized fibers having orientation predominantly in one direction in said annular space with the fiber orientation being normal to the axis of said core, in timed relationship with said rotating receiving member to form a row of the bulky fibrous elements about the periphery of said core member when the rotating receiving member has completed one revolution and indexing the row of elements in said annular space a predetermined distance as the receiving member makes one revolution.

2. A method for forming a fiber pack from bulky fibrous elements which comprises providing a receiving member having an outer shell and a cylindrical core member which define an annular space, said outer shell and said cylindrical core member having holding means positioned to receive the ends of said bulky fibrous elements, rotating said receiving member, positioning said bulky fibrous elements of parallelized fibers having orientation predominantly in one direction in said annular space with the fiber orientation being normal to the axis of said core, in timed relationship with said rotating receiving member to form a row of the bulky fibrous elements about the periphery of said core member when the rotating receiving member has completed one revolution, indexing the row of elements in said annular space a predetermined distance as the receiving member makes one revolution and thereafter bonding said parallelized fibers at a plurality of contact points throughout the three dimensions of said annular space.

3. Method of claim 2 wherein said bulky fibrous elements are comprised of polyamide fibers.

4. Method of claim 2 wherein said bulky fibrous elements are comprised of polyester fibers.

5. Method of claim 2 wherein said bulky fibrous elements are comprised of polyacrylic fibers.

6. Method of claim 2 further comprising cutting the bonded fiber pack to form at least one thin sheet therefrom.

7. Method of claim 6 further comprising laminating said sheet to a backing material.

8. Method of claim 7 wherein the thickness of said sheet is less than about $\frac{1}{4}$ inch.

9. Method of claim 8 wherein said fibers are bonded with a fugitive binder and said binder is washed out after said laminating.

10. An apparatus for forming a fiber pack from bulky fibrous elements which comprises a rotatable receiving means comprising an outer shell and a cylindrical core member, said outer shell and said cylindrical core member defining an annular space, said outer shell and said cylindrical core member having holding means positioned to receive the ends of said bulky fibrous elements, means rotating said receiving means, feeding means positioning said finite bulky fibrous elements of parallelized fibers having orientation predominantly in one direction in said annular space with the fiber orientation being normal to the core member, said feeding means being adapted to position said bulky fibrous elements in timed relationship with said rotating receiving means to form a row of said elements about the periphery of said core member when the rotating receiving means has completed one revolution and means indexing the row of bulky fibrous elements in said annular space a predetermined distance as said receiving means makes one revolution.

11. The apparatus of claim 10 wherein said holding means comprise card clothing rings.

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