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3,145,446

PROCESS FOR PRODUCING TUFTED STRUCTURES

Filed Nov. 21, 1962

2 Sheets-Sheet 1

FIG. 1

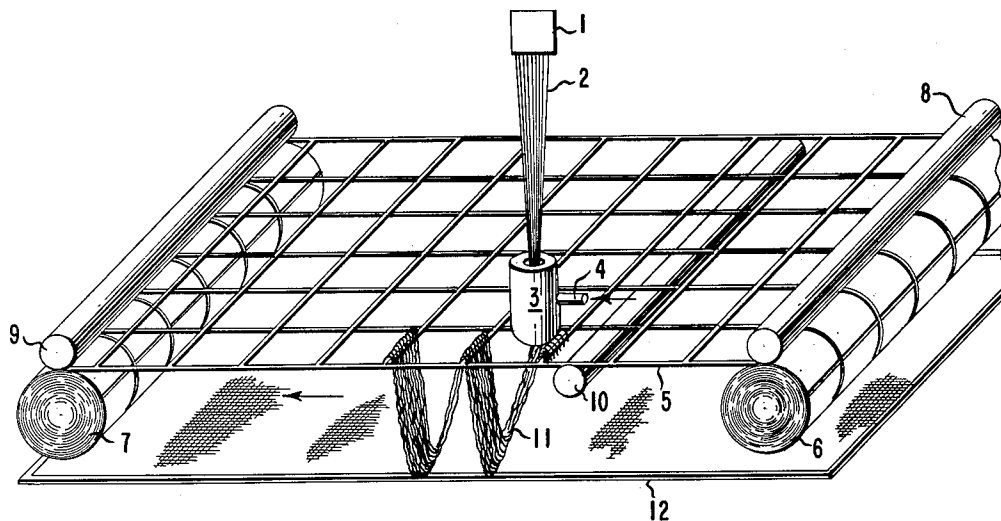
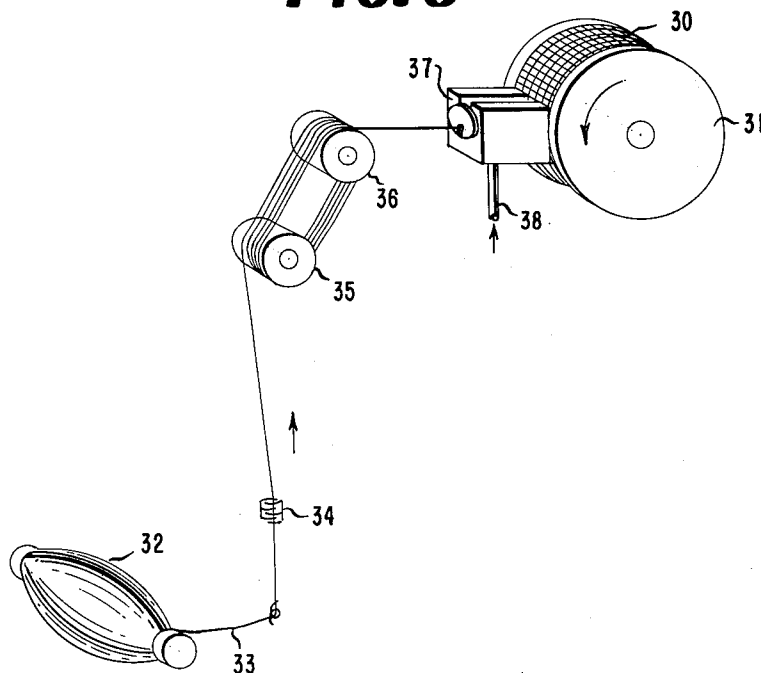


FIG. 3



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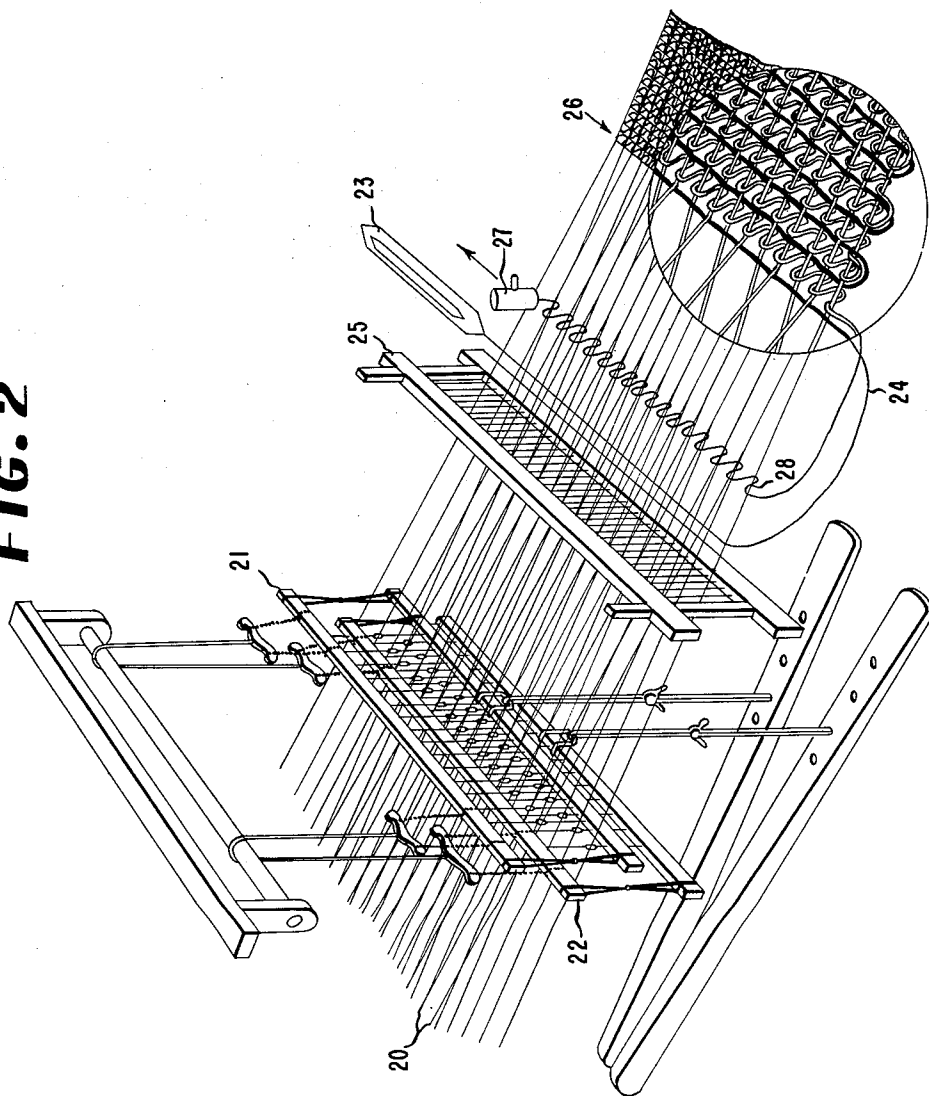
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2 Sheets-Sheet 2

FIG. 2



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PROCESS FOR PRODUCING TUFTED
STRUCTURES

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This invention relates to a novel process for the production of tufted structures.

Tufted or pile surface structures have been made in the past by a variety of processes. Commonly, such structures are made by a needle-tufting operation in which a series of reciprocating needles are used to force loops of yarn through a ground fabric, generally burlap or the like, the loop being held in place on the underside of the fabric by a hook or like element until the needle passes on to the next tufting point. Thus, a loop of the pile-forming yarn is inserted at each point penetrated by the needle. Because of the complexity of the tufting equipment, such tufting processes are expensive and are not adaptable to the production of a variety of tufted products.

An object of the present invention is to provide a novel, rapid, inexpensive and versatile tufting process. A further object of this invention is to provide a process for tufting continuous filaments, yarns, threads, and like filamentary strands into an apertured structure. A further object of this invention is to provide novel tufted structures. Other objects of this invention will become apparent in the course of the following specification and claims.

The objects of this invention are accomplished by utilizing a high velocity fluid to insert tuft loops of a filamentary strand into the openings of a backing material. Preferably, an air jet or like fluid-propelling device is used to simultaneously convey the filamentary strand and to propel it through adjacent successive openings in the backing material.

Accordingly, the present invention provides a process for the continuous production of tufted structures comprising propelling a filamentary strand by means of a high velocity fluid into contact with an apertured backing material, said fluid having sufficient velocity to force the strand beyond the plane of the backing material, and employing relative lateral movement between the strand and the backing material to cause the strand to alternately penetrate the openings of the backing material and suspend itself from the walls of the openings, thereby forming tuft loops in each opening.

In a preferred embodiment of this invention, the tufting process is integrated with the production and/or processing of filamentary strands. Thus, the filamentary strands may be led directly from a spinning, drawing or like operation to a fluid-propelling device, which latter may serve to crimp, bulk or otherwise texture the strand in addition to propelling it.

Alternatively, filaments, yarns, and the like originating from wound bobbins, spools, etc., may be converted into tufted structures by the process of this invention.

The tufting process may be carried out to produce tufts in all openings of the backing member or in a programmed manner to produce a pattern of tufts in selective areas. By varying the rate of relative lateral movement between the strands and the backing member during production of a given tufted structure, it is possible to vary the tuft height to produce textured or sculptured effects.

By "filamentary strand" is meant any continuous filament, yarn, fiber, thread, roving, fibrillated strand, tow or the like. The filamentary strands may consist of any

natural or synthetic, organic or inorganic material, or combinations thereof.

The backing member may be any open mesh, perforated or louvered structure, consisting of a structural portion defining a plurality of openings, the openings being square, rectangular, rhombic, triangular, circular, etc. Suitable backing materials include burlap and other woven or knitted fabrics, netting, screening, woven scrims, perforated plates or sheets, honeycomb, an array of wires, yarns, blades and the like arranged to define any shape and/or size openings, etc. The backing member may be planar or may be preshaped to a 3-dimensional contour for producing a tufted structure ready for use on a contoured surface.

The fluid propelling device may be any air, steam, or hydraulic jet, which is constructed so as to provide a stream of fluid flowing in a direction concurrent with that of the filamentary strand.

In a further embodiment of this invention, tufts are simultaneously produced on both surfaces of an apertured backing material by regulating the velocity of the fluid so as to force a portion of the strand filaments through the openings to form tufts projecting from the bottom surface of the backing material, while the remaining strand filaments loop and form tufts projecting from the top surface of the backing material. Alternately, both sides of the backing material may be provided with tufts by directing strands into different openings of the apertured structure from opposite sides thereof.

In general, the tufted structures of this invention comprise an apertured tuft-supporting member and a plurality of filamentary strands looped into and out of the apertures of said member to form tufts projecting only from the apertures. In one embodiment of this invention, the tufted structures comprise an open mesh tuft-supporting member and a plurality of tufts formed from filamentary strands projecting only from the meshes of said member. By "open mesh" member is meant a structure, the apertures of which are defined by intersecting or crossing linear elements.

In a particular embodiment of this invention, there is provided a tufted structure comprising an apertured tuft-supporting member and a plurality of tuft-forming filamentary strands, the strands being looped into and out of said apertured member to form a plurality of tufts projecting from one surface of the apertured member, the strands of each tuft being shared with those of adjoining tufts in the planar directions of the structure. This type of tuft sharing is produced by traversing the apertured member with a multi-strand stream or streams along a path which permits the strands to traverse all walls of each cell.

In a still further embodiment of this invention, there is provided a self-supporting unitary tufted structure comprising (1) a permanent backing member consisting of randomly interlaced continuous filamentary strands, (2) an intermediate member consisting of an apertured, tuft-supporting member, and (3) a pile portion consisting of a plurality of tufts formed from filamentary strands suspended from said apertures, the strands of the pile portion being continuous with the strands of the backing portion. Such products may be made by first forming a tufted structure and then continuing to deposit filamentary strands on the surface thereof, until a web of randomly entangled strands of any desired thickness is obtained.

If desired, an additional permanent backing may be applied to the non-tuft side of the products of this invention. Such a backing may consist of a non-woven mat, web or the like, fabrics, films, etc., and may be bonded thereto by any suitable means.

Tuft height depends upon the force of the fluid driving

the filamentary strand through the apertures of the backing member, which will vary with the velocity and pressure of the jet fluid; and upon the residence time of the strand in the aperture, which will vary with the velocity of the backing member relative to the strand feed rate. Tuft height may be controlled by placing a deflecting surface, hereinafter referred to as a "stopper screen" beneath and parallel to the apertured member during the tufting process. The presence of the "stopper screen" prevents the strands from traveling the full distance otherwise provided by the driving force of the fluid and the residence time of the strands in the aperture. By using a "stopper screen" having a series of depressions and elevations arranged in a given pattern, tufted structures with varying tuft heights corresponding to any desired pattern may be obtained. If desired, suction may be applied under the "stopper screen" in order to aid tuft formation.

Tuft density may be controlled and/or increased by tufting the filamentary strands into an elastomeric apertured member in the stretched state and subsequently relaxing the apertured member after tufting has been completed. Alternatively, the filamentary strands may be tufted into an apertured member composed of a shrinkable material, followed by shrinking the apertured member upon completion of the tufting process. Tuft density may also be increased by using shrinkable and/or crimpable strands as the tuft-forming elements, and subsequently subjecting the tufted structure to an after-treatment to effect shrinking and/or crimping of the tuft strands. If desired, the filamentary strands may be tufted into an apertured member consisting of an array of parallel or converging blades, wires or the like, to produce structures consisting of parallel or converging rows of tuft loops. By the use of reeds, combs or other means, the individual tuft loops may be moved closer together or farther apart, while still supported by the apertured member, thereby offering an additional method for varying tuft density.

The filamentary strands may be bonded to the apertured member by a variety of process modifications. Thus, the strands may be heated to temperatures high enough to soften them temporarily so that they become anchored to the apertured member during tufting. Alternatively, the strands may be composed wholly or in part of heat-softenable materials, which are subsequently fused to the apertured member by applying heat to the back of the tufted structure. A stretched elastic or a post-shrinkable apertured member may be used during tufting and then be relaxed or shrunk to anchor the tufts. Bonding may also be achieved by applying a resinous binder or adhesive to the back of the tufted structure or by depositing fusible fibers, fibrils, binder particles, etc., to the back of the tufted structure, followed by heating to effect bonding.

Different types and/or colored strands may be used in the production of a single tufted structure, optionally in conjunction with a programmed strand traverse, to produce tufted structures having a programmed surface, hand, aesthetics or color pattern.

The tufted structures of this invention may be subjected to various after-treatments, such as dyeing, embossing, etc., to produce a patterned or otherwise modified structure.

The tuft loops may be sheared or otherwise cut, either during or after production of the tufted structure, to produce a cut pile surface.

The tufted structures produced by this invention are useful as pile products of all types including furs, fleeces, floor coverings, towels, blankets, etc. In addition, they may be used as stuffing materials, padding, filters, liners, etc. Depending on the end use it may be desirable to apply a permanent backing to one or both sides of the tufted structure.

In the drawings, which illustrate specific embodiments

of the process of this invention as practiced with various forms of apparatus,

FIGURE 1 is a schematic view of the production of tufts in woven fabric, with the fabric in a horizontal plane during tufting and with the tufting strand fed directly from a spinneret,

FIGURE 2 is a schematic view of a modification of the process wherein the tufts are produced as the fabric is woven, and

FIGURE 3 is a schematic view of another modification wherein the fabric is tufted on a revolving drum and the tufting strand is fed from a pirn.

Referring now more particularly to the drawing, FIGURE 1 illustrates the preparation of a tufted structure in association with a conventional spinning operation. Freshly formed filaments 2 emerging from spinneret 1 are passed through fluid jet 3 to which a suitable fluid is supplied under pressure through inlet 4. A woven fabric, wire screen, or other suitable apertured structure 5 is unwound from roll 6, fed in a horizontal direction beneath the jet, and is rewound on roll 7. Means for maintaining the fabric taut during passage through the tufting zone are indicated by tension rolls 8 and 9. A tension bar 10 may be provided to apply tension immediately prior to the jet and to guide the fabric in close proximity to the tip of the jet. The jet 3 is located so that apertures of the fabric successively intercept the path of the filaments emerging from the jet. The fluid emerging from the jet then forces the filaments 2 into and through the apertures to form tuft loops 11 suspended from the walls of the apertures. A stopper screen 12 may be placed below the fabric to help control the tuft height.

While the above illustrates the use of a single jet, it is to be understood that a series of jets, preferably arranged so that the filaments emerging from each jet traverse the walls of a given aperture row along the center line of the row, may be used for the continuous production of tufted products. If desired, an applicator roll, spraying device or the like may be used to apply a binder material to the apertured member before or after its passage through the tufting zone.

If desired, a permanent backing is applied to the tufted structure at the end of the tufting zone before the structure is continuously wound up into package 7.

In a variation of the above process, the apertured structure is arranged to traverse the tufting zone in the manner of a conveyor belt. Upon completion of tufting, a permanent backing is continuously applied to the tufted structure.

FIGURE 2 illustrates tufting during the production of a plain weave fabric. Since the weaving operation is conventional, the loom is shown in greatly simplified form. Warp yarns 20 are fed from left to right. Harness frame 21 raises the odd warp ends while harness frame 22 lowers the even warp ends. Shuttle 23 is shot through the warp shed between the odd and even warp ends, leaving filling pick 24 in its wake as shown. Harness frames 21 and 22 are then returned to the center position and reed 25 is swung to the right to beat the loose pick into position as shown at fell 26 of the cloth. The harness frame 21 then lowers the odd warp ends while harness frame 22 raises the even warp ends, the shuttle is shot back through the warp shed and the additional pick is positioned as before.

In accordance with the present invention, tufting jet 27 is alternately traversed across and in close contact with the sheet of warp yarns so as to insert tuft loops 28 between the warp yarns. The movement of the tufting jet parallels that of the shuttle so that rows of tuft loops are separated by picks of filling yarn. Movement of the reed as described above beats both the picks and tufts into place in the fabric. When the tufts are inserted while the warp yarns are separated as shown, a double-tufted fabric is produced having tuft loops pro-

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jecting from both faces of the fabric as indicated in the enlarged portion within the circle.

In the process illustrated in FIGURE 3, the apertured structure 30 to be tufted is secured tautly about the cylindrical surface of drum 31. The area to be tufted is spaced from any surface of the drum and may be supported by vanes or bars which do not impede the insertion of tufts. A pirn 32 is shown for providing the tufting yarn 33, but a strand can obviously be supplied from any convenient source. The yarn 33 passes through tension gate 34 to forwarding rolls 35, 36, which may be heated to soften or plasticize the yarn temporarily. The yarn then passes through jet 37 supplied with fluid under pressure at opening 38. The jetting fluid forces the yarn into apertures of the structure 30 to form tufts. The drum 31 is revolved at suitable speed to form a series of tufts, and the jet 37 is traversed to cover the desired area. Tuft height may be varied by varying the relative speeds at which the yarn is ejected and the drum is revolved. The spacing between the apertures structure and the drum surface also affects the tuft height and type, when the drum surface acts as a stopper screen, in the manner discussed previously. The tufted structure produced is removed from the drum to provide an open width tufted product.

In the continuous production of tufted products, a small roller may be arranged to rotate in contact with the apertured structure immediately behind the fluid jets in order to prevent the already tufted strands from being pulled out of their respective apertures during tufting of the adjacent, succeeding apertures.

In operating the process of this invention, the fluid jet is arranged so that its exit is in close proximity to the surface of the apertured backing material. When a compressible fluid, such as air, is used, the jet should be spaced at a distance of less than one inch from the apertured backing material at which the fluid will force the tufting strand through the apertures of the backing material. The pressure of the fluid admitted to the jet is regulated so as to draw the filamentary strand into the jet and to drive it therefrom into the apertures of the backing material. The strand may be fed to the fluid jet at high or low velocity, even at a very low velocity, such as by hand. Generally, it is preferred to combine the tufting process with the production and/or processing of the strand, in which case the strand is fed to the fluid jet at a substantially constant, predetermined velocity. The fluid exits therefrom at a higher velocity determined by the pressure of the fluid admitted to the jet.

By varying the process conditions, any size, shape, and type of filamentary strand may be tufted into apertured structures having a variety of cell sizes and shapes providing that the stream of fluid has sufficient velocity to force the fibers beyond the plane of the apertured structure and that the cell size is at least twice the diameter of the strand. It is to be understood that if an entire strand bundle, e.g., a continuous filament tow, is to be tufted into each cell, the cell size must be at least twice the minimum cross-sectional area of the strand bundle. If it is desired to insert only a portion of the total number of strand filaments into each cell, the cell size may be smaller. The minimum size of the cell into which a given strand can be tufted is dependent not only on the diameter of the strand but also on its resistance to being bent or doubled upon itself. For higher modulus strands, which resist bending, it is possible to temporarily reduce the strand modulus during tufting, for example, by using steam in the jet to heat and plasticize the strand, to permit tufting under conditions otherwise not possible. Alternatively, it may be sufficient to increase the fluid velocity.

Preferably, the fluid jet is arranged so that the filamentary strand exiting from it travels in a direction substantially perpendicular to the apertured backing material. If it is

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desired to insert an entire strand bundle into each cell of the backing material, the exit orifice of the jet should have a diameter smaller than the cross-sectional dimension of each cell and is preferably positioned so as to permit the exiting strand to traverse the center line of the cell row.

The tuft-forming strands and/or the process conditions may be varied, as desired, to produce products having different types of tufts ranging from fine, fur-like tufts composed of a number of individual filament loops to dense, discrete tufts composed of a single loop of twisted or untwisted yarn.

The production of tufted structures by the process of this invention will be explained more thoroughly in the following examples.

Example I

This example illustrates the tufting of a continuous filament yarn into cheesecloth.

A 70 denier, 34 filament nylon yarn is led from a supply source through a feed roll and guide system and then into a yarn bulking jet. The jet is of the type disclosed in FIG. 8 of Breen U.S. Patent No. 2,783,609, issued March 5, 1957, except that the bottom face of the jet is rounded off to prevent snagging of the jet with the cheesecloth. Air is supplied to the jet at 90 p.s.i. through a pipe on one side of the jet, and the yarn and air exit vertically from the jet at high velocity from an exit orifice at the bottom of the jet.

A commercial cheesecloth, having a cell size of approximately $\frac{1}{32}$ inch, is mounted tautly around two power driven wheels in the manner of a conveyor belt and is passed horizontally beneath and in close contact with the jet exit as illustrated in FIGURE 1.

The high velocity air propels the yarn and forces it into successive openings in the cheesecloth thereby forming tuft loops in the cells of the cheesecloth as it passes in contact with the jet.

Example II

This example illustrates a simultaneous tufting and weaving operation to produce a tightly woven fabric having tuft loops on both sides thereof.

A continuous filament yarn is fed into an air jet as described in Example I. Tufting is carried out in conjunction with the weaving of a fabric from a 70 denier, 34 filament polyethylene terephthalate yarn on a conventional loom. This is accomplished as illustrated in FIGURE 2 by alternately traversing the jet across and in close contact with the sheet of warp yarns (760 ends) so as to insert tuft loops in the interstices between successive warp yarns and then allowing the shuttle to insert the next filling yarn. Filling yarns are inserted at 80 picks per inch. Since the tufting yarn is inserted while the warp yarns are separated into two planes by the motion of the harnesses, the resulting tuft loops project from both surfaces of the woven fabric.

The final product is a tightly woven fabric having a plurality of short tuft loops projecting from both surfaces and is suitable for use as toweling and the like.

Example III

This example illustrates the production of a tufted structure on an aluminum louvered screen, using steam to propel the yarn through the louvers.

Using apparatus of the type shown in FIGURE 3, a 1300 denier, 68 filament trilobal nylon carpet yarn is taken from a pirn over heated feed rolls and into a crimping jet operating with steam at 200 lbs./sq. in. pressure. The exit of the jet is $\frac{1}{16}$ inch from the surface of a drum having an aluminum louvered screen supported so that it will move under the jet at a velocity of 700 feet per minute with the length of the louvers parallel to the axis of the drum. The louvers are $\frac{3}{8}$ inch long, $\frac{1}{16}$ inch apart, and are bent to form an angle of 45° with the radius of the drum. The jet provides tension to pull the

yarn off the feed rolls at 5,200 feet per minute and forces the yarn through the openings of the louvered structure to form loops on the underside thereof.

Under these conditions, a high steam pressure is required to produce tufts. At a steam pressure of 100 p.s.i., the tufting yarn does not penetrate the openings of the louvered structure. At 150 p.s.i., the tufting yarn penetrates only part way through the louvers. At 200 p.s.i., the yarn goes completely through the louvers to form tuft loops as previously described.

Example IV

This example illustrates the production of a tufted carpet structure on scrim, using steam to propel the yarn through the openings of the scrim.

Using apparatus of the type shown in FIGURE 3, a 1300 denier, 68 filament trilobal drawn nylon carpet yarn is taken from a pirn over heated feed rolls and into a crimping jet operating with steam at 200 lbs./sq. in. pressure. The exit of the jet is $\frac{1}{16}$ inch from the surface of a drum having rug-making scrim with square apertures $\frac{3}{16} \times \frac{3}{16}$ inch on $\frac{1}{4}$ inch centers, supported so that it will move under the jet at a velocity of 700 feet per minute with the sides of the squares parallel to the direction of motion and with the centerline of the openings under the centerline of the jet. The jet provides tension to pull the yarn off the feed rolls at a velocity of 5,200 feet per minute. Conditions in the jet form a partial crimp in the yarn, which can later be fully developed by immersing the finished carpet in boiling water. The high velocity steam issuing from the jet exit forces the yarn through the apertures of the scrim, forming looped tufts $\frac{3}{4}$ inch in height. The fact that the crimp is only partially developed allows the yarn to pass easily through the apertures. The tufted carpet is subsequently immersed in boiling water to crimp the filaments more severely and produce a more compact, resilient pile.

Example V

This example illustrates the production of a double-sided loop pipe on plastic netting.

Using apparatus of the type shown in FIGURE 3, a 1300 denier, 68 filament trilobal drawn nylon carpet yarn is taken from a pirn over heated feed rolls and into a crimping jet operating with steam at 150 lbs./sq. in. pressure. The exit of the jet is $\frac{3}{8}$ inch from the surface of a drum having an 8 mesh plastic netting supported so that it will move under the jet at a velocity of 700 feet per minute with the diagonals of the rhombic apertures of the netting parallel to the direction of motion. The yarn is travelling at a velocity of 5,200 feet per minute. During tufting some of the filaments of the yarn pass through the apertures to form tuft loops on the underside of the netting. There is insufficient force to propel all of the filaments through the apertures, but filament loops are formed on the jet side of the netting. The resulting tufted structure consists of a plastic netting, both sides of which are covered with a resilient loop pile of nylon filaments, the netting being hidden by the filaments.

Example VI

This example illustrates the production of a tufted structure on plastic netting wherein individual fibers of each tuft are shared with those of adjacent tufts in all planar directions.

Using apparatus of the type shown in FIGURE 3, a 1300 denier, 68 filament trilobal drawn nylon carpet yarn is taken from a pirn over heated feed rolls and into a crimping jet operating with steam at 250 lbs./sq. in. pressure. The exit of the jet is $\frac{3}{8}$ inch from the surface of the drum having 8-mesh plastic netting supported so that it will move under the jet at a velocity of 700 feet per minute with the diagonals of the rhombic cells of the netting parallel to the direction of motion. Con-

ditions in the jet form a partial crimp in the yarn, which can later be fully developed by immersing the finished structure in boiling water. The filaments, travelling at a velocity of 5,200 feet per minute pack into one cell until no more will pass. They are then diverted into adjacent cells. The diverting of excess filaments into adjacent cells is aided by the tendency of the steam to follow the path of least resistance. When one cell is filled with filaments, the steam is forced to flow into neighboring cells carrying filaments with it.

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 limited by the specific illustrations except to the extent defined in the following claims.

I claim:

1. A process for producing tufted structures which comprises propelling a filamentary strand by means of a high velocity fluid into contact with an apertured backing material, said fluid having sufficient velocity to force the strand through openings in the backing material to form tufts, and forming a series of tufts by relative lateral movement between the strand and backing material to cause the strand to alternately penetrate openings in the backing material and suspend itself from the walls of the openings, thereby forming tuft loops in each opening.

2. A process as defined in claim 1 wherein said strand is produced and fed directly to the tufting process in a continuous operation.

3. A process as defined in claim 1 wherein said strand is supplied from a yarn package.

4. A process as defined in claim 1 wherein said relative lateral movement between the strand and backing material is carried out in a programmed manner to produce a pattern of tufts.

5. A process as defined in claim 1 wherein the rate of relative movement between the strand and backing member is varied to vary the tuft height.

6. A process as defined in claim 1 wherein tufts are produced on both faces of the backing material.

7. A process as defined in claim 1 wherein strands are propelled against both faces of the backing material to produce tufts projecting from both faces of the backing material.

8. A process as defined in claim 1 wherein the backing material is traversed with a plurality of propelled strands to produce tufts having strands suspended from all walls of each opening, the strands of each tuft being shared with those of adjoining tufts in the planar directions of the tufted structure.

9. A process as defined in claim 1 wherein the tuft height is controlled by stopping the strand, after penetration through said openings, against a stopper surface spaced from the apertured backing material.

10. A process as defined in claim 9 wherein said stopper surface is a screen.

11. A process as defined in claim 9 wherein said stopper surface has a three-dimensional configuration to provide a pattern of tufts varying in height.

12. A process as defined in claim 10 wherein suction is applied to the stopper screen to aid in tuft formation.

13. A process as defined in claim 1 wherein said apertured backing material is elastomeric, the backing is stretched during tuft formation and is subsequently relaxed to increase the tuft density.

14. A process as defined in claim 1 wherein said apertured backing material is shrinkable and is shrunk after tuft formation to increase the tuft density.

15. A process as defined in claim 1 wherein said strand is composed of post-deformable material and the tufted product is after-treated to increase the tuft density.

16. A process as defined in claim 1 wherein the openings of said apertured backing material are slots formed by generally parallel elements, the strand is applied to

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form tuft loops over the elements and the loops are subsequently pushed together to increase the tuft density.

17. A process as defined in claim 1 wherein the strand is composed of thermoplastic material and is softened by heating above room temperature and below the melting point when propelled into contact with the backing material.

18. A process as defined in claim 1 wherein the tufted structure is produced in a loom, the apertured backing material is a plurality of warp ends being woven into a fabric and the tufts are formed by suspending the strand over the warp ends to be consolidated into the woven fabric between picks of filling yarn.

19. A process for producing tufted structures which comprises propelling a filamentary strand by means of a high velocity fluid into contact with an apertured backing material, said fluid having sufficient velocity to force the strand through openings in the backing material to form tufts, forming a series of tufts by relative lateral movement between the strand and backing material to cause the

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strand to alternately penetrate openings in the backing material and suspend itself from the walls of the openings, and continuing to propel the strand into contact with the backing material until both tufts and a randomly entangled strand layer are formed to produce a tufted structure having a backing web composed of strands continuous with tuft strands.

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