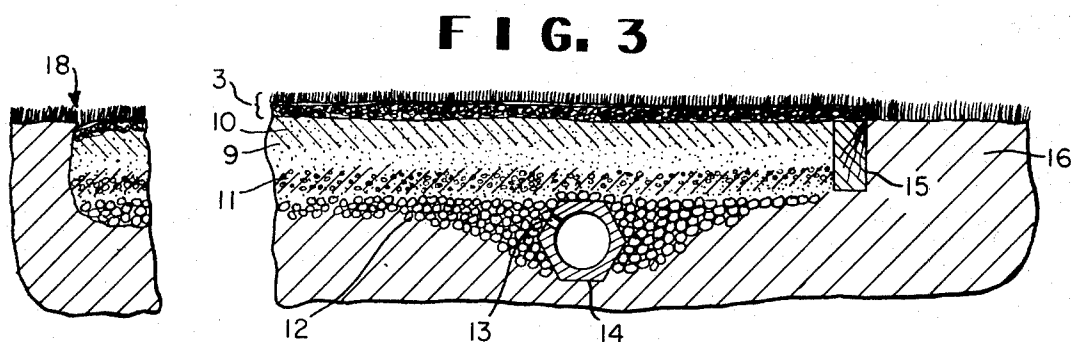
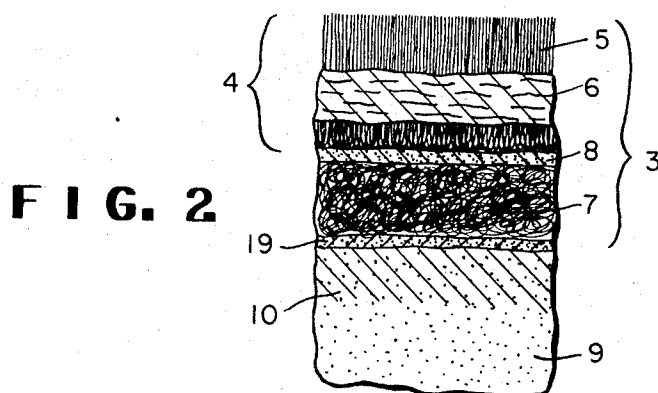
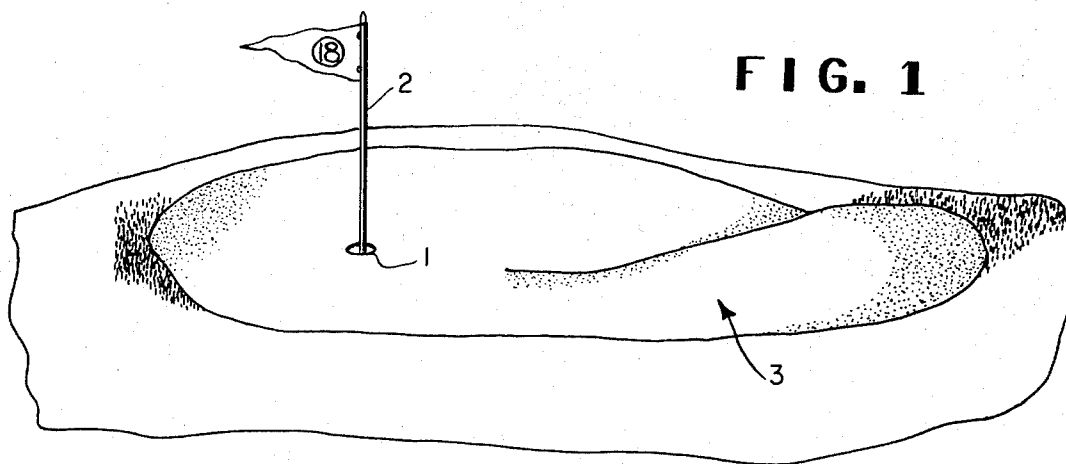


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ARTIFICIAL PLAYING SURFACE

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1 Claim

ABSTRACT OF THE DISCLOSURE

An artificial playing surface is provided which comprises an artificial grass layer having in conjunction therewith a bonded batt comprising synthetic fibers, said batt having a density between 1.88 and 3.75 pounds per cubic foot and a thickness between $\frac{3}{8}$ inch and $\frac{3}{4}$ inch. These in turn are adhered to a well-drained foundation. The artificial grass layer and batt composite comprise a mat suitable for the formation of the above-described surface.

This invention relates to artificial playing surfaces such as golf greens and methods for constructing same.

A natural playing surface such as a football field surface, tennis court surface, and golf green surface, for example, of natural grass requires an extensive amount of cultivation and maintenance to preserve uniformity and appearance. The high cost of such maintenance and cultivation of such grass has led to the recent development of artificial playing surfaces which would be low in initial cost and upkeep. However, such surfaces to be most suitable need to simulate not only the appearance but also the mechanical behavior of the natural grass surface. Various artificial pile surfacing materials have been proposed. Natural grass surface, of course, adheres to the contours in the earth itself and in addition has no significant lateral distribution of compressive forces put on the surface. For example, in playing golf on a natural grass surface, as the player steps on the surface near the position of the golf ball, the compressive forces are borne almost exclusively by the section of turf and grass immediately under the foot. An artificial surface also exhibiting such behavior is desired so that the compressive force of a player standing is not transmitted laterally away from his position. This might affect the lie of, say, a golf ball not far from the foot, and also affect the position of the ball during the swing.

An artificial surface needs to have some compressibility. A very hard surface allows a golf ball (for example) to bounce undesirably high contrary to play on natural surface.

SUMMARY OF THE INVENTION

The present invention provides a mat especially suitable for the preparation of an artificial playing surface for golf comprising:

An artificial grass layer and uniformly adhered thereto and in contiguous contact therewith;

A bonded batt comprised of synthetic fibers, said batt having a first face surface and a second face surface, said batt having a thickness of between about $\frac{3}{8}$ inch to $\frac{3}{4}$ inch and density of about 1.88 to 3.75 lbs./ft.³.

Preferred synthetic fibers used in the batt have a tensile modulus of between 45-60 g.p.d. as measured by ASTM D1380-57T, paragraphs 22-28 and calculated as defined in ASTM D 10 and a Bussé Recovery of between 30-40 as measured by the method described hereinafter.

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Preferably the synthetic fibers are polyester fibers. The fibers preferably have a denier of between 10 and 50 and are crimped to a level of between 3 and 10 crimps per inch.

The batt is bonded and this may be accomplished using a synthetic resin in an amount of 20-50% by weight of the fibers. Densities and thickness limits above recited refer to the batt in its state as adhered to the artificial grass layer. These limitations apply to the bonded structure.

In the mat, the batt is adhered to the artificial grass layer preferably by a latex which is normally used on the underside of carpets. Alternatively, the same resin which may comprise 20-50 by weight of the batt or other relatively elastic, weather-resistant adhesives may be employed.

The artificial playing surface of this invention comprises the aforementioned mat uniformly adhered at the second face of the batt to a well-drained foundation. Preferably the mat is uniformly adhered to the well-drained foundation by a soil stabilizer.

The mat should have a first bounce of between 5 to 25% or less as defined by ASTM D-1564-69 Resilience (Ball Bounce) Test, paragraphs 95-101 and preferably the mat has a first bounce between 10 to 16%. The mat preferably has a third bounce of less than 2%, and most preferably there is no third bounce. Bounce may be affected by the nature of the artificial grass layer, and the batt characteristics as taught hereinafter.

Further, artificial playing surfaces of this invention have minimal lateral transmission of compressive stress thus minimizing any effect on the lie of the ball due to compressive forces exerted on the surface by the player.

DEFINITIONS

By "artificial playing surface" is meant the surface on the ground provided by synthetic materials which substitutes for a natural playing surface, such as grass or turf. This artificial playing surface of the present invention may simulate the ground used in a golf course or football field, but is especially suited for use in golf courses, as discussed and exemplified in greater detail hereinafter.

By "mat" is meant a semi-continuous length of both an artificial grass layer and batt capable of being rolled such as a rug. The mat comprises both an artificial grass layer providing a top surface visible to the player on the artificial playing surface and a batt comprising an under layer.

The "batt" is typically a needlepunched batt but it need only be a nonwoven fabric of staple or continuous filaments of synthetic fibers. The batt has the aforementioned thickness and density.

By "uniformly adhered" is meant that the batt comprising the under layer of the artificial surface and the artificial grass layer are adhered to each other by fusion or adhesive, substantially continuously across the length and width of the mat. Although the points of contact and adherence need not be continuous, they should be no greater than about 3 inches apart and preferably less than about 1 inch apart in both the length and width dimensions of the mat. In part, this proximity of bonding the artificial grass layer to the batt material is believed to obviate the need for stretching the mat material over a well-drained foundation and avoids the "drum head" effect. The adherence may be obtained by fusion or by the use of adhesives applied by spray, roller or brush or other conventional means. This uniform bond-

ing may be accomplished by the application of discrete particles or dots of adhesive or by the application of heat and pressure at such points.

By stating that the batt and the artificial grass layer must be in contiguous contact therewith, it is meant that the second "under" surface of the artificial grass layer (the first face surface simulating grass) and the first surface of the batt are in continuous actual contact with each other in the sense of the uniform bonding heretofore discussed. This contact may be accomplished directly from fiber of one layer to fiber of another layer as by fusion, or by means of an adhesive which may be interposed or intermingled therewith. However, there is no excess length of backing material or artificial grass layer. Wrinkles are avoided.

By "synthetic fibers" is meant those fibers which are classified as man-made fibers in the Textile Products Identification Act of July 3, 1959. It refers to those fibers that are purely of chemical origin.

FIGURES

FIG. 1 is a perspective view of an artificial playing surface of this invention when used as a golf green.

FIG. 2 is a schematic cross-section through the mat of FIG. 1.

FIG. 3 is a cross-section through the artificial playing surface comprising underlying soil.

As shown in FIG. 1, an artificial golf green may be contoured in any desired manner and a cup 1 with flag 2 may be installed at any desired position within artificial surface 3.

In FIG. 2, the construction of a desirable artificial playing surface according to the present invention can be seen to consist of a mat 3 comprising pile fabric 4 which is here shown as a tufted pile fabric in which pile yarns 5 are inserted into backing material 6. Pile fabric 4 is adhered to the upper surface of batt 7 by adhesive 8, which may take the place of the conventional latex which is normally applied to the back of a pile fabric or may be in addition to latex. The batt 7 may then be adhered by adhesive 19 to the upper layer 9 of the foundation. Layer 9 may consist of about 3 inches of loosely compacted asphalt, in which case adhesive 19 will preferably be a bituminous material. Alternatively, layer 9 may be about 3 inches of sand or stone dust treated with soil stabilizer which soaks into the top inch or more of the sand layer to consolidate it. In this case, adhesive 19 will preferably be the soil stabilizer.

FIG. 3 shows a cross-section view of the installed artificial playing surface construction in which mat 3 comprising pile fabric, adhesive and batt is secured to sand layer 9 by soil stabilizer 10. Below the sand layer may be gravel layer 11 and crushed rock 12, providing channels for surface water to flow through the various foundation layers and enter perforations 13 of drainage tile 14. The edges of the artificial surface 3 may be secured by adhesive to wooden members 15 to prevent edge effects. However, the wooden members need not be used to secure the mat in position. An alternative method of anchoring the artificial surface edges is shown at 18, wherein the edges are overgrown with natural grass.

THE INVENTION IN MORE DETAIL

Some suitable synthetic fibers useful in this invention are nylon, acrylic, polyester, polypropylene, or poly-pivalolactone fibers, similar to those used in the artificial grass layer, all as well understood in the art.

By "polyester" is meant a synthetic linear condensation polyester having ester groups in the main polymer chain. Typical of these is the polymeric condensation product of ethylene glycol and terephthalic acid.

The batt may be secured to the artificial grass layer by a latex of a type normally applied to the underside of a carpet to secure the pile tufts into the backing. The prop-

erties of two suitable adhesive materials are listed in Table I.

TABLE I

	"Neoprene" L-400 ¹	SBR ²
Tensile modulus, 600% elongation.....	1,675	375
Tensile strength at break.....	2,875	1,000
Elongation at break, percent.....	800	1,080
Permanent set at break.....	20	32

¹ Chlorinated synthetic rubber.

² Styrenebutadiene rubber.

Alternatively, when the batt is resin bonded the same material used to bond the crossover points of the filaments of the batt may be employed to adhere the batt to the artificial grass layer. An acrylic resin, such as Rohm and Haas HA-16, having a tensile modulus of about 71,000 p.s.i. (about 5,000 kg./cm.²) is typical of preferred resins. A material having a lower melting point than the fiber comprising the structure of the batt may be incorporated in the batt as fibers or as a coating on the batt fibers, and the bonding may be accomplished by heating the structure to use the lower melting component to bond the filaments. Modulus of resin is determined according to ASTM D 412.

Resins having a tensile modulus lower than that of the fiber may be used to bond the batt. The resin should have a modulus sufficient to hold the fibers in substantially the same position relative to each other while at the same time permitting resilience. The modulus should be at least 15 kg./cm.² (210 p.s.i.) equivalent to that of ordinary carpet latex. A resin binder with a 3,000-7,000 kg./cm.² (42,000 p.s.i.-100,000 p.s.i.) tensile modulus is preferred.

The mat comprising the artificial playing surface and the batt backing are adhered to a well-drained foundation and these together comprise a suitable artificial playing surface according to the present invention. This adherence also is substantially uniform and points of adherence of the lower or second face of the batt to the well-drained foundation should be about no more than 1 inch apart. A well-drained foundation is a term understood in the art and may comprise mixed layers of asphalt or stone and sand treated with a soil stabilizer which soaks into the top surface of the sand layer to consolidate it. Alternatively, or in addition thereto, the well-drained foundation may contain under the sand and gravel layers crushed rock providing channels for surface water to flow through the various foundation layers and then through perforations of drainage tiles which may be used to define the periphery of the foundation layer over which the mat is placed. Requirements for a well-drained foundation satisfying the requirements of the present invention are those suitable for the intended use. For a golf course these are set forth in United States Golf Association Green Section Record, U.S.G.A. 1965, I (Nov.).

In the preferred embodiment the material which adheres the batt to the well-drained foundation is also the soil stabilizer.

A preferred soil stabilizer is polyvinyl alcohol preferably gelled with chromic ion, and a most preferred material is polyvinyl alcohol in which gelation time is controlled by the presence of chromic ion together with a water soluble organic acid as disclosed in copending application Ser. No. 831,772, filed June 9, 1969, wherein it is disclosed that polyvinyl alcohol can be gelled at controlled rates to gels having outstanding properties by mixing an aqueous solution consisting essentially of (a) water, (b) polyvinyl alcohol which is at least about 85 mole percent hydrolyzed and has a molecular weight which provides a Hoesppler viscosity of about 4 to 150 centipoises in an amount sufficient to provide a Brookfield viscosity of at least about 20 centipoises, (c) water-soluble chromic salt in an amount sufficient to provide 1 to 100 parts of chromic ion per 100 parts of polyvinyl alcohol, and (d) water-soluble organic acid salt selected

from the group consisting of ammonium, alkali metal and alkaline earth metal salts of organic acids of 1 to 6 carbon atoms. The mixture is sufficient to provide 0.05 to 9 equivalents of organic acid anion per equivalent of chromic ion, with sufficient water-soluble strong alkaline material to provide a pH of at least about 8 and cause gelation of said polyvinyl alcohol within about 10 seconds to 2 hours after mixing. The resulting basic solution contains sufficient polyvinyl alcohol to provide an initial Brookfield viscosity of about 20 to 400 centipoises. The Hoesppler viscosities referred to herein are measured as a 4 percent aqueous solution at 20° C. by the falling ball method using a Hoesppler viscosimeter. Alternative soil stabilizers would be "Petroset," geotechnic emulsions based on SBR rubber, prepared by Phillips Petroleum Company; an acrylamide or an acrylate such as calcium acrylate; or "Siroc" grout, manufactured by Diamond Alkali Company and distributed by Raymond International Distributors, which is a 20-30% silica gel modified with an amide crosslinking reactant probably derived from ethylenediaminetetraacetic acid.

THE ARTIFICIAL GRASS LAYER

The artificial grass layer may comprise a pile fabric 4 which consists of weather resistant materials in both the pile fiber 5 simulating grass and the backing material 6. Suitable materials for pile fibers 5 are nylon, acrylic, polypropylene, or polypivalolactone which may have pigments and materials to stabilize the fibers against ultraviolet light degradation. Pile height is preferably $\frac{3}{16}$ to $\frac{5}{8}$ inch although desired pile height is governed by the intended use of the surface. For golf a surface is preferred which allows the ball to roll straight and uniformly in any direction, lacking much obviously detrimental non-uniformities as all filaments bending in one particular direction of the fabric. Long pile (over $\frac{1}{2}$ -inch finished height) is more likely to have such non-uniform bend (lay) than shorter pile. Pile yarn which has been heat set before tufting is more likely to have lay than yarn which develops crimp during finishing, for equal finished pile heights. The denier of the filaments used in the pile of the artificial grass layer is considerably coarser than normal for carpet uses, 40 to 200 denier and greater being useful where all filaments of the pile are the same denier. Preferably, the pile will comprise filaments as in copending application Ser. No. 46,609, filed June 16, 1970, wherein some filaments are of 200-1500 denier and others are of 6-150 denier and crimped. The larger filaments may have varying cross-sections simulating grass. Such combinations of filaments of different mechanical properties may be used to provide particular degrees of bounce, bite, putting speed, and grass-like appearance. Combinations of filaments having different degrees of retraction during finishing of the fabric provide more than one pile height. If desired, the pile yarn may be heat set before tufting, thereby giving a higher and less dense pile in the finished fabric, providing less bounce for golf balls and more "bite" to shorten the distance a golf ball travels after first impact.

Backing material 6 for the pile fabric is preferably made of weather-resistant synthetic fibers of such polymers as polyester, polypropylene, acrylic, or others, either woven or nonwoven. A fabric woven from black pigmented polyester has particularly low expansion and retraction with changing temperature and humidity and resists degradation.

The pile may be incorporated into the backing comprising the artificial grass surface by weaving, tufting or knitting as is known in the art or cut pile fibers may be attached to a backing by adhesive as in a flocked pile material.

A preferred artificial grass layer according to Ser. No. 46,609, filed June 16, 1970, comprises a fabric comprising a backing and a multiplicity of fibers extending from

said backing in the form of a cut pile layer being secured to the backing by an adhesive, said multiplicity of fibers comprising:

grass-like fibers having a denier per fiber of about 200 to 1500 and a major dimension of cross-section of at least about 0.02 inch, and

crimped fibers having a denier-per-fiber of about 6 to 150,

with the proviso that:

(1) said grass-like fibers and said crimped fibers each comprise at least about 10 weight percent and preferably at least 25% by weight of said multiplicity of fibers, and

(2) the denier-per-filament ratio of the said grass-like fibers to the said crimped fibers is greater than about 8:1 and preferably 10:1.

According to Ser. No. 46,609, the grass-like fibers preferably each comprise a rib and two webs which form a partially folded cross-section, and the crimped fibers have about 10 to 20 crimps per inch. The grass-like and crimped fibers are preferably inserted in the backing fabric as tufts.

The pile fibers of the grass-like layer may be in the form of a combined yarn comprised of first yarn comprising at least one grass-like fiber having a denier per fiber of about 200 to 1500 and a major dimension of cross-section of at least about 0.02 inch, plied together with a second yarn comprising crimped (preferably 6-20 c.p.i.) fibers having a denier per fiber of about 6 to 150, with the proviso that:

(1) said first and second yarns each comprise at least about 10 weight percent and preferably at least about 25% by weight of said combined yarn, and

(2) the denier-per-fiber ratio of the fiber said first yarn to said second yarn be greater than about 8:1 and preferably 10:1.

The pile fibers used in the artificial grass layer to simulate grass according to Ser. No. 46,609, filed June 16, 1970, have a generally elongated shape which may be rectangular in cross-section but may also be oval, diamond-shaped, arcuate, or ribbon-like with a central rib to resist excessive bending and curling. The major dimension of cross-section for these fibers should be at least about 0.02 inch since it has been found that the average human eye cannot distinguish a flattened fiber as grass-like at normal viewing distance if the major dimension is less than that amount. Preferably, the major dimension should be at least 0.03 inch. The lower limit of denier for fibers of such major dimension is about 200.

In order to simulate the randomness of natural grass, it may be desirable to provide more than one denier of grass-like components. Alternatively, the grass-like component may have more than one cross-sectional shape in order to provide a variety of appearance and mechanical properties. The grass-like fiber component should preferably have a relatively low shrinkage, less than 8%, when subjected to finishing operations.

The grass-like fibers may be made from any suitable synthetic polymer by usual spinning techniques. Pigment and materials to protect the polymer from ultraviolet light degradation may be added to the melt. Where the grass-like fibers consist of more than one cross-sectional shape or fiber denier, these components may be produced separately and combined later or they may be spun simultaneously using spinnerets having differently sized or shaped capillaries.

The crimped fibers may be either continuous filament or staple and may have a variety of fiber cross-sectional shapes.

The cross-sectional shape of the crimped fibers preferably should provide good ability to accept and form crimp, to develop or intensify crimp during the scouring or dyeing operation, and to provide the desired resilience, resistance to matting, firm support for the grass-like fibers,

friction, and the other necessary properties. Round and trilobal are among the preferred shapes.

The crimped fibers preferably should not draw down tightly against the backing but should remain in a somewhat extended condition to resist compressive load applied more or less axially to the general direction of the fiber. Since compressive resilience is desirable, filaments whose cross-section has not been deformed severely by the crimping operation are particularly useful. This combination of requirements is best met by products of U.S. 3,186,155 or ones made by the process of U.S. 3,156,028. The crimped fibers may be spun on conventional equipment and subjected to conventional crimping operations. Crimpable fibers may be produced by introducing differential strains into the fibers at the time of spinning, or two or more polymers having different shrinkage properties may be combined into a single fiber. These fibers may be used either as continuous filament or may be cut to staple and spun by usual methods.

The combined yarn should be formed of particular percentage and denier combinations of the grass-like fibers and multifiber strands of crimped and/or crimpable fibers described.

When the grass-like fiber constitutes at least 10 weight percent of the pile yarn (and therefore results in the same weight percent of the pile surface of the fabric), the appearance of the pile fabric appears grass-like (rather than carpet-like) and the mechanical and frictional properties change. The most significant improvement in such properties are seen when the preferred amount, about 25 to 75 weight percent of grass-like fibers are utilized.

One or more of the grass-like fibers may be combined with an appropriate multifiber strand of crimped and/or latently crimpable fibers, preferably by ply-twisting on conventional plying equipment. When a large number or denier of grass-like fibers is employed, it is preferable to ply-twist half of the grass-like fibers with half of the multifiber yarn and ply two of these yarns together with opposite-hand twist, thus producing a combined yarn which is not twist-lively. When more than two levels of pile are desired, two or more yarns which have been crimped or made crimpable by different processes or two different crimp levels may be utilized so that they will retract to different degrees. Yarns which have been crimped or made crimpable by the same process to the same degree may be tensioned by different amounts after crimping so that the fibers of one yarn are practically straight while those of the other have substantial crimp. When these yarns are plied at the same tension, the yarn having the most crimp will extend more than the other, and after the pile is cut, one will retract more than the other on release of tufting tension.

Yarns of Breen and Lauterbach U.S. 2,985,995 or Weiss and Prokesch U.S. 3,156,028 produced under equal bulking conditions may be treated with different amounts of water or finish under different tensions as described in Williams U.S. 3,271,943 to produce yarns having different degrees of retraction.

Pile fabric for use as the artificial grass layer of this invention may be made by weaving, tufting, knitting, or the process of Koller U.S. Pat. No. 3,085,922. The term "pile fabric" as used herein and generally in the art, refers to a fabric with a pile surface; the pile comprises raised loops of fibers which are cut herein and the cut loops form all or part of the surface of the fabric. The yarn used in forming the pile is generally referred to as a "pile yarn." Since tufting is the generally preferred method for preparing fabrics for economic reasons, the preparation of tufted pile fabrics will be illustrated hereinafter. Combined yarn is fed through the needles of a tufting machine and is inserted through a backing material, forming pile loops which are then cut by knives to form a "cut pile fabric." If desired, the cutting knives may be adjusted to cut one leg of the loop slightly longer than the other or at an angle so that the grass-like fibers will

have somewhat random lengths in the final product, simulating the usual randomness of cut grass.

After the fabric has been produced, it may be scoured or dyed in water near the boiling point. At this time, crimped fibers which have been partially straightened by the tensions of drafting and spinning in the case of staple fibers or by the tensions of winding and tufting, in the case of continuous filaments, may recover a substantial portion of their previous crimp. Crimpable fibers develop crimp at this time through release of strains imposed during the spinning operation or through differential shrinkage of the individual components of a multicomponent fiber. If pigment is not introduced into the polymer of all components at spinning or if additional shading is desired, the finished fabric may be dyed. The grass-like and the crimpable fibers may accept different amounts of dye and thus dye to different intensities of the same dye color or they may accept different kinds and colors of dyes in a mixed dye bath.

After the fabric is dried, latex, foam, or other adhesive material is applied to the underside of the fabric to secure the pile fibers to the backing and prevent slippage or extraction of fibers. Latex is usually cured in an oven; and if a fabric has not been scoured or dyed, the crimp is developed at this time. Neither the backing nor the adhesive material is critical herein; any conventional material of this type can be used.

When pile fabric for use as the artificial grass layer in this invention is made by the tufting method, it is desirable to use a backing material which is sufficiently resilient to close on the yarns after the tufting needle is withdrawn and to grip the fibers so that they will not slip through the backing before they have been secured by latex or other tuft-anchoring treatment. Backing materials composed in whole or in part of nonwoven fiber mats, resilient foams, or closely woven ribbon fibers are preferred.

Particular frictional properties of the artificial grass layer may be obtained, for example, by using relatively slippery grass-like fibers and high-friction multifiber yarns, employing a larger proportion or greater pile height of the multifiber yarn if greater friction is desired. The resilience as it is affected by the artificial grass layer may be selected in a similar manner, so that both the height to which a ball bounces and the degree to which its forward progress is slowed upon contact with the layer may be predetermined by the properties of the different components, their proportions, and their pile heights.

The appearance of the surface of the artificial grass layer of this invention can be greatly improved by differential coloration of the components. The crimped fibers are preferably a different shade of green from the grass-like fibers or may be a different color such as black or brown. In natural turf, new growing grass blades have a yellowish cast; healthy mature underturf, a deep green or blue-green; and dead stalks and clippings have shades of brown. A dense underturf appears dark. Therefore, it has been found that one desirable combination is a fabric consisting of grass-like fibers of two shades of green, with an underturf in deeper green, blue-green, brown, or black. Another desirable color combination consists of grass-like fibers in a yellow-green shade simulating rapidly growing grass with the underturf in deep blue-green. A third combination is similar except that the underturf consists of a mixture of deep blue-green fibers and black fibers. In the case of fabrics having two-level underturf, the grass-like fibers may, for example, be yellow-green, the higher underturf blue-green, and the lower level black. As the difference in pile heights between the grass-like and other fibers is reduced, color or luster contrast between the two species becomes increasingly desirable. In a fabric having no difference in pile heights, color or luster, the grass-like fibers are difficult to see and the fabric looks more like carpet than turf. However, if the

grass-like fibers of such a fabric are made more lustrous than the others by providing a smooth reflecting surface or by providing a concave filament surface to concentrate reflected light, the grass-like nature of the fabric begins to be evident. Color contrast, either alone or combined with luster contrast and pile height difference, further enhances the simulation of turf.

THE BATT

The batt may be prepared from synthetic fibers in a form such as crimped staple which are assembled into a sheet several inches thick by a method such as cross-lapping as known and the sheet may be then consolidated by a method such as needle punching. Polyester filaments are particularly suitable as a material for forming the needled batt because of their high modulus but relatively low recovery rate. Several suitable filamentary materials are compared in Table II.

TABLE II

	66 nylon	Dacron® polyester	Orlon® acrylic	Polypropylene
Modulus, grams per denier.....	15-25	45-60	6-10	4-8
Bussé recovery, percent.....	99	34	48	46

Bussé Recovery is determined by cutting the filamentary material into sections ¼-inch long (.635 cm.) and stuffing them into a small cylinder 3.1 inches long and 0.511 inch in diameter. The cylinder is placed with the open end up and a wooden dowel 7 to 8 inches long and .45 to .50 inch in diameter, weighing 17±.5 gram, is inserted into the cylinder. The initial height of the fibers under this load is determined by marking the position of the dowel and calculating the height of the fiber mass. The dowel is removed and a steel piston 2.9 inches long and 0.510 inch diameter is inserted into the cylinder. The cylinder and piston are placed in a hydraulic press and compressed to 10,000 pounds per square inch (703 kilograms per square centimeter) and pressure is maintained for 1 minute. The compressed pellet of filamentary material is then removed from the cylinder and the height of the pellet is measured immediately and then measured again 24 hours later. The Bussé Recovery in percent is calculated by dividing the specimen height after 24 hours of recovery by the original height, as determined by the wooden dowel, multiplied by 100.

The batt is then treated to bond the fibers. "Bonding" has its usual meaning in the art—substantially adhering the fibers in the batt to neighboring fibers to minimize shifts in position of the fibers relative to each other.

Under repeated loadings batts which are not bonded are more prone to "creep" with attendant reduction in thickness and changes in resilience. One method for accomplishing this is to spray the batt vigorously with a material which, when dry, forms a relatively elastic, weather-resistant bond between filaments throughout the entire thickness of the batt.

One practical effect of the lower density batt of this invention is that rain water is apparently not retained in the interstices of the batt sufficiently to create an appreciable difference in playing behavior between wet and dry conditions resulting from such "held water" in the batt.

The resilience of the artificial surface depends upon the combined properties of the artificial grass layer 4, the batt 7, and the adherence of the batt to both the grass layer and the foundation. Changes in pile fiber, choice of fiber for the batt, the nature of binder all contribute to the feature of this invention as hereinbefore discussed.

The nature of the adhesive 8 and the soil stabilizer 10, and the extent to which adhesive 8 and soil stabilizer 10 penetrate and stiffen the fibrous mat 7 may also affect the resilience.

THE FOUNDATION

The batt must be bonded to the artificial grass layer

and the foundation. The fibers of the batt and artificial grass surface may be bonded to each other with adhesives.

Adhesives 8 and 19 may be applied in a continuous coating by spray, roller or brush. Alternatively, adhesive may be applied as discrete particles or dots by a coarse spray or roller or as strips by brush or roller. Such application will provide pores for water to drain through to the sub-soil. However, points of adhesion whether with adhesive or caused by heat and pressure should be spaced no further apart than about 1 inch.

In preparing for the installation of artificial playing surface, the soil is first contoured and excavated, leaving sufficient depth for the installation of the drainage tile, gravel, and sand layers. The drainage tile 14 is then installed with gravel layer 12 around it. Wooden members 15, if desired, are installed around the edges of the green; gravel layer 11 and sand layer 9 are then installed, compacted, and graded to final contour. Soil stabilizer 10 is then sprayed or otherwise applied to the surface of sand layer 9 in sufficient volume to penetrate about 1 to 3 inches into the sand layer surface. Soil stabilizer 10 may be polyvinyl alcohol or other commercial material such as poly N,N-dimethyl acrylamide. Soil stabilizer coheres the sand particles sufficiently to prevent permanent deformation or displacement of the sand during use and provides a solid base to which the artificial surface materials may be adhered. In a particularly useful soil stabilizer, a gelled polyvinyl alcohol whose gelation may be controlled by a cross-linking agent if desired is used.

If asphalt is to be used in lieu of soil stabilizer as the bonding agent between batt and foundation, approximately 3 inches of crushed stone treated with asphalt is spread on top of the sand in the foundation and compacted lightly.

Playing surfaces of this invention are typically contoured so that water from heavy rain may run off the surface. However, soil-stabilized sand provides sufficient pores so that water which has penetrated the fibrous mat can drain into the sub-soil.

When an artificial surface of this invention is adhered to the foundation, care is taken to avoid stretching it. However, sufficient force should be applied to provide a uniform and unrippled playing surface when adhering the mat to the foundation to complete the artificial playing surface.

In the examples which follow all parts are by weight unless otherwise indicated.

EXAMPLE I

Pile fabric is prepared by conventionally tufting bulked 3300-denier 22-filament continuous filaments of nylon 66 into woven Dacron® polyester backing at 34 ounces of pile fiber per square yard to give a pile face yarn weight of 27 to 28 ounces per square yard. The polymer melt contains Monastral green GT-751-D (Du Pont) pigment and Meteor yellow buff 7370 (Harshaw) pigment blended to give a yellow-green shade. The yarns are crimp-set by heating in an autoclave at 300° F. for 30 minutes before tufting. The pile height as tufted varies between ⅞ to ⅝ inch. The fabric is then mock dyed in hot water at 100° C., after which the dried fabric is treated on the backing with a soft (less than 30% filler) styrenebutadiene carpet latex and the pile is sheared to ⅝ inch pile height. This pile fabric is adhered by means of the same carpet latex to the upper surface of a needled bonded Dacron® polyester nonwoven batt. The batt is prepared by forming a carded web of 2-inch long Dacron® polyester staple fibers of 25 denier per fiber which have been crimped to 4-5 crimps/inch in a stuffer box. The Bussé Recovery of the fibers is 34%. The web is fed to a cross-lapper mechanism which distributes about 12 cross laps, of a total of 3½ to 4 inches thick and approximately 1.9 ounces per square foot density. The batt passes once through a needle loom set to give 65 punches per square inch at ⅞ inch depth of penetration,

the final thickness of the mat being $\frac{3}{4}$ inch. An acrylic resin having a tensile modulus of about 5,000 kg./cm.² (about 71,000 p.s.i.) is diluted to 23% solids and applied by a traversing high pressure spray head to the upper surface of the mat during two passes through the spray equipment, a portion of the material penetrating to the bottom of the mat but the greatest amount being concentrated near the upper surface, and the resin is then cured for 10 minutes in an oven at 325° F. The mat is turned over and passed twice through the resin spray and once through the oven, as above. The total resin is approximately 26% by weight of the mat, making the final density of mat plus resin 2.3 lbs./ft.³ (0.037 gms./cc.). The resin bonds the fibers together. A golf green foundation is prepared by excavating the soil to the desired depth, laying drain tile with 4 inches of crushed rock, adding a 4-inch layer of gravel and a 4-inch layer of sand, topped by 3 inches of lightly compacted asphalt. The fibrous mat with the pile fabric attached is adhered to the upper surface of the asphalt with bituminous sealer applied with a roller.

Bounce data were determined by a vertical drop test and by an angle approach shot on a relatively level section of artificial golf green. The data obtained when a hard foundation is used approximate the results of laboratory testing on the mat alone. On the vertical drop test the first bounce was 15 to 28% of the drop height, with an average of about 20% observed in 10 drops. Second bounces were less than 5% and averaged 2.5 to 3%. Third bounces were essentially zero. When using first angle approach shots, damping of the bounce was observed to be about the same as in the vertical drop test. The shots took a maximum bite on the second bounce, which is characteristic of a good grass golf green. The third bounce essentially terminated the bounce and roll, indicating acceptable bite and damping, and is similar to the behavior of a good natural grass green.

EXAMPLE II

Pile fabric is prepared by tufting 2600-denier 26-filament bulked continuous 66 nylon into nonwoven backing of continuous filament polypropylene generally as described in U.S. Pat. 3,502,538 tufted at 32 ounces per square yard to give 26 ounces of pile face yarn per square yard. The pile height is $\frac{1}{16}$ to $\frac{5}{8}$ inch as tufted. The tufted fabric is dyed with Anthraquinone GNN and Lanasyne yellow 3GL in a hot dye bath at about 100° C. where the pile yarn contracts by crimp development to give a pile height of $\frac{7}{16}$ to $\frac{1}{2}$ inch. The pile surface is

sufficiently even not to require shearing, 900–1000 gms./yd.² of latex SBR containing 40% inert clay is applied to the back of the fabric; and while the latex is still wet, the fabric is pressed against the upper surface of the same type fibrous mat as in Example I. The foundation is prepared in the same manner as in Example I except that the sand layer is approximately 7 inches deep and the top 2 to 3 inches of sand is stabilized with polyvinyl alcohol cross-linked with Chromic ion in which gel time was controlled as described in copending application Ser. No. 831,772, filed June 9, 1969. The lower surface of the fibrous mat is sealed to the sand layer by pressing the mat onto the sand while the Elvano® is wet (amount of bonding contact). The first bounce of the surface (installed) is found to be between about 8 and 15%.

What is claimed is:

1. In an artificial grass mat having an upper cut pile layer of nylon fibers tufted through a backing fabric to form a grass-like surface, the improvement for providing resilience characteristics of a high-quality natural golf green wherein the improvement comprises a cut pile layer, having a nylon pile $\frac{3}{8}$ - to $\frac{1}{2}$ -inch in height and weighing about 27 ounces per square yard, uniformly adhered to the upper surface of a needled nonwoven batt about $\frac{3}{8}$ - to $\frac{3}{4}$ -inch thick composed of 10 to 50 denier polyethylene terephthalate fibers, having 3 to 10 crimps per inch and a Bussé Recovery between 30 and 40, bonded in position with acrylic resin in an amount of 20 to 50 percent by weight of the fibers in a batt having a density of about 1.88 to 3.75 pounds per cubic foot to provide a durable grass mat having a first bounce height averaging 10 to 25 percent in the ball bounce test and essentially zero bounce after a second bounce.

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