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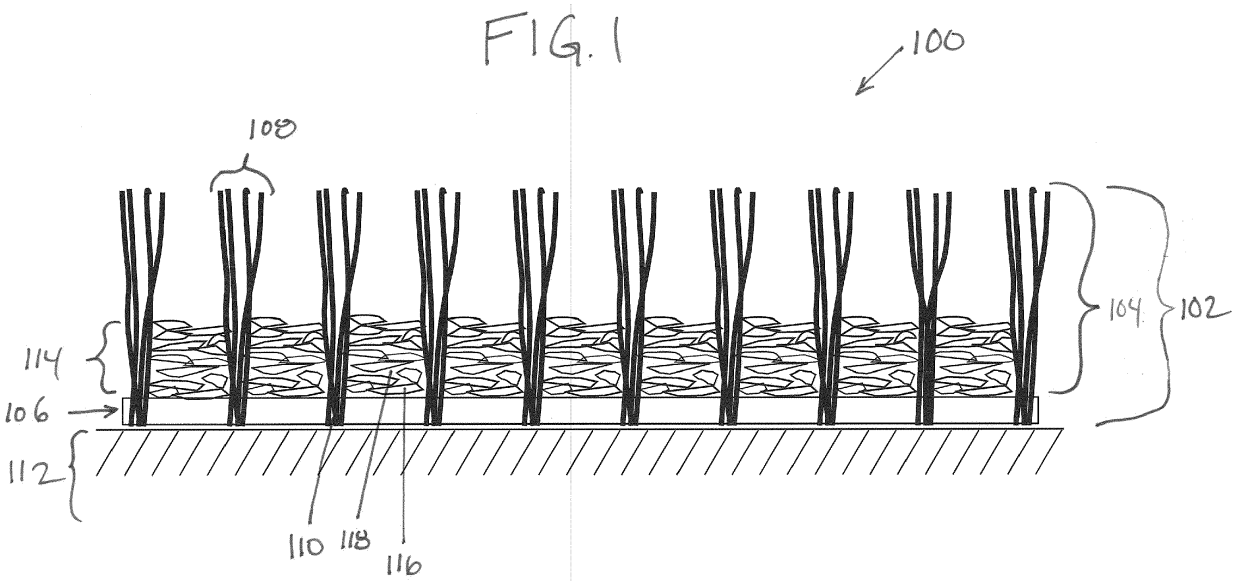
(54) **ARTIFICIAL TURF COMPRISING AN AGGLOMERATE INFILL**

(57) The invention provides for an artificial turf surface (100, 200) comprising an artificial turf carpet (102) with a pile (104), wherein the artificial turf carpet comprises a backing (106). The artificial turf carpet further comprises artificial grass fibers (108). The artificial grass fibers are tufted (110) into the backing. The artificial grass fibers form the pile. The artificial grass fibers are secured to the backing. The artificial turf surface further comprises an artificial turf infill (114) distributed within the pile, wherein the artificial turf infill comprises irregularly shaped grains (116), wherein the grains comprise an agglomerate comprising at least one type of non-elastomeric thermoplastic. At least a portion of the grains have fibrous extensions (302).

FIG. 1



EP 3 272 939 A1

Description

Field of the invention

[0001] The invention relates to artificial turf, in particular to artificial turfs with infill and also infill for artificial turf.

Background and related art

[0002] Artificial turfs are known as a carpet structure resembling natural grass. The structure consists of a fabric to which fibers are tufted and fixed at the bottom side of the fabric. The fibers are monofilamented or twisted yarns of polyethylene or other thermoplastic materials. The fabrics are woven goods made of polypropylene and the fixing material which glues the fibers to the fabric are mixtures of SBR latices and fillers such as calcium carbonate or polyurethane-based adhesives.

[0003] Artificial turfs are used as sports fields whereas the carpets are laid onto a substructure of rubber granules acting as a shock damping layer or onto a substructure that comprises an elastic layer (e-layer). The carpet structure is filled with sand and rubber granules in order to keep the structure in place so that the carpet does not slip and the fibers stay in an upright position. The filling material is also referred to as infill or infill material. Typically in use is SBR-rubber or EPDM-rubber, both elastomeric materials in irregularly granulated form. The SBR-rubber is commonly sourced from used tires.

[0004] An advantage of using artificial turf is that it eliminates the need to care for a grass playing or landscaping surface, like regular mowing, scarifying, fertilizing and watering. Watering can be e.g. difficult due to regional restrictions for water usage. In other climatic zones the re-growing of grass and re-formation of a closed grass cover is slow compared to the damaging of the natural grass surface by playing and/or exercising on the field. Artificial turf fields though they do not require a similar attention and effort to be maintained, may require some maintenance such as having to be cleaned from dirt and debris and having to be brushed regularly. This may be done to help fibers stand-up after being stepped down during the play or exercise. Throughout the typical usage time of 5-15 years it may be beneficial if an artificial turf sports field can withstand high mechanical wear, can resist UV, can withstand thermal cycling or thermal ageing, can resist inter-actions with chemicals and various environmental conditions. It is therefore beneficial if the artificial turf has a long usable life, is durable, and keeps its playing and surface characteristics as well as appearance throughout its usage time.

[0005] The infill of synthetic turfs plays a predominant role concerning the mechanical properties of the complete turf structure. These properties determine the damping of a bouncing ball and running or jumping athletes. It is also desirable that the uppermost structure of a turf would not cause injuries of the athletes, such as burns, scratches, skin abrasions, etc. Filling a synthetic turf only with sand would have an unpleasant effect of energy-sapping, comparable to running on dry sand on a beach. To avoid such uncomfortable attitudes infill systems are commonly in use. At least two layers built up such infill systems, whereas the sand layer is laid first on top of the carpet topping (the opposite side of the backing) and a second layer or elastomeric material laid onto the sand. The elastomeric material normally consists of ground rubber, whereas the particles are coarser than the sand grains. The thickness of an infill system is such that only a small proportion of the grass fibers exceed the infill layer in height. The complete structure then resembles freshly mowed natural grass.

[0006] The FIFA (Federation Internationale de Football Associaton) has set up quality standards in their 'Quality Concept for Football Turf, Handbook of Requirements, January 2012 Edition.' In this handbook, the standards are described as well as the test methods. For synthetic turf infill systems, the following holds:

- force reduction: 60 % - 70 %
- vertical deformation: 4 mm - 10 mm
- rotational resistance: 30 Nm - 45 Nm

all of which in dry and wet condition and after simulated wear.

[0007] According to the FIFA standards the tests are carried out with a so-called advanced artificial athlete - Triple A, a Lisport wear tester and a rotational resistance tester. Artificial turf or artificial grass is surface that is made up of fibers which is used to replace grass. The structure of the artificial turf is designed such that the artificial turf has an appearance which resembles grass. Typically, artificial turf is used as a surface for sports such as soccer, American football, rugby, tennis, golf, for playing fields, or exercise fields. Furthermore, artificial turf is frequently used for landscaping applications.

[0008] Artificial turf may be manufactured using techniques for manufacturing carpets. For example, artificial turf fibers which have the appearance of grass blades may be tufted or attached to a backing. Often times artificial turf infill is placed between the artificial turf fibers. Artificial turf infill is a granular material that covers the bottom portion of the

artificial turf fibers. The use of artificial turf infill may have a number of advantages. For example, artificial turf infill may help the artificial turf fibers stand up straight. Artificial turf infill may also absorb impact from walking or running and provide an experience similar to being on real turf. The artificial turf infill may also help to keep the artificial turf carpet flat and in place by weighting it down.

[0009] United States patent application US 2010/0151158 discloses a method for recycling synthetic turf that includes agglomerating a plurality of synthetic turf fragments and extruding the agglomerated material. The method produces a recycled material for use as infill in a synthetic turf. The agglomerate is extruded and may be in a spherical, cylindrical, oval, or football shaped. The pellets may also be of an irregular shape. The irregular shape may be used to aid tight packing of the granules.

Summary

[0010] The invention provides for an artificial turf surface, a method, and the use of an agglomerate as infill for artificial turf. Embodiments are given in the dependent claims.

[0011] Examples may provide for an artificial turf infill that is at least partially made from an agglomerate comprising one or more non-elastomeric thermoplastics. The agglomerate is formed into irregularly shaped grains. A "grain" as used herein encompasses a small part or portion of a material that is hard.

[0012] Normally, non-elastomeric thermoplastics would be too hard and rigid to use as an artificial turf infill. However, forming them into grains that have fibrous extensions makes them flexible. When the grains are distributed in the pile of the artificial turf, the grains have a tendency to pack loosely because of the fibrous extensions. This produces voids or free space between the grains which makes the resultant infill more elastic although it has been manufactured from non-elastomeric thermoplastics.

[0013] In various examples, the agglomerate may be formed my one or more non-elastomeric thermoplastics and an additional additives such as a pigment powder.

[0014] In some examples, the artificial turf infill that is at least partially made from an agglomerate of at least two non-elastomeric thermoplastics.

[0015] In other examples, material used to form the artificial turf infill is provided as an agglomerate. An extrusion process or an agglomeration process is then used to form the material into the grains with fibrous extensions.

[0016] In one aspect, the invention provides for an artificial turf surface comprising an artificial turf carpet with a pile. The artificial turf carpet comprises a backing. The artificial turf carpet further comprises artificial grass fibers. The artificial grass fibers are tufted into the backing. The artificial turf grass fibers form the pile. The artificial grass fibers are secured to the backing.

[0017] The artificial turf surface further comprises an artificial turf infill which is distributed within the pile. The artificial turf infill may also be described as being distributed between the artificial grass fibers. The artificial turf infill comprises irregularly shaped grains. The grains comprise an agglomerate comprising at least one type of non-elastomeric thermoplastic. Alternatively the grains can be described as comprising an agglomerate comprising at least one type of non-elastomeric thermoplastic. At least a portion of the grains have fibrous extensions.

[0018] In some examples all or a majority of the grains have the fibrous extensions. In other examples at least 40% 50%, 60%, 70%, 80%, or 90% of the grains have the fibrous extensions. A fibrous extension as used herein encompasses a region of the grain that is substantially narrower than another portion of the grain. The material of the grain may be rigid, but the fibrous extension is narrow enough that the fibrous extension is able to flex or bend.

[0019] The use of the irregularly shaped grains as the artificial turf infill may have several benefits. One potential benefit is that the non-elastomeric thermoplastics can be used. Normally the artificial turf infill is made up of an elastomeric material or material which is easily pushed aside so that the artificial turf surface has lifelike properties such as mimicking the give of a real turf surface which has dirt or sand within it. The irregularly shaped grains have the benefit that there may be air pockets and the packing ratio of the artificial turf infill is reduced. This allows the hard non-elastomeric thermoplastics to be used and still have the properties which realistically mimic a real turf surface.

[0020] In another embodiment, the at least one type of non-elastomeric thermoplastic is viscoelastic at temperatures below 100° C.

[0021] In another embodiment, the at least one type of non-elastomeric thermoplastic comprise recycled artificial turf fibers. Recycled artificial turf fibers are equivalent to artificial grass fibers. The recycled artificial turf fibers are artificial turf fibers which have been removed from a previously installed artificial turf surface. The use of the non-elastomeric thermoplastics from recycled artificial turf fibers may have the benefit that the reuse of the thermoplastic reduces the amount of waste which is deposited in landfills. It may also have the benefit that the recycled artificial turf fibers may have additives which would be useful for the artificial turf infill. For instance, the recycled artificial turf fibers may be colored green. Having the artificial turf infill a green color may be beneficial in making the artificial turf surface more lifelike looking. It may also have the benefit that the recycled artificial turf fibers have other additives such as UV protection which will increase the longevity of the artificial turf infill.

[0022] In another embodiment, the irregularly shaped grains have a longitudinally stretched out and curved volume expansion with ratios of length to diameter/cross sectioned within 1 :2 to 1:50.

[0023] In another embodiment, the irregularly shaped grains have a sieve size between 0.2 mm and 12 mm. In this embodiment the irregularly shaped grains have been selected such that they pass through a first sieve with an opening of 12 mm or less. The irregularly shaped grains are further selected such that they are captured by a sieve with openings of 0.2 mm or greater. The opening of the first sieve remains greater than the opening of the second sieve.

[0024] In another embodiment the irregularly shaped grains have a sieve size below 12 mm. In this embodiment the irregularly shaped grains have been selected such that they pass through a sieve with an opening of 12 mm or less.

[0025] In another embodiment, the irregularly shaped grains have a thickness between 0.5 mm and 2 mm.

[0026] In another embodiment, the at least one type of non-elastomeric thermoplastic comprise any one of the following: at least one thermoplastic polymer, a polyolefin, waste plastic, fibrous waste plastic, pre-consumer yarn, post-consumer yarn recovered from synthetic sports fields, artificial turf fiber, recovered waste plastic, recycled packaging material, poly ethylene food packaging, poly ethylene, polypropylene, a poly ethylene and poly propylene mixture, LLDPE, HDPE, LDPE, MDPE, PP, PE, a polyolefin, and combinations thereof. This embodiment may be beneficial because thermoplastic which would normally be disposed of may be used for manufacturing a high quality artificial turf surface.

[0027] In another embodiment, the artificial turf surface further comprises a sand layer between the backing and the artificial turf infill. The use of the sand layer between the backing and the artificial turf infill may further serve to improve the replication of natural turf surface properties by the artificial turf surface. The use of the sand layer may also reduce the amount of artificial turf infill which is required to be used.

[0028] In another embodiment, the majority of the irregularly shaped grains have a curved profile. The curved profile may be in a cross-sectional view of the irregularly shaped grain. Having a curved profile may be beneficial because it may reduce how closely the irregularly shaped grains can be packed next to each other. Having them less dense may be beneficial because the artificial turf infill will have a more springy or elastic profile although the agglomerate is made of a non-elastomeric thermoplastic.

[0029] In another embodiment, the fibrous extensions of the irregularly shaped grains interlock with any one of the following: the artificial grass fibers, the fibrous extensions of other irregularly shaped grains, and combinations thereof. This embodiment may be beneficial because the interlocking of the fibrous extensions may serve to hold the irregularly shaped grains in the same position with respect to each other, and also possibly to help hold their position relative to the artificial grass fibers. This may for example have the benefit of reducing the splash effect when a ball hits an artificial turf surface. Splash is when the impact of a ball or other object causes artificial turf infill to fly up above the surface of the artificial turf surface. It resembles the splash of an object hitting a puddle of water.

[0030] In another embodiment, at least a portion of the fibrous extensions are branched. The branching of the fibrous extensions may be beneficial because it may make the fibrous extensions more flexible. The branching may also produce hook like structures that enable the irregularly shaped grains to better interlock either with themselves or artificial grass fibers.

[0031] In another embodiment, the artificial turf surface further comprises a top infill layer. The irregularly shaped grains are between the backing and the top infill layer.

[0032] In another embodiment, the top infill layer comprises regularly shaped granules. The regularly shaped granules may for example have round, oval, a rounded, or bead shaped appearance. The use of the regularly shaped granules may be beneficial because it may have the effect of reducing the friction between an object sliding on the artificial turf surface and the irregularly shaped grains.

[0033] For example, the regularly shaped grains could be made from an agglomerate that is similar or has an equivalent composition to the irregularly shaped grains. In other examples the regularly shaped granules could be made from a elastomeric compound such as crumb rubber or other materials conventionally used as artificial turf infill. For example, the elastomeric granulates used for artificial turf infill could be placed on the surface artificial turf infill formed by the irregularly shaped grains. This may reduce the amount of elastomeric granulates that are used. As a smaller amount of the elastomeric granulate is used, it may reduce the splash effect when a ball or other object impacts the artificial turf surface.

[0034] In another embodiment, the regularly shaped granules comprise any one of the following: a least one thermoplastic polymer, a polyolefin, waste plastic, fibrous waste plastic, pre-consumer yarn, post-consumer yarn recovered synthetic sports fields, artificial turf fiber, recovered waste plastic, recycled packaging material, poly ethylene food packaging, EPDM, LLDPE, HDPE, LDPE, MDPE, PP, PE, a polyolefin, an elastomeric compound, rubber, crumb rubber, and combinations thereof.

[0035] In another embodiment, the top infill comprises elongated granules. In some examples, the elongated granules may comprise an elastic or flexible material. The use of the elongated granulates in the top infill may have several advantages. First, the elongated shape may help the top infill to remain above or covering the infill made from the irregularly shaped grains. The elongated shape may, in some examples, result in less friction between a person or object sliding on the artificial turf. The use of the elongated granules may also reduce the splash effect when a ball or other

object impacts the artificial turf surface.

[0036] In another embodiment, the elongated granulate are formed from any one of the following: an elastomeric compound, shavings from a block of an elastomeric compound, rubber, crumb rubber, EPDM, and combinations thereof.

[0037] In another embodiment the elongated granulate are shavings formed from a block of an elastomeric compound. The use of the shavings from an elastomeric compound may make the artificial turf surface appear more realistic. The use of shavings from an elastomeric compound may also make the shaving have a fiber like structure that helps to keep them in place and reduce the splash effect.

[0038] In another embodiment, the artificial turf surface further comprises a sand layer between the backing and the artificial turf infill. The artificial turf surface further comprises a top infill layer, wherein the irregularly shaped grains are between the backing and the top infill layer. The top infill comprises irregularly shaped granulate. The irregularly shaped granulate comprises shavings from a block of an elastomeric compound. This embodiment may be beneficial because the irregularly shaped granulate may provide shock absorbency and also may reduce the friction between an object sliding on the artificial turf surface and the irregularly shaped grains.

[0039] In another aspect, the invention provides for a method of manufacturing an artificial turf system. An artificial turf system as used herein encompasses the components which are supplied to manufacture an artificial turf surface.

[0040] The method comprises providing an artificial turf carpet with a pile. The artificial turf carpet comprises a backing. The artificial turf carpet further comprises artificial grass fibers. The artificial grass fibers are tufted into the backing. The artificial grass fibers form the pile surface. The artificial grass fibers are secured to the backing.

[0041] The method further comprises agglomerating the at least one type of non-elastomeric plastic into an agglomerate for forming irregularly shaped grains to provide an infill for the artificial turf carpet.

[0042] In another embodiment, the agglomeration of the at least one type of non-elastomeric thermoplastic into the agglomerate and the forming of the irregularly shaped grains form the agglomerate is performed using an agglomerator. An agglomerator as used herein is a device which applies heat and pressure to agglomerate multiple thermoplastics into a single structure. The agglomerator may also cut or break the agglomeration into the irregularly shaped grains.

[0043] The use of an agglomerator may be beneficial because it may provide for an inexpensive means of manufacturing irregularly shaped grains.

[0044] In another embodiment, the agglomerator is a friction agglomerator. The friction agglomerator may have one or more moving portions which use friction to generate the heat necessary to form the agglomerate.

[0045] In another embodiment, the agglomerator is a disc agglomerator. The disc agglomerator may have one or more rotating discs which receive the heated non-elastomeric thermoplastic and agglomerate them into the agglomerate and form the irregularly shaped grains at the same time.

[0046] In another embodiment, the forming of the irregularly shaped grains from the agglomerate is performed using an extruder. The use of an extruder may be beneficial because the properties of the irregularly shaped grains may be precisely controlled. An extruder as used herein encompasses a device which heats the at least one type of non-elastomeric thermoplastic and then forces them through an orifice to extrude them. There may also be a device which cuts the extruded agglomerate into the irregularly shaped grains. The material extruded from the extruder may be referred to as an extrudate. However, the extrudate is the agglomerate.

[0047] In another embodiment, the extruder comprises any one of the following: an underwater pelletizing system, a water ring pelletizing system, a strand pelletizing system, and a hot-cut pelletizing system.

[0048] In another embodiment, the extruder optionally comprises a pelletizer or granulation system to additionally form the shape of the irregularly shaped trains.

[0049] In another embodiment, the forming of the irregularly shaped grains is performed using an extruder. The use of an extruder may be beneficial because it may allow for precise control of the properties of the irregularly shaped grains such as the length, the amount of curvature of the grain, and the relative size distribution.

[0050] In another embodiment, the extruder comprises an extrusion die plate. The extrusion die plate has at least one orifice for extruding the agglomerate. The at least one orifice has a first portion and an opposing portion. The first portion is rough. The opposing portion is smooth to form irregularly shaped grains that have a curved profile. The first portion, which is rough, causes a breaking or slowing effect as the agglomerate is extruded. This causes the resulting irregularly shaped grain to have a curved profile. This may be beneficial in that it may cause the irregularly shaped grains to pack less densely. This may cause them to have a more elastic behavior although they are made from a non-elastomeric thermoplastic.

[0051] In another embodiment, the extruder comprises multiple orifices. The multiple orifices have at least two distinct sizes. This embodiment may be beneficial because the size distribution of the irregularly shaped grains and their relative frequency can be precisely controlled.

[0052] In another embodiment, the multiple orifices may have an irregular shape or profile. The use of the irregular shape or profile may have the benefit of producing grains of agglomerate that are irregularly shaped.

[0053] In another embodiment, the extruder comprises a cutting system for cutting irregularly shaped grains.

[0054] In another embodiment, the cutting system of the extruder is configured for producing irregularly shaped grains

with varying lengths. This may for instance be achieved by controlling how often the cutting system cuts off extrudate (the agglomerate) that is being extruded. By varying the times between when the agglomerate is cut or choosing a distribution of times the relative size distribution of the irregularly shaped grains can be controlled.

[0055] In another embodiment, the method further comprises mixing at least one additive into the agglomerate before forming the irregularly shaped grains. This may be beneficial in adding various properties to the irregularly shaped grains such as flame retardants, UV protection, or dyes to color to change the appearance of the artificial turf infill.

[0056] In another embodiment, the at least one additive comprises any one of the following: a colorant or dye, a UV stabilizer, a flame retardant, a filler, a blowing agent, an anti-seize agents, a lubricant, compatibilizer, a binding agent, and combinations thereof.

[0057] In another embodiment, the method further comprises recycling used artificial turf to provide the at least one of the at least one type of non-elastomeric thermoplastic. This may be beneficial in that it may reduce the environmental impact of installing a new artificial turf surface. It may also have the benefit that the thermoplastic recovered from the used artificial turf may have additives such as colorants or UV stabilizers or flame retardants that are already present. This may reduce the cost of manufacturing a new artificial turf surface.

[0058] In another aspect, the invention provides for a method of manufacturing an artificial turf surface. The method comprises a method of manufacturing an artificial turf system according to an embodiment. The method further comprises installing the artificial turf carpet. The method further comprises distributing the irregularly shaped grains within the pile and between the artificial grass fibers to form the artificial turf.

[0059] In another embodiment, the method of manufacturing the artificial turf surface comprises distributing a sand layer within the pile before distributing the irregularly shaped grains.

[0060] In another aspect, the invention provides for use of an agglomerate as infill for artificial turf. The agglomerate comprises irregularly shaped grains formed for at least one type of non-elastomeric thermoplastic. At least a portion of the grains may have fibrous extensions.

[0061] It is understood that one or more of the aforementioned embodiments of the invention may be combined as long as the combined embodiments are not mutually exclusive.

Brief description of the drawings

[0062] In the following embodiments of the invention are explained in greater detail, by way of example only, making reference to the drawings in which:

Fig. 1 illustrates an example of an artificial turf surface;
Fig. 2 illustrates a further example of an artificial turf surface;
Fig. 3 illustrates an examples of an irregularly shaped grains;
Fig. 4 illustrates an example of an agglomerator;
Fig. 5 illustrates an example of an extruder;
Fig. 6 illustrates an example of an extrusion die plate;
Fig. 7 illustrates an example of an artificial turf system;
Fig. 8 illustrates a further example of an artificial turf surface;
Fig. 9 illustrates a further example of an extrusion die plate; and
Fig. 10 illustrates a further example of an artificial turf surface.

Detailed Description

[0063] Like numbered elements in these figures are either equivalent elements or perform the same function. Elements which have been discussed previously will not necessarily be discussed in later figures if the function is equivalent.

[0064] Fig. 1 shows an example of an artificial turf surface 100. The artificial turf surface 100 is formed by an artificial turf carpet 102 that has a pile 104. The artificial turf carpet 102 comprises a backing 106. Into the backing there are artificial grass fibers 108 that are tufted 110 into the backing 106. The pile 104 is formed from the artificial grass fibers 108. The artificial grass fibers 108 may for instance be formed from a thermoplastic yarn or artificial grass. The backing 106 may be placed onto a base layer 112. The base layer may take different forms in different examples. In one example the base layer is simply the ground. The artificial turf carpet 102 may simply be placed on the ground. In other examples the base layer 112 may have different components for providing drainage, and absorption of shock from athletes or other users of the artificial turf surface 100.

[0065] Within the pile 104 and between the artificial grass fibers 108 is spread an artificial turf infill 114. In this case the infill 114 comprises irregularly shaped grains 116. The irregularly shaped grains are formed from an agglomerate comprising at least one type of non-elastomeric thermoplastic. The non-elastomeric thermoplastics may also be thermoplastic polymers. The use of the irregularly shaped grains causes voids 118 between a number of the irregularly

shaped grains 116. These voids provide give and elasticity to the irregularly shaped grains 116 that are made of what is considered normally a rigid thermoplastic. This enables a material which would normally be unsuitable for making artificial turf infill function well. The artificial turf infill 114 may provide for helping the artificial grass fibers 108 to stay rigid and in the correct position. They may also provide for shock absorption or other physical properties which help the artificial turf surface 100 more approximate the properties of a real turf surface.

[0066] Fig. 2 shows a further example of an artificial turf surface 200. The artificial turf surface 200 is similar to the artificial turf surface 100 shown in Fig. 1. However, in this example there is additionally a layer of sand between the backing and the infill 114. The example shown in Fig. 2 may further approximate the properties of real turf more accurately. The use of the infill 114 with the irregularly shaped grains 116 may provide a more lifelike and elastic surface than when sand 202 is used alone.

[0067] Fig. 3 shows a photograph of a number of irregularly shaped grains 116. The irregularly shaped grains comprise at least one non-elastomeric polymer. The photograph shows that at least some of the irregularly shaped grains comprise fibrous extensions 302. Not all of the fibrous structure of the extensions is visible in the photograph. Some of the grains also show fibrous extensions 302 with a branched structure 304. Some of the fibrous extensions 302 also have a hook like structure 306. The branched structure 304 or hook like structure 306 may help the irregularly shaped grains interlock with themselves and/or artificial grass fibers. thermoplastics.

[0068] The irregularly shaped grains in Fig. 3 were tested as artificial turf infill. Although made from rigid thermoplastics they exhibited shock absorbency. Recycled SBR rubber infill was compared to irregularly shaped grain infill of two different sizes. The first size of irregularly shaped grain infill had a characteristic dimension of less than 2.5 mm. The second size had a characteristic dimension greater than 2.5 mm. A sieve with a 2.5 mm screen was used to separate the two. In the experiment the force reduction of a soccer ball hitting the surface was measured for three consecutive hits at the same location for each hit. The results are summarized in the table below

	SBR infill As benchmark	agglomerate < 2.5 mm	agglomerate > 2.5 mm
Force reduction 1 st hit	32.8%	40.3%	36.6%
Force reduction 2nd hit	19.3%	9.8%	25.7%
Force reduction 3rd hit	15.8%	6.1%	19.8%

[0069] In the above table it can be see that the agglomerate infill made from the irregularly shaped grains has a shock absorbency that is comparable to the SBR infill made from recycled black crumb rubber. In fact, the larger grains (greater than 2.5 mm) surprisingly showed shock absorbency that was greater than the SBR infill material for all three impacts.

[0070] Fig. 4 shows an example of an agglomerator 400. The agglomerator has a hopper 402 for receiving waste thermoplastic 404. A feeder 406 then feeds the waste thermoplastic 404 into a an agglomerator 408 which comprises a rotating disc and a stationary portion The agglomerator 408 may heat and compress the waste thermoplastic 404. The rotating disc 408 may have veins or gear-like surfaces which compress and cut the waste thermoplastic 404 into the irregularly shaped grains 116.

[0071] Fig. 5 shows an example of an extruder 500. The extruder again has a hopper for receiving waste thermoplastic 404. The waste thermoplastic is then fed by a feeder 406 which heats and forces the waste thermoplastic through an orifice through an extrusion die plate 504. A cutting system 506 then cuts agglomerate that is extruded from the orifice 502 into the irregularly shaped grains 116. The rate at which the cutting system 508 cuts the agglomerate will control the length of the irregularly shaped grains 116. The rate of the cutting system 506 can be varied to produce a distribution of lengths of irregularly shaped grains 116.

[0072] Fig. 6 shows an example of an extrusion die plate 504 with an orifice 502. The orifice 502 has a first portion 600 and an opposing portion 602. The first portion 600 is rough and the opposing portion 602 is smooth. This modification will cause material extruded from the orifice 502 to have a curvature to it.

[0073] Fig. 7 shows a flowchart which illustrates a method of manufacturing an artificial turf system. First in step 700 an artificial turf carpet 102 such as shown in Figs. 1 or 2 is provided. Next in step 702 irregularly shaped grains 116 are manufactured using the machine such as is illustrated in Fig. 4 or 5. At least one type of non-elastomeric thermoplastic is either provided as an agglomerate or formed with another material such as a second elastomeric thermoplastic or a dye in power form. The agglomerate is then forced into the irregularly shaped grains 116. In some examples, the agglomeration process is used to form the irregularly shaped grains. In other examples, an extruder or agglomerator is used to form the agglomerate into the irregularly shaped grains.

[0074] Fig. 8 shows a further example of an artificial turf surface 800. The artificial turf surface 800 is similar to the artificial turf surface 200 shown in Fig. 2. However, in this example there is additionally a top infill layer (801) that comprises regularly shaped granules 802. The top infill layer (801) is on top of the irregularly shaped grains 114. The use of the regularly shaped granules 802 have the advantage of reducing the friction when something slides on the

surface of the artificial turf surface 800. The regularly shaped granules 802 may be made of several different materials. In one example the regularly shaped granules are made from a agglomerate comprising at least one type of non-elastomeric thermoplastic. In another example the regularly shaped granules are made from an elastomer.

[0075] Fig. 9 illustrates another example of an extrusion die plate (504) similar to that shown in Fig. 6. The extrusion die plate has a number of orifices 502' for extruding the irregularly shaped granules. The orifices have a variety of different sizes. The relative sizes of the orifices can be used to generate a distribution of grains with different sizes. The shape or profile of the orifices can also be modified to aid in providing the grains with an irregular shape.

[0076] Fig. 10 shows a further example of an artificial turf surface 1000. The artificial turf surface 1000 is similar to the artificial turf surface 800 shown in Fig. 8. However, in this example the top infill layer comprises either elongated granules 1002 and/or irregularly shaped granulate 1002 on top of the irregularly shaped grains 114. The use of the elongated granules 1002 and/or irregularly shaped granulate 1002 may have the advantage of reducing the friction when something slides on the surface of the artificial turf surface 1002. The elongated granules 1002 and/or irregularly shaped granulate 1002 may be made of several different materials. In one example the elongated granules 1002 and/or irregularly shaped granulate 1002 may for example be manufactured from an elastomeric compound or other flexible material.

[0077] The following examples are several possible practical examples of artificial turf surfaces that use the irregularly shaped grains as artificial turf infill. Artificial turf infill made from irregularly shaped grains is referred to as "polymer agglomerate." All weights refer to the amount of material distributed on the surface of an artificial turf carpet. The polymer agglomerate is placed on top of the sand layer. The term e-layer refers to a substructure made of a shock absorptive layer of rubber granulate, matting, or other material under the artificial turf carpet.

Example 1 (artificial turf carpet with a 40 mm high pile):

Polymer agglomerate:	5	kg/m^2
Sand:	15	kg/m^2
e-layer:	25	mm

Example 2 (artificial turf carpet with a 40 mm high pile):

Polymer agglomerate:	7,5 kg/m^2
Sand:	12.5 kg/m^2
e-layer:	25 mm

Example 3 (artificial turf carpet with a 40 mm high pile):

Polymer agglomerate:	5	kg/m^2
Sand:	15	kg/m^2
e-layer:	30	mm

Example 4 (artificial turf carpet with a 40 mm high pile):

Polymer agglomerate:	5 kg/m^2
Size distribution:	0 - 2.5 mm (sorted by sieve size)
Sand:	15 kg/m^2
e-layer:	25 mm

Example 5 (artificial turf carpet with a 40 mm or 60 mm high pile):

Polymer agglomerate:	5 kg/m^2
Size distribution:	2.5 - 12.5 mm (sorted by sieve size)
Sand:	15 kg/m^2
e-layer:	25 mm

[0078] In the 5 above examples, the numerical values may be varied by up to 10%, 20, or 30% to produce alternative examples.

[0079] In examples 1 through 3, so size distribution of the polymer agglomerate is given. It is understood that any

sieve size between 1 and 12,5 mm may be used to sort agglomerate for these two examples.

[0080] In examples 4 and 5: Grains that pass through the 2,5 mm sieve are used for example 4. The grains that are caught by the 2.5 mm sieve, but pass through a 12.5 mm sieve are used for example 5.

List of reference numerals

[0081]

100	artificial turf surface
102	artificial turf carpet
104	pile
106	backing
108	artificial grass fibers
110	tufting
112	base layer
114	infill
116	irregularly shaped grains
118	void
200	artificial turf surface
202	sand
302	fibrous extensions
304	branched structure
306	hook like structure
400	agglomerator
402	hopper
404	waste thermoplastic
408	agglomerator disk
500	extruder
502	orifice
502'	orifice
504	extrusion die plate
506	cutting system
600	first portion
602	opposing portion
700	provide an artificial turf carpet with a pile,
702	form an agglomerate comprising least one type of non-elastomeric thermoplastic into irregularly shaped grains to provide an infill for the artificial turf carpet
800	artificial turf surface
801	top infill layer
802	regularly shaped granules
1000	artificial turf surface
1002	elongated granules or irregularly shaped granulate

Claims

1. An artificial turf surface (100, 200, 800, 1000) comprising:

- an artificial turf carpet (102) with a pile (104), wherein the artificial turf carpet comprises a backing (106); wherein the artificial turf carpet further comprises artificial grass fibers (108), wherein the artificial grass fibers are tufted (110) into the backing, wherein the artificial grass fibers form the pile, wherein the artificial grass fibers are secured to the backing; and
- artificial turf infill (114) distributed within the pile, wherein the artificial turf infill comprises irregularly shaped grains (116), wherein the irregularly shaped grains comprise an agglomerate, wherein the agglomerate comprises at least one type of non-elastomeric thermoplastic, wherein at least a portion of the grains have fibrous extensions (302).

2. The artificial turf surface of claim 1, wherein the at least one types of non-elastomeric thermoplastic comprise recycled

artificial turf fibers.

3. The artificial turf surface of claim 1 or 2, wherein the irregularly shaped grains have a longitudinally stretched out and curved volume expansion with ratios of length to diameter/cross-section within 1:2 to 1:50.

4. The artificial turf surface of claim 1, 2, or 3, wherein the irregularly shaped grains have a sieve size between 0.2 mm and 12 mm.

5. The artificial turf surface of any one of the preceding claims, wherein irregularly shaped grains have a thickness between 0.05 mm and 2 mm.

6. The artificial turf surface of any one of the preceding claims, wherein the at least one type of non-elastomeric thermoplastic comprise any one of the following: a least one thermoplastic polymer, a polyolefin, waste plastic, fibrous waste plastic, pre-consumer yarn, post-consumer yarn recovered synthetic sports fields, artificial turf fiber, recovered waste plastic, recycled packaging material, poly ethylene food packaging, polyethylene food packaging, poly ethylene, polypropylene, a polyethylene and polypropylene mixture, LLDPE, HDPE, LDPE, MDPE, PP, PE, a polyolefin, and combinations thereof.

7. The artificial turf surface of any one of the preceding claims, wherein the fibrous extensions of the irregularly shaped grains interlock with any one of the following: the artificial grass fibers, the fibrous extensions of other irregularly shaped grains, and combinations thereof.

8. The artificial turf surface of any one of the preceding claims, wherein at least a portion of the fibrous extensions are branched (304) and/or hook shaped (306).

9. The artificial turf surface of any one of the preceding claims, wherein the artificial turf surface further comprises a sand layer (202) between the backing and the artificial turf infill.

10. The artificial turf surface of any one of the preceding claims, wherein the artificial turf surface (800, 1000) further comprises a top infill layer (801), wherein the irregularly shaped grains are between the backing and the top infill layer.

11. The artificial turf surface of claim 10, wherein the top infill layer comprises regularly shaped granules (802).

12. The artificial turf surface of claim 11, wherein the regularly shaped granules comprise any one of the following: a least one thermoplastic polymer, a polyolefin, waste plastic, fibrous waste plastic, pre-consumer yarn, post-consumer yarn recovered synthetic sports fields, artificial turf fiber, recovered waste plastic, recycled packaging material, polyethylene food packaging, poly ethylene, polypropylene, a polyethylene and polypropylene mixture, LLDPE, HDPE, LDPE, MDPE, PP, PE, a polyolefin, an elastomeric compound, rubber, crumb rubber, EPDM, and combinations thereof.

13. The artificial turf surface of claim 10, 11, or 12, wherein the top infill comprises elongated granules (1002).

14. The artificial turf surface of claim 13 or 14, wherein the wherein the elongated granules are formed from any one of the following: an elastomeric compound, shavings from at least one block of an elastomeric compound, rubber, crumb rubber, EPDM, and combinations thereof.

15. The artificial turf surface of any one of claims 1 through 8, wherein the artificial turf surface (1000) further comprises a sand layer (202) between the backing and the artificial turf infill, wherein the artificial turf surface further comprises a top infill layer (802), wherein the irregularly shaped grains are between the backing and the top infill layer, wherein the top infill comprises irregularly shaped granulate (1002), wherein the irregularly shaped granulate (1002) comprises shavings from at least one block of an elastomeric compound.

16. A method of manufacturing an artificial turf system, wherein the method comprises:

- providing (700) an artificial turf carpet (102) with a pile (104), wherein the artificial turf carpet comprises a backing (106); wherein the artificial turf carpet further comprises artificial grass fibers (108), wherein the artificial grass fibers are tufted (110) into the backing, wherein the artificial grass fibers form the pile surface, wherein the artificial grass fibers are secured to the backing; and

- forming (702) an agglomerate comprising at least one type of non-elastomeric plastic to form irregularly shaped grains to provide an infill for the artificial turf carpet.

17. The method of claim 16, wherein the agglomeration of the at least one type of non-elastomeric thermoplastic into the agglomerate and the forming of the irregularly shaped grains from the agglomerate is performed using an agglomerator (400).

18. The method of claim 17, wherein the agglomerator is a friction agglomerator.

19. The method of claim 16, wherein forming of the irregularly shaped grains is performed using an extruder (500).

20. The method of claim 19, wherein the extruder comprises any one of the following: an underwater pelletizing system, a watering pelletizing system, a strand pelletizing system, and hot-cut pelletizing system.

21. The method of claim 19 or 20, wherein the extruder comprises an extrusion die plate (504), wherein any one of the following:

- the extrusion die plate has at least one orifice (502) for extruding the agglomerate, wherein the at least one orifice has a first portion (600) and an opposing portion (602), wherein the first portion is rough, wherein the opposing portion is smooth to form irregularly shaped grains that have a curved profile;
- the extruder die plate comprises multiple orifices, and the multiple orifices have at least two distinct sizes (502') and/or the orifices are irregularly shaped (502'); and
- combinations thereof.

22. The method of any one of claims 19 through 21, wherein the extruder comprise a cutting system (506) for cutting the irregularly shaped grains, wherein the cutting system is configured for producing irregularly shaped grains with varying lengths.

23. The method of any one of claims 16 through 22, wherein the method further comprises mixing at least one additive into the agglomerate before forming the irregularly shaped grains.

24. The method of claim 23, wherein the at least one additive comprises any one of the following: a dye, a colorant, a UV-stabilizer, a flame retardant, a binding agent, a blowing agent, an anti-seize agent, a lubricant, a filler, a compatibilizer, and combinations thereof.

25. The method of any one of claims 16 through 24, wherein the method further comprises recycling used artificial turf to provide the at least one type of non-elastomeric thermoplastic.

26. A method of manufacturing an artificial turf surface, wherein the method comprises the method of any one of claims 16 through 25, wherein the method further comprises:

- installing the artificial turf carpet; and
- distributing the irregularly shaped grains within the pile to form an artificial turf surface.

27. The use of an agglomerate (116) as infill (114) for artificial turf (100, 200, 800, 1000), wherein the agglomerate comprises irregularly shaped grains formed from at least one type of non-elastomeric thermoplastic, and wherein at least a portion of the grains have fibrous extensions.

Amended claims in accordance with Rule 137(2) EPC.

1. An artificial turf surface (100, 200, 800, 1000) comprising:

- an artificial turf carpet (102) with a pile (104), wherein the artificial turf carpet comprises a backing (106); wherein the artificial turf carpet further comprises artificial grass fibers (108), wherein the artificial grass fibers are tufted (110) into the backing, wherein the artificial grass fibers form the pile, wherein the artificial grass fibers are secured to the backing; and
- artificial turf infill (114) distributed within the pile, wherein the artificial turf infill comprises irregularly shaped

grains (116), wherein the irregularly shaped grains comprise an agglomerate, wherein the agglomerate comprises at least one type of non-elastomeric thermoplastic, wherein at least a portion of the grains have fibrous extensions (302); and **characterized in that**: a majority of the irregularly shaped grains have a curved profile.

2. The artificial turf surface of claim 1, wherein the at least one types of non-elastomeric thermoplastic comprise recycled artificial turf fibers.

3. The artificial turf surface of claim 1 or 2, wherein the irregularly shaped grains have a longitudinally stretched out and curved volume expansion with ratios of length to diameter/cross-section within 1:2 to 1:50.

4. The artificial turf surface of claim 1, 2, or 3, wherein the irregularly shaped grains have a sieve size between 0.2 mm and 12 mm.

5. The artificial turf surface of any one of the preceding claims, wherein irregularly shaped grains have a thickness between 0.05 mm and 2 mm.

6. The artificial turf surface of any one of the preceding claims, wherein the at least one type of non-elastomeric thermoplastic comprise any one of the following: a least one thermoplastic polymer, a polyolefin, waste plastic, fibrous waste plastic, pre-consumer yarn, post-consumer yarn recovered synthetic sports fields, artificial turf fiber, recovered waste plastic, recycled packaging material, poly ethylene food packaging, polyethylene food packaging, poly ethylene, polypropylene, a polyethylene and polypropylene mixture, LLDPE, HDPE, LDPE, MDPE, PP, PE, a polyolefin, and combinations thereof.

7. The artificial turf surface of any one of the preceding claims, wherein the fibrous extensions of the irregularly shaped grains interlock with any one of the following: the artificial grass fibers, the fibrous extensions of other irregularly shaped grains, and combinations thereof.

8. The artificial turf surface of any one of the preceding claims, wherein at least a portion of the fibrous extensions are branched (304) and/or hook shaped (306).

9. The artificial turf surface of any one of the preceding claims, wherein the artificial turf surface further comprises a sand layer (202) between the backing and the artificial turf infill.

10. The artificial turf surface of any one of the preceding claims, wherein the artificial turf surface (800, 1000) further comprises a top infill layer (801), wherein the irregularly shaped grains are between the backing and the top infill layer.

11. The artificial turf surface of claim 10, wherein the top infill layer comprises regularly shaped granules (802).

12. The artificial turf surface of claim 11, wherein the regularly shaped granules comprise any one of the following: a least one thermoplastic polymer, a polyolefin, waste plastic, fibrous waste plastic, pre-consumer yarn, post-consumer yarn recovered synthetic sports fields, artificial turf fiber, recovered waste plastic, recycled packaging material, polyethylene food packaging, poly ethylene, polypropylene, a polyethylene and polypropylene mixture, LLDPE, HDPE, LDPE, MDPE, PP, PE, a polyolefin, an elastomeric compound, rubber, crumb rubber, EPDM, and combinations thereof.

13. The artificial turf surface of claim 10, 11, or 12, wherein the top infill comprises elongated granules (1002).

14. The artificial turf surface of claim 13 or 14, wherein the wherein the elongated granules are formed from any one of the following: an elastomeric compound, shavings from at least one block of an elastomeric compound, rubber, crumb rubber, EPDM, and combinations thereof.

15. The artificial turf surface of any one of claims 1 through 8, wherein the artificial turf surface (1000) further comprises a sand layer (202) between the backing and the artificial turf infill, wherein the artificial turf surface further comprises a top infill layer (802), wherein the irregularly shaped grains are between the backing and the top infill layer, wherein the top infill comprises irregularly shaped granulate (1002), wherein the irregularly shaped granulate (1002) comprises shavings from at least one block of an elastomeric compound.

16. A method of manufacturing an artificial turf system, wherein the method comprises:

- providing (700) an artificial turf carpet (102) with a pile (104), wherein the artificial turf carpet comprises a backing (106); wherein the artificial turf carpet further comprises artificial grass fibers (108), wherein the artificial grass fibers are tufted (110) into the backing, wherein the artificial grass fibers form the pile surface, wherein the artificial grass fibers are secured to the backing; and
- forming (702) an agglomerate comprising at least one type of non-elastomeric plastic to form irregularly shaped grains to provide an infill for the artificial turf carpet;

characterized in that:

the forming of the irregularly shaped grains is performed using an extruder (500);
wherein the extruder comprises an extrusion die plate (504); and wherein any one of the following:

- the extrusion die plate has at least one orifice (502) for extruding the agglomerate, wherein the at least one orifice has a first portion (600) and an opposing portion (602), wherein the first portion is rough, wherein the opposing portion is smooth to form irregularly shaped grains that have a curved profile;
- the extruder die plate comprises multiple orifices, and the multiple orifices have at least two distinct sizes (502') and/or the orifices are irregularly shaped (502'); and
- combinations thereof.

17. The method of claim 16, wherein the agglomeration of the at least one type of non-elastomeric thermoplastic into the agglomerate and the forming of the irregularly shaped grains from the agglomerate is performed using an agglomerator (400).

18. The method of claim 17, wherein the agglomerator is a friction agglomerator.

19. The method of claim 16, wherein forming of the irregularly shaped grains is performed using an extruder (500).

20. The method of claim 19, wherein the extruder comprises any one of the following: an underwater pelletizing system, a watering pelletizing system, a strand pelletizing system, and hot-cut pelletizing system.

21. The method of claim 19 or 20, wherein the extruder comprise a cutting system (506) for cutting the irregularly shaped grains, wherein the cutting system is configured for producing irregularly shaped grains with varying lengths.

22. The method of any one of claims 16 through 21, wherein the method further comprises mixing at least one additive into the agglomerate before forming the irregularly shaped grains.

23. The method of claim 22, wherein the at least one additive comprises any one of the following: a dye, a colorant, a UV-stabilizer, a flame retardant, a binding agent, a blowing agent, an anti-seize agent, a lubricant, a filler, a compatibilizer, and combinations thereof.

24. The method of any one of claims 16 through 23, wherein the method further comprises recycling used artificial turf to provide the at least one type of non-elastomeric thermoplastic.

25. A method of manufacturing an artificial turf surface, wherein the method comprises the method of any one of claims 16 through 24, wherein the method further comprises:

- installing the artificial turf carpet; and
- distributing the irregularly shaped grains within the pile to form an artificial turf surface.

26. The use of an agglomerate (116) as infill (114) for artificial turf (100, 200, 800, 1000), wherein the agglomerate comprises irregularly shaped grains formed from at least one type of non-elastomeric thermoplastic, and wherein at least a portion of the grains have fibrous extensions, and **characterized in that**: a majority of the irregularly shaped grains have a curved profile

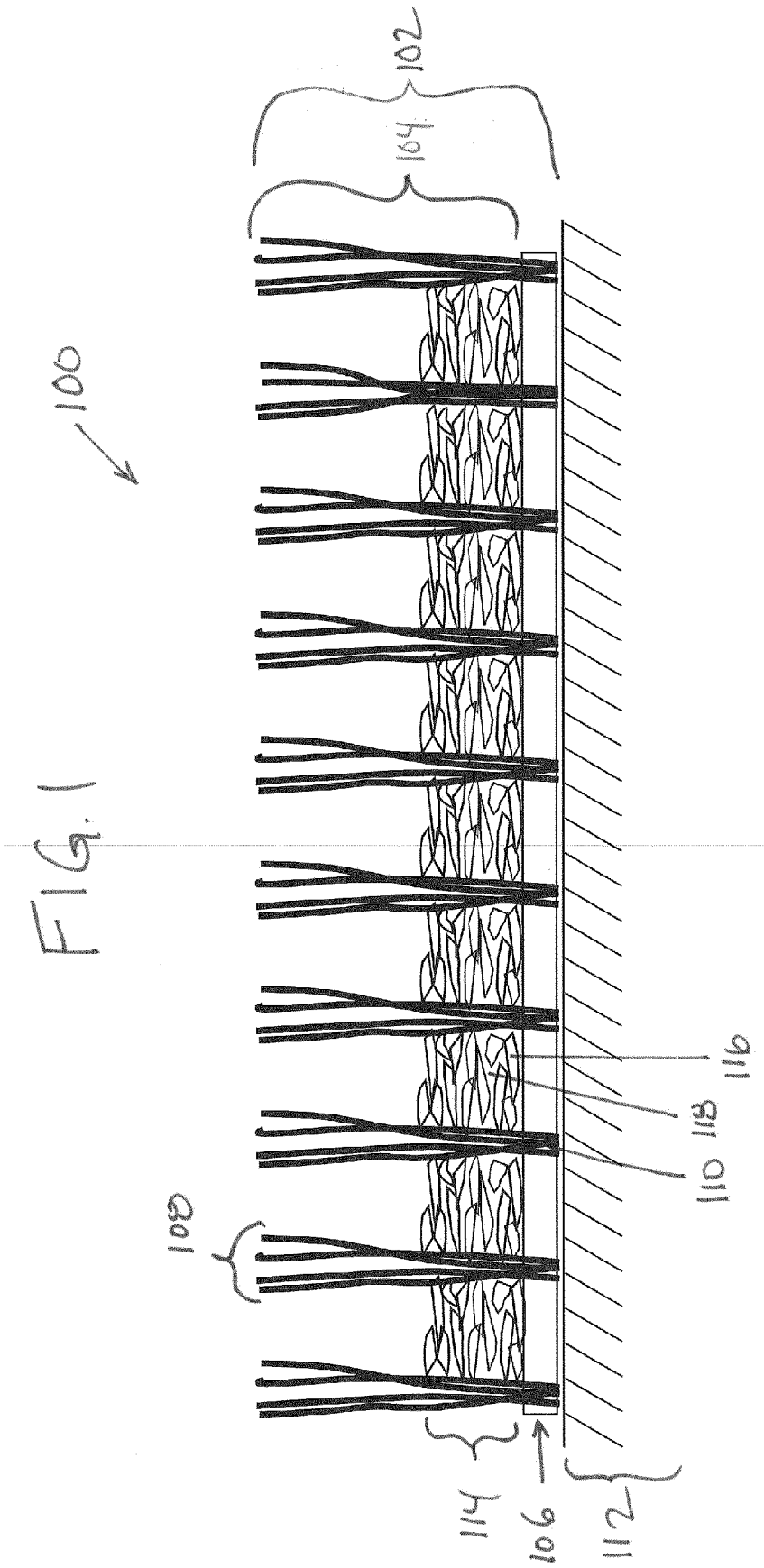


FIG. 1

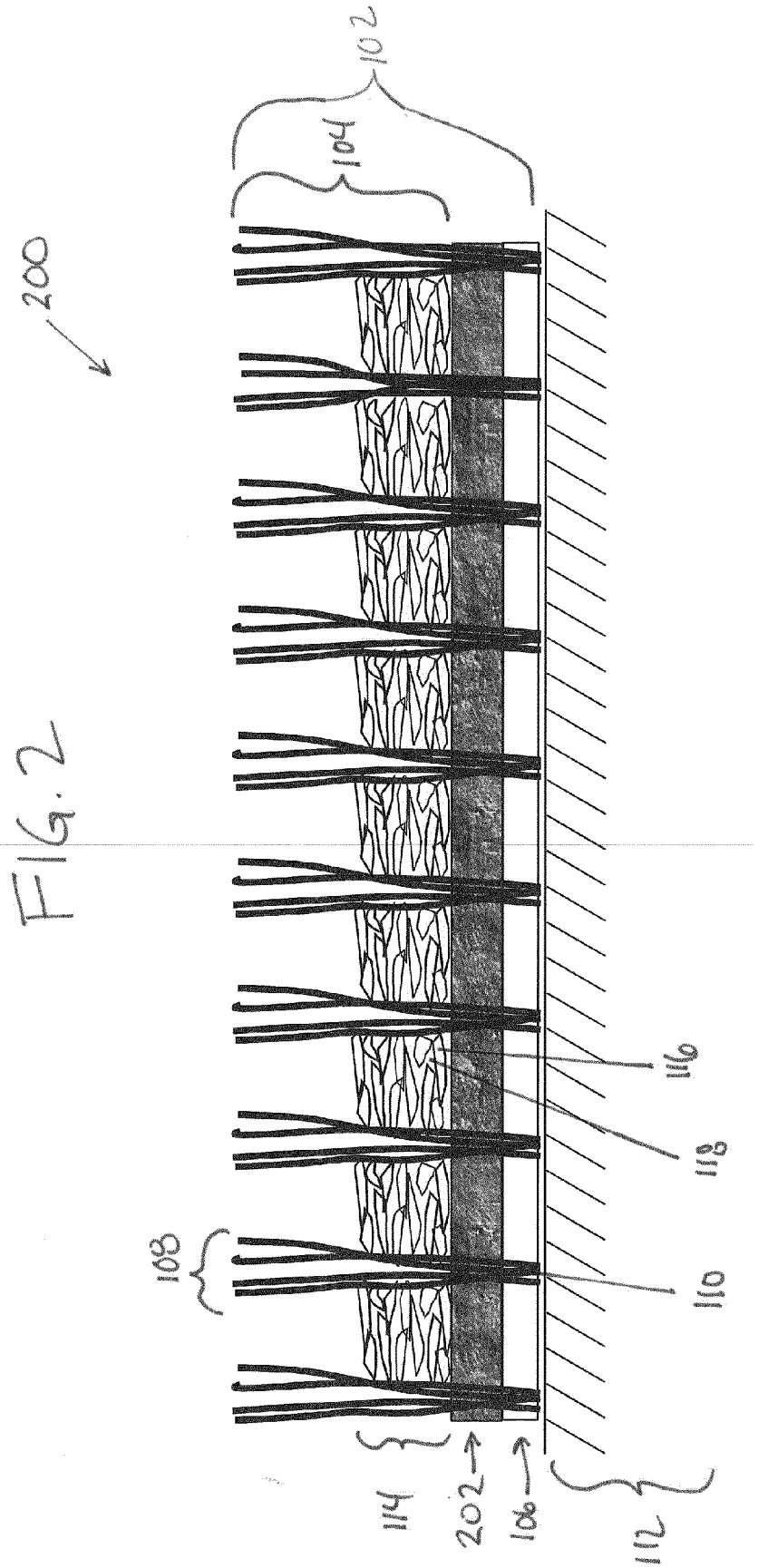


FIG. 2

FIG. 3

FIG. 4

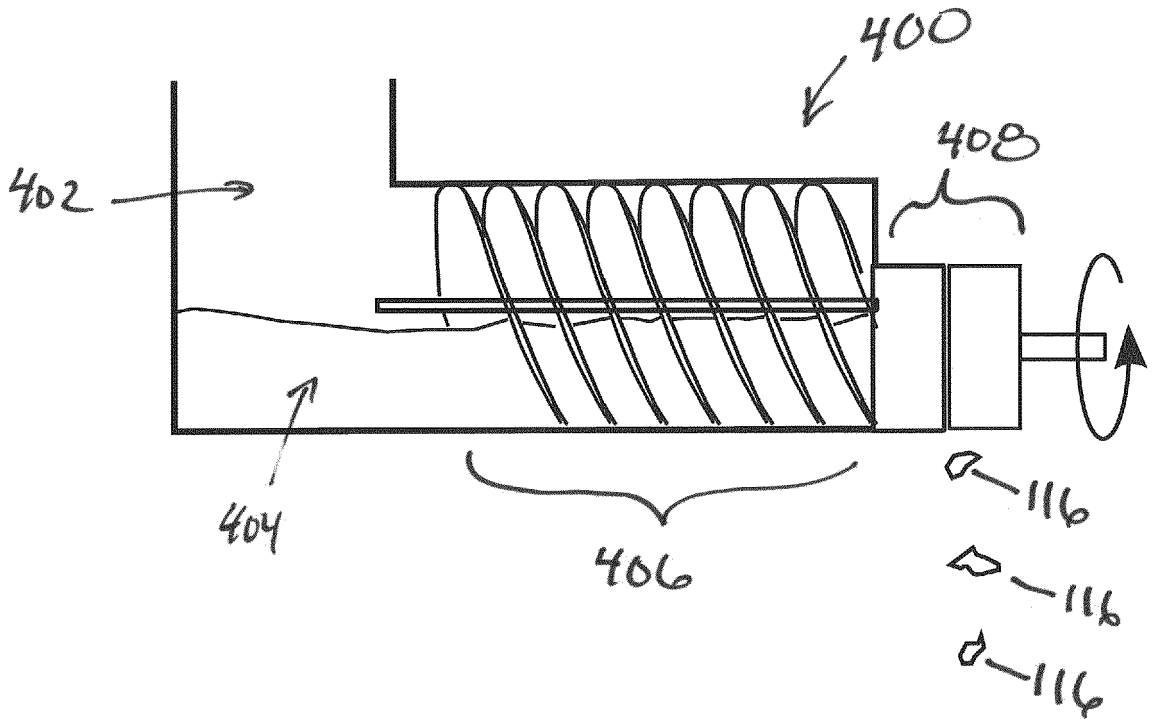

400
408
402
404
406
116
116
116

FIG. 5

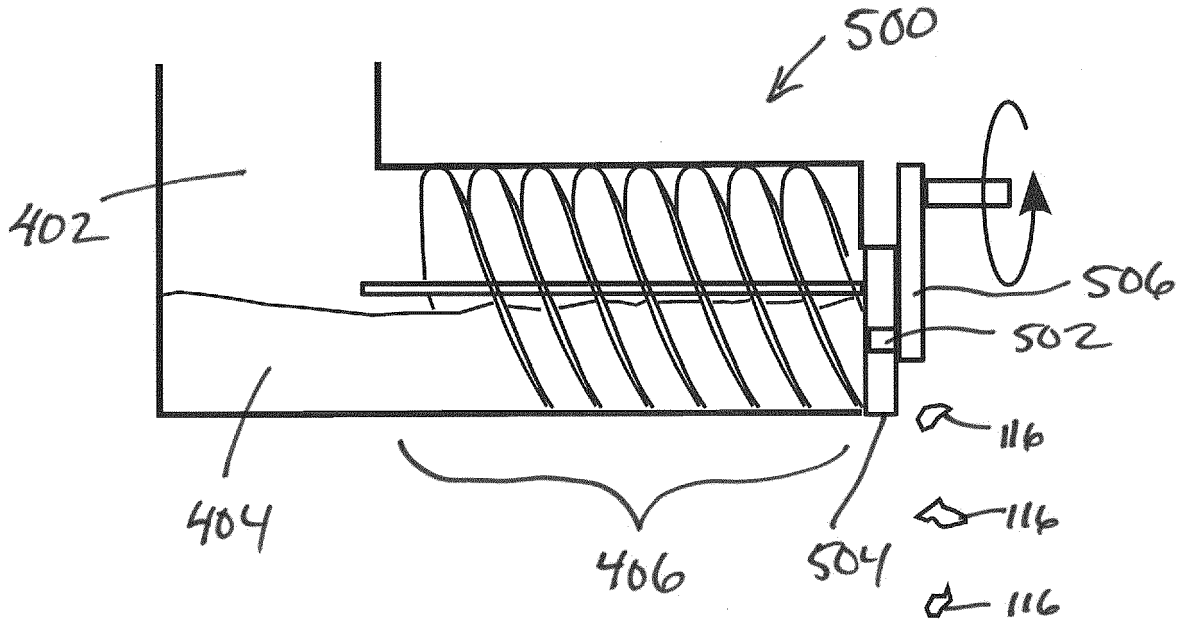

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FIG. 6

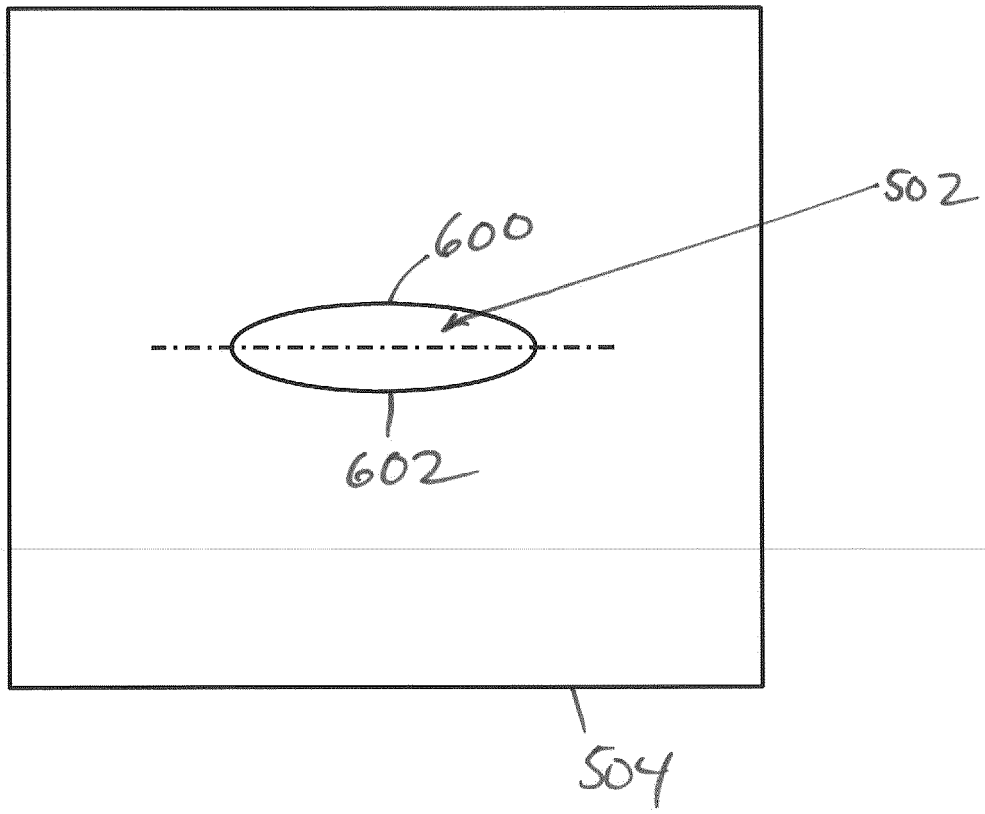


FIG. 7

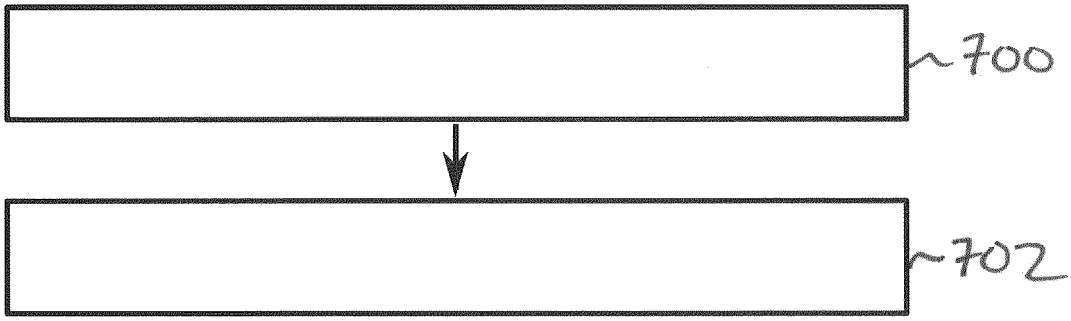


FIG. 8

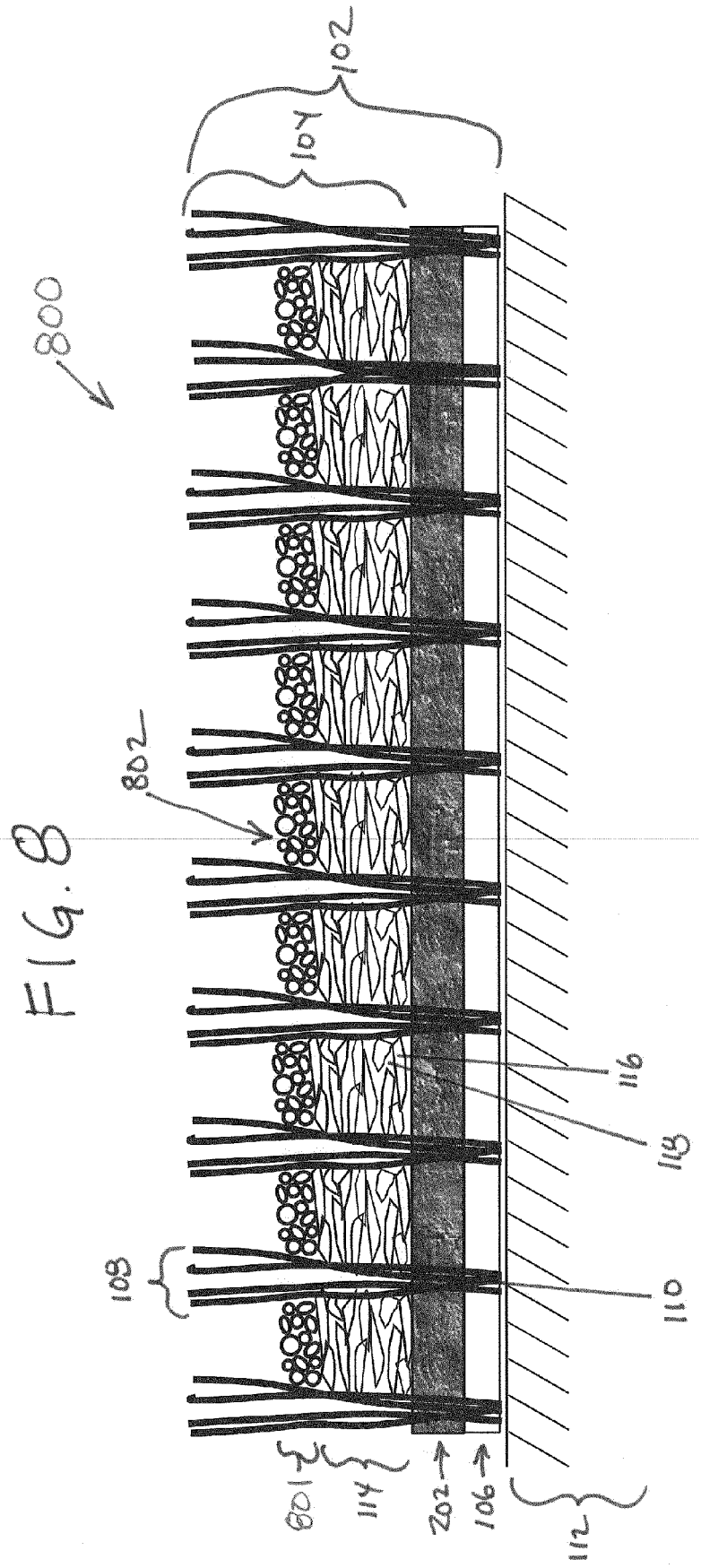


FIG. 9

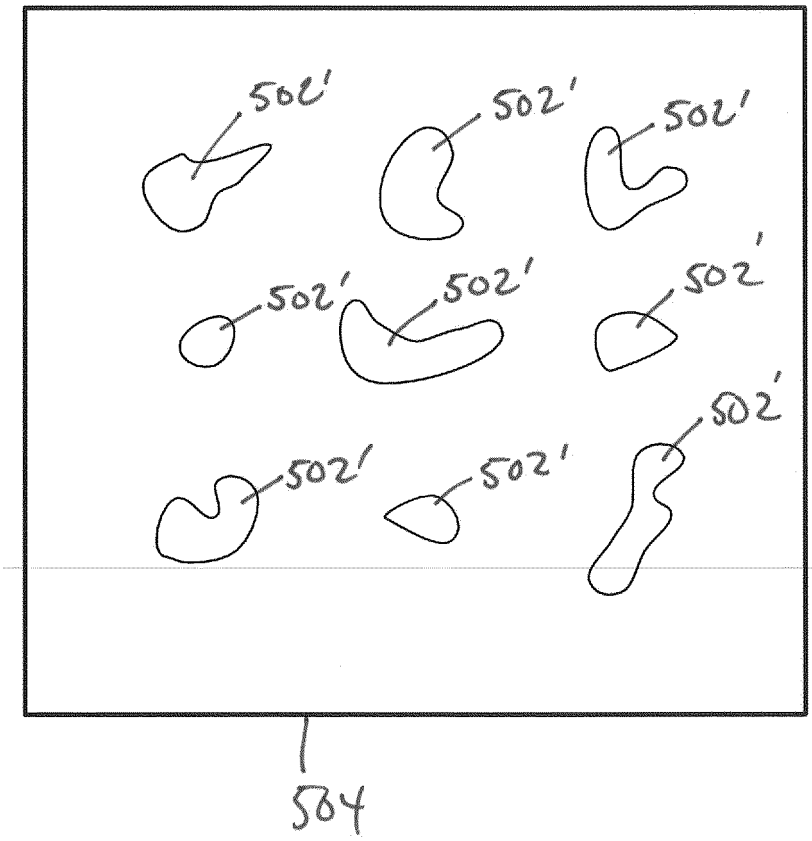
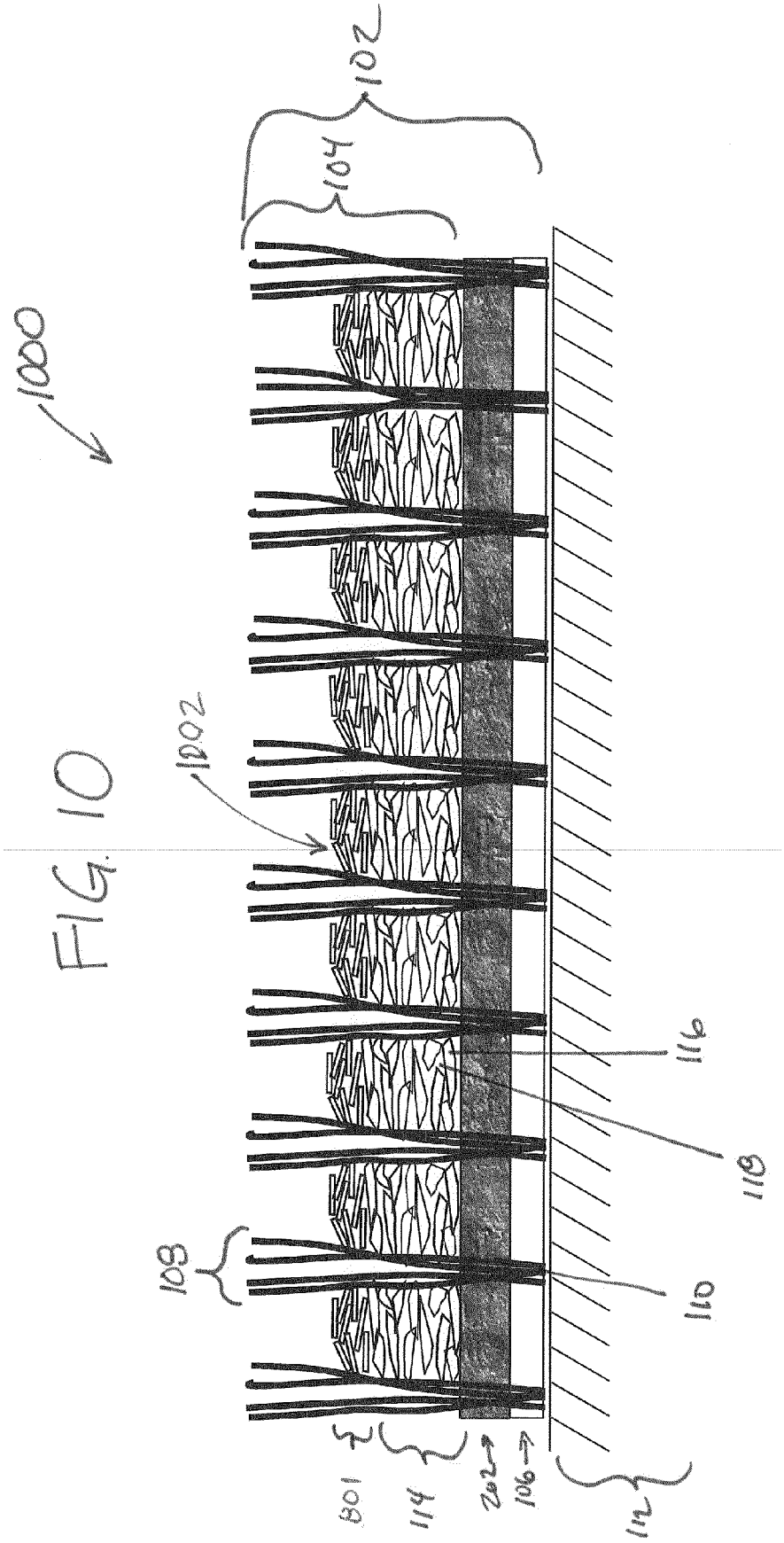


FIG. 10



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EUROPEAN SEARCH REPORT

Application Number
EP 16 18 0026

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D A	US 2010/151158 A1 (MASHBURN LARRY [US] ET AL) 17 June 2010 (2010-06-17) * the whole document * -----	1-20, 22-27 21	INV. E01C13/08
A	DE 94 05 554 U1 (SCHOEPP RALPH [DE]) 1 June 1994 (1994-06-01) * page 1, paragraph 1 * * page 2, paragraph 1 * -----	1-27	

TECHNICAL FIELDS SEARCHED (IPC)

E01C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 October 2016	Kremsler, Stefan

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06-10-2016

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Patent documents cited in the description

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