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(54) **Title**: GEL BEAD PRODUCTION AND INCORPORATION IN FOAM

(57) **Abstract**: Disclosed are gel beads, preferably of styrene block copolymer, a process for the production of gel beads by dissolving styrene block copolymer in a liquid above the melting point of the styrene block copolymer, a method of incorporating gel beads with synthetic foam material by addition to a foam precursor, to liquid foam materials or to partially liquid foam prior to foam precursor reaction completion and cooling, and cushioning products comprising synthetic foam incorporating gel beads.

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Gel Bead Production and Incorporation in Foam

This invention relates to the production of gel beads, the incorporation of gel beads into foam materials and products containing foam incorporated with gel beads.

BACKGROUND

Foam, as in open-cell foam, is used in many shapes and sizes as comfort cushioning in a wide variety of applications, including furniture, bedding, and carpet cushion. Polyurethane foam has especially been developed over the past 40 years to give products such as high resiliency and viscoelastic foams with comfort properties designed for specific applications; comfort cushioning with gel layers or gels filling interstices in foams are known.

PRIOR ART

Document WO 2009/070801 [POLYWORKS Inc. – 4 June 2009] discloses a composite material comprising a layer of open-cell foam material; a layer of gel-infused foam material disposed adjacent to the open-cell foam material; and a barrier layer disposed adjacent to the gel- infused foam material, opposite the open-cell foam material and a method of making a composite material by forming a gel-infused foam material by disposing a gel precursor material onto the foam material, such that at least a portion of the gel precursor material at least partially penetrates the foam material and allowing the gel precursor material to cure. The composite material can be used to improve comfort, durability, heat dissipation, insulation, and aesthetic appearance of cushioning materials for application as padding for mattress toppers and the like.

STATEMENT OF INVENTION

Products, processes and methods in accordance with the present invention and embodiments thereof are set forth in the appended claims.

A feature of an embodiment of the invention is the development of gel beads (or particles) that are added to the foam to bring another dimension to comfort cushioning. The gel is designed to be made over a wide range of softness and high temperature viscosities. In large scale manufacturing, the gel is made into beads. The gel beads' size can be controlled by the process parameters. The gel beads are added into several foam types, but are particularly effective in improving the comfort characteristics of viscoelastic foams. The foams are cut and/or shaped into a wide variety of forms for many comfort applications.

As opposed to the composite material disclosed in Document WO 2009/070801, gel beads can have the advantages of:

Closed cell as well as open cell foams can be used;

Gel bead size is independent of foam cell size;

Gel beads can be distributed throughout foam material;

A barrier layer is not required, allowing more direct contact with the gel;

The concentration of the gel beads in the foam can be easily varied;

The gel beads are incorporated during the foam manufacturing;

No cure time is required after the incorporation.

Brief Description of the Drawings:

Figure 1 shows gel beads after manufacturing with a metric ruler for dimension illustration.

Figure 2 shows gel-infused polyurethane foam (viscoelastic or memory foam in this example).

Figure 3 shows a non-planar or profiled (e.g., convoluted) gel-infused foam composition or material.

Figure 4 shows in schematic fashion examples of gel bead production techniques.

Figure 5 shows in schematic fashion an example of a process for infusing gel beads into foam material and examples of use of a gel infused material as in layers in a product (e.g., a cushion, as in a mattress cushion layer).

Figure 6 shows a process flow sequence from gel formation to cushion product formation with a gel infused foam component or composition.

Figure 7 shows in schematic fashion gel infused foam being subject to manipulation (e.g., laminated layers with one or more inclusive of infused gel beads).

Figures 8 and 9 show a prior art technique for forming convolutions on an exposed surface of a foam layer suitable for use with one or more gel infused foam layers of the present application.

Figure 10 shows a two foam layer cushion embodiment suited for use in mattress construction or the like (with one or more of the layers having the infusion gel characteristic such as the convoluted surfaced layer being that which is shown in Figure 3).

Figure 11 shows a three foam layer cushion embodiment suited for use in mattress construction or the like (with one or more of the layers having the infusion gel characteristic such as the convoluted surfaced layer being of that which is shown in Figure 3).

Gel Formation Examples Under Present Invention

Gel formula examples under embodiments of the present invention include the use of thermoplastic elastomers as the material utilized in the formation of gel beads. Thermoplastic elastomers are a family of polymers that can be stretched without permanently distorting their original shape. They do not require curing or vulcanization and may be processed by techniques such as conventional techniques used to break down or form gel material into particle or bead form. There are several categories of thermoplastic elastomers that may be considered to form gels, including urethanes, polyesters, and polyamides and polyolefin blends. Of particular interest are styrene block copolymers (SBCs) due to their outstanding thermal stability and melt processability. SBCs combine the properties of thermoplastic resins with those of elastomers to give a unique combination of properties that are ideal for gels. SBCs are frequently used in formulating adhesives, sealants, and coatings by melting them in a hot liquid substrate and allowing them to cool to their final form. The present invention is inclusive of dissolving SBCs in a liquid such as oil (e.g., mineral oil) at temperatures above the melting point of the SBCs as to form a gel upon cooling back to room temperature.

A variety of oils may be used to melt SBCs and produce a gel. The oil utilized should be compatible with polyurethane foam and be preferably low in odor, if odor is of concern, as it typically is in certain uses such as in mattresses. Naphthenic and paraffinic oils, including chlorinated oils commonly referred to as Chlorowaxes, that are severely hydrotreated, are preferred for many applications under the present invention. The oil should have enough thermal stability to withstand the temperatures required to melt the SBCs (e.g., up to 125ºC) without degrading. Oils from renewable resources such as castor, soy, or palm oils may also be used to replace all or a portion of the mineral oil.

A wide range of SBCs may be considered to make gel. They are typically di- and tri-block copolymers of styrene with butadiene, isoprene, and ethylene/butylene or propylene. The

SBCs may be linear or branched and unsaturated or hydrogenated, but linear and unsaturated SBCs are preferred for many applications under the present invention. The styrene content in the copolymers suited for use in embodiments of the present invention is preferably from 15 - 50%, a range of 20 - 40% being well suited for embodiments under the present invention. A single SBC may be used or multiple SBC types may be used in combination to impart different properties to the gel. Typically, 2 or 3 SBCs are used in embodiments of the present invention to produce a gel with the preferred softness and melt viscosity. The ratio of oil to SBCs utilized under embodiments of the present invention is from 40:60 to 90:10 with a preferred embodiment being of 60:40 to 80:20. A dye or pigment may optionally be added, as in to the oil during the process, to add color to the resulting gel.

As an example of a processing method under the present invention, the oil is heated with stirring to 120°C or more. The SBCs in this embodiment are added prior to heating although other embodiments include adding the SBC material during heating, inclusive of a sequenced insertion of the material used to form the gel (e.g., insertion under embodiments of the present invention is prior to heating or at any time during the heating process). Under an example of a processing technique, two SBCs are utilized in the formation, although as noted above it is understood that more than two or one SBC(s) may be utilized, in the gel formulation. The introduced SBCs are stirred in the hot oil until they are completely dissolved (e.g., visually dissolved). In one embodiment the hot, homogeneous mixture is cast into a mold and allowed to cool to room temperature. The gel is then removed from the mold and evaluated based on characteristics such as the ability to maintain shape and integrity (no cold flow or leaching of oil), tackiness, hardness as measured for example by Shore A, and viscosity at elevated temperatures. An embodiment features a gel that is stable for >3 days after demolding and is not tacky. The Shore A hardness in embodiments of the invention is less than or equal to 100 Shore A, and preferably <30 (e.g., 10 to 30 Shore A) and the viscosity is preferably 1,000 to 20,000 cps at 120°C in embodiments of the invention as well as greater than or equal to 4,000 cps AT 120°C in embodiments of the invention (e.g., 4000 to 20,000 cps at 120°C). Also the Shore A hardness value of the gel beads is adjustable to suit a desired setting as in being made about equal to the receiving foam (e.g., polyurethane), greater than the receiving foam or less than the receiving foam.

An example of a gel formulation is shown in Table 1 below.

Table 1. Typical formulation to make an acceptable gel for infusion in foam.

Table 1 below illustrates an example of a gel formulation suitable for use under the present invention.

TABLE 1

Chemical	Parts
Hyprene L-500 (hydrotreated naphthenic oil)	69.5
Calprene 540 (styrene-butadiene copolymer, 40% styrene)	15.0
Kraton 1101 (styrene-butadiene triblock, 31 % styrene)	15.0
Milliken Violet (X80LT)	0.5

Relative to the above table:

Hyprene L-500 is a complex combination of hydrocarbons obtained by treating a petroleum fraction with hydrogen in the presence of a catalyst. It consists of hydrocarbons having carbon number predominantly in the range of C20 through C50 and produces finished oil with a viscosity near 150 SUS @ 100oF (30cSt @ 40oC).

Hyprene LI500 is available from Ergon Petroleum Specialties Marketing Division in Jackson, Mississippi USA

Calprene 540 is a 60/40 Butadiene/Styrene thermoplastic copolymer, polymerized in solution and having a linear structure. This product is presented in pellet form and has excellent optical properties, due to its clarity. It is stabilized with a non staining antioxidant system FDA approved for use in food contact applications and is essentially gel free with a very clear color. Calprene 540 is available from Dynasol Elastomers in Houston, Texas USA.

Kraton D1101 K is a clear, linear triblock copolymer based on styrene and butadiene with a polystyrene content of 31%. It is stabilized with a non staining phenolic antioxidant. Kraton D1101K is available from Kraton Polymers in Houston, Texas USA.

MillikenReactint® Violet is a reactive polymeric colorant that consists of violet chromophores which are chemically bound to polyols. Milliken Violet is available from Milliken& Company of Spartanburg, SC, USA.

Colored pigment dispersions may also be used for coloration of the gel. Pigments can be dispersed in a variety of liquid carriers, most preferably a similar oil to that used in the gel bead composition.

As a further example under the present invention, 225 g of oil is heated to 125°C with stirring with 0.3 g of violet colorant. While heating, 25 g of Kraton G1652E, a linear triblock copolymer of styrene and ethylene/butylene with 30% styrene is added and stirred for 3 hours. The hot liquid is dispensed into a mold and allowed to cool to room temperature. The resulting gel is removed from the mold for characterization as described above.

Gel Bead Manufacturing

In an embodiment of the invention the gel formulation is scaled up to allow the formation of beads through an industrial extruder. The mineral oil is heated at a level that, relative to the time of temperature application and conditions (e.g., stirring), achieves a suitable gel product. As for example, a process under an embodiment of the invention includes stirring the gel formulation within a large vat in a range of 110°C to 140°C and for a time period of 2 to 6 hours. A preferred embodiment has the SBCs stirred at a temperature of greater than 110°C and for a time period of greater than 2 hours as there is a greater chance of hard spots (SBC material that is not fully melted) developing at the lower end of the above described temperature and/or heating time range which is undesirable in some uses of the present invention. An example of an embodiment of the invention features heating the gel formulation to 120°C and stirring the mixture for 4 hours.

Following a desired heating period, a quality check can be carried out wherein a sample is taken and allowed to cool to confirm there is present a homogeneous gel indicating that the SBCs are fully melted relative to the heat level and duration of heating. When it is considered that the hot melt is in a suitable state, in one embodiment, the hot mixture is pumped to a heated extruder equipped with, for example, a die plate with circular holes. The mixture is extruded (e.g., directly) into a circulating cold water bath. A spinning blade at the exit chops the extrudates to form gel beads as they are flashed cooled by the water. The beads are separated from the water and blown dry with warm air as in a centrifugal dryer.

The beads are optionally sprinkled with a fine powder such as aluminum or calcium stearate or talc to prevent agglomeration and facilitate further downstream handling.

The size of the beads can be controlled by several process parameters. For example, one or more of the pumping rate through the extruder, the size of the holes in the die, and the speed of the cutting blade are adjusted to give gel beads that are less than 2mm in size as shown in Figure 1. A 1.5 - 2.5 mm size bead is illustrative of a size range well suited for many uses of gel beads utilized under the present invention as in the below described inclusion of gel beads in foam such as polyurethane foam (viscoelastic polyurethane foam, high resiliency polyurethane foam, and other types of foam materials (e.g., latex foam material)). Greater or lesser size beads are also featured under the present invention as in 0.5 to 5mm size beads having utility for the above described gel infusion into foam as well as other utilizations under the present invention.

Figure 1 illustrates an example of gel beads formed under a manufacturing technique described above. Also, Figure 4 shows in schematic fashion examples of gel bead production techniques. As shown in Figure 4, the gel formulation is heated and stirred (e.g., a high shear stirrer) in a tank (140). Under one approach as shown by the dashed line sequence, the heated gel formulation is fed directly, as by pump P, to an extruder (142) such as that described above having an adjustable die plate (144) wherein the size of the extrusion stream diameter can be adjusted. A separator (146), as in the form of a rotating cutter, is placed in close proximity (e.g., within 5mm or as close as possible while avoiding friction contact with the extruder outlet if a mechanical separator is used). The cut stream particles form beads like that in the illustrated in Figure 1 upon cooling with the aforementioned dimensions relative to the largest diametrical component of the respective beads (which can be formed of a variety of shape configurations by way of the processing (e.g., a high pump rate with lower setting cutting speeds can lead to more oblong shapes as compared, for example, to a higher extrusion rate and/or cutting or separating speed that provides a less oblong and more spherical configuration)). Also, measurements include an average value for a group of beads formed under a common process.

Figure 4 further illustrates that the cut stream components are cooled subsequent to cutting (or alternate separation technique) as by a cooling station (148) (e.g., a liquid cooling tank with water or some alternate cooling source liquid). The gel beads (150) once cooled have the aforementioned configuration shown in Figure 1. Also the beads are ready for downstream use as in shipping to a recipient (preferably with an added coating to avoid agglomeration which agglomeration is undesirable in many usage scenarios under the present invention). As an example, the formed gel beads are air dried and dusted with zinc stearate to prevent agglomeration during storage, transport and/or intermixing with other material as in the below described gel infusion.

Under the alternate, solid line approach shown in Figure 4, the heated gel formulation exiting the heating and stirring tank (140) is sent to an upstream cooler (152) wherein suitable shaped solid gel bodies (154) (e.g., solid gel slabs or molded shapes as in barrel shaped bodies are formed for downstream distribution as in a separate in-house facility or a shipped second location). At that downstream location (156) the gel formulation is heated again, and then pumped or otherwise provided to the bead formation section as in the aforementioned extrusion and cutting station which feeds into a second cooler for bead cooling.

Gel-Infused Foam Manufacturing

In techniques under the present invention, synthetic foams such as polyurethane foam are produced by the polyaddition reaction of an isocyanate with a polyalcohol (polyol) often in the presence of a catalyst and other additives. Under embodiments of the invention, the gel beads formed under the present invention are incorporated into a foam with a variety of methods being featured under the present invention. For example, the formed gel beads are added into one of the foam precursor liquids, while in a liquid state, such as in a storage state or during a course of travel to a mixing state, during foam formation. Another example includes adding the formed gel beads post initial contact of the precursor foam materials and while still in a liquid state as in a precursor mixing state or in a post output, still liquid cream state, wherein gel bead infusion is still possible. The gel beads are preferably infused throughout the foam material although limited region introduction is also featured under the present invention as in a top portion of a foam slab layer, or alternate foam body. In other words, the gel bead introduction is preferably carried out through gel bead introduction into one or both of foam precursor materials prior to initial contact of the foam precursors, although also featured is gel bead mixing within a still generally liquid state foam material following foam precursor mixing such as immediately following exiting of the mixed foam material from an outlet (or, in this embodiment, at least sufficiently prior to hardening as to provide, for example, for a relatively random dispersion of beads in the foam body). An illustrative method of the technique involving adding in beads to one or both of the liquid foam precursors prior to mixing of the same, is to suspend the beads in one of the chemical components used to manufacture foam, preferably the polyol precursor. The gel bead to polyol ratio is preferably in the range from 5:95 to 60:40 by weight depending on the desired amount of gel beads in the foam. In an example of an embodiment, the gel bead blend is made in a dedicated tank with stirring to keep the beads well suspended.

Figure 5 illustrates, schematically, the above noted addition of gel beads to one or both of the foam chemical precursors (A and B) prior to mixing together to initiate foam production. Figure 5 also illustrates downstream manipulation of the foam material with intermixed gel beads that exist in the output liquid foam (prior to setting) as described below, and that become infused with the resultant encapsulating foam material, which foam/gel bead combination can be further manipulated to form, for example, a cushioning product.

In embodiments of the invention, the gel beads vary from 1 - 30% by weight in the foam with a suitable range under some uses being from 5 and 20%. In a continuous foaming process, the gel bead blend is preferably introduced to the reaction mixture before the mixhead to insure proper mixing of the polyol carrier and good dispersion of the gel beads in the final foam. In a batch process, the gel bead blend or solid gel beads are added to the mixing vessel before dispensing with the remaining chemicals into a box mold.

The gel beads may be added to a wide variety of foam types and densities as long as the polyol used to make the blend is compatible with the foam formulation. Preferably, the gel beads are added to viscoelastic foams to impart positive characteristics to top-of-the-bed finished articles. Gel-infused viscoelastic foam is shown in Figure 2 as an example of a gel infused polyurethane foam.

Gel-Infused Foam Cushioning Products

The final gel-infused foam blocks may be cut or otherwise reconfigured into a variety of articles for use in comfort cushioning. An example of a preferred application is foam articles for bedding and in particularly for top-of-the-bed items. The gel-infused foam is, for example, used in mattress construction or as separate pads for the top of an existing mattress. The gel-infused foam is also, for example, cut or convoluted to have a specific design such as shown in Figure 3. The gel-infused foam also is also suited for being hole-punched with various sizes of holes and patterns applied.

Figure 5 illustrates schematically examples of downstream treatment of the foam with an infusion of gel beads. In the Figure 2 example, the gel beads are infused throughout the foam body in a highly dispersed fashion. In alternate embodiments the infused gel beads can be intentionally concentrated in certain areas as by varying the feed stream of beads to a traveling precursor of the foam material (e.g., starting stopping a bead feed device that feeds beads into a precursor stream of the foam material (as in upstream of the mix head). Variations of this type can be utilized as in forming zones within the foam body produced by the foam producer such as those conforming to body characteristics in a mattress topper or mattress layer component of a mattress assembly (e.g., high heat generation of the body areas and/or higher force generating body sections as in the buttocks, shoulder, head and heel areas of a user of a mattress or similar cushion). Additional infusion examples include, for instance, sprinkling gel beads over a poured, at least partially still liquid state, foam liquid and allowing gravity capture within an upper region of the foam body ultimately formed upon foam precursor reaction completion and cooling. A combination or subcombinations of the before, at, and/or after mix head bead application is also featured under embodiments of the invention.

Figure 5 illustrates a variety of solid foam with infused gel bead cushion bodies as in the formation of a large solid bun foam body which is suited for downstream further manipulation as in the cutting of desired thickness foam layers well suited for incorporation into a mattress or topper pads.

Figure 5 further illustrates an example of taking the infused gel bead foam and inserting it into a mold configuration such as a pillow mold configuration or some other product molding device including, for example, a mold for a solid foam body insert for a composite cushioning product.

Figure 5 still further illustrates foam filler material wherein discrete foam particles are inclusive of gel beads which is well suited for use in a pillow core and/or surrounding layer in a cushion product; or, in an alternate embodiment, the foam particles are subject to a re-bond process as in use in a re-bond carpet cushion layer. The filler material shown in Figure 5 can be directly formed as part of the initial foam material formation or representative of waste or recycling manipulation such as shredding waste cut products.

Figure 3 illustrates an example of a convoluted gel-infused foam layer (in this embodiment shown on one exposed size with the opposite side being planar although alternate embodiments include convoluted opposite sides with a common or different surface pattern). Also, embodiments of the invention include passageways formed in the layer as in apertures (e.g., through-holes either having a more vertical orientation or a more horizontal orientation or mixes of each type).

Figures 8 and 9 illustrate an example of a conventional convolution apparatus suited for forming a surface pattern in an exposed surface of a foam layer like that shown in Figure 3. As seen, one or more layers of foam can be fed between two compressing and driving rollers (e.g., or other "in-feed" and compression means) that feed the layer(s) to a splitter as in the form of a band saw blade or the like which in turn functions to split or extract off portions of the fed layer(s) as to achieve the desired surface pattern. In the embodiment shown each of the rollers have dies on them to achieve the varied state of compression in the foam layer at the point of separation or splitting such that, upon spring back, projections and valleys are formed in the exposed foam layer surface. In the example shown in Figure 3 there is a checker-board pattern featuring generally independent projections (common lower edge contact only), although a variety of other patterns are featured under the present invention when a profiled surface and non profiled surface is desired including, for example, wave, straight ribs or angled zig-zag, etc.

With reference to Figure 10 there is seen upper layer 22 flipped over and in a pre-securement state relative to the underlying base layer 24. A preferred securement means is by way of an adhesion (e.g., a liquid (applied) adhesive or an intermediate adhesion layer as in a tacky layer of material that bonds the upper and lower layers in a desired stack configuration) or some form of fusing. Alternate securement means include, for example, overmolding of respective material, heat bonding with an intermediate melted and cooled layer, as well as fasteners such as hook and loop type (Velcro) fastener strips secured to the respective layers. In one example of securing layers 22 and 24 there is featured a process wherein a roll coat laminator is used to apply adhesive to the tips of the convoluted pad or layer 22 and the topper layer 22 is adhered to the core piece of foam 24 (or base layer). In an alternate embodiment, a suitable adhesive is provided in a pattern (e.g., a spray pattern corresponding to the peak projection pattern or in continuous layer form to the base layer 24 or contoured surface) and the upper layer 22 and base layer are brought into contact with that adhesive. In an embodiment example, the spray pattern is applied to the contoured layer 22 in a spray pattern that only covers the free end peak portions of some or all of the projections in one or more (e.g., all) of the zones and/or a spray pattern is applied only to the to be contacted regions of the contact surface which the projections contact.

Either all or only one of the two layers shown in Figure 10 comprises the gel infused characteristics described above. For example in an embodiment of the invention the shown upper layer 22 (e.g., the layer typically placed closer to the user in use) is formed as a gel infused layer while the other layer 24 is formed of a non-gel infused layer or less gel infused layer (of the same or different foam encompassing material). Alternatively, each of the layers is formed with similar gel infused characteristics with the foam composition being either the same or different. As an example of an embodiment of the invention there is featured a visco-elastic upper layer with gel bead infusion whereas the lower layer is of a different material free of gel bead infusion as in the below mentioned high resiliency polyurethane foam or one of the other polyurethane foams described below (other than viscoelastic foam). Also, one or more of the illustrated layer can be contoured on one or more surfaces, and the contoured surface can be facing up or down as in the upper layer presenting an exposed, upper convoluted surface.

As noted, first layer 22 can be of the same material as the second layer, although in preferred embodiments the first and second layers are of a different characteristic foam material (e.g., either a different type of foam or foams of different quality values with respect to same type foam material usage as in the above noted gel infusion and no gel infusion combination). For example, embodiments of the upper layer 22 include viscoelastic polyurethane (as in a viscoelastic material with a minimum 2.5 lb./ft^3(40.0 Kg/m^3) density as in 2.5 to 6 pcf (40.0 to 96.1 Kg/m^3)), a polyurethane foam (as in a polyurethane with a 1.2 lb./ft^3(19.2 Kg/m^3) minimum density as in 1.2 to 3.0 pcf (19.2 to 48.1 Kg/m3)) as well as a high-resilience polyurethane (as in an "HR" polyurethane with a 1.8 lb./ft^{3}minimum density as in 1.8 to 5.0 pcf (28.8 Kg/m^3 to 80.1 Kg/m^3)), and latex. The base layer 24 is preferably of a polyurethane (e.g., a high resilience polyurethane), or latex, or combinations of the noted foam materials.

Suitable foams for use under embodiments of the disclosure include, for example, one or more of foams a) to f), available from Carpenter Co. of Richmond, Virginia in the United States, which include the following trade names:

a) Richfoam® (polyurethane foam)

b) Omalon® (a polyurethane foam with densification)

c) Qualux® (HR polyurethane foam as in that made with TDI)

d) Qualatex™ and Avena™ (HR polyurethane foam as in that made with MDI)

e) Avela™ (Viscoelastic polyurethane foam such as that made with MDI)

f) Isotonic® (Viscoelastic polyurethane foam such as that made with TDI)

The above-described foams a) to f) of Carpenter Co. are well suited for inclusion of gel beads such as in the manners described above with embodiments including non-base layers having infused gel beads and base layers being free of gel bead infusion with the former well suited for use as a foam topper and/or intermediate foam layer in the application with the latter (e.g., foam of a) to d)) being well suited for use as a base layer foam. Also, foams suitable for use under the present disclosure further include latex foam as in latex with a density range: 2.0-6.0 lb./ft^3(32.0 to 91.6 Kg/m^3); 25% IFD Range: 5-40 lb.(2.27 to 18.1 Kg) per ASTM D1055 (which is an industry testing standard for latex foam which is slightly different than the ASTM D3574 which is used for polyurethane foam). Thickness ranges for latex use for the individual layers can be the same as for polyurethane in topper, intermediate, and core or base layers. Also, core or base layer urethane foams Density/IFD ranges 1.5-4.0 lb./ft^3(24 to 64 Kg/m^3); 20-50 lb.(9.1 to 22.7 Kg) IFD (and for HR polyurethane 1.8-5.0 lb./ft^3(28.8-80.1 Kg/m^3); 15-50 lb.(6.8 to 22.7 Kg) IFD) are illustrative of embodiments of the disclosure.

Thus, embodiments of the invention include values for 25% IFD of upper layer 22 in a range from 5 lb. to 40 lb. (2.27 to 18.1Kg); as well as values for 25% IFD of base layer 24 in a range from 15 lb. to 45 lb.(6.8 to 20.4 Kg) (both per ASTM D3574, Test Bi), with the 25% IFD value for the base layer preferably higher than that of the topper layer.

Also, embodiments of the invention feature an upper, thinner layer (or layers) and a lower, thicker base layer. For such embodiments, the thickness of the upper foam region in the cushioning device is preferably in a range from 1.5" (3.81cm) to 5" (12.7cm) for a single contoured foam layer and 1.5" (3.81cm) to 8 "(20.32cm)" relative to a laminate or combination topper foam region as where two layers such as X and Y in Figure 7 are placed upon a base layer Z. Embodiments featuring a higher thickness base include, for example, a thickness of 2.5 inches (6.35cm) to 12 inches (30.48cm) in the base layer Z.

A variety of surface contouring methods can be used to form the non-planar, preferably multi-zoned configured pattern and/or different thickness surface 42 in first layer 22. For example, a convoluter assembly or a contouring assembly as in a CNC saw cutting (known as contour cutting) is a technique that can be utilized in providing a contoured surface such as surface 42 in first layer 22. An example of a convolution type contouring assembly is shown in the prior art system shown in Figures 8 and 9. Figure 9 shows a conventional convoluter assembly 50 with material slab 52 being fed between compression rollers 54 and 56 supported by support assembly 58 and with each having (relatively offset) fingers 60. Figures 8 and 9 show slab 52 (as in one with infused beads) being deformed by the respective profile fingers of rollers 54 and 56 and then cut by knife device 62 while being in a state of compression which results in output layers 64 and 66. Output layer 64 is shown as having a plurality of valleys 68 and peaks 70 across its newly exposed, profiled surface 72, which valleys and peaks correspond in opposing, opposite fashion with respective peaks 74b and valleys 76b on newly exposed, profiled surface 78 of opposite output layer 66 in an essentially mirror image relationship.

Convoluter assembly 50 shown in Figures 8 and 9 is illustrative of a conventional profile cutting machine (convoluter) such as sold by Fecken-Kirfel GmbH, of Aachen, Germany. As described in the literature associated with such convoluters, typical materials described for use with such profilers include synthetic and natural rubber (e.g., combined granulated rubber), foams such as polyurethane, polyethylene, open cellular polyvinylchloride flexible foam, latex, and other foam types (including virgin, bonded, and integrated material foam products as in melamine filled polyurethane foam) and other compressible materials. These materials are also suitable for use in the manufacturing process and cushioning device of the present disclosure discussed herein.

Reference is made to Figure 11 showing an alternate embodiment or cushioning device 20' comprises of first, upper layer 22 which is shown having its contoured undersurface 42 (e.g., a wavy pattern gel infused foam layer) facing an upper surface 43 of intermediate layer 45 in a pre-attachment state. Intermediate layer 45 is further shown as having undersurface 47 which is facing upper surface 44 of base layer 24. Upon assembly (e.g., a direct adhesion of the surfaces of the respective layers shown in a pre-stack state in Figure 11) there is provided alternate embodiment cushioning device 20'. In one embodiment, intermediate layer 45 is formed of a foam material as in a viscoelastic material or of a latex such as that described above with or without gel beads. This includes, for example, having first layer 22 of a first type or grade of viscoelastic material and intermediate layer 45 of a second type or grade of viscoelastic material or of a latex material or another polyurethane foam or vice versa (with one or the other or both being gel infused). This includes having upper layer 22 formed of a higher density viscoelastic layer material and intermediate layer 45 of a lower density viscoelastic layer material or of a latex. Also, while layer 24 is referenced as a "base layer" it need not be the lowermost layer in use such as the inclusion of one or more additional underlying layers (with base layer 24 also inclusive of a laminate layer itself with or without additional underlying layers).

Embodiments for cushioning device 20' include having the intermediate layer or a common thickness or of less thickness than upper layer 22 and with the base layer being of greater thickness than each respective above positioned layers 22 and 45 (including embodiments where the sum of the first and intermediate layers is at or less than the thickness of base layer 24). As an example of alternate embodiments, cushioning device 20' includes one having intermediate layer 45 of a greater thickness than upper layer 22 and of less thickness than base layer (the sum of the above positioned layers being less than or equal or greater than the thickness of base layer 24).

Also, in the illustrated cushioning device 20' only the upper layer 22 is shown as having ventilation apertures in the form of through-holes 48, although alternate embodiments include providing intermediate layer with ventilation apertures as in apertures that are aligned with those provided in upper layer (e.g., as by a common perforation step). An additional embodiment includes providing ventilation apertures such as commonly aligned apertures through each of the layers in cushioning device 20' (as well as cushioning device 20).

Reference is also made to PCT Specification No. WO 2011034800 Published 24 March 2011 to Carpenter Co. of Richmond, VA, USA which includes additional examples of foam types and foam layer combinations, which PCT publication is incorporated by reference for the purpose of supplying additional background material.

The layers described above can be inclusive of the aforementioned infused gel bead characteristics as in each of the Figure 11 referenced layers, only one of the referenced layers (e.g., the top layer and not the other two), or any of the various possible subsets relative to the three layers as in the upper two layers shown and not the bottom layer having the same or different infused gel bead characteristics.

Figure 6 further illustrates this concept of having a multistack layer of foam material identified as layers X, Y and Z with layer X represents, for example, a foam layer having gel bead infusion throughout and over its entire length and width. As noted above, various alternate embodiments are featured inclusive of the gel bead infusion only being in intermediate layer Y as with a stack of different thickness viscoelastic foam layers with the top X layer being thinner and without gel bead infusion and the intermediate layer Y thicker and inclusive of gel bead infusion. Again, a variety of other combinations are possible including having one or two of layers X, Y and Z of a non-foam material such as a high-loft non-woven fiber layer in combination with a gel infused foam layer. Any one or all or a subset of layers X, Y and Z can also have a reticulated foam characteristic inclusive of reticulated foam with gel beads or without gel beads infused therein (overall dispersion or in one or more sections of the foam layer only). Furthermore, different zones of gel bead infusion can be provided across the length and/or width and/or thickness of one or any combination of layers X, Y and Z (inclusive of different gel bead zones from one layer to another in the X, Y, Z layer set).

As also noted above, Figure 4 illustrates additional examples of foam product embodiments having a gel bead infusion characteristic as in a molded foam product such a pillow (e.g., an monolithic foam pillow suited for insertion into a cover or a component of a pillow as in an insert or layering of that foam pillow (e.g., a foam core "layer" surrounded by different material as in fiber or foam composition core covering layer(s)).

As also noted above, Figure 4 also illustrates that foam material having gel bead infusion characteristic can be formed as to be discrete articles as for cushion filling material such as a layer of a pillow or a component of a mattress assembly. The body support shown in Figure 3 is a mattress, mattress topper, overlay, or futon, and is illustrated in such form by way of example only. It will be appreciated that the features of the body support shown in the Figures described above are applicable to any other type of body support having any size and shape. By way of example only, these features are equally applicable to head pillows, seat cushions, seat backs, neck pillows, leg spacer pillows, eye masks, and any other element used to support or cushion any part or all of a human or animal body or an object in general (e.g., an anti-vibration machine pad). Accordingly, as used herein, the term "body support" is intended to refer to any and all of such elements (in addition to mattresses, mattress toppers, overlays, or futons). It should also be noted that each of the body supports described and illustrated herein is presented in a particular form, such as a mattress, mattress topper, overlay, futon, or pillow. However, absent description herein to the contrary, any or all of the features of each such body support can be applied to any other type of body support having any other shape and size, including the various types of body supports mentioned above. In addition, "cushion support" is inclusive of the body supports described above as well as more general object support as in a vibration dampening cushion support for a machine.

Provided below is an example of a processing embodiment of the present invention.

Gel beads are made by melting a blend of styrene copolymers (30%) in hot mineral oil (70%). The hot mixture is pumped to an extruder and through a die into cold water. The extrudates are cut at the die exit and form an oblong bead of 1.5 - 2.5 mm diameter in the cold water. The formed gel beads are air dried and dusted with zinc stearate to prevent agglomeration during storage and transport.

The gel beads are suspended in polyol in a stirred tank at 1:2 (bead/polyol) by weight. The suspension is pumped to a mixhead to be dispensed with other chemicals to form polyurethane foam with gel beads incorporated into the foam structure.

CLAIMS

1. A styrene block copolymer (SBC) gel comprising styrene block copolymer dissolved in and gelled with a liquid.

2. The gel of claim 1 wherein the liquid is an oil.

3. The gel of claim 2, wherein the oil is compatible with polyurethane foam.

4. The gel of claim 2 or claim 3, wherein the oil is mineral or organic or a mixture thereof.

5. The gel of claim 4, wherein the mineral oil is naphthenic, paraffinic or chlorinated.

6. The gel of claim 3, wherein the natural oil is castor, soy, or palm.

7. The gel of any of claims 2 to 6, wherein the oil is thermally stable at the melting temperature of a given styrene block copolymer.

8. The gel of any of claims 1 to 7, wherein the styrene block copolymer comprises di- and tri-block copolymers of styrene with butadiene, isoprene, and ethylene/butylene or propylene.

9. The gel of claim 8, wherein the styrene block copolymer is linear or branched and unsaturated or hydrogenated.

10. The gel of claim 8 or claim 9, wherein the styrene content in the copolymer 15 - 50% by weight.

11. The gel of claim 10, wherein the styrene content in the copolymer is 20 - 40% by weight.

12. The gel of any of claims 1 to 11, comprising multiple styrene block copolymer types in combination; thereby to impart different properties a gel.

13. The gel of any of claims 1 to 12, wherein the ratio of oil to styrene block copolymer is from 40:60 to 90:10.

14. The gel of claim 13, wherein the ratio of oil to styrene block copolymer is from 60:40 to 80:20.

15. The gel of any of claims 11 to 14 and comprising:

    hydrotreated naphthenic oil – 69.5 parts;

    styrene-butadiene copolymer, 40% styrene - 15.0 parts;

    styrene-butadiene triblock, 31 % styrene - 15.0 parts;

    reactive polymeric colorant – 0.5 parts.

16. A process for the production of styrene block copolymer (SBC) gel as claimed in any of claims 1 to 15; comprising the steps of:

    a) dissolving styrene block copolymer in a liquid above the melting point of the styrene block copolymer;

    and,

    b) cooling the dissolved styrene block copolymer to form a gel.

17. The gel process of claim 16, comprising the steps of:

    i) heating oil to 120°C or more;

    ii) adding styrene block copolymer material prior to and/or during heating;

    iii) stirring styrene block copolymer material in the hot oil until completely dissolved to form a hot, homogeneous mixture.

18. The gel process of claim 17 further comprising casting the hot, homogeneous mixture into a mold and allowing to cool.

19. The gel of any of claims 1 to 15 or produced by the process of any of claims 16 to 17 and having a hardness less than or equal to 100 Shore A.

20. The gel of claim 19 having a hardness of 10 to 30 Shore A.

21. The gel of any of claims 1 to 15 or claims 19 or 20 or produced by the process of any of claims 16 to 17 and having a viscosity of 1,000 to 20,000 cps at 120°C.

22. The gel of claim 21 and having a viscosity of 4000 to 20,000 cps at 120°C.

23. A method of manufacturing gel beads using the gel of any of claims 1 to 15 or claims 19 or 20 or produced by the process of claim 16 or claim 17, comprising the steps of:

i) stirring a gel formulation in heated oil having a temperature range of 110ºC to 140ºC and for a time period of 2 to 6 hours to produce a hot homogeneous mixture;

ii) pumping the hot homogeneous mixture to a heated extruder (42);

iii) extruding (44) the mixture and separating (46) the extrudate into gel beads (50);

iv) flash cooling (48) and separating (50) the gel beads.

or between steps i) and ii):

v) cooling (52) the hot homogeneous mixture into solid gel bodies or blocks (54);

and,

vi) subsequently reheating (56) and melting the gel blocks.

24. The method of claim 23 further comprising drying and coating the beads with an agglomeration preventative.

25. Gel beads manufactured by the method of claim 23 or claim 24.

26. Gel beads as claimed in claim 25 and of 0.5 to 5mm size.

27. Gel beads as claimed in claim 26 and of 1.5 - 2.5 mm size.

28. A method of incorporating gel beads as claimed in any of claims 25 to 27 with synthetic foam material comprising the steps of:

i) adding formed gel beads (150) into a foam precursor liquid (A or B) while in a liquid state, such as in a storage state or during a course of travel to a mixing state, during foam formation;

or,

ii) adding formed gel beads post initial contact of the precursor foam materials and while still in a liquid state as in a precursor mixing state;

or,

iii) in a post output, still liquid cream state;

or,

iv) adding gel beads to a poured, at least partially still liquid state, foam liquid and allowing gravity capture within an upper region of the foam body ultimately formed and prior to foam precursor reaction completion and cooling.

29. A method as claimed in claim 28 wherein gel beads (150) are incorporated throughout synthetic foam material by:

i) introducing gel beads into one or both of foam precursor materials (A or B) prior to initial contact of the foam precursors;

or,

ii) mixing gel beads within a still generally liquid state foam material following foam precursor.

30. A method as claimed in claim 29 wherein the synthetic foam is polyurethane foam by the polyaddition reaction of an isocyanate with a polyalcohol (polyol) and comprising suspending gel beads (150) in a polyol precursor.

31. A method as claimed in claim 30 wherein gel bead (150) to polyol ratio is in the range from 5:95 to 60:40 by weight.

32. A method as claimed in claim 29 or claim 30 wherein gel beads (150) vary from 1 - 30% by weight in the foam.

33. A method as claimed in claim 32 wherein gel beads (150) vary from 5 and 20%. by weight in the foam.

34. A method as claimed in any of claims 28 to 33 wherein infused gel beads (150) are concentrated in certain foam areas as by varying the feed stream of gel beads to a traveling precursor (A,B) of the foam material.

35. A method as claimed in any of claims 28 to 34, further comprising:

i) forming gel beads (150) the steps of:

a) melting a blend of styrene copolymers (30%) in hot mineral oil (70%),

b) pumping the hot mixture to an extruder and through a die into cold water,

c) cutting the extrudates are cut at the die exit to form an oblong bead of 1.5 - 2.5 mm diameter in the cold water,

d) air drying the formed gel beads,

e) dusting the dried gel beads with zinc stearate to prevent agglomeration during storage and transport;

and,

ii) incorporating gel beads in synthetic foam material by the steps of:

a) suspending gel beads in polyol in a stirred tank at 1:2 (bead/polyol) by weight,

b) pumping the suspension to a mixhead to be dispensed with other chemicals to form polyurethane foam with gel beads incorporated into the foam structure.

36. Synthetic foam incorporating gel beads (150) and produced by the method of any of claims 28 to 35.

37. Cushioning products comprising synthetic foam incorporating gel beads (150) as claimed in claim 36.

38. Cushioning products as claimed in claim 37 and:

i) used in mattress construction or as separate pads for the top of an existing mattress;

and/or,

ii) cut or convoluted to a specific design;

and/or,

iii) hole-punched with various sizes of holes and patterns applied;

and/or,

iv) formed in zones within the foam body;

and/or,

v) taking infused gel bead foam and inserting it into a mold configuration;

and/or,

vi) forming discrete foam particles inclusive of gel beads from initial foam material formation or from waste or recycling foam incorporating gel beads.

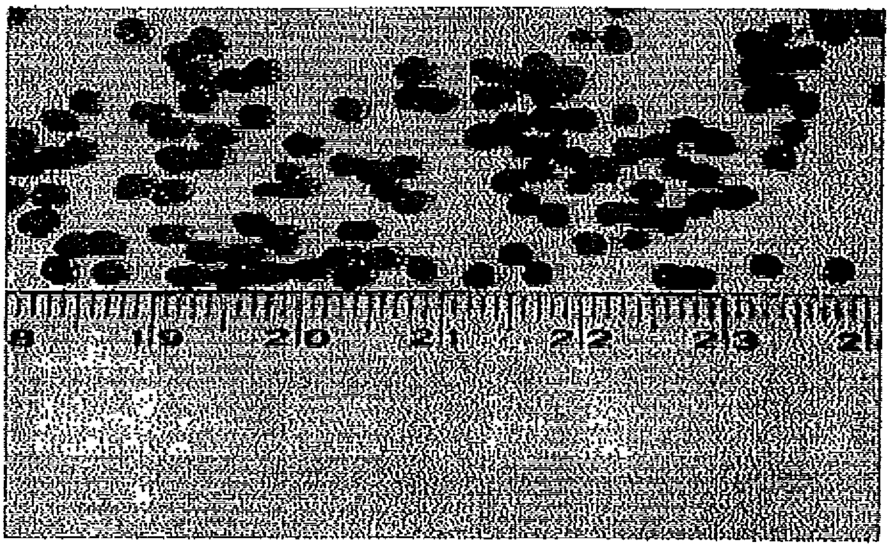

FIG. 1

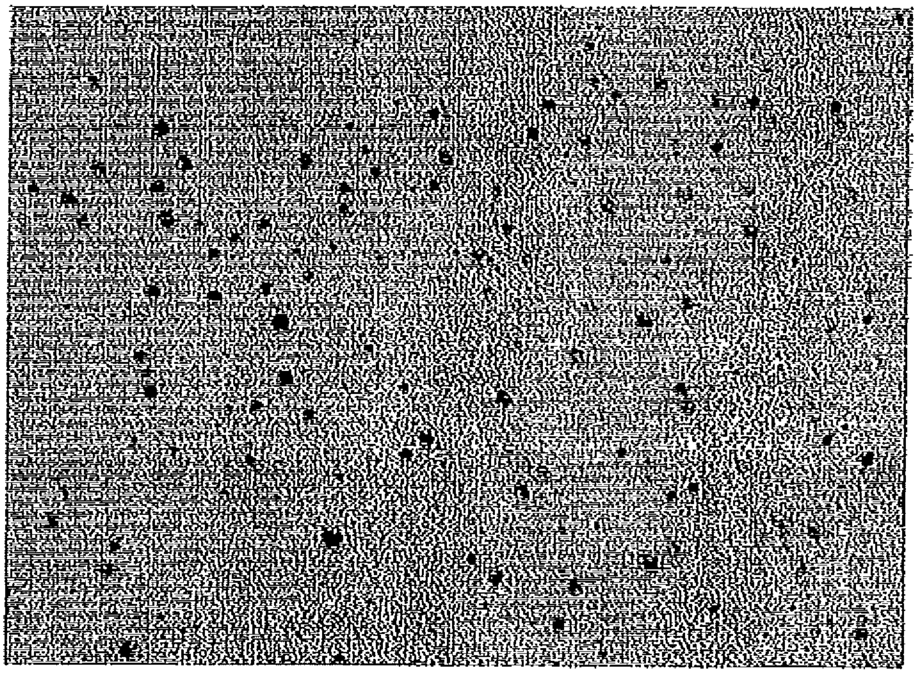

FIG. 2

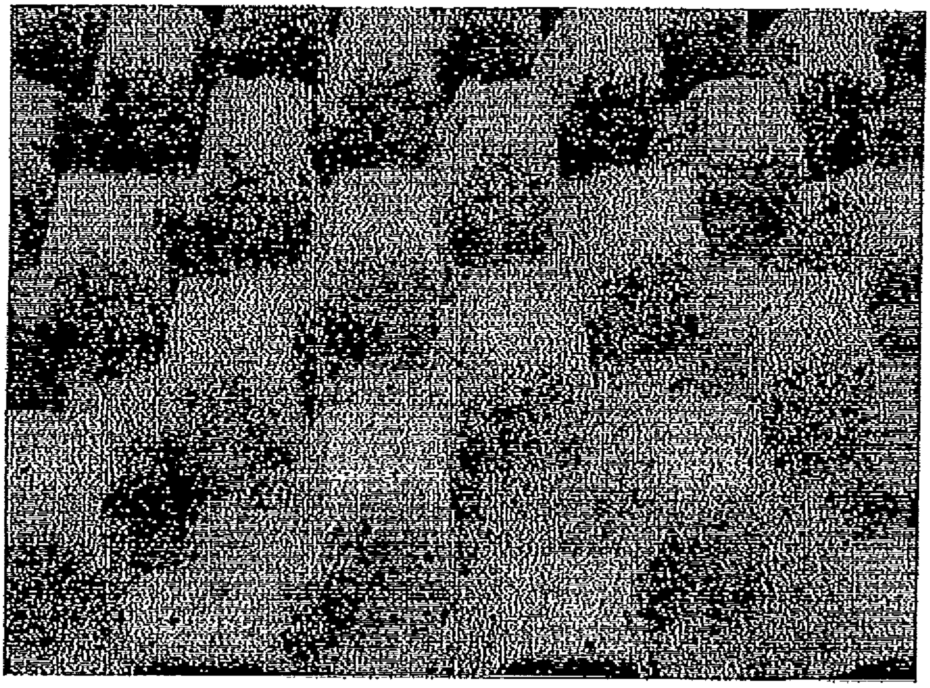

FIG. 3

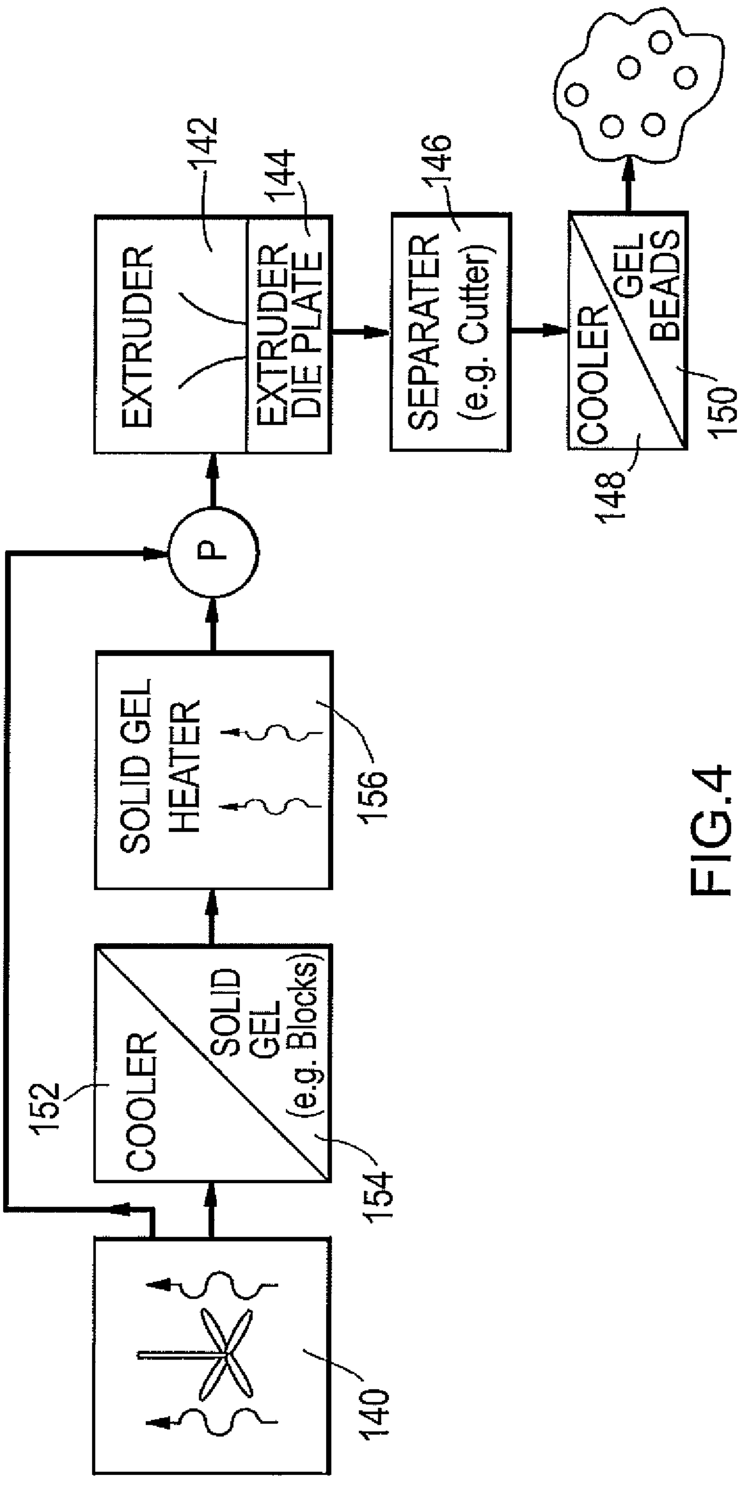
140
152
COOLER
SOLID GEL (e.g. Blocks)
154
SOLID GEL HEATER
156
P
EXTRUDER
142
EXTRUDER DIE PLATE
144
SEPARATER (e.g. Cutter)
146
COOLER
GEL BEADS
148
150

FIG.4

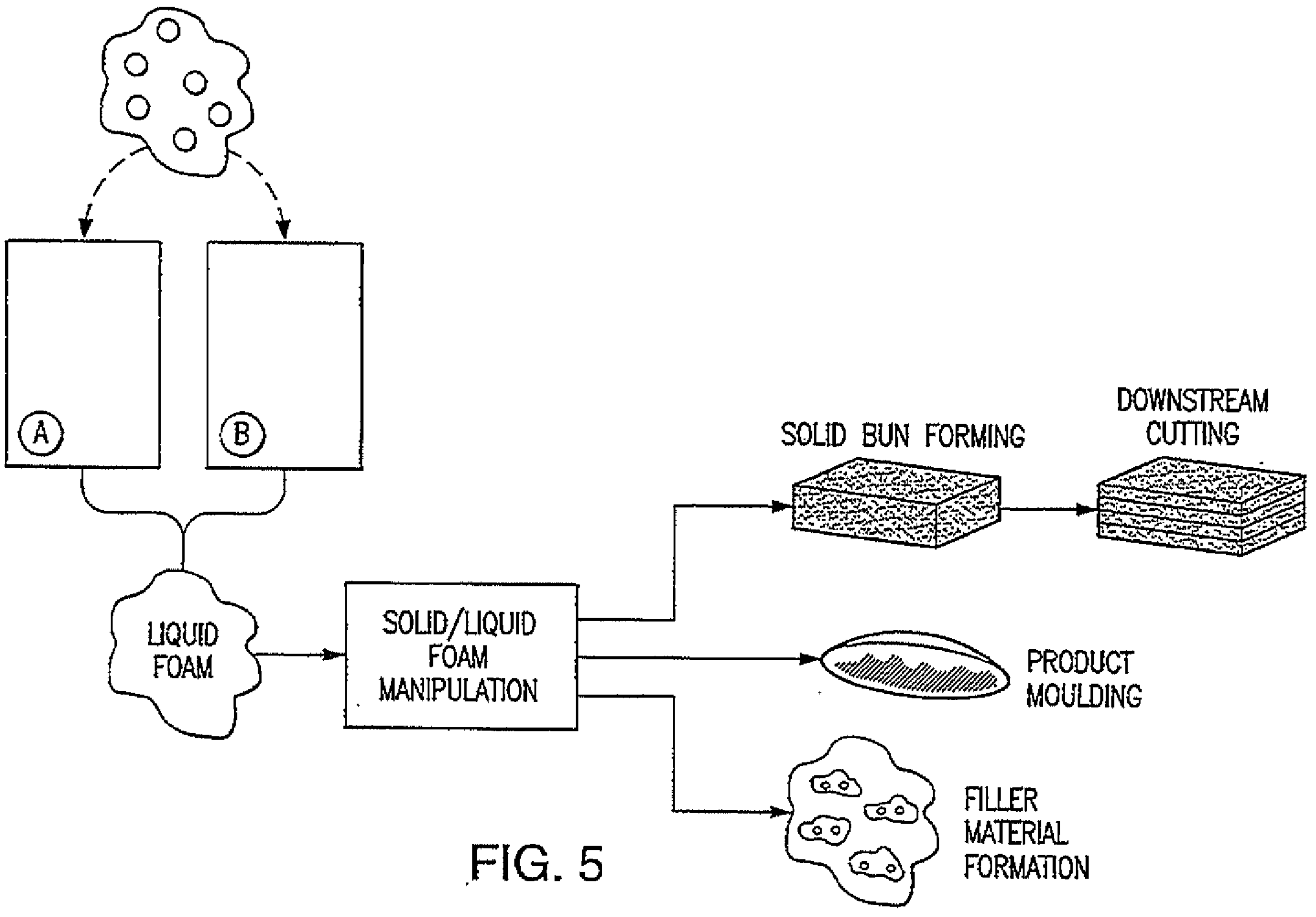
A
B
LIQUID FOAM
SOLID/LIQUID FOAM MANIPULATION
SOLID BUN FORMING
DOWNSTREAM CUTTING
PRODUCT MOULDING
FILLER MATERIAL FORMATION

FIG. 5

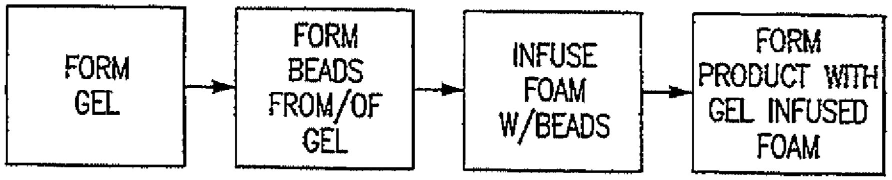

FIG. 6

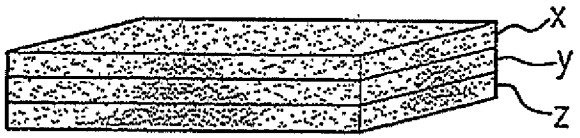

FIG. 7

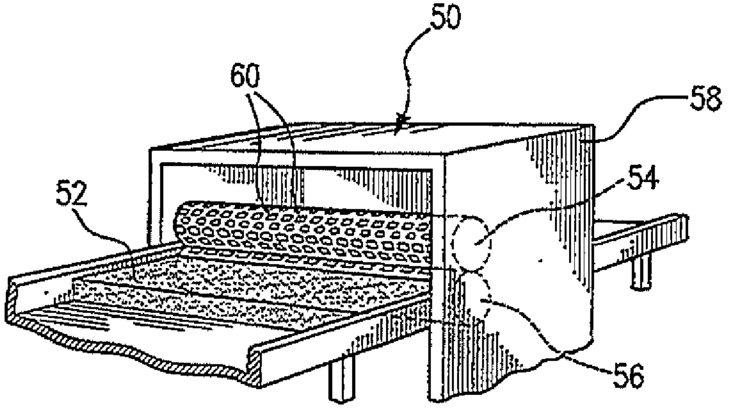

FIG. 8 PRIOR ART

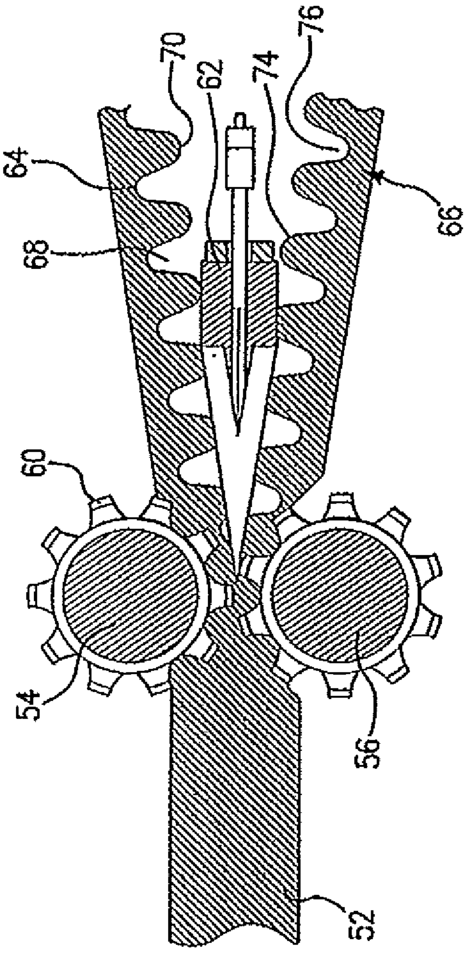

FIG. 9 PRIOR ART

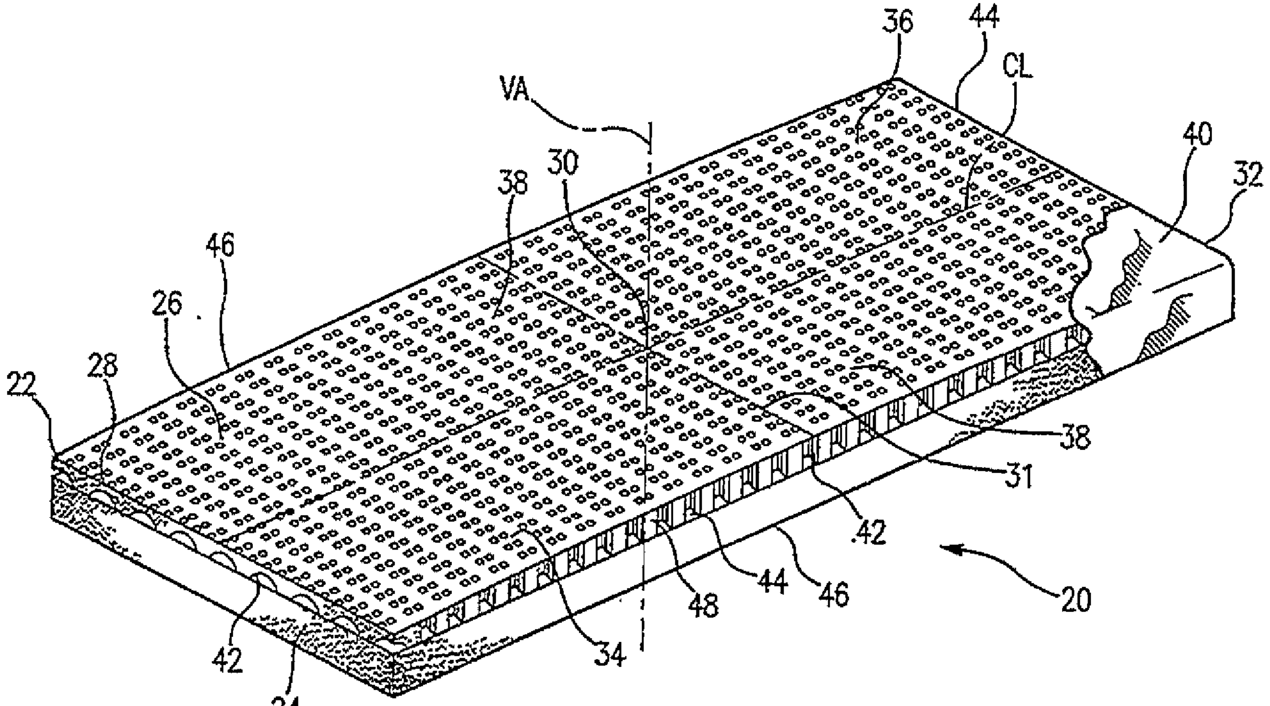

FIG. 10

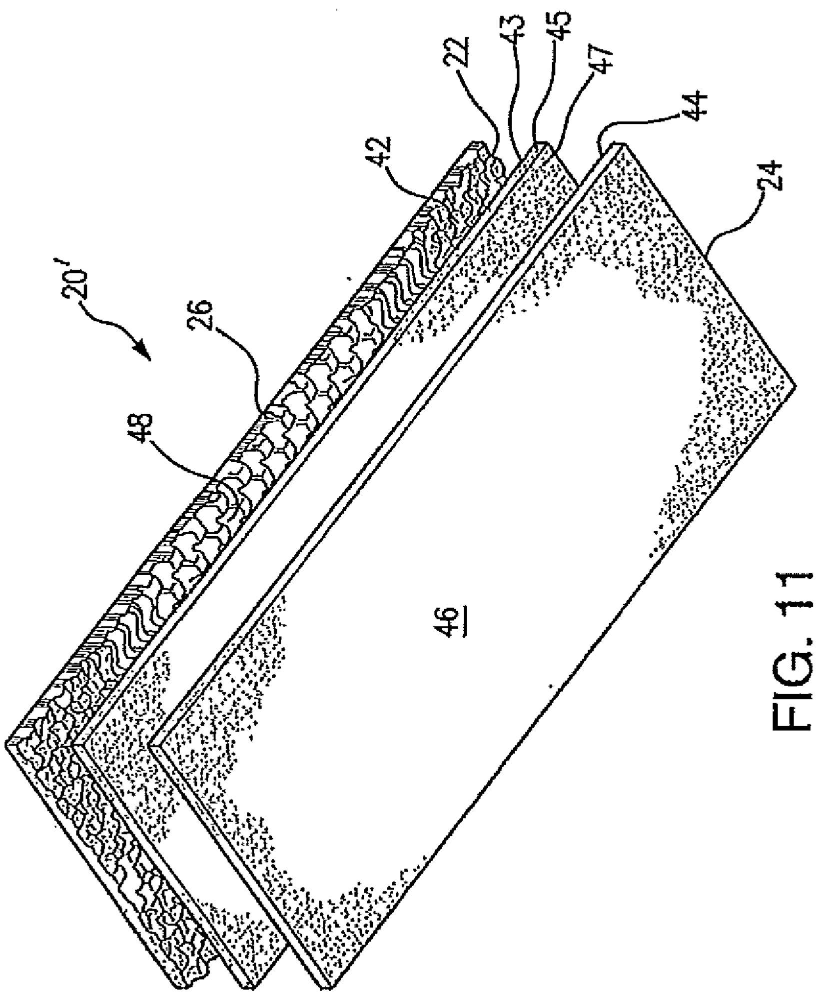

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/050530

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08L53/02 C08J9/00 B29C44/54 B68G11/00 B29D99/00
C08J3/11
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B29C B68G A47C C08J C08L C09K C09J B29D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/017396 A1 (PEARCE TONY M [US] ET AL) 27 January 2005 (2005-01-27) paragraphs [0002], [0211], [0217], [0273] - [0276], [0286], [0350] - [0387], [0538]; claims 1-60 -----	1-22
X	US 6 117 176 A (CHEN JOHN Y [US]) 12 September 2000 (2000-09-12)	1-22
A	column 15, line 66 - column 16, line 31; claims 1-10 -----	23-38
X	US 5 633 286 A (CHEN JOHN Y [US]) 27 May 1997 (1997-05-27)	1-22
A	column 6, line 11 - line 21; figures 1-4 column 9, line 39 - line 57 column 10, line 45 - line 66; examples I-III ----- -/--	23-38

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 21 June 2012	Date of mailing of the international search report 28/06/2012
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Madalinski, Maciej

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2012/050530

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 6 413 455 B1 (YATES PAUL M [US]) 2 July 2002 (2002-07-02) column 1, line 51 - column 1, line 56; claims 1-11 -----	1-38
A	JP 2004 231821 A (INOUE MTP KK; INOAC GIJUTSU KENKYUSHO KK) 19 August 2004 (2004-08-19) the whole document -----	1-38

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2012/050530

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