(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 January 2018 (25.01.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/017978 A1

(51) International Patent Classification:
B62D 25/00 (2006.01) *B62D 29/00* (2006.01)

(21) International Application Number:
PCT/US2017/043332

(22) International Filing Date:
21 July 2017 (21.07.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/365,140 21 July 2016 (21.07.2016) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

(54) Title: REINFORCEMENT STRUCTURE

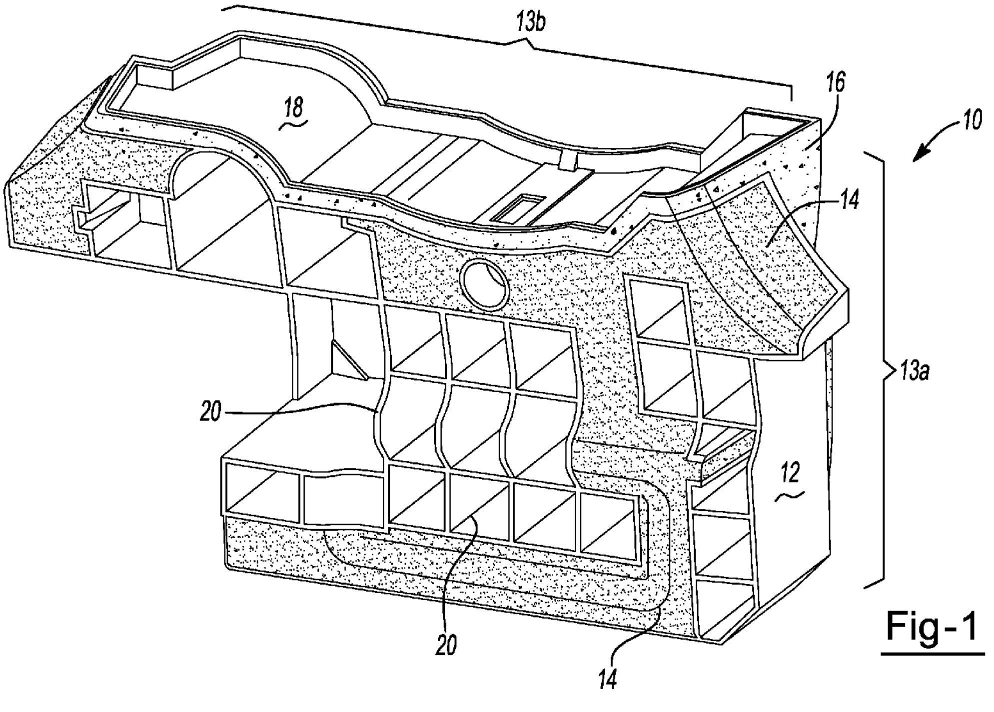

Fig-1

(57) Abstract: A structural reinforcement comprising a base reinforcing structure including a plurality of ribs and having a first surface and a second surface, an expandable adhesive material located onto a first portion of the first surface, and a sealant material located around an edge of the second surface, the second surface being substantially free of any of the plurality of ribs.

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Published:

- — *with international search report (Art. 21(3))*
- — *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

REINFORCEMENT STRUCTURE

Field Of The Invention

[001] The present invention relates generally to reinforcement of structures, and more particularly to reinforcement of vehicle structures using structural reinforcements with associated adhesives and sealants.

BACKGROUND OF THE INVENTION

[002] In various locations throughout transportation vehicles, recent years have seen the increased use of structural reinforcements in which vehicle cavities are commonly fitted with structural reinforcements that aid in controlling deformation from an impact. For some applications, it has become popular in recent years to employ a carrier structure in combination with a secondary material, such as an expandable adhesive material as part of the reinforcement. See e.g., U.S. Patent Nos. 6,932,421; 6,921,130; 6,920,693; 6,890,021; and 6,467,834 all incorporated by reference. Often, these structures are manufactured using injection molding and/or co-extrusion processes.

[003] However, the remains a need for structural reinforcements that include multiple differing secondary materials and/or attachments while still maintaining minimal cycle time during manufacturing.

SUMMARY OF THE INVENTION

[004] The present teachings meet one or more of the above needs by the improved devices and methods described herein.

[005] In one aspect, the present teachings pertain to a structural reinforcement comprising a base reinforcing structure including a plurality of ribs and having a first surface and a second surface, an expandable adhesive material located onto a first portion of the first surface, and a sealant material located around an edge of the second surface, the second surface being substantially free of any of the plurality of ribs.

[006] The expandable adhesive material and sealant material may be free of any direct contact with one another in the green state. The expandable adhesive material and sealant material may be free of any direct contact with one another post-activation. The expandable adhesive material and sealant material may make direct contact with one another during activation. The second surface may include a substantially flat portion. The first portion may be substantially free of any sealant material. The second portion may be substantially free of any structural adhesive material. The first portion may be arranged such that it is in a plane that lies substantially perpendicular to the plane of the second portion. The sealant material may be located along an edge of the second portion that is arranged adjacent to the first portion. The structural adhesive material have a higher expansion rate during activation than the sealant material. The sealant material have a higher expansion rate during activation than the structural adhesive material.

[007] The teachings herein further provide for a method comprising locating a polymeric material in a mold to form a base reinforcing structure including a first portion and a second portion, molding an expandable adhesive material onto the base reinforcing structure, removing the base reinforcing structure and adhesive material from the mold, and extruding a sealant material onto an edge of the base reinforcing structure, wherein the sealant material is located onto the second portion of the base reinforcing structure that is substantially free of any adhesive material.

[008] The sealant material may be extruded via a mini-applicator. The expandable adhesive material and sealant material may be applied so that they are substantially free of any direct contact with one another in the green state. The expandable adhesive material and sealant material may be applied so that they are free of any direct contact with one another post-activation. The expandable adhesive material and sealant material may be applied so that they make direct contact with one another during activation. The second surface may be molded to include a substantially flat portion. No sealant material may be applied to the first portion. No structural adhesive material may be molded onto the second portion. The first portion may be molded such that it is in a plane that lies substantially perpendicular to the plane of the second portion. The sealant material may be extruded along an edge of the second portion that is arranged adjacent to the first portion.

DESCRIPTION OF THE DRAWINGS

[009] Fig. 1 is a perspective view of an illustrative reinforcement in accordance with the present teachings.

[0010] Fig. 2 is a perspective view of the reinforcement of Fig. 1.

[0011] Fig. 3 is a perspective view of the reinforcement of Fig. 1.

DETAILED DESCRIPTION

[0012] The explanations and illustrations presented herein are intended to acquaint others skilled in the art with the invention, its principles, and its practical application. The specific embodiments of the present invention as set forth are not intended as being exhaustive or limiting of the invention. The scope of the invention should be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. The disclosures of all articles and references, including patent applications and publications, are incorporated by reference for all purposes. Other combinations are also possible as will be gleaned from the following claims, which are also hereby incorporated by reference into this written description.

[0013] This application claims the benefit of the priority date U.S. Provisional Application Serial No. 61/365,140, filed July 21, 2016, the contents of that application being hereby incorporated by reference herein for all purposes.

[0014] The invention herein contemplates a unique approach for providing a structural reinforcement that carries at least two different secondary materials.

[0015] The base reinforcing structure may be formed of a moldable material, which may be a polymeric material, which may be a nylon material. The base reinforcing material may be formed by pultrusion. The polymeric material may be a reinforced polymeric material. For example, the polymeric material may be a glass fiber reinforced nylon. The polymeric material may be a polyurethane. The polymeric material may be a thermoset material. The polymeric material may be a thermoplastic material. The polymeric material may be a thermoplastic epoxy material. The polymeric material may be a fiber reinforced thermoplastic epoxy material.

[0016] The adhesive material and/or sealant material may be a material that experiences expansion and/or cure upon exposures to temperatures of between about 148.89°C to about 204.44°C (about 300°F to about 400°F) (i.e., temperatures typically experienced in automotive painting or coating operations). The adhesive material and/or material may be foamed to a volume of at least 5% greater, at least 50% greater, at least 200% greater, at least 1000% greater, at least 2000% greater, at least 5000% greater or higher relative to the original unexpanded volume.

[0017] The adhesive and/or sealant material may be an epoxy based material such as those disclosed in U.S. Patent Nos. 5,884,960; 6,348,513; 6,368,438; 6,811,864; 7,125,461; 7,249,415; and U.S. Patent Publication No. 2004/0076831, hereby incorporated by reference.

[0018] The adhesive materials and sealant materials may include an epoxy resin component. Epoxy resin is used herein to mean any of the conventional epoxy materials containing at least one epoxy functional group. The epoxy resins can be difunctional, trifunctional, multifunctional, combinations thereof or otherwise. Moreover, the term epoxy resin can be used to denote one epoxy resin or a combination of epoxy resins. The polymer-based materials may be epoxy-containing materials having one or more oxirane rings polymerizable by a ring opening reaction. In preferred embodiments, the adhesive and/or sealant material of this invention includes between about 2% and 70% by weight epoxy resin, more preferably between about 7% and 50% by weight epoxy resin and even more preferably between about 15% and 40% by weight epoxy resin and even possibly between about 15% and about 25% by weight epoxy resin.

[0019] The epoxy may be aliphatic, cycloaliphatic, or aromatic. The epoxy may be supplied as a solid (e.g., as pellets, chunks, pieces or the like) or a liquid (e.g., an epoxy resin) or both. As used herein, a resin is considered to be a solid resin if it is solid at a temperature of 23° C. and is considered to be a liquid resin if it a liquid at 23° C. The presence of the epoxy resin increases the adhesion, flow properties, or both of the adhesive and/or sealant. One exemplary epoxy resin may be a phenolic resin, which may be a novalac type or other type resin. For example, bisphenol A resin, bisphenol F resin, a combination thereof or the like may be employed. Moreover, various mixtures of several different epoxy resins may be employed. Examples of suitable epoxy resins are sold under the tradename DER® (e.g., DER 331, DER 661, DER 662), commercially available from the Dow Chemical Company, Midland, Mich.

[0020] Liquid epoxy resins may be utilized. Such resins may be utilized to reduce the overall viscosity of the adhesive or sealant. Liquid epoxy resins that may be used typically have a viscosity at a temperature of 23° C. of at least 5000, more typically at least 8000 and even possibly at least 11,000 cps, but typically less than 30,000, more typically less than 22,000 and even possibly less than 15,000 cps, although higher and lower values may also be possible unless otherwise stated. The liquid epoxy resin typically has an epoxy equivalent weight of at least 80, more typically at least 150 and even possibly at least 185 g/eq, but typically less than 300, more typically less than 220 and even possibly less than 195 g/eq, although higher and lower values may also be possible unless otherwise stated. Preferred liquid resins include diglycidyl ethers that may be aromatic phenol based (bisphenol A or F) and are sold under the tradename DER 331, commercially available from the Dow Chemical Company and EPON 828 and EPON 863, commercially available from Hexion Specialty Chemicals.

[0021] In the preferred embodiment the epoxy resins used are such that the formulated adhesive and sealant are dry to the touch at ambient temperature.

[0022] Additional polymeric materials may be utilized. As one example, one or more thermoplastic modifiers such as polyethers which include pendant hydroxyl moieties. Particularly desirable thermoplastic polyethers are phenoxy resins. As used herein, phenoxy resin is a polyhydroxyether, with ether linkages along the polymer backbone and pendant hydroxyl groups. One useful phenoxy resin is the reaction product of a phenol based difunctional epoxy resin and a difunctional phenol (for example the reaction product of bisphenol A epoxy with bisphenol A). A similar material may also be synthesized directly from a bisphenol (for example bisphenol A) and epichlorohydrin. The terminal epoxy group may be ring opened to generate a terminal alpha glycol group. The phenoxy resins have weight-average molecular weights of at least about 5,000, more typically at least about 25,000 and still more typically at least about 50,000 but less than about 100,000, more typically less than about 75,000 and still more typically less than about 60,000. Other thermoplastic polyethers include aromatic ether/amine repeating units in their backbones such as polyetheramines, poly(amino ethers), copolymers of monoethanolamine and diglycidyl ether, combinations thereof or the like. Examples of thermoplastic polyethers are disclosed in U.S. Pat. Nos. 5,275,853; 5,464,924 and 5,962,093.The thermoplastic modifiers such as the polyethers preferably comprise between 3% and about 40% by weight of the adhesive or sealant material and even more preferably between about 10% and 30% more preferably between 10% and about 15%.

[0023] Several additional polymers may be incorporated into the adhesive and/or sealant material, e.g., by copolymerization, by blending, or otherwise. For example, without limitation, other polymers that might be appropriately incorporated into the sealant material include halogenated polymers, polycarbonates, polyketones, urethanes, polyesters, silanes, sulfones, allyls, olefins, styrenes, acetates, ethylene vinyl acetates, acrylates, methacrylates, epoxies, silicones, phenolics, rubbers, polyphenylene oxides, terphthalates, or mixtures thereof. Other potential polymeric materials may be or may include, without limitation, polyethylene, polypropylene, polystyrene, polyolefin, polyacrylate, poly(ethylene oxide), poly(ethyleneimine), polyester, polyurethane, polysiloxane, polyether, polyphosphazine, polyamide, polyimide, polyisobutylene, polyacrylonitrile, poly(vinyl chloride), poly(methylmethacrylate), poly(vinyl acetate), poly(vinylidene chloride), polytetrafluoroethylene, polyisoprene, polyacrylamide, polyacrylic acid, polymethacrylate, and polyacetals.

[0024] It is possible that the adhesive and/or sealant material includes an acrylate copolymer, acetate copolymer or both. The adhesive and/or sealant material may include ethylene methyl acrylate (EMA), ethylene vinyl acetate (EVA) or a combination thereof. When included, EMA is typically between about 1% and about 70%, more typically between about 30% and about 60% and even more typically between about 44% and about 55% by weight of the adhesive and/or sealant material. A desirable EMA can have a melt index between about 110 and about 150 grams/10 min. (e.g., about 135 grams/10 min.). One preferred EMA is sold under the tradename TC140 and is commercially available from Exxon. When included, EVA is typically between about 1% and about 70%, more typically between about 2% and about 10% and even more typically between about 3% and about 5% by weight of the melt flow material.

[0025] It is also contemplated that the adhesive and/or sealant material can include one or more isocyanate reactive ingredients (e.g., polyols), which can be reactive with blocked isocyanates. Example of such ingredients and isocyanates are disclosed in U.S. Patent Application, Publication No. 2005/0320027, which is incorporated herein by reference for all purposes.

[0026] The adhesive and/or sealant material may include one or more additional polymers (e.g., copolymers), which are typically, but not necessarily copolymers or terpolymers, which can include a variety of different polymers, such as thermoplastics, elastomers, thermosets, thermosettables combinations thereof or the like. For example, and without limitation, polymers that might be appropriately incorporated into the adhesive and/or sealant material include halogenated polymers, polycarbonates, polyketones, and polymers of urethanes, polyesters, silanes, sulfones, allyls, olefins, styrenes, acrylates, methacrylates, epoxies, silicones, phenolics, rubbers, polyphenylene oxides, terphthalates, acetates (e.g., EVA), acrylates, methacrylates (e.g., ethylene methyl acrylate polymer) or mixtures thereof. Other potential polymeric materials may be or may include, without limitation, polyolefin (e.g., polyethylene, polypropylene) polystyrene, polyacrylate, polyethylene oxide), poly(ethyleneimine), polyester, polyurethane, polysiloxane, polyether, polyphosphazine, polyamide, polyimide, polyisobutylene, polyacrylonitrile, polyvinyl chloride), poly(methyl methacrylate), polyvinyl acetate), poly(vinylidene chloride), polytetrafluoroethylene, polyisoprene, polyacrylamide, polyacrylic acid, polymethacrylate. Although not required, it may be desired for the adhesive and/or sealant material to include one or more ethylene polymers or copolymers such as ethylene acrylates, ethylene acetates, or the like. Ethylene methacrylate and ethylene vinyl acetate are two preferred ethylene copolymers. When used, the one or more additional polymers comprises about 0.1% to about 50%, more preferably about 1% to about 20% and even more preferably about 5% to about 15% by weight of the adhesive and/or sealant material.

[0027] The adhesive and/or sealant material can also include one or more materials for controlling the rheological characteristics of the sealant material over a range of temperatures (e.g., up to about 250° C. or greater). Any suitable art-disclosed rheology modifier may be used, and thus the rheology modifier may be organic or inorganic, liquid or solid, or otherwise. The rheology modifier may be a polymer, and more preferably one based upon an olefinic (e.g., an ethylene, a butylenes, a propylene or the like), a styrenic (e.g., a styrene-butadiene-containing rubber), an acrylic or an unsaturated carboxylic acid or its ester (such as acrylates, methacrylates or mixtures thereof; e.g., ethylene methyl acrylate (EMA) polymer) or acetates (e.g., EVA). The rheology modifier may be provided in a generally homogeneous state or suitable compounded with other ingredients. It is also contemplated that the various clays, minerals or other materials discussed in relation to fillers below can be employed to modify rheology of the adhesive and/or sealant material.

[0028] The adhesive and/or sealant material may each include one or more curing agents that assist the adhesive and/or sealant material in curing by crosslinking of the polymers, epoxy resins and other ingredients in the material. The amount of curing agents or curing agent accelerators present in the adhesive and/or sealant material range from about 0.001% by weight to about 9% by weight and more typically from about 0.2 to about 6 wt %, and even more typically from about 2 wt % to about 6% by weight. The curing agent materials can be selected from aliphatic or aromatic amines or their respective adducts, amidoamines, polyamides, cycloaliphatic amines, anhydrides, polycarboxylic polyesters, isocyanates, phenol-based resins (e.g., phenol or cresol novolak resins, copolymers such as those of phenol terpene, polyvinyl phenol, or bisphenol-A formaldehyde copolymers, bishydroxyphenyl alkanes or the like), dihydrazides, sulfonamides, diamino diphenyl solfone, anhydrides, mercaptans, imidazoles, ureas, tertiary amines, BF3 complexes or mixtures thereof. Particular preferred curing agents include modified and unmodified polyamines or polyamides such as triethylenetetramine, diethylenetriamine tetraethylenepentamine, cyanoguanidine, dicyandiamides and the like.

[0029] An accelerator for the curing agents (e.g., a modified or unmodified urea such as methylene diphenyl bis urea, an imidazole, blocked amine or a combination thereof) may also be provided for preparing the adhesive and/or sealant material.

[0030] The adhesive and/or sealant materials may contain other additives such as flexibilizers, impact modifiers, polymers or copolymers fillers and other elongation promoting additives.

[0031] If included, such impact modifiers (e.g., toughening agents) contribute to the desired mechanical properties of the adhesive and/or sealant material such as Lap Shear and T Peel strength by the distribution of energy within the adhesive and/or sealant system. It is generally preferable for the impact modifier to be at least 4%, more typically at 10%, and even more typically at least 20% by weight of the adhesive and/or sealant material and also preferable for the impact modifier to be less than 70%, more typically less than 40% an even more typically less than 30% by weight of the adhesive and/or sealant material. The term “impact modifier” can include one impact modifier or several impact modifiers. The impact modifier can include thermoplastics, thermosets or thermosettables, elastomers, combinations thereof or the like. In a preferred embodiment the impact modifier includes elastomer (including elastomer containing materials), a core/shell polymer (which may include elastomer), or a combination thereof.

[0032] The impact modifier may include a substantial portion of core/shell impact modifier. When it includes a core/shell polymer it is preferred that the impact modifier is comprised of at least 60%, more typically at least 80% and even possibly at least 97% core/shell polymer. As used herein, the term core/shell impact modifier denotes an impact modifier wherein a substantial portion (e.g., greater than 30%, 50%, 70% or more by weight) thereof is comprised of a first polymeric material (i.e., the first or core material) that is substantially entirely encapsulated by a second polymeric material (i.e., the second or shell material). The first and second polymeric materials, as used herein, can be comprised of one, two, three or more polymers that are combined and/or reacted together (e.g., sequentially polymerized) or may be part of separate or the same core/shell systems.

[0033] The first and second polymeric materials of the core/shell impact modifier can include elastomers, polymers, thermoplastics, copolymers, other components, combinations thereof or the like. In preferred embodiments, the first polymeric material, the second polymeric material or both of the core/shell impact modifier include or are substantially entirely composed of (e.g., at least 70%, 80%, 90% or more by weight) one or more thermoplastics. Exemplary thermoplastics include, without limitation, poly-styrenics, poly-acrylonitriles, poly-acrylates, poly-acetates, polyamides, and poly-olefins.

[0034] Preferred core/shell impact modifiers are formed by emulsion polymerization followed by coagulation or spray drying. In certain applications, coagulated grades of core/shell impact modifiers have been found particularly desirable for promoting adhesion to surfaces having impurities thereon such as dirt, oil (e.g., metal stamping oil) or the like. Such impact modifiers can reduce the likelihood of adhesive failure (as opposed to cohesive failure).

[0035] Examples of useful core-shell graft copolymers that may be used as impact-modifiers are those where hard containing compounds, such as styrene, acrylonitrile or methyl methacrylate, are grafted onto a core made from polymers of soft or elastomeric containing compounds such as butadiene or butyl acrylate. U.S. Pat. No. 3,985,703, describes useful core-shell polymers, the core polymers of which are made from butyl acrylate but can be based on ethyl isobutyl, 2-ethylhexyl or other alkyl acrylates or mixtures thereof. The core polymer may also include other copolymerizable containing compounds, such as styrene, vinyl acetate, methyl methacrylate, butadiene, isoprene, or the like. The core polymer material may also include a cross linking monomer having two or more nonconjugated double bonds of approximately equal reactivity such as ethylene glycol diacrylate, butylene glycol dimethacrylate, and the like. The core polymer material may also include a graft linking monomer having two or more nonconjugated double bonds of unequal reactivity such as, for example, diallyl maleate and allyl methacrylate.

[0036] The shell portion may be polymerized from methyl methacrylate and optionally other alkyl methacrylates, such as ethyl and butyl methacrylates or mixtures thereof. Up to 40 percent by weight or more of the shell monomers may be styrene, vinyl acetate, vinyl chloride, and the like. Additional core-shell graft copolymers useful in embodiments of the present invention are described in U.S. Pat. Nos. 3,984,497; 4,096,202; 4,034,013; 3,944,631; 4,306,040; 4,495,324; 4,304,709; and 4,536,436. Examples of core-shell graft copolymers include, but are not limited to, “MBS” (methacrylate-butadiene-styrene) polymers, which are made by polymerizing methyl methacrylate in the presence of polybutadiene or a polybutadiene copolymer rubber. The MBS graft copolymer resin generally has a styrene butadiene rubber core and a shell of acrylic polymer or copolymer. Examples of other useful core-shell graft copolymer resins include, ABS (acrylonitrile-butadiene-styrene), MABS (methacrylate-acrylonitrile-butadiene-styrene), ASA (acrylate-styrene-acrylonitrile), all acrylics, SA EPDM (styrene-acrylonitrile grafted onto elastomeric backbones of ethylene-propylene diene monomer), MAS (methacrylic-acrylic rubber styrene), and the like and mixtures thereof.

[0037] The adhesive and/or sealant composition may be activatable (e.g., foamable) and as such it may contain one or more foaming agents that typically produce inert gasses that transform the adhesive/sealant into an open and/or closed cellular structure. The expansion can help to improve adhesion, sealing capability, acoustic damping, reduce density, or a combination of factors. Amounts of blowing agents and blowing agent accelerators that can be used can vary widely depending upon the type of cellular structure desired, the desired amount of expansion of the adhesive and/or sealant material, the melt viscosity of the materials, and the desired rate of expansion. Exemplary ranges for the amounts of blowing agents and blowing agent accelerators in the activatable material range from about 0.001% by weight to 2%.

[0038] Chemical blowing agents that may be used include one or more nitrogen containing groups such as amides, amines, and the like. Examples of suitable blowing agents include dinitrosopentamethylenetetramine, azodicarbonamide, dinitroso-pentamethylenetetramine, 4,4′oxy-bis-(benzene-sulphonylhydrazide), trihydra-zinotriazine and N,N′-dimethyl-N,N′-dinitroso-terephthalamide.

[0039] Physical blowing agents may additionally or alternatively be employed. As one example, solvent filled polymeric shells that soften and expand upon exposure to heat may be used. A typical example is sold under the trade name Expancel by Akzo Nobel.

[0040] An accelerator for the chemical blowing agents may also be provided in the adhesive and/or sealant material to increase the rate at which the blowing agents form inert gasses. One preferred blowing agent accelerator is a metal salt, such as an oxide, for example zinc oxide. Other preferred accelerators include organic bases such as urea and organic acids such as adipic or benzoic acid. Zinc benzene sulfonate may also be a desirable accelerator.

[0041] The adhesive and/or sealant material of the present invention may also include one or more fillers, including but not limited to particulate materials (e.g., powder), beads, microspheres, or the like. Use of fillers can impart properties such as strength, dimensional stability, and impact resistance to the adhesive and/or sealant they can however reduce elongation properties. Filler addition can also reduce formulation cost and produce products that have less tack prior to cure.

[0042] Examples of fillers that may be used include silica, diatomaceous earth, glass, clay (e.g., including nanoclay), talc, pigments, colorants, glass beads or bubbles, carbon or ceramic fibres and nylon or polyamide fibres (e.g., Kevlar). Examples of suitable fillers include, without limitation, wollastonite, talc, vermiculite, pyrophyllite, sauconite, saponite, nontronite, montmorillonite or mixtures thereof. Clays usable for the adhesive and/or sealant material may be calcined or uncalcined. Clays that may be used as fillers may include clays from the kaolinite, illite, chloritem, smecitite or sepiolite groups, which may be calcined. The clays may also include minor amounts of other ingredients such as carbonates, feldspars, micas and quartz. One or more mineral or stone type fillers such as calcium carbonate, sodium carbonate or the like may be used as fillers. Silicate minerals such as mica may be used as fillers.

[0043] When employed, the amount of fillers in the adhesive and/or sealant material can range from 2% to more than 30% or greater by weight, but more typical from about 8 to 25% by weight, however amounts (below 20%) are preferable in order to retain the desired elongation of the adhesive and/or sealant. According to some embodiments, the adhesive and/or sealant material may include from about 0% to about 3% by weight, and more preferably slightly less than 1% by weight clays or similar fillers. Powdered (e.g. about 0.01 to about 50, and more preferably about 1 to 25 micron mean particle diameter) mineral type filler can comprise between about 5% and 40% by weight, more preferably about 10% to about 25% by weight.

[0044] The adhesives and sealants described herein may be a liquid, a paste or a solid. It is possible that the adhesive and/or sealant material is formed as a material that is solid at ambient temperature, is non tacky to the touch and has a substantially homogeneous composition. Various mixing techniques may be used to obtain such a material.

[0045] According to one embodiment, the adhesive material may be formed by heating one or more of the components that are generally easier to soften or liquidize such as the polymer based materials to induce those components into a mixable state. Thereafter, the remaining components may then be intermixed with the softened components.

[0046] It is also possible that the materials are provided individually, as admixtures or combinations thereof to an extruder. The extruder then mixes the materials to form the adhesive and/or sealant material. Alternatively the adhesive and/or sealant material may be fully mixed and formed and then fed to an extruder for dispensing.

[0047] As shown for example in Figs. 1-3, the reinforcement structure 10 is shown having a base reinforcing structure 12 having a first surface 13a and a second surface 13b, an adhesive material 14 located on the first surface 13a and a sealant material 16 located onto an edge, which may be about the periphery, of the second surface 13b. The first surface may include a plurality of rib structures 20. The second surface may include a substantially flat portion 18. The flat portion 18 is shown in the figures as being substantially free of any adhesive material 14. The rib structures 20 are shown in the figures as being substantially free of any sealant material 16.

[0048] The reinforcement structure may be formed by a combination of molding steps and extrusion steps. The base reinforcing structure may be formed by an injection molding step. The adhesive material may be applied to the base reinforcing structure by a second molding process (e.g., a two-shot molding process) whereby the adhesive material is injection molded onto the base reinforcing structure. The sealant material may then be extruded onto the base reinforcing structure. The extrusion process may be completed by a traditional twin screw extruder, or may be extruded by a robotic extrusion system, including a mini applicator (e.g., mini extruder) attached to a robotic arm. The base reinforcing structure may thus be removed from a molding device (such removal may be automated) and moved in-line to a location where the sealant material is extruded onto a portion of the base reinforcing structure.

[0049] Unless stated otherwise, dimensions and geometries of the various structures depicted herein are not intended to be restrictive of the invention, and other dimensions or geometries are possible. Plural structural components can be provided by a single integrated structure. Alternatively, a single integrated structure might be divided into separate plural components. In addition, while a feature of the present invention may have been described in the context of only one of the illustrated embodiments, such feature may be combined with one or more other features of other embodiments, for any given application. It will also be appreciated from the above that the fabrication of the unique structures herein and the operation thereof also constitute methods in accordance with the present invention.

[0050] The preferred embodiment of the present invention has been disclosed. A person of ordinary skill in the art would realize however, that certain modifications would come within the teachings of this invention. Therefore, the following claims should be studied to determine the true scope and content of the invention.

[0051] The explanations and illustrations presented herein are intended to acquaint others skilled in the art with the invention, its principles, and its practical application. Those skilled in the art may adapt and apply the invention in its numerous forms, as may be best suited to the requirements of a particular use. Accordingly, the specific embodiments of the present invention as set forth are not intended as being exhaustive or limiting of the invention. The scope of the invention should, therefore, be determined not with reference to the above description, but should instead be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. The disclosures of all articles and references, including patent applications and publications, are incorporated by reference for all purposes. Other combinations are also possible as will be gleaned from the following claims, which are also hereby incorporated by reference into this written description.

CLAIMS

What is claimed is:

1. A structural reinforcement comprising:

i) a base reinforcing structure including a plurality of ribs and having a first surface and a second surface;

ii) an expandable adhesive material located onto a first portion of the first surface;

iii) a sealant material located around an edge of the second surface, the second surface being substantially free of any of the plurality of ribs.

2. The structural reinforcement of claim 1, wherein the expandable adhesive material and sealant material are free of any direct contact with one another in the green state.

3. The structural reinforcement of claim 1 or claim 2, wherein the expandable adhesive material and sealant material are free of any direct contact with one another post-activation.

4. The structural reinforcement of any of claims 1 through 3, wherein the expandable adhesive material and sealant material make direct contact with one another during activation.

5. The structural reinforcement of any of claims 1 through 4, wherein the second surface includes a substantially flat portion.

6. The structural reinforcement of any of claims 1 through 5, wherein the first portion is substantially free of any sealant material.

7. The structural reinforcement of any of claims 1 through 6, wherein the second portion is substantially free of any structural adhesive material.

8. The structural reinforcement of any of claims 1 through 7, wherein the first portion is arranged such that it is in a plane that lies substantially perpendicular to the plane of the second portion.

9. The structural reinforcement of any of claims 1 through 8, wherein the sealant material is located along an edge of the second portion that is arranged adjacent to the first portion.

10. The structural reinforcement of any one of claims 1 through 9, wherein the structural adhesive material has a higher expansion rate during activation than the sealant material.

11. A method comprising:

locating a polymeric material in a mold to form a base reinforcing structure including a first portion and a second portion;

molding an expandable adhesive material onto the base reinforcing structure;

removing the base reinforcing structure and adhesive material from the mold;

extruding a sealant material onto an edge of the base reinforcing structure, wherein the sealant material is located onto the second portion of the base reinforcing structure that is substantially free of any adhesive material.

12. The method of claim 11, wherein the sealant material is extruded via a mini-applicator.

13. The method of claim 11 or claim 12, wherein the expandable adhesive material and sealant material are applied so that they are substantially free of any direct contact with one another in the green state.

14. The method of any of claims 11 through 13, wherein the expandable adhesive material and sealant material are applied so that they are free of any direct contact with one another post-activation.

15. The method of any of claims 11 through 14, wherein the expandable adhesive material and sealant material are applied so that they make direct contact with one another during activation.

16. The method of any of claims 11 through 15, wherein the second surface is molded to include a substantially flat portion.

17. The method of any of claims 11 through 16, wherein no sealant material is applied to the first portion.

18. The method of any of claims 11 through 17, wherein no structural adhesive material is molded onto the second portion

19. The method of any of claims 11 through 18, wherein the first portion is molded such that it is in a plane that lies substantially perpendicular to the plane of the second portion.

20. The method of any of claims 11 through 19, wherein the sealant material is extruded along an edge of the second portion that is arranged adjacent to the first portion.

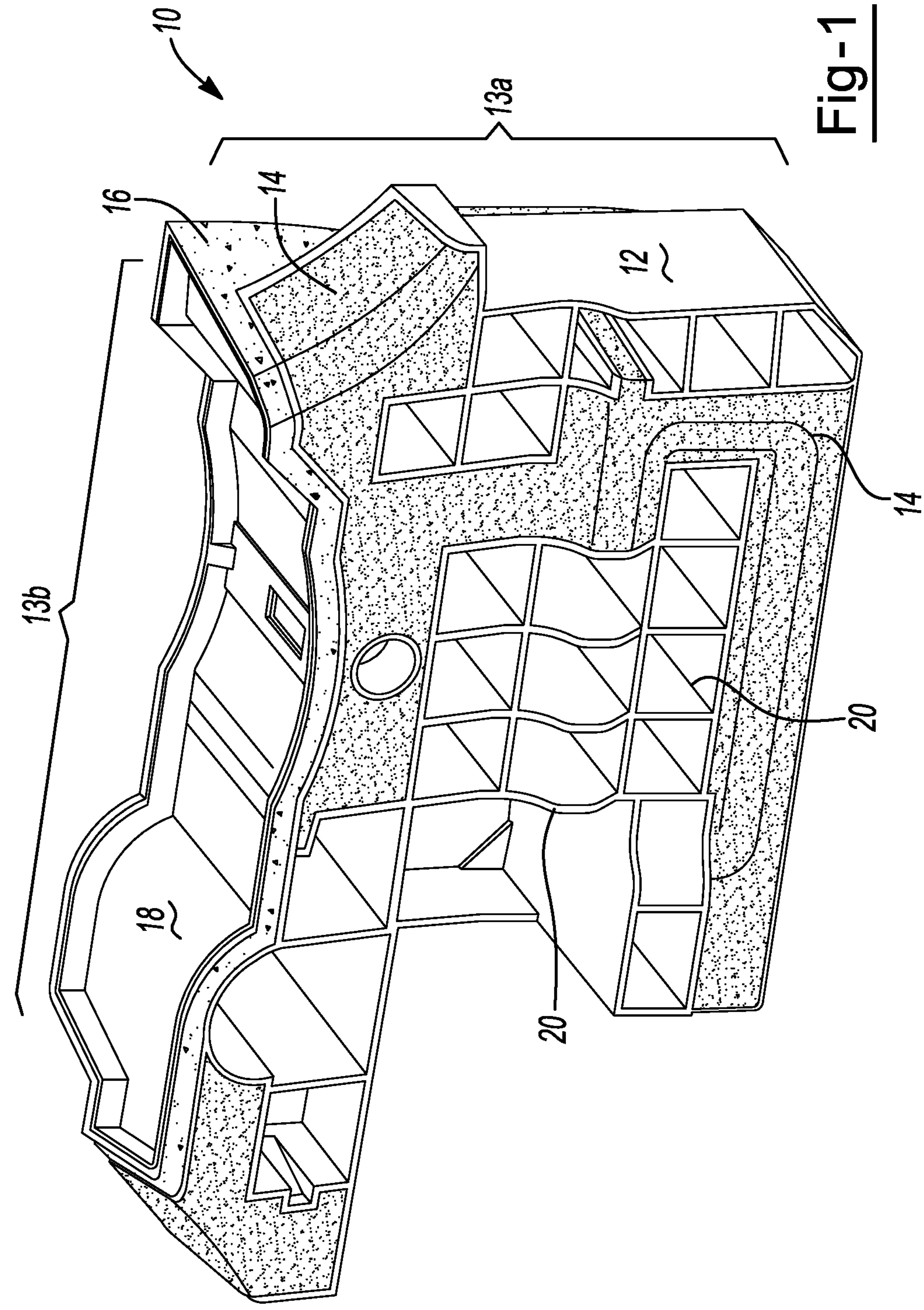

Fig-1

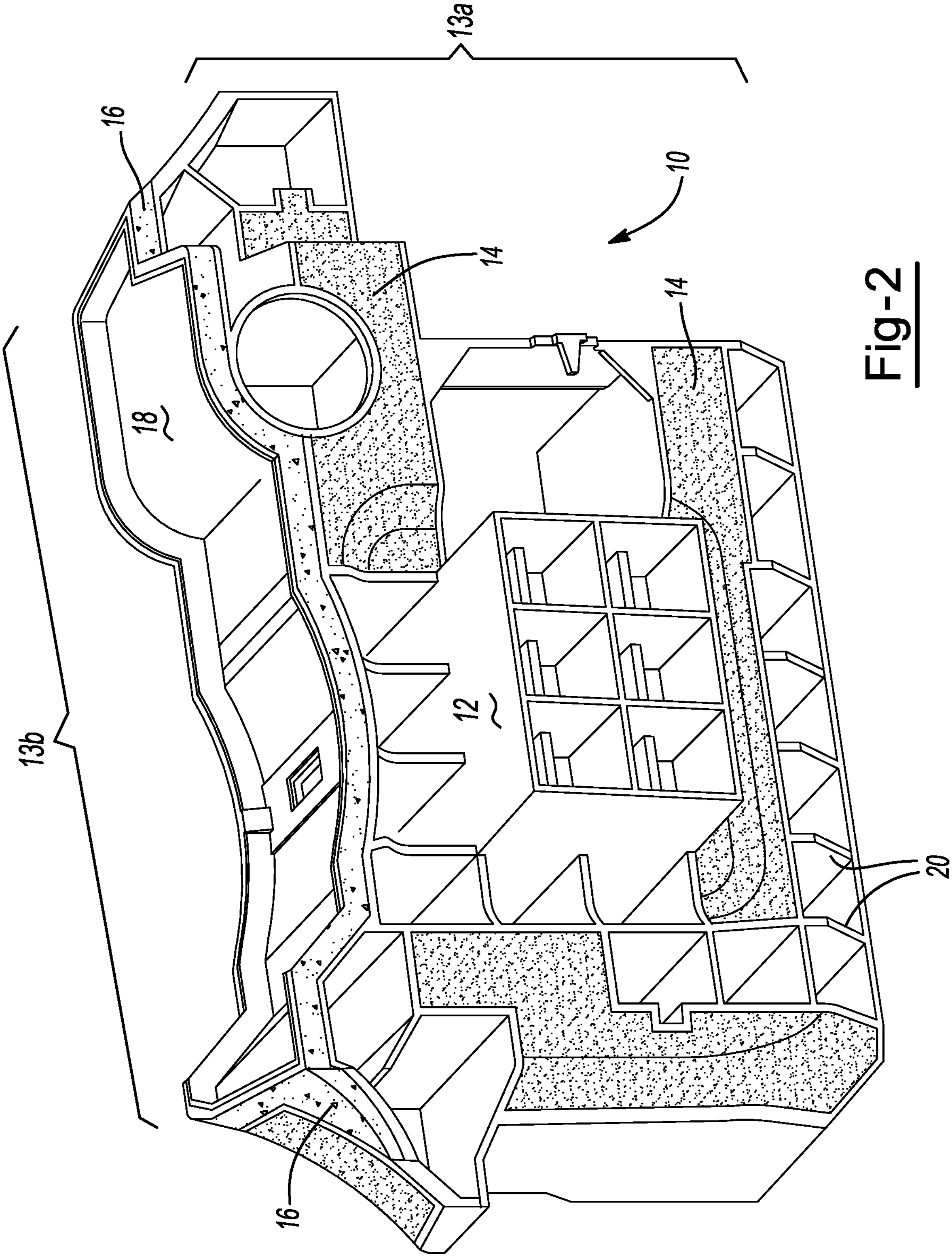

Fig-2

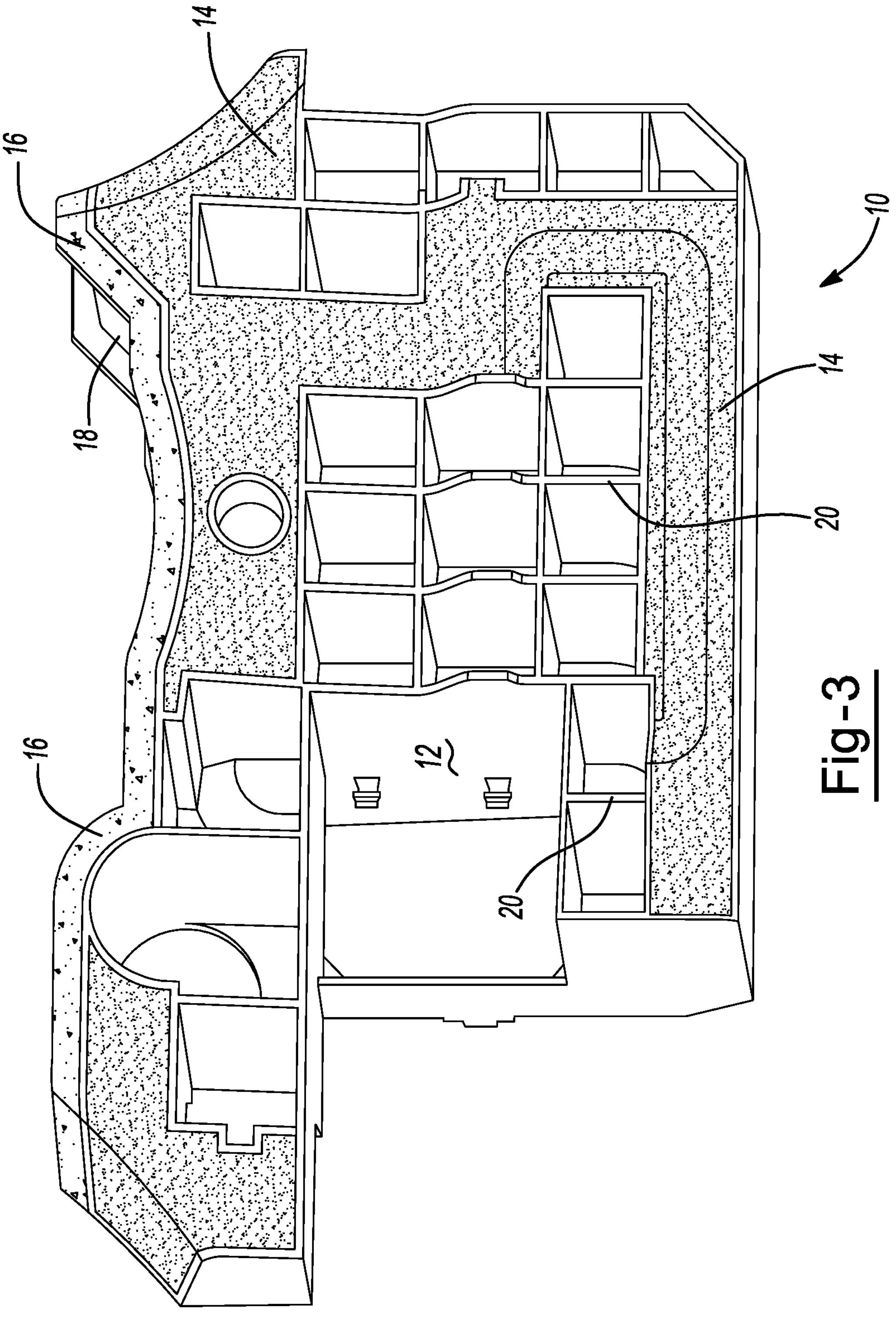

Fig-3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/043332

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62D25/00 B62D29/00
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)
B62D

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.
A	US 6 467 834 B1 (BARZ WILLIAM J [US] ET AL) 22 October 2002 (2002-10-22) cited in the application figure 6 -----	1-20
A	WO 02/074609 A1 (L & L PRODUCTS INC [US]; SHELDON SIMON [GB]; LE GALL ERIC [FR]; BOURDI) 26 September 2002 (2002-09-26) page 9, line 8 - line 16; figures 1-3 -----	1-20
A	GB 2 421 478 A (L & L PRODUCTS INC [US]) 28 June 2006 (2006-06-28) page 8, line 4 - page 9, line 9; figures 1-6 -----	1-20

☐ 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	Date of mailing of the international search report
2 November 2017	10/11/2017

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2017/043332

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