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(54) Title: ROOM TEMPERATURE CROSSLINKED FOAM

(57) Abstract: Low rise, user friendly latex foams for sealing insulative cavities of a building are provided. The foams may be applied to the interface of the sheathing and the studs within the insulative cavities to reduce air leaks. The latex foams may also be applied to the face of the studs to obtain an additional seal against air infiltration. The foam can be used to affix fiberglass batts, batt flanges, and vapor barriers to the framing without mechanical fasteners. A tackifier may be added to impart an adhesive quality to the foam. The tacky nature of the foam permits the drywall or vapor barrier to be repositioned without damage. Drywall is held onto the face of the studs by the tacky foam while mechanical fasteners are inserted to permanently affix the drywall to the framing. The compressive nature of the foam permits drywall to be attached without significant bowing or detachment.

ROOM TEMPERATURE CROSSLINKED FOAM

TECHNICAL FIELD AND INDUSTRIAL APPLICABILITY OF THE INVENTION

The present invention relates generally to spray foams and, more particularly, to user friendly foams formed from latex that are used to fill cavities, cracks, and crevices to enhance the sealing and insulating properties of buildings. Methods of making such foams are also provided.

BACKGROUND OF THE INVENTION

Spray foams have found widespread utility in the fields of insulation and structural reinforcement. For example, spray foams are commonly used to insulate or impart structural strength to items such as automobiles, hot tubs, refrigerators, boats, and building structures. In addition, spray foams are used in applications such as cushioning for furniture and bedding, padding for underlying carpets, acoustic materials, textile laminates, and energy absorbing materials. Currently, spray foams, especially those used as insulators or sealants for home walls, are polyurethane spray foams.

Polyurethane spray foams and their methods of manufacture are well known. Typically, polyurethane spray foams are formed from two separate components, commonly referred to as an "A" side and a "B" side, that react when they come into contact with each other. The first component, or the "A" side, contains an isocyanate such as a di- or poly- isocyanate that has a high percent of NCO (nitrogen, carbon and oxygen) functional groups on the molecule. The second component, or "B" side, contains nucleophilic reagents such as polyols that include two or more hydroxyl groups, silicone-based surfactants, blowing agents, catalysts, and/or other auxiliary agents. The nucleophilic reagents are generally polyols, primary and secondary polyamines, and/or water. Preferably, mixtures of diols and triols are used to achieve the desired foaming properties. The overall polyol hydroxyl number is designed to achieve a 1:1 ratio of first component to second component (A:B).

The two components are typically delivered through separate lines into a spray gun such as an impingement-type spray gun. The first and second components are pumped through small orifices at high pressure to form separate streams of the individual components. The streams of the first and second components intersect and mix with each other within the gun and begin to react. The heat of the reaction causes the temperature of the reactants in the first and second components to increase. This rise in temperature causes the blowing agent located in the second component (the "B" side) to vaporize and form a foam mixture. As the mixture leaves the gun, the mixture contacts a surface, sticks to it, and continues to react until the isocyanate groups have completely reacted. The resulting resistance to heat transfer, or R-value, may be from 3.5 to 8 per inch.

There are several problems associated with conventional polyurethane spray foams. For example, although sealing a building with such polyurethane spray foams reduces drafts and keeps conditioned air inside and external air outside of a building, there is a reduction in the ability of moisture to penetrate the building. As a result, the levels of moisture and air pollutants rise in these tightly sealed buildings that no longer permit moisture penetration into the building.

Another problem associated with conventional polyurethane spray foams is that the first component (the "A" side) contains high levels of methylene-diphenyl-di-isocyanate (MDI) monomers. When the foam reactants are sprayed, the MDI monomers form droplets that may be inhaled by workers installing the foam if stringent safety precautions are not followed. Even a brief exposure to isocyanate monomers may cause difficulty in breathing, skin irritation, blistering and/or irritation to the nose, throat, and lungs. Extended exposure of these monomers can lead to a sensitization of the airways, which may result in an asthmatic-like reaction and possibly death.

An additional problem with such conventional polyurethane spray foams is that residual polymeric methylene-diphenyl-di-isocyanate (PMDI) that is not used is considered to be a hazardous waste. PMDI typically has an NCO of 20%. In addition, PMDI can remain in a liquid state in the environment for years. Therefore, specific procedures must be followed to ensure that the PMDI waste product is properly and safely disposed of in a licensed land fill. Such precautions are both costly and time consuming.

In this regard, attempts have been made to reduce or eliminate the presence of isocyanate and/or isocyanate emission by spray foams into the atmosphere. Examples of such attempts are set forth below.

U.S. Patent Publication No. 2006/0047010 to O'Leary teaches a spray polyurethane foam that is formed by reacting an isocyanate prepolymer composition with an isocyanate reactive composition that is encapsulated in a long-chain, inert polymer composition. The isocyanate prepolymer composition contains less than 1 wt% free isocyanate monomers, a blowing agent, and a surfactant. The isocyanate reactive composition contains a polyol or a mixture of polyols that will react with the isocyanate groups and a catalyst. During application, the spray gun heats the polymer matrix, which releases the polyols and catalyst from the encapsulating material. The polyols subsequently react with the isocyanate prepolymer to form a polyurethane foam.

U.S. Patent No. 7,053,131 to Ko, *et al.* discloses absorbent articles that include super critical fluid treated foams. In particular, super critical carbon dioxide is used to generate foams that assertedly have improved physical and interfacial properties.

U.S. Patent No. 6,753,355 to Stollmaier, *et al.* discloses a composition for preparing a latex foam that includes a latex and a polynitrilic oxide (*for example*, 2,4,6-triethylbenzene-1,3-dinitrile oxide) or a latex and an epoxy silane. The latex may be carboxylated. It is asserted that the composition is stable for at least twelve months and that the one-part coating systems can be cured at room temperature without the release of by-products.

U.S. Patent No. 6,414,044 to Taylor teaches foamed caulk and sealant compositions that include a latex emulsion and a liquid gaseous propellant component. The foamed compositions do not contain a gaseous coagulating component.

U.S. Patent No. 6,071,580 to Bland, *et al.* discloses an absorbent, extruded thermoplastic foam made with blowing agents that include carbon dioxide. The foam is allegedly capable of absorbing liquid at 50 percent or more of its theoretical volume capacity.

U.S. Patent No. 5,741,823 to Hsu teaches producing a smooth, hard coating on a wood substrate. The coating is made of a foamed, polymerized latex emulsion and is applied on the surface of a wood substrate.

U.S. Patent No. 5,585,412 to Natoli, *et al.* discloses a process for preparing flexible CFC-free polyurethane foams that uses an encapsulated blowing agent. The process provides a polyurethane foam having a desired density that avoids the use of chlorofluorocarbons or other volatile organic blowing agents. The encapsulated blowing agent assertedly supplements the primary blowing action provided by water in the manufacture of water-blown polyurethane foam and facilitates in the production of foam having the desired density.

U.S. Patent No. 4,306,548 to Cogliano discloses lightweight foamed porous casts. To manufacture the casts, expanded non-porous polystyrene foam beads or other shapes are coated with a layer of neoprene, natural rubber, or other latex. The coated polystyrene is then encased in a porous envelope, and the envelope is applied to a broken limb. Additional coated polystyrene is added over the envelope and a gaseous coagulant is added to gel the latex, which causes the polystyrene beads to adhere to each other and produce a unified, rigid structure.

Despite these attempts to reduce or eliminate the use of isocyanate in spray foams and/or reduce isocyanate emission into the air, there remains a need in the art for a spray foam that is non-toxic and environmentally friendly.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide two-part foam compositions. In particular, a two-part foam composition is formed of an A-side and a B-side. The A-side of the foamable composition includes a functionalized water-dispersible resin (*for example*, a functionalized latex) and/or a functionalized resin (*for example*, acrylic solution) and the B-side contains a crosslinking agent that crosslinks at or above room temperature and optionally, a non-reactive resin (*for example*, a non-functionalized latex). Additionally, either or both the A-side or the B-side may contain a blowing agent that initiates a foaming reaction and forms a foam.

The inventive foams can be used in any application where a flexible foam is required. Such as spray, molding, extrusion, and injection molding (*for example*, reaction injection molding (RIM)) applications. The foam may be used to fill cavities, cracks, and crevices to enhance the sealing and insulating properties of buildings, cars, and appliances

or to form backing for carpets. The foam may be used in insulation or acoustical applications and in any application where polyurethane foam may be advantageous. Such uses include, but are not limited to, residential and commercial buildings, automobiles, appliances, and aircraft.

The foam may be used in automotive applications such as automotive seating, head liner panels, and in sound dampening applications under the body of the vehicle or in the engine compartment. The foam can also be used to replace masticated rubber.

The foam of the present invention can also be used in furniture applications such as cushions, mattresses, topper pads for mattresses, furniture arms and backs, seat cushions, and pillows.

The foam of the present invention may be used in consumer products and personal products. Such examples include display and cushion packaging, toys, novelty items, mops and sponges, retail and promotional items, perishable goods packaging and cosmetic applicators.

The foam of the present invention may also be used in medical applications such as for lightweight casts and as protection for medical instruments. The foam may also be used in the textile industry as clothing and as padding in clothing.

The foam of the present invention may be used in the building materials industry as an acoustical and/or thermal insulation in residential or commercial applications. Examples include as a spray-on house wrap and as a spray on stud facing to permit the adhesion of batts and vapor barrier to the foam. The foam may be affixed to wood we and act as a means to adhere a plastic vapor barrier material. The foam may also be manufactured into a foam tape which is particularly useful in sealing windows and/or doors.

The foam of the present invention may be used in industrial applications such as in filtration, as filtration media, as an anti-static grade, as protective packaging and to provide a cushioned coating on substrates.

In any of the aforementioned applications, the foam may be layered with other materials to form a composite to provide enhanced acoustical, thermal or cushioning properties. For example, the foam can be used with wood, flexible and/or rigid foam, insulation (acoustical/thermal), metal, fabrics, plastic, and combinations thereof.

The inventive foams do not release any harmful vapors into the air when applied or sprayed. Accordingly, the foams reduce the threat of harm to individuals working with or located near the foam and can be used in the renovation market, as well as in houses that are occupied by persons or animals.

It is another object of the present invention to provide a method for reducing air leaks in an insulative cavity of a building. A first component includes at least one functionalized resin selected from a functionalized water-dispersible resin and a functionalized water-soluble resin and a second component includes a crosslinking agent that crosslinks at or about room temperature. One or both of said first and second component includes a blowing agent. The first and second components are delivered into an application device and mixed to form a foamable reaction mixture. The reaction mixture is then applied to the interface of the studs and sheathing, the top plate and the sheathing, and the bottom plate and the sheathing to "picture frame" the cavity with the inventive foam. The crosslinking agent and functionalized resin are permitted to chemically react while the blowing agent initiates a foaming reaction and forms a foam. The final foamed product becomes cured to the touch within about 2-5 minutes after application. Once the foam has been sprayed around the insulative cavity, a fibrous batt is placed in the cavity. In at least one embodiment, the blowing agent is formed of an acid and a base. When the first component contains the acid, the second component contains the base, and *vice-versa*. Preferably, the base is sodium bicarbonate having a mean particle size from about 2 to about 250 microns, and more preferably a mean particle size from about 2 to about 40 microns. In at least one exemplary embodiment, the sodium bicarbonate is about 11 microns. In preferred embodiments, the acid is a polyacrylic acid that provides the proton needed to react with the base while the remaining anions react with the crosslinking agent and contribute to the foam structure. The foam may also be sprayed or applied at the interface between the floor and the bottom plate to reduce air infiltration between the floor and the bottom plate. In addition, the foam may be applied to the exposed face of the top plates to form a gasket against the drywall to reduce or eliminate the passage of air into the attic.

It is a further object of the present invention to provide a method of forming an insulated internal wall of a building. A first component includes at least one

functionalized resin selected from a functionalized water-dispersible resin and a functionalized water-soluble resin and a second component includes a crosslinking agent that crosslinks at or about room temperature. One or both of said first and second component includes a blowing agent and a tackifier. The first and second components are delivered into an application device and mixed to form a reaction mixture, and the reaction mixture is applied to the faces of the framing studs. The tackifier makes the foam permanently tacky or sticky, and thereby imparts an adhesive quality to the foam. The inventive foam may be used to affix a vapor barrier without the need for any mechanical fasteners such as staples to hold the vapor barrier onto the studs. Drywall may alternatively be placed onto the studs, where it is held in place by the foam while mechanical fasteners are inserted to permanently affix the drywall to the framing. Additionally, the tacky nature of the foam permits the drywall or vapor barrier to advantageously be removed and repositioned without damage. The inventive foam is compliant and contours to the surface of the drywall. Thus, there is not a significant amount of pressure applied to the drywall or vapor barrier due to the giving nature of the foam, and little or no bowing or detachment of the drywall occurs. Further, the compressive nature of the inventive foam allows the vapor barrier to be attached without any significant bulging or stretching of the vapor barrier.

It is also an object of the present invention to provide a method of insulating a building. The foamable composition includes a first component having at least one functionalized resin selected from a functionalized water-dispersible resin and a functionalized water-soluble resin and a second component that includes a crosslinking agent that crosslinks at or about room temperature. One or both of said first and second component includes a blowing agent. To insulate a building, the first and second components are delivered into an application device such as an impingement gun and mixed to form a foamable reaction mixture, which is applied to the faces of the framing studs and circumferentially around the interior boundary of each insulative cavity. The reaction mixture may also be applied along the interface between the floor and the bottom plate to reduce air infiltration between the floor and the bottom plate. Additionally, the reaction mixture may be applied to the exposed face of the first and second top plates, providing a soft gasket to the drywall to reduce or eliminate the passage of air into the

attic. In addition, the foamable reaction mixture may be sprayed around windows, and/or other penetrations, seams, apertures, cracks, and/or other air passageways to eliminate or reduce air infiltration into the building. Once the first and second components are mixed, the crosslinking agent and functionalized resin chemically react and the blowing agent initiates a foaming reaction to form a foam. The inventive foam provides both air-sealing and insulative properties.

It is a further object of the invention to provide a method of sealing a wall cavity. In this embodiment, the inventive latex foams may be applied to fill gaps that can occur at the interface between the top plate and the drywall to reduce or eliminate air infiltration from the wall cavity into the attic. The foamable mixture may be sprayed onto opposing sides of the top plate prior to affixing the drywall panels over the foam. The elastomeric nature of the foam permits the foam to act as a seal when the drywall is applied to the face of the foam. In addition, the foam forms a gasket between the drywall and the top plate to prevent air from passing into and out of the attic space through the gap. Thus, the foam reduces or even prevents unwanted air from passing into the living space or heated or cooled air from escaping the living space of the house.

It is an advantage of the present invention that the inventive foams do not contain the harmful chemicals found in conventional polyurethane spray foams, such as, for example, MDI monomers. As a result, the foams of the present invention do not contain harmful vapors that may cause skin or lung sensitization or generate toxic waste. Additionally, the foams do not emit harmful vapors into the air when the foam is sprayed, such as when filling cavities to seal and/or insulate a building. The inventive foams are safe for workers to install and, therefore, can be used both in the house renovation market and in occupied houses. Additionally, because there are no harmful chemicals in the inventive foams, the foams can be safely disposed without having to follow any stringent hazardous waste disposal precautions.

It is another advantage of the present invention that the foams may be applied using existing spray equipment designed for conventional two-part spray polyurethane foam systems without clogging the spray equipment. Thus, the application gun is capable of repeated use without clogging and the resulting necessary cleaning when the foams of the present invention are utilized.

It is yet another advantage of the present invention that the use of an alcohol co-solvent to partially replace the water in the serum allows for a faster drying/curing of the foam and improves cell structure.

It is a further advantage of the present invention that the components of the foam compositions may be carefully chosen to result in a tacky or sticky foam that can be used to hold the fiberglass batt in place when used to fill cracks or crevices.

It is also an advantage of the present invention that the components of the one-part foam compositions in which the crosslinking agent and base or the acid and base are encapsulated may be mixed and stored in one container without significant reaction until the composition is used.

It is yet another advantage of the present invention that the polyacrylic acid reacts with the crosslinking agent becomes integrated with the structure of the foam.

It is a feature of the present invention that the foam compositions may be used to fill open or closed cavities or to fill cracks and crevices.

It is also feature of the present invention that the foam compositions may be one or two part compositions.

It is another feature of the present invention that polyacrylic acid reacts with a base such as sodium bicarbonate to generate CO_2 gas.

It is yet another feature of the present invention that the dry acid and dry base forming the blowing agent can be encapsulated in a single encapsulant.

It is a further feature of the present invention that the dry acid and dry base forming the blowing agent can be encapsulated in separate encapsulating materials.

It is yet another feature of the present invention that blowing agent or components forming the blowing agent may be encapsulated a wax, a gelatin, a low melting, semi-crystalline, super-cooled polymer such as polyethylene oxide or polyethylene glycol, or a polymer or acrylic that can be broken at the time of the application of the foam.

The foregoing and other objects, features, and advantages of the invention will appear more fully hereinafter from a consideration of the detailed description that follows. It is to be expressly understood, however, that the drawings are for illustrative purposes and are not to be construed as defining the limits of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The advantages of this invention will be apparent upon consideration of the following detailed disclosure of the invention, especially when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic illustration of a portion of a building wall view from an interior viewpoint thereof, each insulative cavity being "picture framed" with an inventive foam according to at least one embodiment of the present invention;

FIG. 2 is a schematic view of a building wall similar to that of FIG. 1, but showing an additional application to the joint at the interface of the first and second top plates and between the bottom wall and the floor;

FIG. 3 is a schematic view of a building wall similar to that of FIG. 1, but having a window inserted into a central portion of the middle insulative cavity; and

FIG. 4 is a schematic view of a building wall similar to that of FIG. 1, but showing application of the foam to the stud faces and/or around the interior boundary of the insulative cavities.

PREFERRED EMBODIMENTS OF THE INVENTION

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention belongs. Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, the preferred methods and materials are described herein. All references cited herein, including published or corresponding U.S. or foreign patent applications, issued U.S. or foreign patents, and any other references, are each incorporated by reference in their entireties, including all data, tables, figures, and text presented in the cited references. The terms "foamable composition", and "foam composition" may be interchangeably used in this application. In addition, the terms "encapsulant" and "encapsulating material" may be used interchangeably herein. Further, the terms "reaction mixture" and "foamable reaction mixture" may be used interchangeably within this application.

The present invention relates to foams used to fill cavities of buildings to improve the sealing and insulation properties. Additionally, the inventive foams may be used to

seal cracks and crevices, such as those around windows and doors. The foams may also be used to form items such as cushions, carpet backing, mattresses, pillows, and toys. The inventive foams can be used in spray, molding, extrusion, and injection molding (*for example,* reaction injection molding (RIM)) applications. In one exemplary embodiment, the inventive foam is formed from two components, namely, an A-side and a B-side. In particular, the A-side of the foam composition includes a functionalized water-dispersible and/or a functionalized water-soluble resin (*for example*, a functionalized latex or a functionalized latex and an acrylic solution) and the B-side contains a crosslinking agent, and optionally, a non-reactive resin (*for example*, a non-functionalized latex). Either or both the A-side or the B-side may contain a blowing agent package. Alternatively, the A-side and the B-side may each contain a component forming a blowing agent package. A plasticizer, a surfactant, a thickener, and/or a co-solvent may optionally be included in either the A- and/or B-side.

In an alternate embodiment, the crosslinking agent and an acid or a base are encapsulated in an encapsulating material to form a one-part foam composition. In a further alternate embodiment, the foamable composition includes a functionalized water-dispersible and/or a functionalized water-soluble resin, a crosslinking agent, and an encapsulated dry acid and/or dry base. In another exemplary embodiment, every component but the functionalized water-dispersible and/or a functionalized water-soluble resin is encapsulated. Unlike conventional spray polyurethane foams, the foams of the present invention do not contain isocyanate. Therefore, no MDI monomers are present in the inventive foams. Because the inventive foam does not contain isocyanate, no harmful chemicals are emitted during installation of the foams.

It is preferred that the foams of the present invention, as well as the components thereof, meet certain performance properties, or Fitness for Use ("FFU") criteria. In particular, the chemical property FFUs that the inventive foam should meet include the following criteria:

- The foam should adhere to various materials such as wood, metal, concrete and plastic
- The chemical constituents should be as safe as possible. If a hazardous chemical is used, it should not be introduced or atomized into the air where it can be inhaled

- The foam may be chemically foamed through the use of a blowing agent or it may be mechanically foamed with a gas
- The installer of the latex foam should be able to work with the material without any specialized personal protective equipment ("PPE"), such as a breathing apparatus, although chemical goggles, dust mask, and gloves are acceptable
- The foam should not lend itself to molding or fungus growth (ASTM C1338)
- The foam should not contain a food source for insects or rodents
- There should be a minimum shelf life of the un-reacted constituents of 9 months.

It is also desirable that the inventive foams of the present invention meet certain physical property FFUs. The physical property FFUs that the inventive foam should meet include the following:

- The foam weight should be between about 0.5 and about 20.0 pounds per cubic foot
- The foam should be fluid enough to be sprayed either at room temperature or by heating (viscosity of <10,000 cP at a high shear rate)
- The foam should not sag or fall in the cavity
- The foam should fill in cracks and crevices or be used to coat the cavity with an air barrier
- Ideally, the cell structure of the foam (closed vs. open) should be a mixture of both a closed and open cell structure to provide appropriate material properties to achieve the other FFUs
- The foam should have a thermal resistance (R-value) of at least 3.0° Fft^2h/BTU per inch
- The foam should be non-sagging and non-dripping (*that is*, fire retardant) during a fire
- The foam should not corrode metal objects such as screws, nails, electrical boxes, and the like
- Air infiltration should be negligible (ASTM E283-04) (spec 0.4 cfm/ sq ft)
- Water vapor infiltration should be greater then 1 perm or $5.72x10^{-8}$ g/Pa-s-m^2
- The foam should have low or no odor.

As discussed above, the A-side of the composition for the foams according to one exemplary embodiment of the present invention includes a functionalized water-dispersible and/or a functionalized water-soluble resin. Preferably, the functionalized water-dispersible resin is a functionalized latex, and even more preferably, the latex system is an acrylic emulsion. Non-limiting examples of suitable water-soluble resins for use in the inventive compositions include acrylic solutions and polyols. In addition to the functionalized water-dispersible and/or functionalized water-soluble resin, the serum can contain a polyacrylic oligomer to increase the total number of the functional groups. It is to be appreciated that although any functionalized water-soluble and/or functionalized water-dispersible resin(s) may be used as a component in the foamable compositions described herein, reference will be made to a preferred embodiment, functionalized latexes with or without an acrylic solution.

There are numerous types of latexes that may be used as the functionalized water-dispersible component in the aqueous resin solution of the present invention. Non-limiting examples of suitable latexes include natural and synthetic rubber resins, and mixtures thereof, including thermosettable rubbers; thermoplastic rubbers and elastomers including, for example, nitrile rubbers (*for example*, acrylonitrile-butadiene); polyisoprene rubbers; polychloroprene rubbers; polybutadiene rubbers; butyl rubbers; ethylene-propylene-diene monomer rubbers (EPDM); polypropylene-EPDM elastomers; ethylene-propylene rubbers; styrene-butadiene copolymers; styrene-isoprene copolymers; styrene-butadiene-styrene rubbers; styrene-isoprene-styrene rubbers; styrene-ethylene-butylene-styrene rubbers; styrene-ethylene-propylene-styrene rubbers; polyisobutylene rubbers; ethylene vinyl acetate rubbers; silicone rubbers including, for example, polysiloxanes; methacrylate rubbers; polyacrylate rubbers including, for example, copolymers of isooctyl acrylate and acrylic acid; polyesters; polyether esters; polyvinyl chloride; polyvinylidene chloride; polyvinyl ethers; polyurethanes and blends; and combinations thereof, including, for example, linear, radial, star, and tapered block copolymers thereof. The preferred latex for use in the inventive foam composition is a carboxylated acrylic latex.

As discussed above, water-dispersible and water-soluble resin is functionalized. The functional group may be any functional group capable of crosslinking, including carboxylic acid, hydroxyl, methylol amide groups, and sulfonates. It is preferred that the

water-dispersible and/or water-soluble resin(s) contain from about 1.0 to about 20 wt% functional groups based on the total dry weight of the resin, and even more preferably from about 2.0 to about 15.0 wt% functional groups based on the total dry weight of the resin. The functionality of the functionalized water-dispersible and/or water-soluble resin can be adjusted by adding or removing functional groups to or from the resin backbone to reach the optimum amount of crosslinking and ultimately the optimum strength and modulus of the foam. In preferred embodiments, a polyacrylic solution is added in amount sufficient to add up to about 50% carboxylate functionality to the final dry foam composition.

The B-side of the foam composition, as indicated previously, contains a crosslinking agent and optionally, a non-reactive resin such as, for example, a non-functionalized latex. In particular, the non-reactive resin is a resin that does not react with the crosslinking agent, but is otherwise non-limiting. The crosslinking agent is a compound that crosslinks at or above room temperature, such as polyfunctional aziridines (*for example*, XAMA®-7 and XAMA®-2, available from Bayer Corporation). Other suitable crosslinking agents include, but are not necessarily limited to, multifunctional carbodiimides (*for example*, Hardner CD, available from Rotta Corporation), melamine formaldehyde, polysiloxanes, and multifunctional epoxies (*for example*, cycloaliphatic diepoxides). It is to be appreciated that when a polyfunctional aziridine (*for example*, XAMA®-7 and XAMA®-2, tri-functional aziridines available from Bayer Corporation) is used as the crosslinking agent, other compounds such as plasticizers or epoxy diluents may be utilized to carry the polyfunctional aziridine and lower the viscosity of the B-side. Also, it has been surprisingly discovered that a polyfunctional aziridine, such as XAMA®-7 and XAMA®-2, does not react with the plasticizers (*for example*, Benzoflex 2088, Benzoflex LA-705, butyl benzoate, Triton X-100, PEG-400, Citroflex 2, and Cirtoflex 4 (discussed in detail below)) that may be used in processing the foam. As a result, when such plasticizers are used, the shelf life of the B-side is greatly improved.

In addition, it has been determined that by eliminating functional groups that are reactive with the polyfunctional aziridine on components present in the B-side, the B-side is stable for extended periods of time, such as six months or greater. Conventionally, polyfunctional aziridine had to be added as the very last component prior to use due to its

high reactivity. However, by choosing the particular components of the B-side, the B-side is able to remain stable in storage for long periods of time until use. Further, by stably incorporating the polyfunctional aziridine into the B-side, the need to add the polyfunctional aziridine separately and immediately prior to use is eliminated.

The crosslinking agent may be present in the B-side in an amount from about 1.0 to about 30 percent by weight of the dry foam composition, preferably in an amount from about 3.0 to about 20 percent by weight. Although a mole ratio of the resin functional groups to the crosslinking agent functional groups of 1:1 is preferred, this molar ratio is variable and may encompass a wider range, such as, for example, from 0.5:1 to 2:1 to provide the optimum crosslinking in the final foam products.

Additionally, the A-side and/or B-side contains a blowing agent package. The blowing agent package may be the combination of two or more chemicals or compounds that when mixed together form a gas (*for example*, an acid and a base such as are discussed below) or a chemical compound that, when heat or light activated, forms a gas. The generated gas may be CO_2, N_2, O_2, H_2, or other non-carcinogenic, gases. For instance, azodicarbonamide is a chemical compound that, upon heating, releases N_2 gas, and would be a suitable blowing agent in the foamable composition. Additionally, alkylsiloxanes, which may release H_2 when reacting with amine hardeners, may be used as a blowing agent in the instant invention. Other examples include diazo compounds (*that is*, CH_2N_2) and aliphatic azide (*that is*, R-N=N=N), which decompose on irradiation to give nitrogen gas, and 1-naphtyl acetic acid and n-butyric acid, which generate carbon dioxide (CO_2) upon photodecarboxylation. Phase change blowing agents such as low boiling point hydrocarbons (*for example*, cyclopentane and n-pentane) and inert gases such as air, nitrogen, carbon dioxide can also be used. It is to be appreciated that the chemical compound is not a conventional blowing agent in the sense that it is a hydro-fluorocarbon (HFC) or a hydro-chloro-fluorocarbon (HCFC) blowing agent.

If the blowing agent package is a single chemical compound, the compound may be included in either the A- or the B-side. On the other hand, if the blowing agent package is formed of two compounds that react to form a gas when mixed, the two components are separated and placed with one component in the A-side and the other component in the B-side.

For instance, an acid and a base forming the blowing agent package may be separated and the acid placed in the A-side and the base placed in the B-side (or *vice versa*). Thus, in addition to the functionalized latex solution, the A-side may contain at least one acid. In exemplary embodiments, the acid is a polyacrylic acid that reacts with a base to generate CO_2. Additionally the polyacrylic acid reacts with the crosslinking agent to become part of the foam structure (*for example*, integrated with the foam structure). The acid may have a solubility of 0.5 g/100 g of water or greater at 30° C. Also, the acid may be a dry acid powder with or without chemically bound water. Non-exclusive examples of suitable acids include citric acid, oxalic acid, tartaric acid, succinic acid, fumaric acid, adipic acid, maleic acid, malonic acid, glutaric acid, phthalic acid, metaphosphoric acid, or salts that are convertible into an acid that is an alkali metal salt of citric acid, tartaric acid, succinic acid, fumaric acid, adipic acid, maleic acid, oxalic acid, malonic acid, glutaric acid, phthalic acid, metaphosphoric acid, or a mixture thereof. Examples of salts which are convertible into acids include, but are not limited to, aluminum sulfate, calcium phosphate, alum, a double salt of an alum, potassium aluminum sulfate, sodium dihydrogen phosphate, potassium citrate, sodium maleate, potassium tartrate, sodium fumarate, sulfonates, and phosphates. The acid(s) may be present in an amount from about 1.0 to about 30 percent by weight of the dry foam composition, preferably in an amount from about 3.0 to about 20 percent by weight.

When the acid and base of the blowing agent package are separated and the A-side contains the acid, the B-side contains at least one base that acts as an acid sensitive chemical blowing agent. Generally, the weak base contains anionic carbonate or hydrogen carbonate, and, as a cation an alkali metal, an alkaline earth metal or a transition metal. Examples of bases suitable for use in the practice of this invention include calcium carbonate, barium carbonate, strontium carbonate, magnesium carbonate, lithium carbonate, sodium carbonate, potassium carbonate, rubidium carbonate, cesium carbonate, calcium hydrogen carbonate, barium hydrogen carbonate, strontium hydrogen carbonate, magnesium hydrogen carbonate, lithium hydrogen carbonate, sodium hydrogen carbonate, potassium hydrogen carbonate, rubidium hydrogen carbonate, cesium hydrogen carbonate, and bicarbonates and combinations thereof. In preferred embodiments, the base is sodium bicarbonate.

In exemplary embodiments, the sodium bicarbonate has a mean particle size from about 2 to about 40 microns, and most preferably a mean particle size of 11 microns. The sodium bicarbonate may be milled or otherwise ground to achieve the desired size. It has been surprisingly discovered that by utilizing such a small particle size, the rate of rise of the inventive foam was approximately ten times faster compared to foams made according to the present invention with sodium bicarbonate that has not been milled (*for example*, sodium bicarbonate having a particle size from 200-300 microns). This significant improvement in the rate of rise of the foam enables a worker to apply the foam and quickly determine whether or not the gap has been filled.

The base may be present in an amount from about 1.0 to about 30% by weight of the dry foam composition. In preferred embodiments, the base is present in the B-side in an amount from about 3.0 to about 20% by weight of the dry foamable composition. Sodium bicarbonate and polyacrylic acid in a ratio of 10:1 to 1:1 are the preferred base and acid acting as the blowing agent package.

In addition to the components set forth above, the A-side and/or the B-side may contain one or more surfactants to impart stability to the acrylic during the foaming process, to provide a high surface activity for the nucleation and stabilization of the foam cells, and to modify the surface tension of the latex suspension to obtain a finely distributed, uniform foam with smaller cells. Useful surfactants include cationic, anionic, amphoteric and nonionic surfactants such as, for example, carboxylate soaps such as oleates, ricinoleates, castor oil soaps and rosinates, quaternary ammonium soaps and betaines, amines and proteins, as well as alkyl sulphates, polyether sulphonate (*for example*, Triton X200K available from Cognis), octylphenol ethoxylate (*for example*, Triton X705 available from Cognis), disodium N-octadecyl sulfosuccinamate (*for example*, Aerosol 18P available from Cytec), octylphenol polyethoxylates (*for example*, Triton X110 available from Cognis), alpha olefin sulfonate, sodium lauryl sulfates (*for example*, Stanfax 234 and Stanfax 234LCP from Para-Chemicals), ammonium laureth sulfates (*for example*, Stanfax 1012 and Stanfax 969(3) from Para-Chemicals), ammonium lauryl ether sulfates (*for example*, Stanfax 1045(2) from Para-Chemicals), sodium laureth sulfates (*for example*, Stanfax 1022(2) and Stanfax (1023(3) from Para-Chemicals), sodium sulfosuccinimate (*for example*, Stanfax 318 from Para-Chemicals), and aliphatic

ethoxylate nonionic surfactants (*for example*, ABEX available from Rhodia). The surfactant may be present in the A- and/or B-side in an amount from about 0 to about 20% by weight of the dry foam composition.

Further, either or both the A-side and B-side may contain a thickening agent to adjust the viscosity of the foam. It is desirable that the A-side and the B-side have the same or nearly the same viscosity to achieve a 1:1 ratio of the A-side components to the B-side components. A 1:1 ratio permits for easy application and mixing of the components of the A-side and B-side. Suitable examples of thickening agents for use in the foamable composition include calcium carbonate, methyl cellulose, ethyl cellulose, hydroxyethyl cellulose (*for example*, Cellosize® HEC available from Union Carbide), alkaline swellable polyacrylates (*for example*, Paragum 500 available from Para-Chem), sodium polyacrylates (*for example*, Paragum 104 available from Para-Chem), bentonite clays, and Laponite® RD clay (a synthetic layered silicate), glass fibers, cellulose fibers, and polyethylene oxide. The Laponite® products belong to a family of synthetic, layered silicates produced by the Southern Clay Products Corporation. The Laponite® products are thixotropic agents that "virtually freeze" the foam structure while the structure is curing to prevent the structure from collapsing. As used herein, the phrase "virtually freeze" is meant to denote a previously fluid/viscous material that is now substantially immobilized by an internal scaffolding-like structure, which may be provided by a thixotropic agent. The thickening agent may be present in an amount up to about 50% by weight of the dry foam composition. Preferably, the amount of thickening agent present is about 0 to about 20% by weight, based on the dry foamable composition, depending upon the nature of the thickening agent.

A plasticizer may also, or alternatively, be present in the A-side and/or B-side to adjust the viscosity of the foam. Non-limiting examples of suitable plasticizers include phthalate ester, dimethyl adipate, dimethyl phthalate, butyl benzoate, Benzoflex® 2088 (a benzoate ester plasticizer available from Genovique Specialties), Benzoflex® LA-705 (a benzoate ester plasticizer available from Genovique Specialties), Triton® X-100 (an octylphenoxypolyethoxyethanol available from Cognis), PEG-400 (a polyethylene glycol available from Cognis), Citroflex® 2 (a triethyl citrate available from Vertellus® Specialties), and Citroflex® 4 (a tributyl citrate available from Vertellus® Specialties), and

epoxidized crop oils (*for example*, Drapex 10.4, Drapex 4.4, and Drapex 6.8 available from Chemtura). In exemplary embodiments, the plasticizer is a benzoate ester or a citric acid ester, The plasticizer may be present in the foamable composition in an amount from about 0 to about 20% by weight of the dry foam composition. Desirably, the plasticizer is present in an amount from about 0 to about 15% by weight or from about 0.1 to about 15% by weight.

Further, an alcohol such as ethanol or isopropanol may be present in the foam composition in the A-side and/or the B-side. The alcohol is preferably miscible with water and has a low boiling point. The alcohol acts as a co-solvent and replaces a portion of the water in the latex serum. Utilizing an alcohol co-solvent allows for a quicker drying/curing time after the foam's application. Additionally, the co-solvent assists in creating a foam with a fine cell structure. Although not wishing to be bound by theory, it is believed that the higher vapor pressure of the alcohol causes the alcohol to be driven off more quickly than the water in the latex solution, and that the alcohol carries the water molecules as the alcohol is removed. The co-solvent is used in small quantities, typically from about 1.0 to about 5.0% by weight of the foam composition.

Depending on the type of particles used in the latex solution, the A- or B-side may also include other optional, additional components such as, for example, foam promoters, opacifiers, accelerators, foam stabilizers, dyes (*for example*, diazo or benzimidazolone family of organic dyes), color indicators, gelling agents, flame retardants, biocides, fungicides, algaecides, fillers (aluminum tri-hydroxide (ATH)), and/or conventional blowing agents. It is to be appreciated that a material will often serve more than one of the aforementioned functions, as may be evident to one skilled in the art, even though the material may be primarily discussed only under one functional heading herein. The additives are desirably chosen and used in a way such that the additives do not interfere with the mixing of the ingredients, the cure of the reactive mixture, the foaming of the composition, or the final properties of the foam.

To form a two-part spray foam of the present invention, the components of the A-side and the components of the B-side are delivered through separate lines into a spray gun, such as an impingement-type spray gun. Alternatively, spray guns utilizing static mixers to combine the components of the A-side and the components of the B-side, as

well as other dynamic mixers, may be used. The two components are pumped through small orifices at high pressure to form streams of the individual components of the A-side and the B-side. The streams of the first and second components intersect and mix with each other within the gun and begin to react. For example, if the blowing agent package is an acid and a base (with the acid contained in the A-side and the base contained in the B-side), the acid and base react to form carbon dioxide (CO_2) gas. If the blowing agent is a single chemical compound, it degrades to form a gas, such as CO_2 or N_2, upon the application of heat or light. In any event, the foaming reaction occurs until all of the blowing agent(s) have been reacted and no more gas is generated.

In addition, the crosslinking agent concurrently (simultaneously) reacts with the functional groups on the acrylic (*for example*, acrylic latex and polyacrylic acid) to support the foamed structure. The crosslinking is important for capturing the bubbles generated by the evolution of the gas in their original, fine structure before they can coalesce and escape the foam. It is to be appreciated that a fine foam structure is more desirable and more beneficial than a coarse foam structure in order to achieve high thermal performance. Additionally, the crosslinking of the functional groups on the functionalized latex quickly builds strength in the foam and permits the foam to withstand the force of gravity when it is placed, for example, in a vertical wall cavity during application. The final foamed product becomes cured to the touch within minutes after application. In exemplary foamed products, the foam cures within about 2 minutes. The resulting resistance to heat transfer, or R-value, may be from about 3.5 to about 8 per inch.

In an alternate embodiment, the blowing agent package includes an acid and a base and the components of the B-side are encapsulated and added to the A-side, thereby creating a one-part foam composition. Specifically, the crosslinking agent and the base (*that is*, acid sensitive chemical blowing agent) are encapsulated in one or two protective, non-reactive shells that can be broken or melted at the time of the application of the foam. For example, the crosslinking agent and the base may be encapsulated in a wax or gelatin that can be melted at the time of the application of the foam. Desirably, the wax has a melting point from about 120 °F to about 180 °F, and more preferably has a melting point from about 120 °F to about 140 °F. Alternatively, the encapsulating shell may be formed of a brittle polymer (such as a melamine formaldehyde polymer) or an acrylic that can be

broken or sheared at the time of the application of the foam to initiate the foaming reaction. The protective shell(s) surrounding the crosslinking agent and base may be heat activated, shear activated, photo-activated, sonically destructed, or activated or destroyed by other methods known to those of skill in the art.

Optionally, the encapsulating material may be a low melting, semi-crystalline, super-cooled polymer. Non-limiting examples of low melting polymers include polyethylene oxide (PEO) and polyethylene glycol (PEG). A preferred low-melting polymer for use as an encapsulant is a polyethylene oxide that has an average molecular weight from about 100,000 Dalton to about 8,000,000 Dalton. Additionally, the glass transition temperature (T_g) of the super-cooled polymer may be adjusted to the application temperature of the reaction system by blending polymers. For example, polymer blends such as a blend of polyvinylchloride (PVC) and polyethylene oxide (PEO) may be used to "fine tune" the glass transition temperature and achieve a desired temperature at which the polymer melts or re-crystallizes to release the crosslinking agent and base. With a PVC/PEO blend, the desired glass transition temperature is a temperature between the T_g of polyvinyl chloride and the T_g of the polyethylene oxide and is determined by the ratio of PVC to PEO in the polymer blend. When the super-cooled polymer is heated above its glass transition temperature, such as in a spray gun, the polymer re-crystallizes and the crosslinking agent and base is expelled from the polymer. This expulsion of the crosslinking agent and base is due to the change in free volume that occurs after re-crystallization of the polymer.

The combination of the A-side components and the encapsulated crosslinking agent and blowing agent(s) may be mixed to form a dispersion (reaction mixture). The dispersion is substantially non-reactive because the crosslinking agent remains encapsulated within the encapsulating shell. The phrase "substantially non-reactive" as used herein is meant to indicate that there is no reaction or only a minimal reaction between the A-side components and the encapsulant in the dispersion. As a result, the one-part foamable reactive composition is stable for extended periods of time.

A single stream of the dispersion containing the functionalized latex, encapsulated crosslinking agent and blowing agent, and optional surfactants, plasticizers, thickening agents, and/or co-solvents may then be fed into an application gun, such as a spray gun,

that has the ability to mix and/or heat the dispersion within the gun. The one-part foam of the present invention requires no expensive or complicated spraying equipment, and is a simple gun, a simple diaphragm, or drum pump. These types of guns are less likely to clog and are also easy to maintain and clean.

Once the dispersion is inside the gun, the crosslinking agent and base are released from the encapsulating material. For example, the dispersion may be heated within the gun to a temperature above the melting point of the long chain polymer or wax containing the crosslinking agent and base so that the crosslinking agent and base are released from the polymer or wax. In this example, the dispersion is heated to a temperature of about 130 °F to about 180 °F. In addition, the mixing action within the gun may assist in the release of the crosslinking agent and base from the encapsulant. Alternatively, the encapsulating shell of the crosslinking agent and base may be shear activated, sonically activated, photo activated, or destroyed by any other suitable method known to those of skill in the art. Once the crosslinking agent and blowing agent package are released from the polymer shell, crosslinking between the crosslinking agent and the functional groups on the functionalized latex begins and the blowing agent concurrently degrades or reacts to form a gas to initiate the foaming reaction and form the foam. The simultaneously reacting mixture is sprayed from the gun to a desired location where the mixture continues to react and form either open or closed cell foams. The foam may have an R-value from about 3.0 to about 8 per inch. The foam is advantageously used in residential housing, commercial buildings, appliances (*for example*, refrigerators and ovens), and hot tubs.

In a further alternative embodiment in which a one-part foam composition is utilized, the foam is formed by encapsulating the dry acid powder and the dry, powdered base in a single encapsulating shell, such as the encapsulating shell described in detail above. It is to be appreciated that separately encapsulating the acid and the base is considered to be within the purview of this invention. The encapsulated acid and base are mixed with a functionalized latex solution, at least one crosslinking agent, and optionally one or more of a surfactant, thickener, plasticizer, and/or co-solvent to form a reaction mixture or dispersion. It is to be noted that there is no foaming reaction due to the encapsulation of the acid and base. Consequently, the reactive mixture is stable for extended periods of time. The mixture is of a sufficient viscosity to enable its passage

through a spray-type application gun. As with the embodiment discussed previously, the encapsulating shell is destroyed, such as by heat, sonic destruction, shear forces, or other known methods, to release the acid and/or the base. Once the acid and base are released from the encapsulating material, crosslinking between the crosslinking agent and the carboxy groups on the functionalized latex begins and the acid and base react to form a gas, which initiates the foaming reaction and forms the inventive foam.

Other non-limiting, exemplary one-part foam embodiments of the present invention include a foamable composition where the crosslinking agent and acid is encapsulated, the acid or the base is encapsulated, or every component but the functionalized latex is encapsulated. In each of these embodiments, the foaming and crosslinking reactions begin when the encapsulated material is released from the encapsulating, protective shell, such as by heat, sonic destruction, shear forces, or photo activation. Additionally, the one part-foam compositions may optionally include thickening agents, plasticizers, alcohol co-solvents, foam promoters, opacifiers, accelerators, foam stabilizers, dyes (*for example*, diazo or benzimidazolone family of organic dyes), color indicators, gelling agents, flame retardants (*for example*, aluminum tri-hydroxide (ATH), ammonium polyphosphates, zinc borate, and boric acid), biocides, fungicides, algaecides, fillers, and/or conventional blowing agents.

Yet another exemplary embodiment of the invention includes utilizing a phase change blowing agent as the blowing agent package. To form a foam utilizing a phase change blowing agent such as a low boiling point hydrocarbon or inert gas, a functionalized water-soluble or functionalized water-dispersible resin (*for example*, functionalized latex or functionalized latex and acrylic solution), crosslinking agent, and phase change blowing agent are pressurized, such as in a pressurized spray-type container. Upon release of the functionalized water-soluble or functionalized water-dispersible resin, the crosslinking agent, and the blowing agent from the pressurized container (*for example*, release into atmospheric pressure), the blowing agent changes from a liquid to a gas to initiate the foaming reaction while the crosslinking agent and functionalized resin react to form an internal foam structure. The foaming reaction continues until all of the blowing agent has been converted into a gas.

In use, the inventive foams may be sprayed into either an open cavity, such as between wall studs, or into a closed cavity where it expands to seal any open spaces. The application is desirably a continuous spray process. Alternatively, the foams may be applied in a manner to fill or substantially fill a mold or fed into an extruder or an injection molding apparatus, such as for reaction injection molding (RIM), and used to form items such as cushions, mattresses, pillows, and toys. For example, a functionalized water-soluble or functionalized water-dispersible resin (*for example*, functionalized latex or functionalized latex and acrylic solution), a crosslinking agent, and a blowing agent may be mixed and applied to a mold where the crosslinking agent reacts with the functionalized resin while the blowing agent degrades or reacts to form a gas and initiate the foaming reaction.

In another embodiment, the foams of the present invention may be used to seal the insulative cavities of a building such as a house and minimize or eliminate air flow into the insulative cavities and effectively seal the building. It is to be appreciated that although the inventive foams are described herein with respect to insulating and sealing, any foam, foamable material, or foamable reaction mixture may be utilized to seal and insulate a building as described in this application. Indeed, any foam (*for example*, elastomeric, insulative, and/or sealing), foamable material, or foamable reaction mixture may be utilized the embodiments described herein, particularly when "picture framing" or otherwise insulating or sealing an insulative cavity as described in detail below. For example, the building frame of a house contains studs generally spaced 16 inches apart externally walled with sheathing formed of boards of wood or other fibrous material(s) (*for example*, oriented strand board). The studs and sheathing form insulative cavities in which fibrous insulation is conventionally placed to insulate the building. In the present invention, the inventive foams may be applied to the interface of the sheathing and the studs, the top plate and the sheathing, and/or the bottom plate and the sheathing to seal any possible gaps or spaces between the sheathing and the studs and reduce or even eliminate air leaks and prevent air from entering into the insulative cavity (and into the building). In particular, the foam may be sprayed along the bottom plate, the top plate, and along the vertical length of the studs.

As shown in FIG. 1, the studs 10 are walled with sheathing 12 and the cavity 14 is "picture framed" by the insulative foam 16 by spraying or otherwise applying the foam 16 along the interface between the exterior sheathing and the bottom plate 18, along the first top plate 20, and along the vertical length of the studs 10 inside the cavity 14. This process is repeated for each insulative cavity so that the insulative cavities are isolated from each other by the application of the spray foam as described above. As such, each cavity is sealed from neighboring cavities and little or no air is able to flow between the cavities. Additionally, the foam reduces air leakage between the framing and the sheathing. The foam may also be sprayed at the seam of two sheets of sheathing within a cavity to reduce or prevent air flow between the sheathing sheets and into the cavity. The foam may be continuously sprayed, or, alternatively, it may be sprayed non-continuously or in determinate, specified areas. Once the foam 16 has been sprayed at the interfaces around the interior boundary of the insulative cavity 14, a fibrous batt (not illustrated) is placed in the cavity 14 in a conventional manner. The fibrous batt may be any conventional batt formed of glass and/or cellulosic fibers. It is to be understood that blown insulation may be equally utilized in the present invention. By "picture framing" the insulative cavities, the insulative effect of the fibrous insulation may be maximized. The inventive foam provides both air-sealing and insulative properties.

The foam may also be sprayed or applied at the interface between the floor (F) and the bottom plate 18 to reduce air infiltration between the floor (F) and the bottom plate 18, as depicted in Figure 2. Spraying the foam at the interface of the first and second top plate 20, 24 forms a gasket against the drywall (not shown), which would subsequently be applied on top of the interior faces of the studs 10 and the first and second top plates 20, 24, to reduce or eliminate the passage of air into the attic. In addition, the foams may be sprayed around windows 22, such as is shown in Figure 3, and/or other penetrations, seams, apertures, cracks, and/or other air passageways to eliminate or reduce air infiltration. The internal wall for the building may be finished by the application of a vapor barrier and drywall (not illustrated).

In a further embodiment of the invention, the inventive latex foams may be applied to fill gaps that can occur at the interface between the top plate and the drywall to reduce or eliminate air infiltration from the wall cavity into the attic. As shown in Figure 4A, a

gap 31 may be found between the interface between the drywall 34 and drywall 32 on both sides of the top plate 30. This gap 31 can permit air to pass from the wall cavity 36, past the top plate 30, around and/or through the fibrous insulation 33, and into the attic space as indicated by arrow 38. This passage of air can be a big loss of warm or cool air from the living space of the home, which, in turn, may increase the homeowner's heating and cooling expenses. Looking at Figure 4B, the inventive foam may be sprayed onto the sides of the top plate 30 facing the drywall 34 prior to the drywall being applied to the sides of the top plate 30 such that the foam 40 forms a gasket between the drywall 34 and the top plate 30 to prevent air from passing into and out of the attic space through the gap 31. The elastomeric nature of the foam permits the foam to act as a seal when the drywall 34 is applied to the face of the foam. In particular, the foam 40 seals the space between the top plate 30 and the drywall 34 and restricts the flow of air both into and from the attic. The foam 40 thus minimizes or prevents unwanted air from passing into the living space or heated or cooled air from escaping the living space of the house. In addition, as depicted by arrow 42, the air within the wall cavity 36 is retained in the wall cavity 36 and cannot contribute to energy loss in the house.

It is to be appreciated that it is not imperative that the foam be neatly or otherwise carefully applied to the insulative cavities. If the spray foam is unintentionally applied to the studs, it may be easily wiped off by a cloth or other such item for several minutes after application (*for example*, approximately 2-5 minutes). This is different from conventional isocyanate foams which harden quickly and have to be scraped off the studs prior to drywall application. Further, conventional foams, such as isocyanate foams, are high rising and rigid, and are therefore not appropriate for spraying onto the surface of the studs. Moreover, isocyanate foams interfere with the drywall application and undesirably provide an uneven surface on the stud face. However, the inventive foams are soft, low rise, open cell foams that will not interfere with the drywall that will be applied over the studs and fibrous insulation. If there is an overfilling of the insulative cavity onto the studs, or if the foams are intentionally applied to the stud faces, the drywall simply compresses the foam. The inventive foam is compliant and will contour to the surface of the drywall. There is not a significant amount of pressure applied to the drywall due to the giving nature of the foam, and little or no bowing or detachment of the drywall occurs.

Accordingly, the foam may be sprayed up and over the studs, or directly onto the stud faces, without any detrimental effect on the drywall (or vapor barrier) application.

Indeed, it may be advantageous to apply the inventive foams to the face of the studs. In at least one embodiment, the foam components are carefully chosen to result in a tacky or sticky foam. For instance, a tackifier may be added to the composition of the foam (either the A-side or the B-side) to make the foam tacky or sticky, and thereby impart an adhesive quality to the foam. Non-limiting examples of tackifiers include Escorez 1300 (a mixed aliphatic and aromatic branched chain resin), Wingtack resins (synthetic terpenes) and wood resins from thermally polymerized natural or synthetic terpenes. Additionally, the nature of the latex and the ratio of latex to acrylic solution may be arranged to provide a tacky foam product. The tackifier is typically included in an amount of about 1 to about 2% tackifying resin in a hydrocarbon solution in a latex based adhesive.

Accordingly, the foam can be used to hold the fiberglass batt and batt flanges in place when the foam is applied to the insulative cavities as described above. Additionally, the inventive foam may be used to affix a vapor barrier (*for example*, plastic vapor barrier such as polyethylene) without the need for any mechanical fasteners such as nails or screws to hold the vapor barrier onto the studs. In such an embodiment, the inventive foam is sprayed onto the external face of the studs and the foam is permitted to dry and cure. After drying, the vapor barrier is simply attached to the tacky foam. Attaching the vapor barrier or batt flanges to the studs without any mechanical fasteners saves both time and money. For instance, workers installing the vapor barrier do not have to take the time to nail or screw the vapor barrier to the individual studs. Thus, construction can proceed more quickly and less labor cost is incurred. Additionally, the elimination of the use of staples or other mechanical fasteners is advantageous because staples tend to interfere with the subsequent installation of the drywall.

Additionally, the inventive latex foams may be applied to the faces of the studs (or the face of the framing of the building) to obtain a superior seal against air infiltration. In particular, the inventive foam is sprayed or otherwise applied to the face of the studs as described above and drywall is attached to the surface of the studs in a conventional manner. Desirably, the foam is sprayed onto the stud faces prior to the insertion of the

insulation into the building cavities. It is to be understood that the foam may be sprayed to the faces of the studs 10 with or without applying the foam around the interior boundary of the insulative cavities 14, as shown in Figure. 5. The elastomeric foam acts as a gasket seal between the stud face and the drywall. In addition, the foam assists in leveling and smoothing the stud surface to which the drywall will be attached. If a tackifier is included in the foam's composition, the foam acquires a tacky or sticky nature. Accordingly, the drywall may be placed onto the studs, where it is held in place by the foam while mechanical fasteners (*for example*, nails or screws) are inserted to permanently affix the drywall to the framing. It is to be appreciated that a vapor barrier may be placed on the face of the studs prior to the application of the drywall. In such a situation, the foam would hold the vapor barrier in place, as is discussed in detail above.

The tacky nature of the foam permits the drywall (or vapor barrier) to advantageously be removed and repositioned without damage. Also, the adhesive qualities of the foam permits the workers to quickly install the drywall as there is no need to manually hold the drywall onto the surface of the studs. Application of the inventive foam to the faces of the studs is also advantageous in that the visco-elastic nature of the foam absorbs sound. In addition, the open cell structure of the foam slows any air flow (air infiltration) through the foam. Additionally, placing the foam on the face of the studs further isolates one insulative cavity from another.

The inventive foam can also be used in applications where extruded polystyrene foam forms the envelope of a building. Although polystyrene foams are good insulators, they have a tendency to buckle and create gaps and/or crevices. Similarly, when a fibrous board is used as the sheathing, gaps and crevices naturally occur, such as at the interfaces between the sheathing and framing due to the natural warping and curvature of fibrous products. The inventive foams may be sprayed into these crevices and gaps as a sealant to reduce or eliminate air infiltration into the insulative cavity.

The foams of the present invention may also be used to insulate buildings such as homes from temperature fluctuations outside of the building's envelope. The foams may serve both as a conductive and a convective thermal barrier. Additionally, the foams of the present invention may serve as a sealant to air infiltration by filling cracks and/or crevices in a building's roof or walls, around doors, windows, electric boxes, and the like.

Further, the inventive foams may also be used in flash and batt where polyurethane foams are not user-friendly due to their high rise and very rigid structure.

The foams of the present invention are preferably non-structural foams. The soft foam nature of the functionalized water-soluble and functionalized water-dispersible resins allows for easy compaction. As such, the inventive foams have several benefits. For example, there is no post-application waste to an open wall cavity. If there is an overfilling of the cavity, the drywall simply compresses the foam back into the cavity. The inventive foams are low rise and compliant, so they will not apply a significant pressure to the drywall and, as a result, little or no bowing or detachment of the drywall will occur.

Another advantage of the foams of the present invention is the safe installation of the foam into cavities. The foams do not release any harmful vapors into the air when applied or sprayed. Therefore, the inventive foams reduce the threat of harm to individuals working with or located near the foam. In addition, the application of the foams is more amenable to the installer as he/she will not need to wear a special breathing apparatus during installation.

Another advantage of the inventive foams is that it can be used in the renovation market, as well as in houses that are occupied by persons or animals. Existing, conventional spray polyurethane foams cannot be used in these applications because of the generation of high amounts of free isocyanate monomers that could adversely affect the occupants of the dwelling. As discussed above, exposure of isocyanate monomers may cause irritation to the nose, throat, and lungs, difficulty in breathing, skin irritation and/or blistering, and a sensitization of the airways.

Yet another advantage of the present invention is that the components of the one-part foam compositions in which the crosslinking agent and base and/or the acid are encapsulated may be mixed and stored in one container without significant reaction until such time that the foam is used. This simplifies the application of the foam because no other components need to be added at the point of application. Instead, the encapsulated components are activated at the point of application.

It is also an advantage of the present invention is that the components of the one-part or two-part foam compositions are carefully chosen to result in a tacky or sticky foam that can be used to hold the fiberglass batt in place when used to fill cracks or crevices.

The one-part foam compositions are advantageous in they do not require metering within the gun. As a result, a simple spray gun having only one inlet may be utilized to spray the foam compositions. Without a sophisticated pumping system and complex spray gun, producing the inventive one-part foams have low manufacturing costs. In addition, the one-part foamable compositions of the present invention are simpler to use in the field than conventional two-part foams. Therefore, less training is required to correctly use the inventive one-part foam compositions.

Having generally described this invention, a further understanding can be obtained by reference to certain specific examples illustrated below which are provided for purposes of illustration only and are not intended to be all inclusive or limiting unless otherwise specified.

EXAMPLES

Example 1:

Table 1 sets forth a list of components that may be used to make at least one exemplary embodiment of the inventive foam.

Table 1

Trade Name	Description	Manufacturer
Functionalized Latex		
Omnapel 6110	Carboxylated Acrylic Latex	Omnova Solutions, Inc.
NovaCryl PSP 170	Carboxylated Acrylic Latex	Omnova Solutions, Inc.
GenFlo	Carboxylated SBR Latex	Omnova Solutions, Inc.

Non-Functionalized Latex		
AcryGen DV300	Acrylic Latex	Omnova Solutions, Inc.
Vycar 660x144	Acrylic Latex	Noveon
F-6694	SBR Latex	Omnova Solutions, Inc.
Crosslinking Agents		
XAMA 7	Multifunctional Aziridine	Bayer Chemical
Lindride 56	Methylhexahydrophthalic Anhydride	Lindau Chemical
Hardner CD	Carbodiimide	Rotta Corp.
YDH 184	Cycloaliphatic Diepoxide	Thai Epoxy
Blowing Agents		
	Sodium Bicarbonate/Citric Acid	Aldrich
	Sodium Carbonate/Citric Acid	Aldrich
	Calcium Carbonate/Sodium Bicarbonate/Citric Acid	Aldrich
	Sodium Bicarbonate/Polyacrylic Acid	Solvay/Rohm&Haas
Surfactant		
G-5M Triton	Non-ionic Surfactant	Dow Chemical

ABEX	Non-ionic Surfactant	Rhodia
Stanfax 234	Sodium Lauryl Sulfate	ParaChem
Aerosol 18P	disodium N-octadecyl sulfosuccinamate	Cytec
Thickening Agents		
Cellosize® HEC	Hydroxyethyl Cellulose	Dow Chemical
Laponite®	Clay	Southern Clay
Cabosil	Fumed Silica	Cabot
Garamite 1958	Nanoclay	Southern Clay
Optigel	clay	Southern Clay
Plasticizer		
Dioctyl Adipate		Aldrich
Diisoocytyl Adipate		Aldrich
Dimethyl Phthalate		Aldrich
Dioctyl Phthalate		Aldrich
Citroflex 4	Acetyl tri-n-butyl citrate	Vertullus
Encapsulants		
	Melamine Formaldehyde	Aldrich
Acrylic		

Solution		
AcryGen 8546	26% Acrylic Solution	Omnova Solutions, Inc.

Prophetic examples of forming the foam, encapsulated catalyst, and the reactive mixture using the exemplary components identified in Table 1 are set forth in Tables 2, 3, and 4.

Table 2 – Two-Part Foam Compositions

Component	**Foam 1 (grams)**		**Foam 2 (grams)**		**Foam 3 (grams)**		**Foam 4 (grams)**		**Foam 5 (grams)**	
	A-side	**B-side**	**A-side**	**B-side**	**A-side**	**B-side**	**A-side**	**B-side**	**A-side**	**B-side**
NovaCryl			900						870	
Acrylic Solution			18							
Citric Acid	45		72		45		36			
GR- 5M Triton			9							
GenFlo		900		900		900				25
Xama-7				27		22.5		90		20
Sodium Bicarbonate		63		63		63		25.2		30
Omnapel	900				900		900			
YDH 184						135				
Aerosol 18p									1	
Hardner CD		20								
ABEX							22.5		1	
Aluminum tri hydroxide									200	
Calcium Carbonate								65		
Polyacrylic Acid									67	
Dioctyl Adipate								90		
Stanfax 234										
Citroflex										25

A4										
Cabosil										
Dimethyl Phthalate										
Propylene glycol									60	
Optigel									2	

Table 3 – Encapsulated Crosslinking Agent and Blowing Agent

Component	**Encapsulating Materials 1 (grams)**	**Encapsulating Materials 2 (grams)**	**Encapsulating Materials 3 (grams)**	**Encapsulating Materials 4 (grams)**
Sodium Bicarbonate	14		7	7
Citric Acid		14	7	7
XAMA	20	20	20	
Melamine formaldehyde	10	10	10	10

Table 4 – One-Part Foam Compositions

Component	**Foam 1 (grams)**	**Foam 2 (grams)**
NovaCryl	900	
Polyacrylic Acid	90	
Encapsulating Materials 1 (Table 3)	64	
Omnapel		900
GR-5M Triton	9	9
Encapsulating Materials 3 (Table 3)		64

The encapsulating materials are made by well-known methods known to these skilled in the art of encapsulation, and as such, will not be described herein.

To form a spray foam using the two-part foam composition of Table 2, the A-side components in Table 2 are mixed together and the B-side components are mixed together. Mixtures of the A-side components and B-side components are pumped separately through hoses to an application gun and combined using a dynamic or static mixer. Reactions

between the acid and base (to generate bubbles) and reactions between the functionalized latex and the crosslinking agent (to support the foam structure) occur when the foam components are sprayed from the gun to a desired location, such as cavities.

To form a foamed product using the two-part foam composition of Table 2, the A-side components in Table 2 are mixed together and the B-side components are combined together to form a reaction mixture. The reaction mixture formed of the A-side components and B-side components is mixed with a propeller blade and poured into a mold, where it is left to react. When the foam is cured, it is released from the mold in the shape of a desired product.

To form a spray foam using the one part foam composition of Table 4, the components in Table 4 are mixed together. The mixtures are pumped through a hose to an application gun. It is envisioned that the application gun will be equipped with a mixing device that destroys the encapsulating shell containing the blowing agent and crosslinking agent. Reactions between the acid and base blowing agent (to generate bubbles) and reactions between the functionalized latex and the crosslinking agent (to support the foam structure) occur when the foam components are sprayed from the gun to a desired location, such as wall cavities.

Example 2: Determination of Air Leakage

Various wall structures were tested for air leakage according to the standards set forth in ASTM E283, which is hereby incorporated herein by reference in its entirety. The framed structures were formed of conventional framing studs spaced 16 inches apart externally walled with sheathing formed of oriented strand boards, similar to that illustrated in Figure 2. The various iterations of the sample wall structures and air leakage results for each are set forth in Table 5.

Table 5 – Air Leakage

Wall Structure	Air Leakage SCFM @ 75 Pa
No Inventive Foam Utilized	
Wall without sealant, no seams taped	37.1[a]

Wall without sealant, seam taped	37.1[a]
Wall without sealant, seam taped, window covered	37.1[a]
Wall insulated and drywalled	26.5
Wall Sealed with Inventive Foam	
Wall sealed with inventive foam and window frame foamed	8.4
Wall sealed with inventive foam, insulation positioned in cavity, and drywall affixed to studs	8.9
Wall sealed with inventive foam and scraped off surface, no insulation or drywall	9.4
Wall sealed with inventive foam and scraped off surface, insulation positioned in cavity, drywall affixed to studs	9.3
Plastic over window	8.4

a) Results shown are an estimate due to the extreme air leakage of these samples.

As shown in Table 5, the wall structures that utilized the inventive foam demonstrated a much lower air leakage compared to the wall structures that did not contain any inventive foam. For instance, a wall structure insulated and drywalled, but which did not contain any inventive foam yielded an air leakage of 26.5 SCFM. On the other hand, wall structures sealed with the inventive foam demonstrated an air leakage of only 8.4 SCFM. Even without the inclusion of any other insulative materials such as insulation positioned within the cavities, the inventive foam provided superior resistance to air leakage compared to those wall structures lacking the inventive foam. Scraping the foam off the surface of the wall structure did not detrimentally affect the resistance of air leakage, and wall samples in which the foam was scraped off demonstrated an air leakage

of approximately 9.3 and 9.4 SCFM. It can be concluded that this superior resistance to air leakage caused by the inventive foam also provides improved insulative properties.

Example 3: Rate of Rise of Foam Containing Sodium Bicarbonate

A foam according to the present invention was prepared according to the procedure set forth above. In particular, a first component containing a functionalized resin (*that is*, a carboxylated acrylic latex) and an acid (*that is*, polyacrylic acid) and a second component containing a room temperature crosslinking agent (*that is*, a polyfunctional aziridine) and sodium bicarbonate were mixed and the components were permitted to react to form a foam. The foam was permitted to rise to a 700 ml expansion. In one sample, the sodium bicarbonate had a mean particle size of 50 microns. In the second sample, the sodium bicarbonate had a mean particle size of 11 microns. The results are set forth in Table 6.

Table 6 – Rate of Rise Due To Sodium Bicarbonate

Size of Sodium Bicarbonate (microns)	Time (seconds)
11	28
50	50

As shown in Table 6, the sodium bicarbonate with a mean particle size of 11 microns reached a 700 ml expansion in 28 seconds. The foam sample that contained sodium bicarbonate with a mean particle size of 50 microns reached a 700 ml expansion in 50 seconds. Thus, the expansion by the foam sample containing the 11 micron sodium bicarbonate exapanded nearly twice as fast as the 50 micron sodium bicarbonate. The faster expansion rate is beneficial because it quickly shows the operator if the crack or gap has been completely covered. This quick visual inspection reduces the amount of rework that would be required to refill a gap that may have been missed due to a slow rising foam. Accordingly, time and money can be saved by using the inventive foam.

The invention of this application has been described above both generically and with regard to specific embodiments. Although the invention has been set forth in what is believed to be the preferred embodiments, a wide variety of alternatives known to those of skill in the art can be selected within the generic disclosure. The invention is not

otherwise limited, except for the recitation of the claims set forth below.

CLAIMS:

1. A method of sealing a building wall formed from generally vertical studs extending between a top plate and a bottom plate with sheathing covering an exterior side of said studs, said top plate, and said bottom plate to define interfaces between said sheathing and each of said studs, said top plate and said bottom plate along said exterior side of said building wall, comprising:

applying a member selected from a foam, a foamable material and a foamable reaction mixture to one or more of said interfaces,

wherein when said member is said foamable material or said foamable reaction mixture, said method further includes the step of initiating a foaming reaction to form a sealing and/or insulative foam.

2. The method of claim 1, wherein said applying step comprises applying said foamable reaction mixture to said one or more of said interfaces, said method further comprising:

delivering a first component including at least one functionalized resin selected from a functionalized water-dispersible resin and a functionalized water-soluble resin through a first delivery line to an application device;

delivering a second component including a crosslinking agent that crosslinks at or about room temperature, wherein one or both of said first and second component includes a blowing agent into said application device; and

mixing said first and second components within said application device to form said foamable reaction mixture, and

wherein said initiating step comprises permitting said crosslinking agent and said at least one functionalized resin to chemically react while said blowing agent initiates said foaming reaction and forms said sealing and/or insulative foam.

3. The method of claim 2, wherein said blowing agent is selected from a single chemical compound that generates a gas upon heating, irradiation, or photo initiation, said

method further including the step of degrading said blowing agent to generate a gas and initiate said foaming reaction.

4. The method of claim 2, wherein said blowing agent is formed of an acid and a base,

wherein said first component includes said base when said second component includes said acid; and

wherein said first component includes said acid when said second component includes said base, said method further comprising the step of reacting said acid and said base to form a gas to initiate said foaming reaction.

5. The method of claim 4, wherein said acid is polyacrylic acid, said base is sodium bicarbonate, and said foam has a structure; and

wherein said polyacrylic acid reacts with said sodium bicarbonate to form CO_2 gas as said blowing agent and said polyacrylic acid further reacts with said crosslinking agent to become integrated with said foam structure.

6. The method of claim 4, wherein said base is sodium bicarbonate having a mean particle size from 2 to 40 microns.

7. The method of claim 2, wherein said blowing agent is a phase change blowing agent under pressure, said method further including the step of releasing said blowing agent from said pressure to initiate a phase change of said blowing agent from a liquid to a gas and initiate said foaming reaction.

8. The method of claim 7, wherein said phase change blowing agent is selected from low boiling point hydrocarbons and inert gases.

9. The method of claim 2, wherein said at least one of said functionalized resin, said crosslinking agent, and said blowing agent are encapsulated in one or more encapsulating

shells, said method further comprising releasing said functionalized resin, said crosslinking agent, and/or said blowing agent from said one or more encapsulating shells.

10. The method of claim 2, further comprising the step of:

permitting said sealing and/or insulating foam to cure, said permitting step occurring in two to five minutes.

11. The method of claim 2, wherein said first component comprises one or more members selected from a functionalized latex and an acrylic solution.

12. The method of claim 2, wherein said second component further comprises a non-functionalized latex.

13. The method of claim 2, wherein at least one of said first component and said second component further includes an alcohol co-solvent.

14. The method of claim 2, wherein said crosslinking agent is selected from aziridines, multifunctional carbodiimides, polyfunctional aziridines, melamine formaldehyde, polysiloxanes and multifunctional epoxies.

15. The method of claim 2, wherein said method further comprises applying said foamable reaction mixture to an interior face of said studs.

16. The method of claim 2, wherein said sheathing is a foam board, said method further comprising applying said foamable reaction mixture to crevices and gaps formed at said top and bottom plate to reduce air infiltration into said insulative cavity.

17. A method of forming an interior surface of a building wall, said building wall including a frame formed of a first top plate, a second top plate, a bottom plate, and a plurality of studs interconnecting said second top plate and said bottom plate, said plurality of studs, said second top plate and said bottom plate forming insulative cavities between said studs, said building wall being backed by sheathing, each of said studs having an interior face, comprising the steps of:

applying a member selected from an elastomeric foam, a foamable material and a foamable reaction mixture to said interior face of said studs, wherein when said member is said foamable material or said foamable reaction mixture, said method further includes the step of initiating a foaming reaction to form a tacky, elastomeric foam; and

positioning an interior member on said elastomeric foam, wherein said elastomeric foam affixes said interior member to said interior face of said studs without requiring mechanical fasteners.

18. The method of claim 17, wherein said applying step comprises applying said foamable reaction mixture to said interior face of said studs, said method further comprising:

delivering a first component including at least one functionalized resin selected from a functionalized water-dispersible resin and a functionalized water-soluble resin through a first delivery line to an application device;

delivering a second component including a crosslinking agent that crosslinks at or about room temperature, wherein one or both of said first and second component includes a blowing agent, and wherein one or both of said first and second component includes a tackifier; and

mixing said first and second components within said application device to form said foamable reaction mixture, and

wherein said initiating step comprises permitting said crosslinking agent and said at least one functionalized resin to chemically react while said blowing agent initiates said foaming reaction and forms said tacky, elastomeric foam.

19. The method of claim 18, wherein said interior member is a vapor barrier, said foam holding said vapor barrier to said interior face of said studs.

20. The method of claim 19, wherein said vapor barrier may be repeatedly repositioned.

21. The method of claim 19, further comprising the step of:

affixing drywall on said vapor barrier with mechanical fasteners without significant bowing or detachment of said drywall from said vapor barrier.

22. The method of claim 21, further comprising the step of:

applying said foamable reaction mixture to a first interface of said studs and said sheathing, a second interface of said top plate and said sheathing, and a third interface of said bottom plate and said sheathing within one or more of said insulative cavities.

23. The method of claim 22, further comprising the step of:

inserting an insulation batt having batt flanges into at least one of said insulation cavities subsequent to applying said foamable reaction mixture to said interfaces within said insulative cavity and subsequent to applying said foamable reaction mixture to said interior faces of said studs, said foam affixing said batt flanges to said interior face of said studs without requiring fasteners.

24. The method of claim 18, wherein said blowing agent is selected from a single chemical compound that generates a gas upon heating, irradiation, or photo initiation, said method further including the step of degrading said blowing agent to generate a gas and initiate said foaming reaction.

25. The method of claim 18, wherein said blowing agent is formed of an acid and a base,

wherein said first component includes said base when said second component includes said acid; and

wherein said first component includes said acid when said second component includes said base, said method further comprising the step of reacting said acid and said base to form a gas to initiate said foaming reaction.

26. The method of claim 25, wherein said acid is polyacrylic acid, said base is sodium bicarbonate, and said foam has a structure; and

wherein said polyacrylic acid reacts with said sodium bicarbonate to form CO_2 gas as said blowing agent and said polyacrylic acid further reacts with said crosslinking agent to become integrated with said foam structure.

27. The method of claim 25, wherein said base is sodium bicarbonate having a mean particle size from 2 to 40 microns.

28. The method of claim 18, wherein said blowing agent is a phase change blowing agent under pressure, said method further including the step of releasing said blowing agent from said pressure to initiate a phase change of said blowing agent from a liquid to a gas and initiate said foaming reaction.

29. The method of claim 28, wherein said phase change blowing agent is selected from low boiling point hydrocarbons and inert gases.

30. The method of claim 18, wherein said at least one of said functionalized resin, said crosslinking agent, and said blowing agent are encapsulated in one or more encapsulating shells, said method further comprising releasing said functionalized resin, said crosslinking agent, and/or said blowing agent from said one or more encapsulating shells.

31. The method of claim 18, wherein said first component comprises one or more members selected from a functionalized latex and an acrylic solution.

32. The method of claim 18, wherein said second component further comprises a non-functionalized latex.

33. The method of claim 18, wherein at least one of said first component and said second component further includes an alcohol co-solvent.

34. The method of claim 18, wherein said crosslinking agent is selected from aziridines, multifunctional carbodiimides, polyfunctional aziridines, melamine formaldehyde, polysiloxanes and multifunctional epoxies.

35. A method of insulating a building, said building including a frame formed of a first top plate, a plurality of studs interconnecting a second top plate and a bottom plate, said plurality of studs, said second top plate and said bottom plate forming insulative cavities backed by sheathing on an exterior side thereof, and said studs having an interior face, comprising the steps of:

applying a member selected from a foam, a foamable material and a foamable reaction mixture circumferentially around one or more of said insulating cavities on said studs, said second top plate, and said bottom plate; and

applying said member to said interior faces of said studs,

wherein when said member is said foamable material or said foamable reaction mixture, said method further includes the step of initiating a foaming reaction to form an insulative foam, said foam reducing the occurrence of air leaks into said building.

36. The method of claim 35, wherein said applying step comprises applying said foamable reaction mixture circumferentially around one or more of said insulating cavities at said intersection of said studs, said second top plate, and said bottom plate, said method further comprising:

delivering a first component including at least one functionalized resin selected from a functionalized water-dispersible resin and a functionalized water-soluble resin through a first delivery line to an application device;

delivering a second component including a crosslinking agent that crosslinks at or about room temperature, wherein one or both of said first and second component includes a blowing agent;

mixing said first and second components within said application device to form said foamable reaction mixture, and

wherein said initiating step comprises permitting said crosslinking agent and said at least one functionalized resin to chemically react while said blowing agent initiates said foaming reaction and forms said insulative foam.

37. The method of claim 36, further comprising the steps of:

applying said foamable reaction mixture to an intersection of said bottom plate and the floor along an interior surface of said bottom plate; and

applying said foamable reaction mixture to an interior portion of an interface between said first and second top plates.

38. The method of claim 36, wherein said blowing agent is selected from a single chemical compound that generates a gas upon heating, irradiation, or photo initiation, said method further including the step of degrading said blowing agent to generate a gas and initiate said foaming reaction.

39. The method of claim 36, wherein said blowing agent is formed of an acid and a base,

wherein said first component includes said base when said second component includes said acid; and

wherein said first component includes said acid when said second component includes said base, said method further comprising the step of reacting said acid and said base to form a gas to initiate said foaming reaction.

40. The method of claim 39, wherein said acid is polyacrylic acid, said base is sodium bicarbonate, and said foam has a structure; and

wherein said polyacrylic acid reacts with said sodium bicarbonate to form CO_2 gas as said blowing agent and said polyacrylic acid further reacts with said crosslinking agent to become integrated with said foam structure.

41. The method of claim 40, wherein said base is sodium bicarbonate having a mean particle size from 2 to 40 microns.

42. The method of claim 36, wherein said blowing agent is a phase change blowing agent under pressure, said method further including the step of releasing said blowing agent from said pressure to initiate a phase change of said blowing agent from a liquid to a gas and initiate said foaming reaction.

43. The method of claim 42, wherein said phase change blowing agent is selected from low boiling point hydrocarbons and inert gases.

44. The method of claim 36, wherein said at least one of said functionalized resin, said crosslinking agent, and said blowing agent are encapsulated in one or more encapsulating shells, said method further comprising releasing said functionalized resin, said crosslinking agent, and/or said blowing agent from said one or more encapsulating shells.

45. The method of claim 36, wherein said first component comprises one or more members selected from a functionalized latex and an acrylic solution.

46. The method of claim 36, wherein said second component further comprises a non-functionalized latex.

47. The method of claim 36, wherein at least one of said first component and said second component further includes an alcohol co-solvent.

48. The method of claim 36, wherein said crosslinking agent is selected from aziridines, multifunctional carbodiimides, polyfunctional aziridines, melamine formaldehyde, polysiloxanes and multifunctional epoxies.

49. A method of sealing a wall cavity defined between opposing vertically oriented drywall panels affixed to opposing sides of a top plate comprising:

applying a gasket member selected from a foam, a foamable material and a foamable reaction mixture on opposing sides of said top plate; and

affixing said drywall panels on said opposing sides of side top plate over said gasket member,

wherein when said gasket member is said foamable material or said foamable reaction mixture, said method further includes the step of initiating a foaming reaction to form a sealing and/or insulative foam, said foam forming said gasket member to restrict the flow of air into an attic space from said wall cavity,

50. The method of claim 49, further comprising:

delivering a first component including at least one functionalized resin selected from a functionalized water-dispersible resin and a functionalized water-soluble resin through a first delivery line to an application device;

delivering a second component including a crosslinking agent that crosslinks at or about room temperature, wherein one or both of said first and second component includes a blowing agent into said application device; and

mixing said first and second components within said application device to form said foamable reaction mixture, and

wherein said initiating step comprises permitting said crosslinking agent and said at least one functionalized resin to chemically react while said blowing agent initiates said foaming reaction and forms said sealing and/or insulative foam.

51. The method of claim 50, wherein said crosslinking agent is selected from aziridines, multifunctional carbodiimides, polyfunctional aziridines, melamine formaldehyde, polysiloxanes and multifunctional epoxies.

52. The method of claim 50, wherein said blowing agent is selected from a single chemical compound that generates a gas upon heating, irradiation, or photo initiation, said method further including the step of degrading said blowing agent to generate a gas and initiate said foaming reaction.

53. The method of claim 50, wherein said blowing agent is formed of an acid and a base,

wherein said first component includes said base when said second component includes said acid; and

wherein said first component includes said acid when said second component includes said base, said method further comprising the step of reacting said acid and said base to form a gas to initiate said foaming reaction.

54. The method of claim 53, wherein said acid is polyacrylic acid, said base is sodium bicarbonate, and said foam has a structure; and

wherein said polyacrylic acid reacts with said sodium bicarbonate to form CO_2 gas as said blowing agent and said polyacrylic acid further reacts with said crosslinking agent to become integrated with said foam structure.

55. The method of claim 50, wherein said blowing agent is a phase change blowing agent under pressure, said method further including the step of releasing said blowing agent from said pressure to initiate a phase change of said blowing agent from a liquid to a gas and initiate said foaming reaction.

FIG. 1

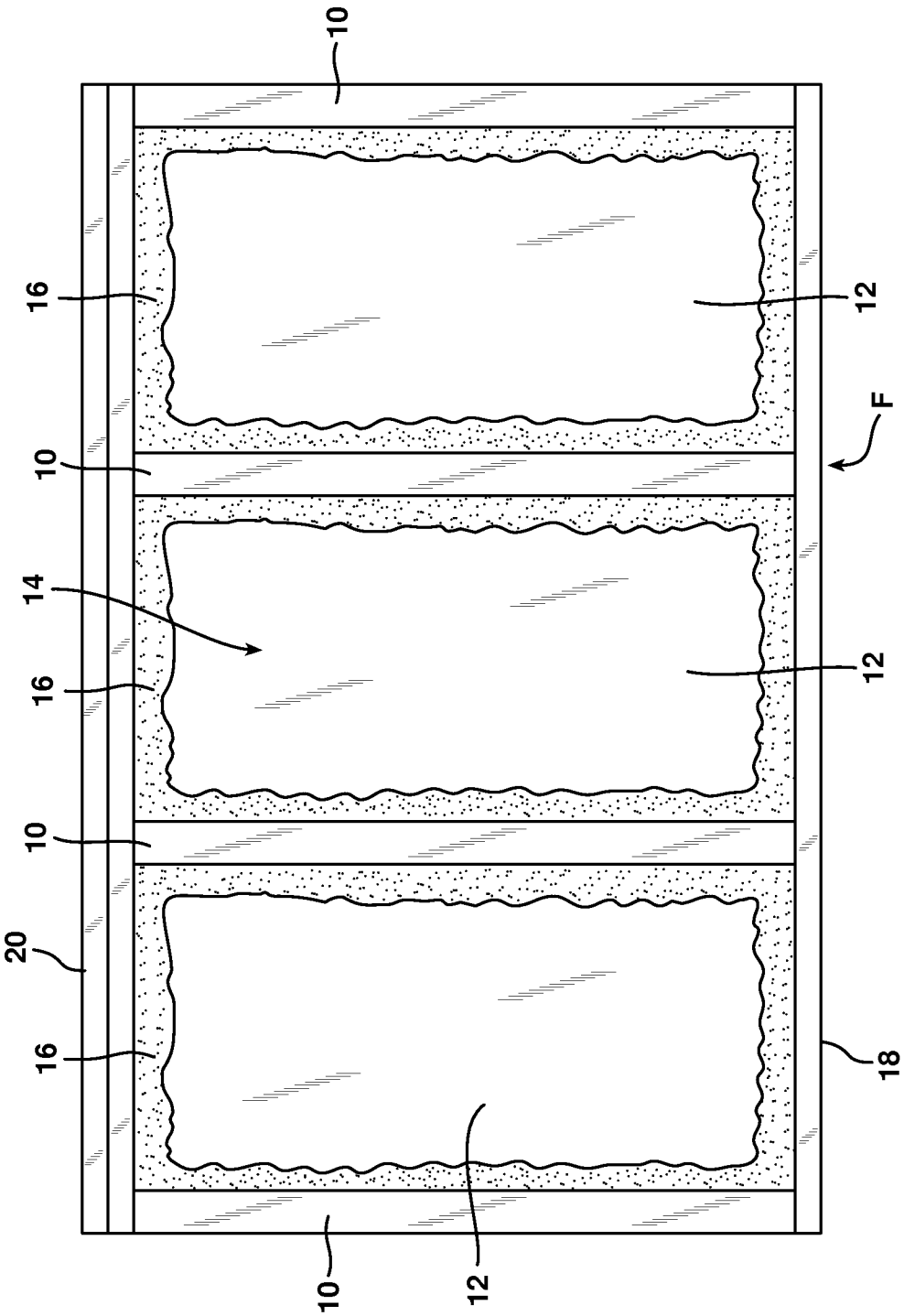


FIG. 2

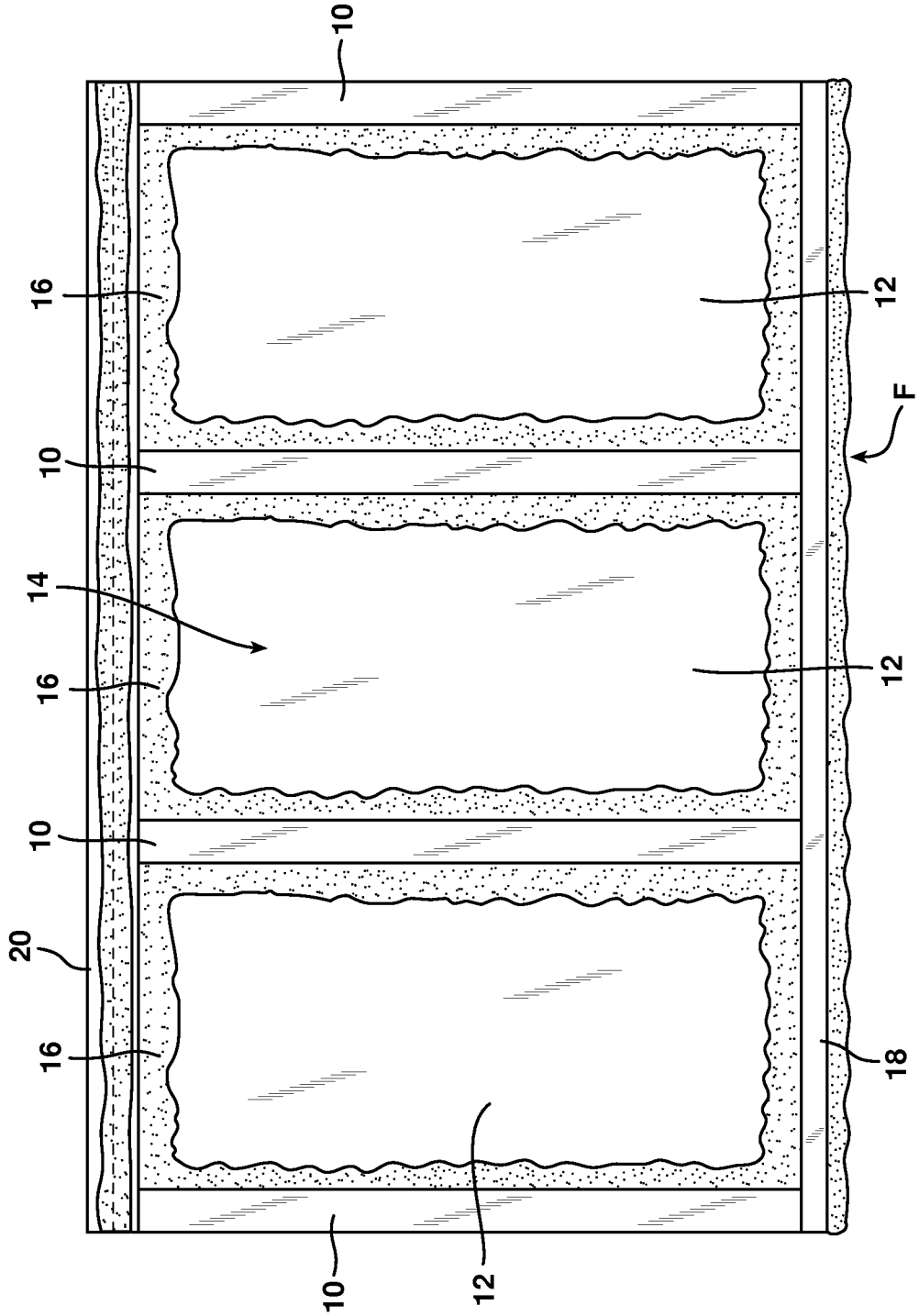


FIG. 3

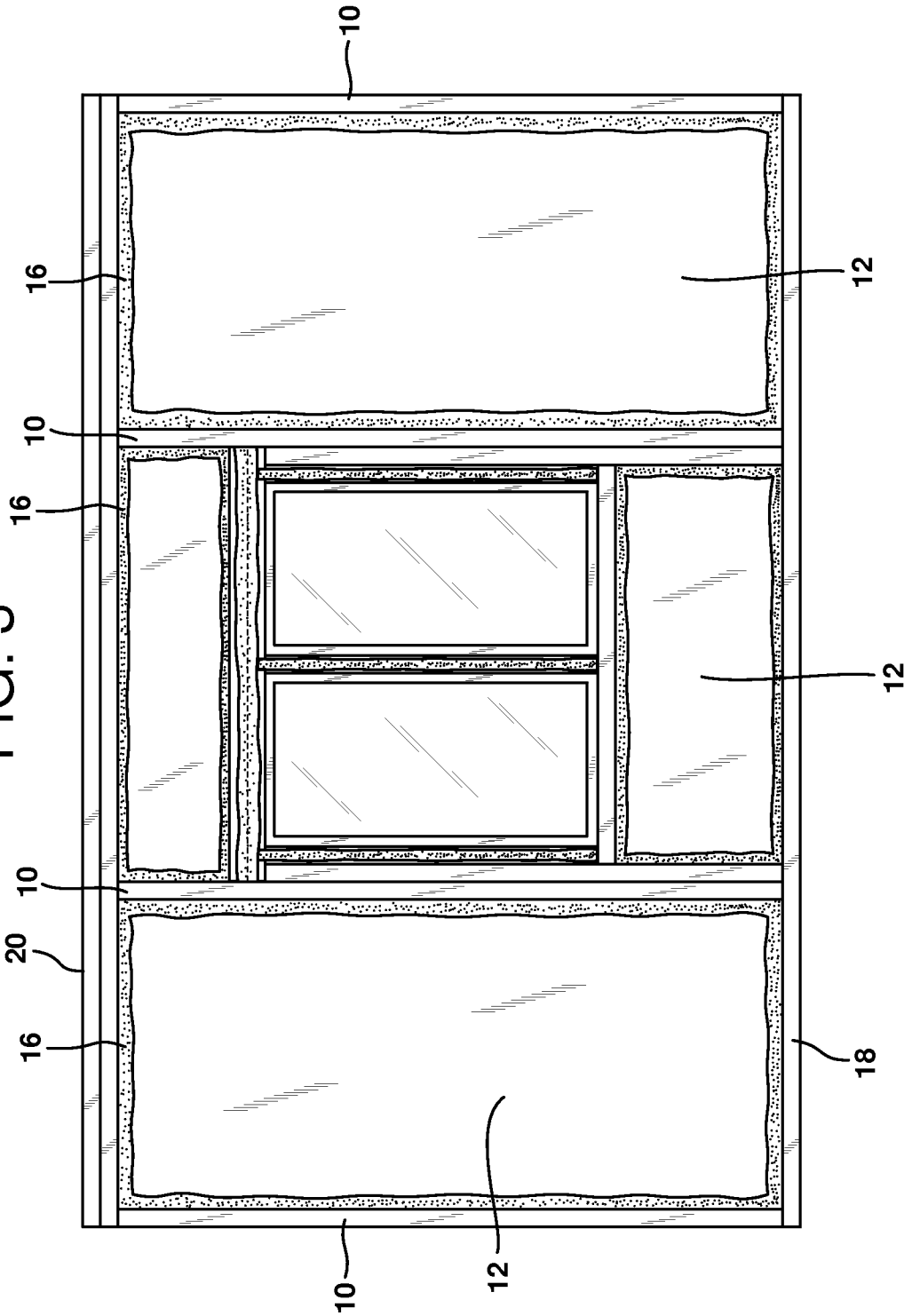


FIG. 4A

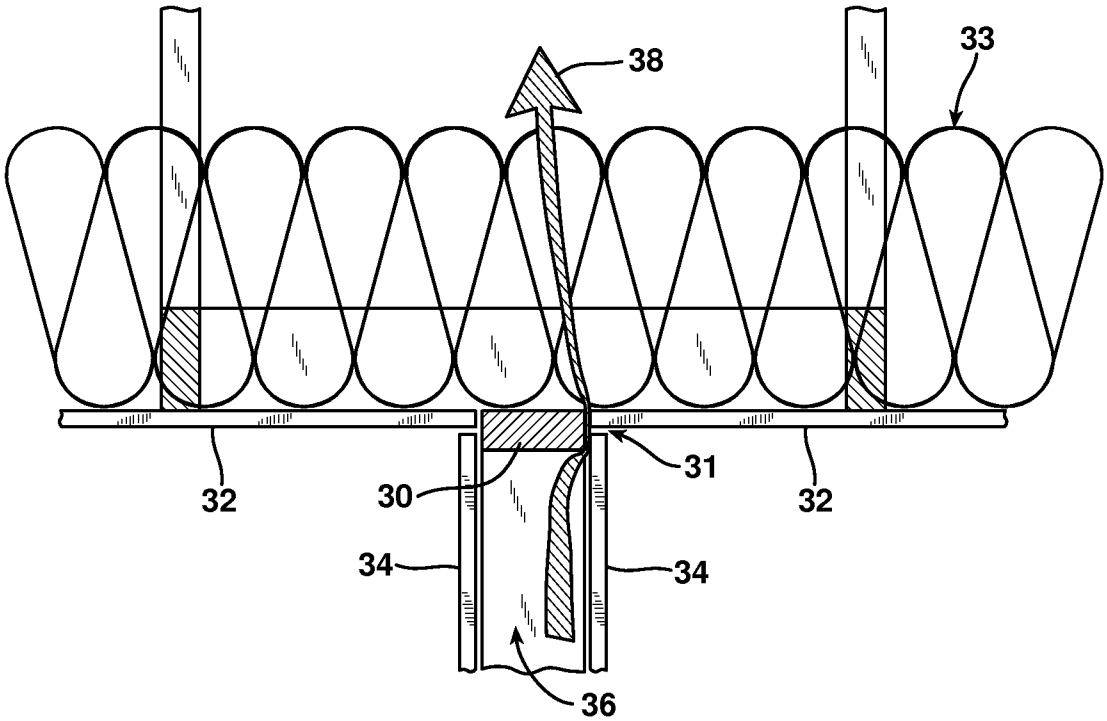


FIG. 4B

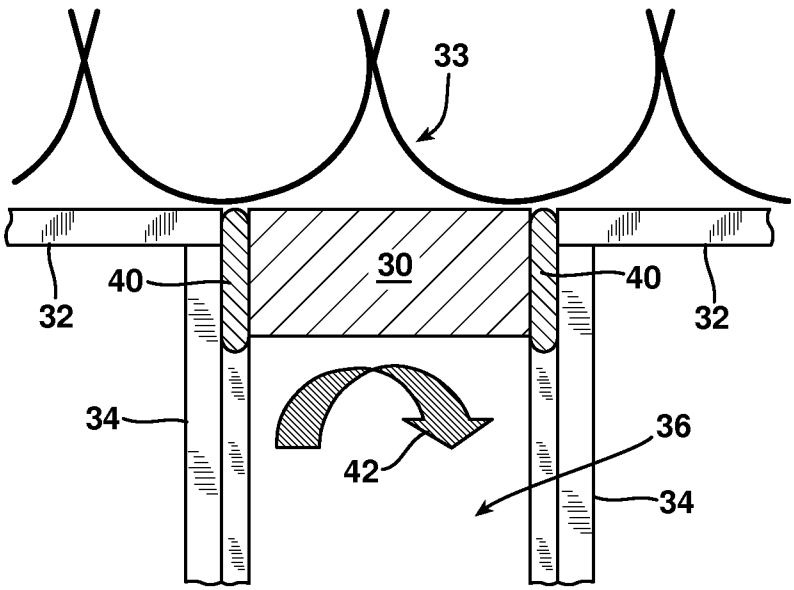
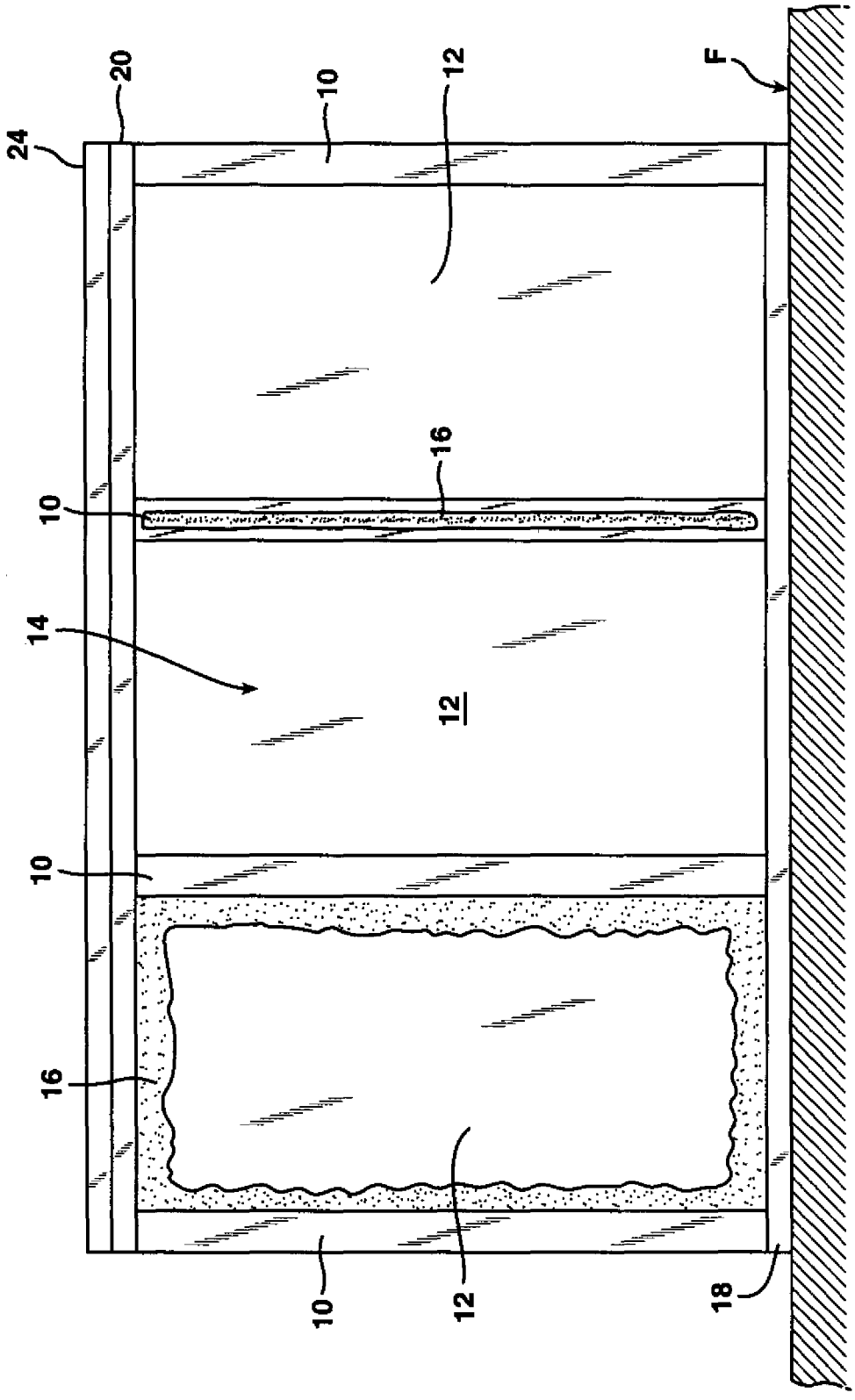


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/021305

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08J9/00 C08J9/30

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)
C08J

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 practical, 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 2003/229153 A1 (STOLLMAIER FRIEDERIKE [DE] ET AL) 11 December 2003 (2003-12-11) cited in the application claims 1-12; examples 1-3	1-55
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 February 2010	09/03/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Glomm, Bernhard

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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2006/047010 A1 (O'LEARY ROBERT J [US]) 2 March 2006 (2006-03-02) cited in the application claims 1-43; examples 1-3	1-55

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