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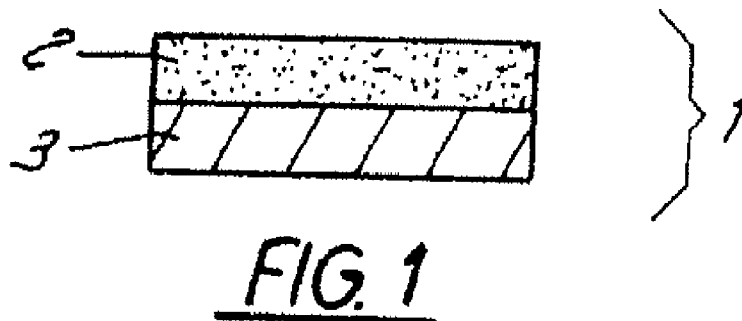
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(54) Title: ANTI-MICROBIAL PAPER SUBSTRATES USEFUL IN WALLBOARD TAPE APPLICATIONS



(57) Abstract: This invention relates to paper products and/or substrates suitable for being made into wallboard tape (also may be known as joint tape and/or dry wall tape) and having improved reduction or inhibition in the growth of microbes, mold and/or fungus. The paper substrate is characterized by its excellent physical properties including cross direction (CD) tensile, machine (MD) tensile, internal bond, wet tensile, hygroexpansivity, curl, bonding properties, bonding of joint tape to joint compound, etc. The paper product of the invention contains a sizing agent and an antimicrobial compound as well as other optional components including without limitation a binder. The paper product of the invention may be produced by contacting the plurality of cellulose fibers with each of the sizing agent, antimicrobial compound, and optional components at any point in the papermaking process, converting process, and/or post-converting process. Finally, the invention relates to methods of using the paper substrate.



ANTI-MICROBIAL PAPER SUBSTRATES USEFUL IN WALLBOARD TAPEAPPLICATIONS

5 The present application claims the benefit of priority under 35 USC §119(e) to United States Provisional Patent Application 61/187,302 entitled "Anti-microbial Wallboard Tape", filed June 16, 2009, which is hereby incorporated, in its entirety, herein by reference.

Field of the Invention

10 This invention relates to paper products and/or substrates suitable for being made into wallboard tape (also may be known as joint tape and/or drywall tape) and having improved reduction or inhibition in the growth of microbes, mold and/or fungus. The paper substrate is characterized by its excellent physical properties including cross direction (CD) tensile, machine (MD) tensile, internal bond, wet tensile, hygroexpansivity, curl, bonding properties, bonding of
15 joint tape to joint compound, etc. The paper product of the invention contains a sizing agent and an antimicrobial compound as well as other optional components including without limitation a binder. The paper product of the invention may be produced by contacting the plurality of cellulose fibers with each of the sizing agent, antimicrobial compound, and optional components at any point in the papermaking process, converting process, and/or post-converting process. Finally, the
20 invention relates to methods of using the paper substrate.

Background of the Invention

 Wallboard (also known as drywall) has become the dominant material in the production of interior building partitions. In particular, interior building partitions generally comprise a studwall
25 of spaced parallel vertical members (studs) which are used as a support for preformed panels

(wallboard) which are attached to the studwall by screws, nails, adhesive or any other conventional attachment system. Obviously, joints exist between adjacent preformed panels. In order to provide a continuous flat surface to the wall, it is necessary to "finish" the joint between adjacent panels.

Generally, such "finishing" may include the building up of multiple layers of a mastic material

5 (joint compound) and the blending of this joint compound and paper substrate suitable for wallboard tape utility into the panel surface so as to form the desired flat and contiguous wall surface. In addition, wallboard tape may be used to bring together a plurality of panels forming a corner which may include but is not limited to corner bead.

10 In order to facilitate this finishing of the joints and/or corners, most manufacturers bevel the longitudinal edges of the wallboard panels so as to allow a build-up of mastic material which will then match the level of the major surface area of the preformed panel. Typically, the buildup of the mastic material in the joint area comprises the application of a first layer of mastic material, the embedding of a wallboard tape (for example a paper tape) in the first layer of mastic material and
15 then the overcoating of the tape with one or more, generally two layers of additional mastic material. This finishing of the joints is a time consuming process, since it is generally necessary to wait 24 hours between each application of a coat of mastic material in order to allow the coat to dry before the application of an overcoat of an additional layer of mastic material. Moreover, it is then necessary generally to sand the joint area so as to produce a finish which will match the major
20 portion of the surface area of the wallboard panels. The "finishing" process thus is both time-consuming and labor-intensive.

In addition to the above, it is desirable to create building materials that are antimicrobial so that they resist or inhibit the growth of microbes such as bacteria, fungus, molds, and mildew.

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Wallboard tape paper is a very challenging paper to make as there is a very narrow window of operation in which to achieve the required high tensile strengths while maintaining other good physical properties such as bonding properties, bonding of joint tape to joint compound, hygroexpansivity, curl, etc. The challenge to the next generation of wallboard tape paper substrate production is to program an addition antimicrobial function into what is already a very specific and stringent set of physical properties such as CD tensile, MD tensile, internal bond, wet tensile, hygroexpansivity, curl, bonding properties, bond of joint tape to joint compound, etc (which are demanded by wallboard tape paper substrate converters and users). Such levels of physical properties such as CD tensile, MD tensile, internal bond, wet tensile, hygroexpansivity, curl, bonding properties, bond of joint tape to joint compound, etc. have been achieved by conventional production of paper substrates under acidic conditions and alkaline conditions. However, an alkaline paper substrate suitable for wallboard tape converting (e.g. have acceptable physical properties such as CD tensile, MD tensile, internal bond, wet tensile, hygroexpansivity, curl, bonding properties, bond of joint tape to joint compound, etc) has been difficult to achieve.

Despite the considerable efforts, there exists a need for a wallboard tape to satisfy the construction industries' requirements wallboard tape having highly sought after physical properties and maintain sustainable antimicrobial properties.

Brief Description of the Drawings

Figure 1: A first schematic cross section of just one exemplified embodiment of the paper substrate that is included in the paper substrate of the present invention.

Figure 2: A second schematic cross section of just one exemplified embodiment of the paper substrate that is included in the paper substrate of the present invention.

Figure 3: A third schematic cross section of just one exemplified embodiment of the paper substrate that is included in the paper substrate of the present invention.

Figure 4: A first pictorial representation of how wallboard and tape samples were tested for antimicrobial performance according to Example 1.

5 Figure 5: A second pictorial representation of how wallboard and tape samples were tested for antimicrobial performance according to Example 1.

Figure 6: A photograph showing the antimicrobial performance of Sample A after 62 days as measured by the process of Example 1.

Figure 7: A photograph showing the antimicrobial performance of Sample B after 62 days as
10 measured by the process of Example 1.

Figure 8: A photograph showing the antimicrobial performance of Sample C after 62 days as measured by the process of Example 1.

Figure 9: A photograph showing the antimicrobial performance of Sample D after 62 days as measured by the process of Example 1.

15 Figure 10: A photograph showing the antimicrobial performance of Sample E after 62 days as measured by the process of Example 1.

Figure 11: A photograph showing the antimicrobial performance of Sample F after 62 days as measured by the process of Example 1.

Figure 12: A photograph showing the antimicrobial performance of Sample G after 62 days as
20 measured by the process of Example 1.

Figure 13: A photograph showing the antimicrobial performance of Sample H after 62 days as measured by the process of Example 1.

Detailed Description of the Invention

The present inventors have now discovered a paper substrate which, until now, was unable to meet the stringent physical properties required by the construction industries for useful wallboard tape application that also has sustainable antimicrobial properties, as well as methods of making and using the same.

The paper substrate of the present invention may contain recycled fibers and/or virgin fibers. Recycled fibers differ from virgin fibers in that the fibers have gone through the drying process at least once.

The paper substrate of the present invention may contain from 1 to 99 wt% of cellulose fibers based upon the total weight of the substrate, including 1, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95 and 99wt%, and including any and all ranges and subranges therein.

Preferably, the sources of the cellulose fibers are from softwood and/or hardwood. The paper substrate of the present invention may contain from 1 to 99 wt%, preferably from 5 to 95 wt%, cellulose fibers originating from softwood species based upon the total amount of cellulose fibers in the paper substrate. This range includes 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, and 100wt%, including any and all ranges and subranges therein, based upon the total amount of cellulose fibers in the paper substrate.

The paper substrate of the present invention may contain from 1 to 99 wt%, preferably from 5 to 95 wt%, cellulose fibers originating from hardwood species based upon the total amount of cellulose fibers in the paper substrate. This range includes 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55,

60, 65, 70, 75, 80, 85, 90, 95, and 100wt%, including any and all ranges and subranges therein, based upon the total amount of cellulose fibers in the paper substrate.

Further, the softwood and/or hardwood fibers contained by the paper substrate of the present invention may be modified by physical and/or chemical means. Examples of physical means include, but is not limited to, electromagnetic and mechanical means. Means for electrical modification include, but are not limited to, means involving contacting the fibers with an electromagnetic energy source such as light and/or electrical current. Means for mechanical modification include, but are not limited to, means involving contacting an inanimate object with the fibers. Examples of such inanimate objects include those with sharp and/or dull edges. Such means also involve, for example, cutting, kneading, pounding, impaling, etc means.

Examples of chemical means include, but is not limited to, conventional chemical fiber modification means. Examples of such modification of fibers may be, but is not limited to, those found in the following patents 6,592,717, 6,582,557, 6,579,415, 6,579,414, 6,506,282, 6,471,824, 6,361,651, 6,146,494, H1,704, 5,698,688, 5,698,074, 5,667,637, 5,662,773, 5,531,728, 5,443,899, 5,360,420, 5,266,250, 5,209,953, 5,160,789, 5,049,235, 4,986,882, 4,496,427, 4,431,481, 4,174,417, 4,166,894, 4,075,136, and 4,022,965, which are hereby incorporated in their entirety by reference.

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The paper substrate of the present invention may contain an antimicrobial compound. The paper substrate's antimicrobial tendency may be measured in part by ASTM standard testing methodologies such as D 2020-92, E 2180-01, G 21-966, C1338, and D2020, all of which can be found as published by ASTM and all of which are hereby incorporated, in their entirety, herein by reference.

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Antimycotics, fungicides are examples of antimicrobial compounds. Antimicrobial compounds may retard, inhibit, reduce, and/or prevent the tendency of microbial growth over time on/in a product containing such compounds as compared to that tendency of microbial growth on/in a product not containing the antimicrobial compounds. The antimicrobial compound when
5 incorporated into the paper substrate of the present invention preferably retards, inhibits, reduces, and/or prevents microbial growth for a time that is at least 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 75, 100, 125, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 700, 800, 900, 1000% greater than that of a paper substrate that does not contain an antimicrobial compound, including all ranges and subranges therein.

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Antimycotic compounds are, in part, mold resistant. Fungicide compounds are, in part, fungus resistant. The antimicrobial compound may have other functions and activities than provide either mold resistance and/or fungus resistance to a product containing the same.

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The antimicrobial compound may also be mildew, bacteria and/or virus resistant. A mold specifically targeted, but meant to be non-limiting, is Black mold as applied to the above-mentioned paper substrate of the present invention.

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It is preferable for the antimycotic and/or fungicide to not be highly toxic to humans.

The antimycotic and/or fungicide may be water insoluble and/or water soluble, most preferably water insoluble. The antimycotic and/or fungicide may be volatile and/or non-volatile, most preferably non-volatile. The antimycotic and/or fungicide may be organic and/or inorganic. The antimycotic and/or fungicide may be polymeric and/or monomeric.

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The antimycotic and/or fungicide may be multivalent which means that the agent may carry one or more active compounds so as to protect against a wider range of mold, mildew and/or fungus species and to protect from evolving defense mechanisms within each species of mold, mildew and/or fungus.

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Any water-soluble salt of pyrithione having antimicrobial properties is useful as the antimicrobial compound. Pyrithione is known by several names, including 2 mercaptopyridine-N-oxide; 2-pyridinethiol-1-oxide (CAS Registry No. 1121-31-9); 1-hydroxypyridine-2-thione and 1 hydroxy-2(1H)-pyridinethione (CAS Registry No. 1121-30-8). The sodium derivative, known as sodium pyrithione (CAS Registry No. 3811-73-2), is one embodiment of this salt that is particularly useful. Pyrithione salts are commercially available from Arch Chemicals, Inc. of Norwalk, Conn., such as Sodium OMADINE or Zinc OMADINE.

Examples of the antimicrobial compound may include silver-containing compound, zinc-containing compound, an isothiazolone-containing compound, a benzothiazole-containing compound, a triazole-containing compound, an azole-containing compound, a benzimidazole-containing compound, a nitrile containing compound, alcohol-containing compound, a silane-containing compound, a carboxylic acid-containing compound, a glycol-containing compound, a thiol-containing compound or mixtures thereof

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Additional exemplified commercial antimicrobial compounds may include those from Intace including B-6773 and B-350, those from Progressive Coatings VJ series, those from Buckman Labs including Busan 1218, 1420 and 1200WB, those from Troy Corp including Polyphase 641, those from Clariant Corporation, including Sanitized TB 83-85 and Sanitized Brand T 96-21, and those from Bentech LLC including Preservor Coater 36. Others include AglON (silver zeolite) from AglON and Microban from Microban International (e.g. Microban additive TZ1,

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S2470, and PZ2). Further examples include dichloro-octyl-isothiazolone, Tri-n-butyltin oxide, borax, G-4, chlorothalonil, organic fungicides, and silver-based fungicides. Any one or more of these agents would be considered satisfactory as an additive in the process of making paper material. Further commercial products may be those from AEGIS Environments (e.g. AEM 5772 Antimicrobial), from BASF Corporation (e.g. propionic acid), from Bayer (e.g. Metasol TK-100, TK-25), those from Bendiner Technologies, LLC, those from Ondei-Nalco (e.g. Nalcon 7645 and 7622), and those from Hercules (e.g. RX 8700, RX 3100, and PR 1912). The MSDS's of each and every commercial product mentioned above is hereby incorporated by reference in its entirety.

Still further, examples of the antimicrobial compounds may include silver zeolite, dichloro-octyl-isothiazolone, 4,5-dichloro-2-n-octyl-3(2H)-isothiazolone, 5-chloro-2-methyl-4-isothiazolin-3-one, 1,2-benzothiazol-3(2H)-one, poly[oxyethylene(ethylimino)ethylene dichloride], Tri-n-butyltin oxide, borax, G-4, chlorothalonil, Alkyl-dimethylbenzyl-ammonium saccharinate, dichloropeyl-propyl-dioxolan-methyl-triazole, alpha-chlorophenyl, ethyl-dimethylethyl-trazole-ethanol, benzimidazol, 2-(thiocyanomethylthio)benzothiazole, alpha-2-(4-chlorophenyl)ethyl-alpha-(1-1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol, (1-[[2-(2,4-dichlorophenyl)-4-propyl-1,3-dioxolan-2-yl]-methyl]-1H-1,2,4-triazole, alkyl dimethylbenzyl ammonium saccharinate, 2-(methoxy-carbamoyl)-benzimidazol, tetrachlorisophthalonitrile, P-[(diiodomethyl) sulfonyl] toluol, methyl alcohol, 3-(trimethoxysilyl) propyldimethyl octadecyl ammonium chloride, chloropropyltrimethylsilane, dimethyl octadecyllamine, propionic acid, 2-(4-thiazolyl)benzimidazole, 1,2-benzisothiazolin-3-one, 2-N-octyl-4-isothiazolin-3-one, diethylene glycol monoethyl ether, ethylene glycol, propylene glycol, hexylene glycol, tributoxyethyl phosphate, 2-pyridinethio-1-oxide, potassium sorbate, diiodomethyl-p-tolysulfone, citric acid, lemon grass oil, and thiocyanomethylthio-benzothiazole.

The antimicrobial compound may be present in the paper substrate at amounts from 1 to 5000 ppm dry weight, more preferably, from 100 to 3000 ppm dry weight, most preferably 50 to 1500 ppm dry weight. The amounts of antimycotic and/or fungicide may be 2, 5, 10, 25, 50, 75, 100, 125, 150, 175, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450, 475, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200, 2300, 2400, 2500, 2600, 2700, 2800, 2900, 3000, 3200, 3500, 3750, 4000, 4250, 4500, 4750, and 5000 ppm dry weight based upon the total weight of the paper substrate, including all ranges and subranges therein. Higher amounts of such antimycotic and/or fungicide may also prove produce an antibacterial paper material and article therefrom as well. These amounts are based upon the total weight of the paper substrate.

The paper substrate of the present invention may contain at least one sizing agent. Examples of the sizing agent may be, but is not limited to, alkaline sizing agents and acid-based sizing agents. Examples of alkaline sizing agents include without limitation unsaturated hydrocarbon compounds, such as C6 to C24, preferably C18 to C20, unsaturated hydrocarbon compounds and mixtures thereof. Examples of acid-based sizing agents include without limitation alum and rosin-based sizing agents such as Plasmine N-750-P from Pasmine Technology Inc.

Figures 1-3 demonstrate different embodiments of the paper substrate **1** in the paper substrate of the present invention. Figure 1 demonstrates a paper substrate **1** that has a web of cellulose fibers **3** and a composition containing an antimicrobial compound **2** where the composition containing an antimicrobial compound **2** has minimal interpenetration of the web of cellulose fibers **3**. Such an embodiment may be made, for example, when an antimicrobial compound is coated onto a web of cellulose fibers during or after papermaking and/or during or after converting the substrate to a useful wallboard tape and/or during or after abrading (such as sanding) the surface of the substrate.

Figure 2 demonstrates a paper substrate **1** that has a web of cellulose fibers **3** and a composition containing an antimicrobial compound **2** where the composition containing an antimicrobial compound **2** interpenetrates the web of cellulose fibers **3**. The interpenetration layer **4** of the paper substrate **1** defines a region in which at least the antimicrobial compound penetrates into and is among the cellulose fibers. The interpenetration layer may be from 1 to 99% of the entire cross section of at least a portion of the paper substrate, including 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, and 99% of the paper substrate, including any and all ranges and subranges therein. Such an embodiment may be made, for example, when an antimicrobial compound is added to the cellulose fibers prior to a coating method and may be combined with a subsequent coating method if required. Addition points may be at the size press, for example.

Figure 3 demonstrates a paper substrate **1** that has a web of cellulose fibers **3** and an antimicrobial compound **2** where the antimicrobial compound **2** is approximately evenly distributed throughout the web of cellulose fibers **3**. Such an embodiment may be made, for example, when an antimicrobial compound is added to the cellulose fibers prior to a coating method and may be combined with a subsequent coating method if required. Exemplified addition points may be at the wet end of the paper making process, the thin stock, and the thick stock.

The web of cellulose fibers and the antimicrobial compound may be in a multilayered structure. The thicknesses of such layers may be any thickness commonly utilized in the paper making industry for a paper substrate, a coating layer, or the combination of the two. The layers do not have to be of approximate equal size. One layer may be larger than the other. One preferably embodiment is that the layer of cellulose fibers has a greater thickness than that of any layer

containing the antimicrobial compound. The layer containing the cellulose fibers may also contain, in part, the antimicrobial compound.

Further examples of sizing agents that may be incorporated into the present invention may include, but is not limited to, those found in the following patents: 6,595,632, 6,512,146, 6,316,095, 6,273,997, 6,228,219, 6,165,321, 6,126,783, 6,033,526, 6,007,906, 5,766,417, 5,685,815, 5,527,430, 5,011,741, 4,710,422, and 4,184,914, which are hereby incorporated in their entirety by reference. Preferred alkaline sizing agent may be, but not limited to, alkyl ketene dimer, alkenyl ketene dimer and alkenyl succinic anhydride.

The paper substrate of the present invention may contain from 0.05 to 1.5 wt% of the alkaline sizing agent based upon the total weight of the substrate. This range includes 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, and 1.5 wt%, including any and all ranges and subranges therein.

The paper substrate of the present invention may have a MD tensile as measured by conventional TAPPI method 494 of from 25 to 100, preferably from 40 to 90 lbf/inch width. This range includes MD tensile of 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, and 100 lbf/inch width, including any and all ranges and subranges therein.

The paper substrate of the present invention may have a CD tensile as measured by conventional TAPPI method 494 of from 5 to 50, preferably from 20 to 50 lbf/inch width, most preferably 25 to 40 lbf/inch width. This range includes CD tensile of 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 lbf/inch width, including any and all ranges and subranges therein.

The paper substrate of the present invention may have a wet strength as measured by conventional TAPPI method 456 of from 5 to 50, preferably from 10 to 25, most preferably from 15 to 25, lb/inch width. This range includes wet strengths of 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50 lb/inch width, including any and all ranges and subranges therein.

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The paper substrate of the present invention may have an internal bond as measured by conventional TAPPI method 541 of from 25 to 350, preferably from 50 to 250, most preferably from 100-200, milli ft-lb/sq. in. This range includes internal bond of 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 125, 150, 175, 200, 225, 250, 275, 300, 325 and 350 milli ft-

10 lb/sq. in. including any and all ranges and subranges therein.

The paper substrate of the present invention may have a pH of at least about 1.0 to about 14.0 as measured by any conventional method such as a pH marker/pen and conventional TAPPI methods 252 and 529 (hot extraction test and/or surface pH test). The pH of the paper may be from

15 about 1.0 to 14.0, preferably about 4.0 to 9.0, most preferably from about 6.5 to 8.5. This range includes pHs of 1.0, 2.0, 3.0, 4.0, 5.0, 6.0 6.5, 6.6., 6.7, 6.8, 6.9, 7.0, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 8.0, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9.0, 9.2, 9.4, 9.5, 9.6, 9.8, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, and 14.0, including any and all ranges and subranges therein.

20 The density, basis weight and caliper of the web of this invention may vary widely and conventional basis weights, densities and calipers may be employed depending on the paper-based product formed from the web.

The paper substrate according to the present invention may be made off of the paper machine

25 having a basis weight of from 50 lb/3000 sq. ft. to 120 lb/3000 sq. ft, preferably from 70 to 120, and most preferably from 80-100 lb/3000 sq. ft. The basis weight of the substrate may be 50, 52, 54, 55.

56, 58, 60, 62, 64, 65, 66, 68, 70, 72, 74, 75, 76, 78, 80, 82, 84, 85, 86, 88, 90, 92, 94, 95, 96, 98, 100, 105, 110, 115 and 120 lb/3000 sq. ft, including any and all ranges and subranges therein.

The paper substrate according to the present invention may be made off of the paper machine having an apparent density of from 5.0 to 20.0, preferably 9.0 to 13.0, most preferably from 9.5 to 11.5, lb/3000sq. ft.per 0.001 inch thickness. The apparent density of the substrate may be 5.0, 5.2, 5.4, 5.5, 5.6, 5.8, 6.0, 6.2, 6.4, 6.5, 6.6, 6.8, 7.0, 7.2, 7.4, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, 14.0, 14.5, 15.0, 15.5, 16.0, 16.5, 17.0, 17.5, 18.0, 18.5, 19.0, 19.5 and 20.0 lb/3000sq. ft.per 0.001 inch thickness, including any and all ranges and subranges therein.

The paper substrate according to the present invention may have a width off the winder of a paper machine of from 5 to 100 inches and can vary in length. The width of the paper substrate may be 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100 inches, including any and all ranges and subranges therein.

Additionally, the paper substrate according to the present invention may be cut into streamers that have a width of from 1.5 to 3.25 inches wide and may vary in length. The width of the paper substrate streamer may have a width of 1.50, 1.60, 1.70, 1.75, 1.80, 1.85, 1.9, 1.95, 2.00, 2.10, 2.20, 2.30, 2.40, 2.50, 2.60, 2.70, 2.80, 2.90, 3.00, 3.05, 3.10, 3.15, 3.20, and 3.25 inches, including any and all ranges and subranges therein.

The paper substrate of the present invention may contain optional components as well including but not limited to binders, wet strength additives, and anionic promoters.

One optional component that is included as one embodiment of the paper substrate of the present invention includes without limitation a binder. Examples of binders include, but are not

limited to, polyvinyl alcohol, Amres (a Kymene type), Bayer Parez, polychloride emulsion, modified starch such as hydroxyethyl starch, starch, polyacrylamide, modified polyacrylamide, polyol, polyol carbonyl adduct, ethanediol/polyol condensate, polyamide, epichlorohydrin, glyoxal, glyoxal urea, ethanediol, aliphatic polyisocyanate, isocyanate, 1,6 hexamethylene diisocyanate, diisocyanate, polyisocyanate, polyester, polyester resin, polyacrylate, polyacrylate resin, acrylate, and methacrylate. When the substrate of the present invention contains a binder, preferable binders include without limitation starch and polyvinyl alcohol.

When the substrate of the present invention contains a binder, the substrate may include any amount of binder including less than 5% of binder. This range includes less than 0.001, 0.002, 0.005, 0.006, 0.008, 0.01, 0.02, 0.03, 0.04, 0.05, 0.1, 0.2, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 2, 4, and 5wt% based on the total weight of the substrate, including any and all ranges and subranges therein.

One optional component that is included as one embodiment of the paper substrate of the present invention includes without limitation a wet strength additive. The paper substrate of the present invention may contain at least one wet strength additive. The wet strength additive may be cationic, anionic, neutral, and amphoteric. A preferred wet strength additive is cationic and/or contains a basic functional group. Examples of the wet strength additive may be, but is not limited to, polymeric amine epichlorohydrin (PAE), urea formaldehyde, melamine formaldehyde and glyoxylated polyacrylamide resins. Further examples of wet strength additives that may be incorporated in to the present invention may include, but is not limited to, those found in the following patents: 6,355,137 and 6,171,440, which are hereby incorporated in their entirety by reference. Preferred wet strength additives include, but are not limited to, polymeric amine epichlorohydrin (PAE).

The paper substrate of the present invention may contain from 0.25 to 2.5 wt% of the wet strength additive based upon the total weight of the substrate. This range includes 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4 and 2.5 wt%, including any and all ranges and subranges therein.

5

One optional component that is included as one embodiment of the paper substrate of the present invention includes without limitation an anionic promoter. The paper substrate of the present invention may contain at least one anionic promoter. Examples of the anionic promoter may be, but is not limited to, polyacrylates, sulfonates, carboxymethyl celluloses, galactomannan hemicelluloses and polyacrylamides. Preferred anionic promoters include, but are not limited to polyacrylates such as Nalco 64873.

10

The paper substrate of the present invention may contain from 0.05 to 1.5 wt% of the anionic promoter based upon the total weight of the substrate. This range includes 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, and 1.5 wt%, including any and all ranges and subranges therein.

15

The paper substrate of the present invention may also optionally include inert substances including without limitation fillers, thickeners, and preservatives. Other inert substances include, but are not limited to silicas such as colloids and/or sols. Examples of silicas include, but are not limited to, sodium silicate and/or borosilicates. Another example of inert substances is solvents including but not limited to water. Examples of fillers include, but are not limited to; calcium carbonate, calcium sulfate hemihydrate, and calcium sulfate dehydrate. A preferable filler is calcium carbonate.

20

25

The paper substrate of the present invention may contain from 0.001 to 20 wt% of the inert substances based on the total weight of the substrate, preferably from 0.01 to 10 wt %, most preferably 0.1 to 5.0wt%, of each of at least one of the inert substances. This range includes 0.001, 0.002, 0.005, 0.006, 0.008, 0.01, 0.02, 0.03, 0.04, 0.05, 0.1, 0.2, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 2, 4, 5, 6, 8, 10, 12, 14, 15, 16, 18, and 20wt% based on the total weight of the substrate, including any and all ranges and subranges therein.

The paper substrate may be made by contacting a plurality of cellulose fibers with a antimicrobial compound and/or a sizing agent consecutively in any order and/or simultaneously.

Further, the contacting may occur in an aqueous environment having a pH of from about 1.0 to about 14.0, preferably from about 6.8 to about 8.5. The pH may be 1.0, 2.0, 3.0, 4.0, 5.0, 6.0 6.5, 6.6., 6.7, 6.8, 6.9, 7.0, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9, 8.0, 8.1, 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, 8.8, 8.9, 9.0, 9.2, 9.4, 9.5, 9.6, 9.8, 10.0, 10.5, 11.0, 11.5, 12.0, 12.5, 13.0, 13.5, and 14.0, including any and all ranges and subranges therein. Accordingly the paper substrate may be made using acidic, near neutral, neutral, or alkaline conditions.

Still further, the contacting may occur at acceptable concentration levels that provide the paper substrate of the present invention to contain any of the above-mentioned amounts of cellulose fibers, antimicrobial compound, sizing agent, optional components, and/or inert substances isolated or in any combination thereof. The contacting may occur anytime in the papermaking process including, but not limited to the thick stock, thin stock, head box, size press, water box, and coater. The cellulose fibers, antimicrobial compound, sizing agent, optional components, and/or inert substances may be contacted serially, consecutively, and/or simultaneously in any combination with each other. The cellulose fibers, antimicrobial compound, sizing agent, optional components, and/or inert substances may be pre-mixed in any combination before addition to the paper-making process.

These methods of making the paper substrate of the present invention may be added to any conventional papermaking processes, as well as converting processes, including abrading or sanding to create a fine nap for greater adhesion qualities, slitting, scoring, perforating, sparking, calendaring, sheet finishing, converting, coating, laminating, printing, etc. Preferred conventional processes include those tailored to produce paper substrates capable to be utilized as wallboard tape. Textbooks such as those described in the "Handbook for pulp and paper technologists" by G.A. Smook (1992), Angus Wilde Publications, describe such processes and is hereby incorporated, in its entirety, by reference.

In one embodiment, the cellulosic fibers and sizing agent may be contacted at anytime during papermaking with or without optional substances or inert substances. In such an embodiment, the cellulosic fibers and sizing agent are contacted at least at the wet end of the paper machine, then the web is dried to make a paper substrate suitable for use as wallboard tape.

Optional substances and/or inert substances may optionally be added at anytime during papermaking including without limitation optionally adding the binder to the web using a size press. The substrate may be sanded creating a nap, preferably a fine nap, for greater adhesion qualities. The surface of the substrate carrying the nap may then be contacted with the antimicrobial compound. The contacting may occur using a size press or any coater apparatus including without limitation a spray coater apparatus. Within this embodiment, the optional components and/or inert substances may optionally be contacted with the surface of the substrate at the same time as the antimicrobial compound.

The present invention is explained in more detail with the aid of the following embodiment example which is not intended to limit the scope of the present invention in any manner.

ExamplesEXAMPLE 1*Materials:*

Handsheet Furnish: 100% refined southern softwood collected on 7/20/07

5 Sizing Agent : Plasmine N-750-P (40% solids)

Aluminum Sulfate (Alum): (40% consistency)

Wet Strength Agent : Poly(amido-amine)-epichlorohydrin (25% solids)

Antimicrobial Agent (A/M): Intace B350

Starch: Tate & Lyle Pearl

10 Antimicrobial Gypsum Board: ½" Dense Armor Plus Mold & Humidity Resistant

gypsum panel from Georgia Pacific

Joint Compound : Ready Mixed Sheetrock All Purpose Joint Compound from
US Gypsum

15 *Method:*

Two Dynamic Sheet Former (DSF) handsheets were made according to the following experimental design:

20 **Table 1: DSF Study for paper substrates for use as antimicrobial wallboard tape**

Design:	I.D.	Liquid Sizing lb/T	Alum lb/T	Wet Strength lb/T	Surface Sizing (Starch)	A/M* Agent	DSF BDBW Target gsm
	A	0	20	12	N	N	131.5
	B	0	20	12	N	Y	131.5

C	10	20	12	N	N	131.5
D	10	20	12	N	Y	131.5
E	0	20	12	Y	N	125.0
F	0	20	12	Y	Y	125.0
G	10	20	12	Y	N	125.0
H	10	20	12	Y	Y	125.0

Due to the size of the wet-press felt, all sheets were divided into thirds and then wet-pressed at a pressure of 40 psi before drying on a rotary drum-dryer.

- 5 All sheets were tested for the following physical properties prior to any surface sizing with starch: Basis Weight (TAPPI T-410), Caliper (TAPPI T-411), Gurley Porosity (TAPPI T-460), and HST with 10% formic acid and dye solution (TAPPI T-530).

10 Samples E-H were then run through a bench-top puddle size press using the Pearl Starch and dried on a drum-dryer. The pearl starch was cooked in two batches having solids measuring 16.7% and 16.3% yielding an approximate pick up of 110 #/Ton.

Sheets for samples E-H were tested again for the same physical properties as before.

- 15 All sheets for samples A-H were manually sanded using a belt sander and 80 grit sand paper.

Samples B, D, F, and H were manually dipped in a bath of Intace B350 anti-microbial agent to yield an approximate pick up of 2 #/Ton. Then each sheet for those samples was dried on a drum-dryer.

- 20 Samples from each condition A-H were cut into 1" wide tape strips. Then they were adhered to 3"x3" squares of anti-microbial gypsum board using joint compound and allowed to air dry.

Prior to inoculation, 3 samples from each condition (A-H) were soaked in ½" of sterile water for 1 hour. Each gypsum board square was placed upright on its edge so that the water comes ½ " up the side of the square that has the tape touching the edge as indicated in Figure 4.

- 5 Sample squares were placed on 150 x 25 mm agar plates and inoculated with 0.38 mL of inoculum containing *Chaetomium globosum*, *Aspergillus terreus*, and *Aspergillus niger*. The inoculum was spread along the bottom half of the sample square (as seen in Figure 5), allowing a portion of the tape to remain uninoculated.
- 10 There was also a set of additional tape samples (A-H) that were not bonded to gypsum panels that corresponded to each gypsum board specimen that was tested. The tape was exposed to water in the same manner as the gypsum board samples, but for 2 minutes instead of 1 hour. They were then inoculated over their entire surface with 0.25 mL of the inoculum.
- 15 Growth observations for all samples were recorded at 7, 21, 33, and 62 days after the samples were inoculated. Photographs of a representative sample for each condition were taken on or near each observation date.
- 20 An amended* form of ASTM Method D2020-92 Standard Test Methods for Mildew (Fungus) Resistance of Paper and Paperboard was followed. The amendments included
 - 1) The test substances were wallboard pieces (i.e. gypsum board square) measuring 3 inches by 3 inches (see above and in Figure 4).
 - 2) Prior to inoculation, each wallboard piece was exposed to a ½ inch of sterile water for 1
 - 25 hour. The test substance pieces were placed on their edge upright so that the water comes ½ inch up the side of the piece that has the tape touching the edge (see Figure 5).

- 3) After exposure to the water, the test substances pieces were placed on the 150 X 25 mm agar plates.
- 4) Each replicate was inoculated with 0.38 mL of the inoculums. The inoculums were spread along the bottom half of the wallboard piece, the bottom being the edge that was immersed. This will allowed a portion of the tape to remain uninoculated.
- 5) For each wallboard piece, there was a corresponding separate piece of tape. The tape was exposed to the water in the same manner as the wallboard for 2 minutes. The tape pieces were inoculated over their entire surface with 0.25 mL of the inoculums.

10 Results;

SUMMARY (Observations until day 33)

- A/M Treatment – Application hinders mold growth from day 7 to 33 in all but one sample (Sample F).
- Starch Content – Mold growth differences in samples with and without starch in them were not noted until day 33. There is a visual difference on day 20: Samples with starch had noticeably more and larger spore clusters than samples without.
- Sizing Content – Mold growth was noticeably smaller in spore size and cluster amounts on samples where sizing was present.
- Growth with Increasing Time – For samples with mold growth, regardless of starch or sizing content, sporulation mostly began on the edges of the tape by the first observation day (7 days after inoculation). By the second observation day (21 days after inoculation), mold growth had spread across the surface of the tape.

TIME-SPECIFIC OBSERVATIONS

Day 7 Observations

- All samples that contain the a/m application show no growth – a/m agent has an effect in prohibiting growth of mold.
- Most growth initiated at the tape edge for samples where slight growth was noted.
- 5 • At this stage of growth sizing and starch content do not appear to have an effect on mold growth due to the fact that replicates where “heavy” growth was noted in the “soaked” portion of the sample had sizing in one and no sizing in the other.
- Most samples did not have growth past the inoculation site.

10 *Day 21 Observations*

- Growth began to occur in the non-inoculated region where water “wicked” up the drywall portion of the sample during the soaking portion of sample prep.
- Sizing still does not seem to hinder mold growth at this stage since occurrences of “heavy” growth appeared on samples with and without sizing. The effects of the content of starch are still
15 not seen at this point either because the “heavy” mold growth appeared on samples with and without starch in them.
- All samples that contain the a/m application still show no growth with the exception of sample F (no starch, no sizing, with a/m). This particular sample is believed to be an outlier. Two replicates for this sample had mold growth on the dry portion of the non-inoculated drywall.
- 20 • Growth is now seen on the surface of all samples that show growth, not just the edge of the tape.

Day 33 Observations

- Still no growth on the samples with the a/m treatment.
- 25 • Most reps have the same mold coverage as day 21 results.

- Additional mold growth is noted along the edge of the inoculated portion of the tape on samples containing starch but no a/m treatment.-effect of added nutrients (aka starch) now visible.

Day 62 Observations-

5

- A/M Treatment – all samples show no growth on the tape itself. Sample F (with starch, no sizing, with a/m) has very slight growth on the drywall above the inoculation point only for two of three reps. No other a/m treated samples have growth anywhere on them.
- Starch Content – For those samples without starch, sporadic mold growth is noted above the inoculation point. Samples that contain starch have evenly spread growth above the inoculation point with slightly larger spores below the inoculation point.
- Sizing Content – Samples without sizing show consistent growth above and below the inoculation point. Samples with sizing show growth mostly confined to the inoculation area.

15

As used throughout, ranges are used as a short hand for describing each and every value that is within the range, including all subranges therein.

20

Numerous modifications and variations on the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the accompanying claims, the invention may be practiced otherwise than as specifically described herein.

25

All of the references, as well as their cited references, cited herein are hereby incorporated by reference with respect to relative portions related to the subject matter of the present invention and all of its embodiment

What is claimed is:

1. A wallboard joint tape, comprising

a web of cellulosic fibers;

at least one antimicrobial compound;

at least one sizing agent; and

optionally at least one binder.
2. The tape according to Claim 1, wherein

the antimicrobial compound is present at an amount ranging from about 10 ppm to about 5,000 ppm;

the sizing agent is present at an amount ranging from about 0.05 to about 1.5 wt%; and

the binder is present at an amount ranging from 0.0% to not more than about 5%.
3. The tape according to Claim 1, further comprising at least one surface that is abraded.
4. The tape according to Claim 1, said tape having:

a basis weight ranging from 50 to 120 lb per 3,000 sq. ft.;

a cross-direction Tensile ranging from 5 to 50 lbf/inch width as measured by Tappi Test Method T 494 om-06; and

a thickness ranging from 0.006 to 0.012 inch thickness as measured by Tappi Test Method T 411 om-05.

5. The tape according to Claim 1, wherein said sizing agent is present within the web and the antimicrobial agent is present at the surface of the web.

6. The tape according to Claim 5, wherein said surface of the web has a nap thereon.

5. A method of making the tape according to Claim 1, comprising
contacting said web to said binder, sizing agent, and antimicrobial compound.

6. The method according to Claim 1, wherein said web is contacted with said binder, sizing agent, and antimicrobial compound simultaneously or consecutively.

7. The method according to Claim 6, wherein said contacting occurs at a size press, water box, a coater.

8. The method according to Claim 6, wherein said contacting occurs by spraying the said binder, sizing agent, and/or antimicrobial compound directly onto at least one surface of a moving web.

9. A method of making the tape according to Claim 1, comprising
contacting a paper substrate comprising a web of cellulosic fibers and a sizing agent with a composition comprising said antimicrobial agent.
10. The method according to Claim 9, further comprising
abrading or sanding a surface of said web.
11. The method according to Claim 9, further comprising
abrading or sanding a surface of said web prior to said contacting.
12. The method according to Claim 11, wherein said contacting is performed such that the composition comprising said antimicrobial agent is contacted with said surface of said web.
13. The method according to Claim 12, wherein said contacting said web with said composition comprising said antimicrobial agent is performed using a size press, a coater, or a sprayer.
14. The method according to Claim 9, wherein said contacting said web with said composition comprising said antimicrobial agent is performed using a size press, a coater, or a sprayer.

15. A method of reducing, inhibiting, preventing, stalling, and/or retarding the growth of mold or fungus on a wallboard joint tape and/or wallboard, comprising

abrading or sanding a surface of a paper substrate comprising a web of cellulosic fibers and a sizing agent;

then contacting said surface with a composition comprising said antimicrobial agent.

16. The method according to Claim 15, further comprising

abrading or sanding a surface of said web.

17. The method according to Claim 15, further comprising

abrading or sanding a surface of said web prior to said contacting.

18. The method according to Claim 17, wherein said contacting is performed such that the composition comprising said antimicrobial agent is contacted with said surface of said web.

19. The method according to Claim 18, wherein said contacting said web with said composition comprising said antimicrobial agent is performed using a size press, a coater, or a sprayer.

20. The method according to Claim 15, wherein said contacting said web with said composition comprising said antimicrobial agent is performed using a size press, a coater, or a sprayer.

21. A composition comprising,
wallboard or gypsum board;
joint compound; and
wallboard joint tape comprising
a web of cellulosic fibers;
at least one antimicrobial compound;
at least one sizing agent; and
optionally at least one binder.

1/10

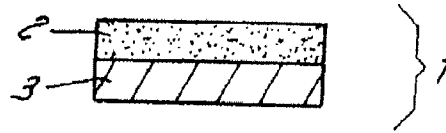


FIG. 1

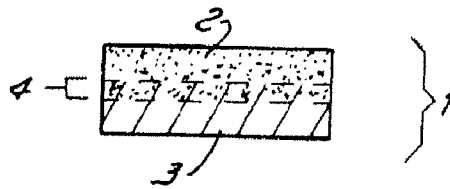


FIG. 2

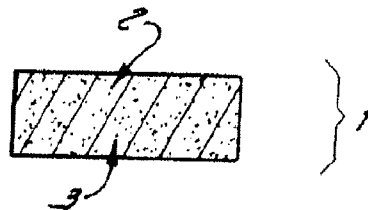


FIG. 3

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Figure 4:

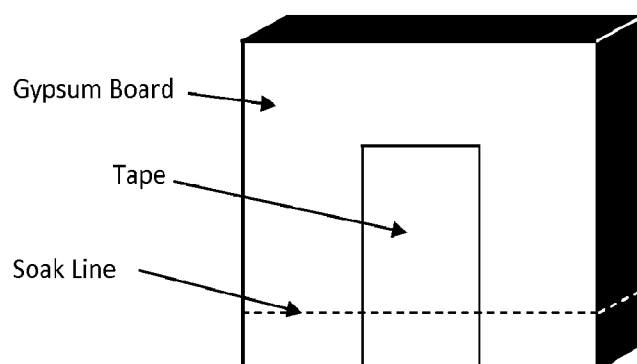
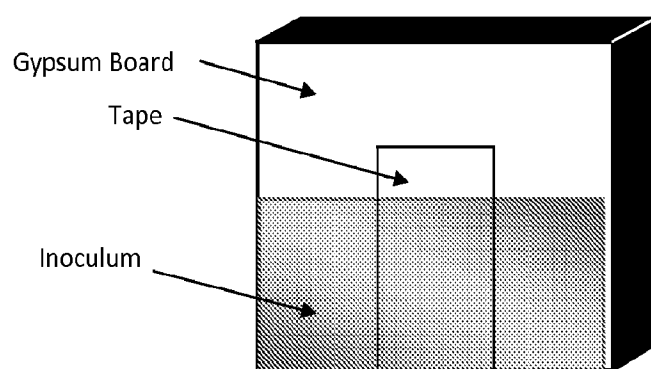


Figure 5:



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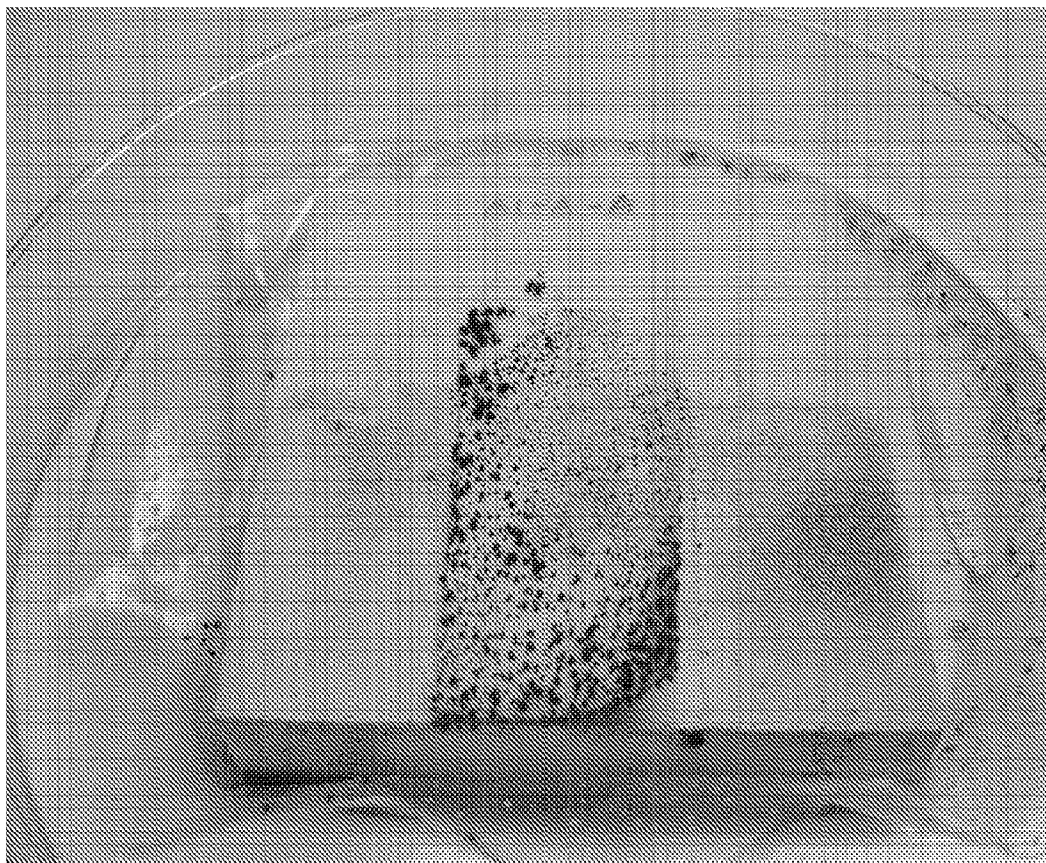


Figure 6

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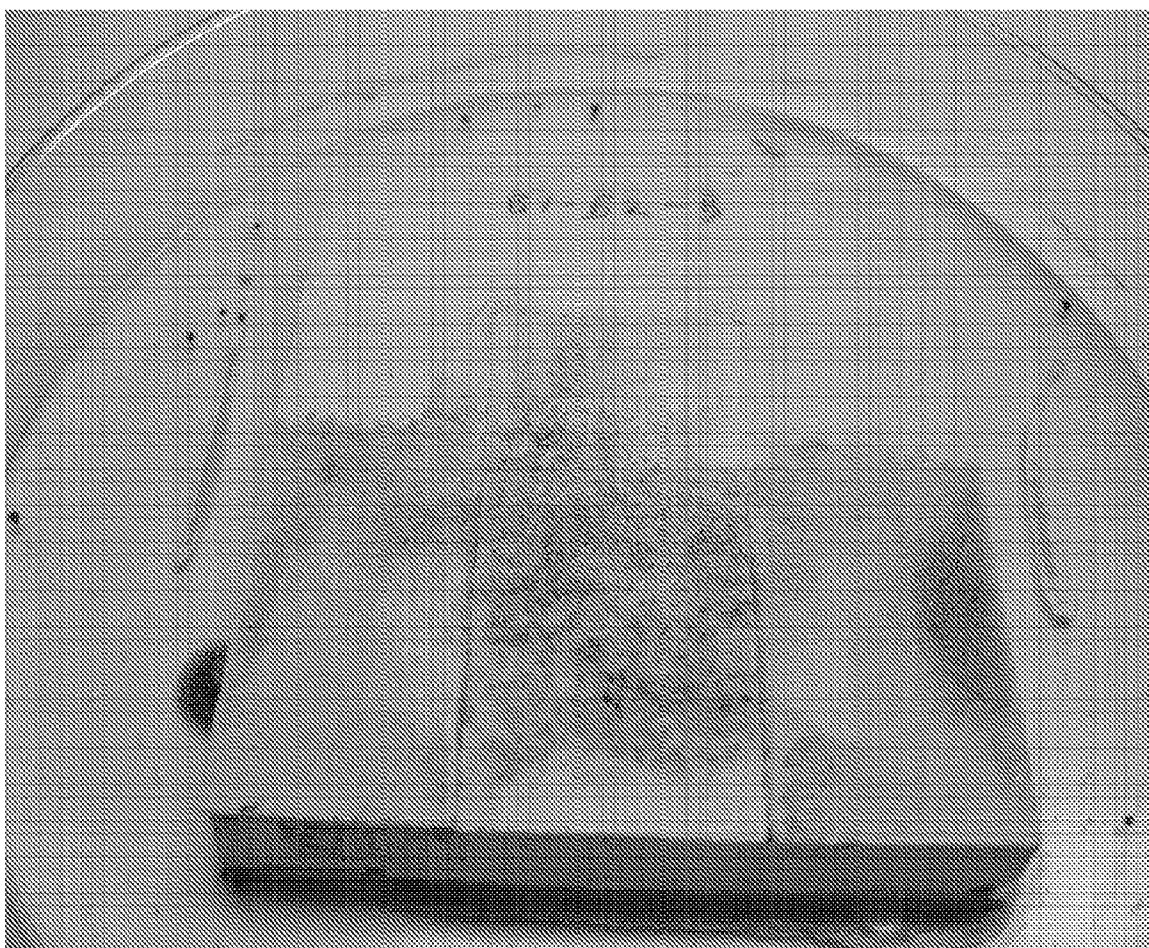


Figure 7

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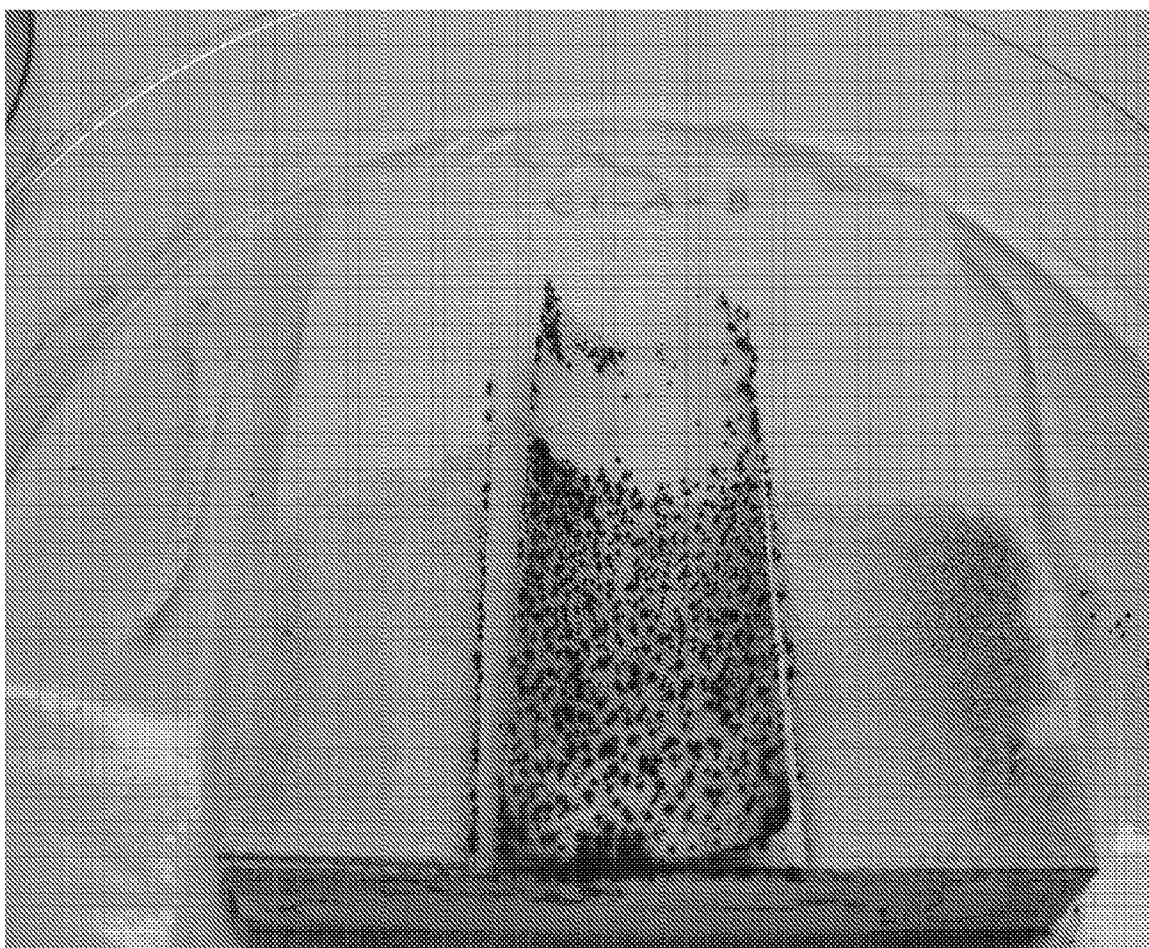


Figure 8

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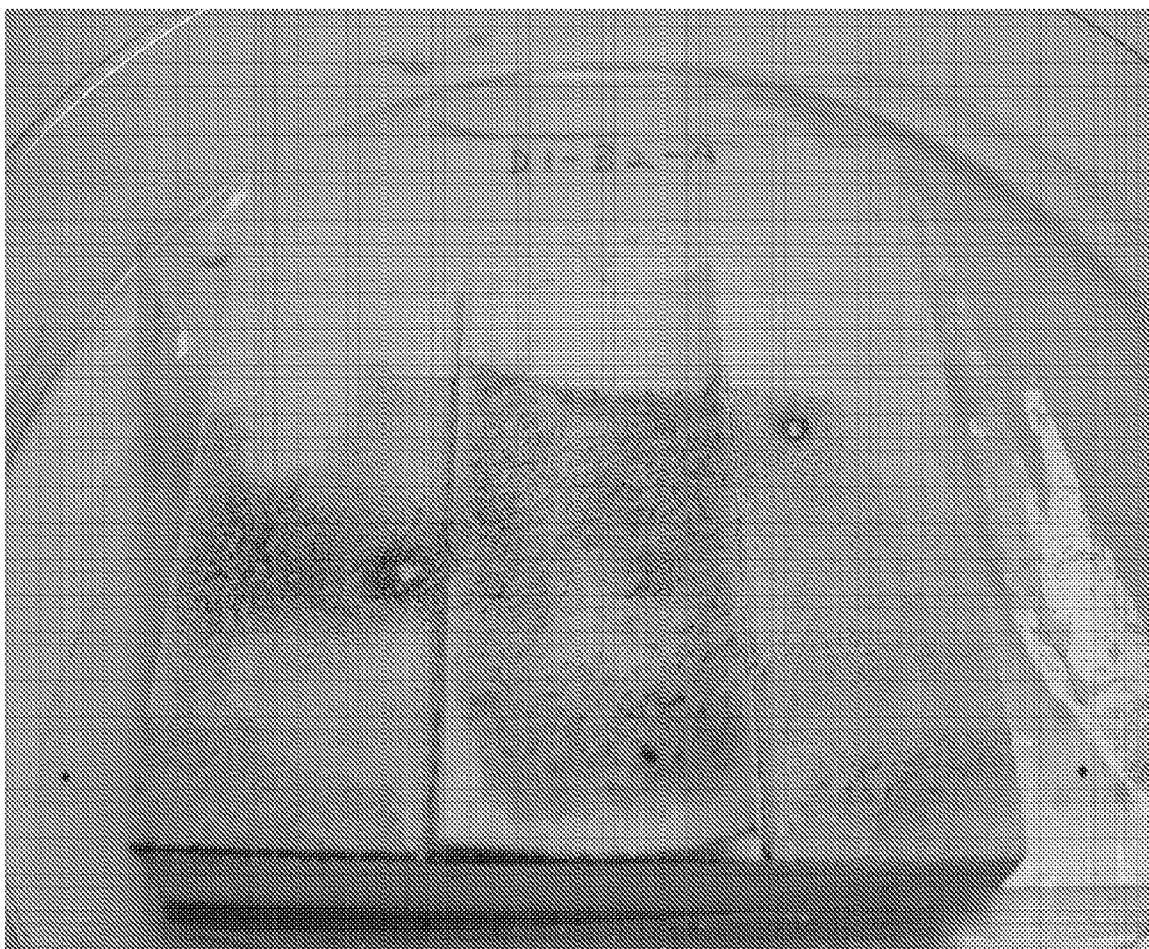


Figure 9

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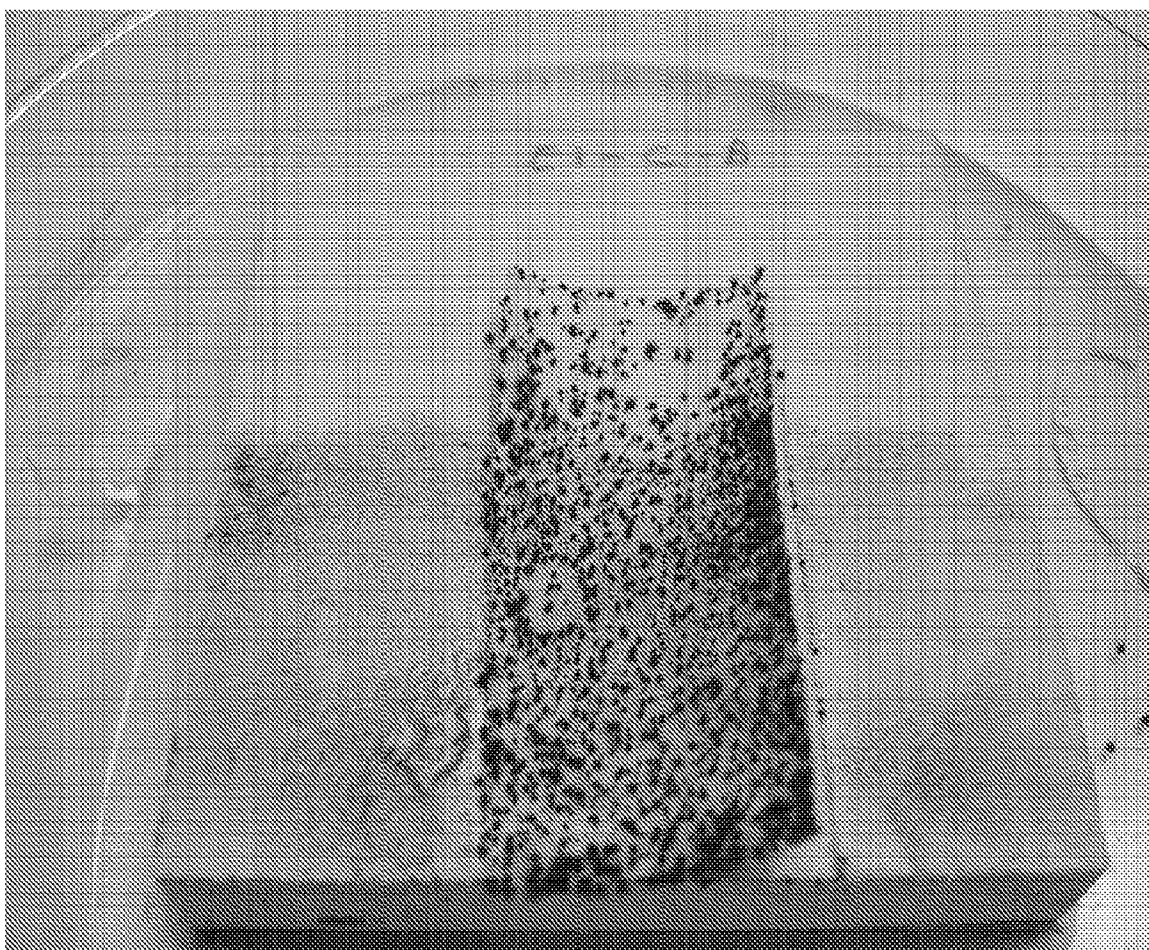


Figure 10

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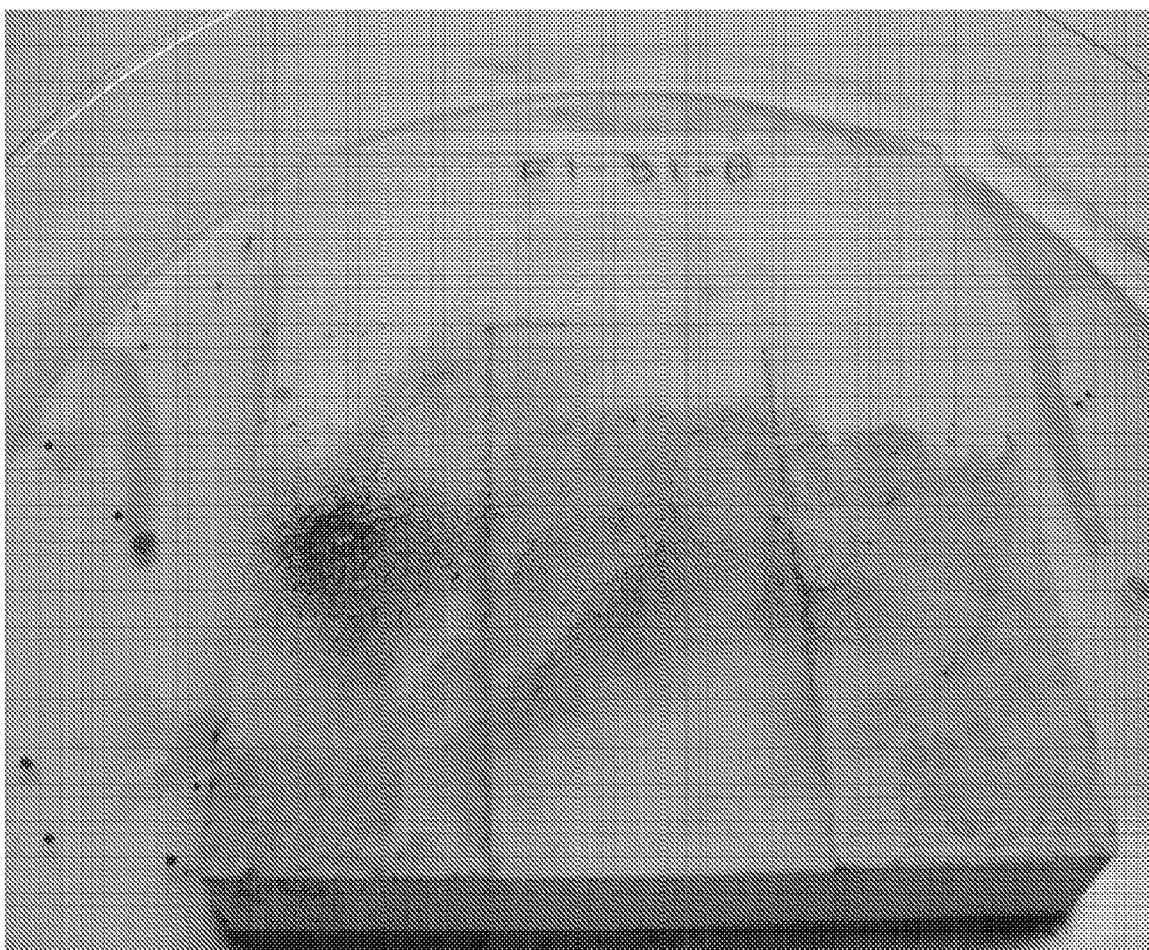


Figure 11

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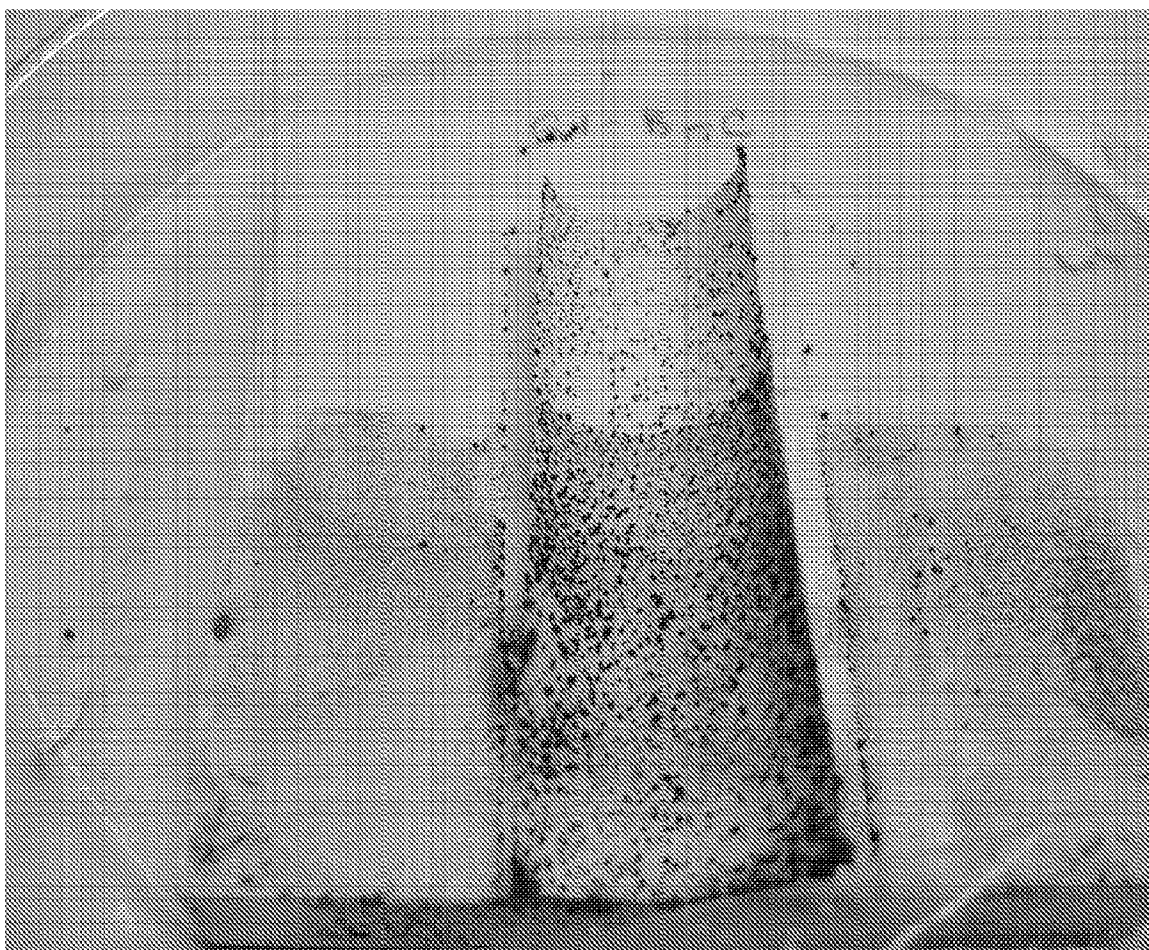


Figure 12

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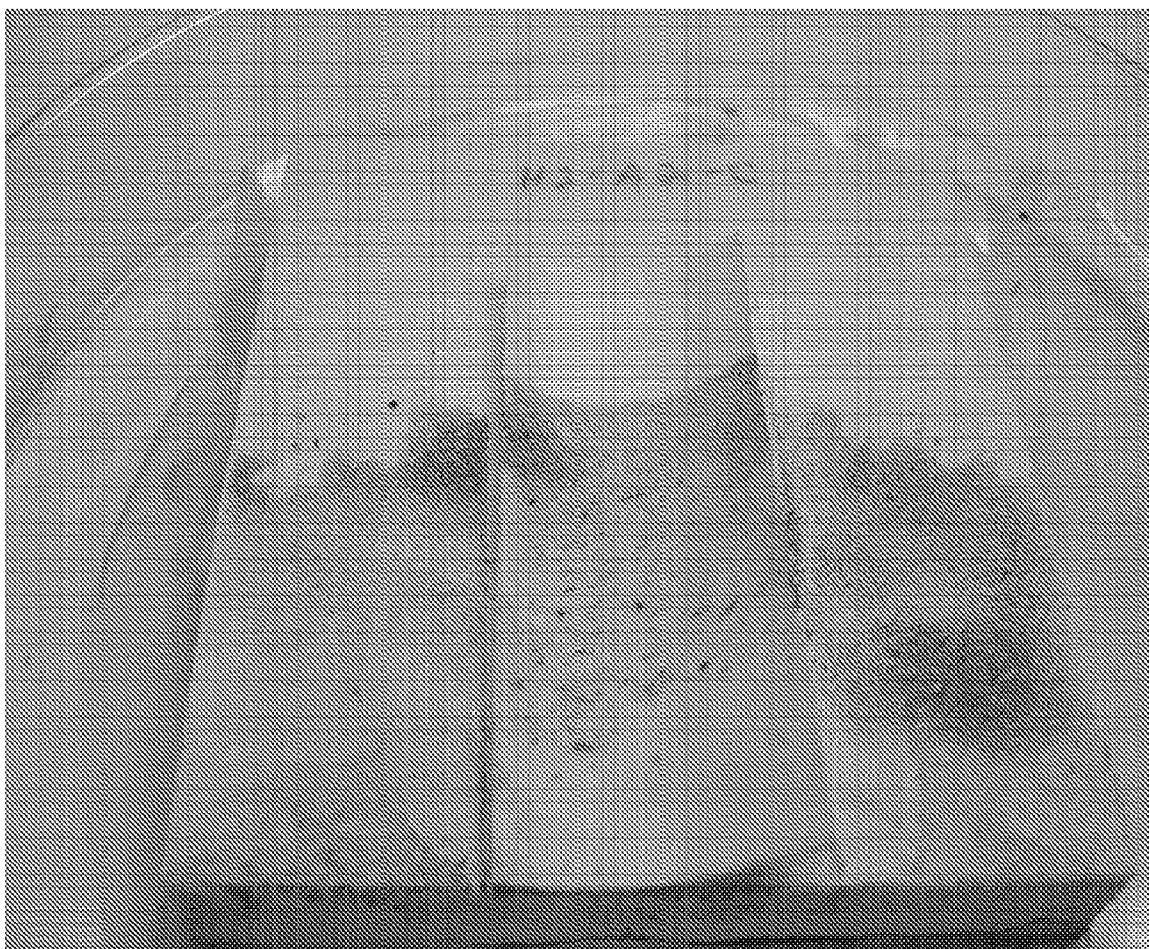


Figure 13

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2010/038919

A. CLASSIFICATION OF SUBJECT MATTER

INV. D21H21/36 D21H27/18 D21H27/20
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D21H

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.
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Y	claims 1,2	1-21
X	US 2006/169431 A1 (MARKS THOMAS I [US] ET AL) 3 August 2006 (2006-08-03)	1,5
Y	claims 1-25	1-21
X	GB 1 429 319 A (UNITED STATES GYPSUM CO) 24 March 1976 (1976-03-24)	1,5
Y	claims 1-13	1-21
X	WO 2006/014426 A1 (INT PAPER CO [US]; NGUYEN HUNG T [US]; HOLBERT VICTOR P [US]; CULHANE) 9 February 2006 (2006-02-09)	1,5
Y	claims 1-41 page 13, line 4 - page 21, line 30	1-21
	-/--	

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

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

29 September 2010

Date of mailing of the international search report

08/11/2010

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2010/038919

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	paragraphs [0026] - [0034]; claims 1,5,6,13,15, -----	1-21
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Y	paragraphs [0028], [0033]; claims 1-17 -----	1-21
X	EP 0 510 225 A1 (SCHOLZ WERNER [DE]) 28 October 1992 (1992-10-28)	1,5
Y	claims 1,6,8 -----	1-21
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Y	claims 1-3,11-15,23 -----	1-21

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2010/038919

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