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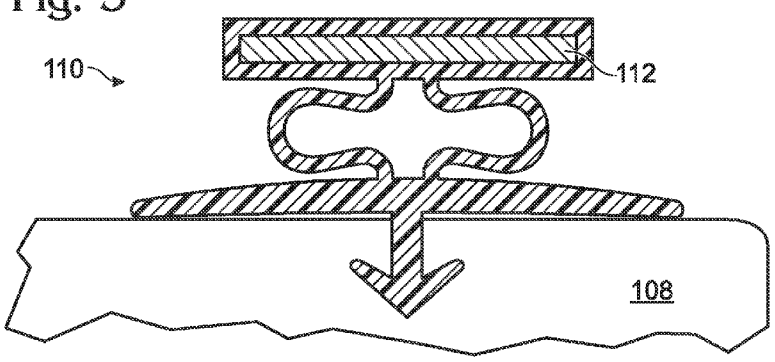
(54) Title: ANTIMICROBIAL SEALING ELEMENT

Fig. 3



(57) Abstract: An antimicrobial sealing element, such as a gasket for an appliance or storage container, can be made of a polymeric resin shaped to associate with a periphery of a surface opening. The polymeric resin has disposed therein one or more antimicrobial agents, providing long-lasting antimicrobial efficacy without perturbing the physical and aesthetic properties of the sealing element.

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ANTIMICROBIAL SEALING ELEMENT

BACKGROUND OF THE INVENTION

1) Field of the Invention

[0001] The present invention relates to a sealing element for a container or the like, and more particularly to an antimicrobial sealing element and to articles fitted therewith.

2) Prior Art

[0002] Containers and the like having a lid covering an opening frequently employ a gasket or other sealing means around the periphery of the opening. Whether the lid is detached or hinged, it is advantageous in some applications to provide for separation of air, liquid, moisture and/or temperature between the container's interior and the environment.

[0003] Conventionally, a household appliance such as a refrigerator has a flexible gasket material affixed near the perimeter of the main opening(s). The gasket serves to retain cooled air inside the refrigerator volume and prevent exchange of air between the interior and outside. A gasket also may help prevent odors from entering or escaping the refrigerator.

[0004] In another example, a front-loading washing (laundry) machine or dishwasher typically has a pliable polymer material likewise affixed about the perimeter of the major aperture. In these examples, retention of water within the appliance's inner space is the primary goal.

[0005] As yet another example, a cooler or a food storage container (such as a glass jar, polymeric container, or companion lid therefor) likewise can be equipped with a sealing gasket to act as an air barrier and thereby thermally insulate the contents.

[0006] In all these cases, there is a threat to the conventional gasket of microbial colonization. Food, liquids, soiled laundry, handling by one or more users, and microbiological flora in the use environment of the article itself each can contribute to microbial contamination.

[0007] Conventional efforts to protect the sealing element from contamination have employed 10,10'-oxybisphenoxyarsine (commonly called "OBPA"), incorporated within the polymeric material of the gasket or sealing element. An arsenic-containing compound, 10,10'-oxybisphenoxyarsine has limited efficacy against some microbes and presents workplace and environmental hazards.

[0008] It would be preferable to incorporate within the entirety or the surface layer of the sealing element one or more antimicrobial agents. It further is preferable that the antimicrobial agent demonstrate efficacy against a broad spectrum of microbes. It further is preferable that the antimicrobial agent not present a human health hazard in the manufacturing setting or an environmental hazard in its disposal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a perspective-view diagram of a conventional refrigerator appliance.

[0010] FIG. 2 is a perspective-view diagram of a conventional passive thermal cooler.

[0011] FIG. 3 is a perspective-view diagram of a conventional gasket as might be found in the refrigerator of FIG. 1.

[0012] FIG. 4 is a perspective-view diagram of a conventional gasket as might be found in the cooler of FIG. 2.

DETAILED DESCRIPTION OF THE PREFERED EMBODIMENTS

[0013] As used herein, the terms "microbe" or "microbial" should be interpreted to encompass any of the microscopic organisms commonly studied by microbiologists. Such organisms include, but are not limited to, bacteria and fungi as well as other single-celled organisms such as mold, mildew and algae. Viral particles and other infectious agents are also included in the term microbe.

[0014] The term "antimicrobial" includes biostatic activity, i.e., where the proliferation of microbiological species is reduced or eliminated, and true biocidal activity where microbiological species are killed. For ease of discussion, this detailed description may make reference to bacteria and antibacterial agents. This method of presentation should not be interpreted as limiting the scope of the invention in any way.

[0015] The term "efficacy," as used herein, is defined as the characteristic of inhibiting the growth and/or proliferation of a microbe on a substrate.

[0016] The term "non-metallic" as used herein means antimicrobial agents, other than quaternary ammonium compounds, that do not contain or utilize metal ions such as, for example, silver or copper.

[0017] In the broadest sense, the present antimicrobial sealing element is a durable polymeric article comprising a first polymeric resin and a first antimicrobial agent incorporated therein. The antimicrobial agent is substantially inert with respect to the polymeric resin and present within the polymeric resin in an amount sufficient to confer persistent antimicrobial properties upon the polymer of the sealing element.

[0018] In general terms, an antimicrobial agent can be substantially uniformly dispersed within the polymeric resin, such that an article manufactured using the antimicrobial polymeric resin exhibits antimicrobial properties for the life of the article. In a second embodiment, the antimicrobial agent can be disposed in a heterogeneous manner within the polymeric material of the sealing element. These embodiments are discussed in more detail below.

[0019] For purposes of illustration and not by way of limitation, the example of a refrigerator gasket is given.

[0020] Turning to FIG. 1, a typical refrigerator 10 includes body 102 defining interior volume 104 accessible through opening 106. Door 108 is typically sized to fit over and thereby cover opening 106, and gasket 110 provides an airtight seal when door 108 is closed. Gasket 110 can be disposed on body 102, door 108, or both.

[0021] In other applications, however, the appliance may have a plurality of openings, with separate doors dedicated to each, a common door covering multiple openings, or other design choices. The fundamental point is that an opening exists which can be covered, and that the seal between the cover (e.g. door) and the appliance body is effected at least in part by way of a sealing element, such as a gasket.

[0022] Another exemplary article which can incorporate a sealing element is cooler 20 (FIG. 2), which typically includes body 202 at least partially defining internal volume 204. Conventional opening 206 is covered by door 208. Cooler 2 may in some embodiments be equipped with gasket 210, usually located at the periphery of opening 206, either on body 202 or door 208.

[0023] Looking at a sealing element in closer detail, flexible gasket 110 conventionally has a construction along the lines of the non-limiting example shown in FIG. 3. One feature common to, but not required of, such gaskets is that they can mate successfully with each of the door and appliance body surfaces.

[0024] Such mating can be facilitated by a flexible structure, accomplished here by way of pleats or an “accordion” shape. A pleated/accordion structure confers flexibility and aids gasket 110 in aligning with the surface to be mated. A magnetic element 112 can be disposed in gasket 110 to further provide positive mating with a magnetic mating surface (e.g. metal refrigerator wall defining the periphery of the opening).

[0025] In other structural embodiments, of course, this pleating need not be present. For example, sealing element 210 (FIG. 4) can have a simpler cross-sectional geometric profile and achieve its sealing purpose via pliancy and/or tack of the polymer (e.g. silicone).

[0026] Alternatively or additionally, the airtightness of the seal may be effected by mechanical pressure between mating surfaces. In one exemplary embodiment, a latch can secure door 108, 208 to the perimeter of the device's opening 106, 206.

[0027] In a first embodiment of the sealing element disclosed herein, a single antimicrobial agent is incorporated into the polymeric resin from which the sealing element is constructed. A suitable antimicrobial agent can be organic or inorganic in nature.

[0028] The concentration of the antimicrobial agent can vary depending on the specific polymer used for the sealing element, the specific antimicrobial agent selected, and against which microbes protection is sought.

[0029] In a second embodiment, a sealing element can have a plurality of antimicrobial agents disposed therein. Selection of the members of the plurality of antimicrobial agents generally is based upon the nature of the desired antimicrobial protection (e.g. bacteria, fungi (either broadly, or mold or mildew specifically)), the compatibility of the agents with the polymer from which the element is constructed, the inter-compatibility of the antimicrobial agents, known synergies of the compounds, and the like.

[0030] Suitable organic antimicrobial agents include 2-phenylphenol; poly(hexamethylene biguanide) hydrochloride; 3,4,4'-trichlorocarbanilide; pyrithione and salts thereof (e.g. zinc, copper, sodium); and oxathiazine (e.g. bethoxazin). Among the potential organic antimicrobial agents, 2,4,4'-trichloro-2'-hydroxydiphenyl ether, which is a diphenyl ether (bis-phenyl) derivative, is particularly efficacious. The combination of 2-phenylphenol and 2,4,4'-trichloro-2'-hydroxydiphenyl ether previously has been reported to exhibit synergistic effects.

[0031] Isothiazolone-based compounds also are useful in the present sealing element, including without limitation 1,2-benzisothiazolin-3-one (CAS No. 2634-33-5); N-butyl-1,2-benzisothiazolin-3-one (CAS No. 4299-07-4); 2-octyl-isothiazolone (CAS No. 26530-20-1); 4,5-dichloro-2-N-octyl-3(2H)-isothiazolone (CAS No. 64359-81-5); methyl-3(2H)-isothiazolone (CAS No. 2682-20-4); and chloro-2-methyl-3(2H)-isothiazolone (CAS No. 26172-55-4) have been found to be efficacious antimicrobial agents.

[0032] Particularly preferred isothiazolinones include, but are not limited to, 2-n-octyl-4-isothiazolin-3-one and N-butyl-1,2 benzisothiazolin-3-one.

[0033] Additional antimicrobial agents suitable for use in the polymeric resin of the sealing element disclosed herein include diiodomethyl p-tolylsulfone; zinc and sodium pyrithiones; azoles (such as propiconazoles); titanium dioxide; and barium metaborate monohydrate.

[0034] As used herein the term "azoles" should be interpreted to include any of the "azole" antimicrobial agents known to those skilled the art. Particularly preferred azoles include, but are not limited to, propiconazole

and tebuconazole and mixtures of these two agents. Mixtures of these two agents have been shown elsewhere to have a synergistic effect that translates to improved efficacy at lower concentrations of agents.

[0035] Inorganic antimicrobial agents include, without limitation, metal-based antimicrobial agents such as silver, copper, or zinc compounds in various forms (e.g. zeolite, amorphous glass, sol-gel, and other ion-exchange formulations).

[0036] Compounding additives, in addition to the antimicrobial agent, can include: surface active agents such as wetting agents, surfactants, de-aeratants, and defoamers; anti-blocking agents; catalysts such as PTSA (para-toluene sulfonic acid), MSA (methane sulfonic acid), oxalic acid, ammonium nitrate and ammonium chloride; fillers; pigments; dielectric modifiers; glossing agents; and dyes.

[0037] MANUFACTURE

[0038] A sealing element conventionally is manufactured by extrusion or co-extrusion, although other methods of manufacture can be employed. An advantage of the present antimicrobial sealing element is that it can be produced by conventional methods without perturbation of the antimicrobial property.

[0039] EXAMPLE 1

[0040] Prototypes of the second embodiment disclosed herein were constructed of flexible polyvinyl chloride ("PVC"). Generally speaking, the gasket body has an extended longitudinal axis, a width, and a height.

[0041] The antimicrobial composition employed was Microban Additive ZO8, the active ingredients of which are substantially equal amounts of zinc pyrithione and N-butyl-1,2-benzisothiazolin-3-one.

[0042] The Additive ZO8 was formulated into a PVC masterbatch at a concentration of 5% based on the weight of PVC masterbatch polymer. The Additive ZO8-containing masterbatch then was added to unadulterated PVC polymer to make experimental sealing elements.

[0043] The masterbatch letdown rates were selected to achieve the targeted final concentrations of ZO8 in the polymer of the sealing element, as shown in the data tables, below. After letdown, for example, a sample containing 1.0% ZO8 would contain 5000 ppm zinc pyrithione and 5000 ppm N-butyl-1,2-benzisothiazolin-3-one.

[0044] Prototype sealing elements were manufactured with Microban Additive ZO8 as described herein, and preliminary physical inspection was undertaken. The assessment of the antimicrobial sealing elements confirmed that the antimicrobial agents did not interfere with the extrusion process, nor did its presence affect other additives (e.g. colorant, plasticizer). The manufactured sealing element prototype showed no perturbation in strength or pliability of the polymer. No unusual appearance or discoloration was observed.

[0045] ANTIMICROBIAL EFFICACY

[0046] EXAMPLE 2

[0047] The antimicrobial efficacy of the prototype sealing elements manufactured of flexible polyvinyl chloride with Microban Additive ZO8 was evaluated. Quantitative and qualitative test methodologies were employed, as detailed below. The results of these evaluations are given in Tables 1 through 5.

[0048] The Kirby-Bauer Antimicrobial Susceptibility Test was employed to qualitatively determine the antimicrobial efficacy of sealing element samples containing antimicrobial additives as described above that were capable of producing a zone of inhibition. Following uniform growth of a bacterial lawn, each sample was placed in the center of the plate and incubated with humidity for 18-24 hours at 37ºC. The plates were examined for the interruption in growth of the challenge organism beneath, surrounding and/or on the test samples. Results are shown in TABLE 1.

TABLE 1

Antimicrobial	*Sau*	*Kpn*
Untreated	0 mm	0 mm
OBPA, 25 ppm	0 mm	0 mm
ZO8, 1.0 %	3 mm	3 mm
ZO8, 1.5 %	4 mm	4 mm
ZO8, 2.5 %	5 mm	5 mm
ZO8, 4.5 %	6 mm	6 mm

[0049] The zones of bacterial inhibition (if present) were calculated by using the equation: W = (T-D)/ 2, where W = width of clear zone of inhibition

(mm); T = total diameter of test specimen and clear zone (mm); and D = diameter of the test specimen (mm).

[0050] OBPA was used at its conventional addition level of 25 ppm. It can be seen that the untreated sealing element and the conventional gasket with OPBA created no zones of inhibition. In contrast, the ZO8-treated gasket sealing elements demonstrated strong antibacterial efficacy against both *S. aureus* and *K. pneumoniae*.

[0051] EXAMPLE 3

[0052] The antifungal efficacy was evaluated for prototype sealing elements manufactured of polypropylene with Microban Additive ZO8. Quantitative and qualitative test methodologies were employed, as detailed below.

[0053] Samples were plated against *Aspergillus niger* (a common household black mold) using the AATCC 30 Part III test, an aggressive 7-day antifungal evaluation where the test samples are exposed to high levels of fungal spores. In this case, the samples each were placed on an agar bed, then 100µl of a suspension of *Aspergillus niger* (>10^5/ml) was evenly spread over the sample area and the agar. The plates were incubated for four days at 20ºC—optimal conditions for the spores to germinate.

[0054] At the end of the 4-day incubation period, the test plates were removed from the humid incubation chamber, and the samples were evaluated for fungal attack and encroachment. Each sample was run in triplicate; the mean results of the evaluation are given in TABLE 2.

TABLE 2

Antimicrobial	*A. niger*
Untreated	0 mm
OBPA, 25 ppm	0 mm
ZO8, 1.0 %	9 mm
ZO8, 1.5 %	10 mm
ZO8, 2.5 %	12 mm
ZO8, 4.5 %	12 mm

[0055] The sealing element prototypes treated with Additive ZO8 showed strong antifungal efficacy at all levels. The untreated control element and the conventional OBPA-treated samples failed to resist fungal growth.

[0056] EXAMPLE 4

[0057] It is highly desirable that the antimicrobial property of the sealing element be persistent. As well, washing relieves the concern that VOC or chemical artifacts from the manufacturing process might be implicated in any bacteriostasis observed.

[0058] Durability of the antimicrobial property was assessed for the samples of EXAMPLE 3. A cohort otherwise identical to that of EXAMPLE 3 was treated prior to testing. Simulated aging entailed subjecting the samples to 288 full cycles of a residential dishwasher. Each sample was thus aged, then assayed in triplicate using the AATCC 30 Part III method; the mean results of the evaluation are given in TABLE 3.

TABLE 3

Antimicrobial	*A. niger*
Untreated	0 mm
OBPA, 25 ppm	0 mm
ZO8, 1.0 %	10 mm
ZO8, 1.5 %	10 mm
ZO8, 2.5 %	9 mm
ZO8, 4.5 %	12 mm

[0059] These data confirm that the ZO8-treated sealing elements retained their original antimicrobial efficacy after being subjected to 288 dishwasher cycles. This level of durability properly supports the conclusion that the present antimicrobial sealing element would retain its antimicrobial property for the useful life of a refrigerator or cooler.

[0060] It will be readily understood by those persons skilled in the art that the present indicator compositions and methods are susceptible of broad utility and application. Many embodiments and adaptations other than those herein described, as well as many variations, modifications and equivalent arrangements, will be apparent from or reasonably suggested to one of ordinary skill by the present disclosure and the foregoing description thereof, without departing from the substance or scope thereof.

[0061] Accordingly, while the present composition and methods have been described herein in detail in relation to its preferred embodiment, it is to be understood that this disclosure is only illustrative and exemplary and is made merely for purposes of providing a full and enabling disclosure. The foregoing disclosure is not intended or to be construed to limit or otherwise to exclude any such other embodiments, adaptations, variations, modifications and equivalent arrangements.

What is claimed is:

1. An antimicrobial sealing element, comprising:

a polymeric resin formed into a geometric shape having an extended longitudinal axis and configured to be associated with at least one of a periphery of an opening in a surface and a door adapted to at least partially seal the opening; and

a first organic antimicrobial agent disposed in the polymeric resin;

wherein the first antimicrobial agent is one of 2-phenylphenol; poly(hexamethylene biguanide) hydrochloride; 3,4,4'-trichlorocarbanilide; an azole, a pyrithione or salt thereof; oxathiazine; an isothiazolone-based compound; diiodomethyl p-tolylsulfone; or 2,4,4'-trichloro-2'-hydroxydiphenyl ether.

2. The antimicrobial sealing element of claim 1, further comprising a second antimicrobial agent.

3. The antimicrobial sealing element of claim 2 wherein the first antimicrobial agent is zinc pyrithione and the second antimicrobial agent is N-butyl-1,2-benzisothiazolin-3-one.

4. The antimicrobial sealing element of claim 3 wherein the first antimicrobial agent and the second antimicrobial agent have concentrations in the range of 5000 ppm based on the weight of the polymeric resin.

5. An antimicrobial sealing element, comprising:

a polymeric resin formed into a geometric shape having an extended longitudinal axis and configured to be associated with at least one of a periphery of an opening in a surface and a door adapted to at least partially seal the opening; and

a first organic antimicrobial agent disposed in the polymeric resin;

wherein the first inorganic antimicrobial agent is one of a silver-based compound, a copper-based compound, or a zinc-based compound.

6. An appliance, comprising:

a body defining an internal volume;

a first opening in the body;

a door configured to mate with a periphery of the first opening to substantially seal the first opening; and

a sealing element configured to be associated with at least one of the periphery of the first opening or the mating aspect of the door;

wherein the sealing element includes:

a polymeric resin formed into a geometric shape having an extended longitudinal axis and configured to be associated with at least one of a periphery of an opening in a surface and a door adapted to at least partially seal the opening; and

a first antimicrobial agent disposed in the polymeric resin.

7. The antimicrobial sealing element of claim 6 wherein the first antimicrobial agent is one of 2-phenylphenol; poly(hexamethylene biguanide) hydrochloride; 3,4,4'-trichlorocarbanilide; an azole, a pyrithione or salt thereof; oxathiazine; an isothiazolone-based compound; diiodomethyl p-tolylsulfone; or 2,4,4'-trichloro-2'-hydroxydiphenyl ether.

8. The antimicrobial sealing element of claim 6, further comprising a second antimicrobial agent.

9. The antimicrobial sealing element of claim 8 wherein the first antimicrobial agent is zinc pyrithione and the second antimicrobial agent is N-butyl-1,2-benzisothiazolin-3-one.

10. The antimicrobial sealing element of claim 9 wherein the first antimicrobial agent and the second antimicrobial agent have concentrations in the range of 5000 ppm based on the weight of the polymeric resin.

Fig. 1

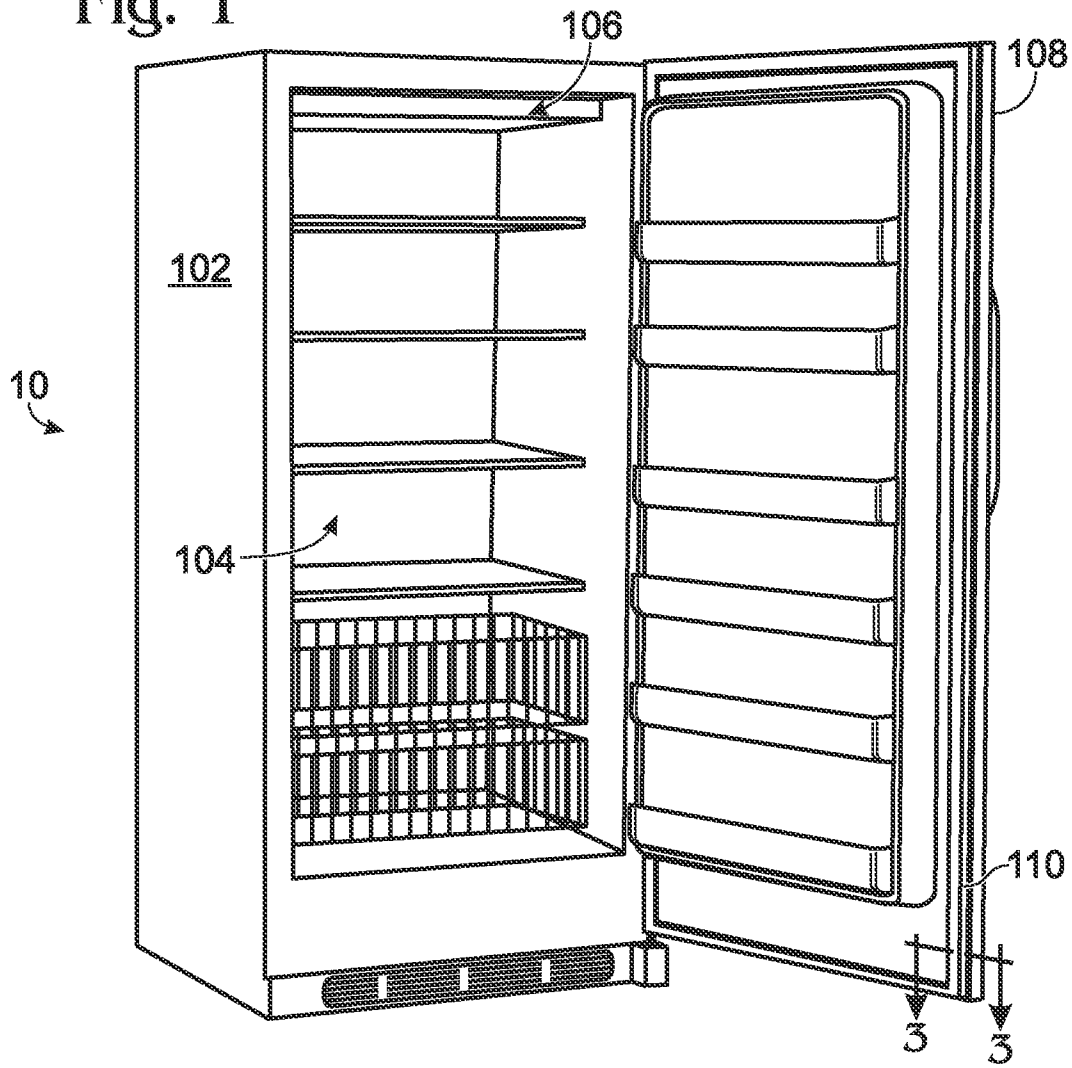

Fig. 3

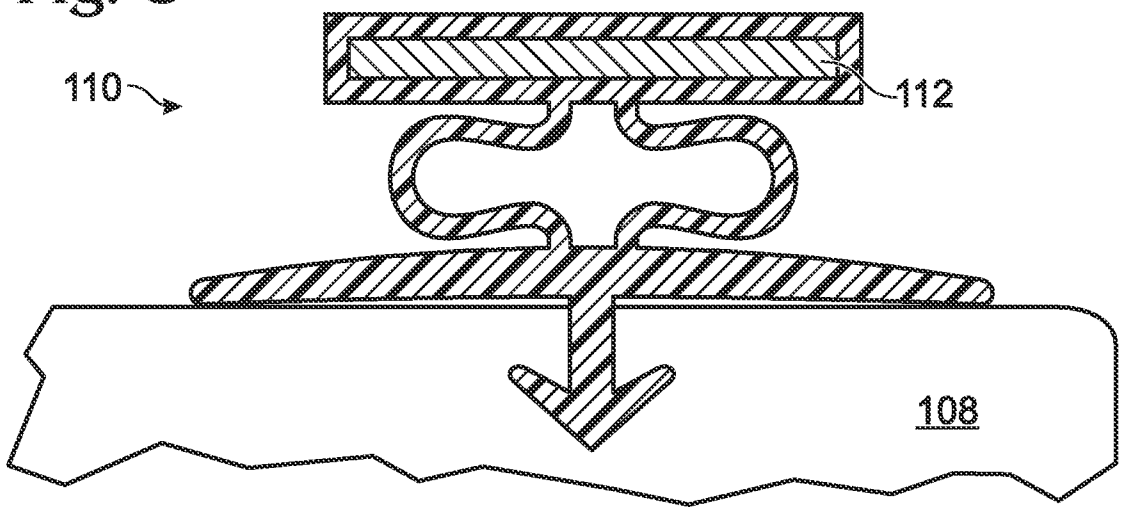

Fig. 2

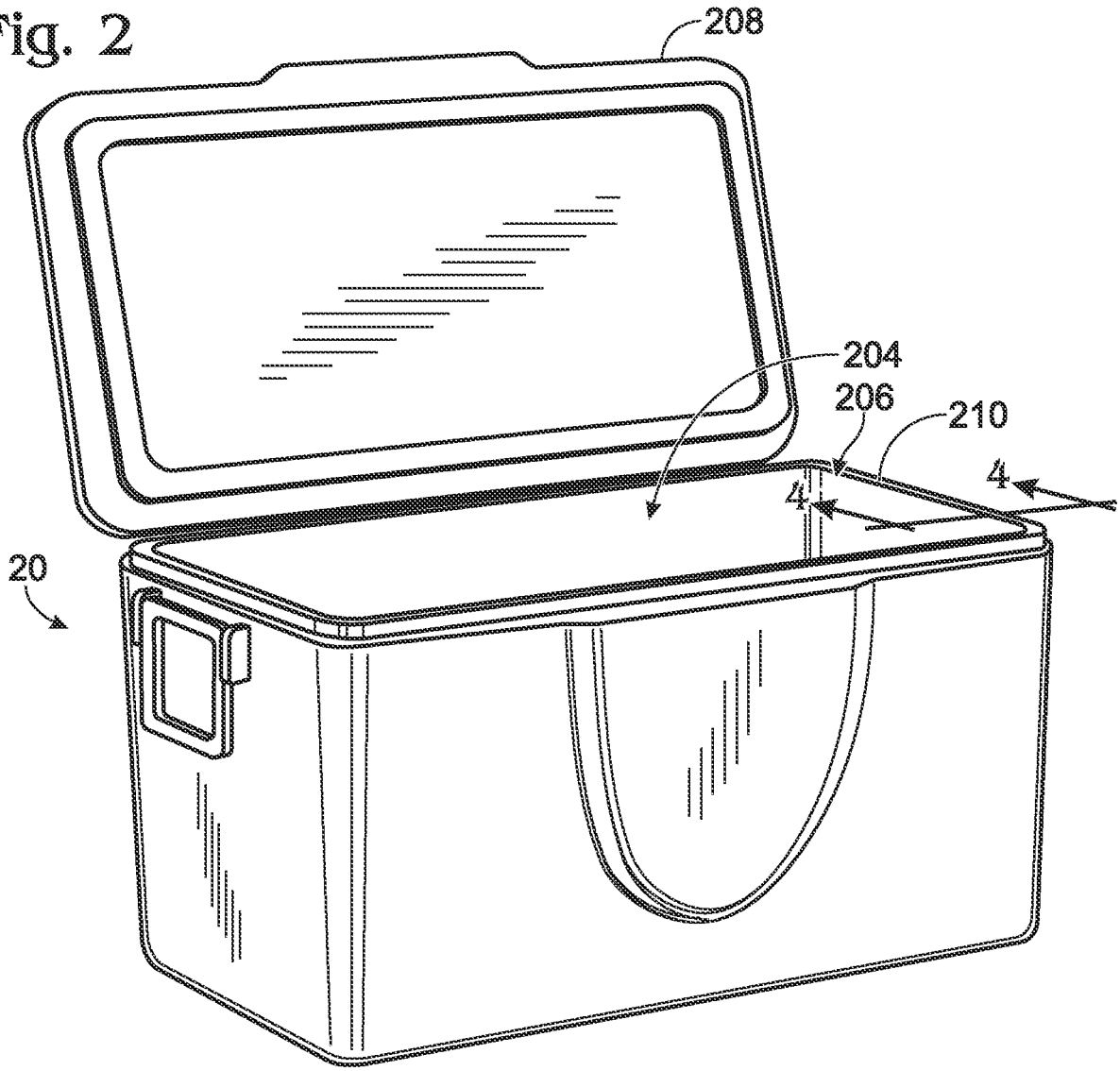

Fig. 4