(54) Title: AN INSULATED UNIT

(57) Abstract: The insulated unit (1) of the present invention comprises an inner liner (9), an outer liner (8), an insulation space (10) between the inner liner (9) and the outer liner (8), an insulating material (2) filling the inner space (10). The inner liner (9) and the outer liner (8) of the insulated unit (1) are formed by a composite sheet (11) including one or more plastic sheets (3) and one or more thin plastic layers.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
AN INSULATED UNIT

The present invention relates to an insulated unit made of a composite sheet.

Insulated units are widely used in our daily life to provide thermal, acoustic or other kind of insulation to make life more comfortable. Examples to such insulation units are refrigerators that are most commonly used as thermal insulators.

The insulation elements of refrigerators generally consist of closed celled foam encapsulated in between the inner and outer liners. The blowing agent, that usually has a high molecular weight, is being used in the foaming process of the closed celled foam. The gas that comes out during the reaction of the foam substance remains inside the closed cells. After the replacement of the blowing agents that contain chlorofluorocarbons with the non-fluorocarbon-containing materials (ex. cyclopentane) due to the environmental reasons; the remaining gas inside the closed cells seemed to weaken the thermal insulating properties of the refrigerators. This is because of the higher thermal conductivity values of the novel blowing agents.

Due to the new energy regulations, it is important to decrease the energy consumption of the refrigerators and freezers. Many different systems and applications have been studied and used in an attempt to increase the heat insulation behaviour of the doors and the walls of a refrigerator cabinet that was reduced in the recent past due to the usage of the chlorofluorocarbon-replacing blowing agent. The application of vacuum panels with very low thermal conductivity values in the insulation section of the refrigerators is an example of such systems. A vacuum panel is manufactured by packing materials such as fibreglass, silica, perlite, aerogel, open celled extruded polystyrene, open celled polyurethane, recycled urethane fluff (RUF) and chemical absorbents in a film like laminated plastic barrier or stainless steel. The material is then evacuated, sealed and kept at a constant vacuum level. The vacuum level depends on the specific filler insulation material. The applied pressure generally
varies between $10^2$-100 mbar. Since, in any case, the thermal conductivity is low, the evacuated insulators have the ability to reduce heat transmission from the ambient to the inner volume of a refrigerator. The vacuum panel applications are described in US4444821, EP0715138, US4681788. In WO 9736129, a vacuum insulation panel that has outside liners made of composite foil comprising a metallic layer, specially an aluminium layer coated by polyethylene polyester or a polypropylene layer on both sides. Since the thickness of the metal layer is low in vacuum insulation panel, it may cause a decrease in vacuum level. However besides its low thermal conductivity, the vacuum insulation panel technology has also its own drawbacks. It is very difficult to keep the vacuum panels at a constant vacuum level. In a period of 15-20 years, the possible gas sources both through the barrier material and the flanges can deteriorate the vacuum. In order to prevent this, it is possible to use materials called getters. The arrangement of the getter materials is given in EP0769117B1.

In EP 0757136, a component which has two covering sheets with a hard plastic foam core, is presented. It is a vacuum element with an open cell hard plastic foam core, whose external and internal sides are sealed by the metal cover sheets and whose longitudinal and transverse sides are sealed air tight by plastic and/or by an integral plastic foam layer and/or by plastic or rubber sheet material. The hard plastic foam core is continuously connected to a vacuum source, i.e. a vacuum pump. A perforated vacuum tube inserted into the core has connections to wall elements adjacent to the pipe with a connecting line to the pump.

In WO 00060292 a vacuum insulated unit comprising inner and outer liners made of a thermoplastic material is described. In order to reduce the permeation of atmospheric gases and water vapor, middle layers are inserted between inner and outer liners and insulating material. These middle layers may be metal sheets or plastic coated aluminium sheets. It is mentioned in this patent application that the metal layers could be applied to the inner and outer liners by sputtering technique.

The object of this invention is to produce an insulated unit wherein the permeation of atmospheric gases and water vapour into its inner filler material is controlled.
The insulated unit which is realised in order to attain the said object of the invention is illustrated in the attached drawings, wherein;

Figure 1, is the three dimensional back view of the insulated unit.

Figure 2, is the three dimensional front view of the insulated unit.

Figure 3, is the schematic view showing the plastic layers while they are being heated.

Figure 4, is the schematic view showing the plastic layers while they are being forced into the mold.

Figure 5a, is the schematic view of the film material cut in order to form a rectangular prism having an open surface.

Figure 5b, is the schematic view of the film material cut in order to form a rectangular prism having an open surface and flanges after being shaped.

Figure 5c, is the schematic view of the film material cut in order to form a refrigerator cabinet having a compressor space after being shaped.

Figure 5d, is the schematic view of the film material cut in a rectangle shape.

Figure 6, is the schematic view showing the plastic layers while being thermoformed.

Figure 7, is the schematic view showing while one of the molds forces and pushes the metal layer towards the other mold.

Figure 8, is the schematic view when layers are combined to form the composite sheet.

Figure 9, is the schematic view showing the molds while the composite sheets are being removed.

Figure 10a, is the schematic view showing the shaped composite sheets when they are brought together to form an insulated unit.

Figure 10b, is the schematic view showing the formed inner and outer liners.

Figure 11, is the three dimensional front view of the inner and outer liners of an insulated unit.

Figure 12, is the three dimensional view showing the inner liner while being inserted into the outer liner.

Figure 13, is the three dimensional front view of an insulated unit formed after joining of the inner and outer liners and also after filling the insulation space with an inner filler material.

Figure 14, is the schematic view showing the composite sheet being heated by the heater.
Figure 15, is the schematic view showing two molds used to shape the heated composite sheet.

Figure 16, is the schematic view showing the shaped liner between two molds.

Figure 17, is the schematic view showing the molds while they are being removed.

Figure 18, is the schematic front view showing two liners of the ceiling, base or unformed body.

Figure 19, is the schematic front view showing the joining of the liners of the ceiling, base, side walls or the unformed body.

Figure 20, is the schematic view showing the formation of the body by using heat to bend the unformed body.

Figure 21a, is the schematic three dimensional view of the shaped body, the ceiling and the base.

Figure 21b, is the schematic three dimensional view showing the formed insulated unit.

Figure 22a, is the exploded three dimensional view of the ceiling, the body and three side walls.

Figure 22b, is the schematic three dimensional view showing the formed insulated unit.

The components shown in the drawings have the following numbers:

1. Insulating unit
2. Insulating material
3. Plastic sheet
4. Heater
5. Lower mold
6. Upper mold
7. Film material
8. Outer liner
9. Inner liner
10. Insulation space
11. Composite sheet
12. Ceiling
13. Base
14. Side walls  
15. Body  
16. Flanges  
17. Unformed body

An insulated unit preferably a thermally insulated unit (1) or, respectively, a device or apparatus with such a unit e.g. an insulated unit being built with liners, is described.

The said insulated unit (1) is obtained by using preferably two liners, an inner liner (9), an outer liner (8), an insulation space (10) between them and an inner insulating material (2), to fill the insulation space (10).

The inner liner (9) and the outer liner (8) are obtained by forming a composite sheet (11) that includes one or more layers of plastic sheets (3) and one or more layers of film materials (7) in order to control the permeation of atmospheric gasses and water vapour. In the preferred application, the composite sheet (11) is made of two plastic sheets (3) and a film material (7) between them. The said film material (7) is a kind of a multi-layer structure that contains metal preferably an Aluminium layer and plastic preferably thin polyolefin containing layers on both sides. The thin polyolefin containing layers that are on both sides of the Aluminium layer are able to adhere on the plastic sheets (3), when the plastics are still relatively soft and slightly warm.

The two preferred methods used to form the thermally insulated unit (1) are described below:

According to the first method; the composite sheet (11) is formed by using a twin sheet thermoforming machine. The said thermoforming machine has a lower mold (5), an upper mold (6), and a heater (4). Lower (5) and upper molds (6) have vacuum units and heat exchangers inside their body. Preferably, the upper mold (6) is male and the lower mold (5) is female.

Before starting, the film material (7) has to be cut such that it can fit onto the upper (6) and lower (5) molds and it has certain shape (Figure 5a - 5d).
The upper (6) and lower (5) molds are heated up to the process temperature by heat exchangers inside them. Two plastic sheets (3) are placed over the heaters (4) of the thermoforming machine between the upper mold (6) and the lower mold (5). Plastic sheets (3) are heated until they are ready for the forming process and then heaters (4) are taken away and vacuum is applied inside the upper (6) and lower (5) molds for giving to the plastic sheets (3) the shape of the upper (6) and lower (5) molds. While forming the plastic sheets (3), the cut film material (7) is inserted between the upper (6) and lower (5) molds. One of the molds, preferably the upper mold (6), moves towards the lower mold taking the film material (7) in between. By this way, the film material (7) and the plastic sheets (3) take the shape of the upper (6) and lower (5) molds. Then, the upper (6) and lower (5) molds are separated from each other and the sandwiched structure called as composite sheet (11) inside them is obtained. The composite sheet (11) forms one of the liners (8,9) of the insulated unit (1). The same procedure has to be followed for forming the other liner (8,9) of the insulating unit (1). The inner (9) and outer liners (8) have different dimensions.

After obtaining the inner liner (9) and the outer liner (8) by thermoforming method, the inner liner (9) is inserted inside the outer liner (8). They are combined by using joining techniques such as laser, hot plate, vibration welding or by adhesives or sealants. A hermetically sealed space called as insulation space (10) is formed between inner and outer liner and this insulation space (10) is filled with a heat insulating material (2), such as open cell polyurethane, fumed silica, powder, aerogel, kieselguhr materials, etc. After the heat insulating material (2) is filled in between the formed inner liner (9) and the outer liner (8) parts of the insulated unit (1); preferably the whole insulation space (10) is evacuated by using a vacuum pump.

The second method to form the insulated unit (1) from a composite sheet (11) is as follows:

Since the insulated unit preferably formed of a body (15) that contains three side walls (14), one of which forms the back wall of the insulated unit (1), a ceiling (12) and a base (13), in this method the ceiling (12), the base (13) and three side walls (14) are formed separately from each other and then joined together.
Firstly the composite sheet (11) is formed by extruding two plastic sheets (3) and a film material (7) between them. Then, the composite sheet (11) is suitably cut in pieces according to the sizes of the ceiling (12), the side walls (14), the base (13) to have inner and outer liners for each. Each piece of composite sheet (11) is heated, then put between the lower mold (5) and the upper mold (6) in order to be shaped (Figure 17). After the composite sheet (11) is shaped the upper mold (6) is separated from the bent composite sheet (Figure 18).

The bent composite sheets form the inner liner (9) or the outer liner (8) of the ceiling (12), the base (13), or the side walls (14). The inner liner (9) and the outer liner (8) have flanges (16) on their edges. The inner liner (9) and the outer liner (8) are joined preferably by laser, hot plate or vibration welding or adhesives or sealants at the flanges (16). By this way, the side walls (14), the ceiling (12) and the base (13) of the insulated unit (1) are obtained.

The connection of the ceiling (12), the base (13) and the side walls (14) of the body (15) is realized by laser, hot plate welding or adhesives or sealants preferably by vibration welding at their flanges (16). For aesthetical reasons, decorative profiles may be used around the welding regions. After the welding operation, each insulation space (10) formed by inner liners (9) and outer liners (8) are filled with insulating material (2). Then insulating spaces (10) are evacuated by means of a vacuum pump.

As an alternative, the body (15) can be formed by shaping a joined inner liner and outer liner structure that can be called as an unshaped body (17). The unshaped body (17) is heated at the connection edges of its side walls and put in the lower mold (5) in order to get the form of the lower mold that is arranged in the shape of the body (15).

As another alternative, the body (15) can be formed by heating and bending an extruded composite sheet (11) in order to obtain the outer liner (8). Another extruded composite sheet is heated and bent to obtain the inner liner (9) of the body (15). The depth of the outer liner (8) is greater than the depth of the inner liner (9). The inner liner (9) and the outer liner (8) are joined by laser, hot plate or vibration welding or adhesives or sealants at the flanges (16).
After obtaining the body (15), the connection of the ceiling (12) the base (13) and the body (15) is realized by laser, hot plate welding or adhesives or sealants or preferably by vibration welding at their flanges (15) again. For aesthetical reasons, decorative profiles may be used here as well and after the welding operation, each insulation space (10) formed by inner liners (9) and outer liners (8) are filled with insulating material (2). Then insulating spaces (10) are evacuated by means of a vacuum pump.

In both of these methods, the vacuum pump used to evacuate the inner space (10) creates a very low pressure, which decreases the thermal conductivity of the inner insulating material (2). As the pressure inside the insulated unit (1) reaches below the critical pressure value of the inner insulating material (2), the vacuum pump is stopped (by means of a sensor that is connected to an electrical control unit.)

Since the film material (7) that is integrated in between the plastic sheets (3) prevents the permeation of gasses such as atmospheric gasses and water vapor into the evacuated region, if it is not used, the pressure created inside the insulation space (10) increases faster, because the water vapor and gas permeability of all the plastics are much more higher than a structure containing the film material (7). The pressure increase rate decreases tremendously by the application of the described invention, so the operating duration of the vacuum pump also decreases and that contributes to less energy consumption of the vacuum pump and the insulated unit (1).
CLAIMS

1- An insulated unit (1) comprising an inner liner (9), an outer liner (8), an insulation space (10) between the inner liner (9) and the outer liner (8), an insulating material (2) filling the inner space (10) and characterized in that the inner liner (9) and the outer liner (8) of the insulated unit (1) are formed by a composite sheet (11) including one or more layers of plastic sheets (3) and one or more layers of film materials (7) that is made of metal and thin plastic layers.

2- An insulated unit according to Claim 1, characterized in that the film material (7) is composed of two plastic layers and one metal layer.

3- An insulated unit according to Claim 1 to 2, characterized in that the metal layer forming the film material (7) is Aluminium.

4- An insulated unit according to Claim 1 to 3, characterized in that the plastic layers coating both sides of the film material (7) are thin polyolefin containing layers.

5- An insulated unit (1) according to Claim 1 to 4, characterized in that the insulating material (2) is open cell polyurethane.

6- An insulated unit (1) according to Claim 1 to 4, characterized in that the insulating material (2) is fumed silica.

7- An insulated unit (1) according to Claim 1 to 4, characterized in that the insulating material (2) is in powder form.

8- An insulated unit (1) according to Claim 1 to 4, characterized in that the insulating material (2) is aerogel.
9- An insulated unit (1) according to Claim 1 to 4, characterized in that the insulating material (2) is kieselguhr.

10- A method to produce an insulated unit (1) according to Claim 1 by means of a thermoforming machine having a lower mold (5), an upper mold (6) and heaters (4), comprising the steps of:
- cutting the film material (7) in order to fit on to the upper (6) and lower (5) molds and according to the sizes of insulated unit (1),
- heating up the upper (6) and lower (5) molds by the heaters (4) to the process temperature,
- placing two plastic sheets (3) over the heaters (4) of the twin sheet thermoforming machine between the upper mold (6) and the lower mold (5),
- taking away the heaters (4) when the plastic sheets (3) are heated until they are ready for the forming process,
- applying vacuum inside the upper (6) and lower (5) molds for giving to the plastic sheets (3) the shape of the upper (6) and lower (5) molds,
- inserting the film material (7) between the upper (6) and lower (5) molds while forming the plastic sheets (3),
- lowering preferably the upper mold (6) towards the lower mold in order to sandwich the film material (7) in between,
- separating the two molds from each other,
- obtaining the shaped composite sheet (11) and forming the inner liner (9) or the outer liner (8) by the said shaped composite sheet (11),
- combining the inner liner (9) and the outer liner (8) preferably by using laser, hot plate or vibration welding or adhesives or sealants while obtaining an insulation space (10) between the inner liner (9) and the outer liner (8),
- filling the insulation space (10) with a heat insulating material (2) and evacuating the inner space (10) filled by insulating material (2) by using a vacuum pump.

11- A method to produce an insulated unit (1) according to Claim 1 formed of a ceiling (12), a base (13), a body (15) formed of side walls (14) and having
flanges (16) on the connection regions of the ceiling (12), the base (13), the side walls (14) of the body (15), comprising the steps of:

- forming the composite sheet (11) by extruding two plastic sheets (3) and a film material (7) between them,

- cutting the composite sheet (11) in pieces suitably to the inner liner (9) or outer liner (8) dimensions of the ceiling (12), the base (13) or the side walls (14) of the body (15),

- heating each piece of the composite sheet (11) and putting it between the lower mold (5) and the upper mold (6) in order to give it the shape of the desired inner (9) or outer liner (8),

- separating the lower mold (5) and the upper mold (6) from each other,

- obtaining the inner liner (9) and the outer liner (8) of the ceiling (12), the base (13), or the side walls (14) of the body (15),

- joining the inner liner (9) and the outer liner (8) together at their flanges (16) by using laser, hot plate or vibration welding, or adhesives or sealants,

- obtaining the ceiling (12), the base (13) and the side walls (14) of the body (15),

- connecting the obtained ceiling (12), base (13) and the side walls (14) of the body (15) preferably by using laser, hot plate or vibration welding, or adhesives or sealants,

- filling the insulation spaces (10) formed by inner liners (9) and outer liners (8) with insulating material (2) and evacuating the insulating spaces (10) by using a vacuum pump.

12- A method to produce an insulated unit (1) according to Claim 1 formed of a ceiling (12), a base (13) and a body (15) formed by shaping an unshaped body (17) which have flanges (16) on the connection regions, comprising the steps of:

- forming the composite sheet (11) by extruding two plastic sheets (3) and a film material (7) between them,

- cutting the composite sheet (11) in pieces suitably to the inner liner (9) or outer liner (8) dimensions of the ceiling (12), the base (13) or the unshaped body (15),
- heating each piece of the composite sheet (11) and putting it between the lower mold (5) and the upper mold (6) in order to give it the shape of the desired inner (9) or outer liner (8),

- separating the lower mold (5) and the upper mold (6) from each other,

- obtaining the inner liner (9) and the outer liner (8) of the ceiling (12), the base (13), or the unshaped body (17),

- joining the inner liner (9) and the outer liner (8) together at their flanges (16) by using laser, hot plate or vibration welding, or adhesives or sealants,

- obtaining the ceiling (12), the base (13) and the unshaped body (17), heating the unshaped body (17) at the connection edges of its side walls and putting in the lower mold (5) in order to get the form of the lower mold (5) that is arranged in the shape of the body (15),

- obtaining the body (15) after giving the desired shape to the unshaped body (17),

- connecting the obtained ceiling (12), base (13) and the body (15) preferably by using laser, hot plate or vibration welding, or adhesives or sealants,

- filling the insulation spaces (10) formed by inner liners (9) and outer liners (8) with insulating material (2) and evacuating the insulating spaces (10) by using a vacuum pump.

13- A method to produce an insulated unit (1) according to Claim 1 formed of a ceiling (12), a base (13) and a body (15) which have flanges (16) on the connection regions, comprising the steps of:

- forming the first piece of composite sheet (11) to get the body (15) by extruding two plastic sheets (3) and a film material (7) between them,

- heating the composite sheet (11) at the connection edges of the outer liner (8) walls and putting it in a suitable lower mold (5) in order to get the form of the lower mold (5) that is arranged in the shape of the outer liner (8) of the body (15),

- heating the composite sheet (11) at the connection edges of the inner liner (9) walls and putting it in a suitable lower mold (5) in order to get
the form of the lower mold (5) that is arranged in the shape of the inner liner (9) of the body (15),

- obtaining the inner liner (9) and the outer liner (8) of the body (15),

- joining the inner liner (9) and the outer liner (8) of the body (15) together at their flanges (16) by using laser, hot plate or vibration welding, or adhesives or sealants to obtain the body (15),

- cutting the film material (7) in order to fit on to the upper (6) and lower (5) molds and according to the sizes of the ceiling (12) or the base (13),

- heating up the upper (6) and lower (5) molds by the heaters (4) to the process temperature,

- placing two plastic sheets (3) over the heaters (4) of the twin sheet thermoforming machine between the upper mold (6) and the lower mold (5),

- taking away the heaters (4) when the plastic sheets (3) are heated until they are ready for the forming process,

- applying vacuum inside the upper (6) and lower (5) molds for giving to the plastic sheets (3) the shape of the upper (6) and lower (5) molds,

- inserting the film material (7) between the upper (6) and lower (5) molds while forming the plastic sheets (3),

- lowering preferably the upper mold (6) towards the lower mold in order to sandwich the film material (7) in between,

- separating the two molds from each other,

- obtaining the shaped composite sheet (11) and forming the inner liner (9) or the outer liner (8) of the ceiling (12) or the base (13) by the said shaped composite sheet (11),

- combining the inner liner (9) and the outer liner (8) of the ceiling (12) or the base (13) preferably by using laser, hot plate or vibration welding or adhesives or sealants while obtaining an insulation space (10) between the inner liner (9) and the outer liner (8),

- connecting the obtained ceiling (12), base (13) and the body (15) preferably by using laser, hot plate or vibration welding, or adhesives or sealants,
- filling the insulation spaces (10) formed by inner liners (9) and outer liners (8) with insulating material (2) and evacuating the insulating spaces (10) by using a vacuum pump.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F25D23/06 B29C51/14

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)
IPC 7 F25D B32B

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, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Date of the actual completion of the international search 31 August 2001

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Name and mailing address of the ISA
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