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Pressure sensor hub for a vacuum-insulated structure

Abstract

A pressure sensor hub for a vacuum-insulated structure includes: (a) a pressure sensor, the pressure sensor including a sensing element and an electrical connector extending from the sensing element; (b) a printed circuit board including conductive pads that are exposed, each of the conductive pads in electrical communication with a different portion of the electrical connector of the pressure sensor; and (c) a body that supports the pressure sensor and the printed circuit board.

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Background/Summary

BACKGROUND OF THE DISCLOSURE

(1) The present disclosure generally relates to vacuum-insulated structures for appliances and, more specifically, to a pressure sensor hub associated with a vacuum-insulated structure that allows a pressure within the vacuum-insulated structure to be determined.

SUMMARY OF THE DISCLOSURE

(2) A refrigerator could include a vacuum-insulated door, such as for use with a vacuum-insulated cabinet structure. The door could include an interior space that is evacuated and sealed, thus forming a low pressure volume (e.g., near vacuum) within the interior space of the door. Insulation material may be disposed in the interior space. The door can include a pressure sensor placed in communication with the interior space. The pressure sensor can be placed in communication with a processor. The pressure sensor could provide input to the processor, which can determine the pressure within the low pressure volume during manufacture of the vacuum-insulated door and after manufacture during the service life of the refrigerator.

(3) There is a general need to permit the pressure sensor to detect pressure of the low pressure

volume while allowing the pressure sensor to communicate with the processor without breaking the low pressure volume. Further, there is a general need to facilitate communication between the pressure sensor and the processor, sometimes without including a wire harness.

(4) The present disclosure addresses those general needs by equipping the vacuum-insulated structure (such as the vacuum-insulated door) with a pressure sensor hub that includes a pressure sensor positioned to read the pressure within the interior space and a printed circuit board with conductive pads in communication with the pressure sensor. The conductive pads are accessible from outside of the insulated structure and the pressure sensor hub. An electrical probe in communication with the processor can make an electrical connection with the pressure sensor via touching the conductive pads at the printed circuit board. The connection with, and receipt of output from, the pressure sensor can thus be made very quickly, in an automated manner, and more quickly than a plug-in type connection with a wire harness. However, the printed circuit board can further include other forms of electrical connector receivers to form a connection with the pressure sensor, such as the aforementioned plug-in type of connection.

(5) According to one aspect of the present disclosure, a pressure sensor hub for a vacuum-insulated structure comprises: (a) a pressure sensor, the pressure sensor comprising a sensing element and an electrical connector extending from the sensing element; (b) a printed circuit board comprising one or more conductive pads that are exposed, each of the one or more conductive pads in electrical communication with a different portion of the electrical connector of the pressure sensor; and (c) a body that supports the pressure sensor and the printed circuit board.

(6) According to another aspect of the present disclosure, a refrigerator comprises: (a) a vacuum-insulated structure comprising a first liner, a second liner opposing the first liner, a space disposed between the first liner and the second liner, wherein an air pressure within the space is less than atmospheric air pressure; and (b) a pressure sensor hub disposed on the first liner, the pressure sensor hub comprising (i) a pressure sensor in fluid communication with the space between the first liner and the second liner, (ii) a printed circuit board in electrical communication with the pressure sensor, and (iii) a body that supports the pressure sensor and the printed circuit board, wherein, the pressure sensor is configured to generate an electrical signal that varies as a function of the air pressure within the space.

(7) These and other features, advantages, and objects of the present disclosure will be further understood and appreciated by those skilled in the art by reference to the following specification, claims, and appended drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) In the drawings:

(2) FIG. **1** is a perspective view of a pressure sensor hub of the present disclosure, illustrating the pressure sensor hub including a body and a printed circuit board attached to the body with conductive pads exposed to an external environment;

(3) FIG. **2** is a top view of the pressure sensor hub of FIG. **1**, illustrating the printed circuit board further including an edge connector when the body further includes heat stake posts that extend through apertures through the printed circuit board to secure the printed circuit board to the body;

(4) FIG. **3** is an elevation view of a cross-section of the pressure sensor hub of FIG. **1** taken through line III-III of FIG. **2**, illustrating the pressure sensor hub further including a pressure sensor with a sensing element disposed within an inner chamber that the body forms;

(5) FIG. **4** is an elevation view of a cross-section of the pressure sensor hub of FIG. **1** taken through line IV-IV of FIG. **2**, illustrating an electrical connector of the pressure sensor extending to and forming an electrical connection with the printed circuit board;

(6) FIG. **5** is a top view of the pressure sensor of FIG. **3**;
(7) FIG. **6** is the top view of the body of the pressure sensor hub of FIG. **1**, illustrating the body including an outer wall system with a ledge to support the printed circuit board and an inner wall system partially surrounded by the outer wall system, the inner wall system at least partially defining the inner chamber within which the pressure sensor is disposed;
(8) FIG. **7** is an elevation view of the body of the pressure sensor hub of FIG. **1**, illustrating the inner wall system of the body having an edge that is distanced from a floor less than an edge of the outer wall system of the body is distanced from the floor;
(9) FIG. **8** is an underside view of the body of the pressure sensor of FIG. **1**, illustrating the body further including a second outer wall system surrounding a second inner wall system, with the second inner wall system further defining the inner chamber, which extends through the body;
(10) FIG. **9** is an elevation view of a cross-section of the body of the pressure sensor hub of FIG. **1**, illustrating heat stake posts extending from the inner wall system;
(11) FIG. **10** is a perspective view of a seal of the pressure sensor hub of FIG. **1**, illustrating the seal including one or more apertures through which the electrical connector of the pressure sensor extends;
(12) FIG. **11** is a view of a vacuum-insulated structure incorporating the pressure sensor hub of FIG. **1**;
(13) FIG. **12** is an elevation view of a cross-section of the vacuum-insulated structure of FIG. **11** taken through line XII-XII of FIG. **11**, illustrating the vacuum-insulated structure further including the first liner to which the pressure sensor hub is attached, a second liner, and a space between the first liner and the second liner;
(14) FIG. **13** is a magnified view of area XIII of FIG. **12**, illustrating the sensing element of the pressure sensor in fluid communication with the space between the first liner and the second liner of the vacuum-insulated structure;
(15) FIG. **14** is a magnified view of area XIV of FIG. **12**, illustrating the one or more conductive pads of the printed circuit board of the pressure sensor hub being exposed to the external environment, and the first liner and the body of the pressure sensor hub each including a mating feature to ensure proper orientation of the pressure sensor hub on the first liner during installation; and
(16) FIG. **15** is a perspective view of an appliance, specifically a refrigerator, incorporating the vacuum-insulated structure of FIG. **12** as a component of a door of the appliance.
(17) The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles described herein.

DETAILED DESCRIPTION

(18) The present illustrated embodiments reside primarily in combinations of apparatus components related to a vacuum-insulated structure. Accordingly, the apparatus components have been represented, where appropriate, by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present disclosure so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein. Further, like numerals in the description and drawings represent like elements.
(19) For purposes of description herein, the terms “upper,” “lower,” “right,” “left,” “rear,” “front,” “vertical,” “horizontal,” and derivatives thereof shall relate to the disclosure as oriented in FIG. **1**. Unless stated otherwise, the term “front” shall refer to the surface of the element closer to an intended viewer, and the term “rear” shall refer to the surface of the element further from the intended viewer. However, it is to be understood that the disclosure may assume various alternative orientations, except where expressly specified to the contrary. It is also to be understood that the specific devices and processes illustrated in the attached drawings, and described in the following specification are simply exemplary embodiments of the inventive concepts defined in the appended

claims. Hence, specific dimensions and other physical characteristics relating to the embodiments disclosed herein are not to be considered as limiting, unless the claims expressly state otherwise.
(20) The terms “including,” “comprises,” “comprising,” or any other variation thereof, are intended to cover a non-exclusive inclusion, such that an article or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such an article or apparatus. An element preceded by “comprises a . . . ” does not, without more constraints, preclude the existence of additional identical elements in the article or apparatus that comprises the element.
(21) Referring to FIGS. **1**-**3**, a pressure sensor hub **10** includes a pressure sensor **12**, a printed circuit board **14**, and a body **16** that supports the pressure sensor **12** and the printed circuit board **14**. The pressure sensor **12** (see FIG. **2**) includes a sensing element **18** and an electrical connector **20** extending from the sensing element **18**. The sensing element **18** can include a piezoresistive, capacitive, or piezoelectric element. The sensing element **18** can include a reference chamber, a transducer, a housing, among other features. The sensing element **18** senses the pressure and converts it into an electrical signal. The electrical connector **20** permits the transmission of the electrical signal from the sensing element **18**. The electrical connector **20** can take the form of leads, as in the illustrated embodiments.
(22) The printed circuit board **14** (see FIG. **1**) includes a substrate **22** and one or more conductive pads **24** supported by the substrate **22**. The substrate **22** can be made of any suitable materials, such as paper phenolic or epoxy. The printed circuit board **14** is in electrical communication with the pressure sensor **12**. In embodiments, each of the one or more conductive pads **24** is in electrical communication with a different portion (e.g., a different lead) of the electrical connector **20** of the pressure sensor **12**. The printed circuit board **14** further includes conductive traces (not separately illustrated) that electrically connect each of the one or more conductive pads **24** to a different portion of the electrical connector **20** of the pressure sensor **12**. For example, one of the conductive pads **24** can be in communication with the ground of the pressure sensor **12**, another one of the conductive pads **24** can be in communication with (e.g., provides) the supply voltage of the pressure sensor **12**, and another one of the conductive pads **24** can be in communication with (e.g., receives) the signal voltage of the pressure sensor **12**, and so on. The one or more conductive pads **24** (and the conductive traces) can be formed of any suitably conductive material, such as copper. The one or more conductive pads **24** are exposed, which allows for a selective electrical connection to be made as further discussed below. The printed circuit board **14** has a perimeter **26**. In embodiments, the printed circuit board **14** further includes an edge connector **28**. Conductive traces in electrical communication with the pressure sensor **12** are also exposed at the edge connector **28**. The edge connector **28** allows for a card edge connector of a wire harness (not illustrated) to make a physical and an electrical connection thereto. The printed circuit board **14** further includes heat stake apertures **30** and a glue aperture **32**. The heat stake apertures **30** and the glue aperture **32** are through the substrate **22**. Other forms of connectors, such as receptive connectors to receive plug-in types of connectors, can be utilized other than the edge connector **28** to provide an electrical connection with the pressure sensor **12** aside from the one or more conductive pads **24**.
(23) Referring now additionally to FIGS. **4**-**9**, the body **16** includes an outer flange **34**, an outer wall system **36**, and an inner wall system **38**. The outer flange **34** defines a perimeter **40** of the pressure sensor hub **10**. In addition, the outer flange **34** defines a first side **42** of the body **16** and a second side **44** of the body **16** that faces away from the first side **42**.
(24) The outer wall system **36** extends from the outer flange **34** at the first side **42** of the body **16**, that is, away from the second side **44** of the body **16**. The outer wall system **36** is a system of one more contiguous outer walls **36**. The outer wall system **36** extends substantially orthogonally from the outer flange **34**. In embodiments, such as those illustrated, the outer wall system **36** includes two outer walls **36***a*, **36***b* that are spaced apart from each other and opposing each other and an outer wall **36***c* generally orthogonal to the two outer walls **36***a*, **36***b*. Further, the outer wall system

36 includes an edge **46** furthest from the outer flange **34** and a ledge **48** proximate the edge **46**. The ledge **48** is disposed inward from the edge **46**. The body **16** further includes a floor **50** inward of the outer wall system **36**. The floor **50** and the outer wall system **36** together define an outer chamber **52** of the body **16**. The floor **50** is contiguous with the outer flange **34**. The outer wall system **36** can include additional outer walls **36***d*, **36***e* that extend to the perimeter **40** defined by the outer flange **34**.

(25) The inner wall system **38** extends from the floor **50** away from the second side **44** of the body **16** within the outer chamber **52**. The outer wall system **36** surrounds the inner wall system **38**. The inner wall system **38** extends substantially orthogonally from the floor **50**. The inner wall system **38** includes contiguous inner walls **38** that define an inner chamber **54**. For example, as in the illustrated embodiments, the inner wall system **38** includes inner walls **38***a*, **38***b* that oppose each other and inner walls **38***c*, **38***d* perpendicular to the inner walls **38***a*, **38***b* that oppose each other. The inner wall system **38** has an edge **56**. The edge **56** of the inner wall system **38** is elevated from the floor **50** about the same as the ledge **48** of the outer wall system **36** is elevated from the floor **50**. The printed circuit board **14** thus is disposed upon the edge **56** of the inner wall system **38**. The inner chamber **54** extends through the body **16**. The inner wall system **38** further includes a ledge **58**. The ledge **58** is proximate the edge **56** and disposed inward toward the inner chamber **54** away from the perimeter **40** of the body **16**. The inner wall system **38** can further include one or more heat stake posts **60** that extend from the edge **56** away from the second side **44** of the pressure sensor hub **10**.

(26) The body **16** of the pressure sensor hub **10** further includes a second inner wall system **62**. The second inner wall system **62** extends from the floor **50** toward the second side **44** of the body **16**. The second inner wall system **62** extends from the floor **50** in an opposite direction as the inner wall system **38**. The second inner wall system **62** further defines the inner chamber **54**, in addition to the inner wall system **38**. The inner chamber **54** thus extends through the body **16**. In embodiments such as those illustrated, the second inner wall system **62** is substantially circular. In other embodiments, the second inner wall system **62** is not substantially circular. In any event, the second inner wall system **62** includes portions **62***a*, **62***b* that oppose each other. The body **16** further includes one or more crossbars **64** that extend across the second inner wall system **62**.

(27) The body **16** of the pressure sensor hub **10** further includes a second outer wall system **66**. The second outer wall system **66** extends from the outer flange **34** away from the first side **42** of the body **16**. The second outer wall system **66** extends contiguously around the second inner wall system **62**. In embodiments such as those illustrated, the second outer wall system **66** is substantially circular. In other embodiments, the second outer wall system **66** is not substantially circular. In any event, the second outer wall system **66** includes portions **66***a*, **66***b* that oppose each other. The second outer wall system **66** includes an edge **68**, the second inner wall system **62** includes an edge **70**, and each of the crossbars **64** includes an edge **72**, respectively. All of the edges **68**, **70**, **72** can be coplanar.

(28) The body **16** can be formed of any suitable material. Suitable materials for the body **16** include plastic or other non-electrically conductive materials.

(29) To assemble the printed circuit board **14**, the pressure sensor **12** is placed within the inner chamber **54**. The sensing element **18** of the pressure sensor **12** is disposed upon the crossbars **64** that connect to the second inner wall system **62**. In embodiments, an edge **74** of the sensing element **18** disposed furthest away from the electrical connector **20** of the pressure sensor **12** is disposed across the crossbars **64** within the inner chamber **54**. The pressure sensor **12** is thus disposed at least partially within the inner chamber **54**. The sensing element **18** is disposed within the inner chamber **54**.

(30) Referring additionally to FIG. **10**, the pressure sensor hub **10** can further include a seal **76** for the pressure sensor **12**. The seal **76** includes one or more apertures **78** and has a perimeter **80** shaped to cover the inner chamber **54** inward of the inner wall system **38**. The electrical connector

20 of the pressure sensor **12** is placed through the one or more apertures **78** of the seal **76**. The seal **76** is disposed upon the ledge **58** of the inner wall system **38**. The inner wall system **38** extends around the perimeter **80** of the seal **76**. The electrical connector **20** of the pressure sensor **12** thus extends through the one or more apertures **78** of the seal **76**.

(31) The printed circuit board **14** is disposed upon the ledge **48** of the outer wall system **36** and opposes the floor **50** and the seal **76**. The heat stake posts **60** extending from the inner wall system **38** are disposed through the heat stake apertures **30** through the substrate **22** of the printed circuit board **14**. The edge **46** of the outer wall system **36** extends around at least a portion of the perimeter **26** of the printed circuit board **14**. Due to the contour of the edge **46** of the outer wall system **36**, and positioning of the heat stake apertures **30** through the printed circuit board **14** for the heat stake posts **60**, the printed circuit board **14** can be attached to the body **16** of the pressure sensor hub **10** in only one orientation. That poke-yoke feature helps ensure correct assembly of the pressure sensor hub **10**.

(32) In embodiments where the printed circuit board **14** includes the edge connector **28**, the edge **46** of the outer wall system **36** does not extend around the edge connector **28**. The electrical connector **20** is placed to extend through one or more apertures **82** of the printed circuit board **14**. A portion **84** of the electrical connector **20** is disposed within inner chamber **54** and a portion **86** is disposed outside of the inner chamber **54**. The portion **86** of the electrical connector **20** disposed outside of the inner chamber **54** is exposed. The heat stake posts **60** can be melted over the printed circuit board **14** to secure the printed circuit board **14** to the pressure sensor hub **10**.

(33) The glue aperture **32** of the printed circuit board **14** is in communication with the inner chamber **54**. Glue (not illustrated) can be inserted into the inner chamber **54** between the printed circuit board **14** and the seal **76** through the glue aperture **32** through the printed circuit board **14**. "Glue" here includes any suitable sealing and bonding material such as cyanoacrylate, epoxy, and silicone, among other options. The glue provides an air-tight seal between the printed circuit board **14** and the seal **76** and prevents air leakage from the external environment into the inner chamber **54** past the seal **76** to the sensing element **18** of the pressure sensor **12**. The glue further mechanically bonds the printed circuit board **14** to the body **16** of the pressure sensor hub **10**. Excess glue can seep out of a glue weep hole **88** between the seal **76** and inner wall system **38**. Incorporation of the glue weep hole **88** helps prevent glue from overflowing onto the one or more conductive pads **24** and avoids a need to mask the printed circuit board **14** during the deposition of the glue. Further, because the heat stake posts **60** attach the printed circuit board **14** to the body **16** of the pressure sensor hub **10**, there is no need to clamp the printed circuit board **14** to the body **16** during insertion of the glue.

(34) Referring now to FIGS. **11-14**, in embodiments, the pressure sensor hub **10** is a component of a vacuum-insulated structure **90**. The vacuum-insulated structure **90** further includes a first liner **92**, a second liner **94**, and a space **96** disposed between the first liner **92** and the second liner **94**. The pressure sensor hub **10** is disposed on the first liner **92**. The second side **44** of the body **16** of the pressure sensor hub **10** faces the first liner **92**, and the first side **42** of the body **16** faces away from the first liner **92**. The outer flange **34** of the body **16** of the pressure sensor hub **10** can include a mating feature **98** that cooperates with a mating feature **100** on the first liner **92** to ensure that the pressure sensor hub **10** is attached to the first liner **92** with the proper orientation. The sensing element **18** of the pressure sensor **12** is in fluid communication with the space **96** between the first liner **92** and the second liner **94**. The first liner **92** and the second liner **94** are sealed together. During use of the vacuum-insulated structure **90**, the space **96** has a pressure that is below atmospheric air pressure. The reduced pressure within the space **96** reduces heat transfer through the vacuum-insulated structure **90** compared to if the pressure within the space **96** was equal to atmospheric pressure. Core insulation material **102** can be disposed within the space **96** to further reduce heat transfer. The core insulation material **102** can be any suitable material, such as fumed silica. The pressure sensor hub **10** allows the pressure within the space **96** of the vacuum-insulated

structure **90**, as determined via output from the pressure sensor **12**, to be monitored via electrical connection with the pressure sensor **12** via the one or more conductive pads **24** or edge connector **28** of the printed circuit board **14**.

(35) Referring now to FIG. **15**, in embodiments, the vacuum-insulated structure **90** is a component of an appliance **104**, such as a refrigerator. The appliance **104** can include a cabinet **106** that defines a refrigerable compartment **108**. The appliance **104** can further include a door **110** cooperating with the cabinet **106** to provide selective access to the refrigerable compartment **108** from an external environment **112**. In embodiments, the vacuum-insulated structure **90** with the pressure sensor hub **10** of the present disclosure is a component of the door **110**. In embodiments, the vacuum-insulated structure **90** with the pressure sensor hub **10** of the present disclosure is a component of the cabinet **106**.

(36) In use, electrical probes (not illustrated) of a device can be made to contact the one or more conductive pads **24** of the printed circuit board **14** of the pressure sensor hub **10**. The electrical probes contacting the one or more conductive pads **24** form an electrical connection that allows output from the sensing element **18** of the pressure sensor **12** to transmit to a processor (not illustrated). A connection between a wire harness in electrical communication with the processor need not be made to monitor the pressure via the pressure sensor **12**. The pressure sensor hub **10** can be utilized to monitor the pressure within the vacuum-insulated structure **90**, such as while air is being withdrawn from the vacuum-insulated structure **90**.

(37) The vacuum-insulated structure **90** can then be incorporated into the appliance **104**. Even when incorporated into the appliance **104**, output from the pressure sensor **12** can be obtained via a connection with the edge connector **28** of the printed circuit board **14** of the pressure sensor hub **10** or some other form of connector, or with electrical probes as described. The pressure within the space **96** can thus be monitored as desired during the life of the appliance **104**. It should be understood that the pressure sensor hub **10** can be a component of a precursor to the vacuum-insulated structure **90**, such as a structure or insulated structure that is otherwise identical to the vacuum-insulated structure **90** but from which air has not yet been evacuated or does not include core insulation material **102**. Such a structure or insulated structure is otherwise configured to become the vacuum-insulated structure **90** upon further manufacture.

(38) According to a first aspect of the present disclosure, a pressure sensor hub for a vacuum-insulated structure comprises: (a) a pressure sensor, the pressure sensor comprising a sensing element and an electrical connector extending from the sensing element; (b) a printed circuit board comprising one or more conductive pads that are exposed, each of the one or more conductive pads in electrical communication with a different portion of the electrical connector of the pressure sensor; and (c) a body that supports the pressure sensor and the printed circuit board.

(39) According to a second aspect of the present disclosure, the pressure sensor hub of the first aspect is presented, wherein the body comprises: (a) an outer flange defining a perimeter of the pressure sensor hub, a first side of the body, and a second side of the body that faces way from the first side, (b) an outer wall system extending from the outer flange away from the second side of the body, the outer wall system comprising (i) two outer walls that are spaced apart from each other and opposing each other, (ii) an outer wall generally orthogonal to the two outer walls and contiguous with the two outer walls, and (iii) a ledge proximate an edge of the outer wall system, wherein (i) the outer wall system defines an outer chamber further defined by a floor contiguous with the outer lip and (ii) the printed circuit board is disposed upon the ledge and opposes the floor and with the edge of the outer wall system extending around at least a portion of a perimeter of the printed circuit board, (c) an inner wall system extending from the floor away from the second side of the body within the outer chamber, the inner wall system comprising contiguous inner walls that define an inner chamber that extends through the body, (d) a second inner wall system extending from the floor toward the second side of the body, the second inner wall system comprising portions that oppose each other and further define the inner chamber that extends through the body,

and (e) a second outer wall system extending from the outer flange away from the first side of the body, the second outer wall system extending contiguously around the second inner wall system, wherein the sensing element of the pressure sensor is disposed within the inner chamber.

(40) According to a third aspect of the present disclosure, the pressure sensor hub of the second aspect is presented, wherein the electrical connector of the pressure sensor extends through one or more apertures of the printed circuit board, with a portion of the electrical connector being disposed outside of the inner chamber and exposed.

(41) According to a fourth aspect of the present disclosure, the pressure sensor hub of any one of the second through third aspects is presented, wherein (i) the inner wall system further comprises a ledge proximate an edge of the inner wall system, the ledge disposed toward the inner chamber, (ii) the pressure sensor hub further comprises a seal that is disposed upon the ledge of the inner wall system and with the inner wall system extending around a perimeter of the seal, and (iii) the seal comprises one or more apertures through which the electrical connector of the pressure sensor extends.

(42) According to a fifth aspect of the present disclosure, the pressure sensor hub of any one of the second through fourth aspects is presented, wherein the printed circuit board comprises a glue aperture in communication with the inner chamber.

(43) According to a sixth aspect of the present disclosure, the pressure sensor hub of any one of the second through fifth aspects is presented, wherein (i) the inner wall system further comprises heat stake posts that extend from the edge away from the second side of the pressure sensor hub, and (ii) the printed circuit board comprises heat stake apertures through which the heat stake posts extend.

(44) According to a seventh aspect of the present disclosure, the pressure sensor hub of any one of the first through sixth aspects is presented, wherein the printed circuit board further comprises an edge connector.

(45) According to an eighth aspect of the present disclosure, the pressure sensor hub of any one of the first through seventh aspects is presented, wherein (i) one of the conductive pads is in communication with the supply voltage of the pressure sensor, and (ii) another one of the conductive pads is in communication with the signal voltage of the pressure sensor.

(46) According to a ninth aspect of the present disclosure, the pressure sensor hub of any one of the first through eighth aspects is presented, wherein (i) the pressure sensor hub is a component of a vacuum-insulated structure, (ii) the vacuum-insulated structure further comprises a first liner, a second liner opposing the first liner, a space disposed between the first liner and the second liner, and (iii) the pressure sensor hub is disposed on the first liner with the sensing element of the pressure sensor in fluid communication with the space between the first liner and the second liner.

(47) According to a tenth aspect of the present disclosure, the pressure sensor hub of the ninth aspect is presented, wherein the vacuum-insulated structure is a component of an appliance.

(48) According to an eleventh aspect of the present disclosure, the pressure sensor hub of the tenth aspect is presented, wherein the appliance is a refrigerator.

(49) According to a twelfth aspect of the present disclosure, the pressure sensor hub of the ninth aspect is presented, wherein the vacuum-insulated structure is a component of a door of a refrigerator.

(50) According to a thirteenth aspect of the present disclosure, the pressure sensor hub of any one of the first through eighth aspect is presented, wherein (i) the pressure sensor hub is a component of a structure, (ii) the structure is configured to be a vacuum-insulated structure and comprises a first liner, a second liner opposing the first liner, and a space disposed between the first liner and the second liner, and (iii) the pressure sensor hub is disposed on the first liner with the sensing element of the pressure sensor in fluid communication with the space between the first liner and the second liner.

(51) According to a fourteenth aspect of the present disclosure, a refrigerator comprises (a) a vacuum-insulated structure comprising a first liner, a second liner opposing the first liner, and a

space disposed between the first liner and the second liner, wherein an air pressure within the space is less than atmospheric air pressure; and (b) a pressure sensor hub disposed on the first liner, the pressure sensor hub comprising (i) a pressure sensor in fluid communication with the space between the first liner and the second liner, (ii) a printed circuit board in electrical communication with the pressure sensor, and (iii) a body that supports the pressure sensor and the printed circuit board, wherein, the pressure sensor is configured to generate an electrical signal that varies as a function of the air pressure within the space.

(52) According to a fifteenth aspect of the present disclosure, the refrigerator of the fourteenth aspect is presented, wherein the printed circuit board includes a substrate and one or more conductive pads supported by the substrate, each of the conductive pads being in electrical communication with the pressure sensor.

(53) According to a sixteenth aspect of the present disclosure, the refrigerator of any one of the fourteenth through fifteenth aspects is presented, wherein the printed circuit board further comprises an edge connector configured to make a physical and electrical connection with a card edge connector of a wire harness.

(54) According to a seventeenth aspect of the present disclosure, the refrigerator of any one of the fourteenth through sixteenth aspects is presented, wherein (i) the body includes an outer flange that defines a perimeter of the pressure sensor hub, and (ii) the outer flange of the body includes a mating feature that cooperates with a mating feature on the first liner to ensure that the pressure sensor hub is attached to the first liner with the proper orientation.

(55) According to an eighteenth aspect of the present disclosure, the refrigerator of any one of the fourteenth through seventeenth aspects is presented, wherein the pressure sensor includes (i) a sensing element in fluid communication with the space between the first liner and the second liner and (ii) an electrical connector extending from the sensing element that transmits electrical signals from the sensing element, the electrical connector being in electrical communication with the one or more conductive pads of the printed circuit board.

(56) According to a nineteenth aspect of the present disclosure, the refrigerator of the eighteenth aspect is presented, wherein (a) the body comprises (i) an outer flange defining a perimeter of the pressure sensor hub, a first side of the body that faces away from the first liner of the vacuum-insulated structure, and a second side of the body that faces away from the first side and toward the first liner, (ii) an inner wall system extending from the floor away from the second side of the body within the outer chamber, the inner wall system comprising contiguous inner walls that define an inner chamber that extends through body, and (iii) a second inner wall system extending from the floor toward the second side of the body, the second inner wall system comprising portions that oppose each other and further define the inner chamber that extends through the body, and (b) the sensing element of the pressure sensor is disposed within the inner chamber, (c) the inner wall system has an edge disposed away from the first liner and a ledge proximate the edge and disposed inward toward the inner chamber away from the perimeter of the body, and (d) the pressure sensor hub further comprises a seal for the pressure sensor, the seal disposed on the ledge of the inner wall system with the inner wall system extending around a perimeter of the seal, the seal comprising one or more apertures through which the electrical connector of the pressure extends.

(57) According to a twentieth aspect of the present disclosure, the nineteenth aspect is presented, wherein (a) the body further comprises an outer wall system extending from the outer flange away from the second side of the body, the outer wall system comprising (i) two outer walls that are spaced apart from each other and opposing each other, (ii) an outer wall generally orthogonal to the two outer walls and contiguous with the two outer walls, and (iii) a ledge proximate an edge of the outer wall system, wherein (i) the outer wall system defines an outer chamber further defined by a floor contiguous with the outer lip and (ii) the printed circuit board is disposed upon the ledge and opposes the floor and with the edge of the outer wall system extending around at least a portion of a perimeter of the printed circuit board, and (b) the pressure sensor hub further comprises glue

within the inner chamber of the body between the printed circuit board and the seal, the glue providing an air-tight seal between the printed circuit board and the seal and mechanically bonding the printed circuit board to the body of the pressure sensor hub.
(58) It will be understood by one having ordinary skill in the art that construction of the described disclosure and other components is not limited to any specific material. Other exemplary embodiments of the disclosure disclosed herein may be formed from a wide variety of materials, unless described otherwise herein.
(59) For purposes of this disclosure, the term “coupled” (in all of its forms, couple, coupling, coupled, etc.) generally means the joining of two components (electrical or mechanical) directly or indirectly to one another. Such joining may be stationary in nature or movable in nature. Such joining may be achieved with the two components (electrical or mechanical) and any additional intermediate members being integrally formed as a single unitary body with one another or with the two components. Such joining may be permanent in nature or may be removable or releasable in nature unless otherwise stated.
(60) It is also important to note that the construction and arrangement of the elements of the disclosure as shown in the exemplary embodiments is illustrative only. Although only a few embodiments of the present innovations have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited. For example, elements shown as integrally formed may be constructed of multiple parts, or elements shown as multiple parts may be integrally formed, the operation of the interfaces may be reversed or otherwise varied, the length or width of the structures and/or members or connector or other elements of the system may be varied, the nature or number of adjustment positions provided between the elements may be varied. It should be noted that the elements and/or assemblies of the system may be constructed from any of a wide variety of materials that provide sufficient strength or durability, in any of a wide variety of colors, textures, and combinations. Accordingly, all such modifications are intended to be included within the scope of the present innovations. Other substitutions, modifications, changes, and omissions may be made in the design, operating conditions, and arrangement of the desired and other exemplary embodiments without departing from the spirit of the present innovations.
(61) The exemplary structures disclosed herein are for illustrative purposes and are not to be construed as limiting.

Claims

1. A pressure sensor hub for a vacuum-insulated structure comprising: a pressure sensor, the pressure sensor comprising a sensing element and an electrical connector extending from the sensing element; a printed circuit board comprising one or more conductive pads that are exposed, each of the one or more conductive pads in electrical communication with a different portion of the electrical connector of the pressure sensor; and a body that supports the pressure sensor and the printed circuit board.
2. The pressure sensor hub of claim 1, wherein the body comprises: an outer flange defining a perimeter of the pressure sensor hub, a first side of the body, and a second side of the body that faces away from the first side, an outer wall system extending from the outer flange away from the second side of the body, the outer wall system comprising (i) two outer walls that are spaced apart from each other and opposing each other, (ii) an outer wall generally orthogonal to the two outer walls and contiguous with the two outer walls, and (iii) a ledge proximate an edge of the outer wall system, wherein (i) the outer wall system defines an outer chamber further defined by a floor

contiguous with the outer flange and (ii) the printed circuit board is disposed upon the ledge and opposes the floor and with the edge of the outer wall system extending around at least a portion of a perimeter of the printed circuit board, an inner wall system extending from the floor away from the second side of the body within the outer chamber, the inner wall system comprising contiguous inner walls that define an inner chamber that extends through body, a second inner wall system extending from the floor toward the second side of the body, the second inner wall system comprising portions that oppose each other and further define the inner chamber that extends through the body, and a second outer wall system extending from the outer flange away from the first side of the body, the second outer wall system extending contiguously around the second inner wall system, wherein the sensing element of the pressure sensor is disposed within the inner chamber.

3. The pressure sensor hub of claim 2, wherein the electrical connector of the pressure sensor extends through one or more apertures of the printed circuit board, with a portion of the electrical connector being disposed outside of the inner chamber and exposed.

4. The pressure sensor hub of claim 2, wherein the inner wall system further comprises a ledge proximate an edge of the inner wall system, the ledge disposed toward the inner chamber, the pressure sensor hub further comprises a seal that is disposed upon the ledge of the inner wall system and with the inner wall system extending around a perimeter of the seal, and the seal comprises one or more apertures through which the electrical connector of the pressure sensor extends.

5. The pressure sensor hub of claim 2, wherein the printed circuit board comprises a glue aperture in communication with the inner chamber.

6. The pressure sensor hub of claim 2, wherein the inner wall system further comprises heat stake posts that extend from the edge away from the second side of the pressure sensor hub, and the printed circuit board comprises heat stake apertures through which the heat stake posts extend.

7. The pressure sensor hub of claim 1, wherein the printed circuit board further comprises an edge connector.

8. The pressure sensor hub of claim 1, wherein one of the conductive pads is configured to provide supply voltage of the pressure sensor, and another one of the conductive pads is configured to receive signal voltage of the pressure sensor.

9. The pressure sensor hub of claim 1, wherein the pressure sensor hub is a component of a structure, the structure is configured to be a vacuum-insulated structure and comprises a first liner, a second liner opposing the first liner, and a space disposed between the first liner and the second liner, and the pressure sensor hub is disposed on the first liner with the sensing element of the pressure sensor in fluid communication with the space between the first liner and the second liner.

10. A vacuum-insulated structure comprising: a first liner, a second liner opposing the first liner, and a space disposed between the first liner and the second liner; and a pressure sensor hub is disposed on the first liner, the pressure sensor hub comprising: a pressure sensor, the pressure sensor comprising a sensing element and an electrical connector extending from the sensing element; a printed circuit board comprising one or more conductive pads that are exposed, each of the one or more conductive pads in electrical communication with a different portion of the electrical connector of the pressure sensor; and a body that supports the pressure sensor and the printed circuit board, wherein, the sensing element of the pressure sensor is in fluid communication with the space between the first liner and the second liner.

11. The vacuum-insulated structure of claim 10, wherein the vacuum-insulated structure is a component of an appliance.

12. A refrigerator comprising: a vacuum-insulated structure comprising a first liner, a second liner opposing the first liner, and a space disposed between the first liner and the second liner, wherein an air pressure within the space is less than atmospheric air pressure; and a pressure sensor hub disposed on the first liner, the pressure sensor hub comprising (i) a pressure sensor in fluid

communication with the space between the first liner and the second liner, (ii) a printed circuit board in electrical communication with the pressure sensor, and (iii) a body that supports the pressure sensor and the printed circuit board, wherein, the pressure sensor is configured to generate an electrical signal that varies as a function of the air pressure within the space.

13. The refrigerator of claim 12, wherein the printed circuit board includes a substrate and one or more conductive pads supported by the substrate, each of the conductive pads being in electrical communication with the pressure sensor.

14. The refrigerator of claim 13 further comprising: a cabinet that defines a refrigerable compartment; and a door cooperating with the cabinet to provide selective access to the refrigerable compartment from an external compartment, wherein, the door comprises the vacuum-insulated structure.

15. The refrigerator of claim 13, wherein the pressure sensor includes (i) a sensing element in fluid communication with the space between the first liner and the second liner and (ii) an electrical connector extending from the sensing element that transmits electrical signals from the sensing element, the electrical connector being in electrical communication with the one or more conductive pads of the printed circuit board.

16. The refrigerator of claim 15, wherein the body comprises: an outer flange defining a perimeter of the pressure sensor hub, a first side of the body that faces away from the first liner of the vacuum-insulated structure, and a second side of the body that faces away from the first side and toward the first liner, an outer wall system extending from the outer flange away from the second side of the body, the outer wall system comprising (i) two outer walls that are spaced apart from each other and opposing each other, (ii) an outer wall generally orthogonal to the two outer walls and contiguous with the two outer walls, and (iii) a ledge proximate an edge of the outer wall system, wherein (i) the outer wall system defines an outer chamber further defined by a floor contiguous with the outer flange and (ii) the printed circuit board is disposed upon the ledge and opposes the floor and with the edge of the outer wall system extending around at least a portion of a perimeter of the printed circuit board, an inner wall system extending from the floor away from the second side of the body within the outer chamber, the inner wall system comprising contiguous inner walls that define an inner chamber that extends through body, and a second inner wall system extending from the floor toward the second side of the body, the second inner wall system comprising portions that oppose each other and further define the inner chamber that extends through the body, the sensing element of the pressure sensor is disposed within the inner chamber, the inner wall system has an edge disposed away from the first liner and a ledge proximate the edge and disposed inward toward the inner chamber away from the perimeter of the body, and the pressure sensor hub further comprises a seal for the pressure sensor, the seal disposed on the ledge of the inner wall system with the inner wall system extending around a perimeter of the seal, the seal comprising one or more apertures through which the electrical connector of the pressure extends.

17. The refrigerator of claim 16, wherein the pressure sensor hub further comprises glue within the inner chamber of the body between the printed circuit board and the seal, the glue providing an air-tight seal between the printed circuit board and the seal and mechanically bonding the printed circuit board to the body of the pressure sensor hub.

18. The refrigerator of claim 13 further comprising: a cabinet that defines a refrigerable compartment; and a door cooperating with the cabinet to provide selective access to the refrigerable compartment from an external compartment, wherein, the cabinet comprises the vacuum-insulated structure.

19. The refrigerator of claim 12, wherein the printed circuit board further comprises an edge connector configured to make a physical and electrical connection with a card edge connector of a wire harness.

20. The refrigerator of claim 12, wherein the body includes an outer flange that defines a perimeter

of the pressure sensor hub, and the outer flange of the body includes a mating feature that cooperates with a mating feature on the first liner to ensure that the pressure sensor hub is attached to the first liner with the proper orientation.