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(54) **ASSEMBLED MANIFOLD FOR THERMAL RUNAWAY VENT GAS TRANSPORT IN BATTERY SYSTEMS**

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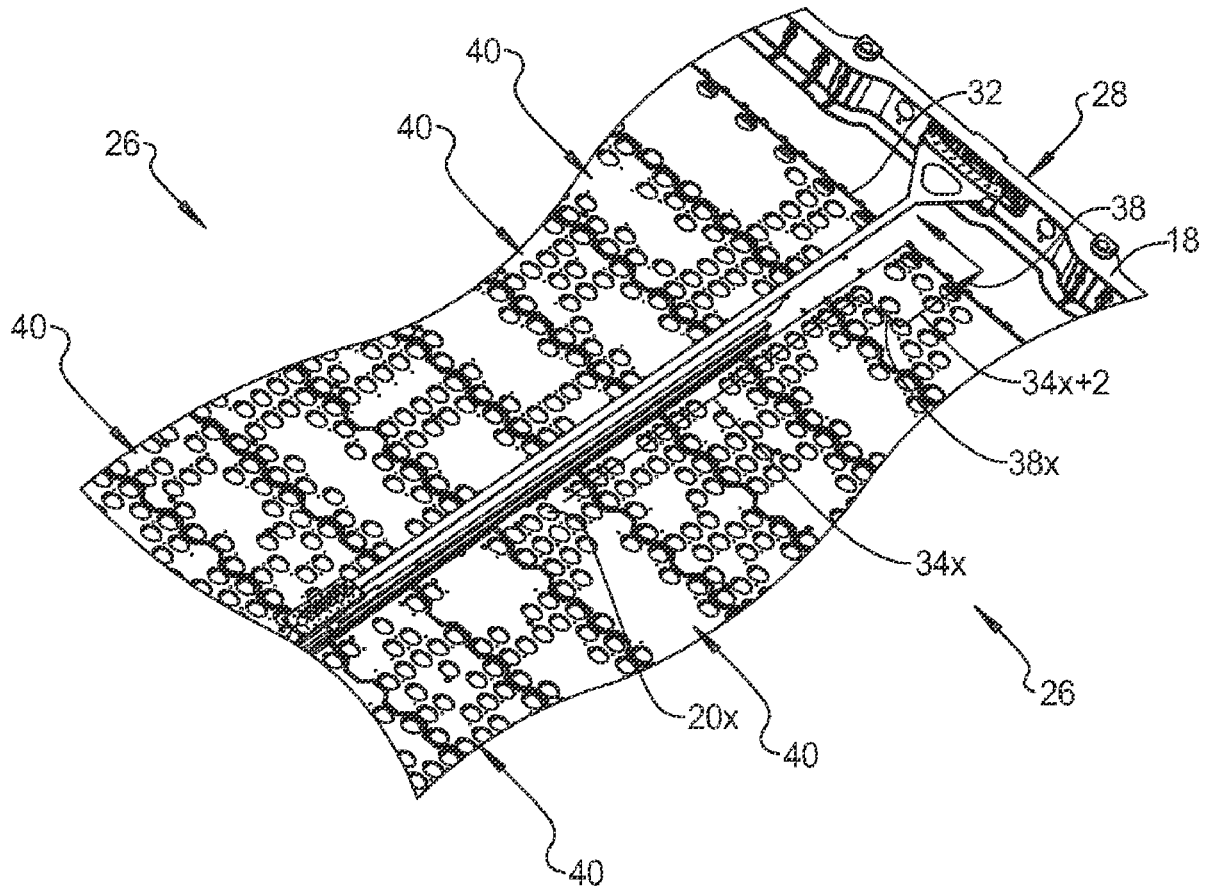
(57) **ABSTRACT**

A battery pack for a vehicle includes a housing including at least one pack vent between an interior and an exterior of the housing; a plurality of battery cells disposed within the housing; and a vent system includes a closed channel network under the cells in connection with a vent of the plurality of battery cells and the at least one pack vent; and a manifold mounted on the closed channel network, a portion of the manifold mounted on the housing including a connector installed from external to the housing that connects the manifold to the closed channel network.



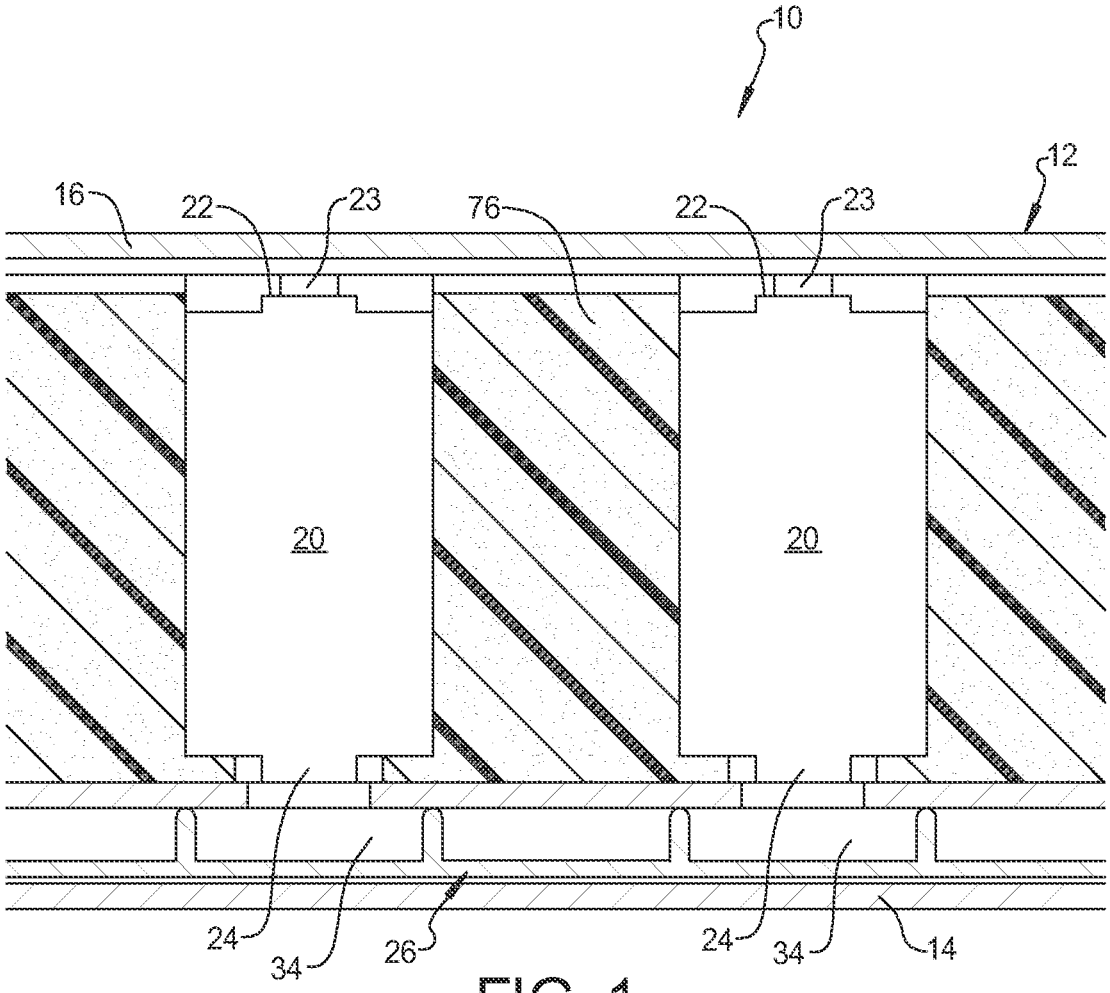


FIG. 1

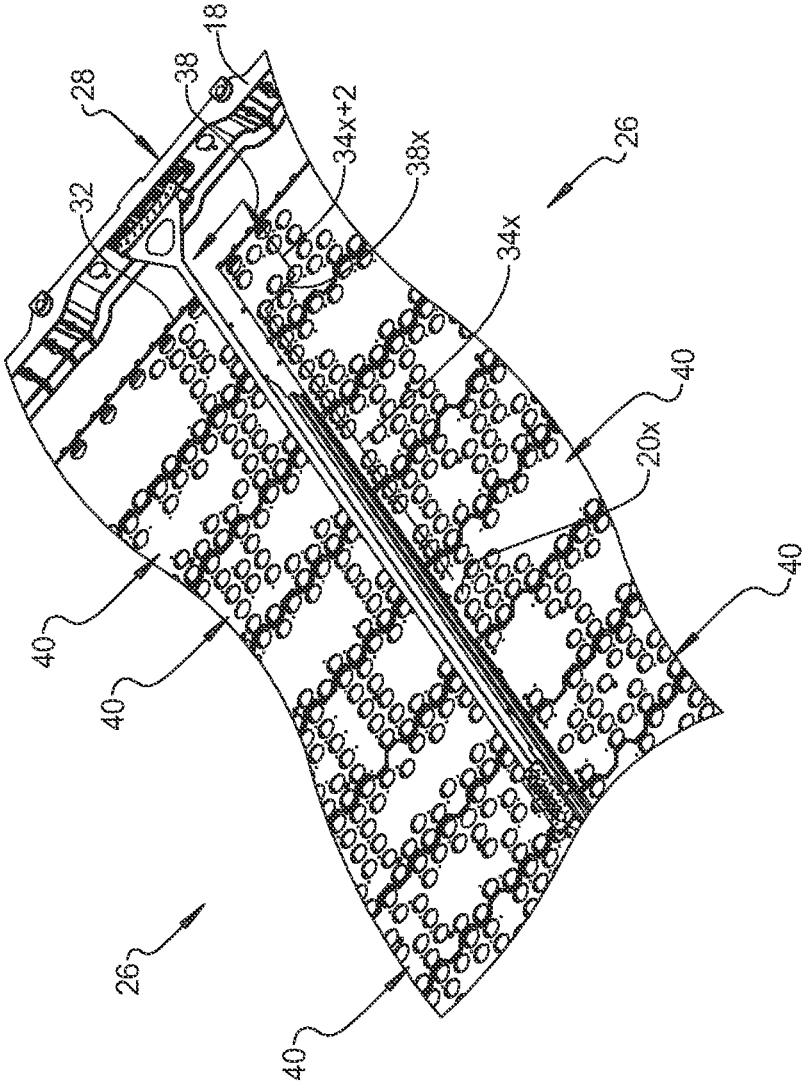


FIG. 2

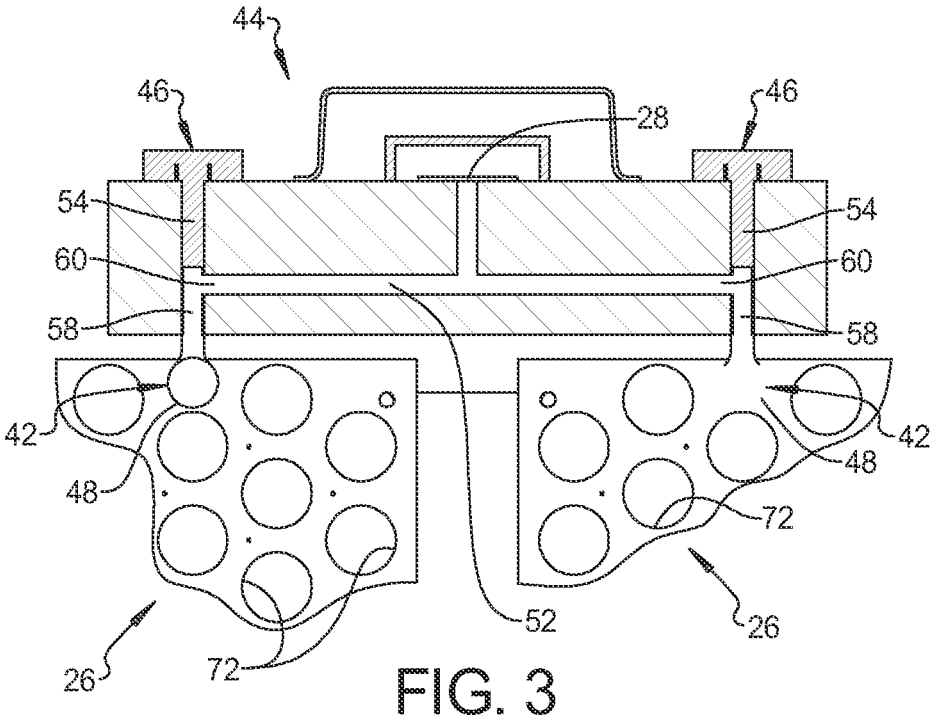

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FIG. 3

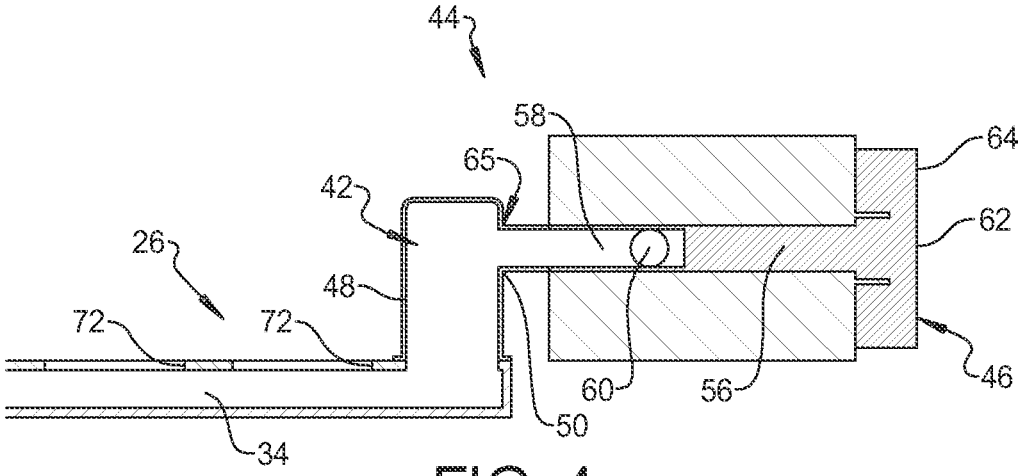
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FIG. 4

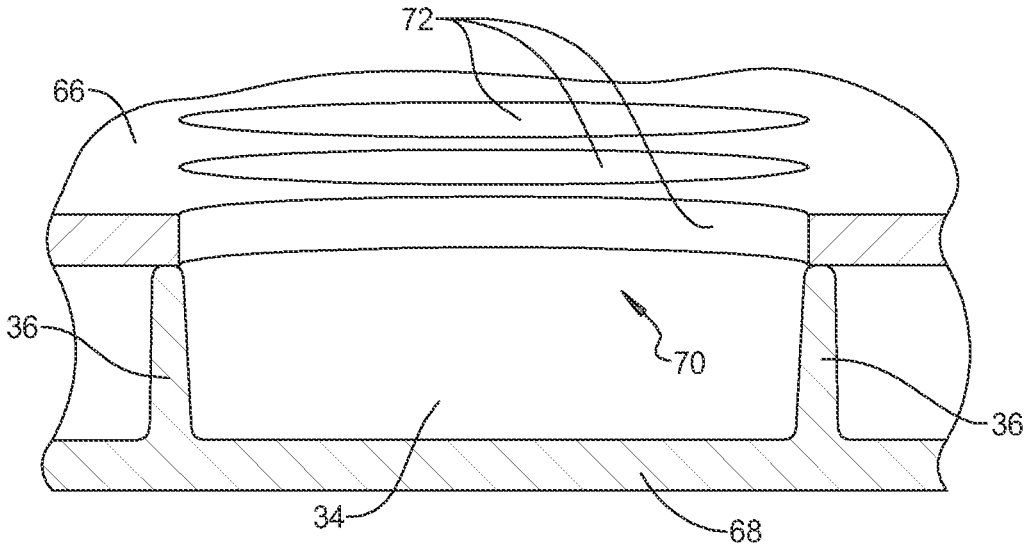

FIG. 5

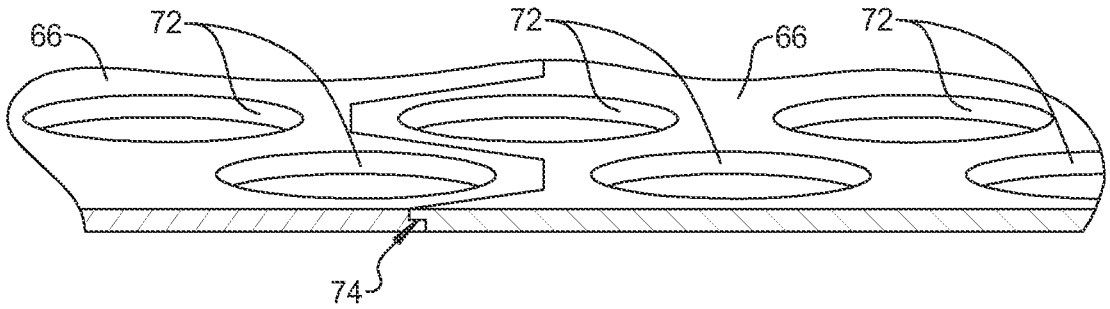

FIG. 6

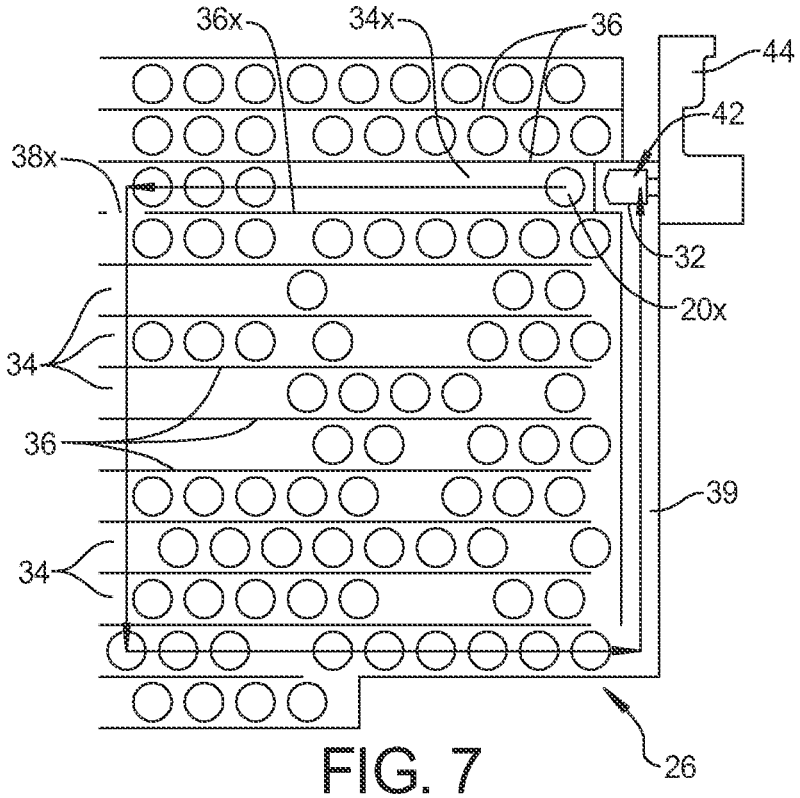

FIG. 7

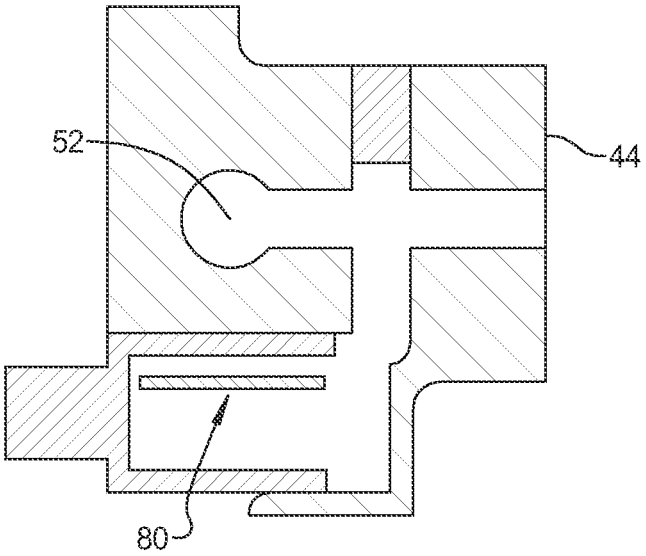

FIG. 8

ASSEMBLED MANIFOLD FOR THERMAL RUNAWAY VENT GAS TRANSPORT IN BATTERY SYSTEMS

INTRODUCTION

[0001] The information provided in this section is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

[0002] Ventilating the battery cells of a battery pack for an electric vehicle is known in the art. The vent system must remain open for gas to traverse during a thermal event so that the gas is able to reach the pack's vent port. The rest of the pack is commonly filled with potting resin (foamed or non-foamed) for electrical isolation, structural performance and thermal insulation. Controlling the position of the potting is challenging. The variability of foam expansion makes the baseline system incompatible with foam potting.

[0003] The present disclosure relates to an assembled manifold for thermal runaway vent gas transport in battery systems.

SUMMARY

[0004] The main objective of the present disclosure is to create a closed volume for the thermal runaway gas vent system. This closed volume cannot be blocked by potting during manufacturing.

[0005] According to an aspect of the present disclosure, a battery pack for a vehicle includes a housing including at least one pack vent between an interior and an exterior of the housing. A plurality of battery cells are disposed within the housing. A vent system includes a closed channel network under the cells in connection with a vent of the plurality of battery cells and the at least one pack vent. A manifold is mounted on the closed channel network, a portion of the manifold mounted on the housing includes a connector installed from external to the housing that connects the manifold to the closed channel network.

[0006] According to another aspect, the pack mounted portion of the manifold includes a sealing material engaging the connector.

[0007] According to another aspect, the sealing material includes a rubber foam.

[0008] According to another aspect, the manifold connects channels coming from at least two modules to a single pack vent.

[0009] According to another aspect, a potting material fills all cavities external to the vent system.

[0010] According to another aspect, the potting material includes one of a blown foam, a syntactic foam, and a non-foamed polymeric resin.

[0011] According to another aspect, the vent system is sealed to prevent potting from entering the vent system during manufacture of the pack.

[0012] According to another aspect, the closed channel network includes a cell channel array.

[0013] According to another aspect, the cell channel array includes at least two pieces per battery module.

[0014] According to another aspect, a gap between the at least two pieces is less than 3 mm.

[0015] According to another aspect, the closed channel network includes cell tray and vent tray stacks sealed with other cell tray and vent tray stacks to create a sealed vent channel battery module.

[0016] According to another aspect, the seal could be achieved using at least one of mechanical joining, fusion bonding, welding, solvent bonding and adhesive bonding.

[0017] According to another aspect, the ends of the cell trays facing another cell tray contain molded features to enable one of snap and press fitting.

[0018] According to another aspect, one of the vent tray and the cell tray include a plurality of ribs defining channels therebetween.

[0019] According to another aspect, a thermal runaway sensor in communication with the channel network.

[0020] According to another aspect, the thermal runaway sensor is mounted in the manifold.

[0021] According to a further aspect, a battery pack for a vehicle includes a housing including at least one pack vent between an interior and an exterior of the housing. A plurality of battery cells are disposed within the housing. A vent system includes a closed channel network under the cells in connection with a vent of the plurality of battery cells and the at least one pack vent. The closed channel network includes cell tray and vent tray stacks sealed with other cell tray and vent tray stacks to create a sealed vent channel battery module. A manifold is mounted on the closed channel network and includes a connector installed from external to the housing that connects the manifold to a cell vent manifold mounted to a cell tray of the closed channel network.

[0022] Further areas of applicability of the present disclosure will become apparent from the detailed description, the claims and the drawings. The detailed description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0024] FIG. **1** is a partial cross-sectional view of a battery pack having a vent system according to the principles of the present disclosure;

[0025] FIG. **2** is a perspective view of a battery vent system with a channel array connecting each battery cell to a pack vent;

[0026] FIG. **3** is a detailed view of the connection between the channel array and the pack vent manifold;

[0027] FIG. **4** is a perspective cut-away view of the connection between the channel array and the pack vent manifold;

[0028] FIG. **5** is a cross-sectional view of the cell tray of the channel array;

[0029] FIG. **6** is a cross sectional view of the interface between adjacent cell trays;

[0030] FIG. **7** is an exemplary schematic view of the channel array system; and

[0031] FIG. **8** is a cross-sectional view of the pack vent manifold.

[0032] In the drawings, reference numbers may be reused to identify similar and/or identical elements.

DETAILED DESCRIPTION

[0033] With reference to FIG. **1**, a battery pack **10** is schematically shown including a housing **12** having a bottom shear plate **14**, a top shear plate **16** and a sidewall enclosure **18** (see FIG. **2**). A plurality of battery cells **20** are disposed within the housing **12**. The battery cells **20** each include electric terminals **22** for connection to a bus bar or other system **23** for electrical connection. The battery cells **20** each include a vent **24** in communication with a vent channel array **26**.

[0034] As shown in FIG. **2**, the channel array **26** connects the vent **24** of each of the battery cells **20** to a pack vent **28** provided in the housing **12** via an outlet port **32** of the channel array **26** that is connected with the pack vent **28**. The channel array **26** includes a plurality of channels **34** separated by a series of ribs **36** that include openings **38** for communicating the vent **24** of each battery cell **20** with the outlet port **32** of the channel array **26**.

[0035] By way of example, as shown in FIG. **7**, the vent from the battery cell **20***x* communicates through a channel **34***x*, through opening **38***x* in rib **36***x* and to channel **34***x*+9 and along a manifold path **39** to the outlet port **32** as indicated by the direction arrows. As shown in FIG. **7**, the ribs **36** include openings **38** to allow the vent **24** of each battery cell **20** to communicate through and across the channels **34** to the outlet port **32**. The channels **34** and the openings **38** can be provided with numerous alternative arrangements for communicating gasses from the battery cells **20** to the outlet port **32**. The system easily enables a longer gas travel path to enable the gas temperature to be reduced prior to the gas exiting the battery pack **10**.

[0036] With reference to FIG. **2**, the channel array **26** is shown being made up of interlocking channel panels **40** that interlock with adjacent channel panels **40** and communicate each battery cell to the outlet ports **32**.

[0037] With reference to FIGS. **3** and **4**, a cell vent manifold **42** to pack vent manifold **44** connection is made by a connector **46** inserted from an exterior of the batter pack **10**. The cell vent manifold **42** includes a cup-shaped body **48** sealingly connected to the channel panel **40** above the outlet port **32**. The cell vent manifold **42** include an aperture **50** in a side thereof. The pack vent manifold **44** supports the pack vent **28** and includes an internal passageway **52** that extends from the pack vent **28** to a pair of apertures **54** that receive the connectors **46**. The connectors **46** include an elongated rod **56** having a passage **58** therein that communicates with an end of the elongated rod and a side aperture **60** that aligns with the internal passageway **52** of the pack vent manifold when the connectors **46** are inserted in the apertures **54**. The connectors **46** can include a head portion **62** that can be connected to the sidewall **18** or pack vent manifold **44** using fasteners **64** or other fastening techniques. The connector **46** utilizes rubber foam gaskets **65** surrounding the aperture **50** in the cell vent manifold **42** that seal over a large area to ensure the potting cannot enter the vent system during manufacturing.

[0038] With reference to FIG. **5-6**, the channel array **26** is shown including battery cell engagement panels **66** and tray panels **68** that combine to define the channels **34** therebetween. The battery cell engagement panels **66** and the tray panels **68** can be formed as injection molded parts. A breakable sheet **70** may be added under the battery cell engagement panels **66** to thermally shield the rest of the cells during a thermal runaway event of the single cell. Sealant may be added to help hold the breakable sheet **70** in place. The breakable sheet **70** may be made from mica, phenolic, or another thermally resilient but brittle material that is breakable in response to a thermal event of a battery cell **20**. The battery cell engagement panels **66** include apertures **72** that communicate with a vent opening of each battery cell **20**. One of the battery cell engagement panels **66** and the tray panels **68** include the ribs **36** for defining the channels **34** of the channel array **26** that communicate each aperture **72** to the outlet port **32**. The ribs **36** can be sealed to the opposing one of the battery cell engagement panel **66** or the tray panel **68** to provide sealed channels **34**. In addition, as shown in FIG. **6**, a scarf joint **74** is provided at an interface of the adjacent battery cell engagement panels **66**. A gap between the scarf joint **74** is less than one half a thickness of the battery cell engagement panel **66** (generally less than 2-3 mm). The battery pack **10** is at least partially filled with potting **76**, as shown in FIG. **1**. The scarf joint **74** prevents the potting **76** from entering the cell channel array **26**. The joint **74** may be further sealed with a sealant or tape. The seal could be achieved using at least one of mechanical joining, fusion bonding, welding, solvent bonding and adhesive bonding. The entire vent system is sealed such that the potting **76** cannot enter the system during manufacture. The potting material **76** includes one of a blown foam, a syntactic foam, and a non-foamed polymeric resin.

[0039] With the channels **34** being sealed, the foam or non-foam potting **76** can be filled to a point that it contacts the upper and lower shear plates **14**, **16**, enabling upper-to-lower shear plate connection through the potting **76**. Once the potting is in place the vent system is sealed sufficiently to contain gas.

[0040] With reference to FIG. **8**, a thermal runaway sensor **80** is shown mounted in the pack vent manifold **44** and is in communication with the gas vent path **52**.

[0041] The battery pack **10** includes a closed ventilation system for transporting and reducing the temperature of discharged gas from a cell undergoing thermal runaway. The purpose of creating this closed system is to ensure potting **66** used to encapsulate the battery cells **20** does not enter the vent system during manufacturing of the battery pack **10**, as well as keep hot vent gases contained and away from the remaining battery cells **20**.

[0042] The foregoing description is merely illustrative in nature and is in no way intended to limit the disclosure, its application, or uses. The broad teachings of the disclosure can be implemented in a variety of forms. Therefore, while this disclosure includes particular examples, the true scope of the disclosure should not be so limited since other modifications will become apparent upon a study of the drawings, the specification, and the following claims. It should be understood that one or more steps within a method may be executed in different order (or concurrently) without altering the principles of the present disclosure. Further, although each of the embodiments is described above as having certain features, any one or more of those features described with respect to any embodiment of the disclosure can be implemented in and/or combined with features of any of the other embodiments, even if that combination is not explicitly described. In other words, the described embodiments are not mutually exclusive, and permutations of one or more embodiments with one another remain within the scope of this disclosure.

[0043] Spatial and functional relationships between elements (for example, between modules, circuit elements, semiconductor layers, etc.) are described using various terms, including "connected," "engaged," "coupled," "adjacent," "next to," "on top of," "above," "below," and "disposed." Unless explicitly described as being "direct," when a relationship between first and second elements is described in the above disclosure, that relationship can be a direct relationship where no other intervening elements are present between the first and second elements, but can also be an indirect relationship where one or more intervening elements are present (either spatially or functionally) between the first and second elements. As used herein, the phrase at least one of A, B, and C should be construed to mean a logical (A OR B OR C), using a non-exclusive logical OR, and should not be construed to mean "at least one of A, at least one of B, and at least one of C."

What is claimed is:

1. A battery pack for a vehicle, comprising:

a housing including at least one pack vent between an interior and an exterior of the housing;

a plurality of battery cells disposed within the housing; and

a vent system includes a closed channel network under the cells in connection with a vent of the plurality of battery cells and the at least one pack vent; and

a manifold mounted on the closed channel network, a portion of the manifold mounted on the housing including a connector installed from external to the housing that connects the manifold to the closed channel network.

2. The battery pack for a vehicle according to claim **1**, wherein the pack mounted portion of the manifold includes a sealing material engaging the connector.

3. The battery pack for a vehicle according to claim **2**, wherein the sealing material includes a rubber foam.

4. The battery pack for a vehicle according to claim **1**, wherein the manifold connects channels coming from at least two modules to a single pack vent.

5. The battery pack for a vehicle according to claim **1**, further comprising a potting material filling all cavities external to the vent system.

6. The battery pack for a vehicle according to claim **5**, wherein the potting material includes one of a blown foam, a syntactic foam, and a non-foamed polymeric resin.

7. The battery pack for a vehicle according to claim **1**, wherein the vent system is sufficiently sealed to prevent potting from entering the vent system during manufacture of the pack.

8. The battery pack for a vehicle according to claim **1**, wherein the closed channel network includes a cell channel array.

9. The battery pack for a vehicle according to claim **8**, wherein the cell channel array includes at least two pieces per battery module.

10. The battery pack for a vehicle according to claim **9**, wherein a gap between the at least two pieces is less than 3 mm.

11. The battery pack for a vehicle according to claim **1**, wherein the closed channel network includes cell tray and vent tray stacks sealed with other cell tray and vent tray stacks to create a sealed vent channel battery module.

12. The battery pack for a vehicle according to claim **11**, wherein the seal could be achieved using at least one of mechanical joining, fusion bonding, welding, solvent bonding and adhesive bonding.

13. The battery pack for a vehicle according to claim **11**, wherein the ends of the cell trays facing another cell tray contain molded features to enable one of snap and press fitting.

14. The battery pack for a vehicle according to claim **11**, wherein one of the vent tray and the cell tray include a plurality of ribs defining channels therebetween.

15. The battery pack for a vehicle according to claim **1**, further comprising a thermal runaway sensor in communication with the channel network.

16. The battery pack for a vehicle according to claim **15**, wherein the thermal runaway sensor is mounted in the manifold.

17. A battery pack for a vehicle, comprising:

a housing including at least one pack vent between an interior and an exterior of the housing;

a plurality of battery cells disposed within the housing; and

a vent system includes a closed channel network under the cells in connection with a vent of the plurality of battery cells and the at least one pack vent, the closed channel network includes cell tray and vent tray stacks sealed with other cell tray and vent tray stacks to create a sealed vent channel battery module; and

a manifold mounted on the closed channel network, a portion of the manifold mounted on the housing including a connector installed from external to the housing that connects the manifold to a cell vent manifold mounted to a cell tray of the closed channel network.

18. The battery pack for a vehicle according to claim **17**, wherein one of the connector and the cell vent manifold include a sealing material for engaging the other of the connector and the cell vent manifold.

19. The battery pack for a vehicle according to claim **18**, wherein the sealing material includes a rubber foam.

20. The battery pack for a vehicle according to claim **17**, further comprising a potting material filling all cavities external to the vent system.

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