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(54) **POWER TOOL AND BATTERY PACK FOR USE WITH THE SAME**

(71) Applicant: **MILWAUKEE ELECTRIC TOOL CORPORATION**, Brookfield, WI (US)

(72) Inventors: **Kyle J. Radovich**, West Bend, WI (US); **James P. Elfering**, Antioch, IL (US); **Zoe L. Hinton**, Milwaukee, WI (US); **Terry L. Timmons**, Oconomowoc, WI (US)

(73) Assignee: **Milwaukee Electric Tool Corporation**, Brookfield, WI (US)

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B25F 5/02 (2006.01)
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CPC ***H01M 50/24*** (2021.01); ***B25F 5/02*** (2013.01); ***H01M 50/213*** (2021.01);
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(58) **Field of Classification Search**
None
See application file for complete search history.

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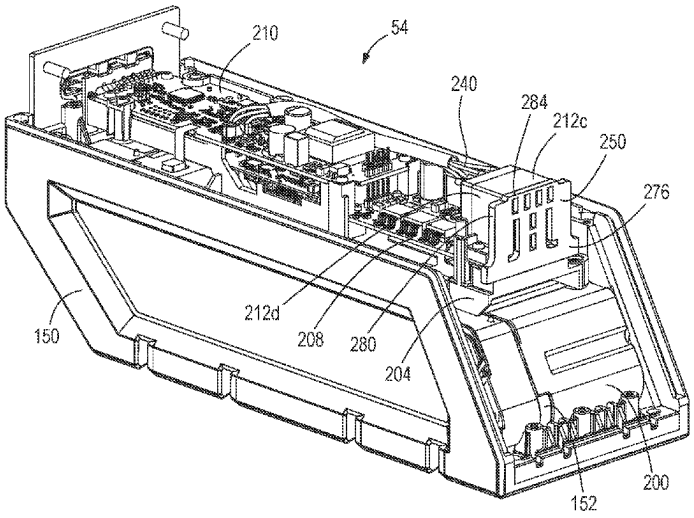
Primary Examiner — Gregg Cantelmo
(74) *Attorney, Agent, or Firm* — Michael Best & Friedrich LLP

(57) **ABSTRACT**

A battery pack for use with a power tool and including a housing having an internal cavity in which one or more battery cells are supported. The housing has a set of openings. A printed circuit board is supported within the housing and in electrical communication with the battery cells. Battery pack contacts are coupled to and in electrical communication with the printed circuit board. A terminal block is supported by the printed circuit board and encloses the battery pack contacts. Each of the battery pack contacts are accessible through one of the set of openings in the housing and the terminal block. A first gasket is positioned between a first wall of the terminal block and the housing and a second gasket is positioned between a second wall of the terminal block and the printed circuit board.

16 Claims, 10 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 62/812,738, filed on Mar. 1, 2019.

(51) **Int. Cl.**

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H01M 50/242	(2021.01)
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H01M 50/296	(2021.01)

(52) **U.S. Cl.**

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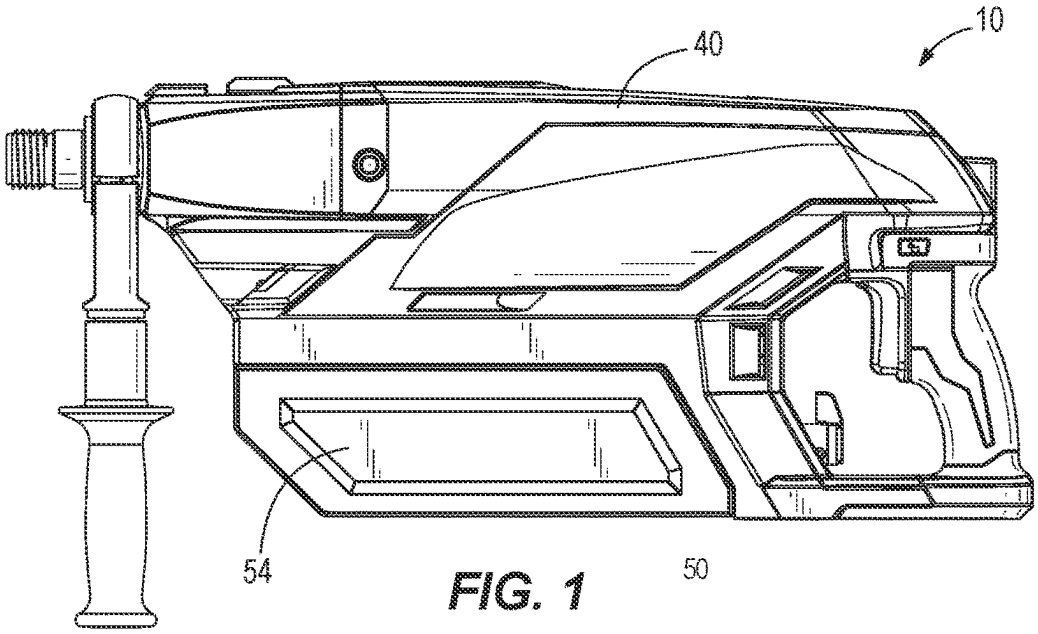
10
40
54
50

FIG. 1

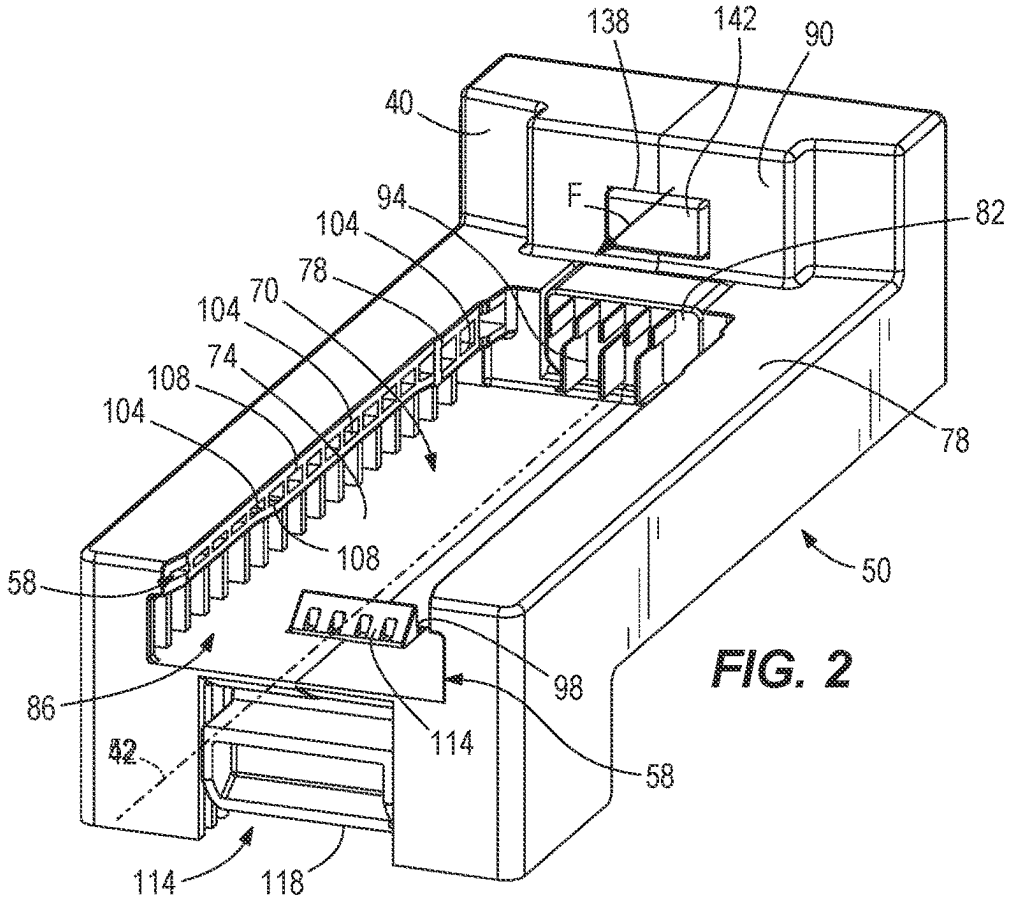
138
142
90
40
F
82
94
104
78
70
104
74
108
104
108
58
78
50
98
86
114
58
42
114
118

FIG. 2

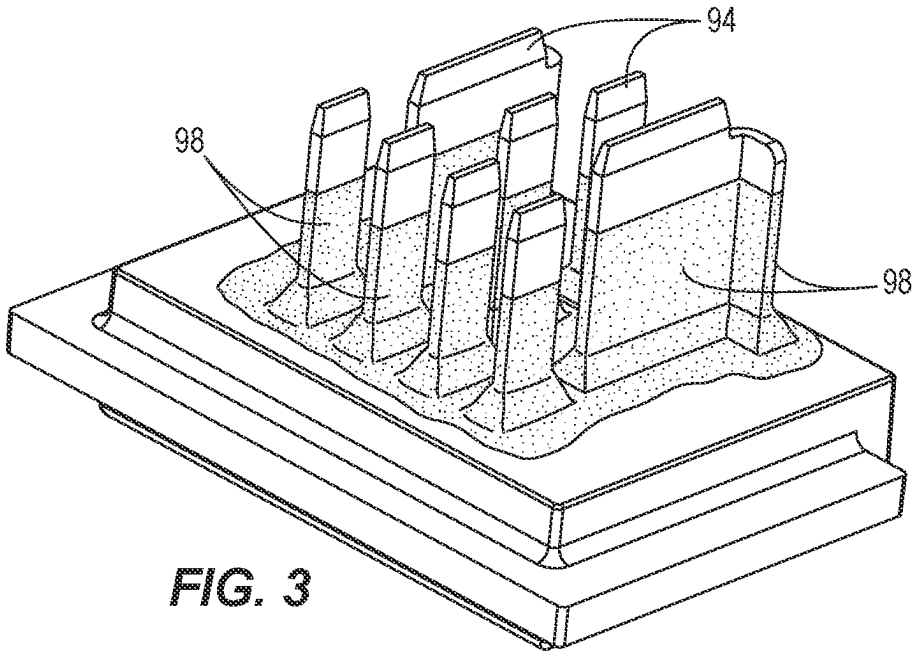

FIG. 3

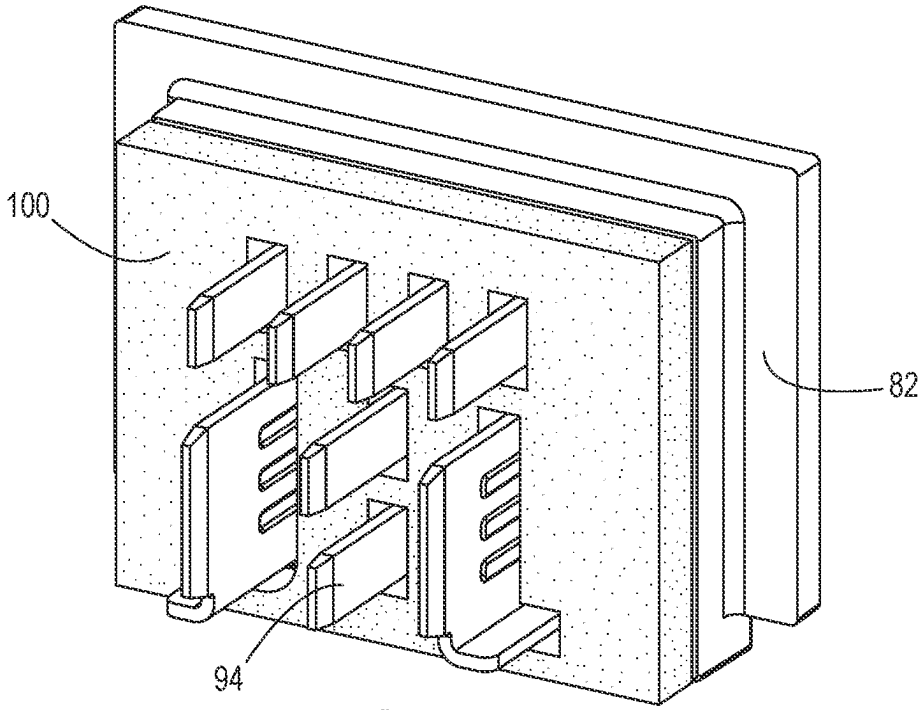

FIG. 4

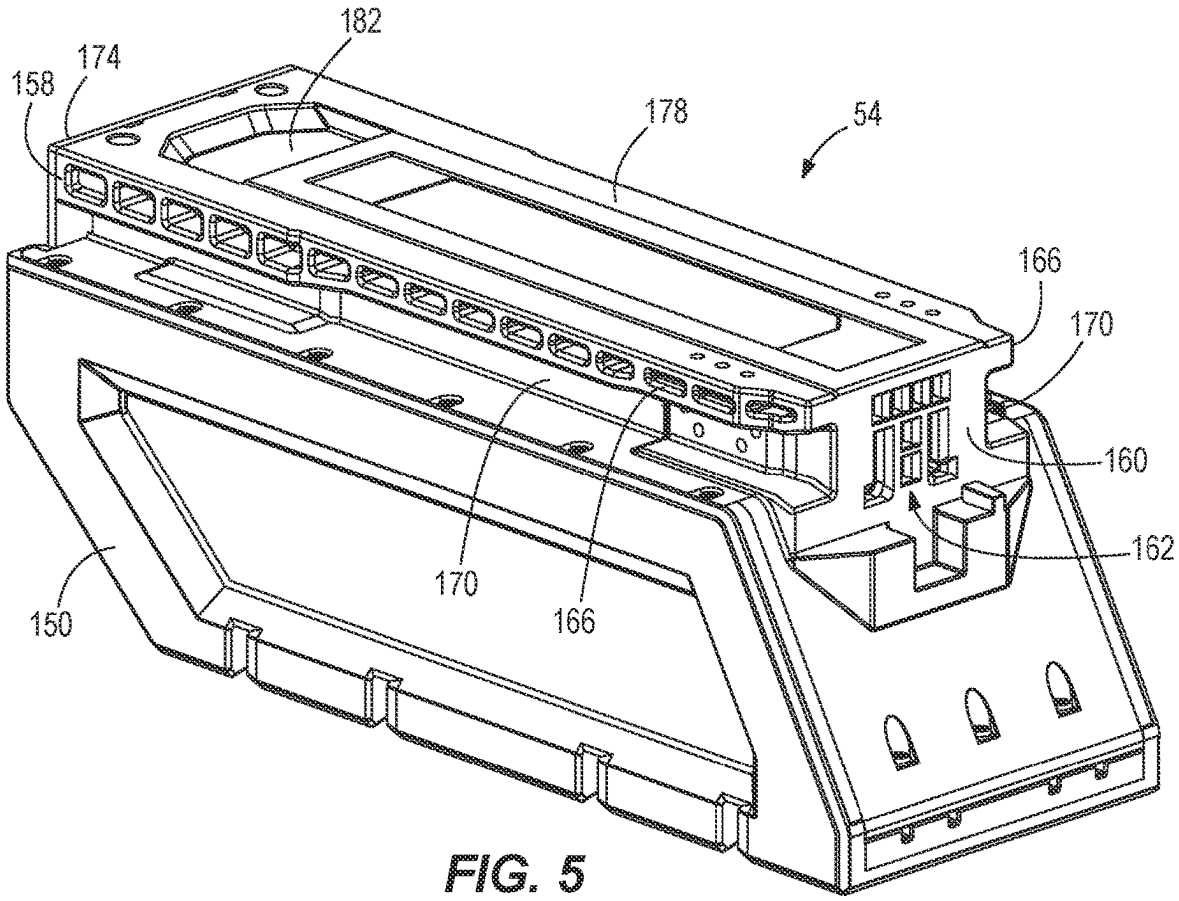

FIG. 5

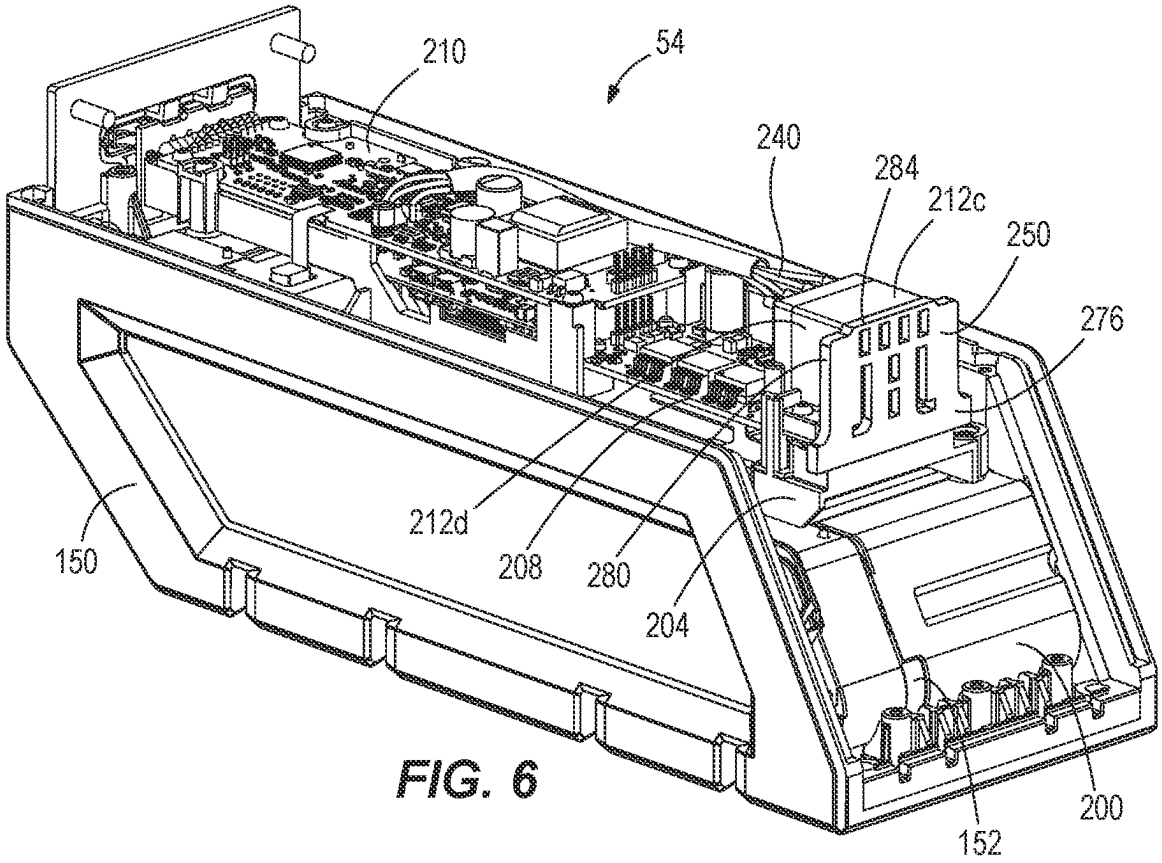

FIG. 6

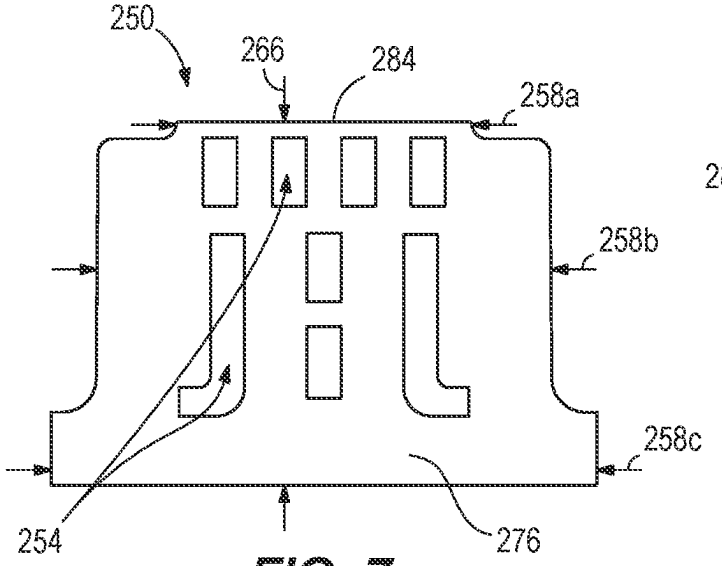

FIG. 7

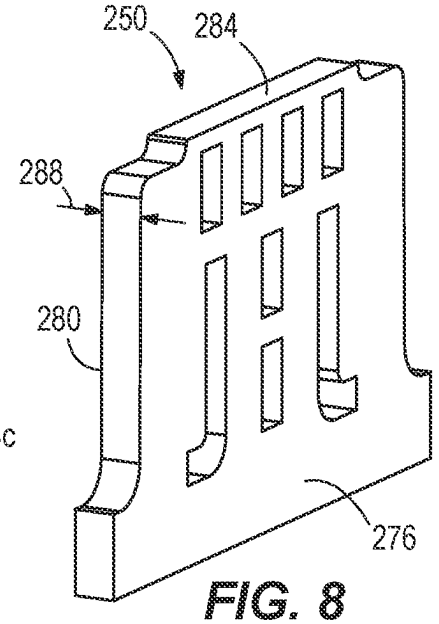

FIG. 8

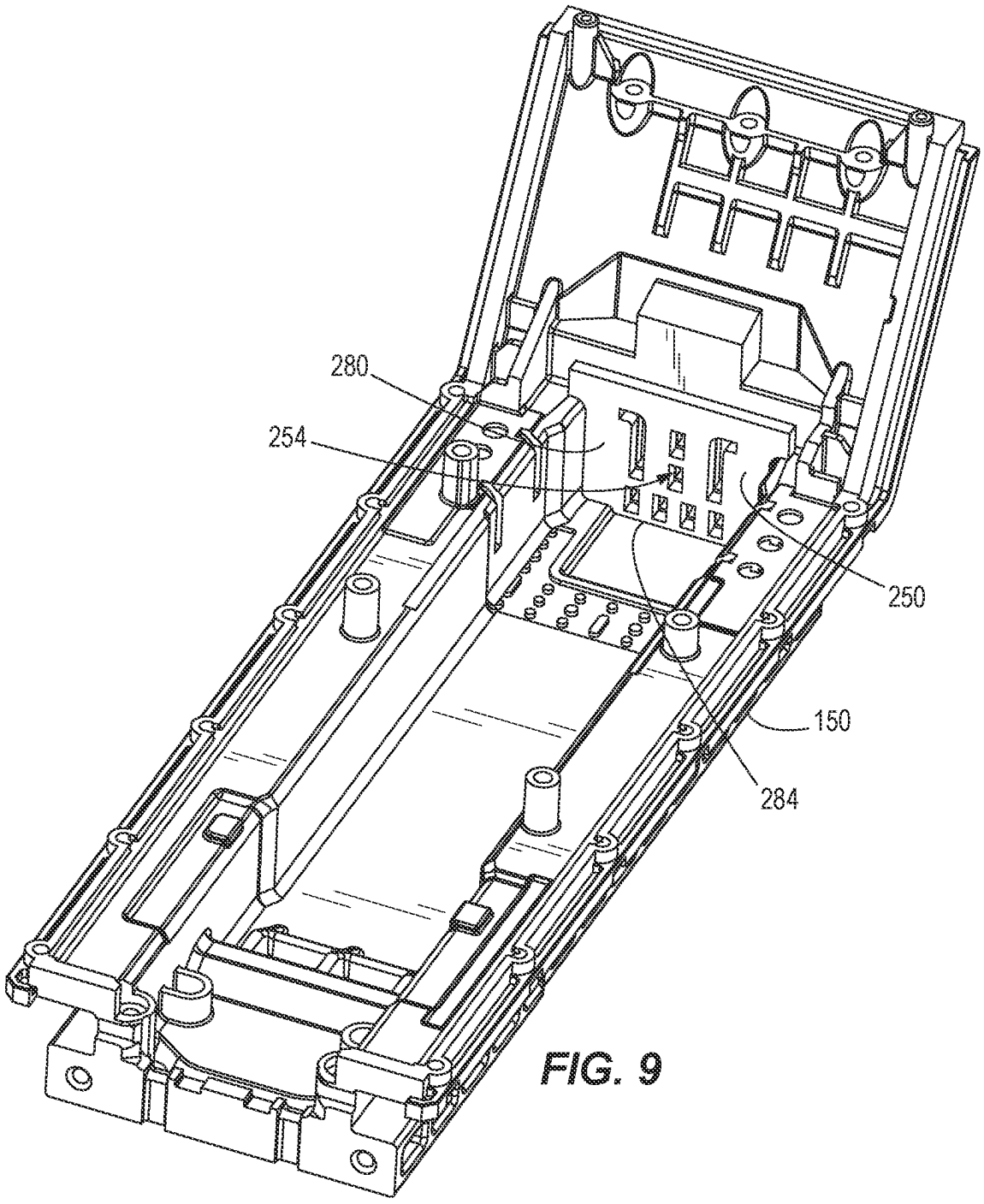

FIG. 9

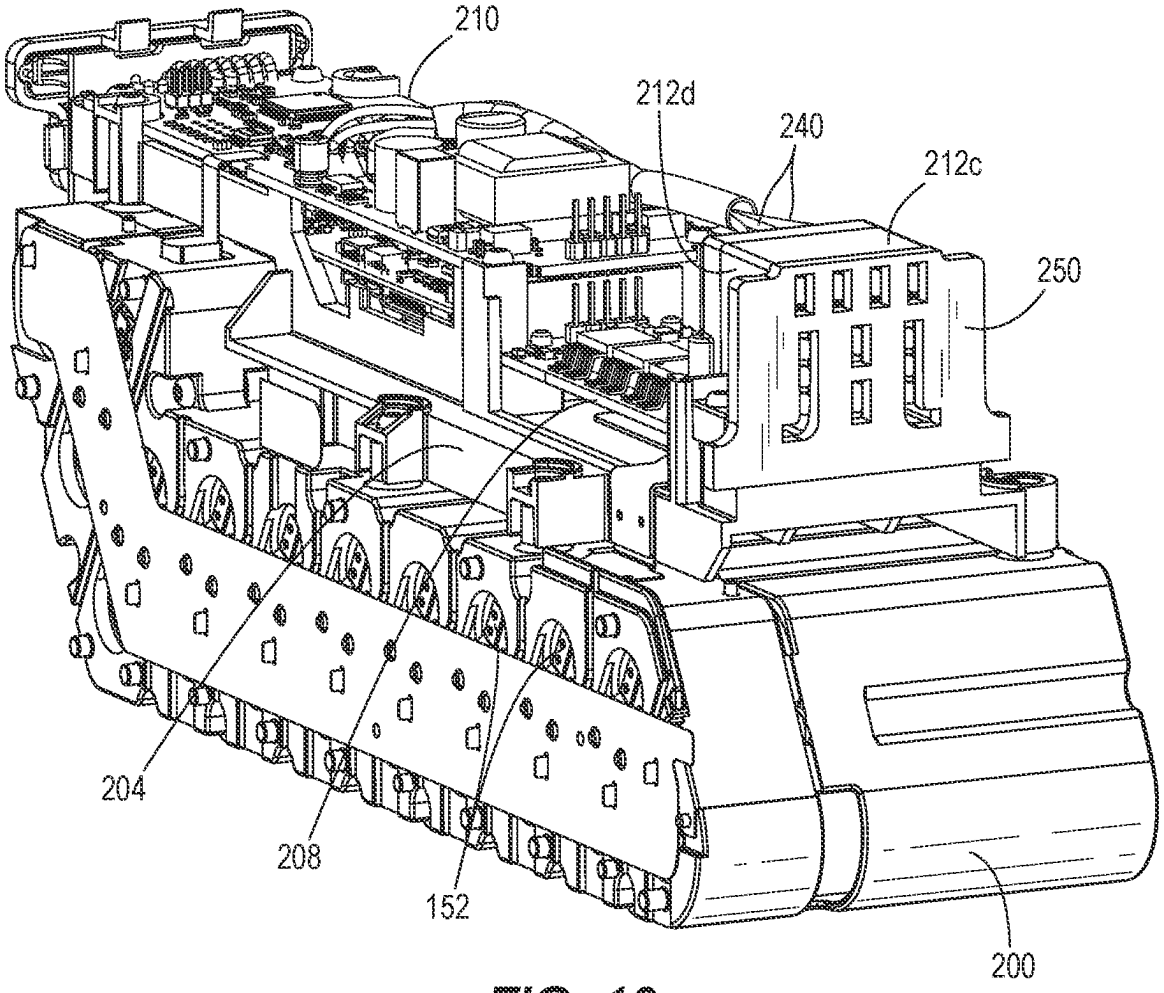

FIG. 10

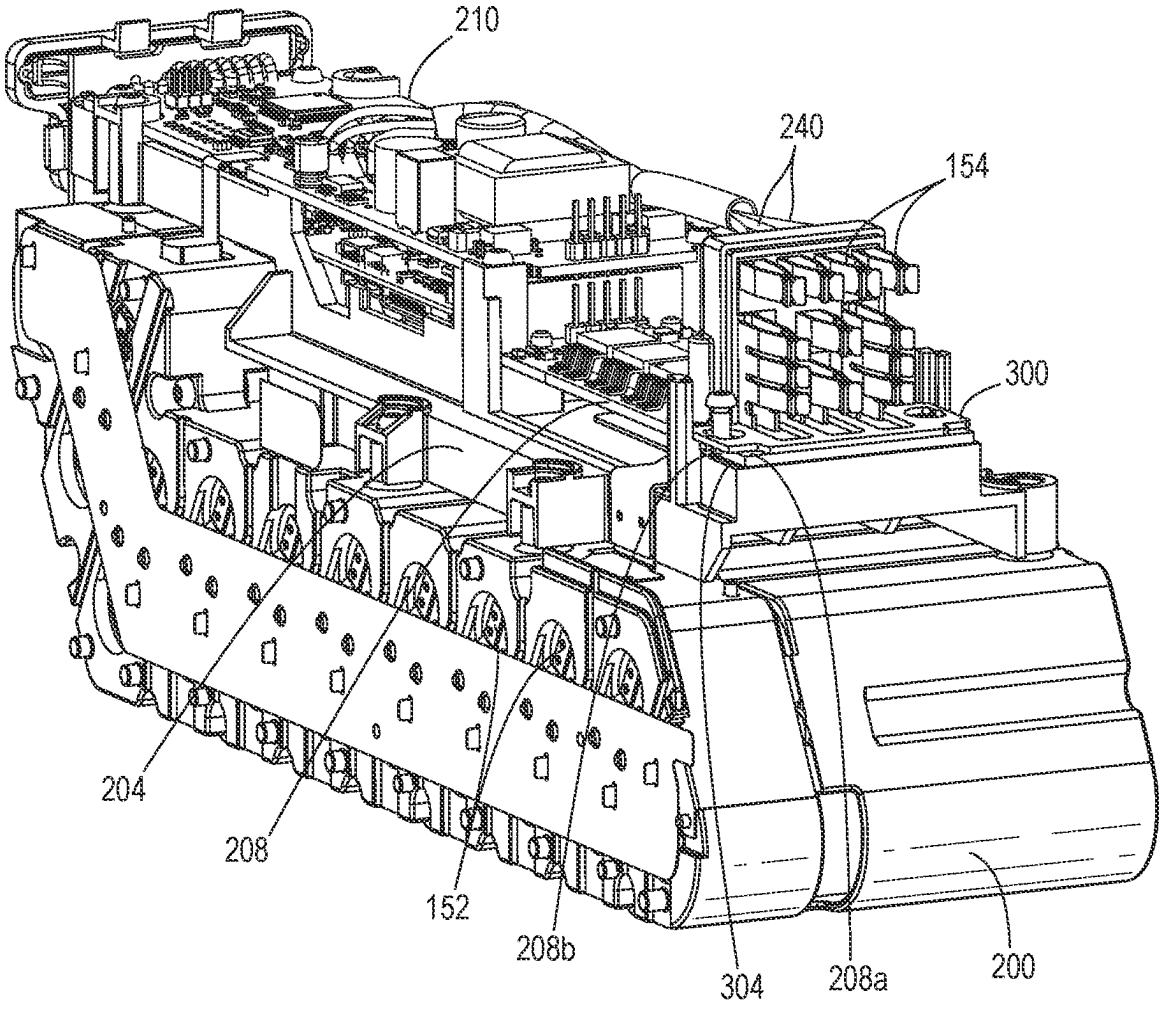

FIG. 11

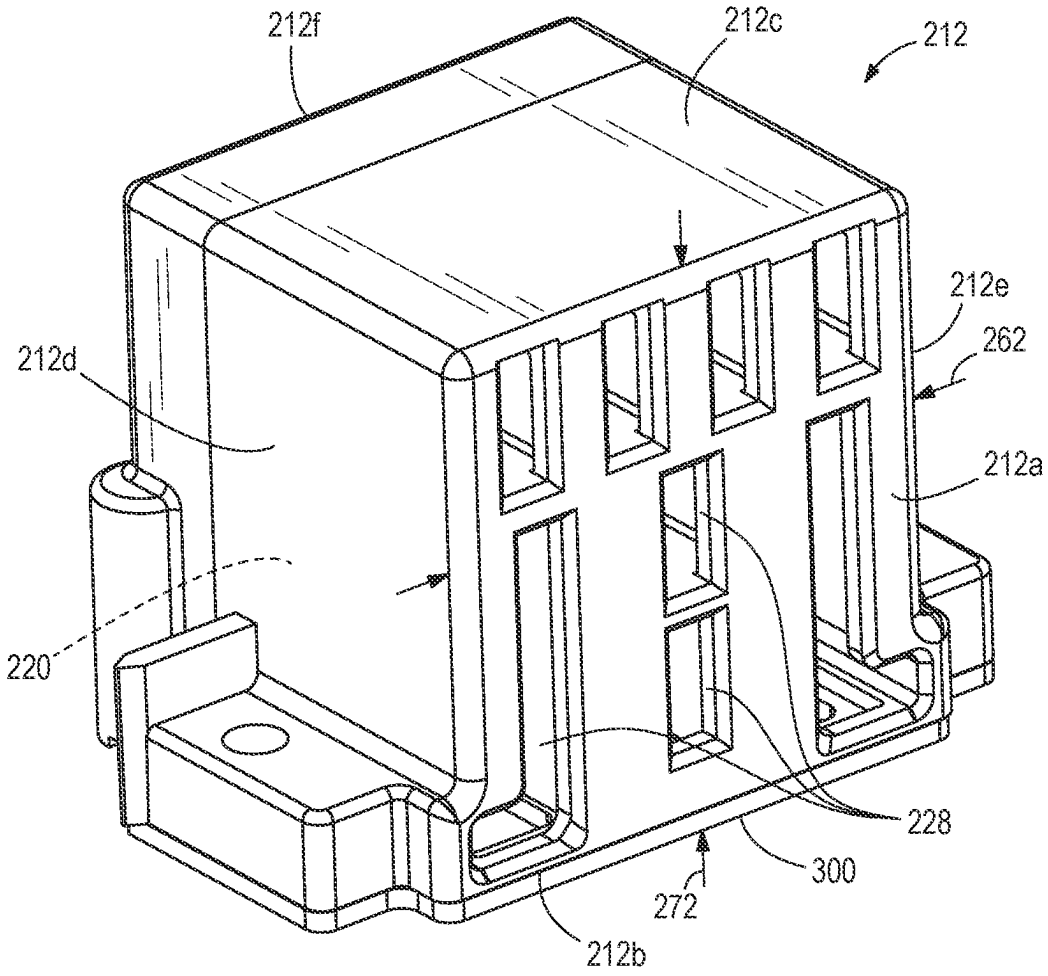

FIG. 12

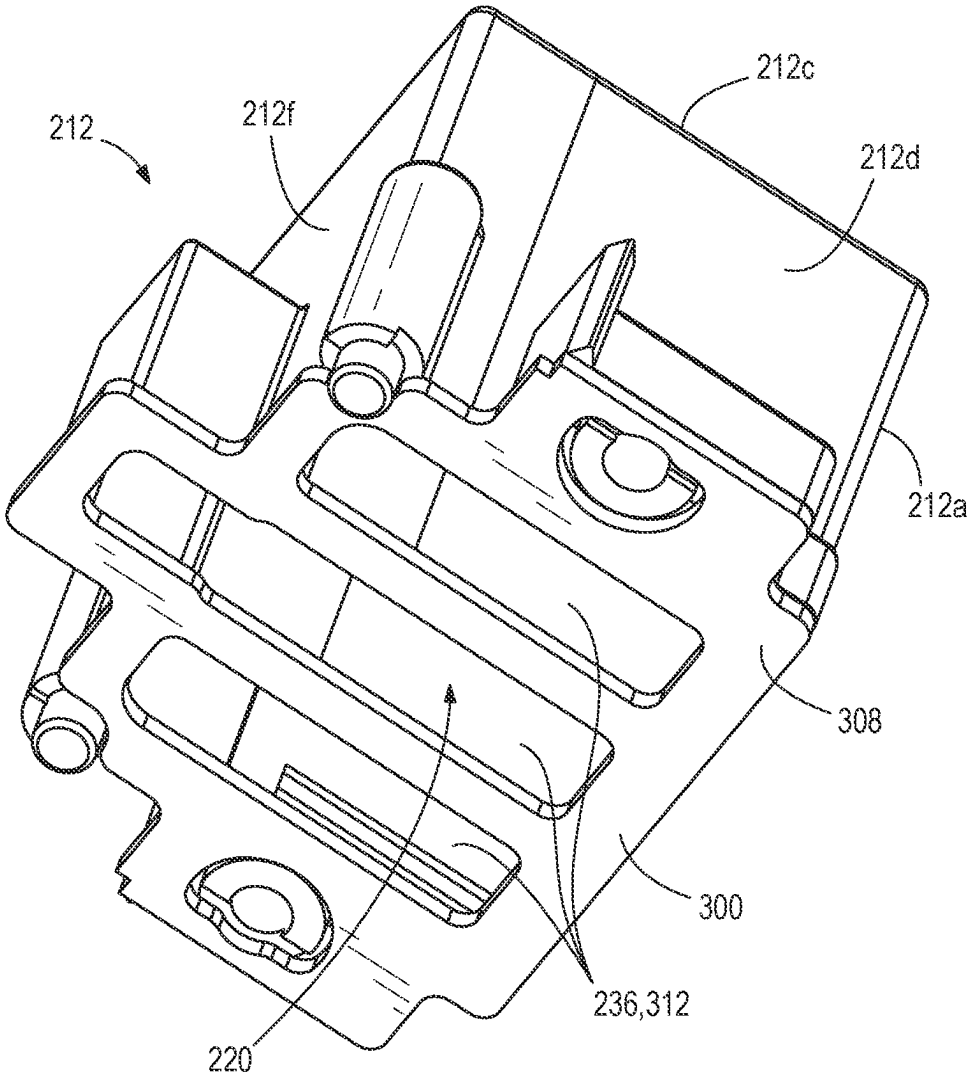

FIG. 13

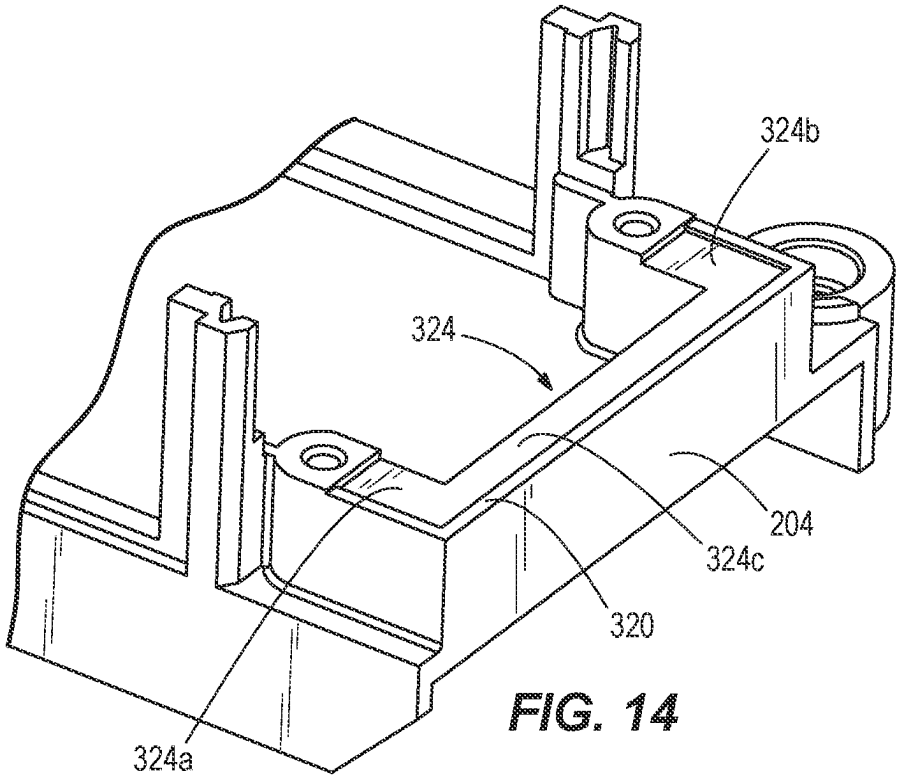

FIG. 14

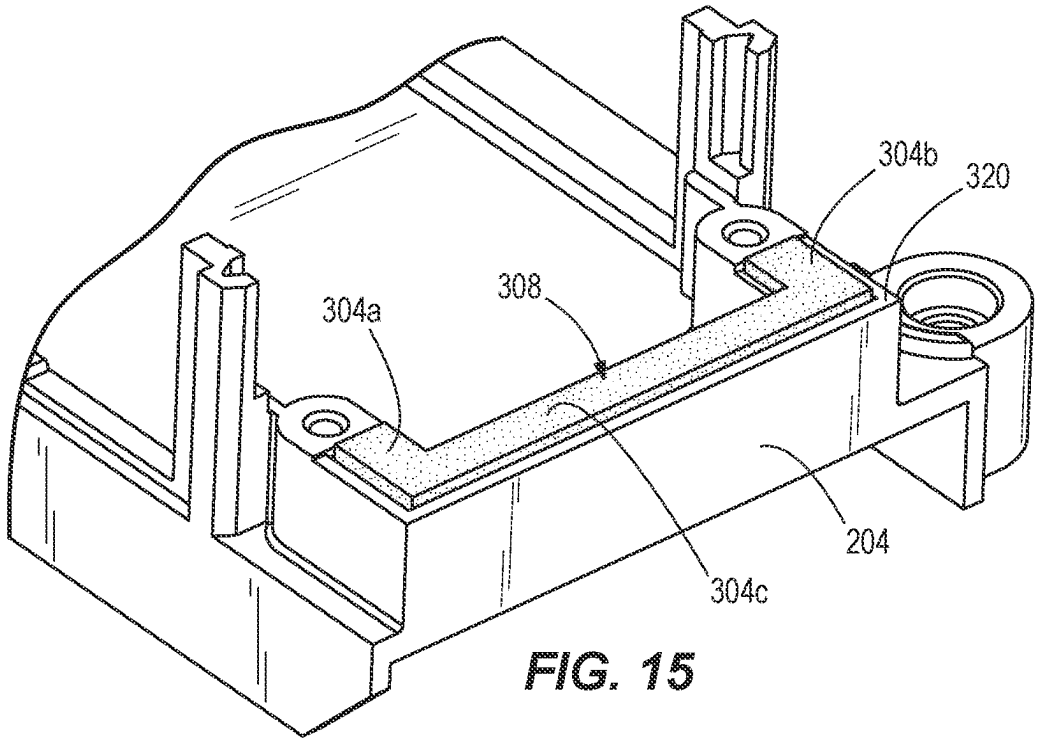

FIG. 15

POWER TOOL AND BATTERY PACK FOR USE WITH THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 16/801,771, filed on Feb. 26, 2020, which claims priority to U.S. Provisional Patent Application No. 62/812,738, filed on Mar. 1, 2019, the entire contents of each of which is incorporated herein by reference.

BACKGROUND

The present invention relates to electric devices (e.g., power tools) and a battery for use with electric devices.

It is important to the health of a power tool and a battery pack for use with a power tool to prevent water and other debris from infiltrating the same. Water and other debris can result in deterioration of the internal components of the power tool and the battery pack.

SUMMARY

In one embodiment a power tool system is disclosed. The power tool system includes a power tool that has a housing with a battery-receiving portion that removably receives a battery pack, and device contacts supported by the housing. The device contacts are configured to mechanically and electrically interface with the battery pack. The battery pack includes a housing that has an internal cavity in which one or more battery cells are supported and a set of openings. A frame member is positioned within the housing. A printed circuit board is supported within the housing by the frame member, and the battery cells are in electrical communication with the printed circuit board. Battery pack contacts are coupled to and in electrical communication with the printed circuit board, and each of the battery pack contacts are accessible through one of the set of openings in the housing. A terminal block is supported by the printed circuit board and encloses the battery pack contacts. The battery pack contacts are accessible through a first wall of the terminal block. A first gasket is positioned between a first wall of the terminal block and the housing, and the first gasket has a surface that abuts the first wall and at least a portion of the frame member. A second gasket is positioned between a second wall of the terminal block and the printed circuit board.

In another embodiment a battery pack for use with a power tool is disclosed. The battery pack includes a housing having an internal cavity in which one or more battery cells are supported and a set of openings. A printed circuit board is supported within the housing, and the battery cells are in electrical communication with the printed circuit board. Battery pack contacts are coupled to and in electrical communication with the printed circuit board, and each of the battery pack contacts are accessible through one of the set of openings in the housing. A terminal block is supported by the printed circuit board and encloses the battery pack contacts. The terminal block includes a wall having a first set of openings, and each of the openings in wall correspond to one of openings in the housing. A gasket is positioned between the first wall of the terminal block and the housing. The gasket includes a set of openings, and each of the openings corresponds to one of the openings in the housing of the battery pack and one of the set of openings in the terminal block.

In another embodiment a battery pack for use with a power tool is disclosed. The battery pack includes a housing having an internal cavity in which one or more battery cells are supported and a set of openings. A printed circuit board is supported within the housing, and the battery cells are in electrical communication with the printed circuit board. Battery pack contacts are coupled to and in electrical communication with the printed circuit board. A terminal block is supported by the printed circuit board and encloses the battery pack contacts. Each of the battery pack contacts are accessible through one of the set of openings in the housing and the terminal block. A first gasket is positioned between a first wall of the terminal block and the housing. The first gasket includes a first surface, a second surface that is opposite the first surface, and a third surface. The first surface is in contact with a first surface of the housing, the second surface is in contact with the wall of the terminal block, and the third surface is in contact with a second surface of the housing. A second gasket is positioned between a second wall of the terminal block and the printed circuit board.

Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTIONS OF THE DRAWINGS

FIG. **1** is a side view of a battery pack coupled to an electric device having a battery-receiving portion.

FIG. **2** is a perspective view of the battery-receiving portion shown in FIG. **1** including electric device terminals.

FIG. **3** is a perspective view the electric device terminals of FIG. **2**.

FIG. **4** is another perspective view the electric device terminals of FIG. **2**.

FIG. **5** is a perspective view of the battery pack shown in FIG. **1** including a housing.

FIG. **6** is a perspective view of the battery pack shown in FIG. **5** with a portion of the housing removed and showing a first gasket.

FIG. **7** is a front view of the first gasket of FIG. **6**.

FIG. **8** is a perspective view of the first gasket of FIG. **6**.

FIG. **9** is a perspective view of a portion of the housing of the battery pack and the first gasket.

FIG. **10** is a perspective view of the battery pack of FIG. **5** with the housing removed, the battery pack including a first gasket.

FIG. **11** is a perspective view of the battery pack of FIG. **5** with the housing, the first gasket, and a portion of the terminal block removed.

FIG. **12** is a perspective view of the terminal block and a second gasket.

FIG. **13** is another perspective view of the terminal block and the second gasket.

FIG. **14** is a perspective view of the auxiliary frame member.

FIG. **15** is a perspective view of the auxiliary frame member with a third gasket.

Before any independent embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other independent embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and termi-

nology used herein is for the purpose of description and should not be regarded as limiting.

Use of "including" and "comprising" and variations thereof as used herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Use of "consisting of" and variations thereof as used herein is meant to encompass only the items listed thereafter and equivalents thereof. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings.

Also, the functionality described herein as being performed by one component may be performed by multiple components in a distributed manner. Likewise, functionality performed by multiple components may be consolidated and performed by a single component. Similarly, a component described as performing particular functionality may also perform additional functionality not described herein. For example, a device or structure that is "configured" in a certain way is configured in at least that way but may also be configured in ways that are not listed.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates an electric device **10** configured to receive a battery pack **54** (e.g., a rechargeable lithium-ion battery pack). In the illustrated embodiment, the electric device is a drill, but the electric device may be any type of power tool, an outdoor tool, or a non-motorized device (e.g., a light, an audio device, etc.).

With reference to FIGS. **1** and **2**, the electric device includes a housing **40** including a battery-receiving portion **50** that defines a longitudinal axis **52** (i.e., battery insertion axis) and has a cavity **70** defined by a lower surface **74**, a pair of sidewalls **78**, and an end wall **82**. An open end **86** is opposite the end wall **82**. In addition, an upper end wall **90** extends above the end wall **82** proximate the cavity **70**. Device contacts **94** are supported on the end wall **82** and are configured to mechanically and electrically interface with the battery pack **54** to transfer electrical power therebetween.

As shown in FIG. **3**, in one embodiment, at least a portion of the device contacts **94** include a coating **98** that is an insulator. In the illustrated embodiment, the insulator is a spray acrylic, but the insulator may have any suitable formulation. Additionally, and as shown in FIG. **4**, in another embodiment, a tool gasket **100** is positioned against the end wall **82** and adjacent to and surrounding the device contacts **94**. The gasket **100** compresses when a battery pack **54** is inserted.

With renewed reference to FIG. **2**, the battery-receiving portion **50** includes stepped grooves **104** extending between the open end **86** and the end wall **82** (e.g., as illustrated, from the open end **86** to the end wall **82**). The stepped grooves **104** are defined by rails **108** disposed on the sidewalls **78**. The rails **108** protrude from the sidewalls **78** to define an upper extent of the grooves **104** that face the lower surface **74**.

In the illustrated embodiment, the battery-receiving portion **50** also includes a latching mechanism **114** that protrudes from the lower surface **74** near the open end **86**. The latching mechanism is coupled to an actuator **118**. The latching mechanism **114** has a first position and a second position. The latching mechanism **114** is biased (i.e., by a spring or cam member, etc.) into the first position. In the first position, the latching mechanism **114** is configured to engage the battery pack **54** to maintain engagement between the battery pack **54** and the electrical device **10** within the battery-receiving portion **50**. However, in other embodiments (not shown), the latching mechanism **114** may be disposed at various locations (e.g., on a sidewall **78**, the end wall **82**, the upper end wall **90**, etc.) such that the latching mechanism **114** engages corresponding structure on the battery pack **54** to maintain engagement between the battery pack **54** and electrical device **10** and retain the battery pack **54** within the battery-receiving portion **50**. In the second position, the latching mechanism **114** is positioned within the housing **40** such that the battery pack **54** is insertable into and removable from the cavity **70** without engaging with the latch mechanism **114**. The actuator **118** is movable to move the latching mechanism **114** from the first position to the second position.

With further reference FIG. **2**, an ejector **138** is supported on the end wall **90**. The ejector **138** includes an ejection member **142** biased by a biasing member (e.g., one or more springs (not shown)) to protrude through the end wall **90**. When the battery pack **54** is attached to the battery-receiving portion **50** of the housing **40**, the ejection member **142** is pushed into the end wall **90** to compress the biasing member. From this position, the ejector **138** is configured to exert a force F on the battery pack **54** to push the battery pack **54** out of the battery-receiving portion **50** (e.g., upon release of the latching mechanism **114**).

FIGS. **5**, **6**, and **10** illustrate the battery pack **54** for use with the battery-receiving portion **50**, described above. The battery pack **54** includes a housing **150** defining an internal cavity in which one or more battery cells **152** are supported. Each battery cell **152** may have a nominal voltage between about 3 V and about 5 V and may have a nominal capacity between about 2 Ah and about 6 Ah (in some cases, between about 3 Ah and about 5 Ah). The battery cells **152** may be any rechargeable battery cell chemistry type, such as, for example, lithium (Li), lithium-ion (Li-ion), other lithium-based chemistry, nickel-cadmium (NiCd), nickel-metal hydride (NiMH), etc.

The battery cells **152** may be connected in series, parallel, or combination series-parallel to provide the desired electrical characteristics (e.g., nominal voltage, current output, current capacity, power capacity, etc.) of the battery pack **54**. The battery cells **152** are electrically coupled to battery pack contacts **154** (FIG. **11**) supported on or within the housing **150** and configured to electrically and mechanically engage the device contacts **94** to facilitate the transfer of electrical power between the device **10** and the battery pack **54**.

Further with respect to FIG. **5**, the housing **150** includes a protrusion **158** supporting, at a front end **160**, the battery pack contacts **154** (FIG. **11**). In particular, the front end **160** includes a set of openings **162**. Each of the openings **162** corresponds to one of the battery pack contacts **154**. On each lateral side, a rail **166** extends laterally outwardly and to define a groove **170**. Proximate a rear end **174**, a top surface **178** defines a slot or recess 182 sized and shaped to cooperate with the latch mechanism **114**.

The battery pack **54** is coupled to the battery-receiving portion **50** by aligning the rails **166** of the battery pack **54** with the grooves **58** of the battery-receiving portion **50**, and subsequently sliding the battery pack **54** along a battery insertion axis **52** until the device contacts **94** engage the battery pack contacts **154**.

It should be understood that, if the size and shape of the battery-receiving portion **50** is modified, corresponding variations in the size and shape of the battery pack **54** may be made. For example, the geometric configuration of the

rails **108**, **166** will be consistently varied in order to maintain the mating engagement between the battery pack **54** and the battery-receiving portion **50**. It should be understood that, in other constructions (not shown), the orientation of the rails **108**, **166** may be reversed with the rails **108** being directed outwardly and the rails **166** being directed inwardly.

As shown in FIGS. **6** and **10**, positioned within the housing **150** is a battery cell holder **200**, an auxiliary frame member **204**, a first printed circuit board (PCB) **208**, a second printed circuit board **210**, and a terminal block **212** (FIGS. **12** and **13**). As shown in FIG. **10**, the battery cell holder **200** restrains the battery cells **152**. The auxiliary frame member **204** is positioned on one side of the battery cell holder **200** within the housing **150**. The battery cells **152** are in electrical communication with the first PCB **208**. The first PCB **208** has a first surface **208***a* and a second surface **208***b* opposite the first surface **208***a* (FIG. **11**), and the first PCB **208** is supported by the auxiliary frame member **204**. The battery pack contacts **154** are coupled to, extend from, and are in communication with the first PCB **208**. The terminal block **212** is supported by the first PCB **208** and encloses the battery pack contacts **154**.

With respect to FIGS. **12** and **13**, the terminal block **212** has a first wall **212***a*, a second wall **212***b*, a third wall **212***c*, a fourth wall **212***d*, a fifth wall **212***e*, and a sixth wall **212***f* The six walls **212***a*-**212***f* define an interior compartment **220** in which the battery pack contacts **154** are positioned. The first or front wall **212***a* has a first set of openings **228** that extend therethrough. Each of the openings **228** corresponds to one of the battery pack contacts **154**. Accordingly, each of the first openings **228** is sized and shaped to receive the respective mating device contact **94**. The second or bottom wall **212***b* has a second set of openings **236** that extend therethrough. The bottom wall **212***b* (and therefore the second openings **236**) are positioned to face the first PCB **208**, such that the battery pack contacts **154** extend from the first PCB **208** through the second plurality of openings **236** and into the interior **220** of the terminal block **212**. The third or top wall **212***c* of the terminal block **212**, the fourth wall **212***d* (e.g., first sidewall), fifth wall **212***d* (e.g., second sidewall), and the sixth or rear wall **212***f* are closed (i.e., have no openings). The four closed walls **212***c*-**212***f* help prevent fluid and other debris from entering into the terminal block **212**.

With respect to FIGS. **6**-**9**, a first gasket **250** is positioned adjacent to the front wall **212***a* of the terminal block **212**. That is, the first gasket **250** is positioned between and in contact with the terminal block **212** and the housing **150**. The first gasket **250** includes openings **254**, each of which corresponds to one of the openings **162** in the housing **150** of the battery pack and one of the first openings **228** in the terminal block **212**. Moreover, each of the openings **254** corresponds to one of the battery pack contacts **154**. Accordingly, each of the openings **254** is sized and shaped to receive the respective mating device contact **94**. Each of the openings **254** in the first gasket **250** entirely surround the respective opening **228** in the terminal block **212**. In the illustrated embodiment, the first gasket **250** covers and extends beyond an outer periphery of the first wall **212***a* of the terminal block **212**. That is, the first gasket **250** has a greater width **258** than a width **262** (FIG. **12**) of the terminal block **212** and a greater height **266** than a height **272** (FIG. **12**) of the terminal block **212**. More specifically, the first gasket **250** includes a first width **258***a*, a second width **258***b* that is greater than the first width **258***a*, and a third width **258***c* that is greater than the second width **258***c*. Each of the widths **258***a*-**258***c* is greater than the width **262** of the terminal block **212**. In other or additional embodiments, the first gasket **250** may have a smaller width **258** than the width **262** of the terminal block **212** and a smaller height **266** than the height **272** of the terminal block **212**, as long as the first gasket **250** has a width and height sufficient to entirely surround the openings **228** in the terminal block **212**.

Additionally, and with respect to FIG. **7**, the first gasket **250** includes a first or front surface **276** that abuts a surface of the housing **150**, a second or rear surface **280** that is opposite the front surface **276**, and a third or top surface **284** that abuts another surface of the housing **150**. The first width **258***a* corresponds to the top surface **284**. The rear surface **280** of the first gasket **250** abuts both the front wall **212***a* of the terminal block **212** and at least a portion of the auxiliary frame member **204**. A thickness **288** of the first gasket is defined between the front and rear surfaces **276**, **280**. The thickness **288** corresponds to and fills a gap (not shown) between the terminal block **212** and the housing **150**. The gap is defined by a distance between the front wall **212***a* of the terminal block **212** and the housing **150**. The first gasket **250** creates a seal between the openings **162** in the housing **150** and the openings **228** in the terminal block **212**. Accordingly, the first gasket **250** prevents fluid and other debris from entering the housing **150** through the openings **162**, and also prevents any fluid and debris that may be in the housing from entering into the terminal block **212**. Moreover, the first gasket **250** acts as an anti-vibration mechanism by taking up the gap between the terminal block **212** and the housing **150**. That is, the first gasket is configured to reduce vibration between the housing and the terminal block.

As shown in FIGS. **6** and **11**-**15**, a second gasket **300** (FIGS. **11**-**13**) is positioned adjacent the first surface **208***a* of the first PCB **208** and a third gasket **304** (FIGS. **14**-**15**) is positioned adjacent the second surface **208***b* of the first PCB **208**. In particular, the second gasket **300** is positioned between the terminal block **212** and the first surface **208***a* of the first PCB **208**, while the third gasket **304** is positioned between the second surface **208***b* of the PCB **212** and the auxiliary frame member **204**.

As shown in FIGS. **11**-**13**, the second gasket **300** includes a body **308** with openings **312**. Each of the openings **312** in the second gasket **300** corresponds to one of the second openings **236** in the bottom wall **212***b* of the terminal block **212**. The second gasket **300** acts as a seal that prevents fluid or debris that may enter the terminal block **212** from reaching the first PCB **208**, and prevents fluid and debris that may be in the housing from entering into the terminal block **212**.

As shown in FIGS. **14**-**15**, the third gasket **304** is sized and shaped to conform to a lip **320** of the auxiliary frame member **204**. In the embodiment of FIGS. **14**-**15**, the third gasket **304** includes first and second leg portions **304***a*, **304***b* that extend from opposite sides of a central portion **304***c*. Moreover, the lip **320** of the auxiliary frame member includes a groove **324** that is sized and shaped to receive the third gasket **304**. Accordingly, the groove **324** also includes first and second leg portions **324***a*, **324***b* that extend from opposite sides of a central portion **324***c*. The third gasket **304** keeps potting material (not shown) contained within the auxiliary frame member **204**. The third gasket **304** may also act as an additional seal that prevents fluid or debris that may enter the terminal block **212** from reaching the first PCB **208**, and prevents fluid and debris that may be in the housing from entering into the terminal block **212**.

In the illustrated embodiment, each of the gaskets **250**, **300**, **304** are constructed of foam. In other embodiments,

each of the gaskets **250**, **300**, **304** may be constructed from any suitable material, and the material need not be the same for each.

In the illustrated embodiment, together, the gaskets **250**, **300**, **304** eliminate space between various structures contained in the battery pack **54**. That is, the gaskets **250**, **300** prevent the egress of fluid and debris into the housing **150**. Moreover, the gaskets **250**, **300** also prevent fluid and debris that are able to enter the housing **150** from reaching the first PCB **208** and other electrical components contained within the housing **150** of the battery pack **54**. Similarly, the first and second gaskets **250**, **300** also prevent any fluid and debris that may be in the housing from entering into the terminal block **212**. The third gasket **304** helps contain the potting compound within the battery pack **54**, as discussed above.

Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of one or more independent aspects of the invention as described.

What is claimed is:

1. A battery pack for use with a power tool, the battery pack comprising:

a housing having an internal cavity in which one or more battery cells are supported, the housing having a set of openings defined therein;

a printed circuit board supported within the housing, the one or more battery cells being in electrical communication with the printed circuit board;

battery pack contacts in electrical communication with the printed circuit board;

a terminal block supported by the printed circuit board, the battery pack contacts positioned within the terminal block and accessible via the set of openings in the housing;

a first gasket positioned between a wall of the terminal block and the housing; and

a second gasket positioned between the printed circuit board and the terminal block.

2. The battery pack of claim **1**, wherein the first gasket prevents fluid and debris from entering the housing and the terminal block.

3. The battery pack of claim **1**, wherein a thickness of the first gasket corresponds to a distance between the wall of the terminal block and the housing, the first gasket configured to reduce vibration between the housing and the terminal block.

4. The battery pack of claim **1**, the second gasket preventing fluid and debris from entering the terminal block.

5. The battery pack of claim **1**, wherein the first gasket extends beyond an outer periphery of the wall of the terminal block.

6. The battery pack of claim **1**, wherein the first gasket includes a first surface that abuts a first surface of the housing and a second surface that abuts a second surface of the housing.

7. The battery pack of claim **1**, further comprising a frame member positioned within the housing and configured to support the printed circuit board.

8. The battery pack of claim **7**, wherein the first gasket includes a first surface that abuts a first surface of the housing and a second surface that is opposite the first surface, the second surface abutting the wall of the terminal block and a portion of the frame member.

9. A battery pack for use with a power tool, the battery pack comprising:

a housing having an internal cavity in which one or more battery cells are supported, the housing having a set of openings;

a printed circuit board supported within the housing, the one or more battery cells being in electrical communication with the printed circuit board;

battery pack contacts in electrical communication with the printed circuit board;

a terminal block supported by the printed circuit board, each of the battery pack contacts being accessible through a respective one of the set of openings in the housing, the terminal block including a wall having a plurality of openings defined therein; and

a gasket positioned between the wall of the terminal block and the printed circuit board, the gasket including a plurality of openings defined therein, each opening of the plurality of openings in the gasket corresponding to a respective one of the plurality of openings in the wall of the terminal block.

10. The battery pack of claim **9**, wherein the gasket prevents fluid and debris from the terminal block.

11. The battery pack of claim **9**, wherein the gasket is a first gasket and the wall of the terminal block is a first wall, and further comprising a second gasket positioned between a second wall of the terminal block and the housing.

12. The battery pack of claim **11**, wherein the second gasket includes a first surface and a second surface that is opposite the first surface, the first surface being in contact with a first surface of the housing and the second surface being in contact with the first wall of the terminal block.

13. The battery pack of claim **11**, wherein the second gasket extends beyond an outer periphery of the first wall of the terminal block.

14. The battery pack of claim **11**, wherein the second gasket prevents fluid and debris from entering the housing and the terminal block.

15. The battery pack of claim **11**, wherein a thickness of the second gasket corresponds to a distance between the wall of the terminal block and the housing, the second gasket configured to reduce vibration between the housing and the terminal block.

16. A battery pack for use with a power tool, the battery pack comprising:

a housing having an internal cavity in which one or more battery cells are supported;

battery pack contacts in electrical communication with the battery cells;

a terminal block including a wall having a plurality of openings defined therein, the battery pack contacts positioned within the terminal block and accessible via the openings in the wall of the terminal block; and

a gasket positioned between the wall of the terminal block and the housing, the gasket including a plurality of openings defined therein, each opening of the plurality of openings in the gasket corresponding to a respective one of the plurality of openings in the wall of the terminal block.

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