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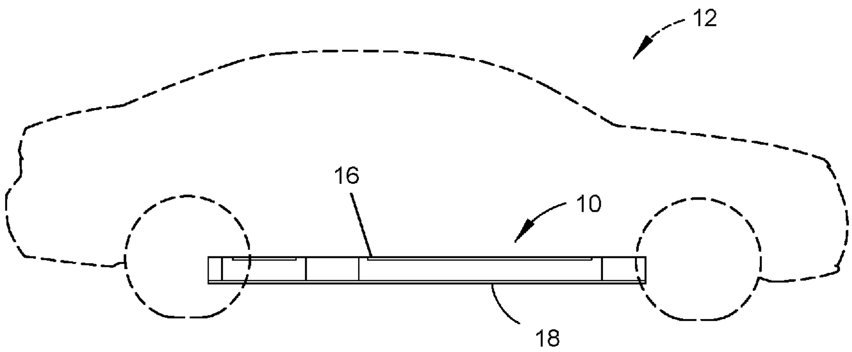

FIG. 1

(57) Abstract: A battery support tray for an electric vehicle includes a tray floor structure that has an upper surface that is configured to interface with battery modules. The battery support tray also includes a plurality of cooling features that integrally extend along portions of the tray floor structure that are configured to draw heat away from the battery modules supported at the upper surface of the tray floor structure. The tray floor structure may also have a cross-sectional profile that is substantially consistent longitudinally along a length of the tray floor structure or laterally across a width of the tray floor structure, such as formed from extruding a metal, such as an aluminum alloy.

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COOLING SYSTEM INTEGRATED WITH VEHICLE BATTERY TRAY

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims benefit and priority to U.S. provisional application Serial No. 62/637,155, filed March 1, 2018, which is hereby incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure generally relates to vehicle battery support structures, and more particularly to cooling systems or devices for batteries stored in such trays or structures, such as for battery packs or modules or the like that power electric and hybrid-electric vehicles.

BACKGROUND

[0003] Electric and hybrid-electric vehicles are typically designed to locate and package battery modules on the vehicle in a manner that protects the batteries from damage when driving in various climates and environments. These batteries are also located and packaged to protect the batteries from different types of impacts. It is also relatively common for vehicle frames to locate batteries in a portion of the frame or sub-structure of the vehicle, such as between the axles and near the floor of the vehicle, which can distribute the weight of the batteries across the vehicle frame and establish a low center of gravity for the vehicle.

SUMMARY

[0004] The present disclosure provides a battery tray or structure for an electric vehicle, such as an all-electric or hybrid-electric vehicle, that has a tray floor structure that may be integrated with cooling features for cooling batteries contained in or supported by the battery tray or structure. The cooling features may include liquid coolant channels that may be integrally formed in enclosed portions of the battery tray, such as within the tray floor structure or perimeter wall members of the tray, so as to provide a cooling effect to battery modules contained in the tray. Such integrally formed coolant channels may remove or reduce coolant lines that would otherwise be contained within the battery containment area of the tray. The battery tray may provide one or more tray sections that may be extruded, such as with aluminum, or pultruded, such as with a resin and composite substrate, to form a cross-sectional profile that is substantially consistent in the direction of formation, such as to provide openings that may function as coolant channels for cooling the battery modules. Also, the peripheral wall members of the battery tray may include hollow areas that are similarly configured to function as coolant

channels that may be connected, such as via a coupling, with coolant channels in the floor structure. Further supplemental cooling elements, such as cooling plates, may be attached to the coolant channels to direct coolant to a desired location, such as to a side portion or an internal portion of a battery module.

[0005] According to one aspect of the present disclosure, a battery support tray for a vehicle includes a tray floor structure that has an upper surface that is configured to interface with battery modules. The battery support tray also includes a plurality of cooling features that integrally extend along portions of the tray floor structure that are configured to draw heat away from the battery modules supported at the upper surface of the tray floor structure. The tray floor structure may also have a cross-sectional profile that is substantially consistent longitudinally along a length of the tray floor structure or laterally across a width of the tray floor structure, such as formed from extruding a metal, such as an aluminum alloy.

[0006] According to another aspect of the present disclosure, a battery support tray for a vehicle includes a floor structure that has a plurality of enclosed coolant channels that extend within portions of the floor structure. The coolant channels are configured to carry liquid coolant that draws heat away from batteries supported at the floor structure. A frame member may be coupled with an outer portion of the floor structure, such as along an edge of the floor structure, where the frame member may include a passage that interconnects with at least one of the enclosed coolant channels for carrying the liquid coolant. Optionally, the tray floor structure may have panel sections that each include a cross-sectional profile that is substantially consistent laterally across a width of the tray floor structure, where the panel sections may attach together and extend laterally between side reinforcement members that at least partially form a peripheral sidewall that borders a battery containment area.

[0007] According to yet another aspect of the present disclosure, a cooling system for a vehicle battery support tray includes a tray floor structure that is configured to support an array of battery modules. The battery support tray may also include a protective cover that is disposed over the tray floor to enclose a battery containment area for the battery modules. A plurality of coolant channels may be disposed within the tray floor structure that are configured to carry liquid coolant. The cooling system may also provide a heat exchanger may be arrange external to the battery containment area and a pump that is connected between the heat exchanger and the coolant channels for moving the liquid coolant as it draws heat away from battery modules disposed in the battery containment area. Optionally, the battery modules may include coolant channels that interconnect with the coolant channels disposed in the tray floor structure to further circulate the liquid coolant and draw heat away from battery modules.

[0008] These and other objects, advantages, purposes, and features of the present disclosure will become apparent upon review of the following specification in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a side elevation view of a battery support tray secured at a vehicle;

[0010] FIG. 2 is an upper perspective view of a battery support tray with a cooling system in accordance with the present disclosure;

[0011] FIG. 2A is an exploded perspective view of the battery support tray shown in FIG. 2;

[0012] FIG. 3 is an enlarged upper perspective view of a lateral end portion of the floor structure shown in FIG. 2A, showing interlocking seams between panel sections;

[0013] FIG. 3A is an end elevation view of a panel section shown in FIG. 3;

[0014] FIG. 4 is an upper perspective view of a lateral end portion of an additional example of a floor structure that shows an alternative coolant channel arrangement;

[0015] FIG. 4A is an end elevation view of a panel section shown in FIG. 4;

[0016] FIG. 5 is an upper perspective view of a lateral end portion of an additional example of a floor structure that shows a coolant channel disposed in a cross member;

[0017] FIG. 5A is an end elevation view of a panel section shown in FIG. 5;

[0018] FIG. 6 is a cross-sectional view of a fluid coupling interface between a frame member and a floor panel of the tray floor structure shown in FIG. 2;

[0019] FIG. 7 is a cross-sectional upper perspective view of an additional example of a tray floor structure that attaches directly to rocker rails of a vehicle frame;

[0020] FIG. 8 is a cross-sectional upper perspective view of yet an additional example of a tray floor structure that attaches directly to rocker rails of a vehicle frame;

[0021] FIG. 9 is a cross-sectional upper perspective view of an additional example of a tray floor structure that shows battery cell dividers extending upward into battery modules from the tray floor structure;

[0022] FIG. 10 is an upper perspective view of a further example of a battery support tray having an array of battery modules disposed within the battery containment area;

[0023] FIG. 10A is an upper perspective view of the battery support tray shown in FIG. 10 with the battery modules and tray structure shown in phantom lines to show coolant channels;

[0024] FIG. 11 is an exploded upper perspective view of a battery module shown in FIG. 10, showing coolant channels in the tray floor structure and the module end castings;

[0025] FIG. 12 is a top plan view of the battery support tray shown in FIG. 10A;

[0026] FIG. 12A is an enlarged view of the section denoted as section A on the battery support tray shown in FIG. 12;

[0027] FIG. 13 is a bottom perspective view of an additional example of a battery support tray that has coolant channels and an illustrated direction of coolant follow;

[0028] FIG. 13A is a perspective view of the direction of coolant follow shown in FIG. 13;

[0029] FIG. 14 is a cross-sectional view of an end cap that attaches to the floor structure of the battery support tray shown in FIG. 13; and

[0030] FIG. 15 is a bottom perspective view of another example of a battery support tray showing coolant channels that integrate plate coolers on battery modules;

[0031] FIG. 16 is an exploded upper perspective view of a plate cooler for a battery module;

[0032] FIG. 17 is an upper perspective view of the battery support tray shown in FIG. 15, showing coolant flow paths within engaged plate coolers;

[0033] FIG. 18 is a coolant circuit diagram that corresponds with the coolant flow paths shown in FIG. 17; and

[0034] FIG. 19 is an exploded upper perspective view of an additional example of a cooling system integrated with a floor structure and battery of a battery support tray.

DETAILED DESCRIPTION

[0035] Referring now to the drawings and the illustrative embodiments depicted therein, a vehicle battery tray or structure 10 is provided for supporting and protecting batteries, such as battery packs or modules or the like, for an all-electric or hybrid-electric vehicle 12 (FIG. 1). The battery tray 10 may be attached or mounted at or near the lower frame or rocker rails of the vehicle frame, such as shown in FIGS. 7 and 8, so as to locate the contained battery modules 14 (FIG. 3A) generally in a central location on the vehicle 12, away from probable impact locations, and also in a location that evenly distributes the weight of the battery modules 14 and provides the vehicle with a relatively low center of gravity. The battery tray 10 may span below the vehicle 12, such as shown in FIG. 1 with a generally thin profile as defined between the upper and lower surfaces 16, 16, so as to accommodate various vehicle body types and designs. It is contemplated that the battery tray 10 may be disengaged or detached from the rocker rails or other engaged portion of the vehicle frame, such as for replacing or performing maintenance on the battery module 14 or related electrical components.

[0036] The battery tray 10 includes a tray floor structure 20 that may be engineered or configured to provide integral cooling features for cooling the battery modules 14 contained in or supported by the battery tray 10. The cooling features may be integrally formed in portions of the battery tray 10, such as within the tray floor structure 20 or perimeter wall members 26, so as to provide a cooling effect to battery modules 14 contained in the tray 10. As shown in FIG. 3A, the tray floor structure 20 battery support tray 10 may include an upper surface 20a that is configured to interface with battery modules 14. The cooling features may integrally extend along portions of the tray floor structure 20 that are configured to draw or transfer heat away from the battery modules 14 supported at the upper surface 20a of the tray floor structure 20. For example, the cooling features may extend within the tray floor structure, such as the coolant channels shown in FIGS. 2-6. As another example, the cooling features may extend downward from the tray floor structure, such as the heat sink fins shown in FIG. 7. Further, the cooling features may extend upward from the tray floor structure to more effectively transfer heat downward, such as the battery cell unit dividers shown in FIG. 9, or any combination of these or other integrally formed cooling features.

[0037] The tray floor structure 20 may also have a cross-sectional profile that is substantially consistent in a direction of formation, such as along a length of the tray floor structure or laterally across a width of the tray floor structure. In doing so, the cooling features may be formed with a consistent shape along the tray floor structure, such as to have a cross-sectional profile that is substantially consistent longitudinally along a length of the tray floor structure (FIG. 8) or laterally across a width of the tray floor structure (FIGS. 2-6). The tray floor structure 20 may be formed by extruding a metal, such as an aluminum alloy. It is also contemplated that additional embodiments of a tray floor structure may be formed by pultruding various types of fibers through a resin to provide a composite-based structure. Such a pultruded tray floor structure may have openings or channels formed within and along its consistent cross-sectional shape, which may function as coolant channels, such as by providing the openings or channels with pipes or conduit liners or the like.

[0038] As shown in FIGS. 2-6, the cooling features may include liquid coolant channels 22, 24 that may be integrally formed in enclosed portions of the battery tray 10, such as within the tray floor structure 20 or perimeter wall members 26, so as to transverse liquid coolant through the channels as part of a cooling circuit to provide a cooling effect to battery modules 14 contained in the tray 10. Such integrally formed coolant channels 22, 24 may remove or reduce coolant lines that may otherwise be contained within the battery containment area 28 of the battery tray 10 to provide liquid cooling. As shown in FIG. 2, the battery containment area 28 of the tray 10 may be at least partially surrounded or bordered by a side reinforcement member or peripheral frame member 26 that may be coupled with an outer portion of the floor structure 20, such as along a lateral edge of the floor structure 20. The peripheral frame member 26 may also include coolant passages or channels 24 that interconnects with at least one of the enclosed coolant channels 22 of the floor structure 20 for transferring the liquid coolant through the portions of the battery tray 10 desired to be cooled.

[0039] The battery tray 10 may provide one or more sections that may be extruded, such as with aluminum, or pultruded, such as with a resin and composite substrate, to form a cross-sectional profile that is substantially consistent in the direction of formation. As illustrated in FIG. 2A, the tray floor structure 20 may have panel sections 32a, 32b, 32c, 32d that each include the same or similar cross-sectional profile that is taken transverse to the direction of formation and that is substantially consistent laterally across a width of the tray floor structure 20. The illustrated panel sections may attach together at seams, such as via welding, where the seams may also extend laterally across the width of the tray floor structure 20. As shown in FIG. 3, the seams 30 may be an overlapping or interlocking connection, such as to assist in welding or attaching in a manner that provides a water-tight seal. The illustrated seam overlap has a flange 33 that protrudes from a lower edge area of the panel section and an upward protruding recess 34 at the lower edge area of the adjacent panel section, such that the flange 33 is configured to mate with the recess 34. The illustrated overlapping arrangement may be reversed in additional embodiments with the flange and recess at upper edge areas of the panels or may be an alternative configuration of overlapping or interlocking features.

[0040] The floor panel structure 20 may also include front and rear end panel sections 36a, 36b, such as shown in FIG. 2A to provide enclosed ends to the battery containment area 28. These end panel sections 36a, 36b may have a wall portion 38 that attaches with the side reinforcement members 26 to further form a sealed peripheral sidewall. Also, the end panel sections 36a, 36b may have a base portion 40 that attaches with the corresponding base portion of the adjacent panel section, such as to generally align the upper surfaces across the seams of the adjacent panel sections. Thus, the end panel sections 36a, 36b may form an overlapping or interlocking connection with the forward and rearward most interior panel sections 32a, 32d. The front end panel section 36a has a recess 44 at the lower edge area of the base portion to interface and mate with the flange 33 that protrudes forward from a lower edge area of the panel section 32a. Similarly, the rear end panel section 36b has a flange 46 at the lower edge area of the base portion to interface and mate with the recess 34 that protrudes upward at a lower edge area of the panel section 32d.

[0041] The panel sections, such as further shown in FIG. 2A, may each have a cross member 48 portion that integrally extends upward from the base portion of the panel section. The cross member portions 48 extend laterally between and engage interior surfaces of the side reinforcement members 26, such as via welding, adhesive, and/or fasteners. The structure of the cross member portion 48 may stiffen the base portion of the panel for supporting the battery weight, may provide cross-car load transfer paths for lateral impacts and the like, and may serve as a contamination barrier between sections of the battery containment area, among other potential purpose. Accordingly, the shape and thickness of the cross member portions 48 of the panels may be configured for the desire characteristics, such as based on the battery module layout, tray design, and design of the base portion of the floor structure. To provide further distribution of liquid coolant near and around the battery modules, the cross member portions 48'' of the panel sections may also provide one or more integral coolant channels 23'', such as shown at an upper edge area of the cross member portions 48'' in FIGS. 5 and 5A.

[0042] The panel sections may attach between the peripheral frame members 30, such as shown in FIG. 2A, where the panel that at least partially form a peripheral sidewall that borders the battery containment area 28. It is understood that the attachment of the panel sections to each other and to the side reinforcement members may be done by various forms of welding, adhesive, fasteners, or the like or combinations thereof to provide a stable and sealed attachment interface. Also, as shown in FIG. 2A, a sealing member may be disposed about the upper portion of the seam between the peripheral frame members 30 and the base portion of the panel sections 32a, 32b, 32c, 32d. To accommodate space for this sealing member, the cross-member portions may each include a notch at the interface of the cross-member portion and the base portion of the panel sections, such as shown in FIGS. 3 and 4. The peripheral frame member in additional embodiments may, however, include various cross-sectional profile shapes, thicknesses, hollow area configurations and the like.

[0043] With further reference to FIG. 2A, the peripheral frame member 26 may include a flange 50 at the lower edge area that engages and supports the lower lateral edges of the floor panel structure 20. The lower edge area of the peripheral frame member 30 may also include a lateral indentation 52 along the frame member for matably receiving the lateral edges of the floor panel structure 20. As shown in FIG. 6, the area provided at the lateral indention 52 also provides space for couplings or fittings 54 to engage between the coolant channels 22 in the floor structure and the coolant passages or channels 24 that extend longitudinally along the peripheral frame member 26. The couplings or fittings may be threaded, press-fit, adhered, or welded attachments or combinations thereof, such as the illustrated fitting 54 that has a threaded engagement 56 with the peripheral frame member 26 and a connection formed at the floor structure by expandable sealant adhesive 58 that may expand from the application of heat, such as heat generated b welding the floor structure 20 to the frame member 26. It is also understood that the passages or channels, such as the channel 24 extending along the peripheral frame member 26 may be integral channels that do not require any liners or inserts to function as a flow channel or may house an inserted tube or pipe or other conduit piece, such as a made of rubber or plastic, which may be less susceptible to damage than relying entirely on the integrated channels.

[0044] The coolant channels 22 formed in the floor structure 20 may be formed in various shapes and arrangements to provide the channels at the desired locations for efficiently distributing the coolant to effectuate heat transfer from the battery modules. For example, as shown in FIGS. 3 and 3A, the channels 22 are located at a vertically offset position that is closer to the upper surface 20a of the floor structure than the lower surface. Further, a mass of conductive material 60 is disposed between directly between the coolant channel and the upper surface, while an air gap 62 is disposed directly between the coolant channel 22 and the lower surface of the floor structure. The air gap 62 is formed by opposing support legs 64 that extend diagonally between the coolant channel 22 and a lower panel section of floor structure. As another example, as shown in FIGS. 4 and 4A, the coolant channels 22’ are similarly disposed at a vertically offset position that is closer to the upper surface 20a’ of the floor structure than the lower surface. The material surrounding the coolant channels 22’ in FIGS. 4 and 4A is integrated with an upper panel section of the floor structure, while a spacer piece or leg 64’ is provided between the material surrounding the coolant channels and the lower panel section. Thus, there may be more conductive material provided between the coolant channel and the upper surface that supports the battery modules and the lower surface of the floor structure.

[0045] Referring now to FIGS. 7 and 8, the tray floor structure may be mounted directly to the frame or rocker rails 166, 266. This, the supportive structure of the tray and the cooling features of the tray may be integrated with the floor structure, so as to illuminate peripheral frame members of the tray. The cooling features may integrated into the tray floor structure, for example as shown in FIG. 7 by providing downward protruding fins 168. These fins 168 can act provide heat dissipation from the batteries 114 similar to a heat sink, such as aided by air flow under the vehicle from movement of the vehicle. Also, the fins 168 can provide longitudinal stiffness to the floor structure 120, such as to otherwise reduce or eliminate demands on an outer frame structure. It is understood that the fins 168 may also or alternatively be oriented in a lateral direction relative to the vehicle and may be alternatively shaped and structured to increase surface area for airflow contact. Further, it is contemplated that structural and heat dissipating fins may be incorporated into the other illustrated floor structures disclosed herein and other various floor structures within the scope of the present disclosure.

[0046] Another example of a tray floor structure mounted directly to the frame or rocker rails 266 is shown in FIG. 8, which also illustrates longitudinally disposed coolant channels 222 integrally extending along the tray floor structure 220. The coolant channels 222 that are shown in FIG. 8 are provided with separate coolant lines, such as pipes or tubes, that are disposed within some of the coolant channels 222 to transfer the coolant longitudinally along the tray, such as to allow vertically oriented openings in the upper surface of the floor tray structure 220 to access the coolant lines, such as for cooling an individual battery module or set of modules.

[0047] A shown in FIG. 9, the tray floor structure 320 may also or alternatively be integrated with the structure of the battery modules 314. The battery modules 314 illustrated in FIG. 9 include an outer housing 370 that has four walls 372 attached to the upper surface of the tray floor structure 320 and a cover 374 attached around the upper edges of the walls to enclose an array of battery cell units 376, such as pouches or the like. The tray floor structure includes dividers 378 that integrally protrude upward from the upper surface of the tray floor within the module area surrounded by the housing walls 372 and cover 374. The dividers 378 may interface with vertical surfaces of the battery cell units 376 so as to dissipate or transfer heat downward from the battery cell units into the tray floor structure, which may have integrated coolant channels 322, as shown in FIG. 9.

[0048] Further supplemental cooling elements, such as additional cooling lines or cooling plates, may be attached to the coolant channels formed into the floor structure to direct the coolant to a desired location, such as at an additional surface of a battery module. With reference to FIGS. 10-12A, the battery modules 414 may include end castings 480 that may be configured with an integral coolant channel 482, whereby the end castings 480 may each have couplings that engage the coolant channels in the floor structure. As shown in FIG. 11, the end casting 480 may have downward extending protrusions 484 that engage openings or ports extending through the upper surface of the floor structure 420 to interconnect with the coolant channels. The illustrated end castings 480 may be arranged as opposing walls of the battery module 414, whereby support rods 486 may extend between the end castings 480 to engage a series of vertically oriented battery cell units 476. The end castings may be drawn toward each other to hold the battery cell units together, such as by threadably tightening the rods and the rod interface with the end castings. The coolant channels extending with the end castings may connect with the coolant channels in the floor structure so that the coolant flows through the each end casting in series, such as shown in FIGS. 12 and 12A. It is contemplated that the coolant flow in additional embodiments may be differently arranged from that shown in FIG. 12, such as with different oriented flow channels disposed in the floor structure.

[0049] As shown in FIGS. 13-13A an additional embodiment shows a coolant flowing into the tray floor structure 520 at a centrally located inlet and dissipating laterally outward through a series of serpentine channels 522 that lead to outlets disposed at or near the laterally outermost portion of the tray floor structure, such as that portion that attaches with the tray peripheral walls or the vehicle frame rails. The curved ends 522a of the serpentine channels may be provided by an end cap 588, such as shown in FIG. 14, that have curved coolant channels and through holes for connecting the end cap 588 to the floor, in a manner that aligns the openings of curved channels 522a in the end cap with the channels in the floor, which may be extruded to provide linear coolant channels. Such an end cap 588 arranged, as shown in FIG. 13, may be utilized for various embodiments or portions of the battery tray, such as ends of the tray floor structure and plate coolers. Battery cells may heat up relatively uniformly from their core, whereby battery packs or modules may subsequently heat up from their center, such that the temperature profile may fall to its outer boundaries, as shown in the heat map overlaid on the lower surface of the tray floor structure shown in FIG 13. Accordingly, the flow pattern shown in FIGS. 13 and 13A provide cooling flow that starts with cold coolant liquid or medium coming from external heat exchanges to the center of the tray and distributing outwards to increase cooling efficiency.

[0050] The cooling provided by the coolant channels integrated into the tray floor structure may be supplemented or replaced by accessory cooling systems, such as a cooling plate system 621 shown in FIGS. 17 and 18. As shown in FIG. 16, a cooling plate 690 may have an inlet 692 and an outlet 693, such as a plug that engages a hole or port in the tray floor structure. The inlet 692 and outlet 693 lead to a body 694 or housing that has a series of flow channels so as to distribute the coolant within the body of the cooling plate. The channels within the body of the cooling plate may be machines or extruded, whereby in extrusion the interior channels can be capped off at the sides with a cover 695 or plate, as shown in FIG. 16. The inlet and out may be engaged with a separate loop of coolant channels, such as shown in FIGS. 15 and 17, whereby separate loops that engage the plate coolers are integrated on each side of the tray floor structure or battery pack. The separate loops can run through a common external heat exchanger, however they may have separate flow pumps to individually control flow rates. It is understood that the size of the cooling plate can be custom to the battery module or tray design.

[0051] As shown in FIGS. 17 and 18, the coolant channels may be disposed within the tray floor structure that are configured to carry liquid coolant. The cooling system may also provide a heat exchanger 696 may be arrange external to the battery containment area and a pump 697 that is connected between the heat exchanger 696 and the coolant channels for moving the liquid coolant as it draws heat away from the plate coolers disposed at the battery modules in the battery containment area. A controller 698 may be connected to temperature sensors 699 at the plate coolers and to the coolant pump to regulate the coolant flow for achieving the desire temperatures at the plate coolers.

[0052] With reference to another example of integrating cooling features with a tray floor structure 720, such as shown in FIG. 19, a battery module 714 has an inlet 792 and an outlet 793 that are engaged with coolant channels 722 disposed in the tray floor structure 720. Instead of passing coolant through channels in the floor structure 720 to create a cold plate, the structural channels 722 in the tray structure 720 pass coolant to the battery module 714 itself. As shown in FIG. 19, the channels 722 extend laterally across the tray, similar to those shown in FIG. 3.

[0053] As illustrated in FIG. 19, the tray floor structure 720 may have panel sections 732a, 732b that each include the same or similar cross-sectional profile that is taken transverse to the direction of formation and that is substantially consistent laterally across a width of the tray floor structure 720. The illustrated panel sections may attach together at seams, such as via welding, where the seams may also extend laterally across the width of the tray floor structure 720. As shown in FIG. 19, the seams 730 may be an overlapping or interlocking connection, such as to assist in welding or attaching in a manner that provides a water-tight seal. The illustrated seam overlap has a flange 733 that protrudes from a lower edge area of the panel section and an upward protruding recess 734 at the lower edge area of the adjacent panel section, such that the flange 733 is configured to mate with the recess 734.

[0054] The panel sections 732a, 732b, such as shown in FIG. 19, may each have a cross member 748 portion that integrally extends upward from the base portion of the panel section. The structure of the cross member portion 748 may stiffen the base portion of the panel for supporting the battery weight, may provide cross-car load transfer paths for lateral impacts and the like, and may serve as a contamination barrier between sections of the battery containment area 728, among other potential purposes. Accordingly, the shape and thickness of the cross member portions 748 of the panels may be configured for the desire characteristics, such as based on the battery module layout, tray design, and design of the base portion of the floor structure.

[0055] With further reference to FIG. 19, the panel sections 732a, 732b may attach between peripheral frame members of the tray structure, where the panel that at least partially form a peripheral sidewall that borders the battery containment area. It is understood that the attachment of the panel sections to each other and to the side reinforcement members may be done by various forms of welding, adhesive, fasteners, or the like or combinations thereof to provide a stable and sealed attachment interface. The peripheral frame members may have hollow interiors that engage with the channels 722 of the panel sections 732a, 732b at the interface, such as similar to the interface shown in FIG. 6. However, each panel section may have an end portion of one of the channels 722 that is plugged, such as with a plug member 723, to entirely or substantially prevent the follow the coolant through the plugged channel. The adjacent channel 722 in the adjacent panel section may however be open, such as to allow coolant to flow into the channel of the panel section from the peripheral member. For example, the panel section 732a may have an open channel 722 to receive coolant, while the adjacent channel 722 of the adjacent panel section 732b may have a plug member 723. Thus, the battery containment area 728 between the cross member portions 748 may receive a batter module 714 that engages the adjacent coolant channels 722, such as via quick disconnect (QD) connectors at the inlet 792 and the outlet 793 of the batter module 714. In this arrangement, the coolant flows into the inlet 792, circulates through the battery module 714, and exits through another QD connector at the outlet 793 disposed at the other end of the battery module 714. This coolant then exits the battery module into the channel 722 with the plugged end and flows in the floor and out to the return channel disposed at the opposing frame member or side rail.

[0056] In example shown in FIG. 19, aluminum extruded floor panels with integrated cross-car members and cooling channels can accommodate any vehicle width by simply varying the length of the extrusion. Also, the length of the battery enclosure could be incrementally changed by the trim and number of floor panels used. Depending on the type of cooling method used, aluminum or composite materials could be used to tailor the design for cost, weight and performance.

[0057] It is also contemplated that additional embodiments of a tray floor structure may be formed by pultruding various types of fibers through a resin to provide a composite-based structure. Such a pultruded tray floor structure may have openings or channels formed within and along its consistent cross-sectional shape, which may function as coolant channels, such as by providing the openings or channels with pipes or conduit liners or the like. Moreover, the battery tray may be formed with more or fewer tray sections from the embodiments disclosed herein.

[0058] Several different attachment techniques and configurations may be used to permanently or releasable secure the battery support structure to a vehicle frame, such as below a floor of the vehicle and generally between the axles. Further, with respect to the general installation or attachment or formation, the steps discussed herein may be performed in various different sequences from those discussed to result in engaging, disengaging, or forming the battery support structure or components thereof.

[0059] For purposes of this disclosure, the terms “upper,” “lower,” “right,” “left,” “rear,” “front,” “vertical,” “horizontal,” and derivatives thereof shall relate to the orientation shown in FIG. 1. However, it is to be understood that various alternative orientations may be provided, 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 this 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.

[0060] Changes and modifications in the specifically described embodiments may be carried out without departing from the principles of the present disclosure, which is intended to be limited only by the scope of the appended claims as interpreted according to the principles of patent law. The disclosure has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation. Many modifications and variations of the present disclosure are possible in light of the above teachings, and the disclosure may be practiced otherwise than as specifically described.

CLAIMS

WHAT IS CLAIMED IS:

1. A battery support tray for a vehicle, said battery support tray comprising:

a tray floor structure having an upper surface configured to interface with battery modules; and

a plurality of cooling features integrally extending along portions of the tray floor structure that are configured to draw heat away from the battery modules supported at the upper surface of the tray floor structure.

2. The battery support tray of claim 1, wherein the tray floor structure comprises a cross-sectional profile that is substantially consistent longitudinally along a length of the tray floor structure or laterally across a width of the tray floor structure.

3. The battery support tray of claim 2, wherein the tray floor structure and the plurality of cooling features are integrally formed together and comprise an aluminum extrusion.

4. The battery support tray of claim 1, wherein the cooling features comprise at least one of heat sink fins or coolant channels.

5. The battery support tray of claim 1, wherein the cooling features comprise heat sink fins integrally extending upward into a battery containment area disposed above the upper surface of the tray floor structure, and wherein the heat sink fins are separated from each other at a spacing configured to be disposed between cell units of a battery module supported at the upper surface of the tray floor structure.

6. The battery support tray of claim 1, wherein the tray floor structure includes outer lateral portions that extend along opposing lateral edges of the tray floor structure and that each have an attachment surface that is configured to interface with at least one of a rocker rail of the vehicle or a longitudinal tray frame member for forming a peripheral sidewall of the battery support tray that borders a battery containment area above the upper surface of the tray floor structure.

7. A battery support tray for a vehicle, said battery support tray comprising:

a floor structure having a plurality of enclosed coolant channels extending within portions of the floor structure that are configured to carry liquid coolant that draws heat away from batteries supported at the floor structure; and

a frame member coupled with an outer portion of the floor structure along an edge of the floor structure, wherein the frame member includes a passage that interconnects with at least one of the plurality of enclosed coolant channels for carrying the liquid coolant.

8. The battery support tray of claim 7, wherein the floor structure comprises a cross-sectional profile that is substantially consistent longitudinally along a length of the floor structure or laterally across a width of the floor structure.

9. The battery support tray of claim 7, wherein the floor structure comprises an aluminum extrusion.

10. The battery support tray of claim 7, wherein the floor structure comprises a plurality of panel sections that each comprise a cross-sectional profile that is substantially consistent laterally across a width of the floor structure.

11. The battery support tray of claim 10, wherein the plurality of panel sections each comprise a base portion and a cross member portion integrally extending upward from the base portion, and wherein the cross member portions are disposed laterally between side reinforcement members that at least partially form a peripheral sidewall that borders a battery containment area.

12. A cooling system for a vehicle battery support tray, said cooling system comprising:

a tray floor structure configured to support an array of battery modules;

a protective cover disposed over the tray floor to enclose a battery containment area;

a plurality of coolant channels disposed within the tray floor structure that are configured to carry liquid coolant;

a heat exchanger arrange external to the battery containment area; and

a pump connected between the heat exchanger and the plurality of coolant channels for moving the liquid coolant as it draws heat away from battery modules disposed in the battery containment area.

13. The cooling system of claim 12, further comprising a frame member that is coupled with the tray floor structure, wherein the frame member includes a passage that interconnects with at least one of the plurality of coolant channels for carrying the liquid coolant, and wherein the passage is connected with a line that leads to the pump.

14. The cooling system of claim 12, wherein the tray floor structure comprises a plurality of panel sections that each are extruded of aluminum to have a cross-sectional profile that is substantially consistent laterally across a width of the tray floor structure.

15. The cooling system of claim 14, wherein the plurality of panel sections each comprise a base portion and a cross member portion integrally extending upward from the base portion, and wherein the cross member portions are disposed laterally between side reinforcement members that at least partially form a peripheral sidewall that borders the battery containment area.

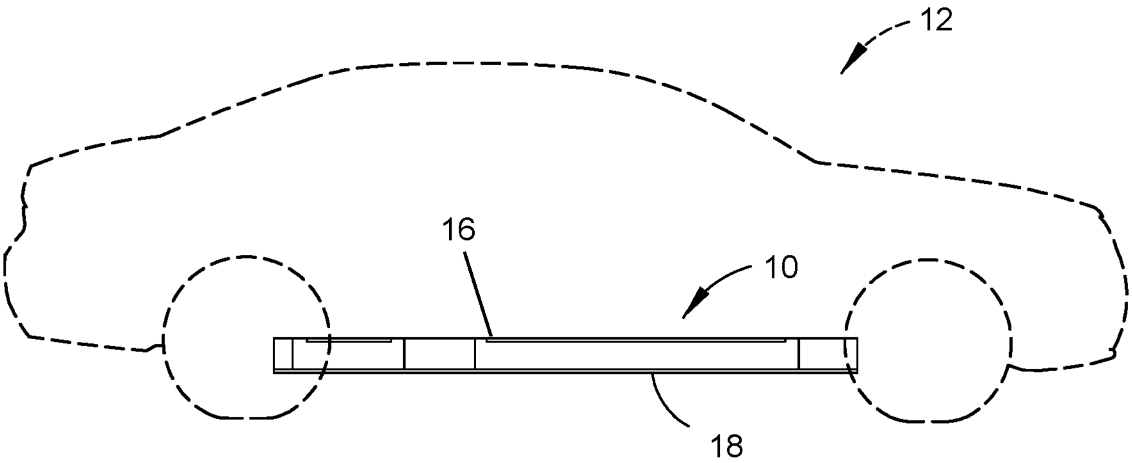

FIG. 1

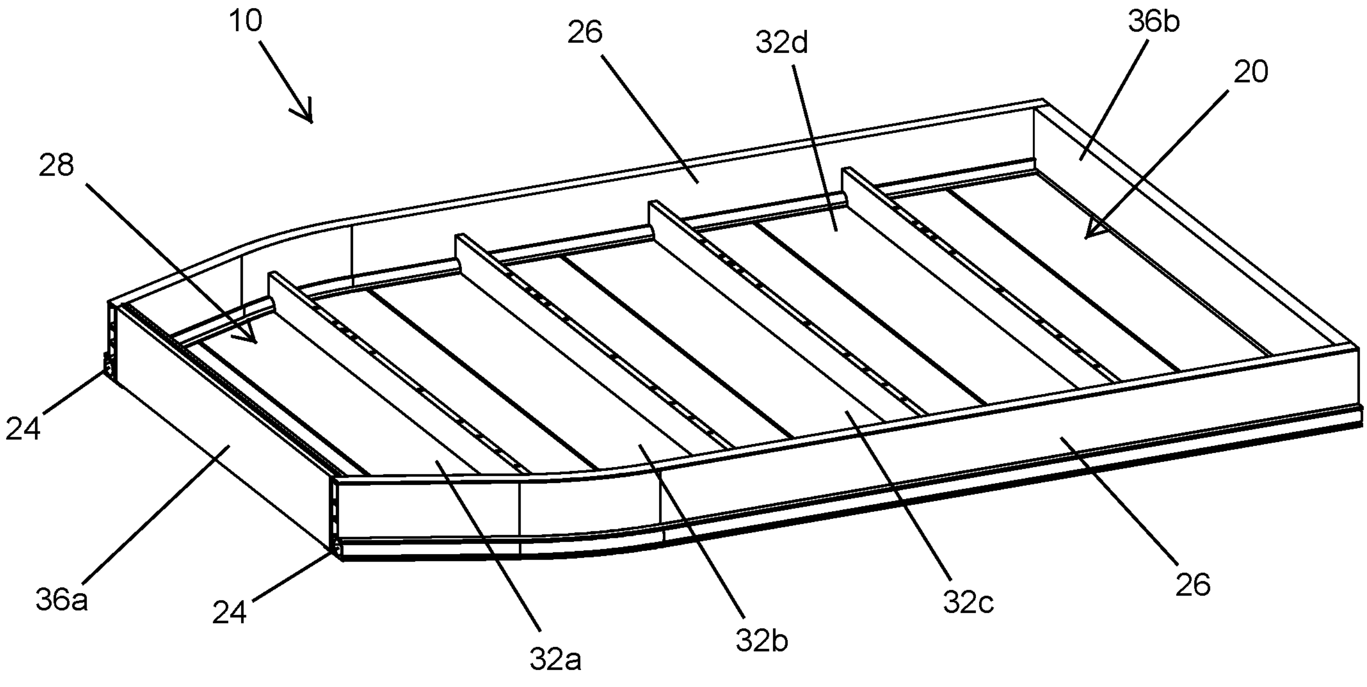

FIG. 2

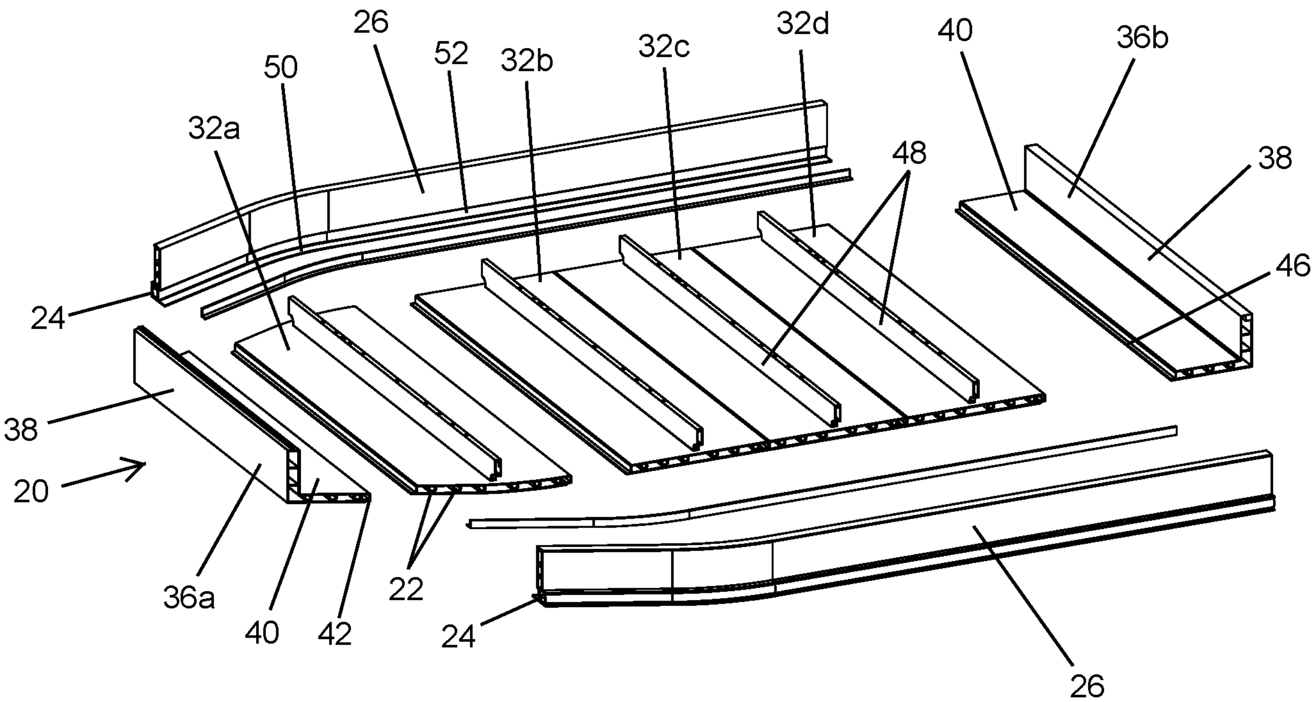

FIG. 2A

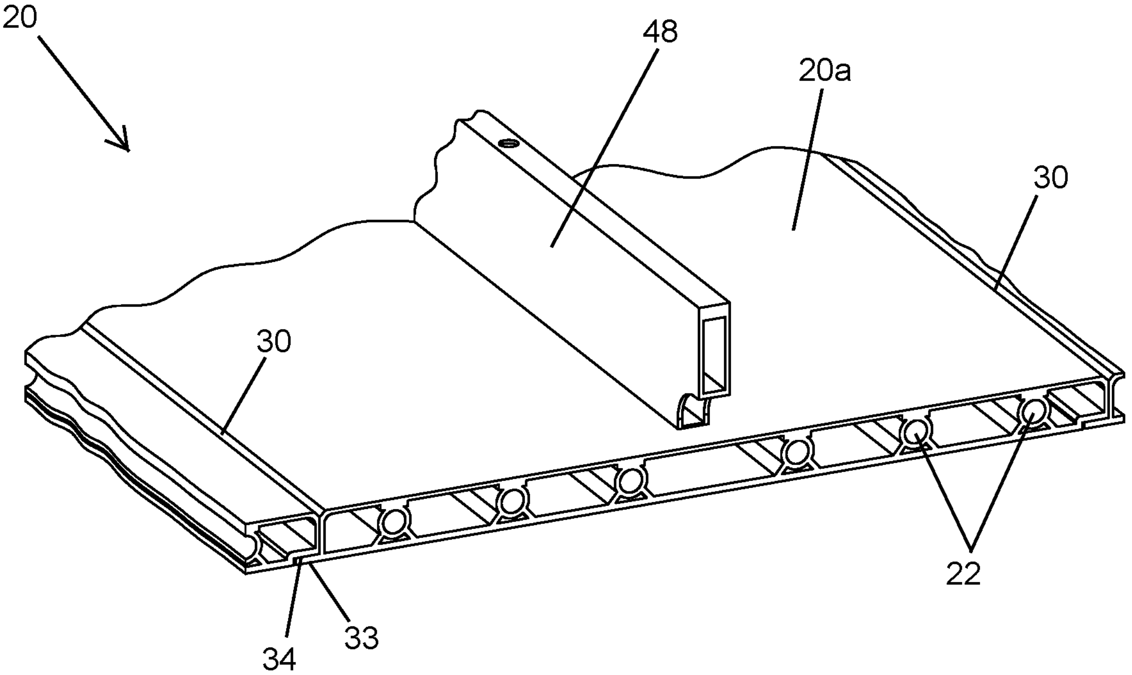

FIG. 3

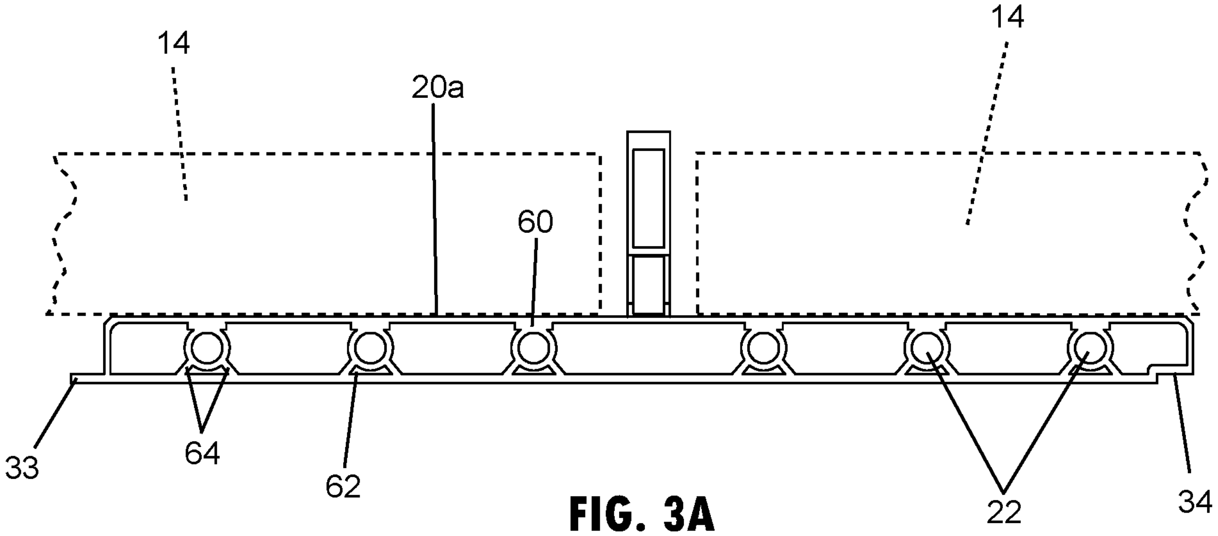

FIG. 3A

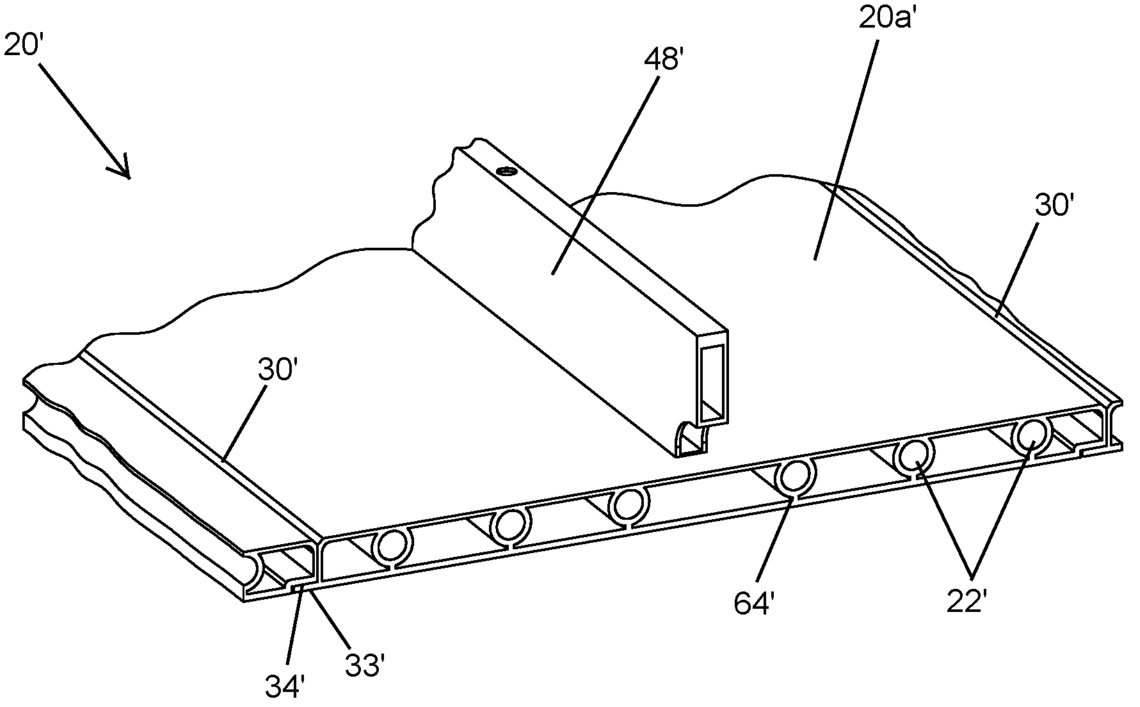

FIG. 4

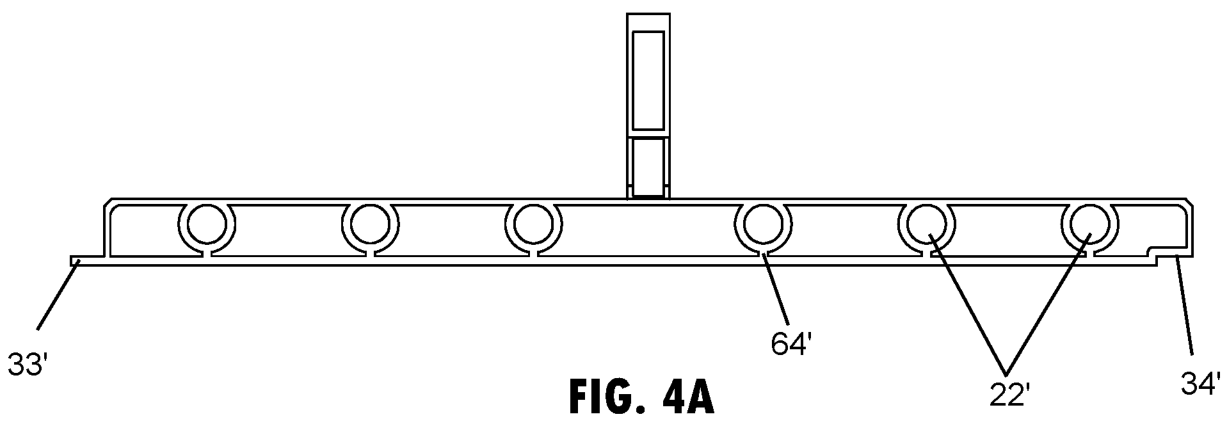

FIG. 4A

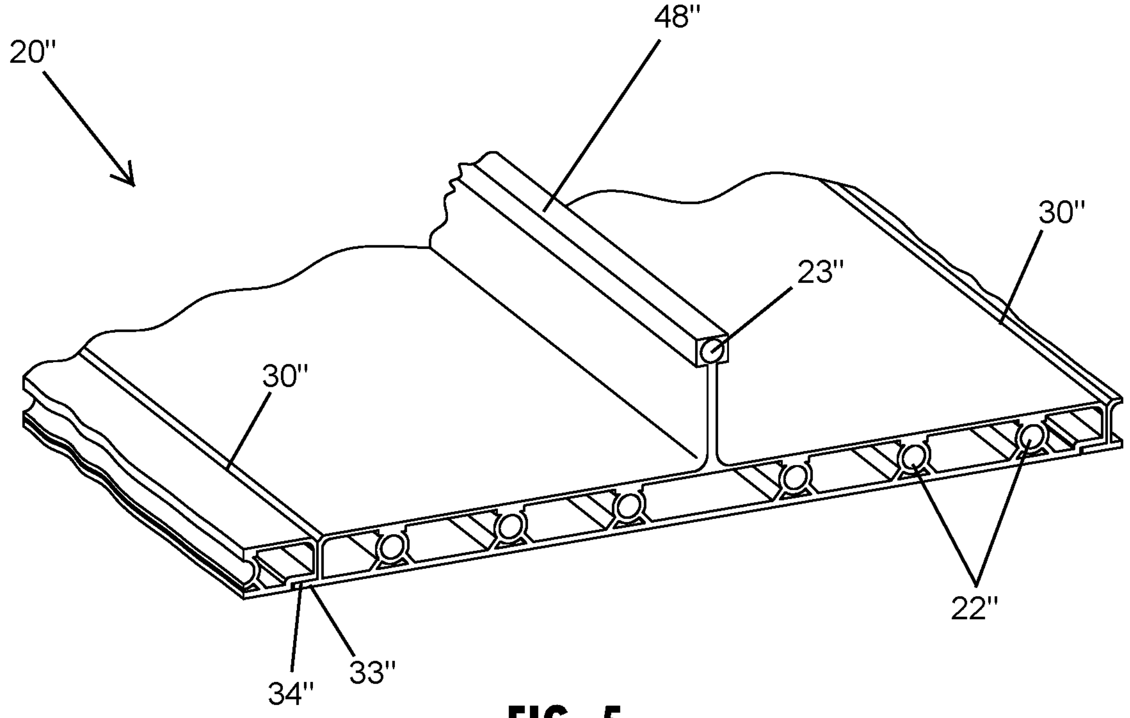

FIG. 5

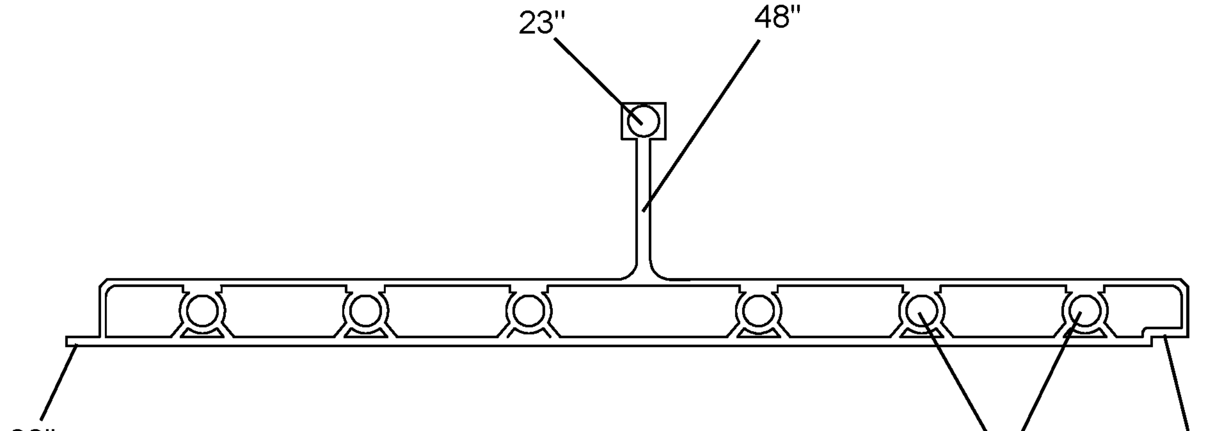

FIG. 5A

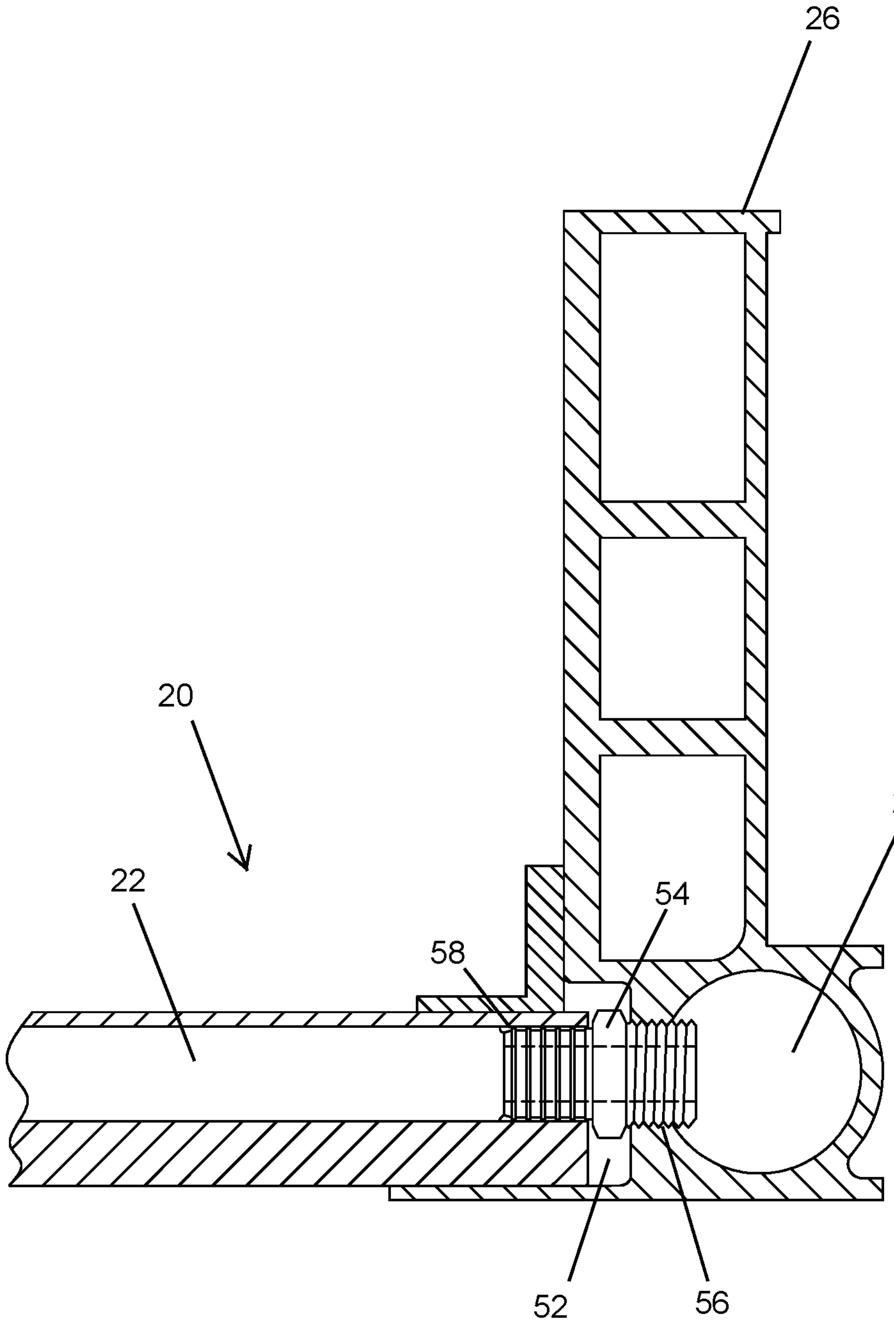

FIG. 6

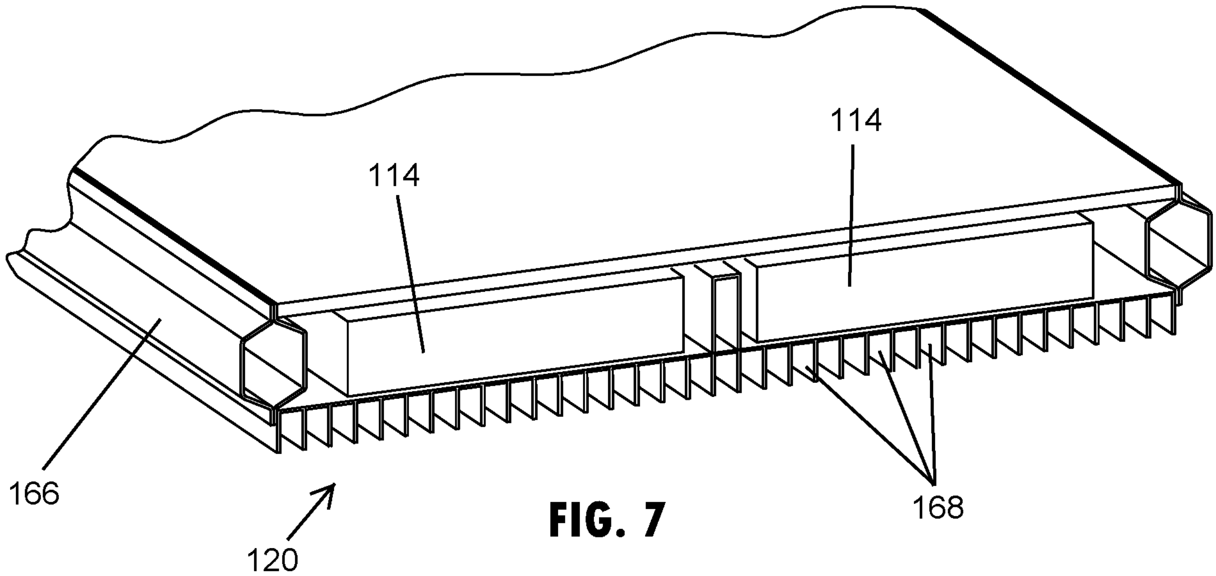

FIG. 7

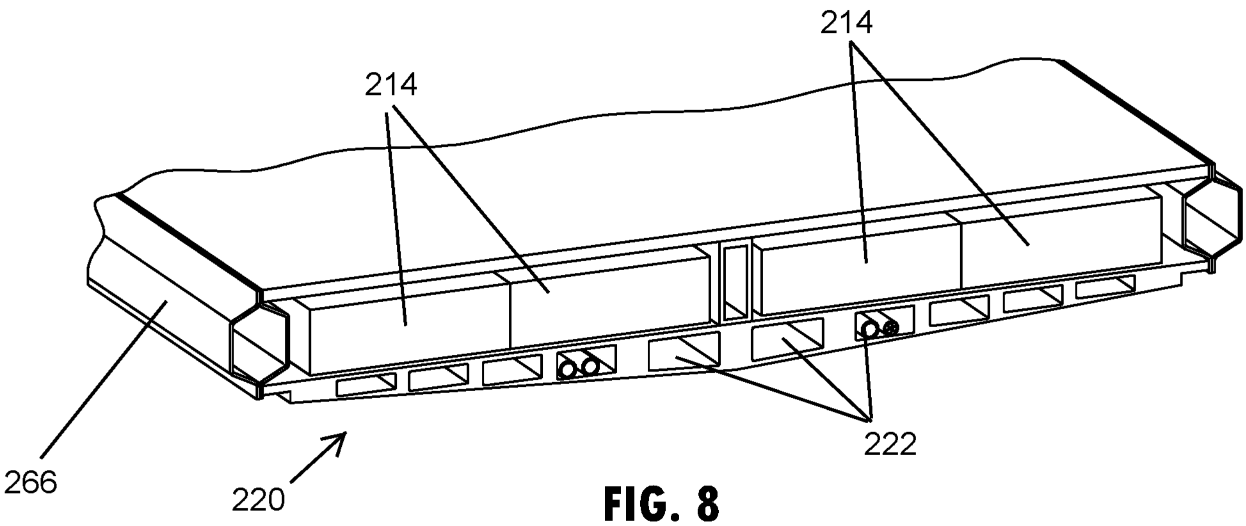

FIG. 8

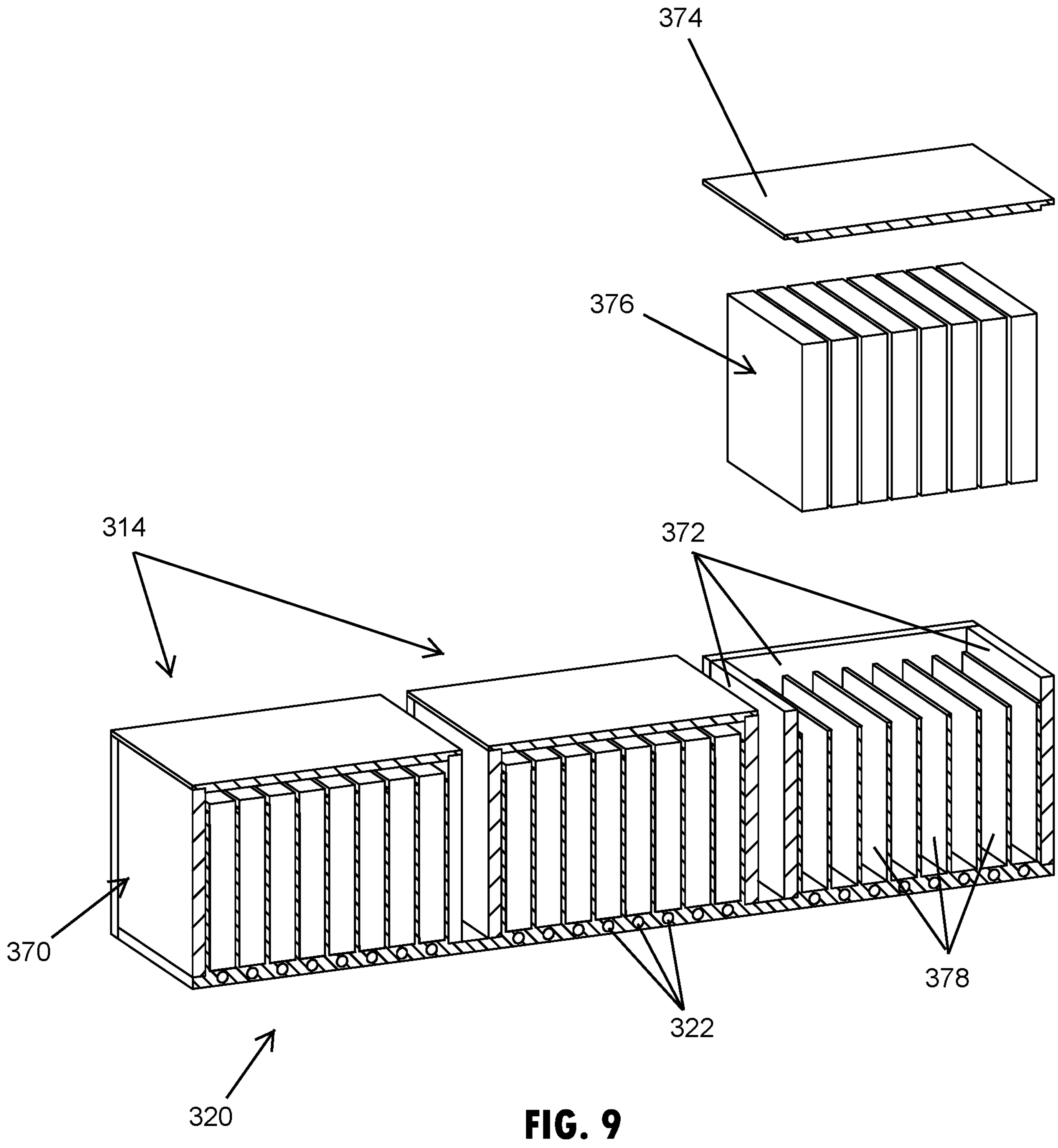

FIG. 9

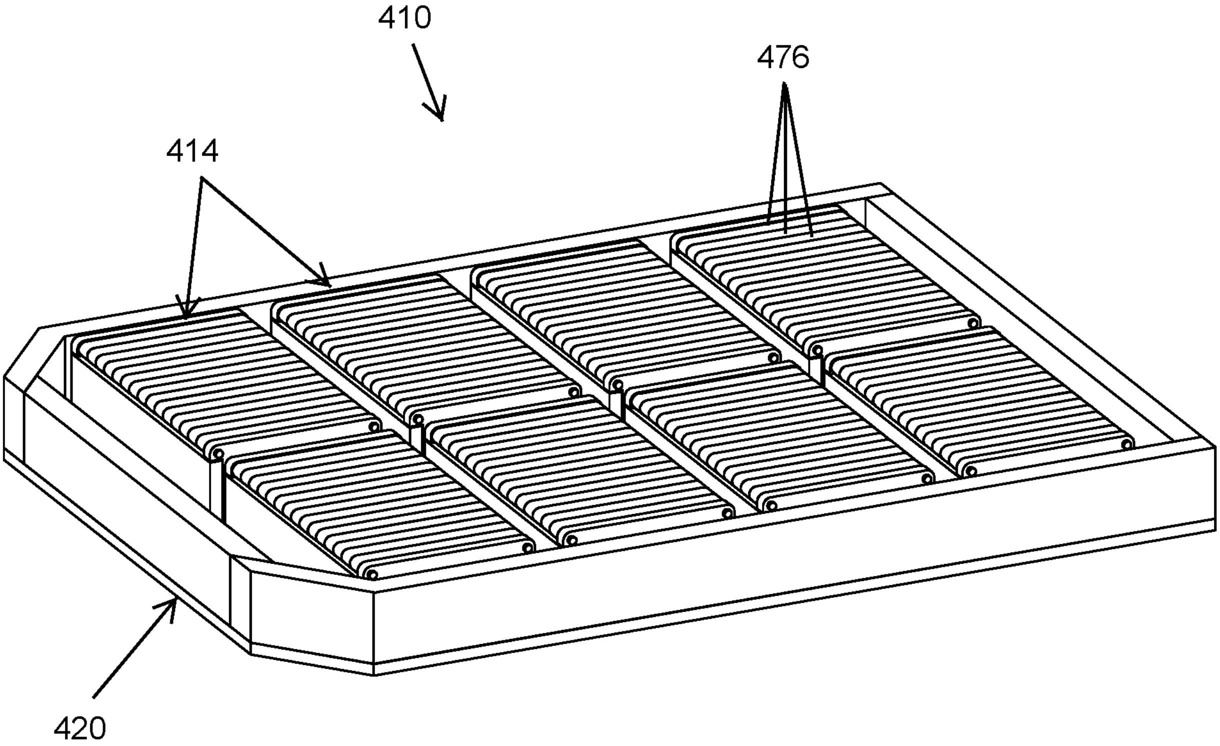

FIG. 10

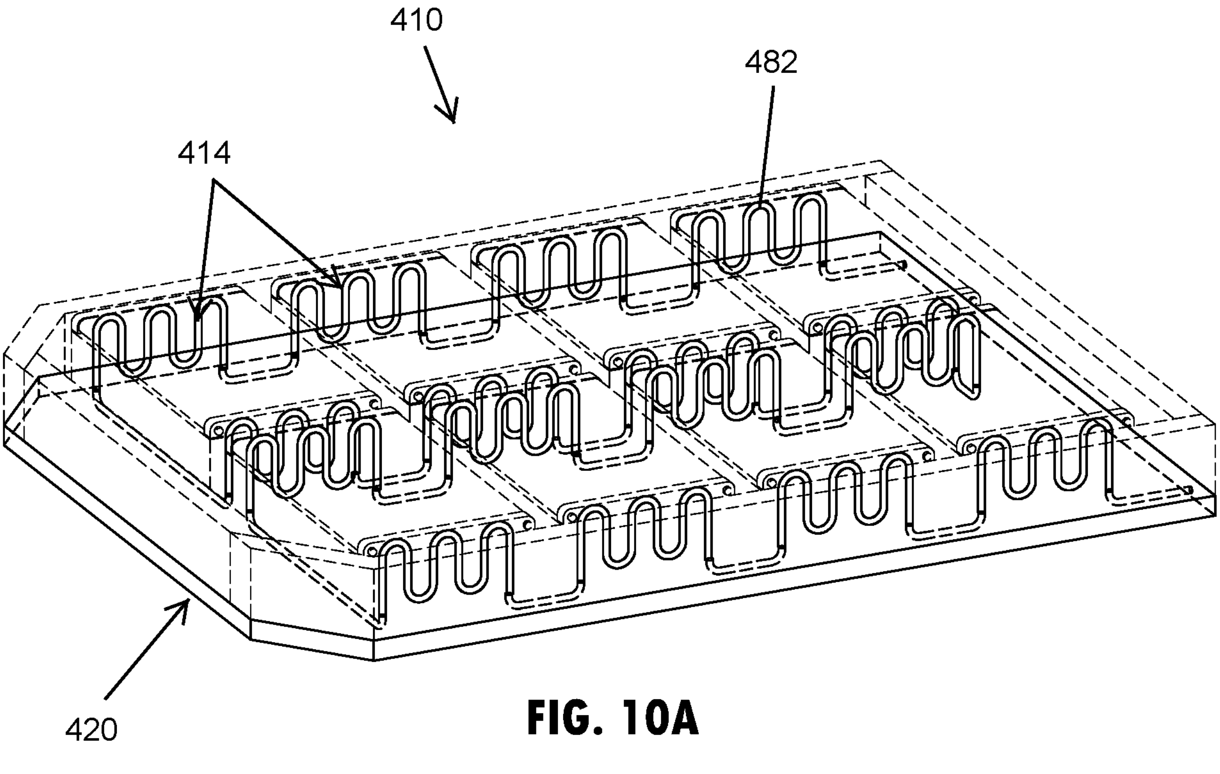

FIG. 10A

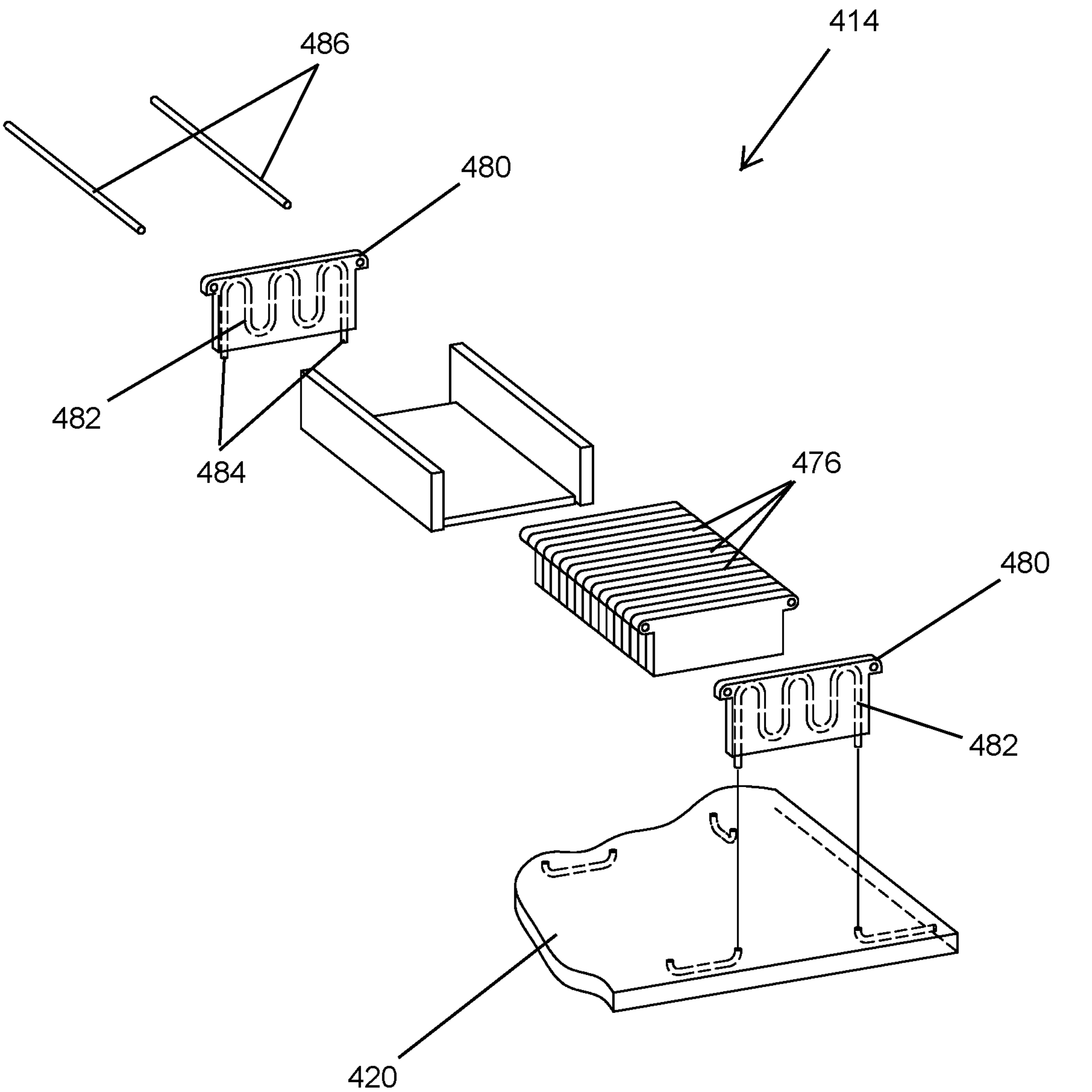

FIG. 11

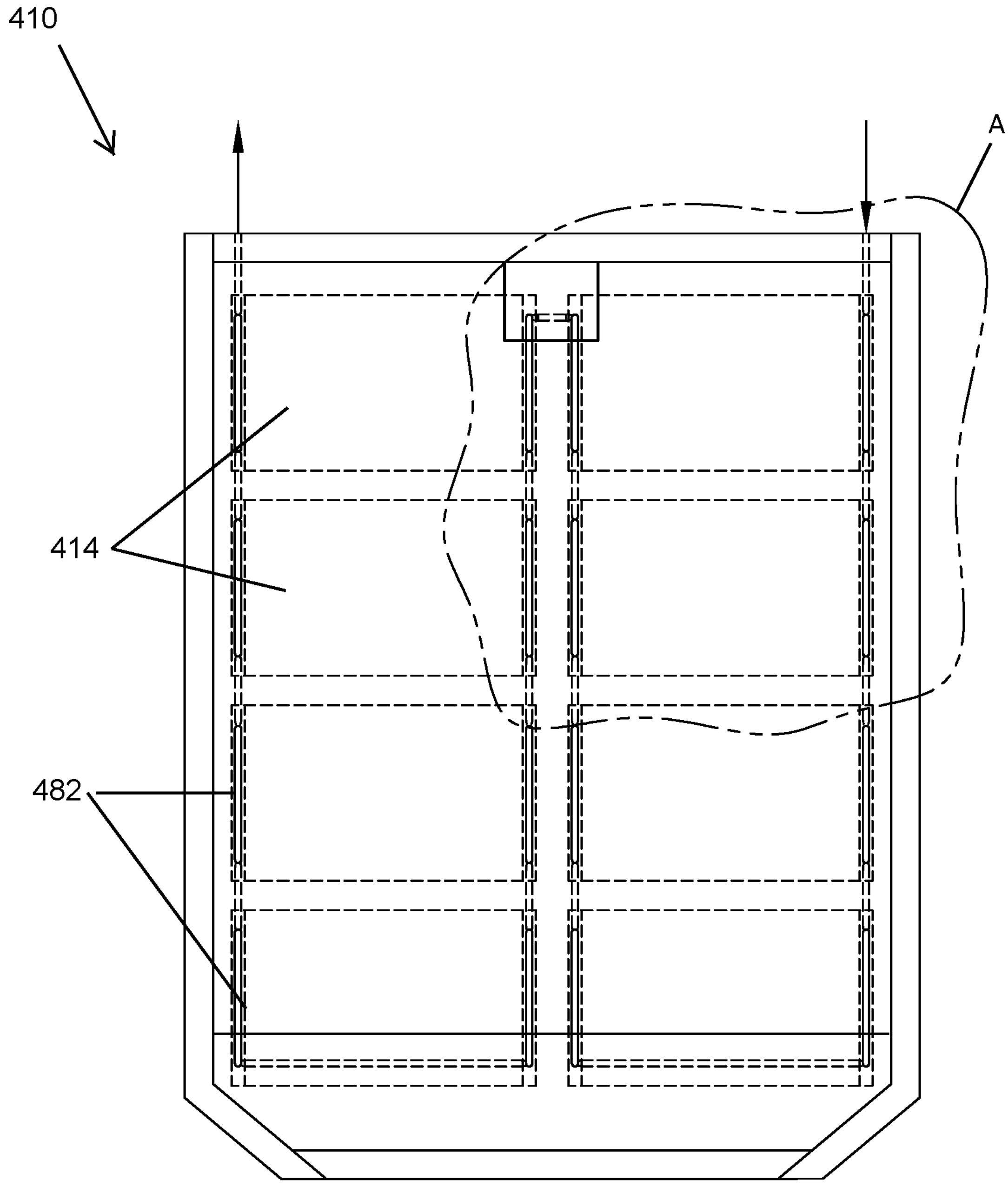

FIG. 12

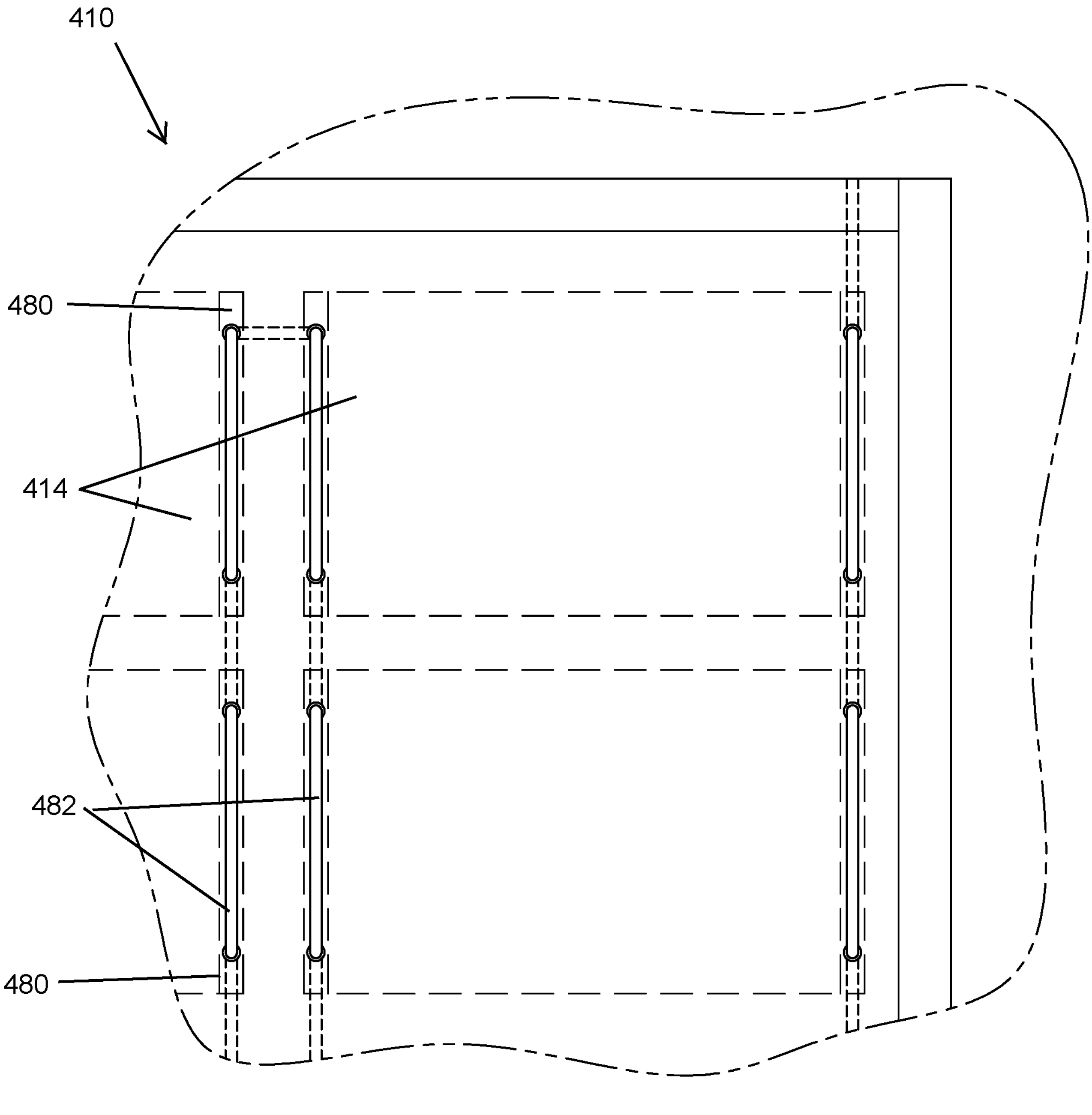

FIG. 12A

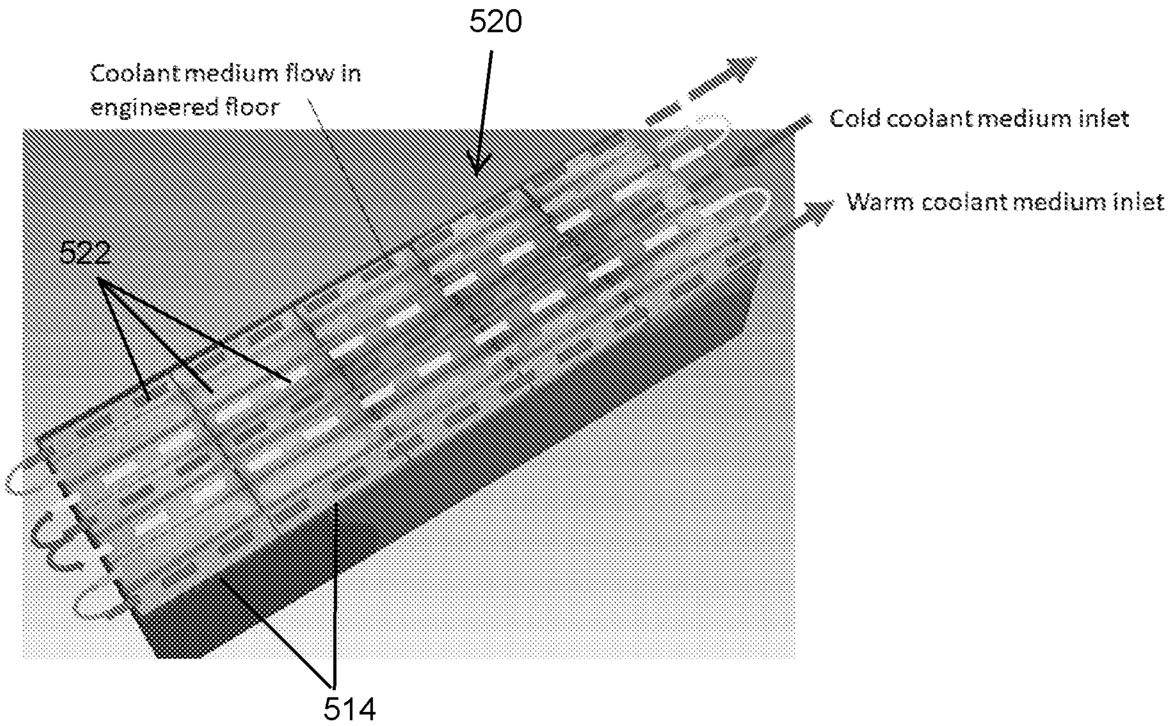

FIG. 13

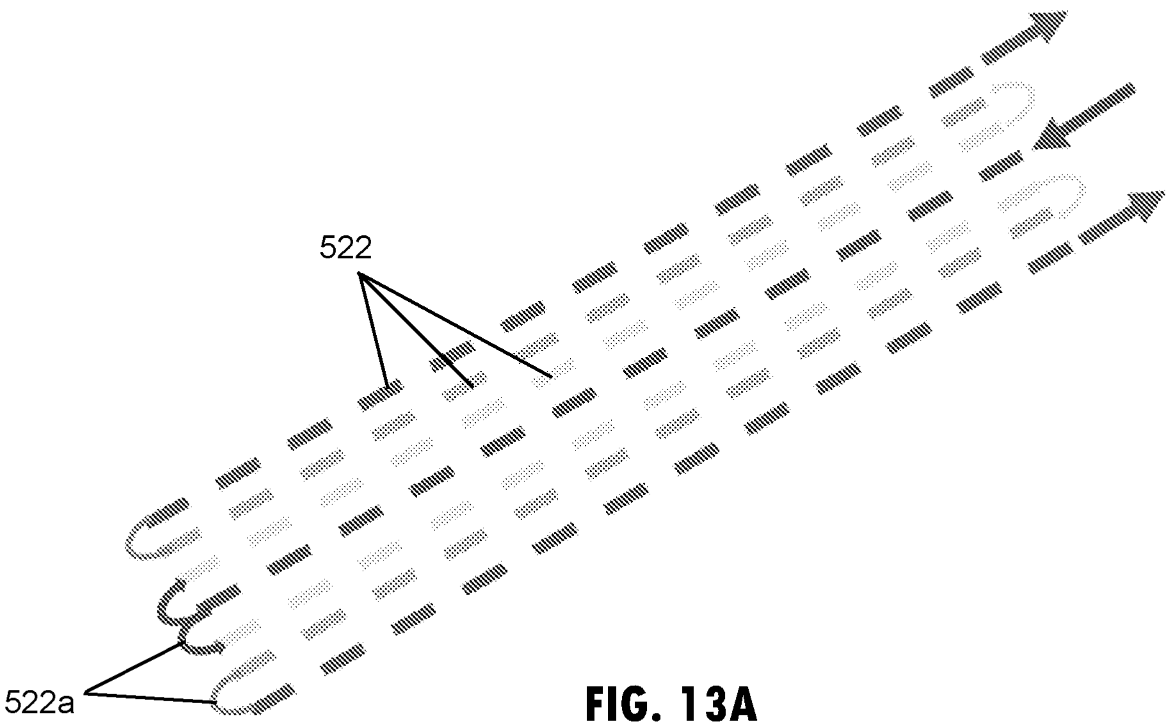

FIG. 13A

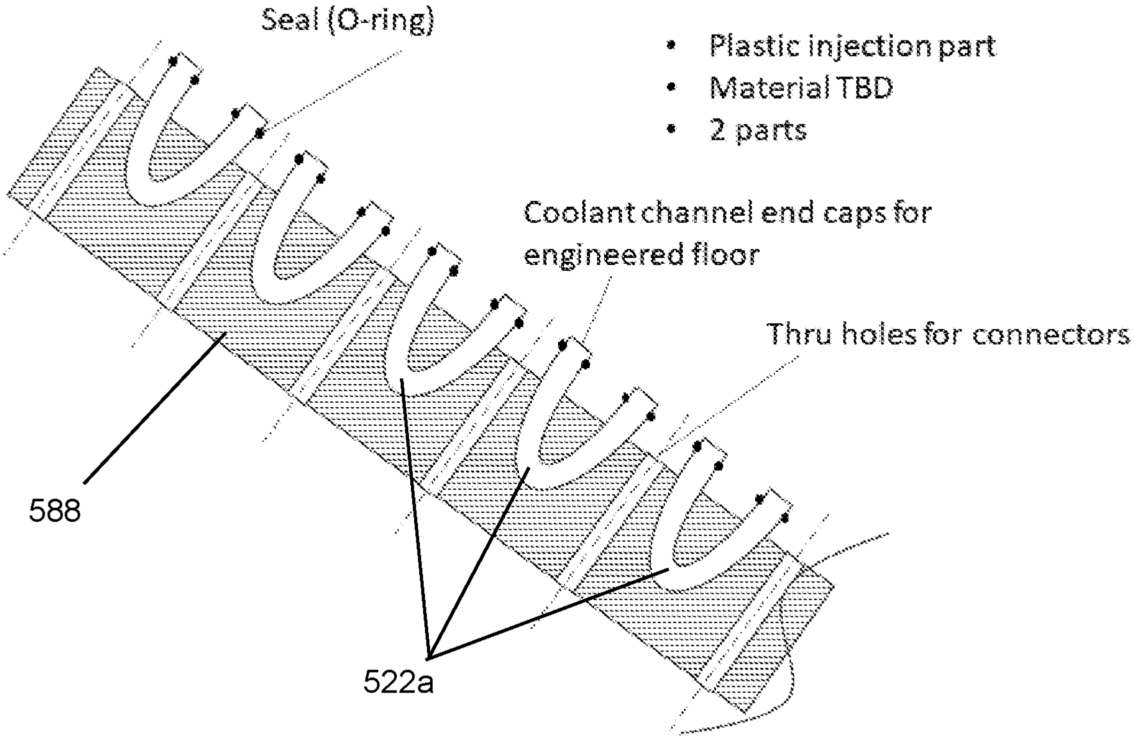
Seal (O-ring)
• Plastic injection part
• Material TBD
• 2 parts
Coolant channel end caps for engineered floor
Thru holes for connectors
588
522a

FIG. 14

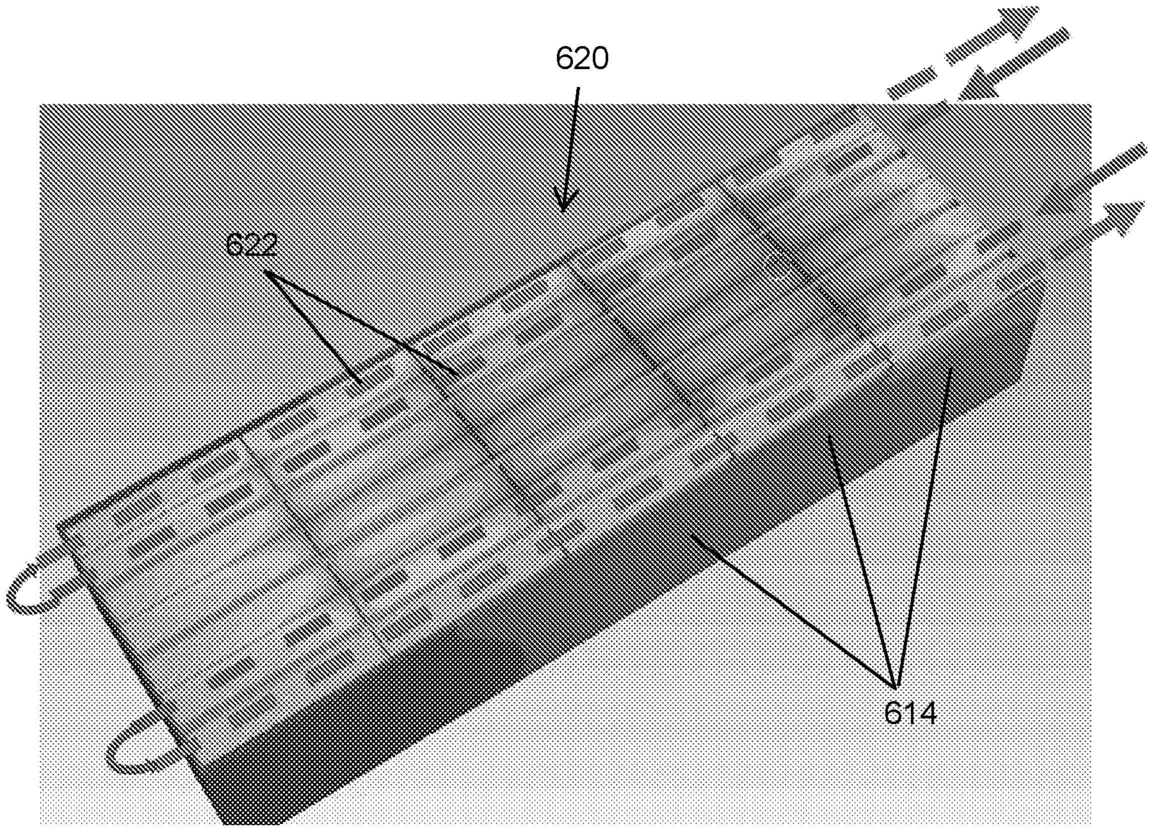

FIG. 15

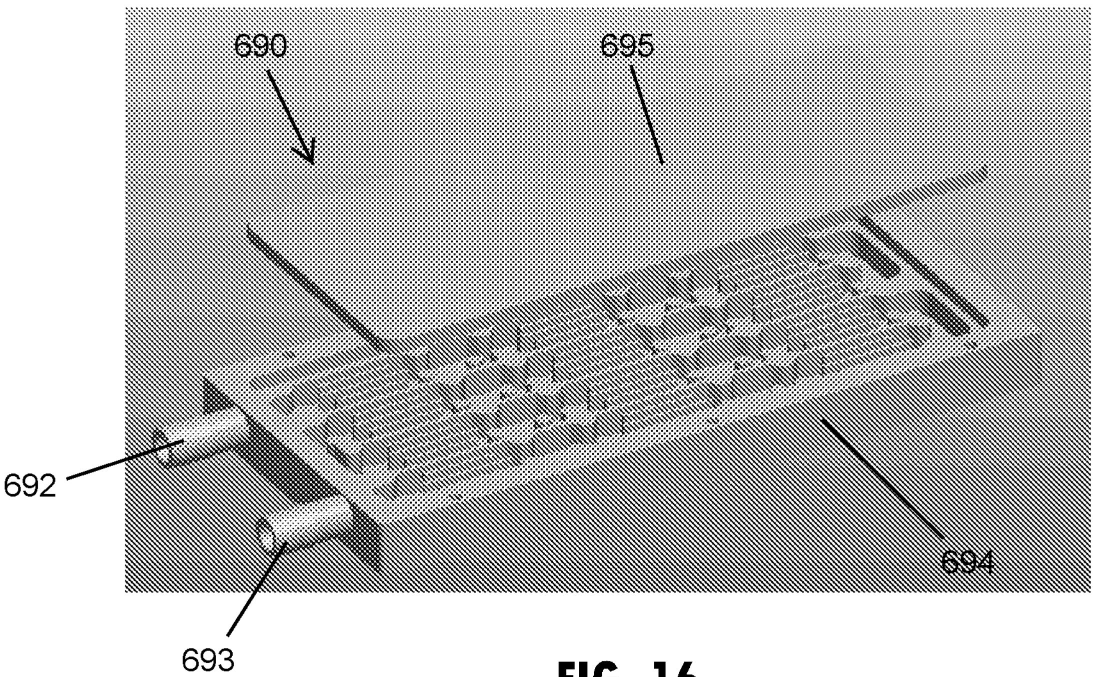

FIG. 16

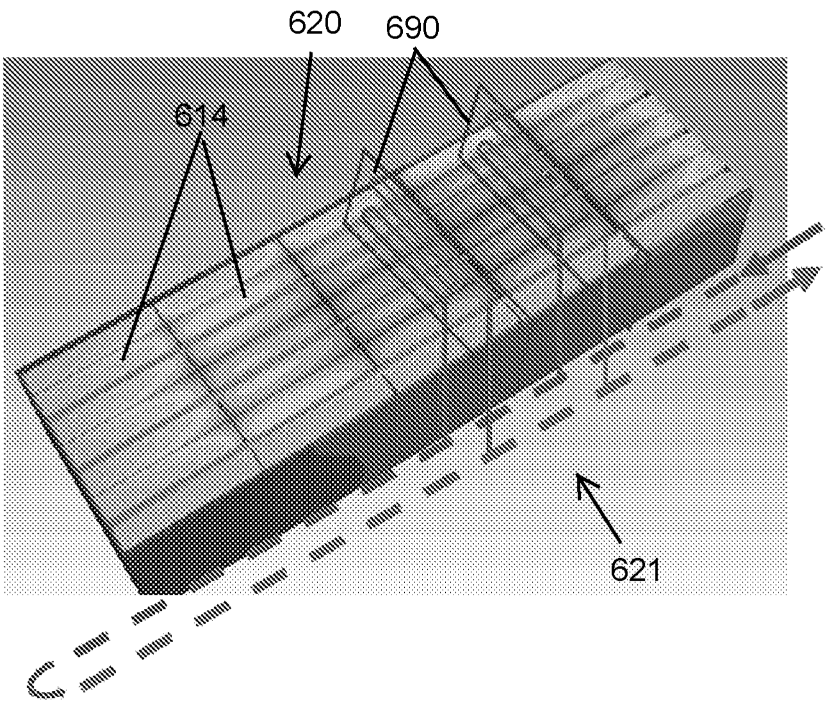
620
690
614
621

FIG. 17

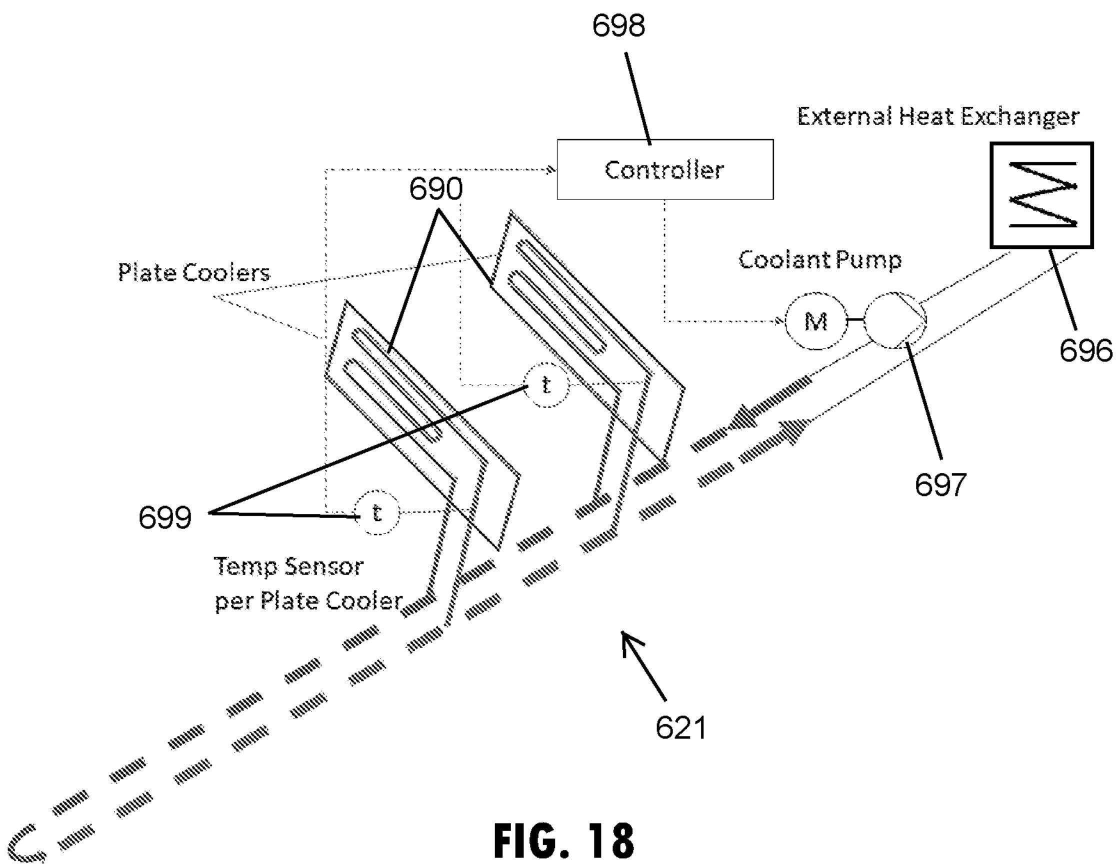
698
External Heat Exchanger
Controller
690
Plate Coolers
Coolant Pump
M
696
t
697
699
t
Temp Sensor
per Plate Cooler
621

FIG. 18

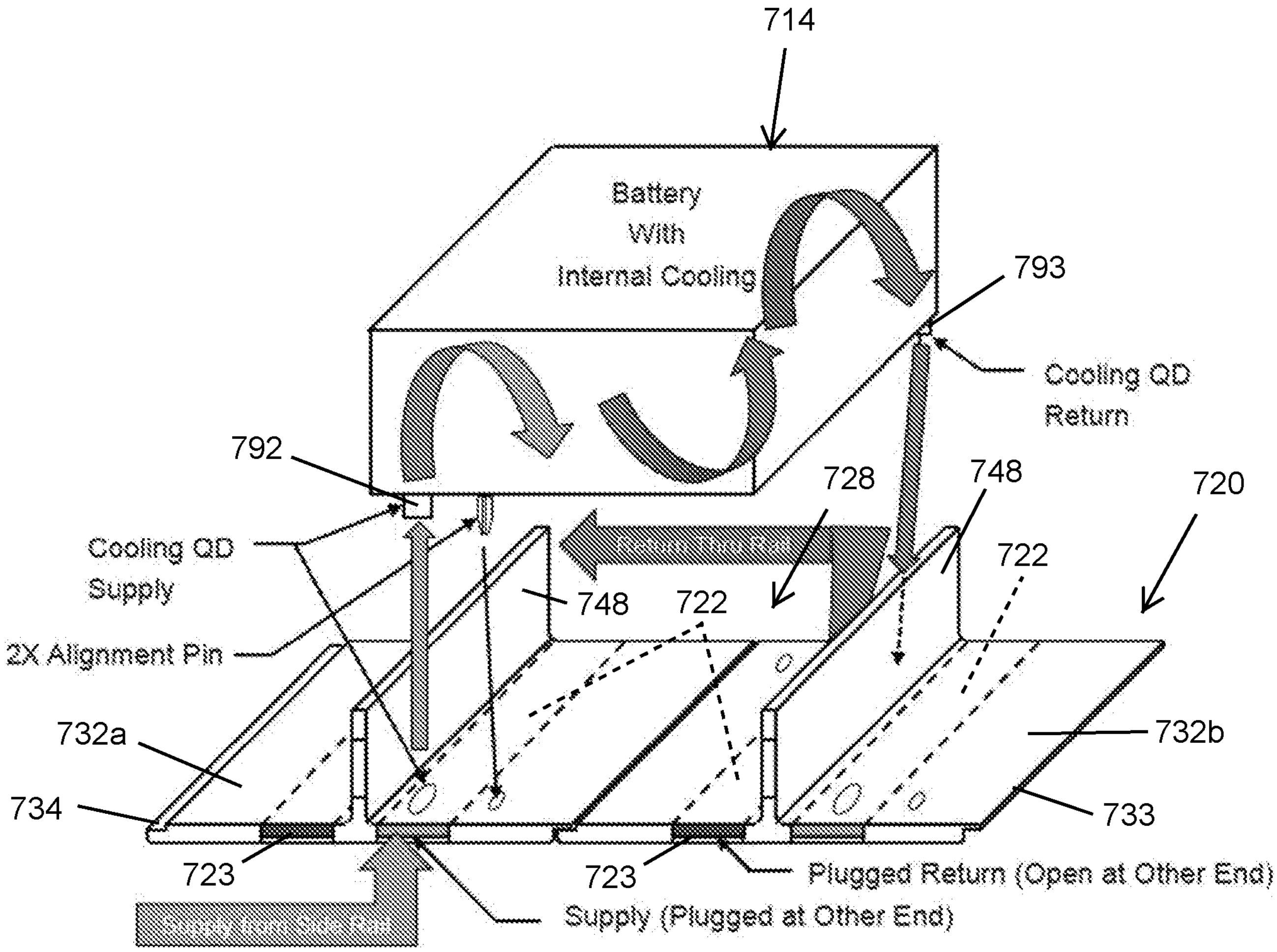
714
Battery
With
Internal Cooling
793
Cooling QD
Return
792
728
748
720
Cooling QD
Supply
748
722
722
2X Alignment Pin
732a
732b
734
733
723
723
Plugged Return (Open at Other End)
Supply (Plugged at Other End)

FIG. 19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/019964

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H01M10/6552(2014.01)i, B60K1/04(2019.01)i, H01M2/10(2006.01)i, H01M10/613(2014.01)i, H01M10/6551(2014.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. H01M10/6552, B60K1/04, H01M2/10, H01M10/613, H01M10/6551

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2019
Registered utility model specifications of Japan 1996-2019
Published registered utility model applications of Japan 1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2014-149929 A (HITACHI VEHICLE ENERGY, LTD.) 2014.08.21, Figs.1-18, [0011], [0027], [0105] (No Family)	1,7,9 2-5,8,10-15 6
X Y A	JP 2012-119156 A (SANYO ELECTRIC CO., LTD.) 2012.06.21, Figs.1,2,4, [0001], [0026], [0054] (No Family)	1,7,12-13 2-5,8-11,14-15 6
X Y A	US 2011/0020676 A1 (SANYO ELECTRIC CO., LTD.) 2011.01.27, Figs.1,2,4-8, [0078], [0088], [0106] & JP 2009-259785 A(Figs.1,2,4-8, [0022], [0032], [0050]) & WO 2009/119037 A1 & EP 2262048 A1 & CN 101978549 A	1,4-5,7,9 2-3,8,10-15 6

☑ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04.04.2019	11.06.2019

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	5T 4234 BANDO, Hiroshi Telephone No. +81-3-3581-1101 Ext. 3568

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 9-298070 A (THE TOKYO ELECTRIC POWER CO., INC.) 1997.11.18, Figs.1,2,8-10, [0063], [0065], [0069], [0070] (No Family)	1,4-5,7,9,12-13 2-3,8,10-11,14-15 6
Y A	US 2014/0370353 A1 (GS YUASA INTERNATIONAL LTD.) 2014.12.18, Figs.1-3,6,9,12, [0092], [0104]-[0106], [0140] & JP 2015-18790 A(Figs.1-3,6,9,12, [0075], [0087]-[0089], [0123]) & EP 2816633 A1	2-5,8-15 6
Y A	JP 2012-156057 A (PANASONIC CORPORATION) 2012.08.16, Figs.1,3,5,7-10,13-16, [0024], [0044], [0053] (No Family)	2-5,8-15 6