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(54) MULTI-VALVE FLUID DISTRIBUTION SYSTEM

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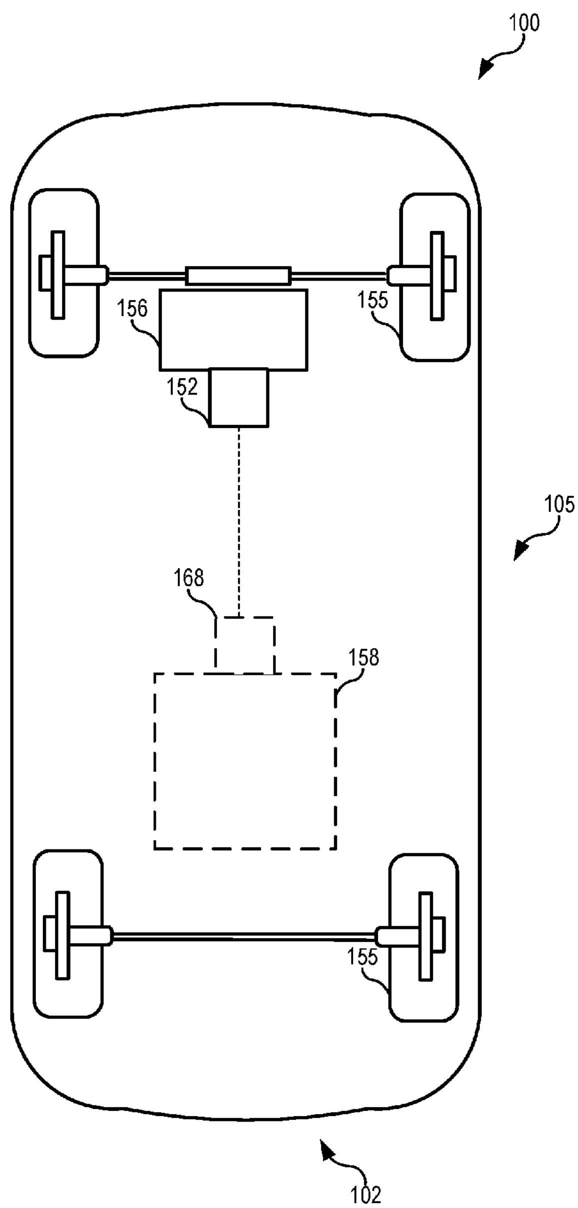
(57) **ABSTRACT**

Systems are provided for a fluid distribution system of for reconfigurable thermal management. In one example, a fluid distribution system comprises a fluid manifold that includes a plurality of sections with a plurality of inlet and outlet ports, and a pilot assembly including a plurality of manifold sections, a plurality of selectively couplable fluid chambers, and a plurality of solenoid-actuated pilot valve assemblies. The plurality of solenoid-actuated pilot valve assemblies control fluid flow through the plurality of selectively couplable fluid chambers by controlling pressure differential across a plurality of main diaphragms.



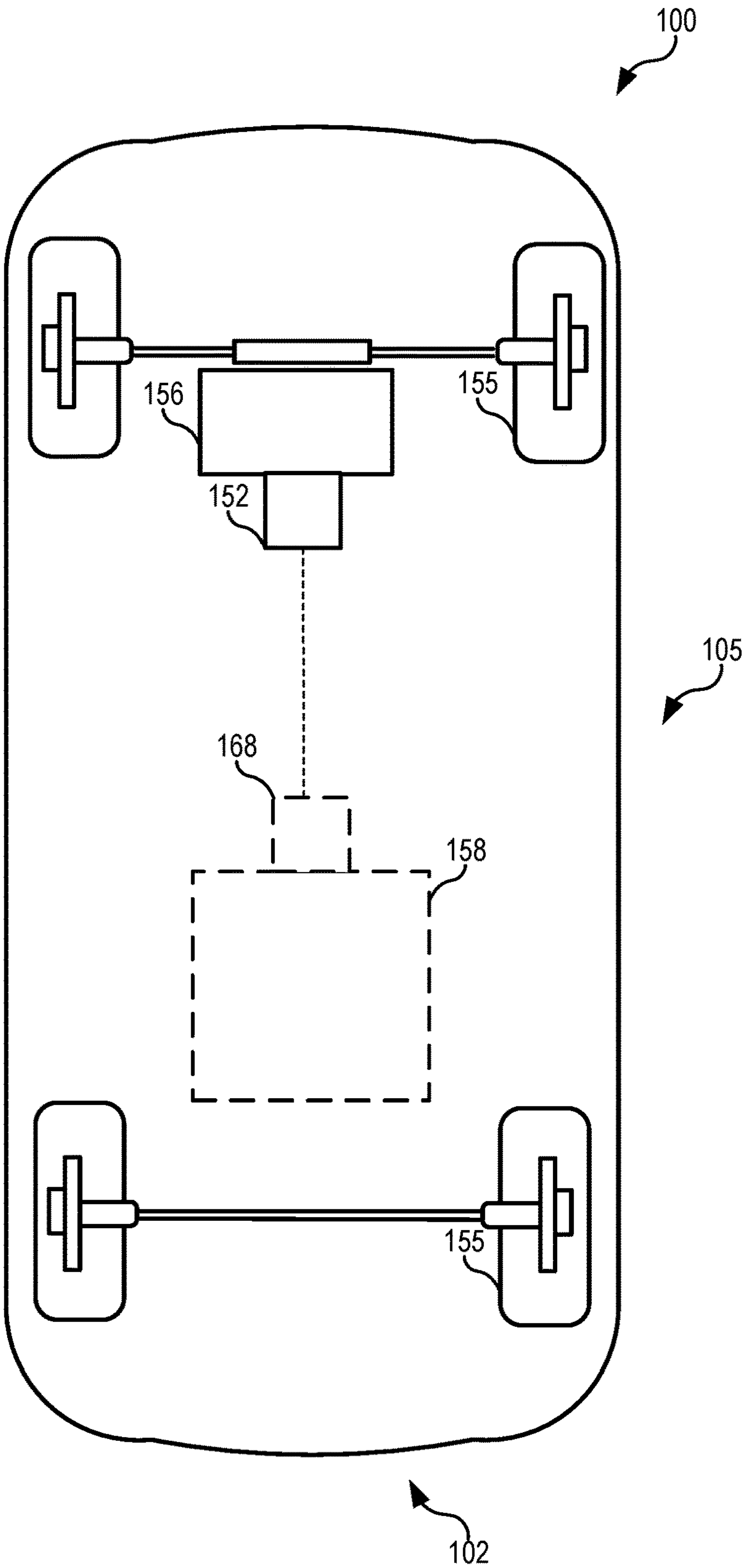


FIG. 1

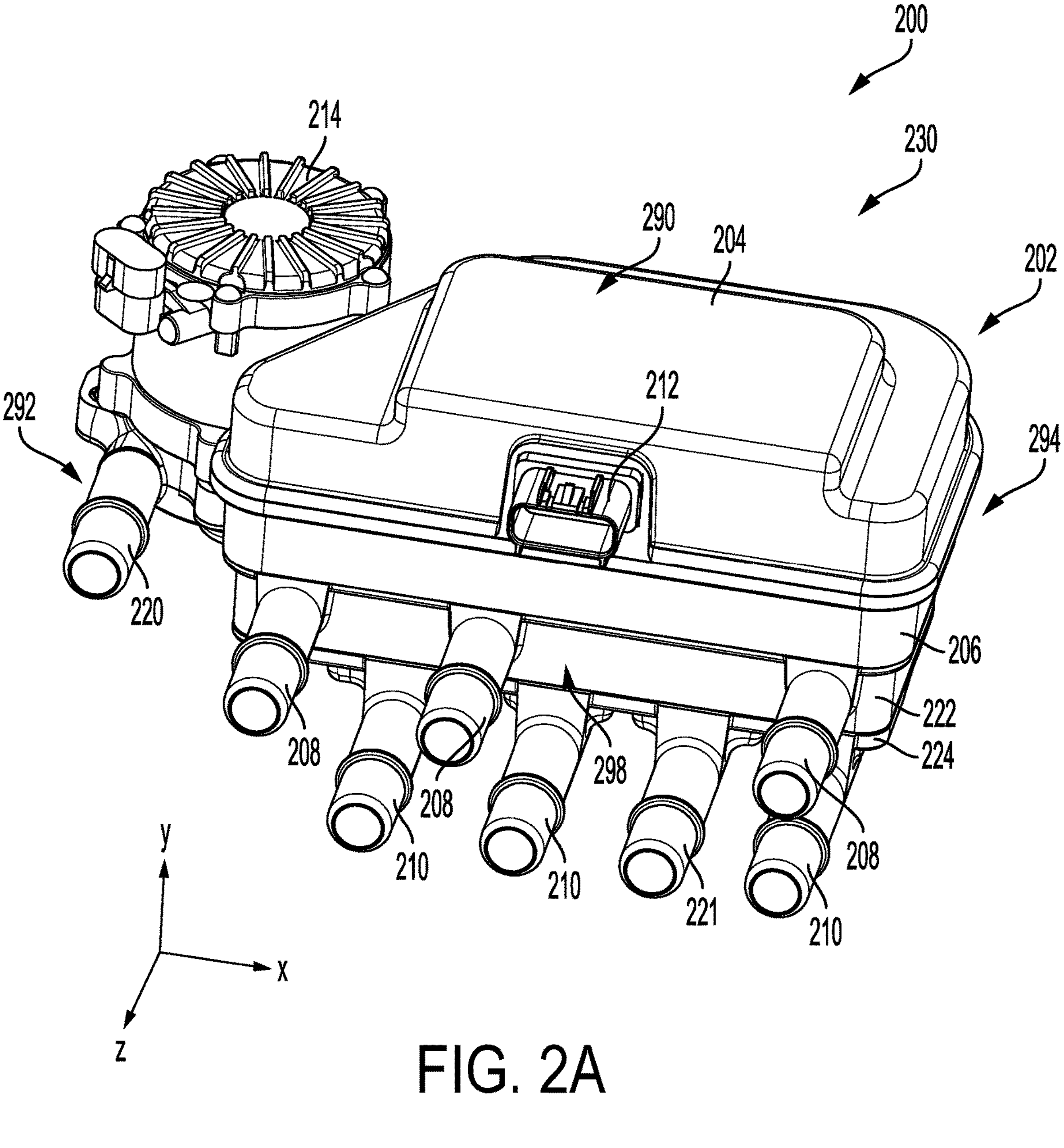

200
230
214
290
204
202
212
292
294
220
206
222
224
208
208
298
208
210
210
221
210
y
x
z

FIG. 2A

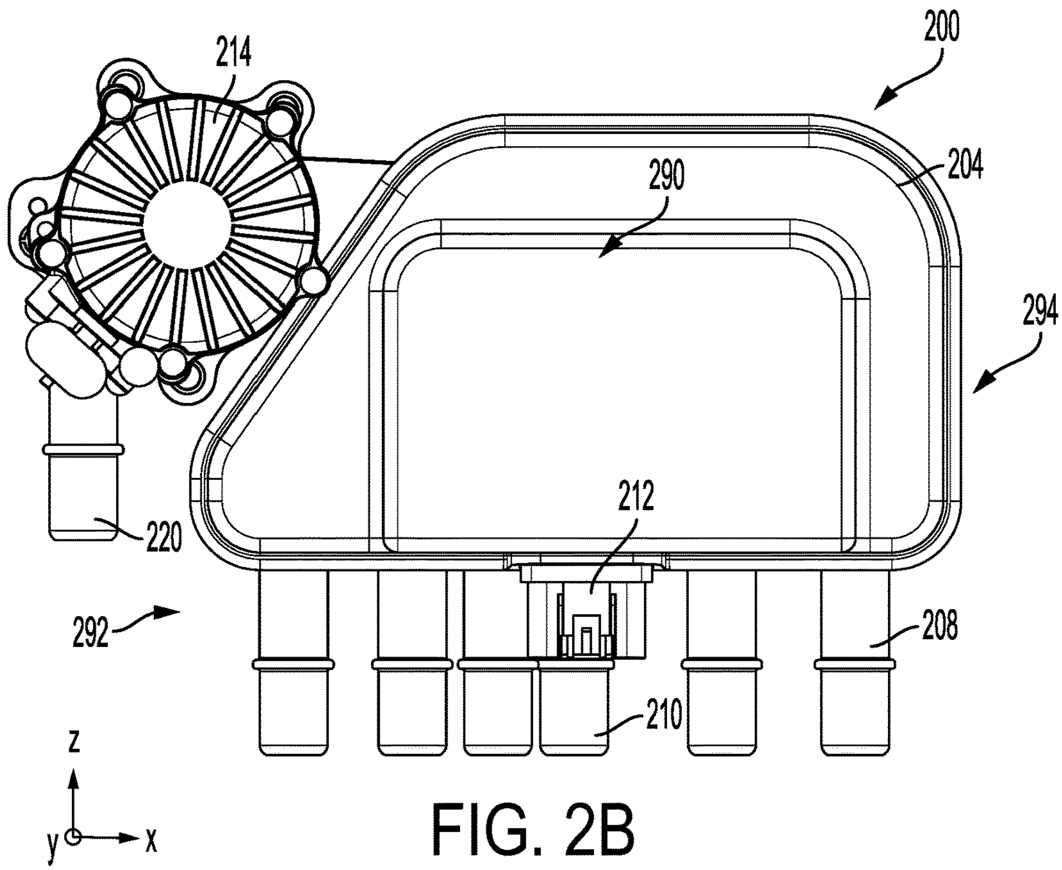

200
214
204
290
294
212
220
292
208
210
z
y
x

FIG. 2B

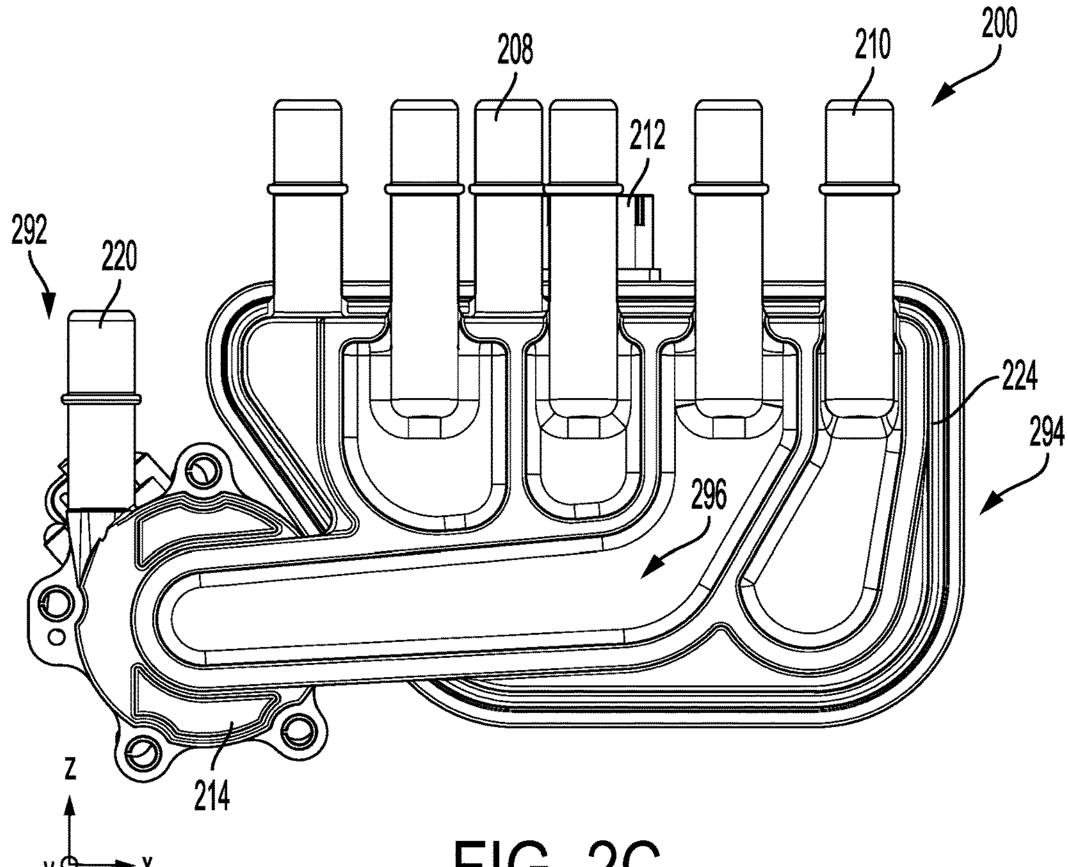

200
208
210
212
292
220
224
294
296
214
z
y
x

FIG. 2C

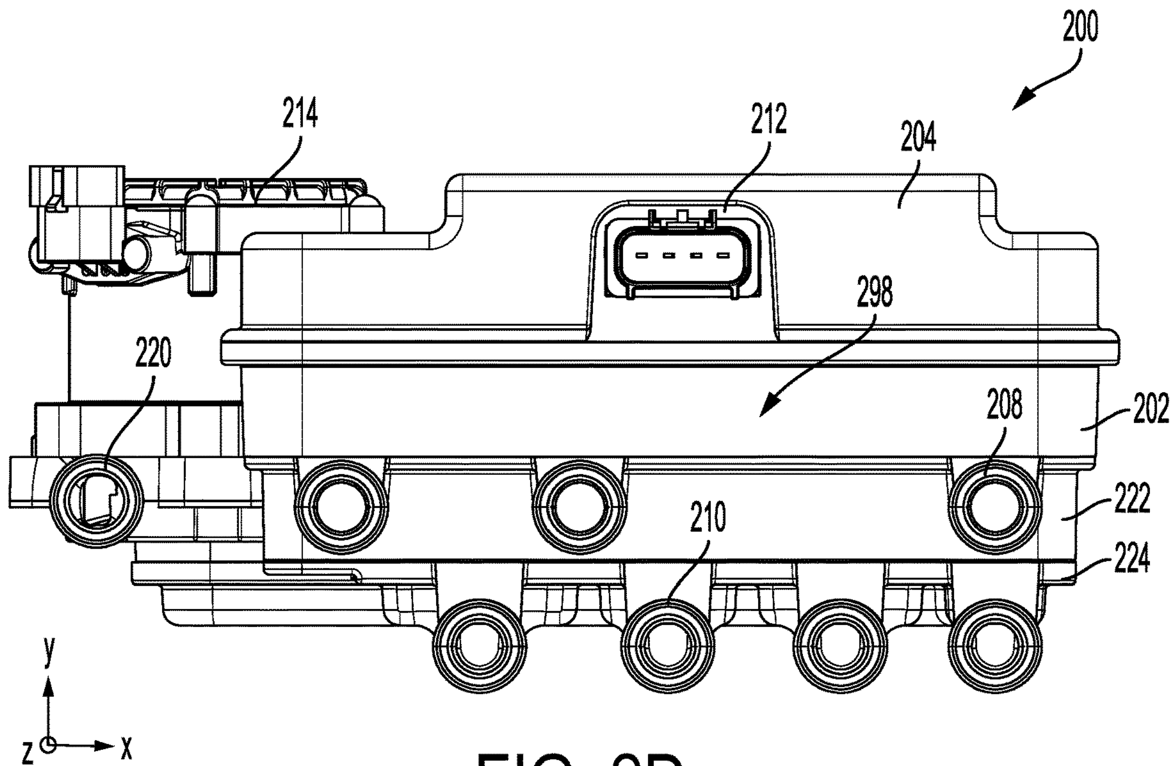

200
214
212
204
298
220
208
202
222
210
224
y
z
x

FIG. 2D

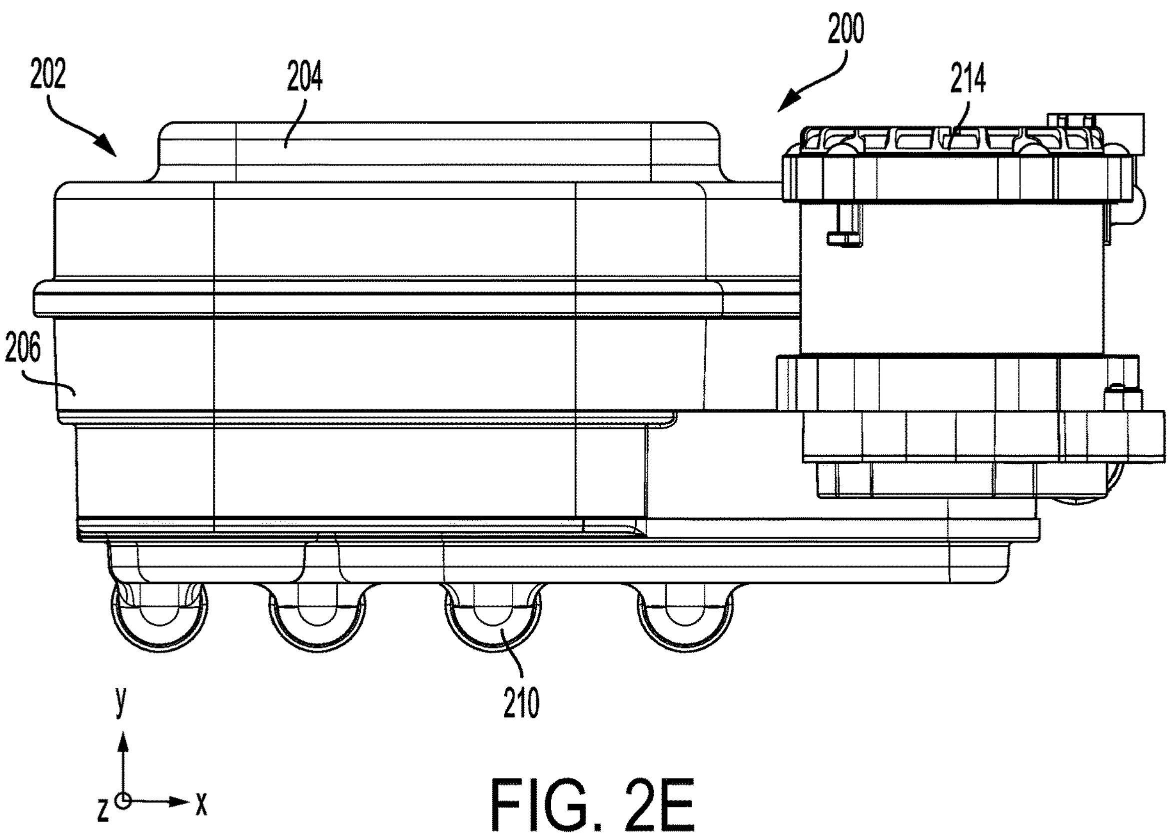

200
202
204
214
206
210
y
z
x

FIG. 2E

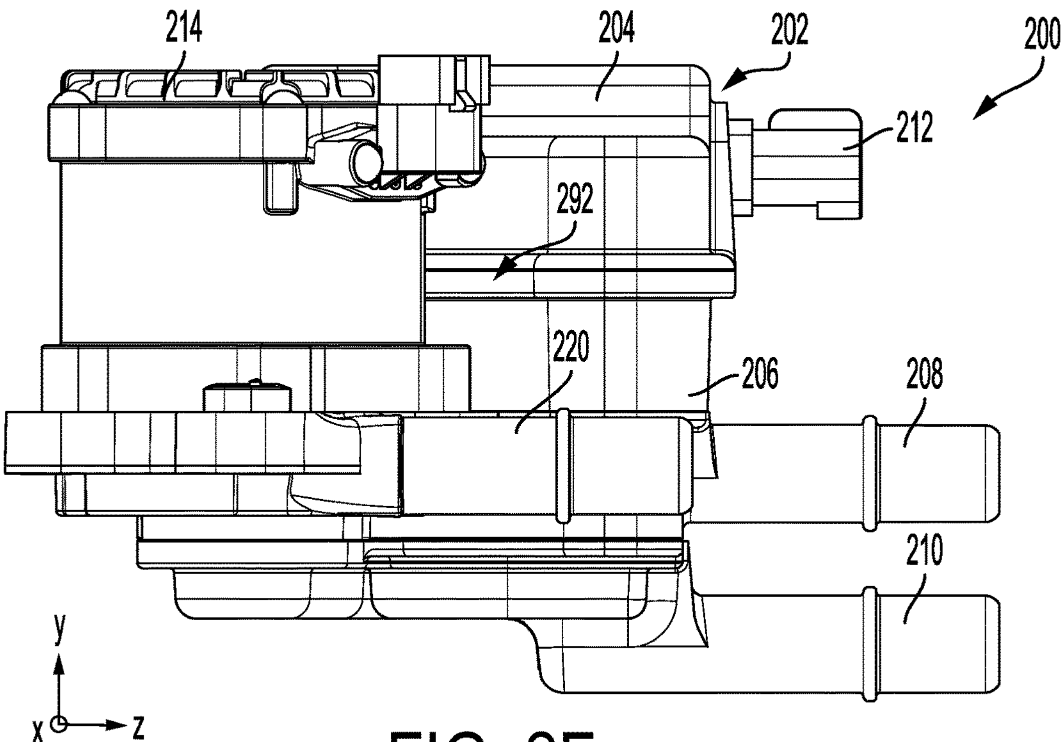

214
204
202
200
212
292
220
206
208
210
y
x
z

FIG. 2F

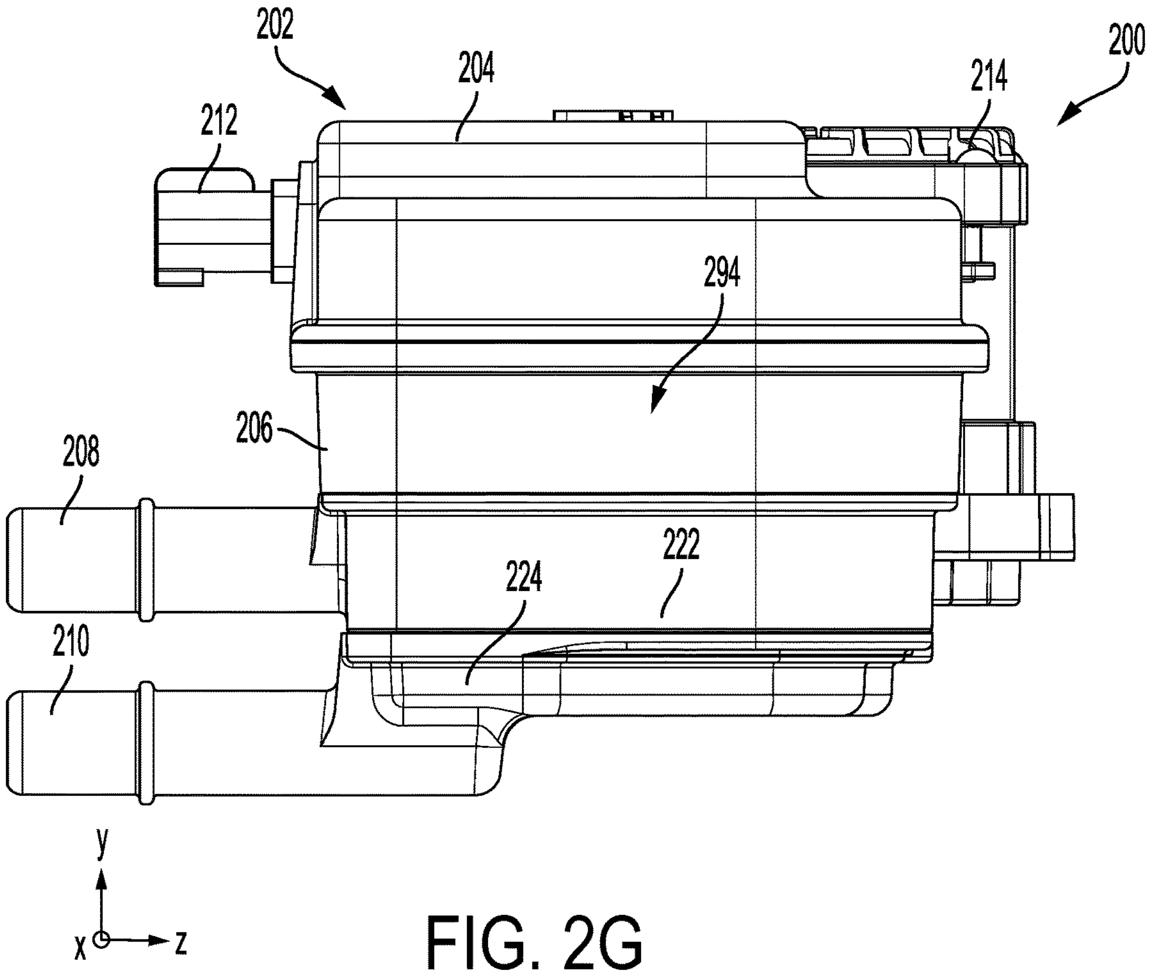

202
204
200
212
214
294
206
208
222
224
210
y
x
z

FIG. 2G

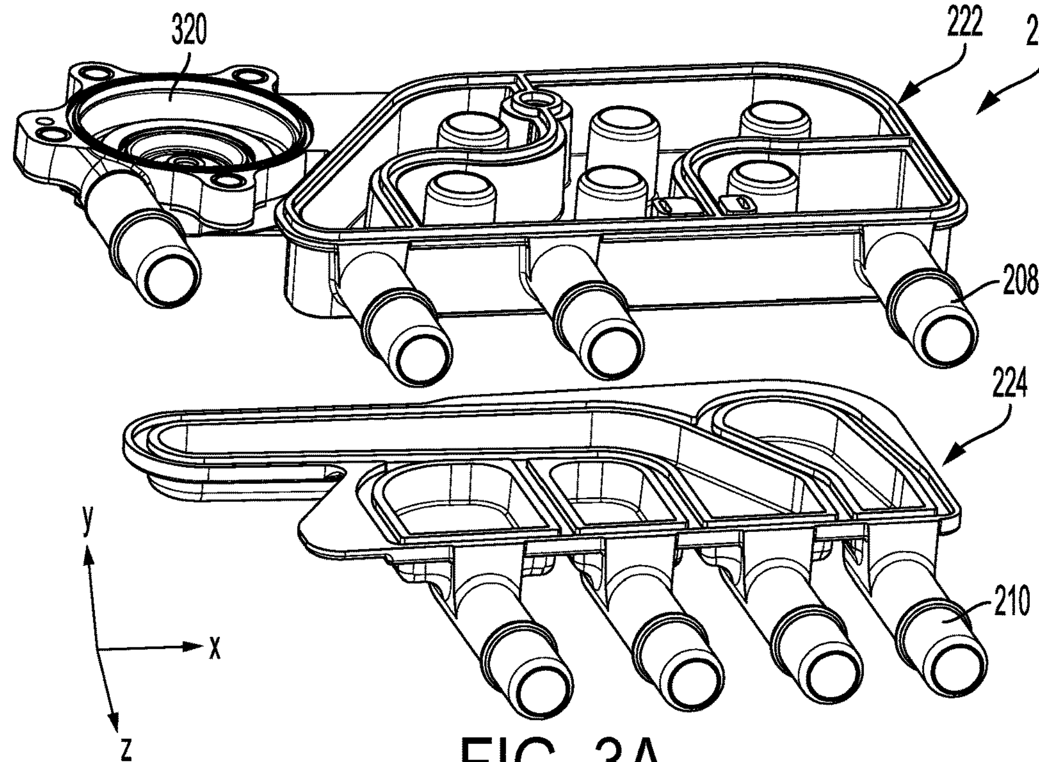

320
222
230
208
224
y
x
z
210

FIG. 3A

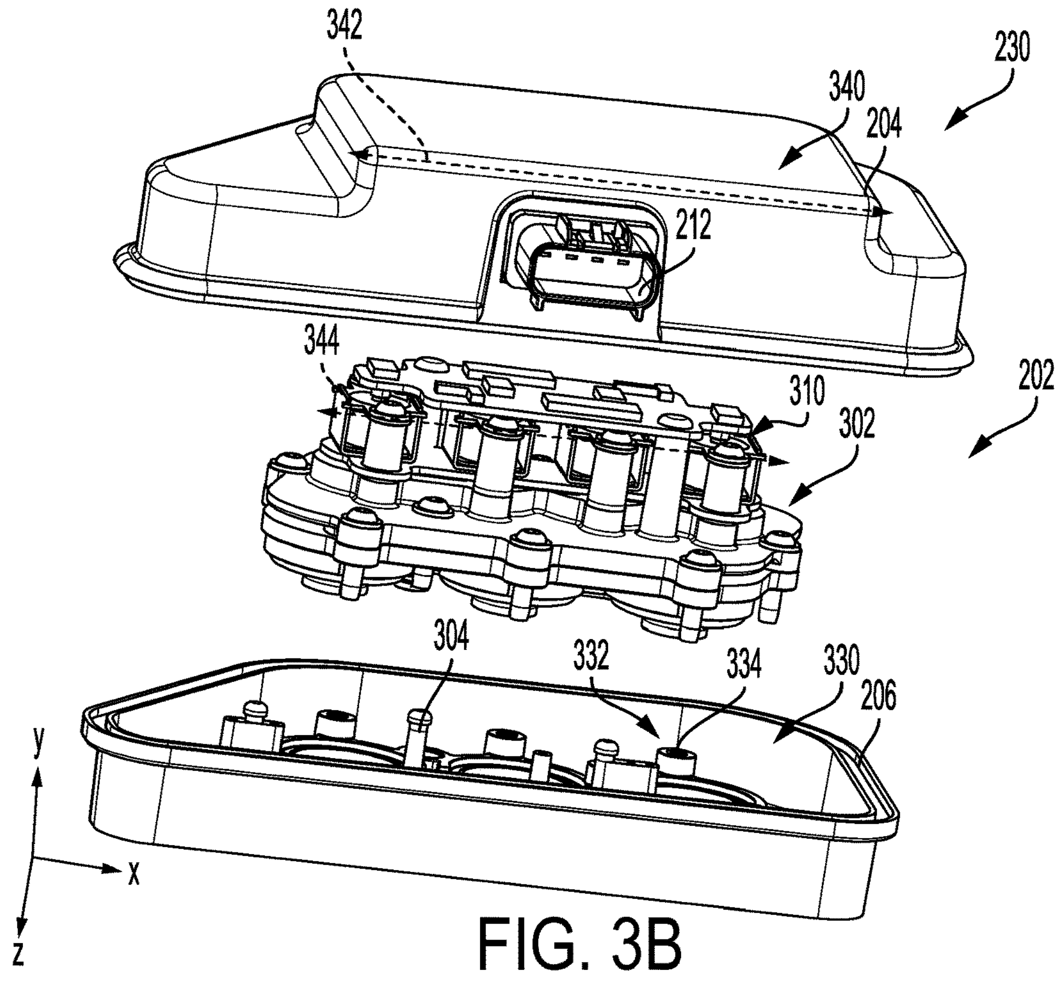

342
230
340
204
212
344
310
302
202
304
332
334
330
206
y
x
z

FIG. 3B

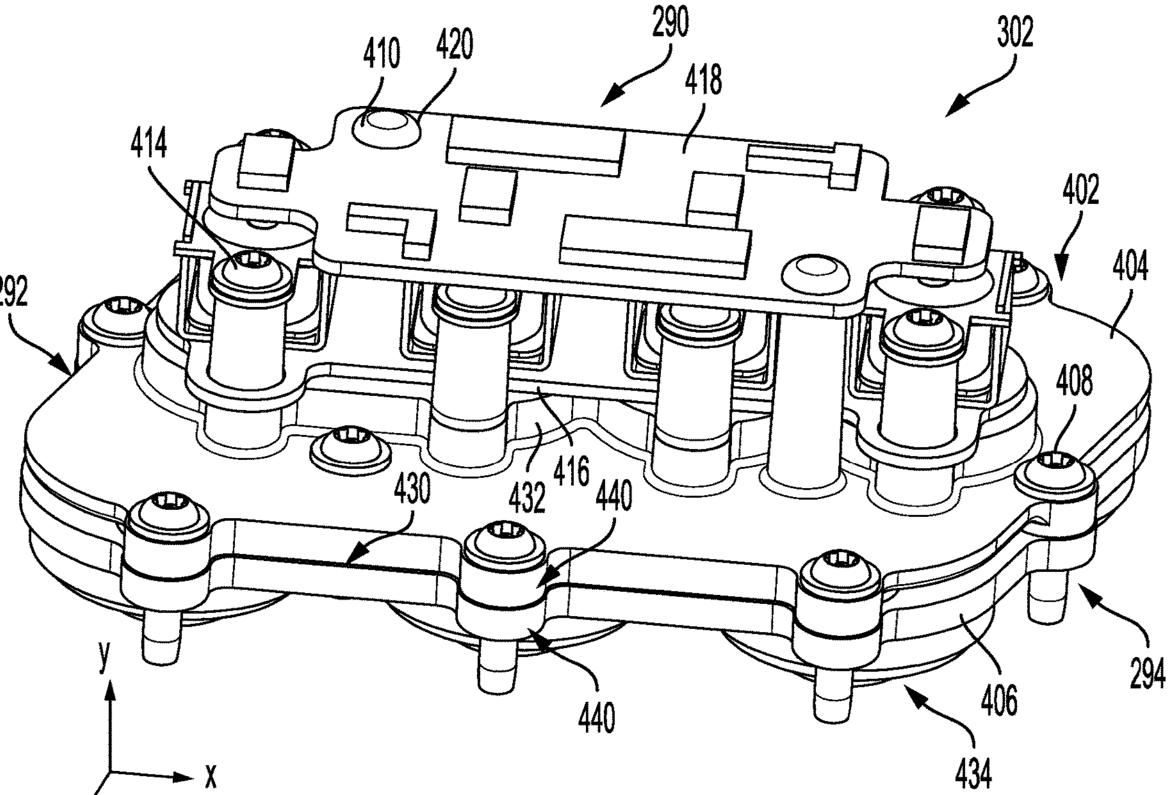

290
302
410
420
418
414
402
404
292
408
416
432
430
440
440
294
406
434
y
x
z

FIG. 4A

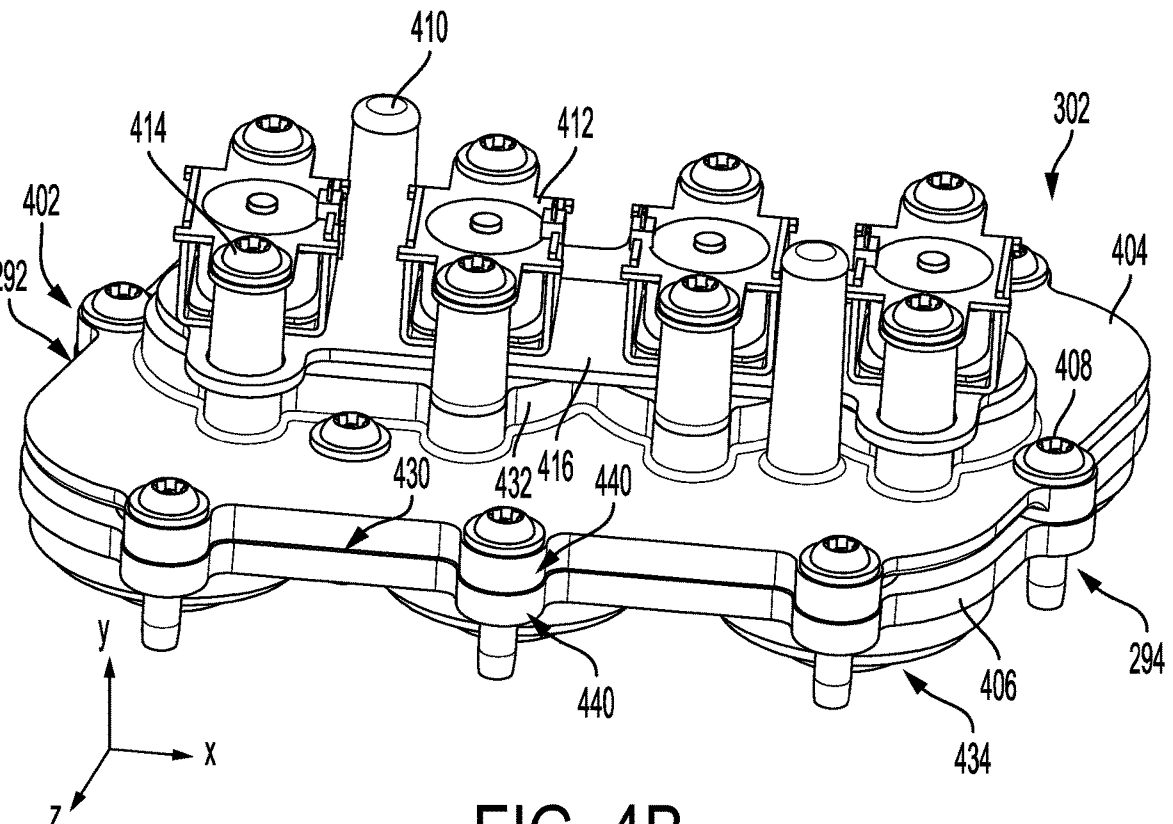

410
302
414
412
402
404
292
408
416
432
430
440
440
294
406
434
y
x
z

FIG. 4B

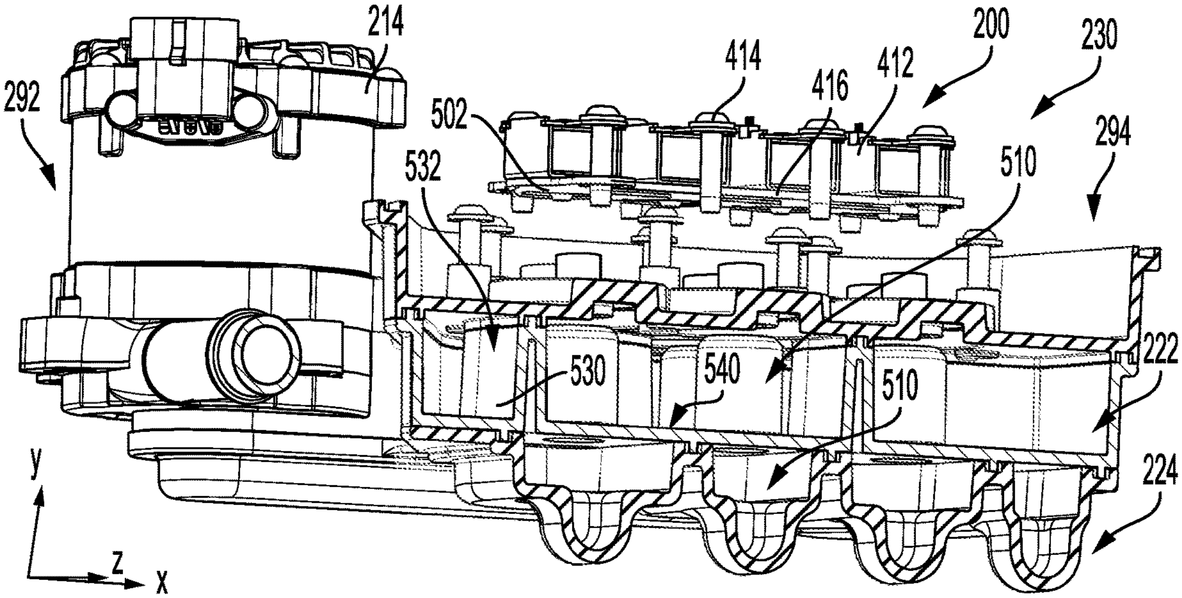

214
292
414
416
412
200
230
502
532
510
294
530
540
510
222
224
y
z
x

FIG. 5A

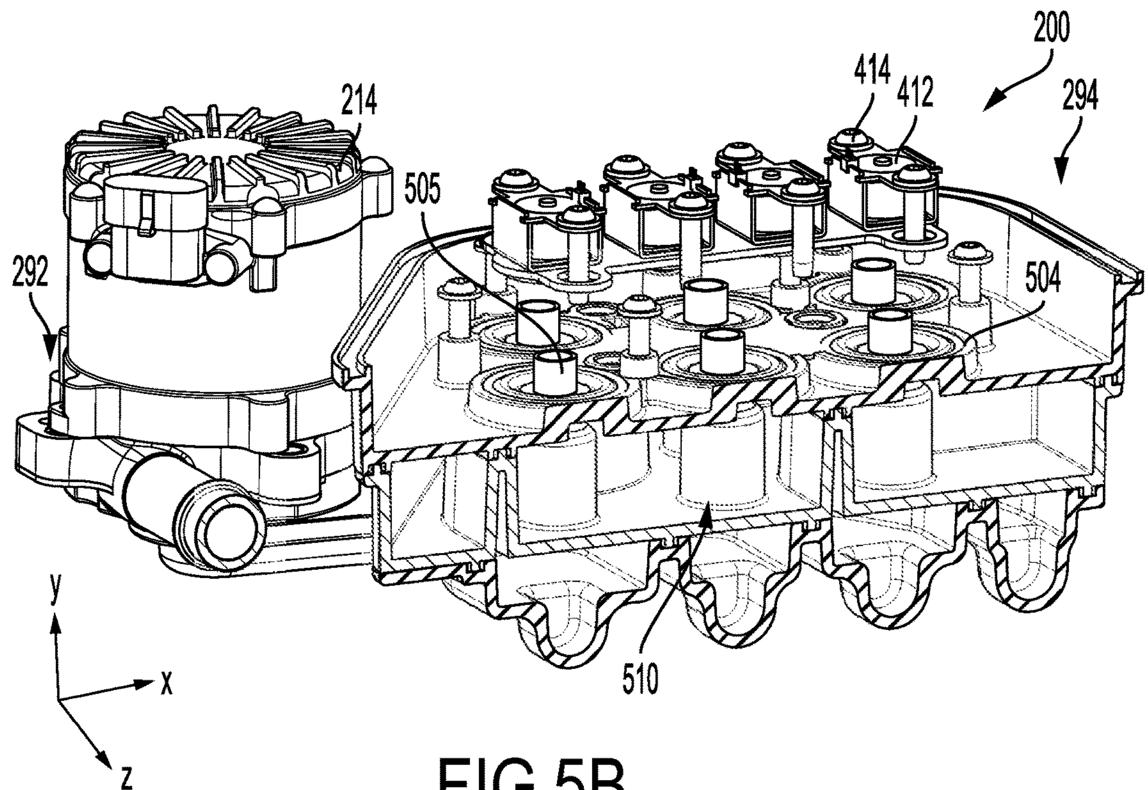

200
414
412
294
214
505
292
504
510
y
x
z

FIG.5B

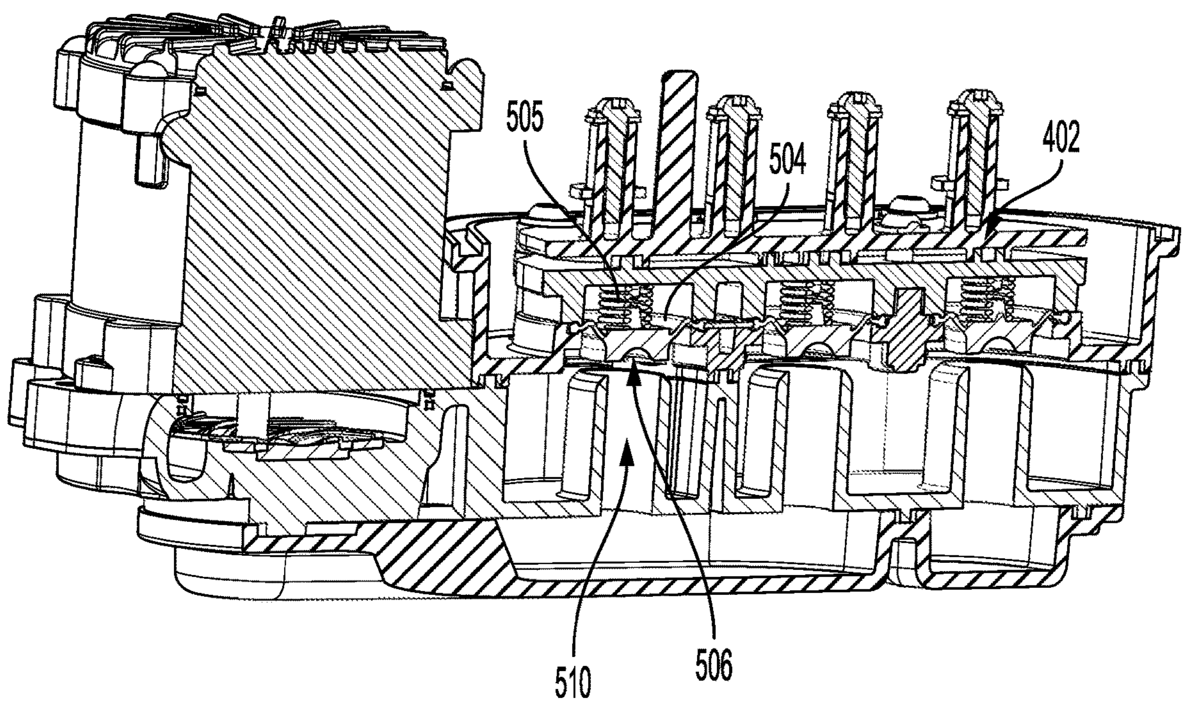


FIG. 5C

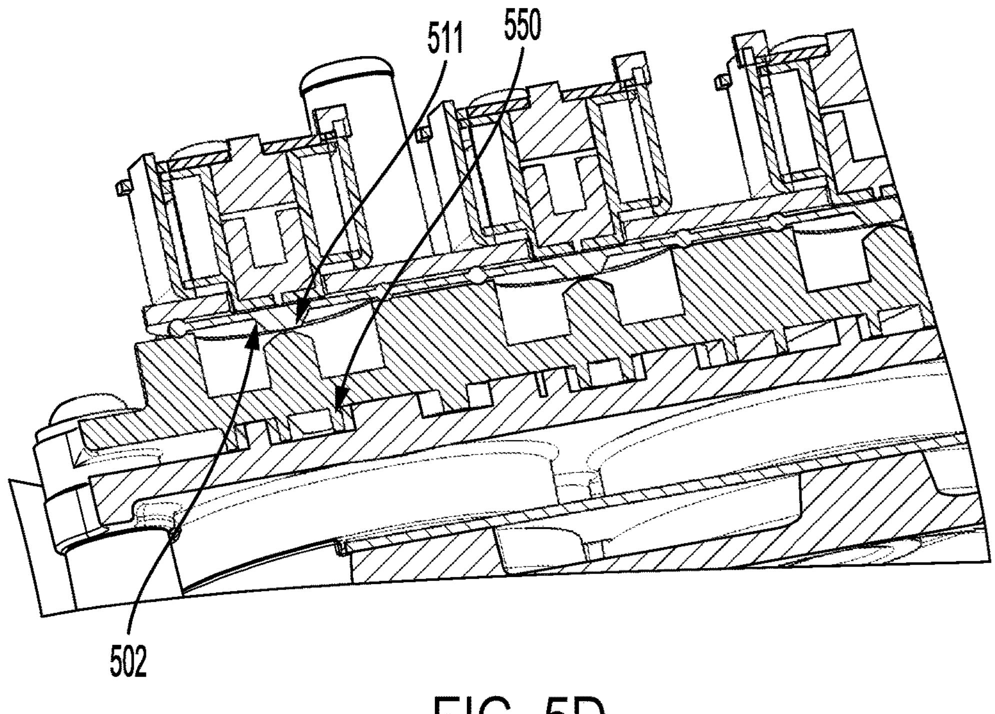


FIG. 5D

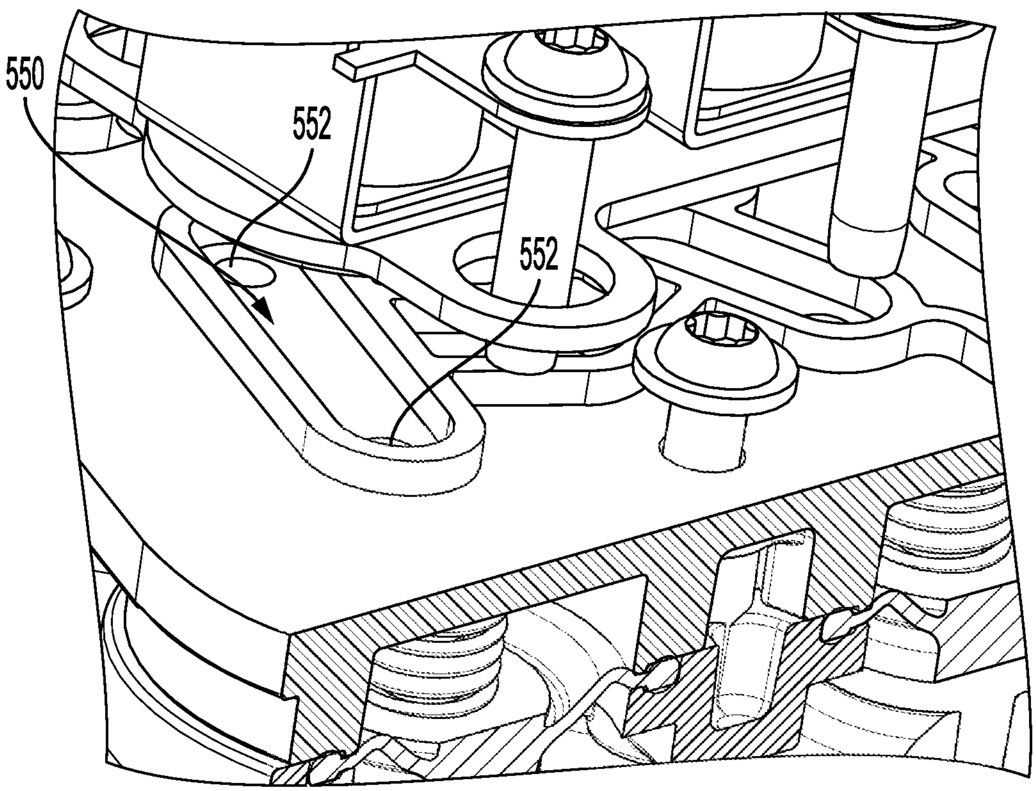


FIG. 5E

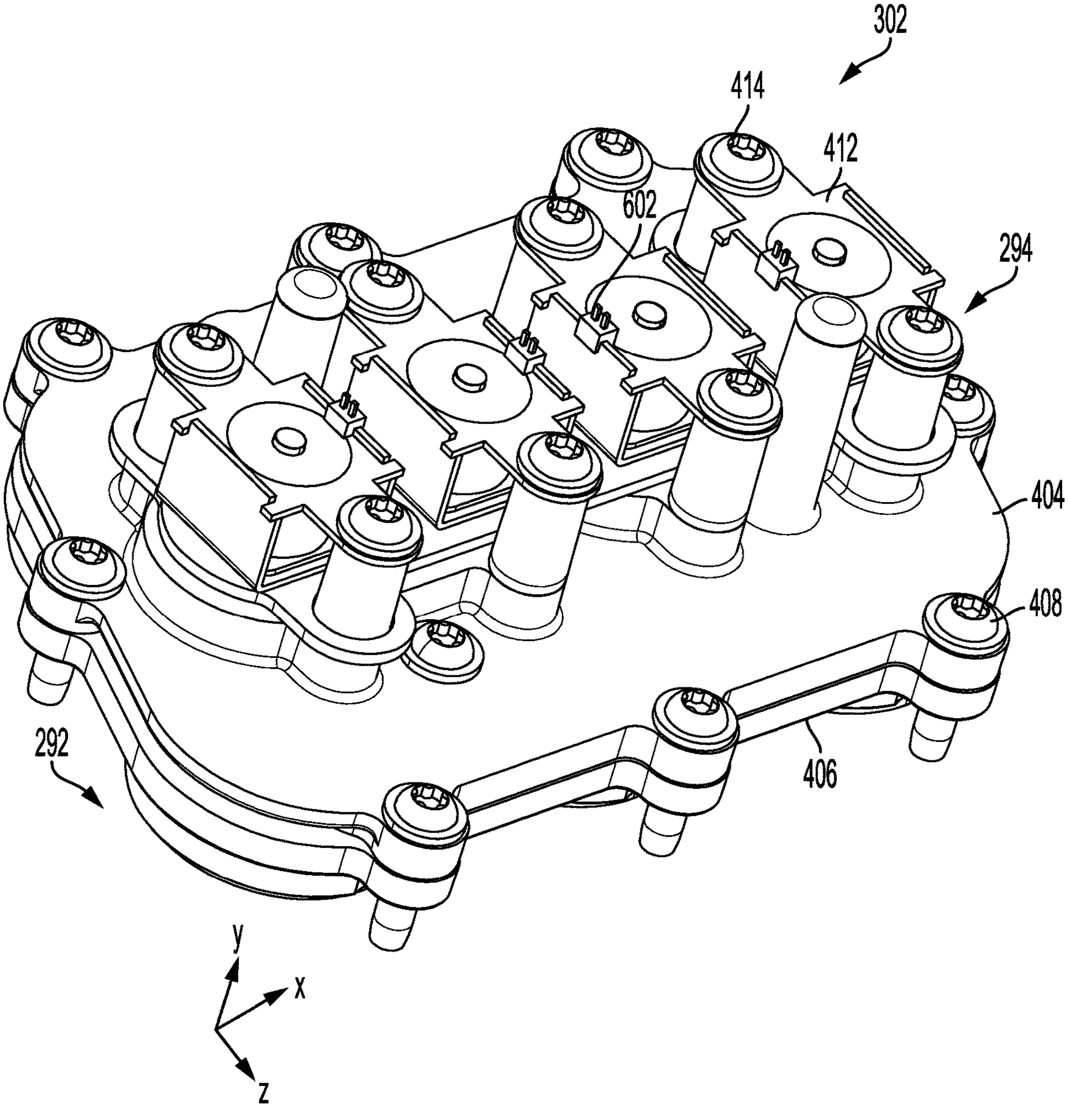


FIG. 6

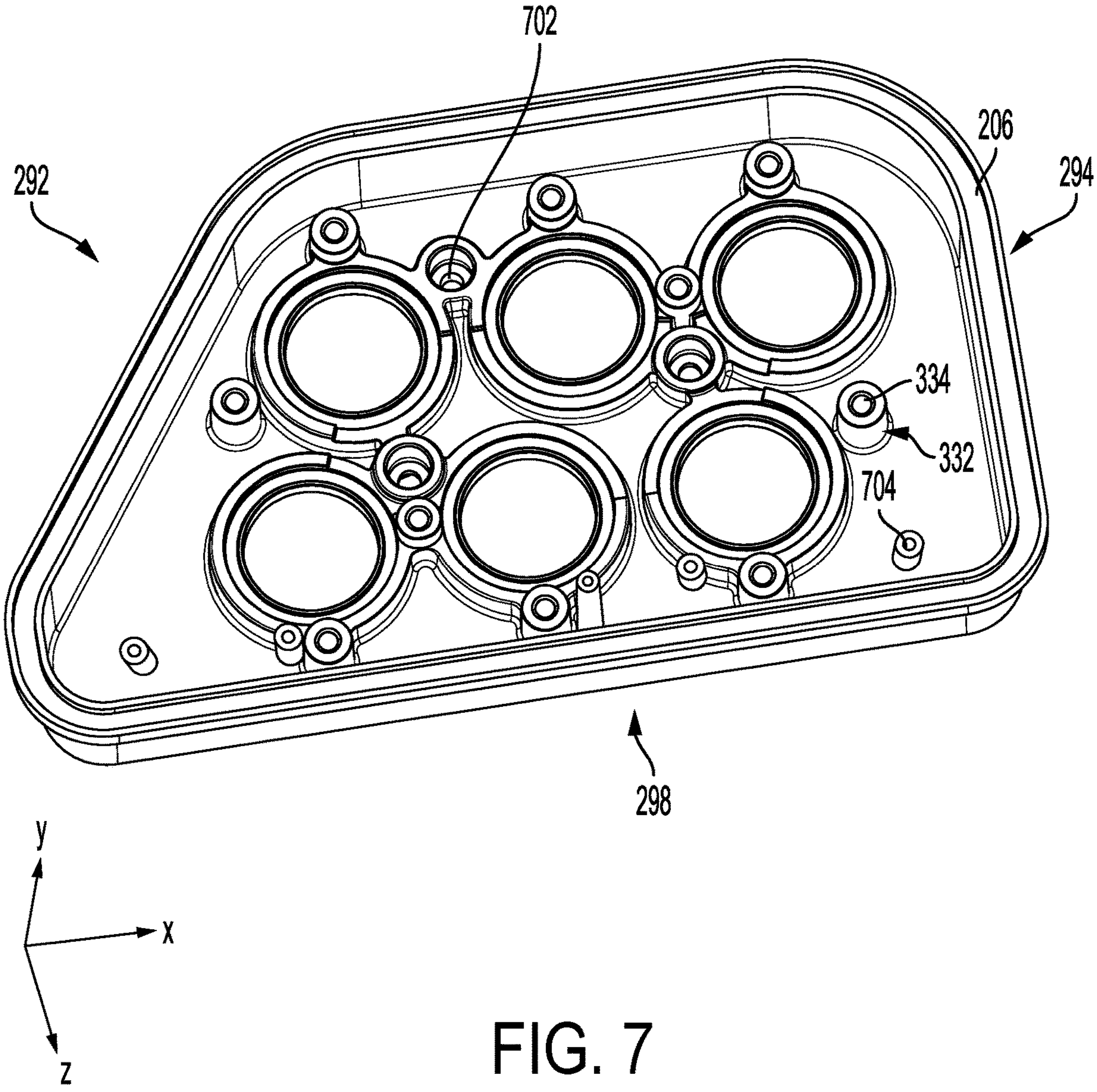


FIG. 7

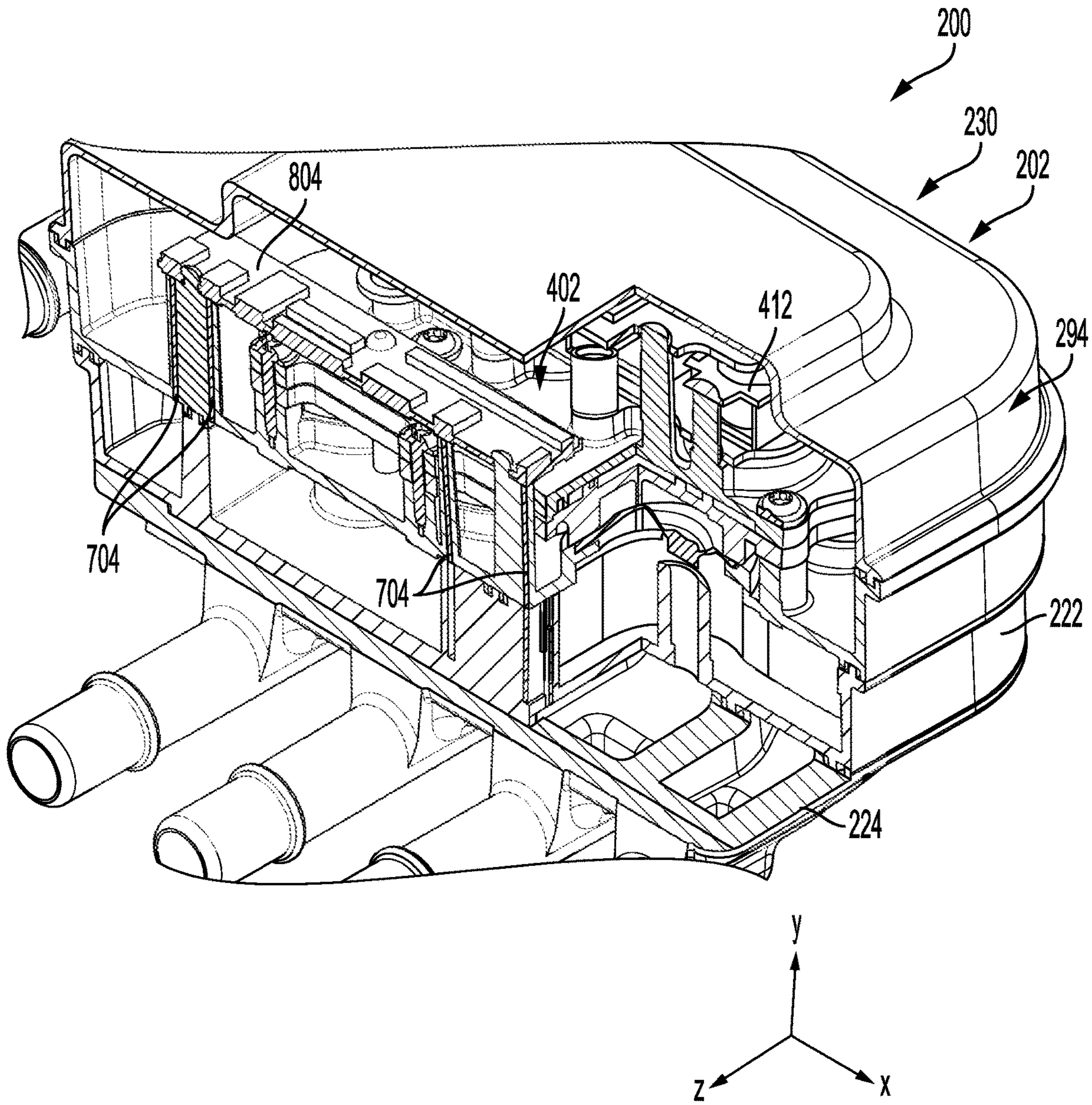


FIG. 8

MULTI-VALVE FLUID DISTRIBUTION SYSTEM

TECHNICAL FIELD

[0001] Embodiments of the subject matter disclosed herein relate to thermal management and more particularly to a multi-valve integrated fluid distribution system for reconfigurable vehicle thermal management.

BACKGROUND AND SUMMARY

[0002] Automotive thermal management systems utilize fluid to transfer heat from one system to another. In many automotive systems, actuated valves are used to control pressures or to control fluid flow. Direct solenoid flow valves, as often used, are simple in operation-utilizing a continuous direct current in the solenoid to allow or block fluid passage. Hydraulic flow valves controlled by a pilot pressure supplied by solenoid-actuated pilot valve assemblies are sometimes used to replace direct solenoid flow valves as a measure to reduce power consumption and valve size. In either type of valve, a solenoid is included with each of the valves included in the system which leads to increased manufacturing costs and weight of the package.

[0003] In order to serve required drive cycles and ambient conditions, reconfiguration of fluid flow within the vehicle is needed in order to divert cold, warm, and hot fluids to components in the vehicle, such as a battery system. Current thermal management systems for electric vehicles often utilize multiple individual valves to accomplish rerouting of fluid throughout the vehicle. The valves of such a distribution system occupy a significant amount of package space. The valves are often solenoid actuated, either direct or indirect as discussed, and therefore include coils (e.g., copper coils), which contribute to high manufacture and production costs as well as increased package weight and size.

[0004] The inventors herein have recognized the aforementioned issues and present a fluid distribution system for reconfigurable thermal management for an electric vehicle. The fluid distribution system disclosed comprises a fluid manifold with multiple sections arranged in layers and a pilot assembly that includes multiple manifold sections and a plurality of solenoid-actuated pilot valve assemblies that control position/status of a plurality of main diaphragms via changes in pressure differential. Each of the solenoid-actuated pilot valve assemblies includes a plurality of solenoids arranged side-by-side and a plurality of pilot diaphragms arranged side-by-side and positioned vertically below the plurality of solenoids.

[0005] A control board positioned directly above the one or more solenoids selectively provides current to the each of the plurality of solenoids in order to energize and/or de-energize the each of the plurality of solenoids. The plurality of solenoids control position/status of the plurality of pilot diaphragms and when one of the plurality of solenoid-actuated pilot valve assemblies is opened and/or closed, one or more of the plurality of main diaphragms may be opened and/or closed. Opening of a main diaphragm in this way allows for flow via an orifice that allows for fluid communication between selectively couplable fluid chambers that are arranged in separate sections of the fluid manifold. Similarly, closing of the main diaphragm disenables flow via the orifice, selectively decoupling fluid chambers. Each of the manifold sections includes one or more external fluid connections and one or more internal fluid connections, allowing for inflow and outflow of fluid via the manifold. A first section of the manifold is an inlet manifold that includes or is otherwise coupled to a plurality of inlet ports. A second section of the manifold is an outlet manifold that includes or is otherwise coupled to a plurality of outlet ports.

[0006] The multi-valve, multi-port design provides a compact, integrated package that provides for distribution and retrieval of fluid to and from multiple vehicle components. The fluid distribution system disclosed herein further includes an integrated pump, wherein an involute of the pump integrated into one of the manifold sections. In this way, weight of the pump may be reduced as the involute is manufactured along with the manifold.

[0007] As actuation of one of the plurality of solenoid-actuated pilot valve assemblies controls actuation of more than one of the main diaphragms, a single solenoid may control flow through/to more than one of the fluid chambers. In this way, number of solenoids demanded to reconfigure fluid flow may be reduced. Reduced number of solenoids, and consequently reducing amount of coils (e.g., copper coils) in the overall system, may decrease weight and size of the package.

[0008] It should be understood that the brief description above is provided to introduce in simplified form a selection of concepts that are further described in the detailed description. It is not meant to identify key or essential features of the claimed subject matter, the scope of which is defined uniquely by the claims that follow the detailed description. Furthermore, the claimed subject matter is not limited to implementations that solve any disadvantages noted above or in any part of this disclosure.

BRIEF DESCRIPTION OF THE FIGURES

[0009] The above, as well as other advantages of the present disclosure, will become readily apparent to those skilled in the art from the following detailed description when considered in light of the accompanying drawings in which:

[0010] FIG. **1** shows an example of an at least partially electrified vehicle.

[0011] FIG. **2**A shows a perspective view of an example of a fluid distribution system.

[0012] FIG. **2**B shows the fluid distribution system from a top down view.

[0013] FIG. **2**C shows the fluid distribution system from a bottom up view.

[0014] FIG. **2**D shows the fluid distribution system from a frontal view.

[0015] FIG. **2**E shows the fluid distribution system from a rear view.

[0016] FIG. **2**F shows the fluid distribution system from a first lateral view.

[0017] FIG. **2**G shows the fluid distribution system from a second lateral view.

[0018] FIG. **3**A shows an exploded view of a portion of the fluid distribution system.

[0019] FIG. **3**B shows an exploded view of another portion of the fluid distribution system.

[0020] FIG. **4**A shows an example of a manifold subassembly of the fluid distribution system.

[0021] FIG. **4**B shows another example of the manifold subassembly of the fluid distribution system.

[0022] FIG. **5**A shows a cross-sectional view of the fluid distribution system with the manifold subassembly removed.

[0023] FIG. **5**B shows another cross-sectional view of the fluid distribution system with the manifold subassembly removed.

[0024] FIG. **5**C shows another cross-sectional view of the fluid distribution system with the manifold subassembly in place.

[0025] FIG. **5**D shows another cross-sectional view of the fluid distribution system.

[0026] FIG. **5**E shows a perspective view of a cavity of the manifold subassembly.

[0027] FIG. **6** shows a perspective view of the manifold subassembly.

[0028] FIG. **7** shows an enclosure of a pilot assembly of the fluid distribution system.

[0029] FIG. **8** shows a cross-sectional perspective view of the fluid distribution system.

DETAILED DESCRIPTION

[0030] The following description relates to a multi-valve, multi-port integrated fluid distribution system for reconfigurable thermal management of a vehicle, such as an electric vehicle. The fluid distribution system comprises a manifold with first and second manifold sections and a pilot assembly that includes a manifold subassembly. The manifold subassembly comprises multiple sections arranged in two separate layers, the manifold layers having selectively couplable fluid chambers arranged on/within the separate layers. Fluid chambers arranged in separate layers are selectively couplable as controlled by solenoid-actuated pilot valve assemblies included and main diaphragms included in the manifold subassembly in order to direct fluid to a plurality of components of the vehicle via outlet ports. An example of the vehicle is depicted in schematic form in FIG. **1**. External views of the fluid distribution system herein described are shown in FIGS. **2**A-**2**G. Exploded views of the fluid distribution system, including the enclosure, cover, inlets/outlets, and manifold subassembly are shown in FIGS. **3**A-**3**B. The manifold subassembly and components included therein is depicted in FIGS. **4**A-**4**B. Internal components of the fluid distribution system are depicted in cross-sectional views wherein the manifold subassembly has been removed for visualization in FIGS. **5**A-**5**E. A perspective view of the manifold subassembly is shown in FIG. **6**. The enclosure of the pilot assembly is shown in FIG. **7**. Pressure sensor ports and connected circuit board are depicted in a cross-sectional view of the fluid distribution system in FIG. **8**.

[0031] Turning now to FIG. **1**, an example vehicle **105** is shown. In some examples, vehicle **105** may be a hybrid vehicle with multiple sources of torque available to one or more vehicle wheels **155**. In other examples, vehicle **105** may be an all-electric vehicle, powered exclusively by an energy storage device such as a battery assembly, herein referred to as a battery **158**. In the example shown, vehicle **105** includes an electric machine **152** which may be a motor or a motor/generator. Electric machine **152** receives electrical power from the battery **158** which is converted to rotational energy, e.g., torque, at a transmission **156**. The torque is delivered to vehicle wheels **155**. Electric machine **152** may also be operated as a generator to provide electrical power to charge battery **158**, for example, during a braking operation.

[0032] While electric machine **152** is shown providing rotational energy to the vehicle wheels **155** proximate to a front end **100** of vehicle **105**, e.g., at front wheels of the vehicle, via the transmission **156**, it will be appreciated that the transmission **156** may be alternatively arranged at rear wheels of vehicle **105**, e.g., vehicle wheels **155** proximate to a rear end **102** of the vehicle, and energy from the electric machine **152** transmitted thereto. Furthermore, in other examples, each of the front wheels and the rear wheels may be coupled to individual transmissions, such as when vehicle **105** is configured with all-wheel drive.

[0033] In some examples, the vehicle **105** may further comprise a thermal management system **168**. The thermal management system **168** may be in communication with the battery **158** to provide fluid of variable temperatures to alter a temperature of the battery **158**. The thermal management system **168** may be in further communication with the electric machine **152**, as well as other components not depicted. The thermal management system **168** may be configured to control external and internal temperature conditions as well as regulating optimal temperature of the battery **158**, the electric machine **152**, and more. In some examples, the thermal management system **168** includes a fluid distribution system for reconfiguring fluid of variable temperatures to components of the vehicle **105**.

[0034] The battery assembly (e.g., the battery **158**) may be a single battery or may include a plurality of cells or modules electrically coupled to one another. A quantity of the plurality of cells may determine a capacity of the battery **158**. The battery **158** may be configured with a high power-to-weight ratio, high specific energy, and high energy density to provide power over long periods of time. Examples of battery types which may be used in vehicle **105** include lithium-ion, lithium polymer, lead-acid, nickel-cadmium, and nick-metal hydride batteries, amongst others. The battery **158** may be a rechargeable battery, such as a battery formed of lithium-ion cells. When configured as a rechargeable battery, the battery **158** may be recharged by regenerative braking operations or an external power source. Battery performance and life may depend on the applied load (and therefore on the charge/discharge rate), as well as operating conditions (such as temperature). The battery **158** may work efficiently over a range of discharge rates (e.g., C/8-2C), within a target range of operating temperatures (typically from 20° C. to 45° C.), and at relatively uniform temperature (e.g., temperature uniformity of less than 5° C.).

[0035] Temperature and/or pressure within the battery **158** may rise to a level that is not sustainable for operation of the battery **158** or otherwise results in degradation of the battery **158**. The thermal management system **168** as well as the fluid distribution system therein may regulate and/or maintain temperatures within the battery **158**, as well as other components discussed herein, in order to reduce degradation and increase longevity of the battery **158**.

[0036] Turning now to FIGS. **2**A-**2**G, external views of an example fluid distribution system **200** are shown. FIG. **2**A specifically depicts the fluid distribution system **200** from a perspective view, FIG. **2**B specifically depicts the fluid distribution system **200** from a top down perspective, FIG. **2**C specifically depicts the fluid distribution system **200** from a bottom up view, FIG. **2**D specifically depicts the fluid distribution system **200** from a frontal view, FIG. **2**E specifically depicts the fluid distribution system **200** from a rear view, FIG. **2**F specifically depicts the fluid distribution system **200** from a first lateral view, and FIG. **2**G specifically depicts the fluid distribution system **200** from a second lateral view. An axis system is provided in FIGS. **2**A-**2**G, as well as FIGS. **3**A-**8**, for reference. The y-axis may be a vertical axis (e.g., parallel to a gravitational axis), the x-axis may be a lateral axis (e.g., horizontal axis), and/or the z-axis may be a longitudinal axis, in one example. However, the axes may have other orientations in other examples.

[0037] The fluid distribution system **200** may be part of the thermal management system **168** of the vehicle **105** of FIG. **1**. The fluid distribution system **200** may comprise a fluid manifold **230**, which comprises a first section **222**, and a second section **224**, a pilot assembly **202**, and a pump **214**. The first section **222** may be positioned closer to a top end **290** of the fluid distribution system **200** than the second section **224**. The first and second sections **222**, **224** may be coupled together when the fluid distribution system **200** is assembled. When assembled, the top end **290** of the second section **224** may be coupled to a bottom end **296** of the first section **222**. A plurality of inlet ports **208** and a plurality of outlet ports **210** may be a portion of or otherwise coupled to the first section **222** and the second section **224**. In some embodiments, each of the plurality of inlet ports **208** may be coupled to the first section **222** and each of the plurality of outlet ports **210** may be coupled to the second section **224**. In such embodiments, the first section **222** may be an inlet manifold and the second section **224** may be an outlet manifold. However, other configurations of inlet ports and outlet ports have been contemplated. The pilot assembly **202** may be integrated into the fluid manifold **230**. In an example, being integrated into may include being housed within and coupled to receded regions of a mold of the fluid manifold **230**, as will be further explained.

[0038] The plurality of inlet ports **208** and plurality of outlet ports **210** may be positioned at and/or protrude from a front **298** of the fluid distribution system **200**. "Front" of the fluid distribution system **200** is herein used illustratively and is not meant to describe orientation of the fluid distribution system **200** when positioned within the vehicle. In some examples, the first section **222** may comprise three inlet ports and the second section **224** may comprise three outlet ports. Each of the plurality of inlet ports **208** and the plurality of outlet ports **210** may be in fluid communication with chambers of the pilot assembly **202**. A pump inlet port **221** may be in fluid communication with the pump **214** such that the pump **214** receives fluid from the pump inlet port **221**. Further, each of the inlet ports **208** and outlet ports **210** may be in fluid communication with one or more components of the vehicle such as a Heating. Ventilation, and Air Conditioning (HVAC) system, an Energy Storage System (ESS), and the like. In some examples, a vehicle component may receive fluid from the fluid distribution system **200** via one of the outlet ports and may deliver fluid to the fluid distribution system **200** via one of the inlet ports.

[0039] The first section **222** and the second section **224** may both include one or more external fluid connections and one or more internal fluid connections. In this way, fluid from other components in the vehicle may be directed into and/or out of the fluid distribution system **200** and through internal fluid passages within the fluid distribution system **200**. In this way, the fluid manifold **230** may combine a plurality of ports with a plurality of solenoid valves housed therein into a single package to allow for fluid to be distributed throughout the vehicle. In some examples, the fluid distribution system **200** may be paired with a second fluid distribution system to create a fluid management system.

[0040] The pump **214** may pressurize fluid entering and/or being outputted from the fluid distribution system **200** via the plurality of inlet ports **208** and the plurality of outlet ports **210**. A pump outlet port **220** is included with the pump **214**. Direction of flow and which of the plurality of inlet ports **208** and plurality of outlet ports **210** are used may be determined based on the needs of the various vehicle systems, taking into account prioritization factors. For example, some systems may have higher priority warming/cooling needs than others. Which valve opens and/or closes at a given time is defined by an intelligent control system included in the vehicle, which may actuate a given solenoid based on input parameters received from temperature, pressure, and/or other sensors located in different places and associated with different systems within the vehicle. The pump **214** may be an electronically commuted centrifugal pump or other type of electric or non-electric (e.g., mechanical or other) fluid pump that provides a plurality of components (e.g., the battery **158** of FIG. **1**) of the vehicle **105** with necessary fluid flow. The pump **214** may be in communication with a power source, such as battery **158** of the vehicle **105**.

[0041] The pump **214** may be positioned on a first side **292** of the fluid manifold **230**, opposite a second side **294**. The fluid manifold **230**, e.g., either the first or second sections **222**, **224**, may be integrated with or otherwise coupled to the pump **214**. As an example, the first section **222** of the fluid manifold **230** may be formed as a mold that includes an involute of the pump **214** such that the pump **214** is integrated into the fluid distribution system **200**, as shown in the bottom up view of FIG. **2**C. Integrating the pump **214** into the fluid distribution system **200** may reduce weight of the pump **214** as portions of the pump **214** may be manufactured with the fluid manifold **230**.

[0042] The pilot assembly **202** may comprise a cover **204** and a pilot assembly enclosure **206**, as well as a manifold subassembly housed within the pilot assembly enclosure **206** and the cover **204** when the pilot assembly enclosure **206** and the cover **204** are coupled together. Each of the components of the pilot assembly **202** may be manufactured separately and then assembled and tested as a unit prior to being coupled to the first and second sections **222**, **224** of the fluid manifold **230**. In this way, errors in manufacturing or components may be determined prior to assembly of the fluid distribution system **200**, reducing downstream effects during production.

[0043] When assembled, the top end **290** of the first section **222** may be coupled to the bottom end **296** of the pilot assembly enclosure **206** and the top end **290** of the pilot assembly enclosure **206** may be coupled to the bottom end **296** of the cover **204**. The cover **204** may include a connector **212** that connects the fluid manifold **230** to another component within the vehicle. In some examples, the connector **212** may be an electrical interface that couples a control board (e.g., control board **418** referenced with respect to FIG. **4**A) to an electrical system of the vehicle, thereby providing current to the control board. The connector **212** may be positioned at the front **298** of the cover **204**.

[0044] The first section **222**, the second section **224**, the pilot assembly enclosure **206** and the cover **204** may include joint surfacing that is planar. In this way, welding to couple the second section **224** to the first section **222**, the first section **222** to the pilot assembly enclosure **206**, and the pilot assembly enclosure **206** to the cover **204** is simplified, reducing manufacturing time.

[0045] Exploded views of the fluid manifold **230** of the fluid distribution system **200** are shown in FIGS. **3**A and **3**B. In some examples, an involute **320** of the pump **214** may be integrated as part of a mold of the first section **222**, which, as noted, may reduce weight of the pump **214**. The pilot assembly **202** may house a manifold subassembly **302**. The manifold subassembly **302** may couple to the pilot assembly enclosure **206** via pins **304**, thereby reducing shifting of the manifold subassembly **302** within the pilot assembly enclosure **206** which may reduce degradation to the manifold subassembly **302**. The cover **204**, when coupled to the pilot assembly enclosure **206**, may further protect the manifold subassembly **302** from degradation.

[0046] The manifold subassembly **302** may comprise a plurality of solenoid-actuated pilot valve assemblies **310**. Solenoid valves that are pilot-operated may provide increased flow capability, reliability, and lower power consumption in comparison to direct-acting solenoid valves. As will be described in greater detail below, each of the plurality of solenoid-actuated pilot valve assemblies **310** may comprise a solenoid and a pilot diaphragm. Further, the plurality of solenoid-actuated pilot valve assemblies **310** may be housed in a common assembly. In an example, the common assembly may be a unitary housing (e.g., the pilot assembly **202**) that at least partially encloses each of the plurality of solenoid-actuated pilot valve assemblies **310**. Each of the solenoid-actuated pilot valve assemblies **310** may be mounted directly to components of the fluid manifold **230**, thereby integrating the plurality of solenoid valves into the fluid distribution system **200**. As each of the solenoid-actuated pilot valve assemblies are integrated with the manifold subassembly **302** (e.g., fixedly coupled to), only one control board (not shown in FIGS. **3**A-**3**B) and electrical interface (e.g., the connector **212**) are demanded, which may decrease overall package size and weight, increasing versatility of use in various vehicle applications.

[0047] As shown in FIG. **3**B, the pilot assembly enclosure **206** may include a recessed region **330** and a plurality of protrusions **332**. Each of the plurality of protrusions **332** may couple the manifold subassembly **302** to the pilot assembly enclosure **206**, maintaining contact and position of the manifold subassembly **302**. Each of the plurality of protrusions **332** may include a central hole **334** into which a corresponding protrusion or fastener of the manifold subassembly **302** may insert into in order to couple the manifold subassembly **302** to the pilot assembly enclosure **206**. Similarly, the cover **204** may include a raised region **340** configured to accommodate the top end **290** of the manifold subassembly **302** when the fluid manifold **230** is assembled. As such, a first width **342** of the raised region **340** may be larger than a second width **344** of the manifold subassembly **302**.

[0048] Turning now to FIGS. **4**A and **4**B, the manifold subassembly **302** is shown. In some examples, the manifold subassembly **302** comprises a upper section **404** of a pilot manifold **402**, a lower section **406** of the pilot manifold **402**, a first plurality of fasteners **408**, a plurality of solenoids **412**, a second plurality of fasteners **414**, a pressure plate **416**, a control board **418**, and a plurality of pilot diaphragms (not shown). The upper section **404** and the lower section **406** are separated by a first coupling plane **430**. FIG. **4**A depicts the manifold subassembly **302** with the control board **418** positioned atop the plurality of solenoids **412** while FIG. **4**B depicts the manifold subassembly **302** without the control board **418**.

[0049] The control board **418** may include one or more tooling holes **420** (e.g., mounting holes) that align with one or more protrusions **410** of the upper section **404** of the pilot manifold **402**. The one or more protrusions **410** may protrude axially upwards (e.g., in a positive vertical direction) away from the upper section **404**. Each of the one or more protrusions **410** may extend through one of the one or more tooling holes **420**, thereby maintaining a lateral and longitudinal position of the control board **418** as it is assembled atop the plurality of solenoids **412**. Maintaining a position of the control board **418** during assembly may reduce degradation to the control board **418** from positioning errors and/or contact with other components. As will be described further below, the control board **418** may be removably coupled to the plurality of solenoids **412** via pin connectors.

[0050] In some examples, each of the plurality of solenoids **412** may comprise an electromagnetic coil (not shown) that may be energized or de-energized based on current provided by the control board **418**. The plurality of solenoids **412** may be arranged side-by-side such that each of the plurality of solenoids **412** is laterally adjacent to at least one other solenoid. The plurality of solenoids **412** may be positioned directly on top of the pressure plate **416**, thereby maintaining a stable position of the pressure plate **416**. The upper section **404** of the pilot manifold **402** may include a raised region **432** positioned for the pressure plate **416** to be in direct face sharing contact with. The plurality of solenoids **412** may also maintain pressure between the pressure plate **416** and components directly underneath, such as the raised region **432** of the upper section **404**, thereby reducing number of fasteners demanded in the fluid distribution system **200** to maintain positions of components therein. The lower section **406** may include a recessed region **434** positioned to couple a plurality of main diaphragms (not shown in FIGS. **4**A-**4**B) to the lower section **406**.

[0051] The first plurality of fasteners **408** may couple the upper section **404** of the pilot manifold **402** and the lower section **406** of the pilot manifold **402** together. The second plurality of fasteners **414** may couple the plurality of solenoids **412** to the upper section **404**, maintaining a stable position of the plurality of solenoids **412**. The pressure plate **416** may be positioned between the plurality of solenoids **412** and the upper section **404**. The upper and lower sections **404**, **406** of the pilot manifold **402** may be configured with an irregular shape that includes a plurality of rounded lateral protrusions **440** with central holes (not shown). Each of the first plurality of fasteners **408** may extend through a pair of corresponding central holes of the plurality of rounded lateral protrusions **440**, the pair including a central hole of a rounded lateral protrusion of the upper section **404** and a central hold of a rounded lateral protrusion of the lower section **406**. Rounded lateral protrusions of the upper section **404** and rounded lateral protrusion so the lower section **406** may couple at the first coupling plane **430**. Further, in some examples, each of the first plurality of fasteners **408** may correspond to one of the plurality of protrusions **332** with central holes **334** such that each of the plurality of fasteners

408 is a point of fastening between the pilot manifold **402** and the pilot assembly enclosure **206**.

[0052] In some examples, the control board **418** may include a plurality of sensors positioned within the control board **418** such that when the control board **418** is positioned atop the plurality of solenoids **412**, each of the plurality of sensors is directly above one of the plurality of solenoids **412**. The sensors may sense pintle position of each of the plurality of solenoids **412**. In some examples, the sensors may be Hall effect sensors. The plurality of sensors may allow for detection of solenoid position errors during operation which may decrease possibility of erroneous fluid flow to components of the vehicle.

[0053] As seen in FIGS. **5**A-**5**E, the fluid distribution system **200** further includes a plurality of pilot diaphragms **502** and a plurality of main diaphragms **504**. FIG. **5**A specifically depicts the plurality of pilot diaphragms **502** while the pilot manifold **402** has been removed for visualization and FIG. **5**B specifically depicts the plurality of main diaphragms **504** while the pilot manifold **402** has been removed for visualization. FIG. **5**C specifically depicts the plurality of main diaphragms **504** with the pilot manifold **402** in place. FIG. **5**D specifically depicts a cross-section of the pilot manifold **402** showing the plurality of pilot diaphragms **502** and a pressure differential chamber. FIG. **5**E specifically shows an example of a cavity in communication with a pressure differential chamber (not shown in FIG. **5**E). The pilot diaphragms **502**, along with the plurality of solenoids **412**, make up a plurality of solenoid-actuated pilot valve assemblies. The pilot diaphragms **502** and the main diaphragms **504** may be formed, respectively, as single injection molded pieces of material (e.g., a single injection mold), which may reduce manufacturing time and installation time during assembly of the fluid distribution system **200**.

[0054] The pilot diaphragms **502** may be arranged side-by-side, similar to the plurality of solenoids **412**, when formed as a single injection mold. Each of the pilot diaphragms **502** may be positioned directly below one of the plurality of solenoids **412** and may be in communication with the plurality of solenoids **412** to form the solenoid-actuated pilot valve assemblies **310**. For example, a solenoid, when energized via current from the control board **418**, opens a pilot diaphragm (e.g., the pilot diaphragm is pulled upwards or pushed downwards) to allow for a change in pressure differential across one or more main diaphragms. Each of the solenoid-actuated pilot valve assemblies **310** includes one solenoid and one pilot diaphragm. For example, a fluid distribution system **200** that includes four solenoid-actuated pilot valve assemblies **310**, as depicted in FIG. 4B, may include four solenoids and four pilot diaphragms. A quantity of solenoid-actuated pilot valve assemblies **310** in the fluid distribution system **200** may not be equal to a quantity of main diaphragms **504**, however. For example, a fluid distribution system that includes four solenoid-actuated pilot valve assemblies may include six main diaphragms **504**, as depicted in FIG. **5**B.

[0055] Each of the plurality of main diaphragms **504** may include a valve spring **505** that when contracted or extended as a result of pressure, changes a status of one of the plurality of main diaphragms **504** from open to closed or from closed to open in order to disenable or enable fluid flow through an orifice, thereby selectively coupling or decoupling fluid chambers. Regardless of the quantity of solenoid-actuated pilot valve assemblies **310** and/or the quantity of main diaphragms **504**, the plurality of inlet ports **208** and the plurality of outlet ports **210** may be integrated into the fluid manifold **230** (e.g., formed as part of the mold of the first and second sections **222**, **224** or otherwise fixedly coupled to the fluid manifold **230**). In this way, quantity of valves and/or main diaphragms may be increased or decreased to fit an application without demanding a change in placement of ports.

[0056] The pilot diaphragms **502** may be positioned directly underneath and in direct contact with the pressure plate **416**, the pressure plate **416** holding the pilot diaphragms **502** in place. The pilot diaphragms **502** may further be positioned directly on top of (e.g., in face sharing contact with) the upper section **404** (not shown in FIGS. **5**A-**5**B). The pressure plate **416** may maintain a position of the pilot diaphragms **502** between the upper section **404** and the pressure plate **416**. Close proximity between the pilot diaphragms **502** and the plurality of solenoids **412** may enable for a single printed circuit board (PCB) (e.g., the control board **418**) to control each of the plurality of solenoid-actuated pilot valve assemblies.

[0057] The plurality of main diaphragms **504** may be positioned around a plurality of orifices **506**. Each of the plurality of orifices **506** may be in fluid communication with one or more of a plurality of selectively couplable fluid chambers **510**. The plurality of selectively couplable fluid chambers **510** may be arranged in layers, e.g., some of the plurality of selectively couplable fluid chambers **510** included in the first section **222** and other of the plurality of selectively couplable fluid chambers **510** included in the second section **224**, the layers of selectively couplable fluid chambers **510** arranged on opposing ends of a second coupling plane **540**. Fluid chambers arranged in separate layers may be in fluid communication, for example, a first fluid chamber arranged above the second coupling plane **540** may be in fluid communication with a second fluid chamber arranged below the second coupling plane **540**.

[0058] The first section **222** may include a plurality of walls **530** that separate a plurality of rooms **532** from one another. Each of the plurality of rooms may house one or more of the plurality of selectively couplable fluid chambers **510** of the first section **222**. For example, a first pair of selectively couplable fluid chambers **510** comprising the first fluid chamber arranged above the coupling plane **540** and the second fluid chamber below the coupling plane **540**, may be housed within a first pair of rooms **532**, the first chamber housed in a first room and the second chamber housed in a second room. Each pair of fluid chambers may be housed within a different pair of rooms. In some examples, each of the plurality of selectively couplable fluid chambers **510** and/or the plurality of rooms **532** may be in fluid communication with an inlet or an outlet of the first or second sections **222**, **224** such that fluid may be outputted from or received into a fluid chamber or room through an outlet or inlet, respectively.

[0059] The plurality of main diaphragms **504** may be pneumatically or hydraulically operated to enable or disenable fluid flow through the plurality of orifices **506**, the main diaphragms **504** acting as on/off control valves. As discussed, the plurality of main diaphragms **504** open and/or close based on pressure differential controlled by the solenoid-actuated pilot valve assemblies **310**. Actuation (e.g., opening and/or closing) of one of the solenoid-actuated pilot valve assemblies **310** may result in opening and/or closing of one or more of the main diaphragms **504**. A single pilot diaphragm may be in fluid communication with a pressure differential chamber **511** that is in communication with multiple main diaphragms via a cavity **550**. Each cavity **550**, as seen in FIG. **5**E, may include one or more ports **552** that are each in fluid communication with a main diaphragm. In this way, a single pilot diaphragm may open or close one or more main diaphragm. In some examples, a cavity **550** may include only one port **552** in communication with a main diaphragm. Pilot diaphragms in fluid communication with a cavity that includes only one port may change pressure differential to open or close a single main diaphragm. In some examples, increase in pressure differential across the plurality of main diaphragms **504** may cause the main diaphragms **504** to open to enable flow through the plurality of orifices **506**. Pressure acting upon or removed from one of the diaphragms may cause the diaphragm to either open or close in order to enable or disenable flow. Which of the plurality of main diaphragms **504** are opened may control which of the plurality of inlet ports and outlet ports deliver and/or receive fluid.

[0060] In order to reconfigure distribution of variable temperature (e.g., cold, warm, hot) fluid, the pilot assembly **202** may use the plurality of solenoid-actuated pilot valve assemblies **310** in order to control pressure differential across each of the plurality of main diaphragms **504** to cause them to open and close. The plurality of solenoids **412** may be energized or de-energized, causing a change in position of one or more of the pilot diaphragms **502**, as previously described. Change in position of a pilot diaphragm may cause a change in pressure differential across one or more main diaphragms **504** that opens or closes one or more of the plurality of orifices **506**. Opening and/or closing one or more of the plurality of orifices **506** may selectively couple and/or decouple sets of fluid chambers. Selective opening and closing of each of the main diaphragms **504** may result in a fluid flow between inlet and outlet ports of each of the various vehicle systems that route through the fluid distribution system **200**. For example, in a normal state, pressure from the pump **214** may maintain an open position of the pilot diaphragms **502**, which in turn results in the main diaphragms **504** being closed and therefore no flow is permitted between inlet and outlet ports via the fluid chambers. When thermal, pressure, or other parameter detected via a sensor, as described with respect to FIGS. **2**A-**2**G, dictate that flow is to occur to and/or from one or more of the vehicle systems routed through the fluid distribution system **200**, one or more of the solenoids is actuated. When actuated, corresponding pilot diaphragm(s) may close, and closure of the corresponding pilot diaphragm(s) may result in opening of corresponding main diaphragm(s). When the corresponding main diaphragm(s) are in the open position, fluid flow is allowed between inlet and outlet ports for the dictated one or more vehicle systems. Differential pressure for the pilot assembly **202** that is used to open and/or close the main diaphragms **504** may come from the fluid of the plurality of inlet ports **208** of the first section **222** of the fluid manifold **230** and the pump inlet port **221**.

[0061] As actuation of one of the solenoid-actuated pilot valve assemblies **310** may affect more than one of the plurality of main diaphragms **504**, number of solenoids demanded may be reduced, thereby reducing overall weight of the package (e.g., by reducing amount of copper, or other suitable metal, demanded to manufacture a solenoid). Additionally, the multi-valve arrangement, wherein the plurality of fluid chambers are arranged in layers and in fluid communication with a plurality of inlet and outlet ports arranged in layers, may reduce overall package size, therefore increasing compactness and versatility for installation options.

[0062] As noted, in some examples, multiple of the plurality of main diaphragms **504** may be controlled by one of the solenoid-actuated pilot valve assemblies **310** In this way, selective coupling of multiple sets of fluidically connected fluid chambers may be realized with a single signal and coil (e.g., from a solenoid). In this way, number of solenoids demanded to reconfigure distribution of fluid may be further reduced, thereby further reducing weight of the overall system.

[0063] FIG. **6** shows the manifold subassembly **302**. Pin connectors **602** may be included with each of the plurality of solenoids **412** such that each of the plurality of solenoids **412** includes a pin connector to connect to the control board **418**. In this way, a single control board **418** may be used to control the plurality of solenoids **412**. The pin connectors **602** may project axially upwards (e.g., in a positive direction along the vertical axis) from the plurality of solenoids **412**. When the control board **418** is positioned in direct face sharing contact with the plurality of solenoids **412**, the pin connectors **602** may connect directly to the control board **418** in order to adhere the control board **418** to the plurality of solenoids **412** and electrically couple the control board **418** to the plurality of solenoids **412** to allow for transfer of current from the control board **418** to the plurality of solenoids **412**. Further, the side-by-side configuration of the plurality of solenoids **412** may allow for a reduced size of the control board **418**. The pin connectors **602** may reduce demand for soldering between the control board **418** and the plurality of solenoids **412**, thereby reducing weight of the system (e.g., by reducing amount of tin, lead, and/or other metals used for soldering.)

[0064] FIG. **7** shows the pilot assembly enclosure **206** disassembled from the manifold subassembly **302** and the cover **204**. In some examples, the pilot assembly enclosure **206** may include a plurality of particle filters **702**. The plurality of particle filters **702** may be positioned within the pilot assembly enclosure **206** to align with connection points to the manifold subassembly **302**. The plurality of particle filters **702** may be configured to prevent debris from entering the pilot assembly enclosure **206** and/or the plurality of fluid chambers **510**, which may reduce degradation or clogging of small passages from debris. Additionally, the plurality of particle filters **702**, by preventing debris from entering the pilot assembly enclosure **206**, may reduce leaks and inaccurate control of pilot diaphragm fluid flow that would result from contamination.

[0065] The pilot assembly enclosure **206** may further include a plurality of pressure ports **704**. The plurality of pressure ports **704**, as is further described below, may allow for a plurality of pressure sensors (not shown) to monitor pressure in various fluid chambers and/or rooms. In some examples, each of the plurality of pressure ports **704** may feed from a pressure sensor located in one of the plurality of rooms **532**, thereby allowing monitoring of pressure within each of the plurality of rooms **532** separately.

[0066] FIG. **8** shows a cross-sectional view of the fluid distribution system **200** in an assembled state. The pilot assembly **202** may further house a circuit board **804**. The plurality of pressure ports **704** leading from the first and second sections **222**, **224** may lead to a common location adjacent to the plurality of solenoids **412**. The plurality of pressure ports **704** may enable a plurality of pressure sensors (not shown) included in the pilot assembly **202** (e.g., included in the circuit board **804** and/or in the control board **418**) to sense pressure to determine performance and detect any errors in valve state. The circuit board **804** may process data provided by the plurality of pressure sensors to determine if a change in a state of one or more solenoid valves is warranted. The circuit board **804** may include sensors as well that provide data to the vehicle's intelligent control system, thereby enabling the intelligent control system to detect solenoid state and predict fault conditions. In this way, the fluid distribution system **200** may self-detect errors in performance or actuation based on sensor data acquired by the circuit board **804** and the plurality of pressure ports **704** and pressure sensors.

[0067] In some examples, the fluid distribution system **200** may include a fluid reservoir, bottle, or tank that is attached to the pilot assembly or otherwise integrated into the system. The fluid reservoir, bottle, or tank may be accessed in order to pull fluid into the system and/or into the pump **214**. In other examples, the fluid reservoir, bottle, or tank may be located external to the fluid distribution system **200** and accessed via the plurality of inlet ports **208** and/or the pump inlet port **221**.

[0068] A technical effect of the fluid distribution system herein described is that a compact, integrated fluid distribution assembly is provided that includes a plurality of valves and a plurality of ports into a single unit. The fluid distribution system, which includes a plurality of pilot-actuated solenoid valves, reduces quantity of solenoids demanded to reconfigure fluid distribution throughout a vehicle while maintaining number of inlet and outlet ports. The multi-section and multi-layered design allows for directional fluid flow between multiple sets of fluid chambers arranged in separate layers of the manifold from a single signal and solenoid. Reduction in quantity of solenoids, as well as integrating portions of a pump (e.g., an involute of the pump) into the fluid manifold, reduces weight and size of the package. Reduced weight and size of the package increases overall versatility and usability of the system in various vehicle platforms, including those with space constraints.

[0069] In another representation, a method for a fluid distribution system for reconfigurable thermal management of a vehicle comprises receiving fluid into a first section of a fluid manifold via a plurality of inlets, controlling pressure differential across a plurality of main diaphragms by opening and/or closing one or more solenoid-actuated pilot valve assemblies in response to energization and/or de-energization of one or more solenoids via a control board, opening one or more main diaphragms in response to a change in pressure differential resultant from the opening of the one or more solenoid-actuated pilot valve assemblies, selectively coupling one or more pairs of fluid chambers in response to opening of the one or more main diaphragms, and outputting fluid to one or more components of the vehicle via one or more outlets in fluid communication with the one or more fluid chambers.

[0070] FIGS. **1-8** show example configurations with relative positioning of the various components. If shown directly contacting each other, or directly coupled, then such elements may be referred to as directly contacting or directly coupled, respectively, at least in one example. Similarly, elements shown contiguous or adjacent to one another may be contiguous or adjacent to each other, respectively, at least in one example. As an example, components laying in face-sharing contact with each other may be referred to as in face-sharing contact. As another example, elements positioned apart from each other with only a space therebetween and no other components may be referred to as such, in at least one example. As yet another example, elements shown above/below one another, at opposite sides to one another, or to the left/right of one another may be referred to as such, relative to one another. Further, as shown in the figures, a topmost element or point of element may be referred to as a "top" of the component and a bottommost element or point of the element may be referred to as a "bottom" of the component, in at least one example. As used herein, top/bottom, upper/lower, above/below, may be relative to a vertical axis of the figures and used to describe positioning of elements of the figures relative to one another. As such, elements shown above other elements are positioned vertically above the other elements, in one example. As yet another example, shapes of the elements depicted within the figures may be referred to as having those shapes (e.g., such as being circular, straight, planar, curved, rounded, chamfered, angled, or the like). Further, elements shown intersecting one another may be referred to as intersecting elements or intersecting one another, in at least one example. Further still, an element shown within another element or shown outside of another element may be referred as such, in one example.

[0071] The disclosure also provides support for a fluid distribution system, comprising: a fluid manifold having a plurality of ports in fluid communication with a plurality of selectively couplable fluid chambers, a pilot assembly comprising a plurality of solenoid-actuated pilot valve assemblies controlling fluid flow between the plurality of selectively couplable fluid chambers, wherein: the plurality of selectively couplable fluid chambers are arranged in a first section and a second section of the fluid manifold, the first section and the second section separated by a coupling plane, fluid chambers in fluid communication are arranged in opposing ends of the coupling plane, the plurality of solenoid-actuated pilot valve assemblies are housed in a common assembly and mounted directly to the fluid manifold, and one or more of the plurality of solenoid-actuated pilot valve assemblies controls flow through at least one of the selectively couplable fluid chambers. In a first example of the system, the plurality of solenoid-actuated pilot valve assemblies comprise a plurality of solenoids and a plurality of pilot diaphragms. In a second example of the system, optionally including the first example,: the plurality of pilot diaphragms are arranged side-by-side and formed as a single injection mold, the plurality of solenoids are arranged side-by-side, and each of the plurality of pilot diaphragms are in communication with one of the plurality of solenoids. In a third example of the system, optionally including one or both of the first and second examples, the pilot assembly further comprises a plurality of main diaphragms formed as a single injection mold, wherein each of the plurality of solenoid-actuated pilot valve assemblies controls pressure differential across one or more of the plurality of main diaphragms. In a fourth example of the system, optionally including one or more or each of the first through third examples, the plurality of main diaphragms, controlled by the plurality of solenoid-actuated pilot valve assemblies, controls fluid flow between fluid chambers arranged in separate sections by opening and/or closing a plurality of orifices. In a fifth example of the system, optionally including one or more or each of the first through fourth examples, the pilot assembly further comprises an enclosure that includes a plurality of particle filters positioned between the fluid manifold and the plurality of selectively couplable fluid chambers. In a sixth example of the system, optionally including one or more or each of the first through fifth examples, actuation of one of the plurality of solenoid-actuated pilot valve assemblies changes pressure differential across more than one of the plurality of main diaphragms. In a seventh example of the system, optionally including one or more or each of the first through sixth examples, the plurality of ports comprises a plurality of inlet ports and a plurality of outlet ports, the plurality of inlet ports being coupled to the first section of the fluid manifold and the plurality of outlet ports being coupled to the second section of the fluid manifold. In a eighth example of the system, optionally including one or more or each of the first through seventh examples, the system further comprises: an integrated pump and a pump inlet port coupled to the integrated pump. In a ninth example of the system, optionally including one or more or each of the first through eighth examples, each of the plurality of solenoids is electronically coupled to a control board via a pin connector, the control board providing current to energize each of the plurality of solenoids.

[0072] The disclosure also provides support for a fluid distribution system for reconfigurable thermal management of a vehicle, comprising: a fluid manifold including a first section and a second section, the first section including a plurality of inlet ports in fluid communication with a plurality of fluid chambers and the second section including a plurality of outlet ports in fluid communication with the plurality of fluid chambers, a pilot assembly including a manifold subassembly, the manifold subassembly including an upper section and a lower section, and a pump in fluid communication with the plurality of fluid chambers, wherein the plurality of outlet ports selectively direct fluid flow to a plurality of components of the vehicle in which the fluid distribution system is housed. In a first example of the system, the plurality of fluid chambers are arranged in the first section of the fluid manifold and the second section of the fluid manifold, fluid chambers of the first section and fluid chambers of the second section being in selective fluid communication via a plurality of orifices when the plurality of orifices are open. In a second example of the system, optionally including the first example, the plurality of orifices are opened and/or closed based on pressure differential across a plurality of main diaphragms. In a third example of the system, optionally including one or both of the first and second examples, pressure differential across the plurality of main diaphragms is controlled by a plurality of solenoid-actuated pilot valve assemblies. In a fourth example of the system, optionally including one or more or each of the first through third examples, the pump includes a pump inlet port in fluid communication with one or more components of the vehicle. In a fifth example of the system, optionally including one or more or each of the first through fourth examples, an involute of the pump is formed with a mold of the first section of the fluid manifold.

[0073] The disclosure also provides support for a pilot assembly for a fluid distribution system, comprising: a pilot manifold with a plurality of manifold sections, the pilot manifold coupled to a fluid manifold, a plurality of selectively couplable fluid chambers arranged in sections of the fluid manifold, a plurality of main diaphragms arranged to allow flow between the selectively couplable fluid chambers, and a plurality of solenoid valves in fluid communication with the plurality of main diaphragms, wherein the pilot assembly is integrated into the fluid manifold of the fluid distribution system. In a first example of the system, the plurality of solenoid valves are pilot-operated and configured to be operated to control pressure differential across the plurality of main diaphragms to open and/or close a plurality of orifices in fluid communication with the plurality of main diaphragms. In a second example of the system, optionally including the first example, opening of one of the plurality of orifices selectively couples fluid chambers arranged in separate sections of the fluid manifold. In a third example of the system, optionally including one or both of the first and second examples, the system further comprises: a control board that provides current to energize the plurality of solenoid valves, wherein the control board is electrically coupled to the plurality of solenoid valves and an electrical interface integrated into the fluid manifold.

[0074] The following claims particularly point out certain combinations and sub-combinations regarded as novel and non-obvious. These claims may refer to "an" element or "a first" element or the equivalent thereof. Such claims should be understood to include incorporation of one or more such elements, neither requiring nor excluding two or more such elements. Other combinations and sub-combinations of the disclosed features, functions, elements, and/or properties may be claimed through amendment of the present claims or through presentation of new claims in this or a related application. Such claims, whether broader, narrower, equal, or different in scope to the original claims, also are regarded as included within the subject matter of the present disclosure.

1. A fluid distribution system, comprising:

a fluid manifold having a plurality of ports in fluid communication with a plurality of selectively couplable fluid chambers;

a pilot assembly comprising a plurality of solenoid-actuated pilot valve assemblies controlling fluid flow between the plurality of selectively couplable fluid chambers, wherein:

the plurality of selectively couplable fluid chambers are arranged in a first section and a second section of the fluid manifold, the first section and the second section separated by a coupling plane;

fluid chambers in fluid communication are arranged in opposing ends of the coupling plane;

the plurality of solenoid-actuated pilot valve assemblies are housed in a common assembly and mounted directly to the fluid manifold; and

one or more of the plurality of solenoid-actuated pilot valve assemblies controls flow through at least one of the selectively couplable fluid chambers.

2. The fluid distribution system of claim **1**, wherein the plurality of solenoid-actuated pilot valve assemblies comprise a plurality of solenoids and a plurality of pilot diaphragms.

3. The fluid distribution system of claim **2**, wherein:
the plurality of pilot diaphragms are arranged side-by-side and formed as a single injection mold;
the plurality of solenoids are arranged side-by-side; and
each of the plurality of pilot diaphragms are in communication with one of the plurality of solenoids.

4. The fluid distribution system of claim **1**, wherein the pilot assembly further comprises a plurality of main diaphragms formed as a single injection mold, wherein each of the plurality of solenoid-actuated pilot valve assemblies controls pressure differential across one or more of the plurality of main diaphragms.

5. The fluid distribution system of claim **4**, wherein the plurality of main diaphragms, controlled by the plurality of solenoid-actuated pilot valve assemblies, controls fluid flow between fluid chambers arranged in separate sections by opening and/or closing a plurality of orifices.

6. The fluid distribution system of claim **1**, wherein the pilot assembly further comprises an enclosure that includes a plurality of particle filters positioned between the fluid manifold and the plurality of selectively couplable fluid chambers.

7. The fluid distribution system of claim **4**, wherein actuation of one of the plurality of solenoid-actuated pilot valve assemblies changes pressure differential across more than one of the plurality of main diaphragms.

8. The fluid distribution system of claim **1**, wherein the plurality of ports comprises a plurality of inlet ports and a plurality of outlet ports, the plurality of inlet ports being coupled to the first section of the fluid manifold and the plurality of outlet ports being coupled to the second section of the fluid manifold.

9. The fluid distribution system of claim **1**, further comprising an integrated pump and a pump inlet port coupled to the integrated pump.

10. The fluid distribution system of claim **2**, wherein each of the plurality of solenoids is electronically coupled to a control board via a pin connector, the control board providing current to energize each of the plurality of solenoids.

11. A fluid distribution system for reconfigurable thermal management of a vehicle, comprising:
a fluid manifold including a first section and a second section, the first section including a plurality of inlet ports in fluid communication with a plurality of fluid chambers and the second section including a plurality of outlet ports in fluid communication with the plurality of fluid chambers;
a pilot assembly including a manifold subassembly, the manifold subassembly including an upper section and a lower section; and
a pump in fluid communication with the plurality of fluid chambers; wherein the plurality of outlet ports selectively direct fluid flow to a plurality of components of the vehicle in which the fluid distribution system is housed.

12. The fluid distribution system of claim **11**, wherein the plurality of fluid chambers are arranged in the first section of the fluid manifold and the second section of the fluid manifold, fluid chambers of the first section and fluid chambers of the second section being in selective fluid communication via a plurality of orifices when the plurality of orifices are open.

13. The fluid distribution system of claim **12**, wherein the plurality of orifices are opened and/or closed based on pressure differential across a plurality of main diaphragms.

14. The fluid distribution system of claim **13**, wherein pressure differential across the plurality of main diaphragms is controlled by a plurality of solenoid-actuated pilot valve assemblies.

15. The fluid distribution system of claim **11**, wherein the pump includes a pump inlet port in fluid communication with one or more components of the vehicle.

16. The fluid distribution system of claim **11**, wherein an involute of the pump is formed with a mold of the first section of the fluid manifold.

17. A pilot assembly for a fluid distribution system, comprising:
a pilot manifold with a plurality of manifold sections, the pilot manifold coupled to a fluid manifold;
a plurality of selectively couplable fluid chambers arranged in sections of the fluid manifold;
a plurality of main diaphragms arranged to allow flow between the selectively couplable fluid chambers; and
a plurality of solenoid valves in fluid communication with the plurality of main diaphragms, wherein the pilot assembly is integrated into the fluid manifold of the fluid distribution system.

18. The pilot assembly of claim **17**, wherein the plurality of solenoid valves are pilot-operated and configured to be operated to control pressure differential across the plurality of main diaphragms to open and/or close a plurality of orifices in fluid communication with the plurality of main diaphragms.

19. The pilot assembly of claim **18**, wherein opening of one of the plurality of orifices selectively couples fluid chambers arranged in separate sections of the fluid manifold.

20. The pilot assembly of claim **17**, further comprising a control board that provides current to energize the plurality of solenoid valves, wherein the control board is electrically coupled to the plurality of solenoid valves and an electrical interface integrated into the fluid manifold.

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