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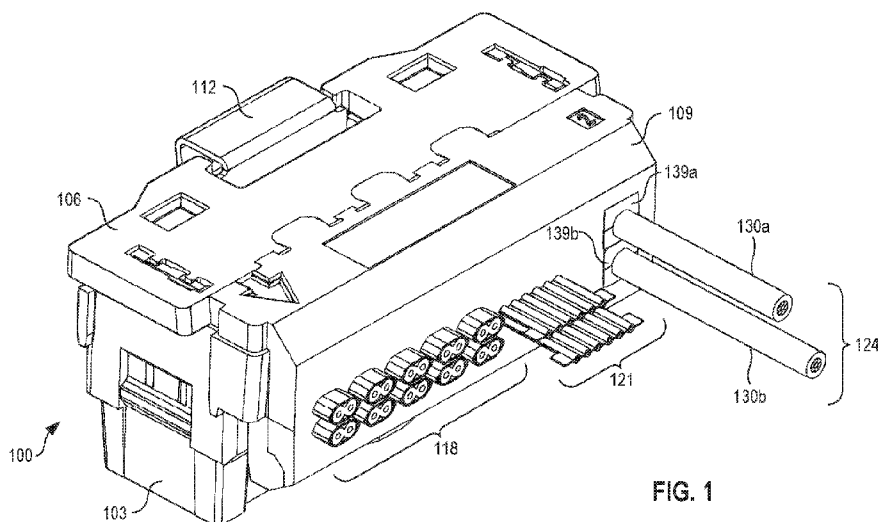


FIG. 1

(57) Abstract: A receptacle connector is described that includes signal and power wafer assemblies. The connector includes a first power cable having a distal end and a termination end, the first power cable being coupled to a first power terminal of the first power wafer assembly, and a second power cable having a distal end and a termination end, the second power cable being coupled to a second power terminal of the second power wafer assembly. A first and second crimp ring are positioned on the termination end of the first and second power cable, respectively. A first overmold housing is positioned over the termination end of the first power cable, where the first crimp ring is encapsulated by the first overmold housing, and a second overmold housing is positioned over the termination end of the second power cable, where the second crimp ring is encapsulated by the second overmold housing.

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CABLE CONNECTOR ASSEMBLY WITH POWER BAY AND STRAIN RELIEF

RELATED APPLICATION

[0001] This patent application claims the benefit of United States Provisional Patent Application No. 63/440,136, filed January 20, 2023, which is incorporated by reference in its entirety.

BACKGROUND

[0002] The amount of data processed by computers, computing systems, and computing environments continues to increase. For example, data centers can include hundreds of computing and networking systems interconnected using copper cables, optical cables, and various connectors, cable assemblies, and related terminations between them. The data throughput of these interconnects is high and increasing. A range of cable and connector assemblies are available to facilitate the data interconnect applications, such as board-to-board, wire-to-wire, and wire-to-board applications. An example wire-to-board connector assembly includes a free-end connector that is attached to one or more wires or cables and a fixed-end connector that is attached to a board. A wide range of suitable designs exist for each type of data interconnect application, depending on the requirements and the environment in which the cable and connector assemblies are used.

[0003] For applications where high data rates are needed and physical space is restricted, competing concerns make the design of cable and connector assemblies more challenging. High data rate applications often rely upon differentially coupled signal pairs in which two conductors are electrically coupled and physically arranged in pairs to transmit a differential signal. Differential signaling provides greater resistance to spurious signals and electronic crosstalk, among other benefits, and preferably maintains sufficient signal spacing to avoid inadvertent signaling modes with adjacent signals pairs. In the connector interface, ground terminals can be added to create a return path to electrical ground and to provide shielding between differential pairs.

[0004] Cable and connector assemblies are typically designed to meet both mechanical and electrical requirements. High speed or high data rate electrical connectors are often used, for example, in backplane applications that require very high conductor density and high data rates. To achieve the desired mechanical and electrical requirements, such connectors often incorporate a plurality of wafer assemblies including an insulative web that supports a plurality of electrically conductive terminals. The use of wafer assemblies is often desirable to create a structure capable of achieving the desired high data rate that is also robust enough to support the desired assembly processes.

TECHNICAL FIELD

[0005] This disclosure relates to the field of input/output (IO) connectors and, more specifically, to IO connectors suitable for use in high data rate applications.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Many aspects of the present disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, with emphasis instead being placed upon clearly illustrating the principles of the disclosure. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

[0007] FIG. 1 is a top perspective view of a receptacle connector in accordance with various embodiments of the present disclosure.

[0008] FIG. 2 is a bottom perspective view of the receptacle connector in accordance with various embodiments of the present disclosure.

[0009] FIG. 3 is a top perspective view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0010] FIG. 4 is a side perspective view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0011] FIG. 5 is a top perspective view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0012] FIG. 6 is a side perspective view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0013] FIG. 7 is a side elevation view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0014] FIG. 8 is an enlarged perspective view of a crimp ring and a power cable in accordance with various embodiments of the present disclosure.

[0015] FIG. 9 is a top plan view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0016] FIG. 10 is an enlarged top plan view of a portion of FIG. 9 in accordance with various embodiments of the present disclosure.

[0017] FIG. 11 is an enlarged side perspective view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0018] FIG. 12 is another enlarged side perspective view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0019] FIG. 13 is another enlarged side perspective view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0020] FIG. 14 is another enlarged side perspective view of the receptacle connector with outer housing components not shown in accordance with various embodiments of the present disclosure.

[0021] FIG. 15 is a series of sequential modifications of a power wire to form an arrangement of various components of the receptacle connector in accordance with various embodiments of the present disclosure.

DETAILED DESCRIPTION

[0022] Various embodiments are described for a connector assembly having power and strain relief, as well as associated methods, apparatuses, and the like. As mentioned above, the amount of data processed by computers, computing systems, and computing environments continues to increase. For example, data centers can include hundreds of computing and networking systems interconnected using optical cables, copper cables, and various

connectors, cable assemblies, and terminations between them. The data throughput of these interconnects is high and increasing.

[0023] As examples, many data centers incorporate a combination of 10 Gigabit Ethernet (10GbE), 25 GbE, 50 GbE, and 100 GbE network interfaces and interconnects. 200 GbE, 400 GbE, and 800 GbE interconnection technology is also being developed and deployed. Other interconnection solutions rely upon 56 Gigabit per second (Gb/s) and 112 Gb/s network interfaces and interconnects, and 224 Gb/s interconnection technology is being developed. A range of cable assemblies are available for data interconnects. A variety of designs exist for each cable assembly, depending on the requirements of the data communications environment in which the connectors are used.

[0024] An example wire-to-board connector assembly includes a free-end connector that is attached to one or more wires or cables and a fixed-end connector that is attached to a circuit board or like substrate. When inserted into the fixed-end connector, the free-end and fixed-end connectors can exert forces upon each other, and the housings of both the fixed-end and the free-end connectors may experience a range of forces and stresses. Additionally, depending upon the type (e.g., gauge, size, weight, and so forth) and manner in which cables or wires are coupled to a free-end connector, the cables or wires may inadvertently act as a type of lever, presenting certain forces on the free-end connector and, in some cases, the fixed-end connector. Over time, such forces can cause the connectors and connector housings to bend, deform, and possibly crack or break at certain locations.

[0025] Any loss of structural integrity due to damage in connector housings, whether that of a plug connector or a receptacle connector, may translate to loss of signal coupling integrity through the associated connector. The housing is thereby intended to support wafer assemblies in a precise and controlled manner by design. Thus, damage to or deformation of a connector housing may result in the application of unwanted, undesirable, and unexpected forces being presented on wafer assemblies within the housings, which can result in an unexpected and unwanted loss of signal coupling integrity.

[0026] In the context outlined above, a receptacle connector is described that addresses potential stress points in a wire-to-board connector while providing various improvements over existing connectors. The receptacle connector includes a first power wafer assembly and a second power wafer assembly, among other potential wafer assemblies. A first power cable

has a distal end and a termination end. The first power cable is coupled to a first power terminal of the first power wafer assembly, where a first crimp ring is positioned on the termination end of the first power cable. A second power cable has a distal end and a termination end. The second power cable is coupled to a second power terminal of the second power wafer assembly, where a second crimp ring is positioned on the termination end of the second power cable. A first power cable housing is positioned over the termination end of the first power cable, where the first crimp ring is encapsulated by the first power cable housing. Similarly, a second power cable housing is positioned over the termination end of the second power cable, where the second crimp ring is encapsulated by the second power cable housing.

[0027] The first power cable housing may be positioned vertically over the second power cable housing in a stacked arrangement. Each of the first power cable housing and the second power cable housing may include a plurality of interlocking components configured to engage with corresponding interlocking features of one of the first and second power wafer assemblies, or an intermediary body positioned therebetween. The second power cable housing may include a ridge projecting from a top surface thereof that is configured to be positioned in a recess on a bottom surface of the first power cable housing. Each of the first power cable housing and the second power cable housing may be overmolded onto the first power cable and the second power cable, for instance, via low-pressure overmolding, injection molding, or other suitable molding process.

[0028] In some embodiments, the receptacle connector further includes a first signal wafer assembly and a second signal wafer assembly separate from one another. Each of the first signal wafer assembly and the second signal wafer assembly may include terminals configured to engage with corresponding terminals of a plug connector. The receptacle connector may further include a first cable collection coupled to the first terminal wafer and a second cable collection coupled to the second terminal wafer.

[0029] The first cable collection may include first cables, and the second cable collection may include second cables. The first cables may be high-speed data cables, and the second cables may be low-speed data cables, for example. The first cables may include a bend at a termination end thereof, and the second cables may similarly include a bend at a termination end thereof. Thus, a termination portion of the first cables before the bend may be at a first

height relative to a bottom surface of the receptacle connector, and a distal portion of the first cables after the bend may be at a second height different than the first height. Likewise, a termination portion of the second cables before the bend may be at a first height relative to a bottom surface of the receptacle connector, and a distal portion of the second cables after the bend may be at a second height different than the first height.

[0030] A wall may be positioned between the power wafer assemblies and the signal wafer assemblies. The wall may be formed of a material and/or having dimensions suitable for reducing or preventing electromagnetic interference between the first power wafer and the second power wafer, and between the first terminal wafer and the second terminal wafer. Additionally, the receptacle connector may include one or more wire support organizers having apertures through which the first cables and the second cables are positioned. At least one of the first power cable and the second power cable may be coupled to a power terminal of a respective power wafer via ultrasonic welding or soldering in one example.

[0031] The first power wafer assembly and the second power wafer assembly may be offset from one another in a horizontal plane, a vertical plane, or in both a horizontal plane and in a vertical plane. Similarly, the first signal wafer assembly and the second signal wafer assembly may be offset from one another in a horizontal plane, a vertical plane, or in both a horizontal plane and a vertical plane. The receptacle connector may further include a first stiffener positioned on an outer side of the first signal terminal assembly towards a rear of the receptacle connector, and a second stiffener positioned on an outer side of the second signal terminal assembly towards a front of the receptacle connector.

[0032] In some embodiments, the receptacle connector further includes cable alignment blocks, where each of the cable alignment blocks includes a generally rectangular body extending horizontally along a body of the receptacle connector. The cable alignment blocks may include apertures that align with those of the overmold organizer that retain at least one of the first cable collection and the second cable collection in a bended form.

[0033] In some aspects, a method is described that includes providing a power cable and cutting the first power cable to a predetermined length, crimping a crimp ring onto a jacket of the power cable, forming a power cable housing over the power cable as crimped through low-pressure overmolding, stripping the power cable to expose a plurality of conductors of the power cable, and terminating the power cable as crimped and overmolded to a power

terminal of a power wafer assembly via ultrasonic welding, soldering, and other suitable connection method.

[0034] Turning now to the drawings, FIG. 1 shows a top perspective view of a receptacle connector **100** and FIG. 2 shows a bottom perspective view of the receptacle connector **100** according to various embodiments of the present disclosure. Referring to FIGS. 1 and 2 collectively, the receptacle connector **100** may generally include a housing **103**, a top cover **106**, and an overmold organizer **109** (also referred to as a “wire support organizer”) according to various embodiments. The receptacle connector **100** may further include a clip assembly **112** that may facilitate in securing the receptacle connector **100** to a plug connector (not shown), where the plug connector may be mounted on or otherwise communicatively coupled to a circuit board or other substrate. For instance, the clip assembly **112** may facilitate locking to or unlocking the receptacle connector **100** from a plug connector mounted on a circuit board.

[0035] The housing **103** may contain one or more signal wafer assemblies **115a**, **115b** (collectively “signal wafer assemblies **115**”) and power wafer assemblies **117a**, **117b** (collectively “power wafer assemblies **117**”) having a multitude of terminals therein, where terminating ends of various terminals of the wafer assemblies **115**, **117** are shown in FIG. 2. In the depicted implementation, the signal wafer assemblies **115** are in a common row in alignment with the power wafer assemblies **117**, but are spaced apart from one another, as will be further described. The top cover **106** may further retain (or apply downward pressure on) the wafer assemblies **115**, **117**, providing a tight arrangement of the wafer assemblies **115**, **117** as well as other components of the receptacle connector **100**, as will be described.

[0036] Further, the receptacle connector **100** may include, for example, a first cable collection **118**, a second cable collection **121**, and a third cable collection **124**. Each cable collection **118**, **121**, and **124** may include one or more cables, as may be appreciated, and may be one of a multitude of varying types of cables. While three cable collections are illustrated, it is understood that other varying numbers of cable collections may be employed. In the non-limiting example of FIGS. 1 and 2, the first cable collection **118** includes twin-axial cables (e.g., high-speed data cables for differential signaling), the second cable collection **121** includes ribbon cables (e.g., low-speed data cables), and the third cable collection **124** includes power cables for applications in which power is required.

[0037] To provide strain relief for at least the first cable collection **118** and the second cable collection **121**, the overmold organizer **109** includes apertures that retain at least the first cable collection **118** and the second cable collection **121** in a predetermined strain relief arrangement. To this end, FIG. 3 shows the receptacle connector **100** without the housing **103**, the top cover **106**, the overmold organizer **109**, and the clip assembly **112**. The first cable collection **118** and the second cable collection **121** include bends **127a**, **127b** (collectively “bends **127**”) that provide strain relief. The bends **127** prevent stress from occurring on a connection point between the signal wafer assemblies **115** and individual cables of the first cable collection **118** and/or the second cable collection **121**. The bends **127** may be formed in the cables prior to an overmolding process in which the overmold organizer **109** is formed.

[0038] As a result of bends **127** being positioned in the first cable collection **118**, a termination portion of the first cable collection **118** before the bend **127** is at a first height relative to a bottom surface of the receptacle connector **100**, and a distal portion of the first cable collection **118** after the bend is at a second height different than the first height. A first row of the cables in the first cable collection **118** are bent towards a second row of the cables therein to create a tight arrangement of the cables. Likewise, a termination portion of the second cable collection **121** before the bend **127** is at a first height relative to a bottom surface of the receptacle connector **100**, and a distal portion of the second cable collection **121** after the bend **127** is at a second height different than the first height. A second row of the cables in the second cable collection **121** are bent towards a second row of the cables therein to further define the tight arrangement of the cables.

[0039] FIGS. 4 and 5 show side and top perspective views, respectively, of the portion of the receptacle connector **100** shown in FIG. 3. Notably, like FIG. 3, FIGS. 4 and 5 show the receptacle connector **100** without the housing **103**, the top cover **106**, the overmold organizer **109**, and the clip assembly **112**. Disposed below the overmold organizer **109** may be one of a multitude of cable alignment blocks **128a**, **128b** (collectively “cable alignment blocks **128**”). The cable alignment blocks **128** may include generally rectangular bodies extending horizontally along a body of the receptacle connector **100**. Further, the cable alignment blocks **128** may include apertures that align with those of the overmold organizer **109**, shown

FIGS. 1 and 2, and may further retain at least one of the first cable collection **118** and the second cable collection **121** in their bended form.

[0040] Referring among FIGS. 3, 4, and 5, the third cable collection **124** of the receptacle connector **100** may include, for example, a first power cable **130a** and a second power cable **130b** (collectively “power cables **130**”). It is understood, however, that other numbers of power cables **130** greater or less than two may be employed in alternative arrangements. The receptacle connector **100** may further include the first power wafer assembly **117a** and the second power wafer assembly **117b** described above, each having respective power terminals **136a**, **136b** (collectively “power terminals **136**”).

[0041] The first power cable **130a** may have a distal end and a termination end, where the termination end of the first power cable **130a** may be coupled to the power terminal **136a** of the first power wafer assembly **117a**. Similarly, the second power cable **130b** may have a distal end and a termination end, where the termination end of the second power cable **130b** may be coupled to the power terminal **136b** of the second power wafer assembly **117b**.

[0042] Further, in various embodiments, the receptacle connector **100** may include a first power cable housing **139a** and a second power cable housing **139b** (collectively “power cable housings **139**”). The first power cable housing **139a** may be positioned over the termination end of the first power cable **130a**, whereas the second power cable housing **139b** may be positioned over the termination end of the second power cable **130b**. The first power cable housing **139a** and/or the second power cable housing **139b** may be formed through an overmolding process (e.g., a low-pressure overmold, injection overmold, and so forth), whereby a polymer material (e.g., plastic) is deposited on a termination end of a respective power cable **130**, thereby securing the power cables **130** in the position as shown in FIGS. 3-5. The power cable housings **139** may allow a small amount of play to occur in the respective power cables **130**.

[0043] A multitude of projections **140a...140d** (collectively “projections **140**”) may extend from top surfaces of the cable alignment blocks **128** and/or a first power cable housing **139** where the projections **140** may nest in the top cover **106** or the overmold organizer **109**, further retaining the components of the receptacle connector **100**. In some embodiments, the projections **140** are square-shaped projections, although it is understood that other shapes may be employed.

[0044] Termination pads **141a**, **141b** (collectively “termination pads **141**”) may be positioned above or below the power terminals **136**. The termination pads **141** may include a substantially planar body having a square or rectangular shape, which facilitates welding or soldering connections while permitting the cable termination to be straight. It is understood, however, that other shapes of the termination pads **141** may be employed. For instance, in some implementations, the termination pads **141** may be U-shaped for soldering connections. The termination pads **141** may assume other shapes, for instance, when other connections are employed beyond soldering, welding, and the like. Additionally, in some embodiments, the termination pads **141** may be planar with contact terminals and a wafer plastic body. The termination pads **141** may include a hole through which the power cables **130** are inserted and/or bent, which may then be soldered, welded, or the like.

[0045] Moving along to FIGS. 6 and 7, side perspective and side views of the receptacle connector **100**, respectively, are shown with the power cable housings **139** of FIGS. 4 and 5 hidden for further explanation. As shown in FIGS. 6 and 7, the first power wafer assembly **117a** and the second power wafer assembly **117b** may be offset from one another in a horizontal plane and a vertical plane. Similarly, the first signal wafer assembly **115a** and the second signal wafer assembly **115b** may be offset from one another in a horizontal plane and a vertical plane. For instance, the first power wafer assembly **117a** and the second power wafer assembly **117b** are separated from one another in a front-to-back arrangement, and the first signal wafer assembly **115a** and the second signal wafer assembly **115b** are separated from one another in a front-to-back arrangement.

[0046] In various embodiments, crimp rings **142a**, **142b** (collectively “crimp rings **142**”) may be used to further secure a power cable **130** with respect to the power terminal **136**. For instance, a first crimp ring **142a** may be positioned on the first power cable **130a** and/or a second crimp ring **142b** may be positioned on the second power cable **130b**. More specifically, in some implementations, the first crimp ring **142a** and the second crimp ring **142b** may be positioned on termination ends of a respective power cable **130**. The crimp rings **142** may be positioned a predetermined distance from a distal end of the power cable **130**, such as 1.5 mm or other suitable distance, as well as a predetermined distance from a respective power terminal **136**. The crimp rings **142** may provide strain relief and prevent

wear occurring, for instance, when the power cables **130** are pulled in a direction parallel to an orientation of the power cables **130**.

[0047] FIG. 6 further illustrates a multitude of stiffeners **143a**, **143b** (collectively “stiffeners **143**”) which may be formed in a part of the receptacle connector **100** (e.g., via overmolding) or otherwise positioned in the housing **103** or the overmold organizer **109**. The stiffeners **143** may prevent deformation of the housing **103**, the overmold organizer **109**, and/or the components positioned therein. For instance, a first stiffener **143a** may be positioned on an outer side of the first signal wafer assembly **115a** towards a rear of the receptacle connector **100**, and a second stiffener positioned on an outer side of the second signal wafer assembly **115b** towards a front of the receptacle connector **100**.

[0048] The stiffeners **143** may be stamped or sheared from a metal or metal alloy material sheet in one example. The material sheet may have a thickness “T” in a range between 0.25 mm and 0.75 mm for example. As particular examples, the stiffeners **143** may be 0.25 mm, 0.35 mm, 0.40 mm, 0.45 mm, 0.5 mm, 0.55 mm, 0.60 mm, 0.65 mm, 0.70 mm, or 0.75 mm in thickness, although other thicknesses can be relied upon. The material sheet can preferably have a relatively high level of stiffness or rigidity and, particularly, higher than that of the material from which the housing **103** or overmold organizer **109** is formed.

[0049] As shown in FIG. 8, the power cable **130** can include a jacket **145** or sheath that surrounds one or more conductors **148**. In the enlarged view of the crimp ring **142** shown in FIG. 8, the crimp rings **142** may substantially (e.g., 70% or more) surround the power cable **130**. In alternative embodiments, however, the crimp rings **142** may fully surround and encapsulate the power cable **130**. The crimp ring **142** can be crimped on or over the jacket **145** of the power cable **130**. The crimp rings **142** may be formed of a suitable material to permit crimping (e.g., pressure applied to two or more areas of the crimp ring **142**) to deform the crimp ring **142** and force a connection with the power cable **130** and/or a jacket **145** thereof. To provide additional stability, in some implementations, the crimp ring **142** includes a tail **149** that projects from a body of the crimp ring **142**. While the tail **149** makes the crimp ring **142** easier to manufacture and handle on a manufacturing floor, the tail **149** may further increase a volumetric profit of the crimp ring **142** such that, when an overmold (e.g., power cable housing **139**) covers the crimp ring **142**, there is more of the crimp ring **142** for plastic or other material to mold around and grip onto. The crimp ring **142** may be

formed of a suitable metal material. For example, the crimp ring **142** may be formed of aluminum, steel, stainless steel, copper, or alloys thereof. In some cases, the crimp ring **142** can be formed of a plastic or polymer material.

[0050] Turning now to FIGS. 9 and 10, top views of wafer assemblies **115**, **117** and other select components of the receptacle connector **100** are shown. In some embodiments, the first crimp ring **142a** and the termination end of the first power cable **130a** may be encapsulated or otherwise positioned in the first power cable housing **139a**, as shown in FIG. 9. Similarly, the second crimp ring **142b** and the termination end of the first power cable **130b** may be encapsulated or otherwise positioned in the second power cable housing **139b**. Together, the crimp rings **142**, as nested within the power cable housings **139**, prevent a load from being transferred directly to a wire termination at the power terminal **136**.

[0051] Further, as shown in the various views of FIGS. 11-14, the first power cable housing **139a** may be positioned vertically over or on top of the second power cable housing **139b** in a stacked arrangement. As such, the first power cable housing **139a** and the second power cable housing **139b** may be positioned vertically with respect to one another. Specifically, FIG. 14 does not show the first power cable housing **139a** while showing the second power cable housing **139b**. As shown in FIG. 14, the second power cable housing **139b** may include a ridge **144** that projects from a top surface of the second power cable housing **139b**. A bottom surface of the first power cable housing **139a** may include a recessed portion that receives and substantially conforms to the ridge **144**.

[0052] Referring back to FIGS. 9 and 10, at least one of the first power cable housing **139a** and the second power cable housing **139b** may include interlocking components **152** configured to engage with corresponding interlocking features of a power wafer assembly **117**, such as a power wafer assembly **117**. For instance, the interlocking components **152** include a multitude of “teeth” or projections and recesses on front and side portions of the power cable housings **139**. In some implementations, the power cable housings **139** may include a rectangular, elongated body **155** and a square- or rectangular-shaped side projection **158**. The interlocking components **152** may be positioned proximate the side projection **158** and/or on opposing sides of the power cable housing **139**.

[0053] As the power cable housings **139** may be formed through an overmolding process, the interlocking components **152** are thus formed through the overmolding process. The

overmolding process may include a low-pressure overmolding process, generally with a temperature range of 250 to 450° F according to some embodiments. As best shown in FIG. 13, the interlocking components **152** of at least the first power cable housing **139a** may be configured to engage with corresponding interlocking features of one of the first power wafer assembly **117a** and the second power wafer assemblies **117b**, or an intermediary body positioned therebetween.

[0054] Referring back to FIG. 3, each of the wafer assemblies **115**, **117** may include one or more terminals configured to engage with corresponding terminals of a plug connector, for example. The terminals may be formed of a conductive material, such as copper, or other metal. The terminals may be mounted on or affixed to a terminal housing, which may be formed of a non-conductive polymer material. The terminal housing may keep terminal pairs spaced apart from adjacent terminal pairs, and may provide rigidity to the wafer assemblies **115**, **117**. As noted above, a first plurality of cables (e.g., cables of the first and second cable collections **118**, **121**) may be coupled to the first signal wafer assembly **115a**, and a second plurality of cables (e.g., other cables of the first and second cable collections **118**, **121**) may be coupled to the second signal wafer assembly **115b**.

[0055] As best seen in the bottom perspective view of FIG. 2, the first signal wafer assembly **115a** and the second signal wafer assembly **115b** are positioned parallel to one another and spaced apart from one another, thereby defining two rows of terminals (e.g., two rows of signal terminals and power terminals). It is understood, however, that one row of terminal, three rows of terminals, and so forth may be implemented based on a desired application.

[0056] As best shown in the side perspective view of FIG. 6, the first signal wafer assembly **115a** and the second signal wafer assembly **115b** may be offset from one another in a horizontal plane and a vertical plane. For instance, the first signal wafer assembly **115a** may have a first insertion depth when positioned in the housing **103**, whereas the second signal wafer assembly **115b** may have a second insertion depth less than the first insertion depth when positioned in the housing **103**. However, terminals of the first signal wafer assembly **115a** and the second signal wafer assembly **115b** may have terminate at a common distance relative to a plug connector. Similarly, the first power wafer assembly **117a** and the second power wafer assembly **117b** may be offset from one another in a horizontal plane and a vertical plane. For instance, the first power wafer assembly **117a** may have a first insertion

depth when positioned in the housing **103**, whereas the second power wafer assembly **117b** may have a second insertion depth less than the first insertion depth when positioned in the housing **103**. However, terminals of the first power wafer assembly **117a** and the second power wafer assembly **117b** may have terminate at a common distance relative to a plug connector.

[0057] Referring to the top plan view of FIG. 10 and the bottom perspective view of FIG. 2, the receptacle connector **100** may include a wall **164** positioned between the power wafer assemblies **117** and the signal wafer assemblies **115**, thereby defining a power bay **167** that includes the power wafer assemblies **117** and a signal bay **170** that includes the signal wafer assemblies **115**. As the power bay may generate heat and create electromagnetic interference (EMI), in various scenarios, the wall **164** may create a physical separation and barrier that is suitable for preventing electromagnetic interference and thermal transfer between the power wafer assemblies **117** and the signal wafer assemblies **115**.

[0058] In addition, the wall **164** may make the receptacle connector **100** suitable for alternative implementations that may be desired. For instance, a separation between the power bay **167** and the signal bay **170** may facilitate last-mate-first-break applications. As such, an insertion depth of the wafer assemblies **115**, **117**, a length of the terminals thereof, and like characteristics, may be adjusted to employ a last-mate, first-break implementation.

[0059] Turning now to FIG. 15, a sequential diagram for crimping and overmolding a power cable **130** is shown to form a connection. First, a power cable **130** may be cut to a predetermined length. Next, a crimp ring **142** may be crimped onto a jacket of the power cable **130**. In some embodiments, the crimp ring **142** is crimped approximately 1.5 mm from termination. Thereafter, a power cable housing **139** may be formed over the power cable **130** as crimped. In some embodiments, the power cable housing **139** is formed through low-pressure overmolding. Next, the power cable **130** may be stripped to expose conductors **148**. Finally, the cable assembly with the overmolded power cable housing **139** may be terminated to a power terminal **136** of a power wafer assembly **117**, for example. To this end, a termination may include ultrasonic welding, soldering, and other suitable connection method.

[0060] The features, structures, or characteristics described above may be combined in one or more embodiments in any suitable manner, and the features discussed in the various embodiments may be interchangeable, if possible. In the following description, numerous

specific details are provided in order to fully understand the embodiments of the present disclosure. However, a person skilled in the art will appreciate that the technical solution of the present disclosure may be practiced without one or more of the specific details, or other methods, components, materials, and the like may be employed. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the present disclosure.

[0061] Although the relative terms such as “on,” “below,” “upper,” and “lower” are used in the specification to describe the relative relationship of one component to another component, these terms are used in this specification for convenience only, for example, as a direction in an example shown in the drawings. It should be understood that if the device is turned upside down, the “upper” component described above will become a “lower” component. When a structure is “on” another structure, it is possible that the structure is integrally formed on another structure, or that the structure is “directly” disposed on another structure, or that the structure is “indirectly” disposed on the other structure through other structures.

[0062] In this specification, the terms such as “a,” “an,” “the,” and “said” are used to indicate the presence of one or more elements and components. The terms “comprise,” “include,” “have,” “contain,” and their variants are used to be open ended, and are meant to include additional elements, components, etc., in addition to the listed elements, components, etc. unless otherwise specified in the appended claims.

[0063] The terms “first,” “second,” etc. are used only as labels, rather than a limitation for a number of the objects. It is understood that if multiple components are shown, the components may be referred to as a “first” component, a “second” component, and so forth, to the extent applicable.

[0064] The above-described embodiments of the present disclosure are merely possible examples of implementations set forth for a clear understanding of the principles of the disclosure. Many variations and modifications may be made to the above-described embodiment(s) without departing substantially from the spirit and principles of the disclosure. All such modifications and variations are intended to be included herein within the scope of this disclosure and protected by the following claims.

CLAIMS

Therefore, the following is claimed:

1. A receptacle connector, comprising:
 - a first power wafer assembly and a second power wafer assembly;
 - a first power cable having a distal end and a termination end, the first power cable being coupled to a first power terminal of the first power wafer assembly, wherein a first crimp ring is positioned on the termination end of the first power cable;
 - a second power cable having a distal end and a termination end, the second power cable being coupled to a second power terminal of the second power wafer assembly, wherein a second crimp ring is positioned on the termination end of the second power cable;
 - a first power cable housing positioned over the termination end of the first power cable, the first crimp ring being encapsulated by the first power cable housing; and
 - a second power cable housing positioned over the termination end of the second power cable, the second crimp ring being encapsulated by the second power cable housing.
2. The receptacle connector according to claim 1, wherein the first power cable housing is positioned vertically over the second power cable housing in a stacked arrangement.

3. The receptacle connector according to claim 2, wherein each of the first power cable housing and the second power cable housing comprises a plurality of interlocking components configured to engage with corresponding interlocking features of one of the first and second power wafer assemblies, or an intermediary body positioned therebetween.
4. The receptacle connector according to claim 3, wherein the second power cable housing comprises a ridge projecting from a top surface thereof that is configured to be positioned in a recess on a bottom surface of the first power cable housing.
5. The receptacle connector according to any of claims 1-4, wherein each of the first power cable housing and the second power cable housing are overmolded onto the first power cable and the second power cable.
6. The receptacle connector according to any of claims 1-5, further comprising:
a first signal wafer assembly and a second signal wafer assembly separate from one another, each of the first signal wafer assembly and the second signal wafer assembly comprising a plurality of terminals configured to engage with corresponding terminals of a plug connector;
a first cable collection coupled to the first terminal wafer; and
a second cable collection coupled to the second terminal wafer.
7. The receptacle connector according to claim 6, wherein the first cable collection comprising a first plurality of cables, and the second cable collection comprises a second plurality of cables.
8. The receptacle connector according to claim 7, wherein the first plurality of cables are high-speed data cables, and the second plurality of cables are low-speed data cables.
9. The receptacle connector according to claims 7 or 8, wherein the first plurality of cables comprise a bend at a termination end thereof, and the second plurality of cables comprise a bend at a termination end thereof.

10. The receptacle connector according to claims 7 or 8, wherein:
a termination portion of the first plurality of cables before the bend is at a first height relative to a bottom surface of the receptacle connector, and a distal portion of the first plurality of cables after the bend is at a second height different than the first height; and
a termination portion of the second plurality of cables before the bend is at a first height relative to a bottom surface of the receptacle connector, and a distal portion of the second plurality of cables after the bend is at a second height different than the first height.

11. The receptacle connector according to any of claims 6-10, further comprising:
a wall positioned between the first and second power wafer assemblies, and the first and second signal wafer assemblies,
wherein the wall reduces electromagnetic interference between the first power wafer assembly and the second power wafer assembly, and the first signal wafer assembly and the second signal wafer assembly.
12. The receptacle connector according to claim 7, further comprising a wire support organizer comprising a plurality of apertures through which the first plurality of cables and the second plurality of cables are positioned.
13. The receptacle connector according to claim 1, wherein the first power cable is coupled to the first power terminal of the first power wafer via ultrasonic welding, and the second power cable is coupled to the second power terminal of the second power wafer via ultrasonic welding.
14. The receptacle connector according to claim 1, wherein the first power cable is coupled to the first power terminal of the first power wafer via soldering, and the second power cable is coupled to the second power terminal of the second power wafer via soldering.
15. The receptacle connector according to claim 1, wherein the first power wafer assembly and the second power wafer assembly are offset from one another in a horizontal plane and a vertical plane.
16. The receptacle connector according to claim 6, wherein the first signal wafer assembly and the second signal wafer assembly are offset from one another in a horizontal plane and a vertical plane.
17. The receptacle connector according to claim 6, wherein the first power wafer assembly and the second power wafer assembly are separated from one another in a front-to-back

arrangement, and the first signal wafer and the second signal wafer are separated from one another in a front-to-back arrangement.

18. The receptacle connector according to claim 17, further comprising a first stiffener positioned on an outer side of the first signal terminal assembly towards a rear of the receptacle connector, and a second stiffener positioned on an outer side of the second signal terminal assembly towards a front of the receptacle connector.

19. The receptacle connector according to claim 18, further comprising a plurality of cable alignment blocks, each of the cable alignment blocks comprising a generally rectangular body extending horizontally along a body of the receptacle connector.

20. The receptacle connector according to claim 19, wherein each of the cable alignment blocks comprises apertures that align with corresponding apertures of an overmold organizer of the receptacle connector that retain at least one of the first cable collection and the second cable collection in a bended form.

21. The receptacle connector according to claim 6, further comprising an overmold organizer that retains at least one of the first cable collection and the second cable collection in a bended form.

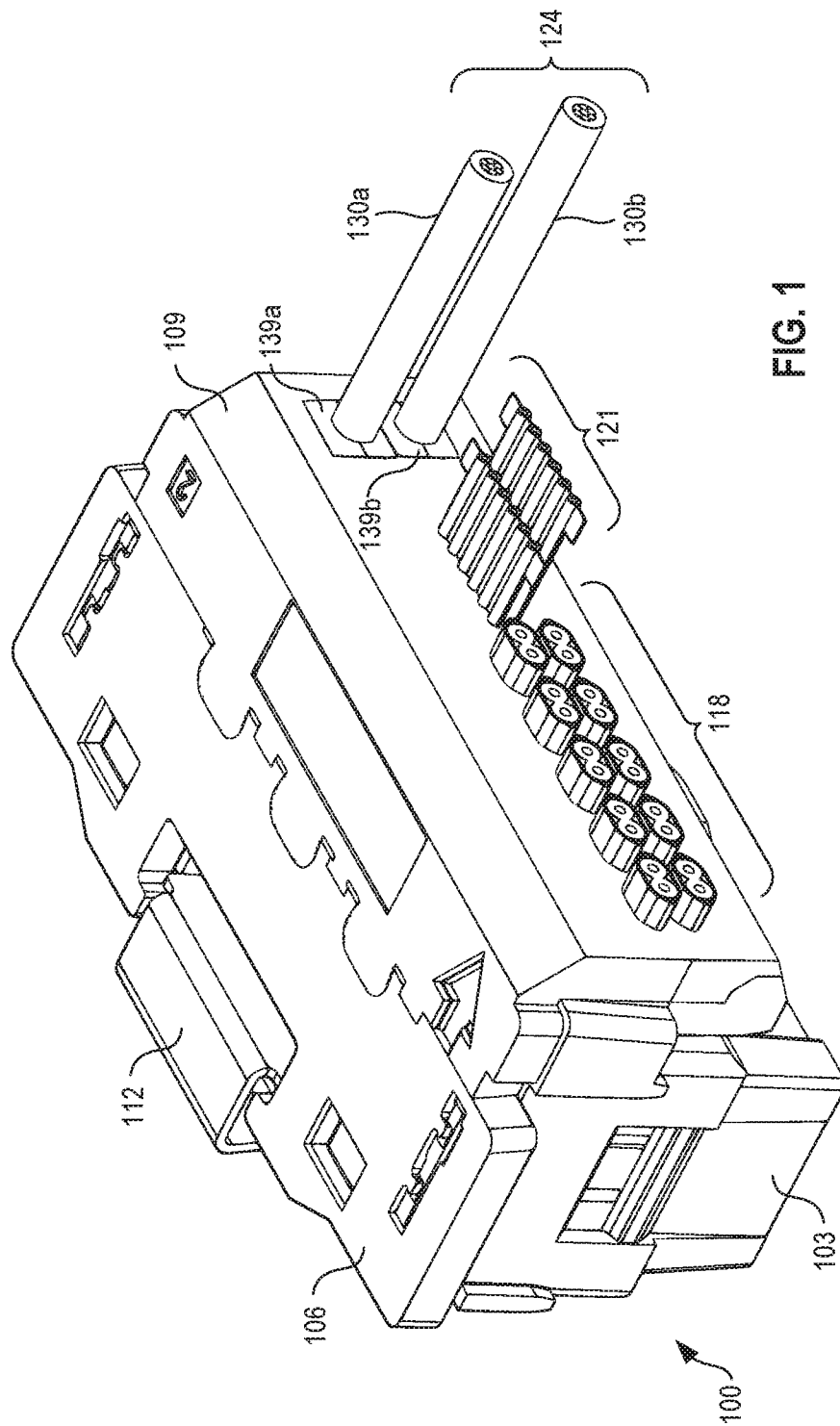
22. A method, comprising:

providing a power cable and cutting the first power cable to a predetermined length;

crimping a crimp ring onto a jacket of the power cable;

forming a power cable housing over the power cable as crimped through low-pressure overmolding; and

stripping the power cable to expose a plurality of conductors of the power cable; terminating the power cable as crimped and overmolded to a power terminal of a power wafer assembly via ultrasonic welding, soldering, and other suitable connection method.



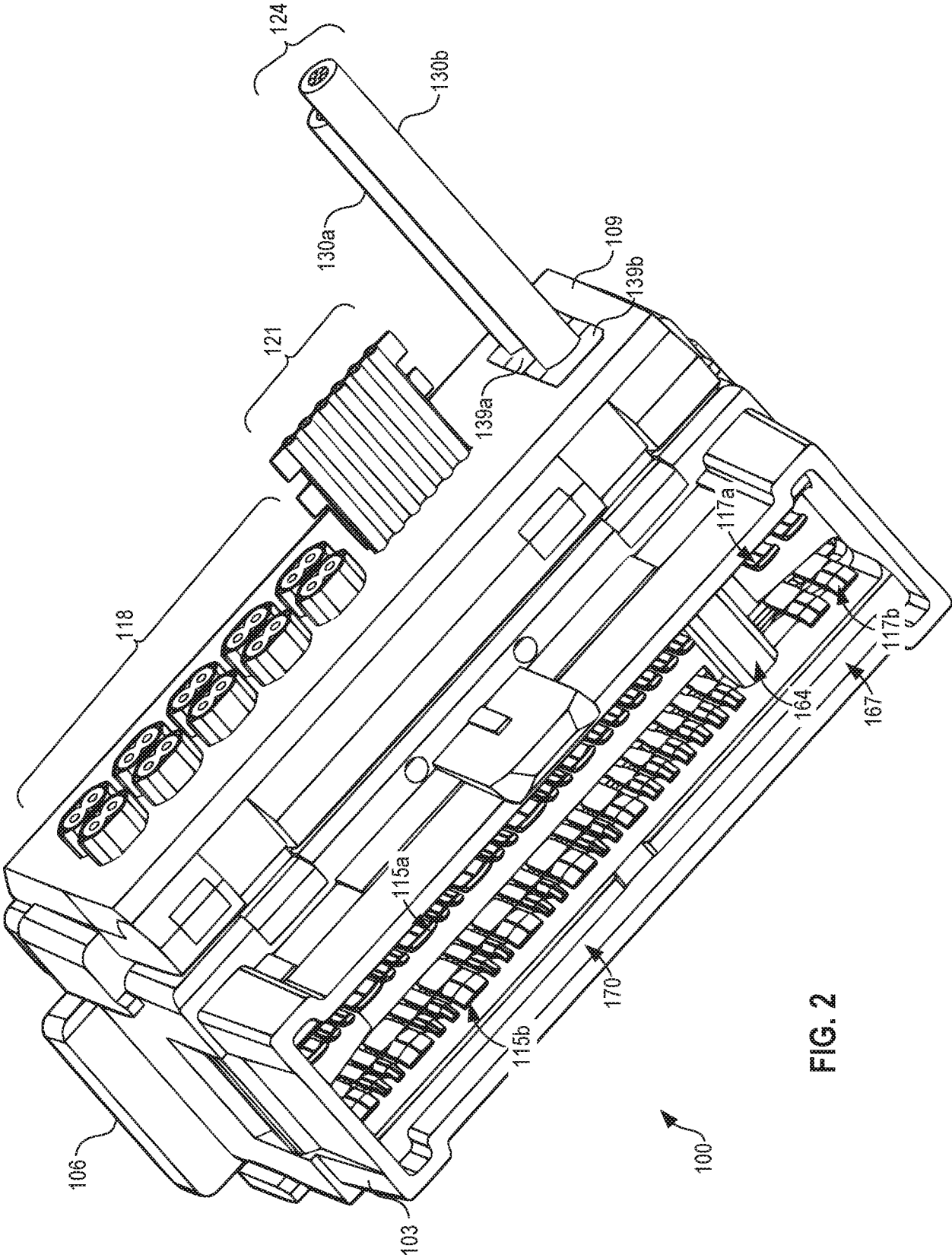
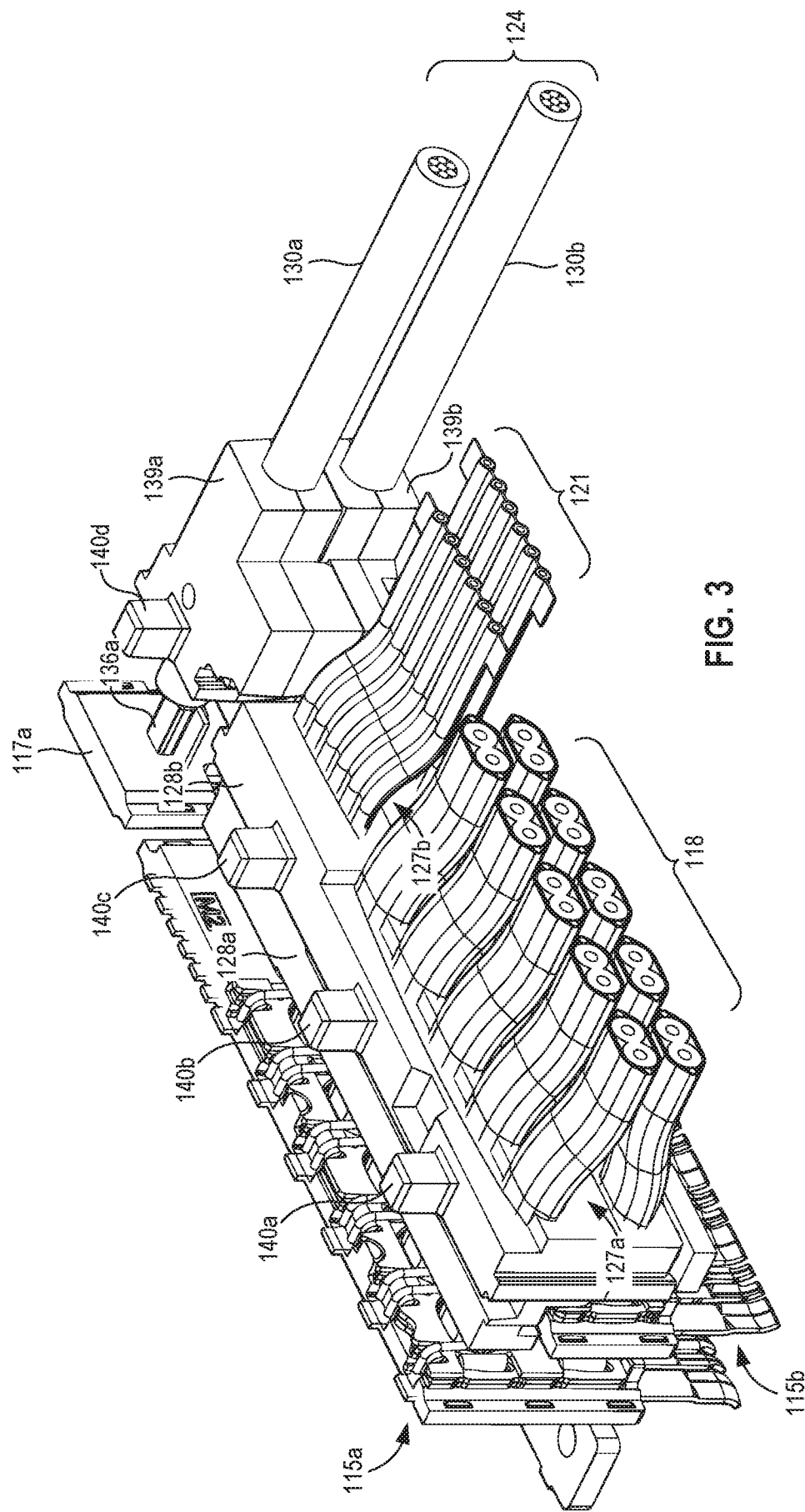


FIG. 2



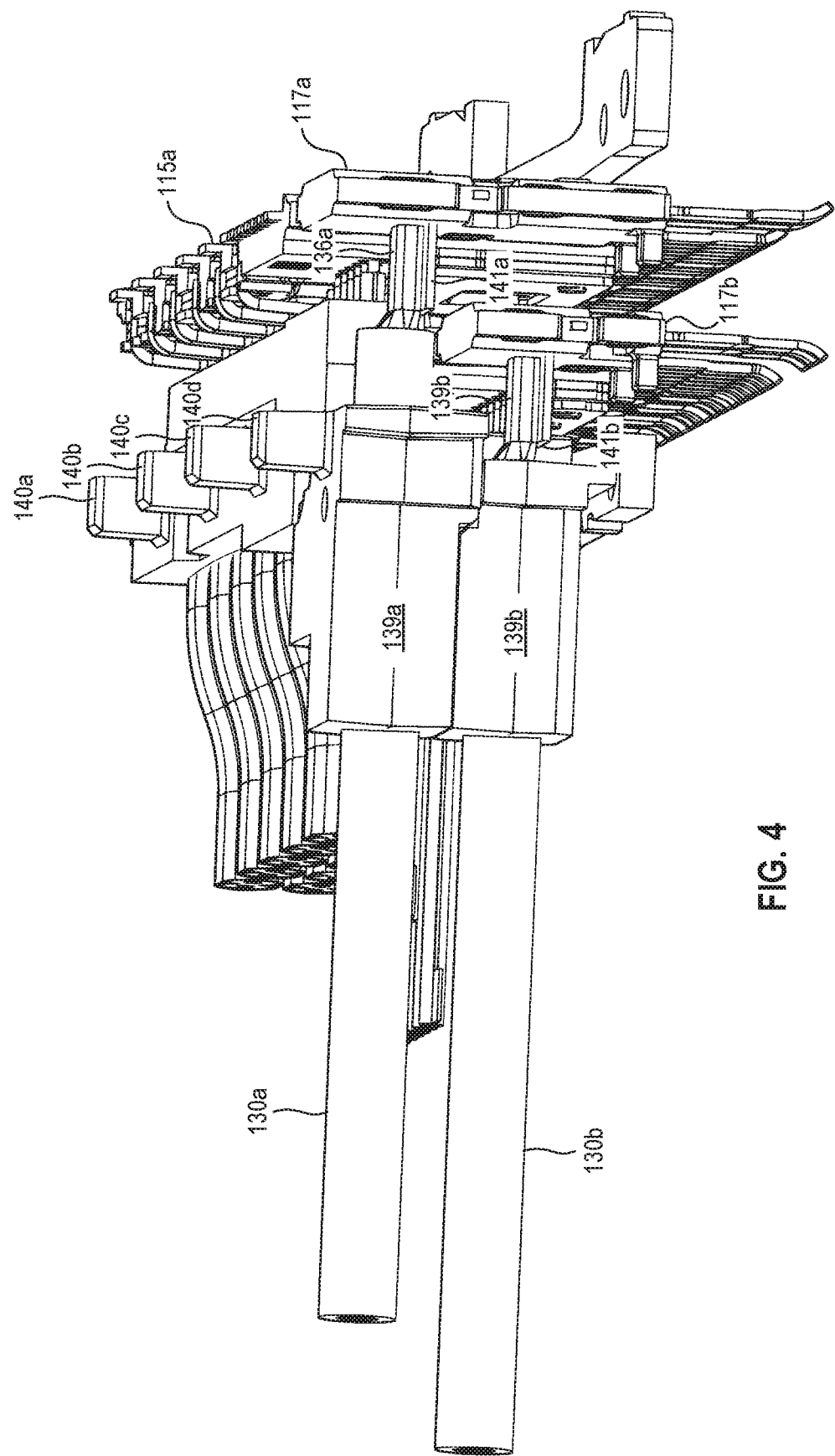


FIG. 4

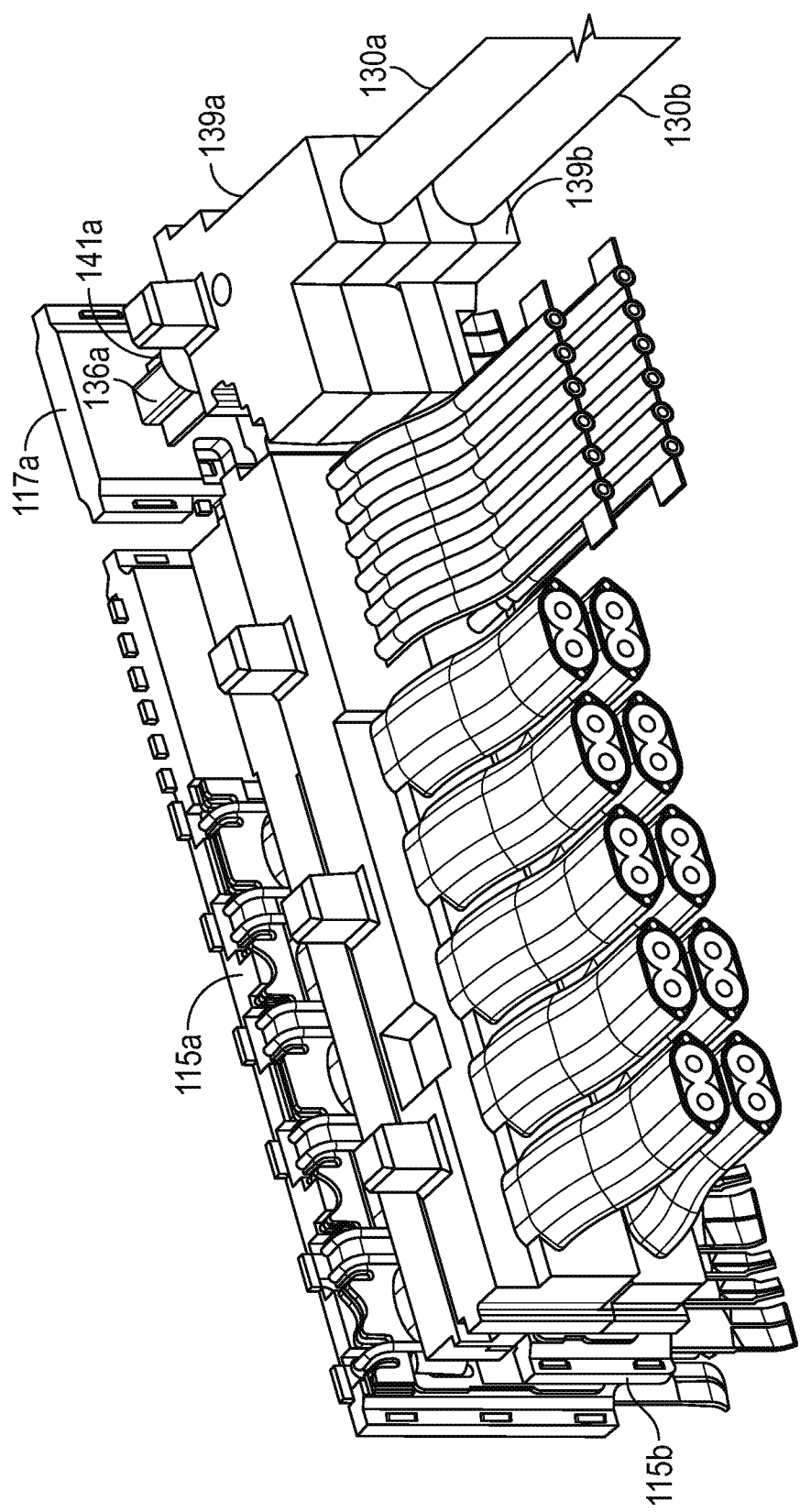


FIG. 5

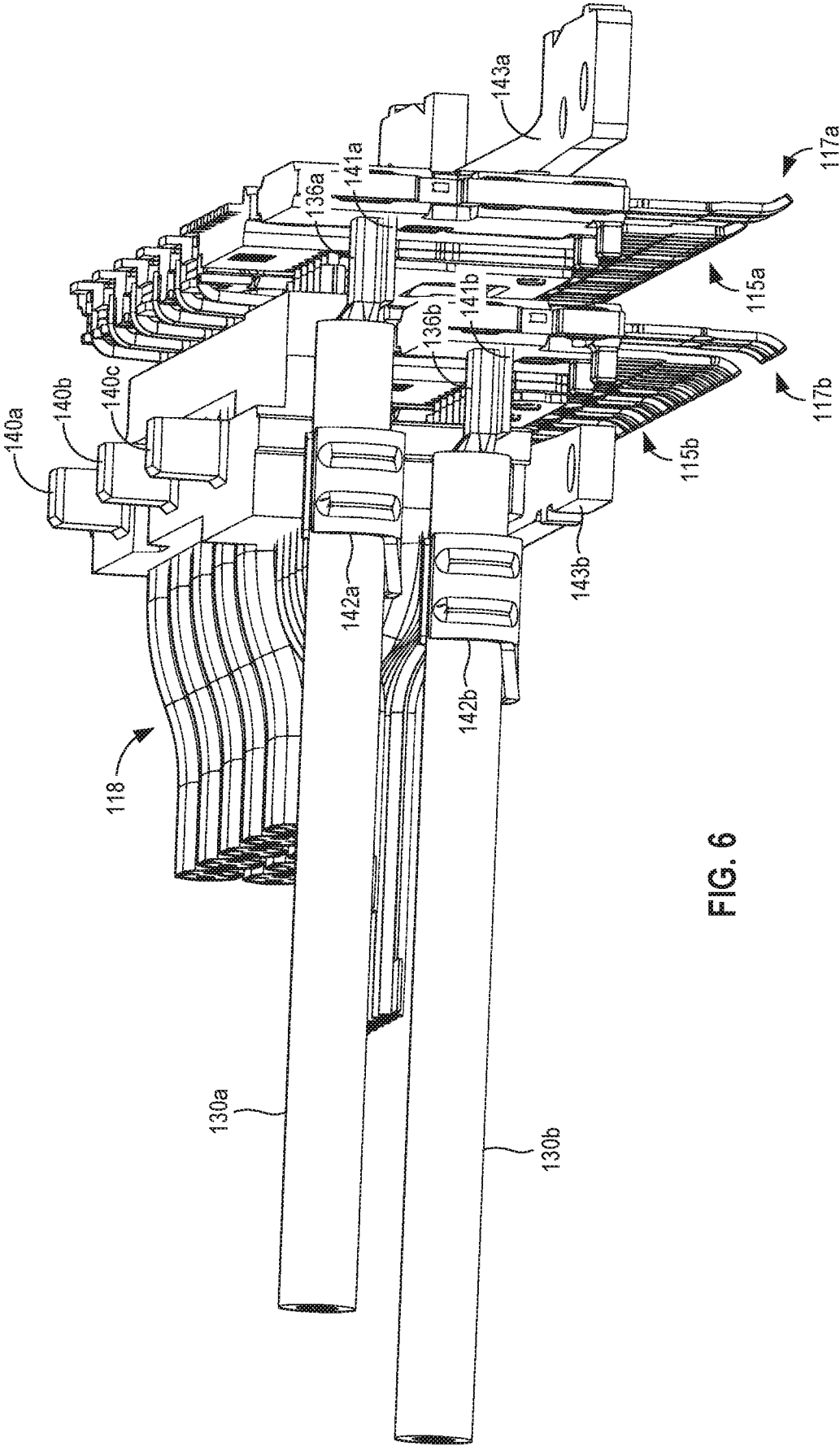


FIG. 6

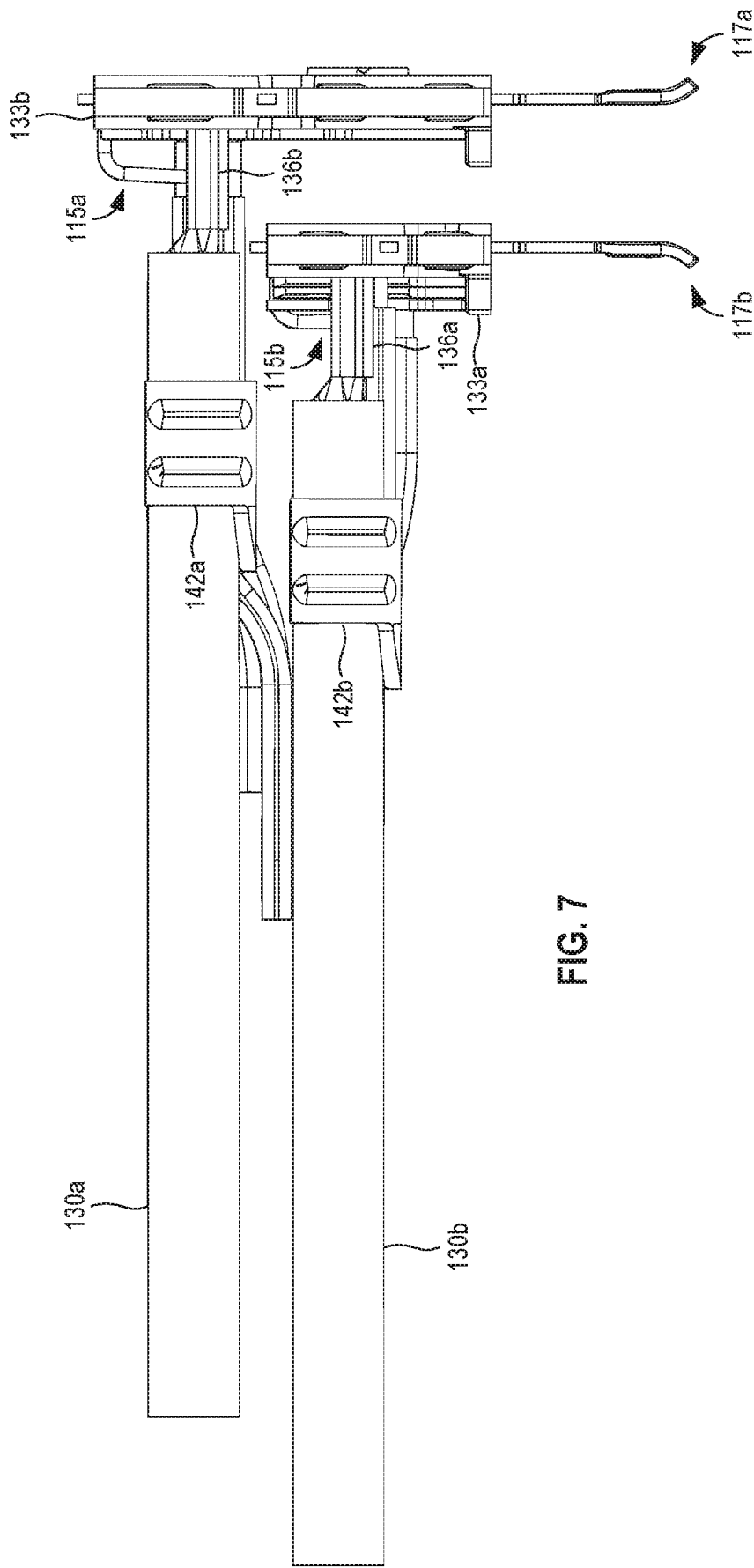


FIG. 7

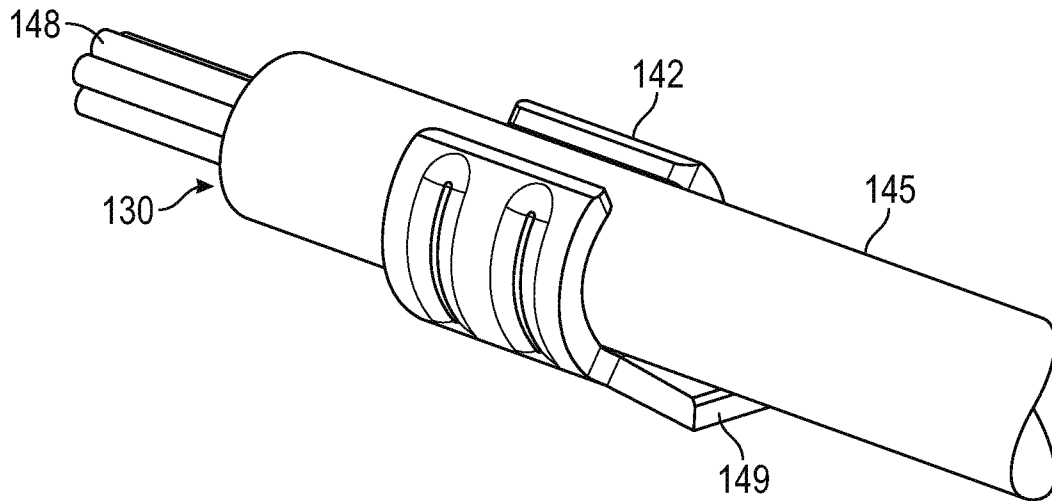


FIG. 8

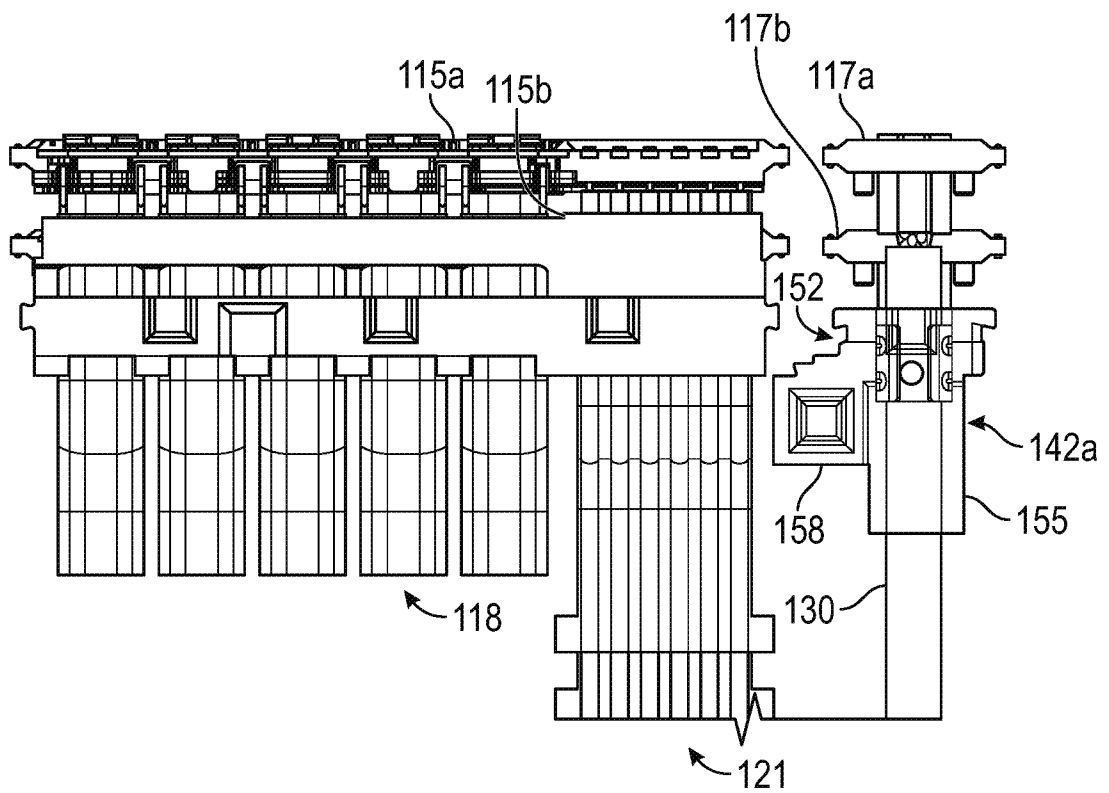


FIG. 9

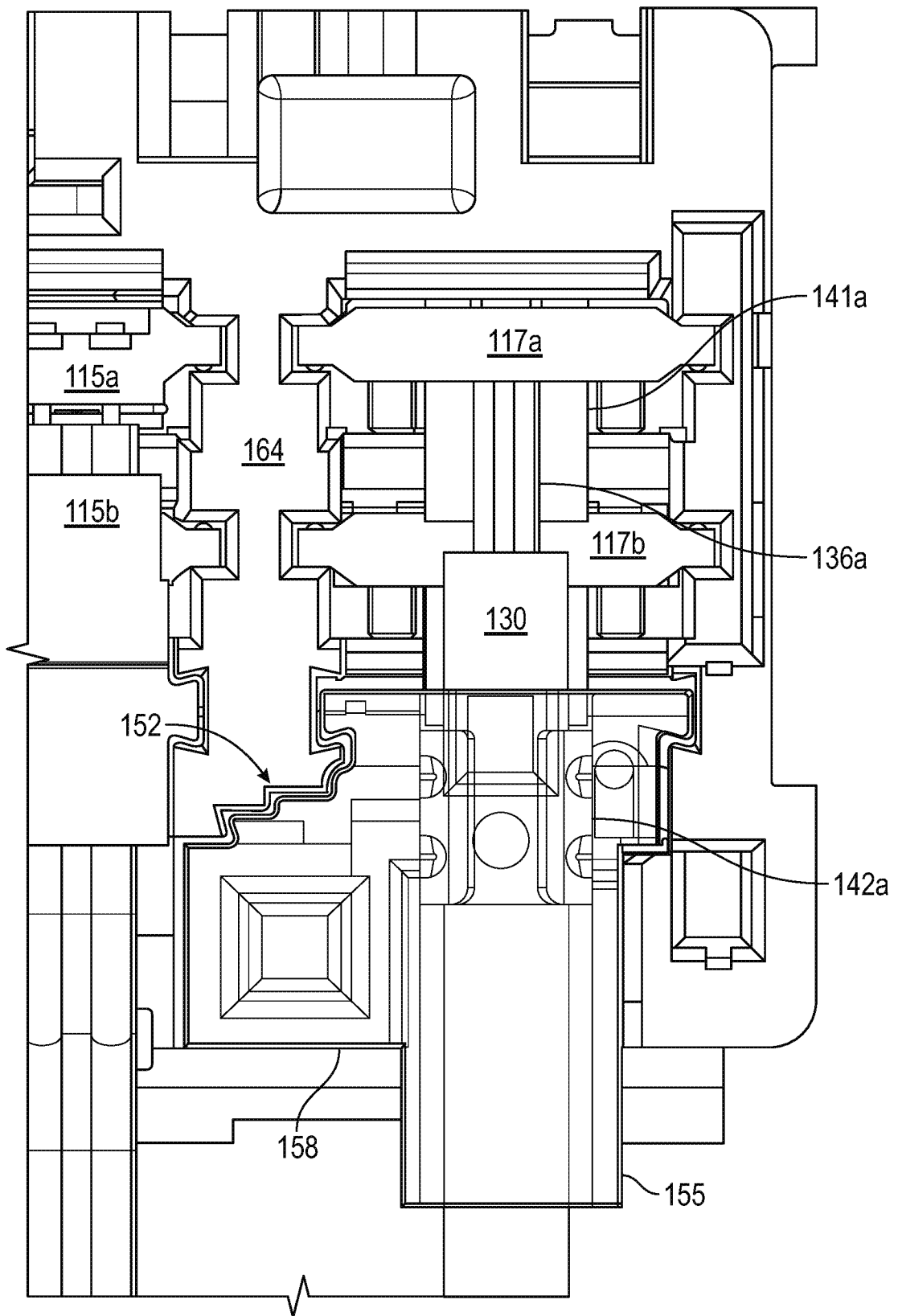


FIG. 10

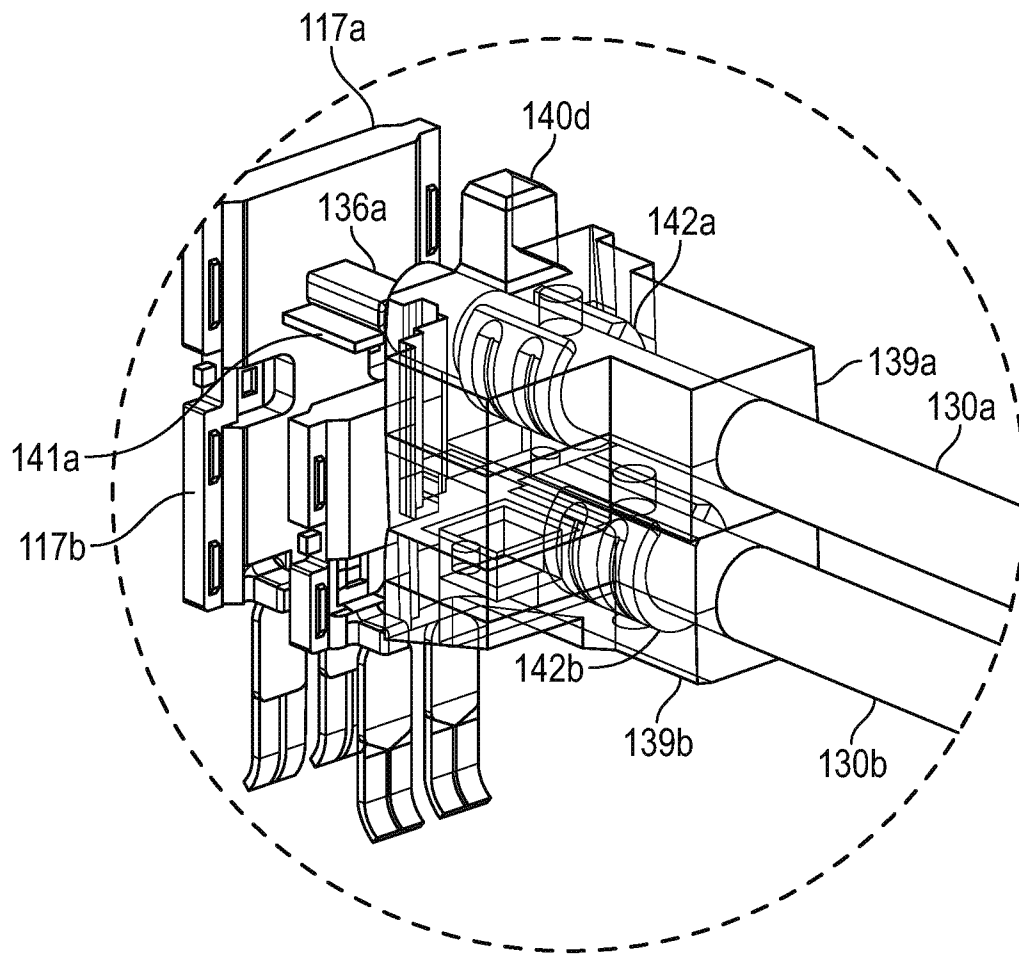


FIG. 11

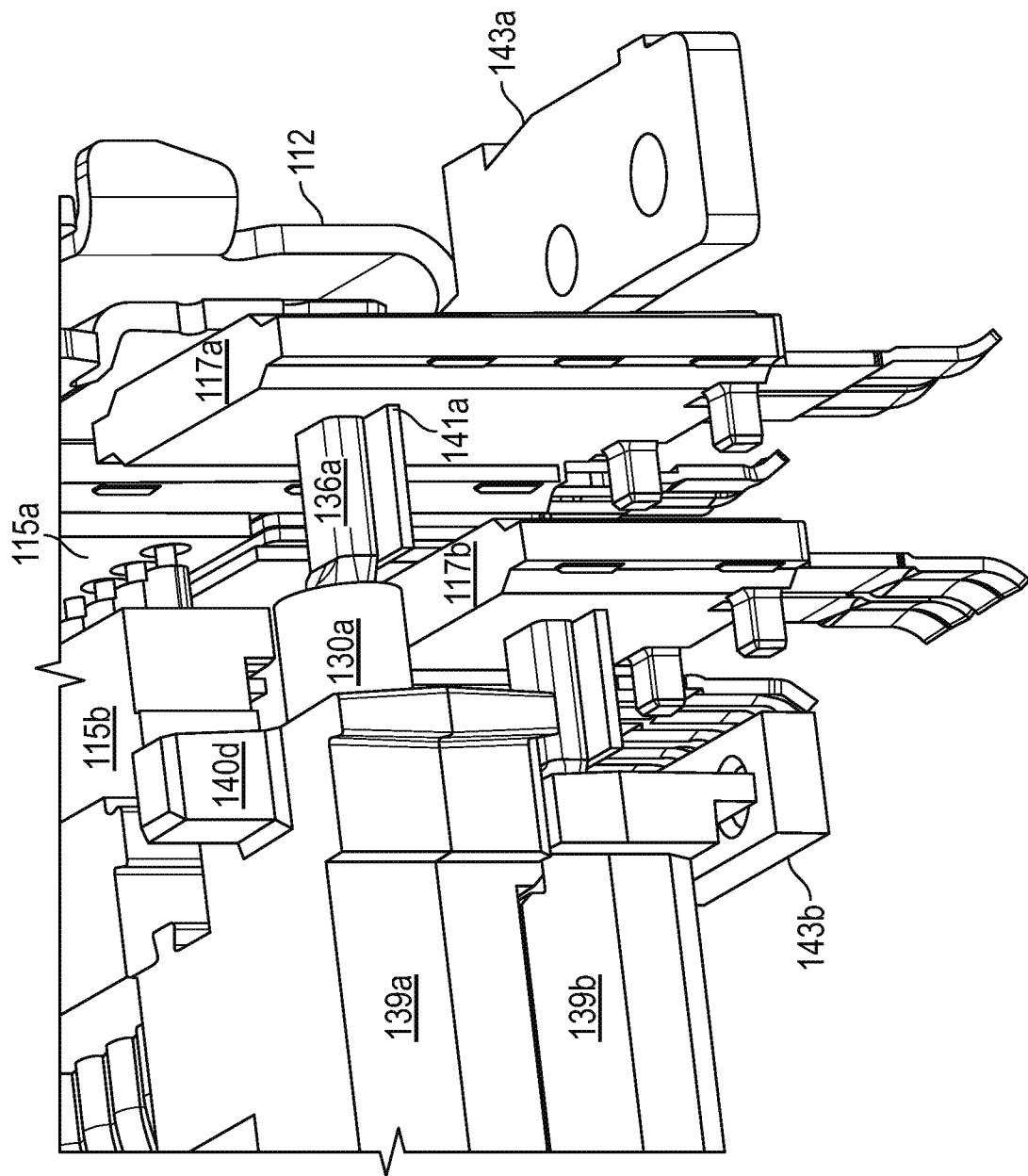


FIG. 12

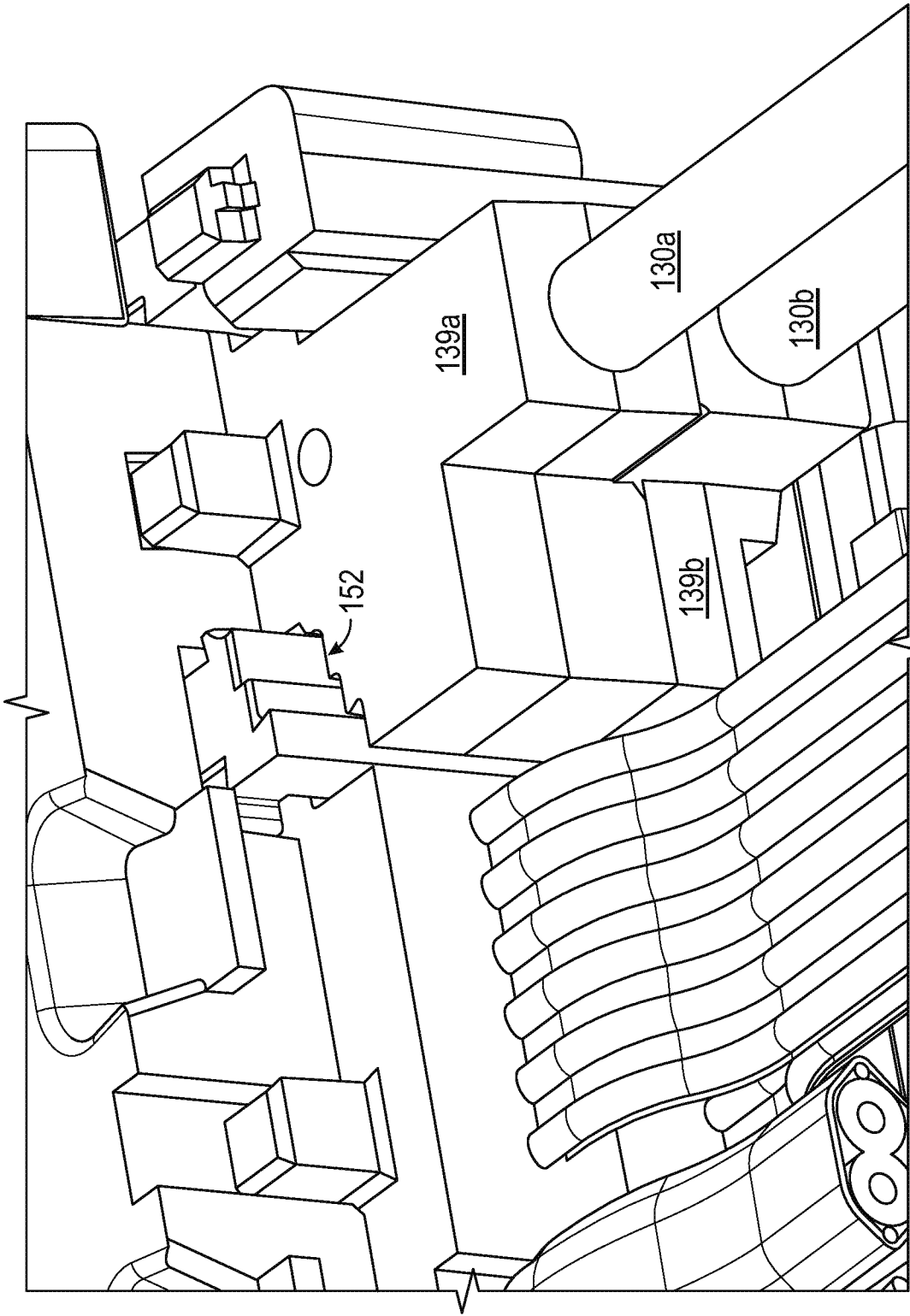


FIG. 13

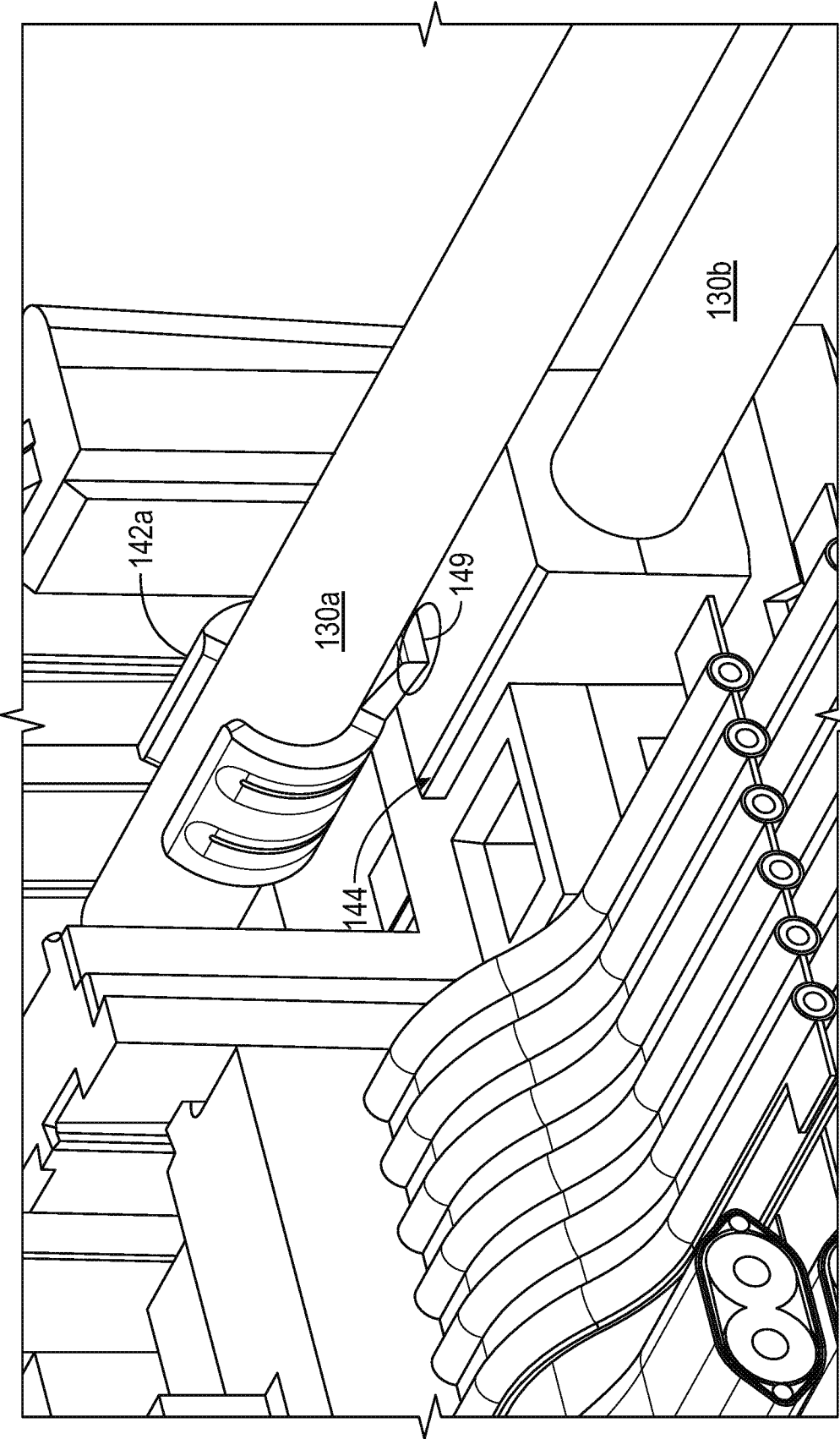


FIG. 14

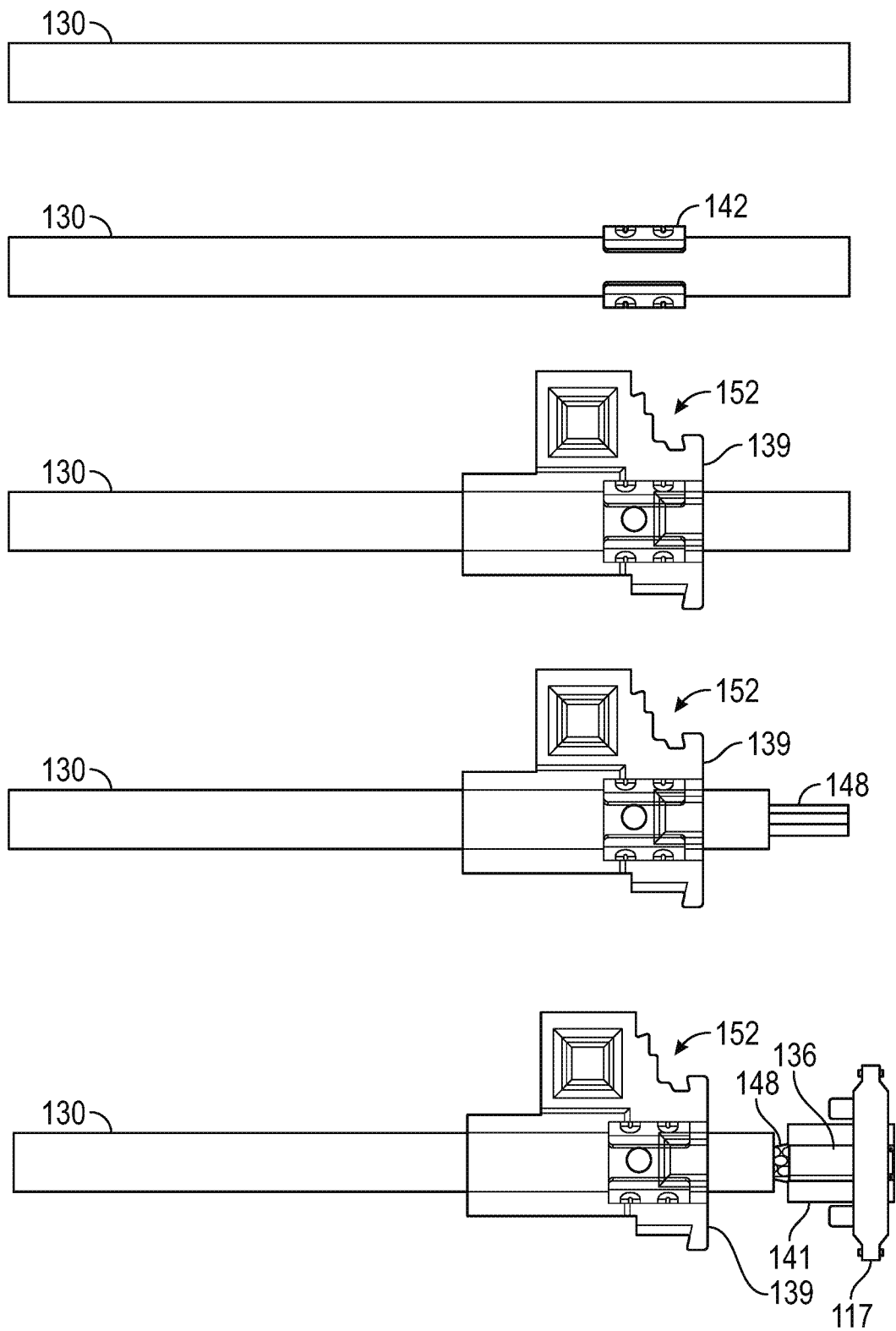


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2024/050493

A. CLASSIFICATION OF SUBJECT MATTER**H01R 13/58(2006.01)i; H01R 9/03(2006.01)i; H01R 24/38(2011.01)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)

H01R 13/58(2006.01); H01R 13/514(2006.01); H01R 13/6585(2011.01); H01R 24/66(2011.01); H01R 33/46(2006.01);
H01R 4/18(2006.01); H01R 4/70(2006.01)

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

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: receptacle connector, power wafer assembly, power cable, power terminal, power cable housing, crimp ring, encapsulation

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1964216 B1 (TYCO ELECTRONICS CORPORATION) 04 January 2012 (2012-01-04) See paragraphs [0019]-[0029] and figures 1-6.	1-2,5,13-15
A		3-4,22
Y	US 2017-0005445 A1 (MOLEX, LLC) 05 January 2017 (2017-01-05) See paragraphs [0009]-[0051] and figures 2-4A.	1-2,5,13-15
A	US 2011-0028047 A1 (FENGLIANG WANG) 03 February 2011 (2011-02-03) See paragraphs [0006]-[0049] and figures 1-10.	1-5,13-15,22
A	JP 2015-011926 A (FUJIKURA LTD.) 19 January 2015 (2015-01-19) See paragraphs [0012]-[0032] and figures 1-7.	1-5,13-15,22
A	US 2004-0185705 A1 (JERRY WU) 23 September 2004 (2004-09-23) See paragraphs [0015]-[0023] and figures 1-5.	1-5,13-15,22

☐ 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

“D” document cited by the applicant in the international application

“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

18 April 2024

Date of mailing of the international search report

18 April 2024

Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB2024/050493

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: **7-8,12,16-21**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Claims 7-8,12,16-21 are regarded to be unclear because they refer to multiple dependent claims which do not comply with PCT Rule 6.4(a).

3. ☒ Claims Nos.: **6,9-11**
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/IB2024/050493

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
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				EP	1964216	A1	03 September 2008
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				WO	2009-121221	A1	08 October 2009
				WO	2009-121239	A1	08 October 2009
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				US	6793520	B1	21 September 2004