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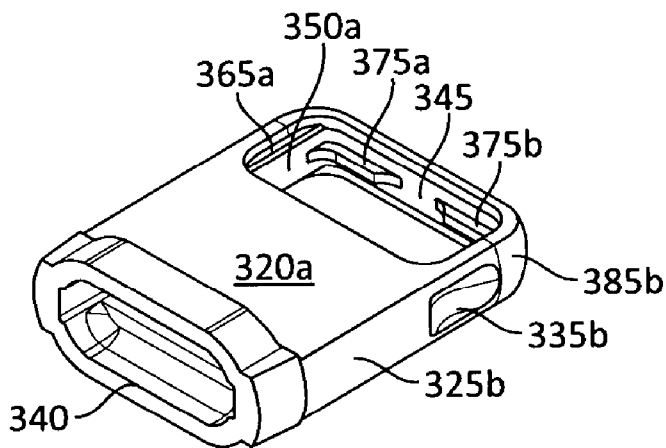


FIG. 3E

(57) Abstract: Frames for plug connectors capable of being a reduced size may include features to support contacts, house circuitry for coupling with the contacts, facilitate the flow of molten material during the molding of the frame, and allow for ease of insertion and removal of the plug connector to and from a corresponding receptacle connector. For example, a frame may include ledges, interlocks and rounded and tapered openings. Methods for manufacturing the frame are also provided.



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CONNECTORS AND METHODS FOR MANUFACTURING CONNECTORS

BACKGROUND OF THE INVENTION

[0001] The present invention relates generally to electronic connectors such as audio and data connectors, and in particular ground rings or frames for plug connectors.

[0002] Many electronic devices mate with electrical connectors that receive and provide power and data. For example, devices, such as tablets, laptops, netbooks, desktops, and all-in-one computers; cell, smart, and media phones; storage devices, portable media players, navigation systems, monitors, and others, use electrical connectors for power and/or data.

[0003] These electrical connectors are often plug connectors that are designed to mate with corresponding receptacle connectors on an electronic device. Many previously known plug connectors, such as USB connectors, include a plurality of contacts that are surrounded by a metal shell. The metal shell creates a cavity in which debris may collect and adds to the thickness of the connector. As electronic devices continue to become smaller, there is an increasing demand for smaller plug connectors and corresponding receptacle connectors.

BRIEF SUMMARY OF THE INVENTION

[0004] Various embodiments of the invention pertain to a frame (sometimes referred to as a ground ring) that can be used in a plug connector to provide support for a plurality of external contacts on one or more sides of the frame. For example, a plug connector capable being of a reduced size may include a frame having features to support external contacts, house circuitry for coupling with the contacts, facilitate the flow of molten material during the molding of the frame, and allow for ease of insertion and removal of the plug connector to and from a corresponding receptacle connector.

[0005] Embodiments of the present invention may also provide methods for easily manufacturing the plug connector frames described herein. For example, methods are provided for metal injection molding processes for forming a plug connector frame that includes some or all of the features described above. Some of these methods may result in a plug connector frame having distinctive physical characteristics, including an outer layer with increased density,

surface hardness and/or reduced porosity as compared to a remainder of the plug connector frame.

[0006] According to another embodiment, a frame for an electrical plug connector is provided. The frame can include a width, height and length dimension. The frame can include an insertion end configured to be inserted into an electrical receptacle connector corresponding to the electrical plug connector. The insertion end can include: (i) first and second opposing sides extending in the width and length dimensions where the first side can include a first opening and the second side including a second opening registered with and opposite the first opening, and (ii) third and fourth opposing sides extending between the first and second sides in the height and length dimensions. The frame can include a flanged end that includes a third opening that communicates with a cavity that extends in the length, width and height dimensions from the flanged end toward the insertion end past the first and second openings. The first, second, third and fourth sides of the insertion end each can include an outer layer that has a porosity less than a porosity of a remainder of each side; the outer layer at the first and second sides can be thinner than the outer layer at the third and fourth sides.

[0007] According to another embodiment, a method of manufacturing a frame for an electrical plug connector is provided. A metal injection molding process can be used to form a green part from a feedstock comprising metal and thermoplastic polymers; the green part can include: (i) a width, height and length dimension; (ii) an insertion end that can include first and second opposing sides extending in the width and length dimensions, the first side can include a first opening and the second side can include a second opening registered with and opposite the first opening, and third and fourth opposing sides extending between the first and second sides in the height and length dimensions; and (iii) a flanged end that can include a third opening that communicates with a cavity that extends in the length, width and height dimensions from the flanged end into the insertion end past the first and second openings. Thereafter, the green part can be debinded to form a brown part. Thereafter, the brown part can be sintered to form a metal part including the insertion end and flange end. Thereafter, the first and second sides of the insertion end of the metal part can be machined without machining the third and fourth sides of the insertion end.

[0008] Although aspects of the invention are described in relation to a ground ring or plug connector frame for a particular plug connector, it is appreciated that these features, aspects and

methods can be used in a variety of different environments, regardless of the corresponding plug connector size or type.

[0009] To better understand the nature and advantages of the present invention, reference should be made to the following description and the accompanying figures. It is to be understood, however, that each of the figures is provided for the purpose of illustration only and is not intended as a definition of the limits of the scope of the present invention. Also, as a general rule, and unless it is evident to the contrary from the description, where elements in different figures use identical reference numbers, the elements are generally either identical or at least similar in function or purpose.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1A illustrates a rendering of one particular electronic media device.

[0011] FIGS. 1B-1D depict an eight contact in-line dual orientation plug connector that may include a ground ring or frame according to embodiments of the present invention.

[0012] FIGS. 2A-2F depict plug connector 100 at the various stages of manufacture.

[0013] FIGS. 3A-3F illustrate an ground ring or frame according to an embodiment of the present invention.

[0014] FIGS. 4A-4D are cross sectional views that further illustrate the frame of FIGS. 3A-3F.

[0015] FIGS. 5A-5C illustrate side views of ground rings or frames according to embodiments of the present invention.

[0016] FIGS. 6A-6F illustrate another ground ring or frame according to an embodiment of the present invention.

[0017] FIGS. 7A and 7B are cross sectional perspective views of two opposing portions of the frame of FIGS. 6A-6F.

[0018] FIG. 8A illustrates an overview of a method of manufacture according to embodiments of the present invention.

[0019] FIG. 8B illustrates sub-steps steps for performing each of the steps of the method of FIG. 8A.

[0020] FIGS. 9A and 9B illustrate frames having machined surfaces according to the present invention.

[0021] FIG. 10A illustrates a simplified perspective view of a guide rail for routing frames according to embodiments of the present invention into contact with disks of a double-disk grinding machine.

[0022] FIG. 10B illustrates a simplified top view of a guide rail routing frames into a double-disk grinding machine.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The present invention will now be described in detail with reference to certain embodiments thereof as illustrated in the accompanying drawings. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art, that the present invention may be practiced without some or all of these specific details. In other instances, well known details have not been described in detail in order not to unnecessarily obscure the present invention.

[0024] As discussed earlier, the invention may apply to a variety of plug connectors which use a variety of different connector technologies. Accordingly, this invention may be used with many electronic devices that mate with a variety of electrical connectors in order to receive and provide power and data. Examples of electronic devices that may be used with embodiments of the present invention are shown in the following figure.

I. ELECTRONIC DEVICES FOR USE WITH THE INVENTION

[0025] FIG. 1 depicts an illustrative rendering of one particular electronic media device 10. Device 10 includes a multipurpose button 15 as an input component, a touch screen display 20 as both an input and output component, and a speaker 25 as an output component, all of which are housed within a device housing 30. Device 10 also includes a primary receptacle connector 35 and an audio plug receptacle 40 within device housing 30. Each of the receptacle connectors 35 and 40 can be positioned within housing 30 such that the cavity of the receptacle connectors into which a corresponding plug connector is inserted is located at an exterior surface of the device housing. In some embodiments, the cavity opens to an exterior side surface of device 10. For simplicity, various internal components, such as the control circuitry, graphics circuitry, bus,

memory, storage device and other components are not shown in FIG. 1. Embodiments of the invention disclosed herein are particularly suitable for use with plug connectors that are configured to mate with primary receptacle connector 35, but in some embodiments can also be used with audio plug receptacle 40. Additionally, in some embodiments, electronic media device 10 has only a single receptacle connector 35 that is used to physically interface and connect the device (as opposed to a wireless connection which can also be used) to the other electronic devices.

[0026] Although device 10 is described as one particular electronic media device, embodiments of the invention are suitable for use with a multiplicity of electronic devices that include a receptacle connector that corresponds to a plug connector including a frame. For example, any device that receives or transmits audio, video or data signals among may be used with the invention. In some instances, embodiments of the invention are particularly well suited for use with portable electronic media devices because of their potentially small form factor. As used herein, an electronic media device includes any device with at least one electronic component that may be used to present human-perceivable media. Such devices may include, for example, portable music players (e.g., MP3 devices and Apple's iPod devices), portable video players (e.g., portable DVD players), cellular telephones (e.g., smart telephones such as Apple's iPhone devices), video cameras, digital still cameras, projection systems (e.g., holographic projection systems), gaming systems, PDAs, desktop computers, as well as tablet (e.g., Apple's iPad devices), laptop or other mobile computers. Some of these devices may be configured to provide audio, video or other data or sensory output.

[0027] In order to better appreciate the features and aspects of ground rings or frames of the present invention, further context for the invention is provided in the following section by discussing a one particular plug connector in which the invention may be implemented.

II. PLUG CONNECTORS THAT MAY INCLUDE THE INVENTION

[0028] FIGS. 1B-1D depict an eight contact in-line dual orientation plug connector 100 that may include a ground ring or frame according to embodiments of the present invention. FIG. 1B is a simplified perspective view of plug connector 100 and FIGS. 1C and 1D are simplified top and bottom plan views, respectively, of plug connector 100. As shown in FIG. 1B, plug connector 100 includes a body 42 and a tab or insertion end 44 that extends longitudinally away from body

42 in a direction parallel to the length of the connector. A cable 43 is attached to body 42 at an end opposite of Insertion end 44.

[0029] Insertion end 44 is sized to be inserted into a corresponding receptacle connector, such as connector 35, during a mating event and includes a first contact region 46a formed on a first major surface 44a and a second contact region 46b (not shown in FIG. 1B) formed at a second major surface 44b opposite surface 44a. Surfaces 44a, 44b extend from a distal tip or end of the insertion end to a flanged end 109. When insertion end 44 is inserted into a corresponding receptacle connector, surfaces 44a, 44b abut a housing of the receptacle connector or host device the receptacle connector is incorporated in. Insertion end 44 also includes first and second opposing side surfaces 44c, 44d that extend between the first and second major surfaces 44a, 44b. In some embodiments, insertion end 44 is between 4 and 7 mm wide, between 1 and 2 mm thick and has an insertion depth (the distance from the distal tip of insertion end 44 to flanged end 109) between 5 and 10 mm.

[0030] The structure and shape of insertion end 44 and flanged end 109 are defined by a ground ring or frame 105 that can be made from stainless steel or another conductive material. Plug connector 100 includes retention features 102a, 102b formed as curved recesses in the sides of ground ring 105. Body 42 is shown in FIG. 1B in transparent form (via dotted lines) so that certain components inside the body are visible. As shown, within body 42 is a printed circuit board (PCB) 104 that extends into ground ring 105 between contact regions 46a and 46b towards the distal tip of plug connector 100. One or more integrated circuits (ICs), such as Application Specific Integrated Circuit (ASIC) chips 108a and 108b, can be operatively coupled to PCB 104 to provide information regarding plug connector 100 and any accessory or device that plug connector 100 is part of and/or to perform specific functions, such as authentication, identification, contact configuration and current or power regulation.

[0031] Bonding pads 110 can also be formed within body 42 near the end of PCB 104. Each bonding pad can be connected to a contact or contact pair within regions 46a and 46b. Wires (not shown) within cable 43 can then be soldered to the bonding pads to provide an electrical connection from the contacts to the accessory or device that plug connector 100 is associated with. Generally, there is one bonding pad and one wire within cable 43 for each set of electrically independent contacts (e.g., a pair of electrically connected contacts, one in region 46a and one in region 46b) of plug connector 100. Additionally, one or more ground wires (not

shown) from cable 43 can also be soldered or otherwise connected to frame105 for a ground signal.

[0032] As shown in FIGS.1C and1D, eight external contacts 106(1)...106(8) are spaced apart along a single row in each of contact regions 46a, 46b. Each contact in contact region 46a is electrically connected to a corresponding contact in contact region 46b on the opposite side of the connector. Contacts 106(1)...106(8) can be used to carry a wide variety of signals including digital signals and analog signals as well as power and ground as previously discussed.

[0033] In one embodiment, plug connector 100 can be the plug connector portion of a plug connector/receptacle connector pair that can be the primary physical connector system for an ecosystem of products that includes both host electronic devices and accessory devices. Examples of host devices include smart phones, portable media players, tablet computers, laptop computers, desktop computers and other computing devices. An accessory can be any piece of hardware that connects to and communicates with or otherwise expands the functionality of the host. Many different types of accessory devices can be specifically designed or adapted to communicate with the host device through plug connector 100 to provide additional functionality for the host. Plug connector 100 can be incorporated into each accessory device that is part of the ecosystem to enable the host and accessory to communicate with each other over a physical/electrical channel when plug connector 100 from the accessory is mated with a corresponding receptacle connector in the host device. Examples of accessory devices include docking stations, charge/sync cables and devices, cable adapters, clock radios, game controllers, audio equipment, memory card readers, headsets, video equipment and adapters, keyboards, medical sensors such as heart rate monitors and blood pressure monitors, point of sale (POS) terminals, as well as numerous other hardware devices that can connect to and exchange data with the host device.

[0034] An example of how the elements of plug connector 100 are manufactured and assembled together is shown in the following figures.

[0035] FIGS. 2A-2F depict plug connector 100 at the various stages of manufacture. The manufacture of plug connector 100 can start with the fabrication of ground ring or frame105, the construction of printed circuit board 104 and the construction of contact assemblies 116a, 116b each of which may occur independent of the others in any order. Frame105 (FIG. 2A) may be fabricated using a variety of techniques, which will be discussed in detail below.

[0036] Printed circuit board 104 (FIG. 2B) can be formed with a set of bonding pads 110 formed at one end and a second set of bonding pads 112 formed at the opposing end. Bonding pads 110 can serve as a solder attachment point for wires from cable 43 as discussed above and can be formed on one or both sides of PCB 104 as needed for connections. Eight bonding pads 112 corresponding to the eight contacts 106(1)...(8) are formed on each of the opposing sides 104a, 104b of PCB 104. Additionally, a third set of bonding pads 114 can be formed on either or both sides of PCB 104 to electrically connector one or more integrated circuits, such as ICs 108a, 108b, to the printed circuit board using a flip-chip or other appropriate connection method.

[0037] After ICs 108a, 108b are attached to the printed circuit board, PCB 104 is inserted through a back opening of frame 105 so that bonding pads 112 are positioned within opening 106. Next, contact assemblies 116a, 116b (FIG. 2D) are positioned within the openings 106 on each side of frame 105. Each contact assembly includes a frame 115 (FIG. 2D) that can be formed from a dielectric material such as polypropylene, and includes eight slots – one for each of contacts 106(1)...(8). The contacts can be made from a variety of conductive materials and as examples, can be nickel-plated brass, stainless steel or palladium nickel. The contacts can be cut to size in a stamping or similar process from a metal sheet and placed in respective slots of each frame 115.

[0038] The assembled ground ring/PCB/contact assembly structure (FIG. 2E) is then placed in a molding tool and a thermoplastic or similar dielectric overmold 118 can be formed around the contacts to provide smooth and substantially flat upper and lower surfaces of the tab or insertion end of plug connector 100 and provide a finished look (FIG. 2F). In one embodiment, dielectric overmold 118 is formed with an injection molding process using polyoxymethylene (POM).

[0039] A cable bundle (e.g., cable 43 shown in FIG. 1B) having individual signal wires (not shown), one for each of the functional contacts of plug connector 100 as well as one or more ground wires can be coupled to frame 105. The individual signal wires are cut and stripped, the jacket of the cable bundle is stripped and the cable shields are folded back over the jacket. The cable bundle can then be attached to the frame/PCB assembly by soldering each of the signal wires to its respective bonding pad 110 and soldering ground wires to frame 105. The solder joints and exposed wires can be potted with a UV glue to further secure the connections.

[0040] At this stage of manufacture the end of cable bundle (e.g., cable 43 shown in FIG. 1B) is attached to the PCB assembly via the soldered wires and a dielectric strain relief jacket (not

shown) can be formed around the attachment point between cable 43 and PCB 104 encasing the portion of PCB 104 that extends out of frame 105 including ICs 108a, 108b. The strain relief jacket can be formed using an injection molding or similar process. The construction of plug connector 100 can then be completed by sliding an outer enclosure around the strain relief jacket. The outer enclosure butts up against and is even with flanged end 109 of frame 105 forming body 42 of plug connector 100. The outer enclosure can be formed from ABS or a similar dielectric material and adhered to the ground ring and inner jacket using any appropriate adhesive suitable for the particular materials being bonded.

[0041] As discussed above, although frame 105 is described in relation to one particular plug connector (plug connector 100), embodiments of the invention are suitable for a multiplicity of plug connectors that correspond to receptacle connectors for electronic devices, e.g., devices discussed above.

[0042] Frame 105 may include a number of features to accommodate the elements of plug connector 100 described above. In addition, embodiments of the present invention may include features to aid in manufacturing connectors and/or insertion and removal of a connector from a corresponding receptacle connector. Examples of these features are shown in the following figures.

III. GROUND RING FEATURES

[0043] FIGS. 3A-3F illustrate a ground ring or frame 300 according to an embodiment of the present invention. FIGS. 3A-3D are top, bottom, front and back views, respectively, of ground ring or frame 300 according to an embodiment of the present invention. FIGS. 3E and 3F are perspective views of frame 300. Frame 300 may include a flanged end 305 and an insertion end 310 that extending longitudinally away from flanged end 305 in a direction parallel to the length dimension of frame 300.

[0044] Insertion end 310 may be sized to be inserted into a corresponding receptacle connector during a mating invention and includes first and second openings 315a, 315b on first and second opposing major surfaces 320a, 320b, respectively. In one embodiment, openings 315a, 315b are identically sized and shaped and directly opposite each other such that insertion end 310 may be a 180 degree symmetrical part. As shown in FIGS. 3A-3B, openings 315a, 315b may be rectangular with rounded corners. In other embodiments, opening 315a, 315b may be otherwise shaped, e.g., the opening may be triangular, circular or irregularly shaped. Insertion end 310 also

includes first and opposing side surfaces 325a, 325b. Surfaces 320a, 320b, 325a and 325b extend from a distal tip or end 330 of insertion end 310 to flanged end 305. When insertion end 310 is inserted into a corresponding receptacle connector, surfaces 320a, 320b, 325a, and 325b may abut inner walls of a housing of a corresponding receptacle connector of a host device. In one particular embodiment, insertion end 310 is 6.6 mm wide in the width dimension, 1.5 mm thick in the height dimension and has an insertion depth (the distance from distal end 330 of insertion end 310 to flanged end 305) in the length dimension of 7.1 mm.

[0045] Frame 300 may include retention features 335a, 335b that are formed as curved recesses on surfaces 325a, 325b, respectively, proximate distal end 330. These retention features may engage with corresponding retention features disposed in a receptacle connector of a host device and aid in holding a plug connector that includes frame 300 within the receptacle connector. A flanged end surface 335 of flanged end 305 includes an opening 340 that communicates with a cavity that extends in the length, width and height dimensions. The cavity may be defined in part by inner left and right surfaces 350a, 350b and inner top and bottom surfaces 350c, 350d. Opening 340 may be sized to receive a PCB (e.g., PCB 104 shown in FIG. 2B) that extends towards an inner end surface 345 proximate distal end 330 and between openings 315a, 315b.

[0046] As shown in FIGS. 3A and 3B, the widths 355a, 355b of openings 315a, 315b, respectively, may be greater than the distance 360 between surfaces 350a, 350b thereby forming ledges 365a, 365b and 365c (shown in FIGS. 4A and 4B), 365d, respectively. Ledges 365a and 365d may be defined by a first ridge (ridge 370a shown in FIG. 4A) and ledges 365b and 365c may be defined by a second ridge (ridge 370b shown in FIG. 4B). These ledges may be used to support contacts assemblies (e.g., contacts assemblies 116a, 116b shown in FIG. 2D) that are assembled with frame 300. In some embodiments, ledges of frame 300 may define additional ridges for supporting contact assemblies. As discussed with regards to plug connector 100, a thermoplastic may be formed around contacts assembled with frame 305, e.g., by overmolding, such that the contacts assemblies are held in place relative to positioning ledges 365a-365d.

[0047] Also shown in FIGS. 3A-3F are interlocks 375a, 375b, which may further define the cavity of frame 300. Interlocks 375a, 375b may be disposed on inner end surface 345, protrude toward the third opening and have a thickness in the height dimension. Interlocks 375a, 375b

may assist in preventing material overmolded around contacts assemblies assembled with frame 305 from dislodging and moving in the height dimension. Accordingly, interlocks may prevent displacement of the overmolded contact assemblies when forces are applied to the contacts assemblies in the direction of the height dimension. These forces may be caused by users pressing down on the contact assemblies or otherwise subjecting the contact assemblies to forces, e.g., dropping or hitting the contact assemblies of the plug connector.

[0048] Frame 300 also includes an outer end surface 380 that extend between surfaces 325a, 325b. As shown in FIGS. 3E and 3F, outer end surface 350 may be connected to surfaces 325a and 325b by rounded portions 355a and 355b, respectively. Rounded portions 355a, 355b may serve to help guide a plug connector including frame 305 into a corresponding receptacle connector. For example, where a plug connector including frame 305 is moved towards a receptacle connector sized to receive the plug connector in a direction that is not aligned with the opening of the receptacle connector, rounded portions 335a, 335b may allow for a greater margin of error in aligning the plug connector for insertion into the opening of the receptacle connector. That is, rounded portions 335a, 335b of the plug connector may render the profile of frame 105 at distal end 300 smaller relative to the opening of the receptacle connector and thus easier to insert into the opening. Once frame 105 enters the cavity of the receptacle connector, rounded portion 335a, 335b may also guide the remainder of frame 105 as the rounded portions 335a, 335b interface with interior walls of the receptacle connector and cause the plug connector including frame 105 to become aligned with the opening of the receptacle connector.

[0049] FIGS. 4A-4D are cross sectional views that further illustrate frame 300. FIGS. 4A and 4B are cross sectional perspective views of two opposing portions of frame 300. FIGS. 4C and 4D are also cross section views and provide side and partial perspective cross sectional views of frame 300. FIGS. 4A and 4B illustrate a portion of the cavity of frame 300 as well as including inner surface 350c, which was not visible in FIGS. 3A-3F. FIGS. 4A and 4B also show that first and second opening 315a and 315b may include tapered sidewalls 390a and 390b, respectively. Sidewalls 390a and 390b may extend into the cavity at a distance 391a and 391b, respectively. Tapered sidewalls 390a, 390b are drafted at draft angle 392. For example, draft angle 392 of tapered sidewalls 390a, 390b may be between 0 and 20 degrees or 5 and 20 degrees. In other embodiments, sidewalls 390a, 390b may be drafted at different angles, e.g., one may be drafted a 5 degrees and the other at 10 degrees. These tapered opening 315a, 315b may more readily receive and align contact assemblies, e.g., contacts assemblies 116a, 116b.

[0050] As shown in FIGS. 4C and 4D, the inner surfaces connecting insertion end 310 and flanged end 305 may include complex geometry. This may be due in part to the process by which frames according to the present invention may be formed. As discussed in greater detail below, frame 300 may be formed through a metal injection molding process wherein the molten material is injected into a mold through a portion of the mold corresponding to flanged end 305 of frame 300. As such, this complex geometry may be designed to eliminate sharp corners near the flanged end 305 in order to optimize the flow of material injected into a mold in order to form frame 300.

[0051] For example, flat inner surfaces 350c and a flat portion 394a of flanged end 305 may be connected by rounded portions 395a and 396a. Flat inner surface 350d may also be connected to flat portion 394b by similar rounded portions (not clearly shown in FIG. 4C-4D). Additionally, inner surface 350a may be connected to inner surfaces 350c, 350d by rounded portion 398a and 398b, respectively. Similarly, inner surface 350b may be connected to inner surfaces 350c, 350d by rounded portions (only one rounded portion 398c is shown in FIG. 4A-4D). Rounded sections 397a may connect flat portion 394a to rounded portion 398a and rounded sections 397b may connect flat portion 394b to rounded portion 398b. Similar rounded portions may connect flat portions 394a, 394b to rounded portions connecting surface 350b and surfaces 350c, 350d, respectively (e.g., rounded portion 398a).

[0052] Although flanged end 305 is shown in FIGS. 3A-3F and 4A-4D as having a particular geometry, other embodiments of the present invention may include a flanged end on a plug connector frame having other geometries. For example, a flanged end having a wider geometry is discussed below. A variety of otherwise shaped flanged ends may also be suitable for the present invention as flanged end 305 may not be intended to be inserted into a receptacle connector such that it would have to conform to any particular geometry of the corresponding receptacle connector.

[0053] In addition to those features described above in relation to FIGS. 3A-3F and 4A-4D, frames according to the present invention may include other features instead of or in addition to those features previously described herein. Examples of these additional features are shown in the following figures.

[0054] FIGS. 5A-5C illustrate side views of ground rings or frames according to embodiments of the present invention. As shown in FIG. 5A, a frame 500 may include a flanged end 505 and

an insertion end 510 that extends longitudinally away from flanged end 505 in a direction parallel to the length dimension of frame 500. Insertion end 510 may include first and second opposing major surfaces 515a, 515b, respectively. Surfaces 515a, 515b may include curved lead-ins 520a, 520b proximate the distal end of frame 500. Curved lead-ins 520a, 520b may connect an outer end surface 516 with first and second opposing surfaces 515a, 515b, respectively. The curved lean-in feature may render the plug connector in which frame 500 is implemented more readily insertable into a corresponding receptacle connector. In some embodiments, frame 500 may only include curved lead-in 520a while others may only include curved lead-in 520b.

[0055] FIG. 5B illustrates an embodiment of a frame 530 that does not include the curved lead-in feature of frame 500. Instead, frame 530 includes flat first and second opposing major surfaces 545a, 545 of insertion end 540 that connect with an outer end 546. This design may be desirable where the curved lean-in describes with reference to FIG. 5A is not useful or otherwise not appropriate for a given situation.

[0056] FIG. 5C illustrates yet another embodiment of a frame 550 including drafted surfaces. In this embodiment, insertion end 560 includes first and second opposing major surfaces 570a, 570b that are drafted at draft angle 575. Draft angle 575 may range between about 0.1 to 1.0 degrees, e.g., 0.5 or 0.25 degrees. In some embodiments only one of surfaces 570a, 570b may include a draft angle. In other embodiments, other surfaces of frame 530 may be drafted in addition to or instead of surfaces 570a, 570b. Drafted surfaces 570a, 570b may result from the method of manufacture as described below.

[0057] As discussed above, the flanged end of frames according to the present invention may vary from those embodiments illustrated in FIGS. 3A-3F and 4A-4D. An example of one particular flanged end variation is shown in the following figures.

[0058] FIGS. 6A-6F illustrate a ground ring or frame 600 according to an embodiment of the present invention. FIGS. 6A-6D are top, bottom, back and front views, respectively, of ground ring or frame 600 according to an embodiment of the present invention. FIGS. 6E and 6F are perspective views of frame 600. Similar to frame 300 discussed above, frame 600 may include a flanged end 605 and an insertion end 610 that extends longitudinally away from flanged end 605 in a direction parallel to the length dimension of frame 600. Insertion end 610 may include first and opposing major surfaces 620a, 620b. Insertion end 610 may include all the same features

and incorporate also the same variations as described above with regards to insertion end 310 (shown in FIGS 3A-3F). However, flanged end 605 may include a number of variations not specifically discussed above with regards to flanged end 305.

[0059] As shown in FIGS. 6A-6F, flanged end 605 may be wider in the width dimension than flanged end 305 and include geometry such as wings 605a, 605b connected by a base portion 605c. The wider flanged end 605 may help spread the load when torque is applied to insertion end 610. Depending on the particular application of a plug connector, frame600 may help prevent damage to a plug connectors including frame600 and corresponding receptacles mated with frame600 when torque is applied to the plug connector.

[0060] FIGS. 7A and 7B are cross sectional perspective views of two opposing portions of frame600. FIGS. 7A and 7B illustrate a portion of the cavity and inner surfaces of frame600, some of which may not have been visible in FIGS. 6A-6F. As shown in FIGS. 7A and 7B, the inner surfaces of flanged end 605 may be tapered. As with the geometry of the inner surfaces of flanged end 305, the geometry of the inner surfaces of flanged end 605 may be due in part to the process by which frames according to the present invention may be formed. Frame 600 may also be formed through a metal injection molding process wherein the molten material is injected into a mold through a portion of the mold corresponding to flanged end 605 of frame 600. As such, this tapered geometry may be designed to eliminate sharp corners near the flanged end 605 in order to optimize the flow of material injected into a mold in order to form frame 600.

[0061] For example, as shown in FIGS. 7A and 7B, flanged end 605 may include tapered first and second opposing surfaces 694a, 694b and tapered third and fourth opposing surfaces 694c, 694d. The tapered surfaces may connect with corresponding inner surfaces of insertion end 610, e.g., third and fourth opposing inner surfaces 650c, 650d (shown in FIG. 6D) and first and second opposing inner surfaces 650a (shown in FIG. 6E), 650b. Tapered sidewalls 694a-694d may be drafted at draft angle 695. For example, draft angle 695 of tapered sidewalls 694a-694d may be between 5 and 35 degrees or 10 and 30 degrees. In some embodiments, sidewalls 694a-694d may be drafted at different draft angles, e.g., some may have a draft angle of 17 degrees and the others 10 degrees.

[0062] Although flanged end 605 is shown in FIGS. 6A-6F and 7A-7B as having a particular geometry, other embodiments of the present invention may include a other wider or narrower

flanged end geometries. A variety of variable thickness, width and height flanged ends may be included in embodiments of the present invention.

[0063] Ground rings or frames described herein, e.g., frames 300 and 600, may be made from a variety materials including metals, dielectrics or a combination thereof. For example frames according to the present invention may be made from stainless steel or conductive polymers. In some embodiments, frames according to the present invention may be made from a single piece of electrically conductive material, .e.g., stainless steel 630.

[0064] As discussed above, frame designs of the present invention may take into account their method of manufacture. A number of different methods of manufacturing frames of the present invention may be suitable for frames of the invention. Examples of these methods are shown in the following figures.

IV. METHODS OF MANUFACTURE

[0065] Embodiments of the present invention may provide a plug connector ground ring or frame that may be easily manufactured. For example, techniques such as a metal injection molding (MIM) in combination with machining and finishing operations may be used to form frames of the invention.

[0066] FIG. 8A illustrates an overview of a method of manufacture according to embodiments of the present invention. This figure, as with the other included figures, is shown for illustrative purposes and does not limit either the possible embodiments of the present inventions or the claims.

[0067] As shown in FIG. 8A, method 800 includes three general steps. At the first step, step 810, a MIM process is performed in order to form a metal part. At step 820, select surfaces of the metal part are machined. Lastly, at step 830, finishing operations are performed on the metal part to complete the manufacture of a ground ring or frame. These steps may be used to form embodiments of frames 300 and 600 described above.

[0068] FIG. 8B illustrates sub-steps for performing each of the steps of method 800. Examples of these sub-steps are discussed below.

[0069] MIM step 810 includes three sub-steps: steps 812, 814 and 816. At step 812, a green part or green frame is molded. To produce the green part, a MIM feedstock is blended and injected into a molding machine in molten form. Once the liquefied feedstock cools, it may be

de-molded in the molding machine. The feedstock may include variety of elements chosen to produce a metal part with particular characteristics. In one embodiment, a feedstock for use with the invention may include atomized metal powder, a thermoplastic polymer and wax based plastic. The atomized metal powder may be an atomized steel powder, e.g., atomized steel 630 powder. The thermoplastic polymer may provide the plastic binding agent for the MIM process and the wax based plastic may provide the wax binding agent for the MIM process.

[0070] At step 814, the binders are removed (de-binded) from the green part to produce a brown part or brown frame. The binding material may be removed using heat, solvents (e.g., nitric acid), and/or other methods or a combination thereof.

[0071] At step 816, the brown part is sintered to produce a MIM part or frame and the MIM process is completed. The sintering process includes subjecting the brown part to temperatures that cause the atomized metal powders to bind together and form the MIM part or frame.

[0072] The MIM process may also result in parts having a number of characteristics typically associated with the MIM process. For example, the outer surfaces of frames, e.g., embodiments of frames 300 and 600 described above, manufactured according to step 810 may include an outer skin layer or outer layer that has different properties than a remainder of the frame. For example, surfaces 320a, 320b, 325a, 325b and 340 (shown in FIGS. 3A-3F) all may include an outer layer that has different properties than a remainder of material below the outer layer where frame 300 is formed by a MIM process (e.g., step 810). The remainder material of a given side may extend between an outer layer on an outer surface or side, e.g., 320a, and an outer layer on a corresponding inner surface or side of the frame, e.g., surface 350c may correspond to outer surface 320a. The outer layer may have a thickness of less than around 1000 microns and between 200 and 800 microns in some embodiments.

[0073] The outer layer of a given side surface may have a porosity less than the porosity of remainder material of the side. Additionally, the outer layer of a given side may also have a greater density and/or greater surface hardness than the remainder of the side. In some embodiments, outer layers of surfaces of frames may possess all three or some combination thereof of the characteristics described above – decreased porosity, increase density, and increased surface hardness – relative to the remainder of each respective surface or side.

[0074] In some embodiments, implementing a MIM process, e.g., step 810 above, to produce a frame may be desirable because it provides flexibility in achieving a desired geometry and can

result in a molded part that is close to the final desired shape, which in turn, may require less machining. Machining may still be required for some features, e.g., retention features, but these may be easily machined into the sides of the ground ring or frame after it is formed and then surfaces of the ground ring or frame can be smoothed using blasting process and then plated, as described above.

[0075] Although a particular method of manufacturing a frame according to the invention is discussed above, embodiments of the invention may include manufacturing the frame by other methods, including pressed powder sintering, investment casting, and simply computer numerical control (CNC) machining.

[0076] At the conclusion of the MIM process (step 810), surfaces of the frame may be machined at step 820. For example, at step 822, surfaces of the insertion end (e.g., 310, 610 above) may be machined. And at step 824, surfaces of the flanged end may be machined. A further discussion regarding which surfaces are machined, why those surfaces are machined, and the resulting characteristics of the machined surfaces will be discussed in detail below with regards to FIGS. 9A and 9B. The machining of step 820 may be accomplished by a CNC machine, a grinding machine or other suitable machinery.

[0077] At the conclusion of the machining operation (step 820), finishing operation may be performed on the frame at step 830. For example, at step 832, the frame may enter a sandblasting machine and/or a tumbling machine. In some embodiments, the media tumbling may be performed before the blasting. These machines may be used to remove burrs from the frame and polish the surface of the frame. At step 834, a plating operation may be performed on the frame. For example, a nickel plating operation may be implemented. In some embodiments, the plating process may be a nickel electroplating process using nickel sulfate or an electroless nickel plating process, e.g., high phosphorus electroless nickel. For nickel electroplating, the plating process may include a number of steps such as electrolytic degreasing, rinsing with pure water, activating acid, rinsing with pure water, nickel pre-plating, rinsing with pure water, nickel plating, rinsing with pure water, rinsing with hot pure water, cooking in an oven, and drying on a counter. Alternatively, other standard nickel electroplating processes and electroless nickel plating processes may be used at step 834.

[0078] As mentioned above, the machining of the frame in method 800 may only pertain to specific surfaces of the insertion and flanged ends of a frame. Examples of machining step 820 are included in the following figures.

[0079] FIGS. 9A and 9B illustrate frames 905 and 910 having machined surfaces according to the present invention. Machining surfaces of a frame may serve a number of functions, including reducing or eliminating the draft angle of drafted surfaces (e.g., surfaces 570a, 570b), providing a cosmetic finish, reducing surface roughness, and/or more precisely controlling tolerances of frames formed in a MIM process.

[0080] FIG. 9A illustrates a frame 905 manufactured according to embodiments of step 810 above and having machined surfaces as indicated by hatch patterns. Frame 905 includes first and second major opposing surfaces 915a and 915b (not shown in FIG. 9A) as well as first and second opposing side surfaces 916a and 916b (not shown in FIG. 9A). Frame 905 may also include a flanged end surface 920 surrounding opening 921.

[0081] In some embodiments, surfaces 915a, 915b may be machined according to step 820 (as indicated by a first hatch pattern) while surfaces 916a, 916b may not be machined. For example, the outer layers (as defined in above with reference to step 816) of surfaces 915a, 915b may be machined to reduce their respective outer layer thicknesses by 10-200 microns. Accordingly, in this embodiment, the outer layers of surfaces 916a, 916b may be thicker than the outer layers of 915a, 915b. As mentioned above, machining a surface may reduce its surface roughness. Accordingly, surfaces 915a, 915b may have a surface roughness that is less than the surface roughness of surfaces 916a, 916b. Again, the machining of surfaces 915a, 915b may also be used to remove the draft on those surfaces.

[0082] Alternatively, or in addition to the machining of surfaces 915a and 915b, flanged end surface 920 may be machined to reduce its outer layer thickness by 50-300 microns (as indicated by a second hatch pattern). The machining of surface 920 may aid in achieving tighter tolerances for frame 900 such that it may be fitted in custom overmolding tooling for additional assembly steps as described above. In addition, the surface roughness of flanged end surface 320 may be decreased.

[0083] FIG. 9B illustrates a frame 910 manufactured according to embodiments of step 810 above and having machined surfaces as denoted by hatch patterns. Similar to frame 905, frame 910 may include machined surfaces as described with reference to FIG. 9A. However, a flanged

end surface 930 including opening 931 may be machined to reduce its outer layer according to a range of smaller values than that of outer flange surface 920 of FIG. 9A. For example, flanged end surface 930 may be machined to reduce its outer layer by 10-200 microns, instead of 50-300 microns.

[0084] Although FIGS. 9A and 9B illustrate particular surfaces of frames 905 and 910 are machine and machined to reduce the thickness outer layers of surfaces by particular amounts, other embodiments of the present invention may include frames having different surfaces machined and/or outer layer thicknesses reduced by different amounts.

[0085] As mentioned above, the machining of step 820 may be accomplished by a number of different machining tools. One particular machining method using a double-disk grinding machine will be described in greater detail in relation to the following figures.

[0086] FIG.10A illustrates a simplified perspective view of a guide rail 1000 for routing frames according to embodiments of the present invention into contact with disks of a double-disk grinding machine. Guide rail 1000 may include supports 1005 for coupling frames 1010 to guide rail 1000. Retention features 1015a, 1015b may secure frames 1010 on supports 1005. Supports 1005 may orient frames 1010 in vertical direction with respect to feed direction 1020 of guide rail 1000. Supports 1005 may also position frames 1010 relative to a double-disk grinding machine (shown in FIG. 13) such that only the insertion end or portion 1025 of frame 1010 is machined by the double-disk grinding machine during a grinding operation by the double-disk grinding machine. A flanged end or portion 1030 may be positioned by guide rail 1000 such that it does not come into contact with the double-disk grinding machine while the insertion portion is being machined.

[0087] FIG. 10B illustrates guide rail 1000 routing frames into a double-disk grinding machine 1040. Double-disk grinding machine 1040 includes first and second grinding disks 1040a, 1040b. When fed into grinding machine 1040, front and back sides 1010a, 1010b of insertion portion 1025 (shown in FIG. 10A) of frame 1010 are simultaneously machined by disks 1040a, 1040b, respectively. As discussed above, the flanged end 1030 (as shown in FIG. 10A) is positioned by guide rail 1000 such that it is not machined by grinding machine 1040 while the insertion end 1025 (shown in FIG. 10A) is being machined.

[0088] The double disk grinding machine arrangement described above may allow for high-volume production of frames of the present invention that require the machining of their

insertion ends. Although FIGS. 10A-10B are illustrated and described as only allowing for the machining of the insertion end of a frame according to the present invention, other embodiment may modify this arrangement so as to machine other surfaces of the frames of the invention.

[0089] Also, while a number of specific embodiments were disclosed with specific features, a person of skill in the art will recognize instances where the features of one embodiment can be combined with the features of another embodiment. For example, some specific embodiments of the invention set forth above were illustrated with specific types of frames for plug connectors. A person of skill in the art will readily appreciate that any of the other types of plug connectors described herein may include frames of the invention having the features described herein, and may be manufactured according to the methods of manufacture specifically mentioned herein and various embodiments thereof. Also, those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the inventions described herein. Such equivalents are intended to be encompassed by the following claims.

WHAT IS CLAIMED IS:

1. A frame for an electrical plug connector, the frame comprising:
a width, height and length dimension;
an insertion end configured to be inserted into an electrical receptacle connector corresponding to the electrical plug connector, the insertion end having: (i) first and second opposing sides extending in the width and length dimensions, the first side including a first opening and the second side including a second opening registered with and opposite the first opening, and (ii) third and fourth opposing sides extending between the first and second sides in the height and length dimensions;
a flanged end including a third opening that communicates with a cavity that extends in the length, width and height dimensions from the flanged end toward the insertion end past the first and second openings;
wherein each of the first, second, third and fourth sides of the insertion end has an outer layer that has a porosity less than a porosity of a remainder of each side, and wherein the outer layer at the first and second sides is thinner than the outer layer at the third and fourth sides.
2. The frame of claim 1 wherein the outer layer has a thickness between 200 and 800 at each of the first, second, third and fourth sides.
3. The frame of claim 1 wherein the outer layer is between 20 and 400 microns thinner at the first and second sides than at the third and fourth sides.
4. The frame of claim 1 wherein an outer surface of the first and second sides has a surface roughness that is less than a surface roughness of the third and fourth sides.
5. The frame of claim 1 wherein the flanged end includes an outer surface that joins the first, second, third and fourth sides of the insertion end and an end surface that surrounds the third opening, the outer surface having an outer layer that is thicker than an outer layer of the end surface.
6. The frame of claim 5 further comprising a layer of nickel plated over the outer layer of the first, second, third and fourth sides of the insertion end and plated over the outer surface and end surface of the flange end.

7. The frame of claim 1 wherein the frame is formed with stainless steel.
8. A method of manufacturing a metal frame for an electrical plug connector, the method comprising:
 - using a metal injection molding process to form a green part from a feedstock comprising metal and thermoplastic polymers, the green part having:
 - (i) a width, height and length dimension;
 - (ii) an insertion end including first and second opposing sides extending in the width and length dimensions, the first side including a first opening and the second side including a second opening registered with and opposite the first opening, and including third and fourth opposing sides extending between the first and second sides in the height and length dimensions; and
 - (iii) a flanged end including a third opening that communicates with a cavity that extends in the length, width and height dimensions from the flanged end into the insertion end past the first and second openings;
 - thereafter, debinding the green part to form a brown part;
 - thereafter, sintering the brown part to form a metal part having the insertion end and flange end; and
 - thereafter, machining the first and second sides of the insertion end of the metal part without machining the third and fourth sides of the insertion end.
9. The method of claim 8 further comprising performing finishing operations on the frame after the machining step.
10. The method of claim 8 wherein the finishing operations include plating the metal frame.
11. The method of claim 8 wherein the feedstock comprises atomized steel powder, a thermoplastic polymer and wax based plastic.
12. The method of claim 11 wherein the atomized steel powder comprises atomized stainless steel powder.

13. The method of claim 11 wherein the thermoplastic polymer comprises polyoxymethylene.

14. The method of claim 8 further comprising machining a side of the flanged end that includes the third opening.

15. The method of claim 8 wherein the machining step comprises:
coupling the metal frame to a guide rail such that the frame is oriented in a vertical direction with respect to the guide rail; and
feeding the frame into a double-disk grinding machine in a horizontal direction while the frame is coupled to the guide rail such that only the first and second sides of the insertion portion of the metal frame are machined during the machining step.

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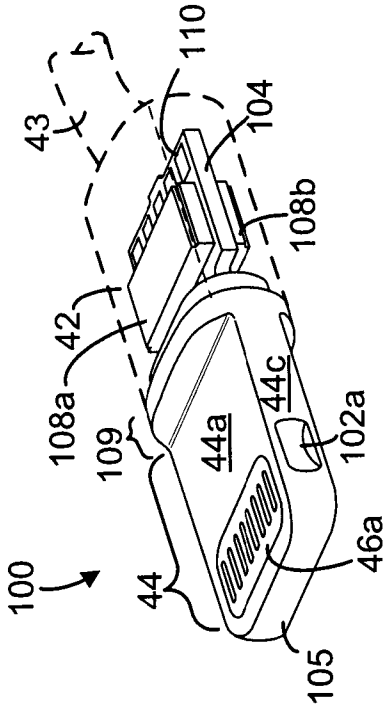


FIG. 1B

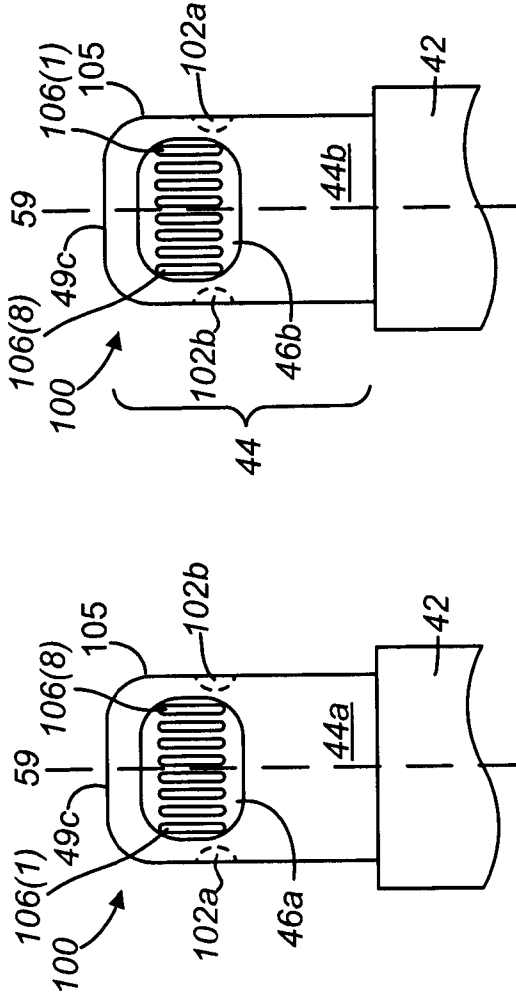


FIG. 1D

FIG. 1C

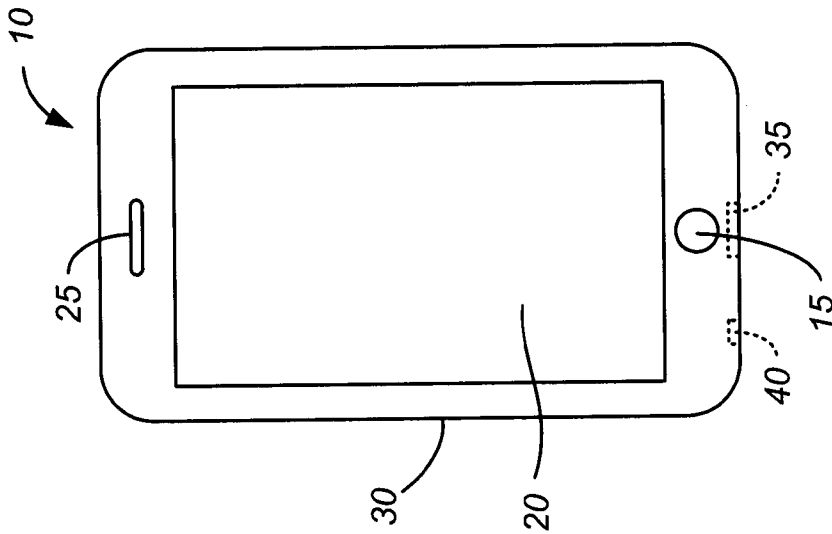


FIG. 1A

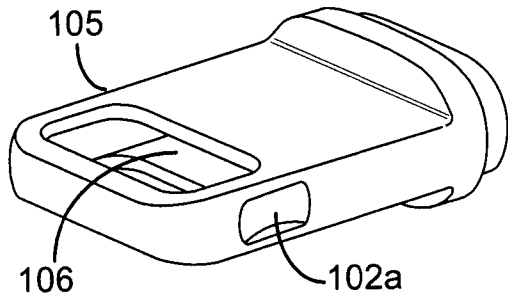


FIG. 2A

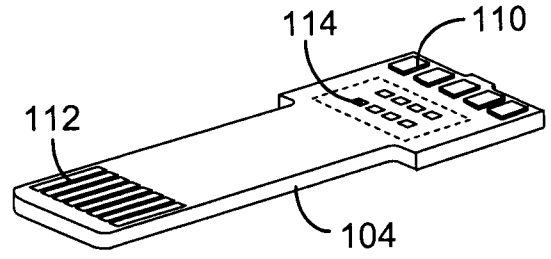


FIG. 2B

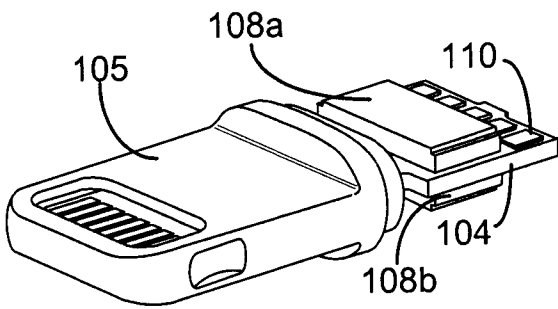


FIG. 2C

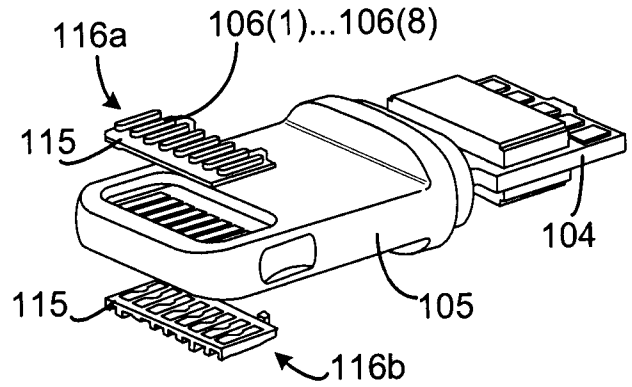


FIG. 2D

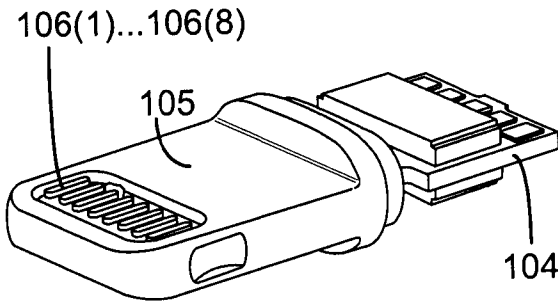


FIG. 2E

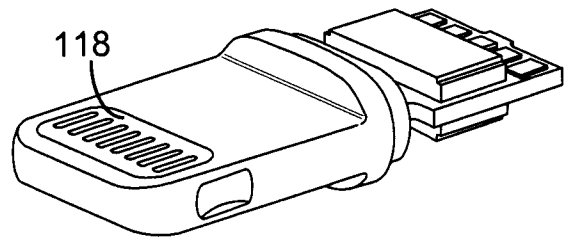


FIG. 2F

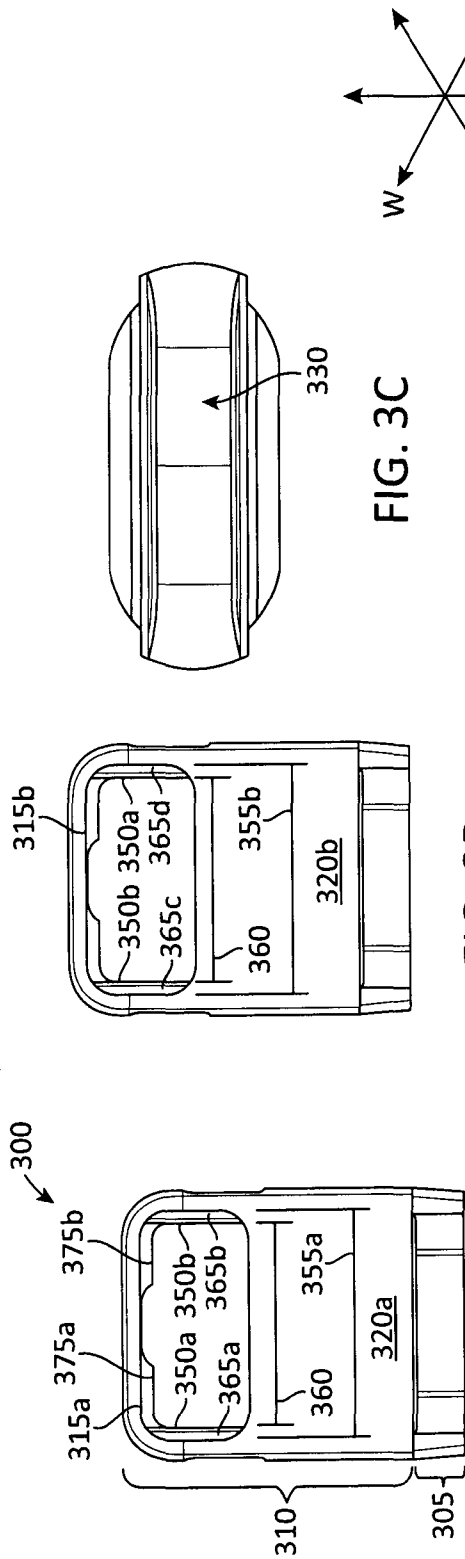


FIG. 3C

FIG. 3B

FIG. 3A

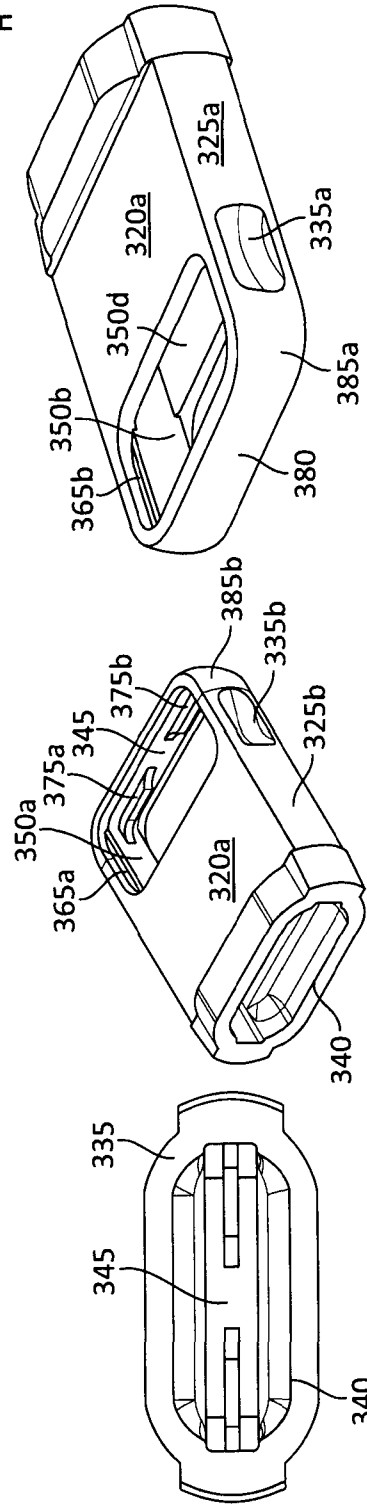


FIG. 3F

FIG. 3E

FIG. 3D

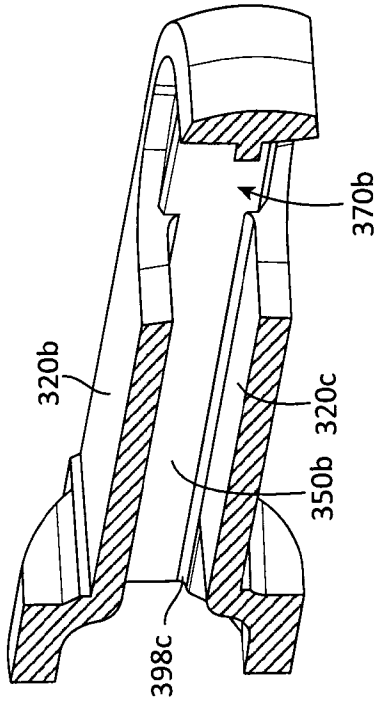


FIG. 4B

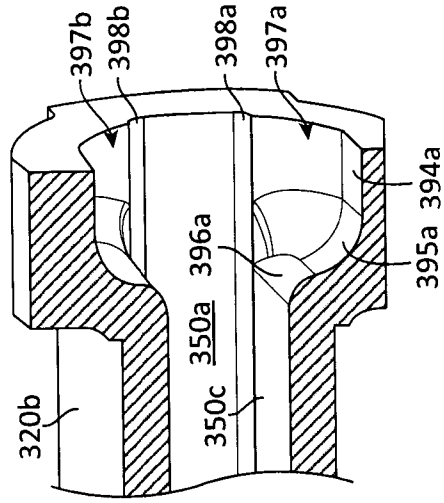


FIG. 4D

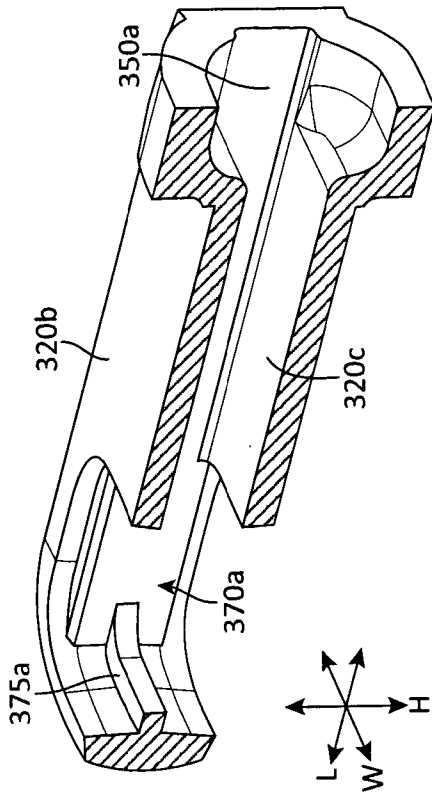


FIG. 4A

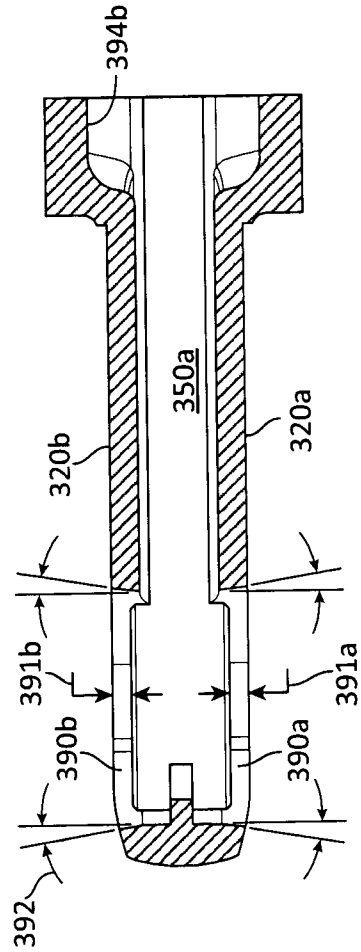


FIG. 4C

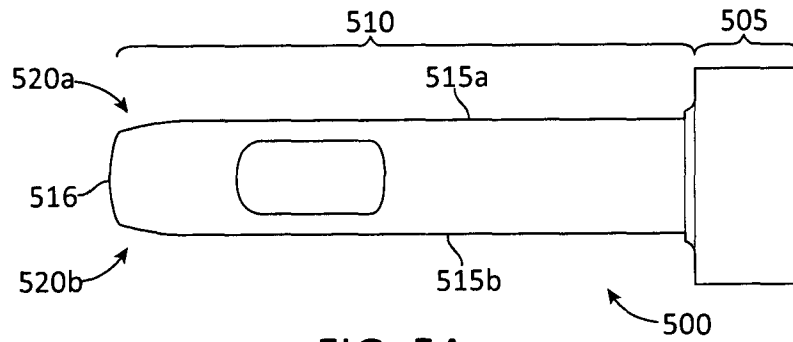


FIG. 5A

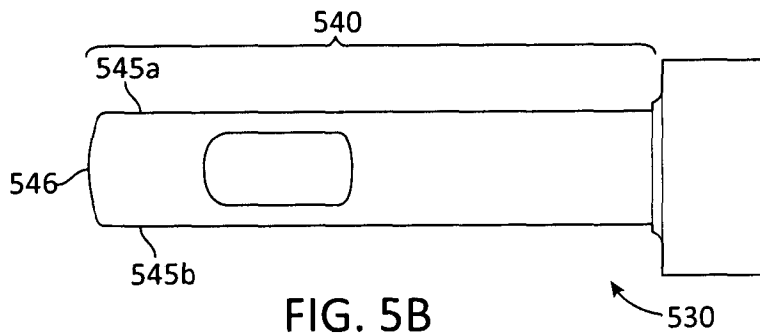


FIG. 5B

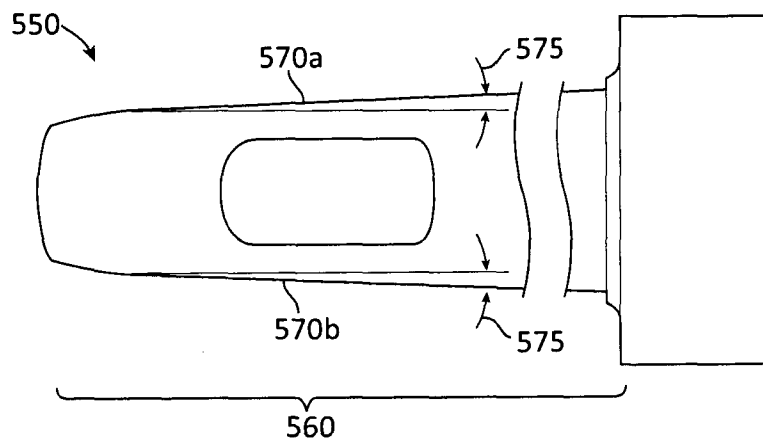
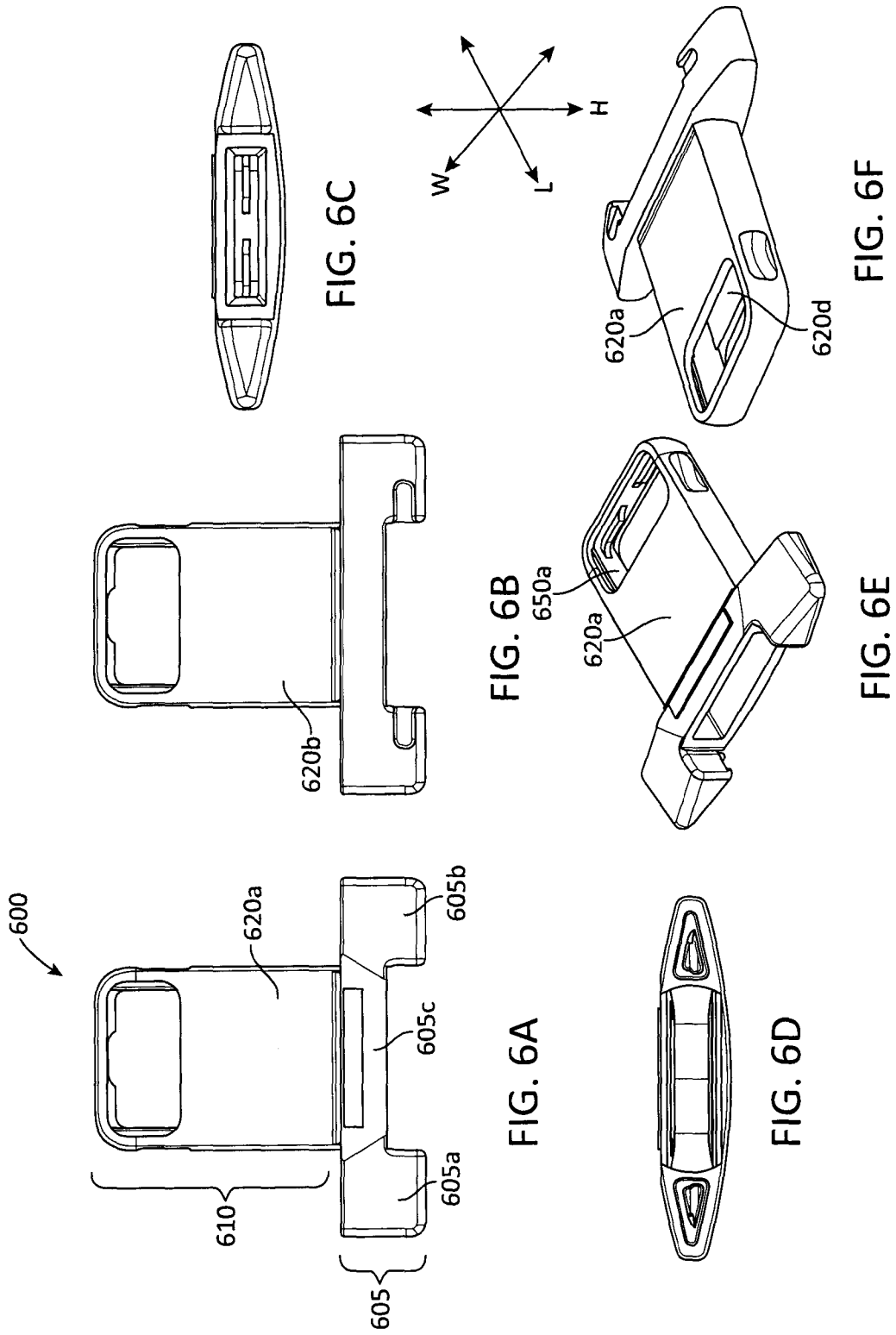
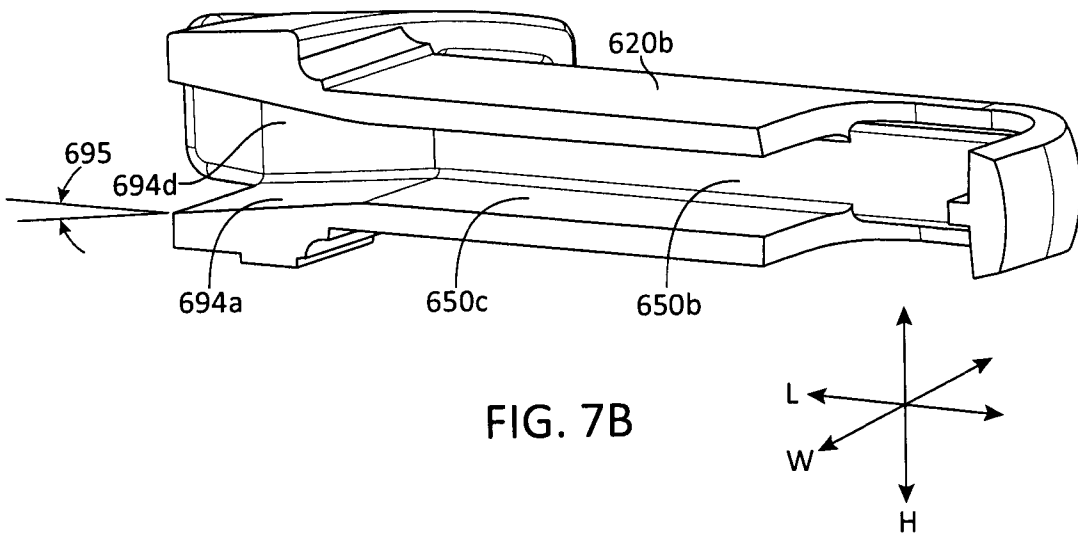
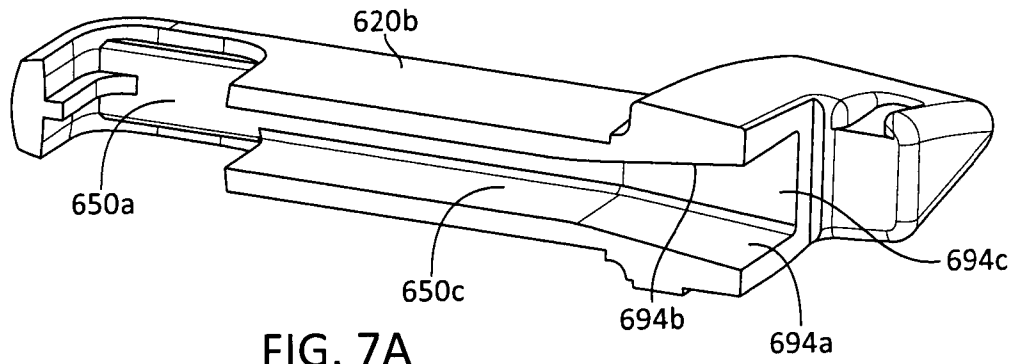


FIG. 5C





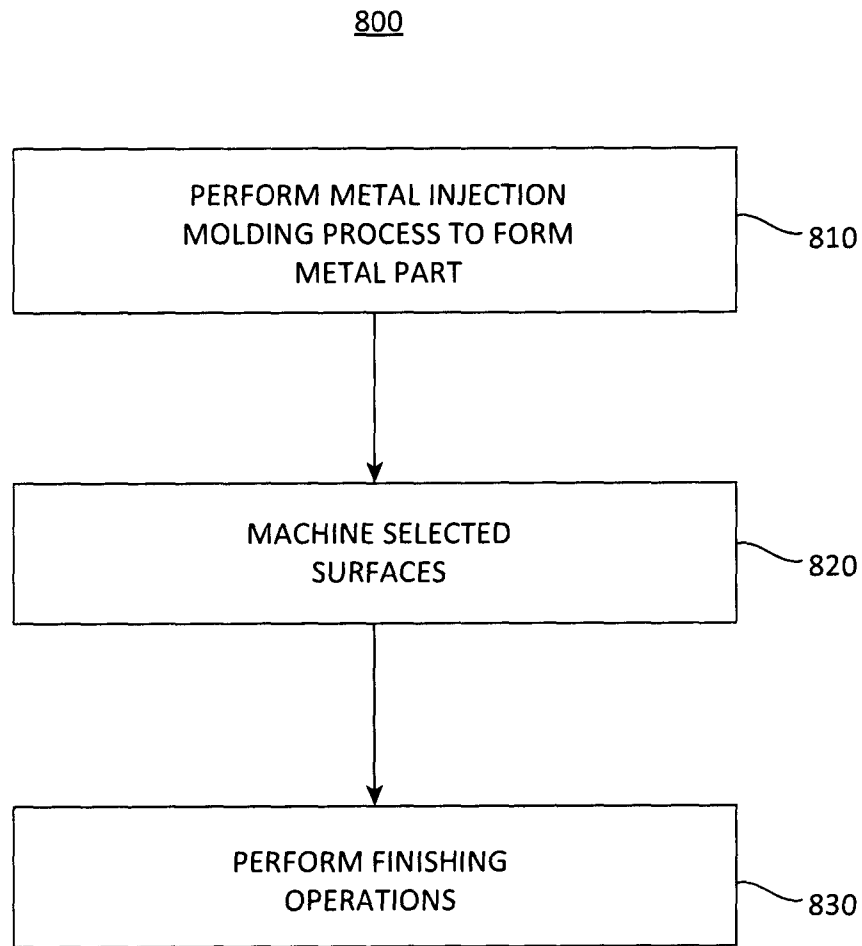


FIG. 8A

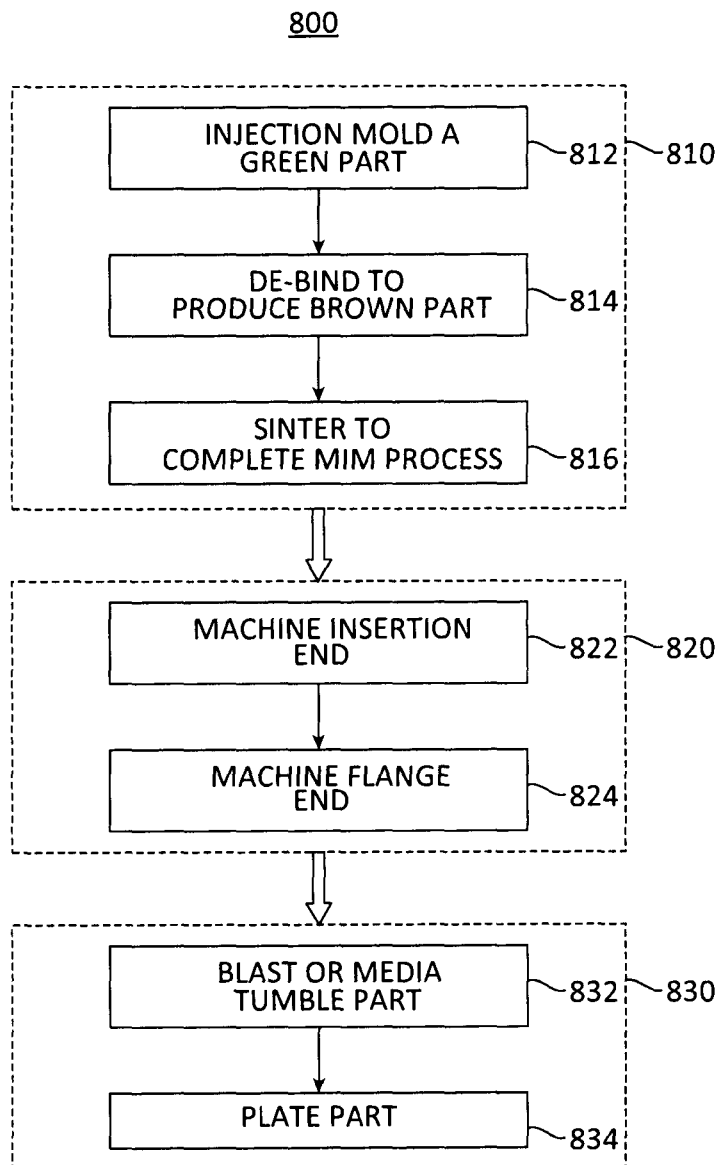


FIG. 8B

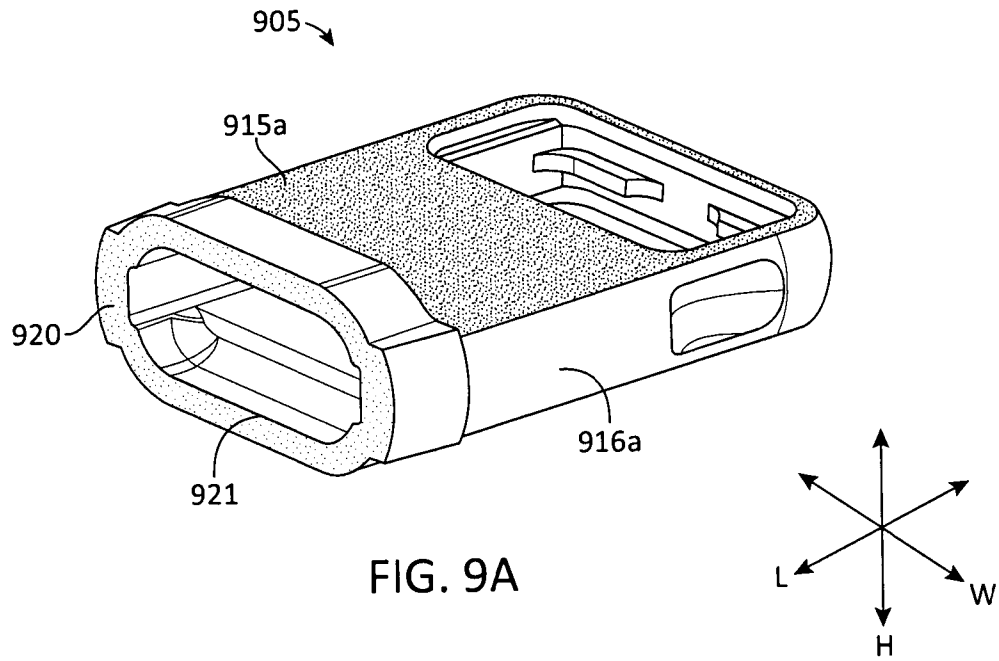


FIG. 9A

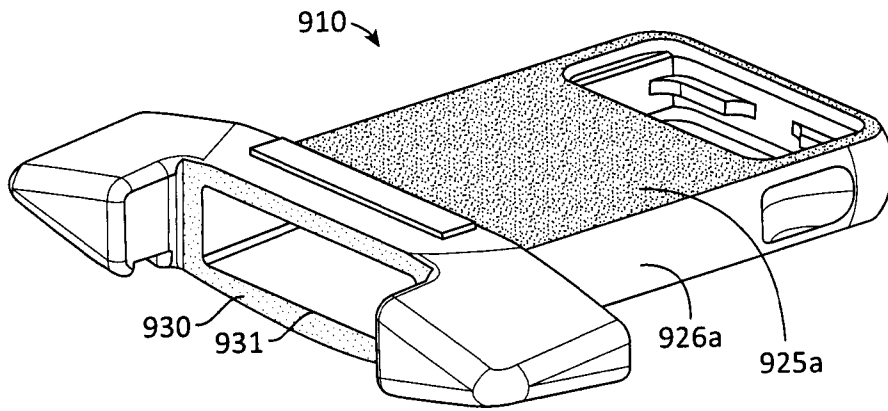


FIG. 9B

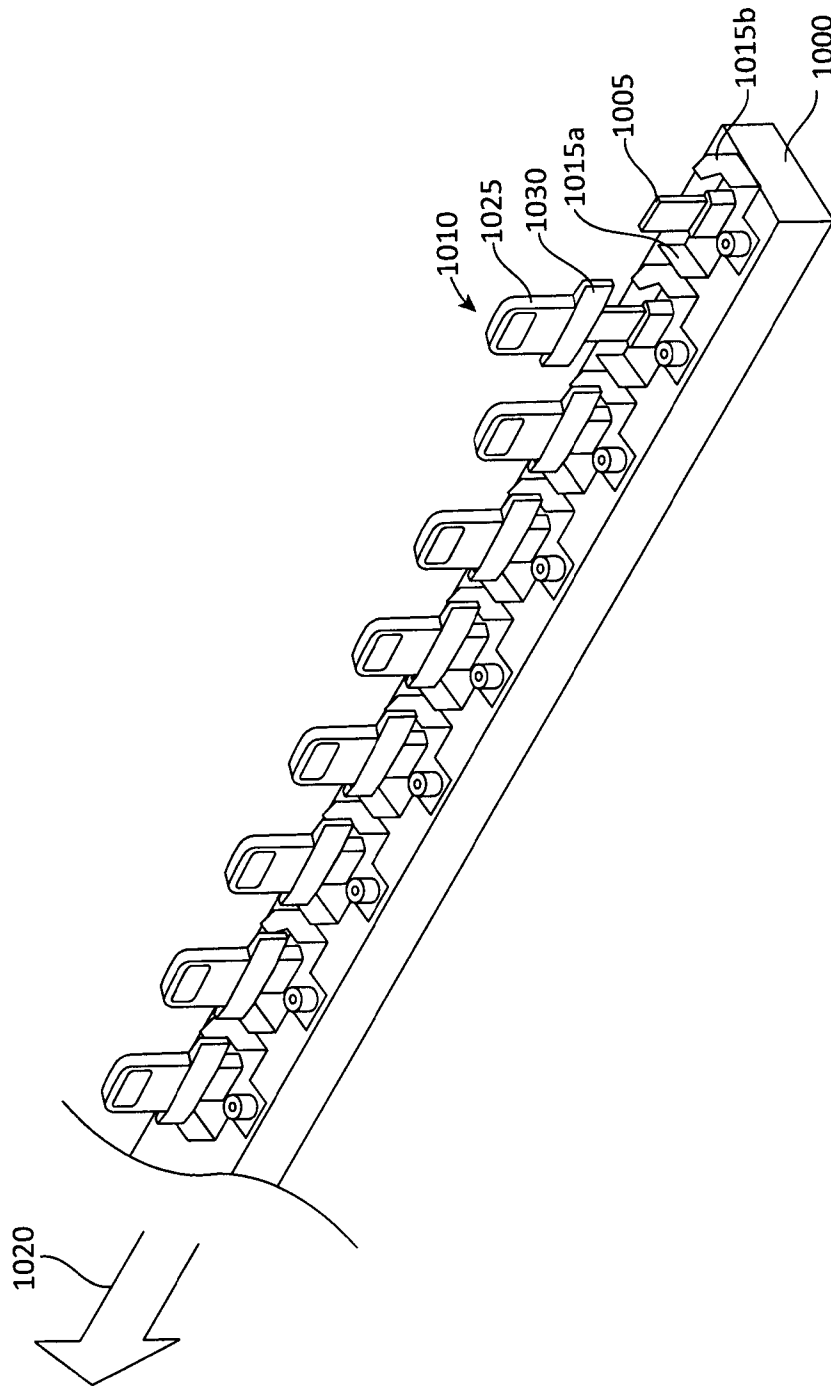


FIG. 10A

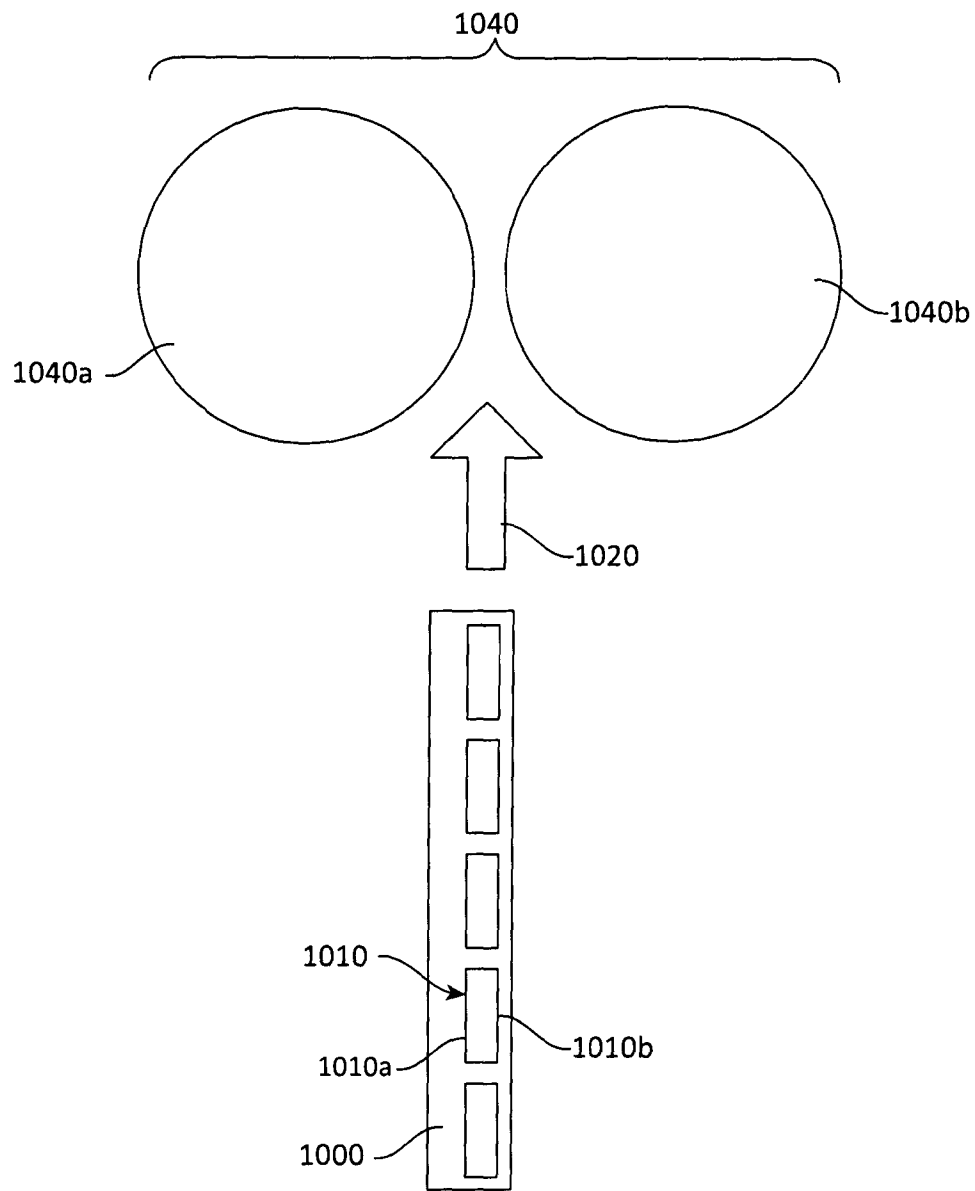


FIG. 10B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/081257

A. CLASSIFICATION OF SUBJECT MATTER

H01R 13/648 (2006.01) 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)

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

IPC:H01R

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

WPI, EPODOC, CNPAT, GOOGLE: connector, plug, socket, receptacle, jack, opening, cavity, porosity, flange, USB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US7364445B1(SUPER TALENT ELECTRONICS, INC.) 29 April 2008(29.04.2008) description, column 7, lines 50-63, figure 10	1-7
A		8-15
A	US7074052B1(SUPER TALENT ELECTRONICS, INC.) 11 July 2006(11.07.2006) the whole document	1-15
A	CN101783466A(BEIJING AIGO DIGITAL STORAGE TECHNOLOGY CO., LTD.) 21 July 2010(21.07.2010) the whole document	1-15

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

* Special categories of cited documents:	“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
“A” document defining the general state of the art which is not considered to be of particular relevance	“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
“E” earlier application or patent but published on or after the international filing date	“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
“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)	“&” document member of the same patent family
“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	

Date of the actual completion of the international search 29 May 2013 (29.05.2013)	Date of mailing of the international search report 20 Jun. 2013 (20.06.2013)
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Name and mailing address of the ISA/CN
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2012/081257

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN201402871Y(BEIJING AIGO DIGITAL STORAGE TECHNOLOGY CO., LTD.) 10 February 2010(10.02.2010) the whole document	1-15
A	CN201533091U(BEIJING AIGO DIGITAL STORAGE TECHNOLOGY CO., LTD.) 21 July 2010(21.07.2010) the whole document	1-15

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
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Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
US7364445B1	29.04.2008	None	
US7074052B1	11.07.2006	None	
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