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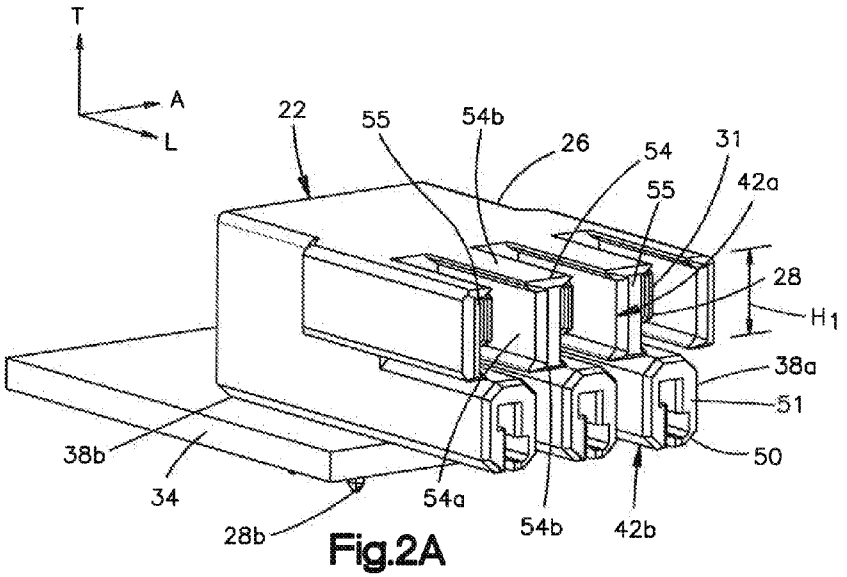

Fig.2A

(57) Abstract: An electrical power connector can include an electrically insulative connector housing, a first plurality of electrical contacts supported by the connector housing, and a second plurality of electrical contacts supported by the connector housing. The first plurality of electrical contacts can be of a first type, and the second plurality of electrical contacts are of a second type and positioned adjacent to the first plurality of electrical contacts. The arrangment of the electrical contact can provide creepage protection for the electrical connector. Further, the electrical contacts can include mating portions that are touch proof.

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ELECTRICAL POWER CONNECTOR

BACKGROUND

[0001] Connectors used to transmit electrical power, such as alternating current (AC) power and/or direct current (DC) power include power contacts mounted within an electrically-insulated housing.

SUMMARY

[0002] In accordance with one embodiment, an electrical power connector includes an electrically insulative connector housing, a first plurality of electrical contacts supported by the connector housing, and a second plurality of electrical contacts supported by the connector housing. The first plurality of electrical contacts is of a first type, and the second plurality of electrical contacts is of a second type and positioned adjacent to the first plurality of electrical contacts. Each of the first plurality of electrical contacts can extend along a respective length to a mating portion, and the housing can extend beyond the mating portions of the first plurality of electrical contacts such that each of the first plurality of electrical contacts is touch proof. Each of the second plurality of electrical contacts can extend along a respective length to a mating portion, and the housing can extend beyond the mating portions of the second plurality of electrical contacts such that each of the second plurality of electrical contacts is touch proof. In an example embodiment, the first plurality of electrical contacts is plug contacts, and the second plurality of electrical contacts is receptacle contacts.

[0003] In accordance with another embodiment, an electrical power connector includes a dielectric connector housing that includes a plurality of beams and a plurality of shrouds that each terminate at a respective distal end. The plurality of beams and the plurality of shrouds can define a mating interface that is configured to mate with a complementary electrical power connector along a mating direction. The electrical power connector can further include a first plurality of electrical contacts that is supported by the connector housing. The first plurality of electrical contacts can be spaced apart from each other along a lateral direction that is substantially perpendicular to the mating direction. The electrical power connector can further

include a second plurality of electrical contacts that is supported by the connector housing. The second plurality of electrical contacts can be spaced apart from each other along the lateral direction. The second plurality of electrical contacts can be spaced from the first plurality of electrical contacts along a transverse direction that is substantially perpendicular to both the mating and lateral directions. The first plurality of electrical contacts terminate at a first distal end that is configured to mate with a complementary electrical contact of the complementary electrical connector, and the second plurality of electrical contacts terminate at a second distal end configured to mate with a complementary electrical contact of the complementary electrical connector. The distal end of the beams extends beyond the first distal end of the first plurality of electrical contacts along the mating direction, and the distal end of the shrouds extends beyond the second distal end of the second plurality of electrical contacts along the mating direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The foregoing summary, as well as the following detailed description of example embodiments, are better understood when read in conjunction with the appended diagrammatic drawings. For the purpose of illustrating the invention, the drawings show illustrative embodiments. The invention is not limited, however, to the specific embodiments disclosed in the drawings.

[0005] Fig. 1 is a perspective view of an electrical power connector assembly including first and second electrical connectors configured to be mounted to respective first and second substrates;

[0006] Fig. 2A is a perspective view of the first electrical connector illustrated in Fig. 1 shown mounted to the first substrate;

[0007] Fig. 2B is a perspective view similar to Fig. 2A, but with the housing of the first electrical connector removed;

[0008] Fig. 3A is a perspective view of the second electrical connector illustrated in Fig. 1 shown mounted to the second substrate;

[0009] Fig. 3B is a perspective view similar to Fig. 3A, but with the housing of the first electrical connector removed;

[0010] Fig. 4 is an enlarged view of a portion of the connector housings of each of the first and second electrical connectors, constructed in accordance with one embodiment;

[0011] Fig. 5 is a perspective view of an electrical power connector assembly constructed in accordance with an alternative embodiment, including first and second electrical connectors configured to be mounted to respective first and second substrates;

[0012] Fig. 6A is a perspective view of the first electrical connector illustrated in Fig. 5, shown with the connector housing removed;

[0013] Fig. 6B is a perspective view of the second electrical connector illustrated in Fig. 5;

[0014] Fig. 7A is a perspective view of the first electrical connector constructed in accordance with an alternative embodiment;

[0015] Fig. 7B is a perspective view of the second electrical connector constructed in accordance with an alternative embodiment;

[0016] Fig. 8A is a perspective view of another first electrical connector constructed in accordance with yet another alternative embodiment;

[0017] Fig. 8B is a perspective view of another second electrical connector constructed in accordance with yet another alternative embodiment;

[0018] Fig. 8C is a perspective view of another electrical power connector assembly constructed in accordance with another alternative embodiment, including the first electrical connector of Fig. 8A mated with the second electrical connector of Fig. 8B;

[0019] Fig. 8D is a perspective view of the electrical connector shown in Fig. 8A, shown with the housing removed;

[0020] Fig. 9 is a bottom plan view of the substrate and the second electrical connector of Fig. 3A, wherein the second electrical connector is mounted to the substrate;

[0021] Fig. 10A is a top plan view of a probe used in conjunction with UL Standard 1977, Section 10.2;

[0022] Fig. 10B is a side elevation view of the probe shown in Fig. 10A; and

[0023] Fig. 10C is a cross section of the probe shown in 10A.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0024] Referring initially to Figs. 1-3B, 7A, and 7B, an electrical connector assembly 20 includes a first electrical connector 22 and a second electrical connector 24 configured to mate with the first electrical connector. The first electrical connector 22 includes a dielectric or electrically insulative connector housing 26 and at least one electrical contact 28 such as a plurality of electrical contacts 28 supported by the connector housing 26. Similarly, the second electrical connector 24 includes a dielectric or electrically insulative connector housing 30 and at

least one electrical contact 32 such as a plurality of electrical contacts 32 supported by the connector housing 30. Each of the first and second electrical connectors 22 and 24 can be configured as an electrical power connector as illustrated, and thus is configured to transfer electrical power between a respective complementary electrical component and the other of the first and second electrical connectors 22 and 24. Thus, the electrical contacts 28 and 32 can include electrical power contacts configured to carry electrical power, and the electrical connector assembly 20 can be referred to as an electrical power connector assembly. It should be appreciated that one or more of the electrical contacts 28 can additionally or alternatively be configured as electrical signal contacts configured to carry data signals, and one or more of the electrical contacts 28 can alternatively or additionally be configured as ground contacts. Similarly, it should be appreciated that one or more of the electrical contacts 32 can additionally or alternatively be configured as electrical signal contacts configured to carry data signals, and one or more of the electrical contacts 32 can alternatively or additionally be configured as ground contacts. The electrical connector assembly 20 can further include a first complementary electrical component, such as a first substrate 34 that can be configured as a printed circuit board that includes a plurality of electrical traces, and a second complementary electrical component, such as a second substrate 36 that can be configured as a printed circuit board that includes a plurality of electrical traces.

[0025] The first and second electrical connectors 22 and 24 are configured to be mated to each other so as to establish an electrical connection between the first and second electrical connectors 22 and 24. For instance, the electrical contacts 28 can define respective mating portions 28a and respective mounting portions 28b opposite the mating portions 28a. Similarly, the electrical contacts 32 can define respective mating portions 32a and respective mounting portions 32b opposite the mating portions 32a. In one embodiment, each of the electrical contacts 32 include only one mounting portion 32b, and each of the electrical contacts 28 include only one mounting portion 28b. The mating portions 28a and 32a are configured to mate with each other as the electrical connectors 22 and 24 are mated to each other so as to place respective ones of the electrical contacts 28 and 32 in electrical communication with each other. Further, the electrical contacts 28 can terminate at respective free distal ends 31 that are configured to mate with a complementary electrical contact of a complementary electrical connector, for instance the electrical contacts 32 of the second electrical connector 24. Similarly, the electrical contacts 32 can terminate at respective free distal ends 35 that are configured to mate with a complementary electrical contact of a complementary electrical connector, for instance the electrical contacts 28 of the first electrical connector 22. Thus, the mating portion 28a can

include the distal end 31, and the mating portion 32a can include the distal end 35. The first electrical connector 22 can be configured to be mounted to the first complementary electrical component so as to place the electrical connector 22 and the first complementary electrical component in electrical communication with each other. The second electrical connector 24 can be configured to be mounted to the second complementary electrical component so as to place the second electrical connector 24 and the second complementary electrical component in electrical communication with each other. For instance, the mounting portions 28b are configured to be placed in electrical communication with respective ones of the electrical traces of the first substrate 34 when the first electrical connector 22 is mounted to the first substrate 34. Thus, the first substrate 34 can be placed in electrical communication with the second electrical connector 24 when the electrical connector 22 is mounted to the first substrate 34 and mated with the second electrical connector 24. Similarly, the mounting portions 32b are configured to be placed in electrical communication with respective ones of the electrical traces of the second substrate 36 when the second electrical connector 24 is mounted to the second substrate 36. Thus, the second substrate 36 can be placed in electrical communication with the first electrical connector 22 when the second electrical connector 24 is mounted to the second substrate 36 and mated with the first electrical connector 22. Accordingly, the substrates 34 and 36 are placed in electrical communication with each other when the first electrical connector 22 is mounted to the first substrate 34, the second electrical connector 24 is mounted to the second substrate 36, and the first and second electrical connectors 22 and 24 are mated with each other.

[0026] The mounting portions 28b can be press-fit tails that are configured to be inserted, or press-fit, into respective vias of the respective first substrate 34, thereby electrically connecting the mounting portions 28b and the corresponding electrical contacts 28 to respective electrical traces of the first substrate 34 when the first electrical connector 22 is mounted to the first substrate 34. The vias can be configured as plated through-holes that electrically connect the mounting portions 28b to respective electrical traces of the underlying first substrate 34. While the mounting portions 28b are configured as press-fit tails, it should be appreciated that the mounting portions can be configured to be placed in electrical communication with electrical traces of the first substrate 34 in accordance with any suitable alternative embodiment. For instance, the mounting portions 28b can be surface mounted and configured to be fused, for instance soldered, to complementary contact pads of the first substrate 34, so as to place the mounting portions 28b in electrical communication with the electrical traces.

[0027] Similarly, the mounting portions 32b can be press-fit tails that are configured to be inserted, or press-fit, into respective vias of the respective second substrate 36, thereby

electrically connecting the mounting portions 32b and the corresponding electrical contacts 32 to respective electrical traces of the second substrate 36 when the second electrical connector 24 is mounted to the second substrate 36. The vias can be configured as plated through-holes that electrically connect the mounting portions 32b to respective electrical traces of the underlying second substrate 36. While the mounting portions 32b are configured as press-fit tails, it should be appreciated that the mounting portions can be configured to be placed in electrical communication with electrical traces of the second substrate 36 in accordance with any suitable alternative embodiment. For instance, the mounting portions 32b can be surface mounted and configured to be fused, for instance soldered, to complementary contact pads of the second substrate 36, so as to place the mounting portions 32b in electrical communication with the electrical traces.

[0028] The connector housing 26 defines a mating interface 38a and a mounting interface 38b. The first electrical connector 22 can be configured as a right-angle connector, such that the mating interface 38a and the mounting interface 38b are oriented perpendicular with respect to each other. For instance, the mating interface 38a can be at least partially defined by a front end of the connector housing 26, and the mounting interface 38b can be at least partially defined by a bottom end of the connector housing 26. Alternatively, the first electrical connector 22 can be configured as a vertical connector, whereby the mating interface 38a is oriented parallel to the mounting interface 38b. For instance, the mating interface 38a can be at least partially defined by the front end of the connector housing 26, and the mounting interface 38b can be at least partially defined by a rear end of the connector housing 26. The electrical contacts 28 can be supported by the connector housing 26 such that the mating portions 28a are disposed proximate to the mating interface 38a, and the mounting portions 28b are disposed proximate to the mounting interface 38b. Thus, when the first electrical connector 22 is configured as a right-angle electrical connector, the mating portions 28a are oriented perpendicular with respect to the mounting portions 28b. Alternatively, if the first electrical connector 22 is configured as a vertical electrical connector, the mating portions 28a are oriented parallel with respect to the mounting portions 28b.

[0029] Similarly, the connector housing 30 defines a mating interface 40a and a mounting interface 40b. The second electrical connector 24 can be configured as a vertical connector, such that the mating interface 38a and the mounting interface are oriented parallel with respect to each other. For instance, the mating interface 38a can be at least partially defined by a front end of the connector housing 30, and the mounting interface 38b can be at least partially defined by a rear end of the connector housing 40. Alternatively, the second electrical

connector 24 can be configured as a right-angle connector, whereby the mating interface 40a is oriented perpendicular with respect to the mounting interface 40b. For instance, the mating interface 40a can be at least partially defined by the front end of the connector housing 40, and the mounting interface 40b can be at least partially defined by a rear end of the connector housing 30. The electrical contacts 32 can be supported by the connector housing 40 such that the mating portions 32a are disposed proximate to the mating interface 40a, and the mounting portions 32b are disposed proximate to the mounting interface 40b. Thus, when the second electrical connector 24 is configured as a vertical electrical connector, the mating portions 32a are oriented parallel with respect to the mounting portions 32b. Alternatively, if the second electrical connector 24 is configured as a right-angle electrical connector, the mating portions 32a are oriented perpendicular with respect to the mounting portions 32b.

[0030] Various structures of the electrical connector assembly 20, including each of the first electrical connector 22 and the second electrical connector 24, are described herein as extending horizontally along a first or longitudinal direction "L" and a second or lateral direction "A" that is substantially perpendicular to the longitudinal direction L, and vertically along a third or transverse direction "T" that is substantially perpendicular to each of the longitudinal direction L and the lateral directions A. Thus, unless otherwise specified herein, the terms "lateral," "longitudinal," and "transverse" are used to describe the orthogonal directional components of various components. Further, the term "in" when used with a specified direction component is intended to refer to the single specified direction, and the term "along" when used with a specified direction component is intended to refer to either or both of opposed directions. It should be appreciated that while the longitudinal and lateral directions are illustrated as extending along a horizontal plane, and that while the transverse direction is illustrated as extending along a vertical plane, the planes that encompass the various directions may differ during use, depending, for instance, on the orientation of the various components. Accordingly, the directional terms "vertical" and "horizontal" are used to describe the electrical connector assembly 20 and its components as illustrated merely for the purposes of clarity and convenience, it being appreciated that these orientations may change during use.

[0031] As illustrated, the first electrical connector 22 is configured to be mated to the second electrical connector 24 along a respective forward mating direction, and unmated from the second electrical connector 24 along a respective rearward direction. Similarly, the second electrical connector 24 is configured to be mated to the first electrical connector 22 along a respective forward mating direction, and unmated from the first electrical connector 22 along a respective rearward direction. Both the forward and rearward directions of each of the first and

second electrical connectors 22 and 24 are defined along the longitudinal direction L. Thus, the mating portions 38a and 40a of the electrical contacts are oriented generally along the longitudinal direction L. The respective mounting portions are oriented generally along the longitudinal direction L when the electrical connector is configured as a vertical connector, and along the transverse direction T when the electrical connector is configured as a right-angle connector. Further, the front and rear ends of the connector housings 26 and 30 of the first and second electrical connectors 22 and 24, respectively, are spaced along the longitudinal direction L. Top and bottom ends of the connector housings 26 and 30 of the first and second electrical connectors 22 and 24, respectively, are spaced along the transverse direction T.

[0032] With continuing reference to Figs. 1-3B, 7A, and 7B, the mating interface 38a can be configured to receive, or be received by, the mating interface 40a. Thus, the mating interface 40a can be configured to receive, or be received by, the mating interface 38a. Alternatively still, a first portion 42a of the mating interface 38a can be configured to receive a corresponding first portion 44a of the mating interface 40a, and a second portion 42b of the mating interface 38a can be configured to be received by a corresponding second portion 44b of the mating interface 40a. Thus, the first portion 44a of the mating interface 40a can be configured to be received by the corresponding first portion 42a of the mating interface 38a, and the second portion 44b of the mating interface 40a can be configured to receive the corresponding second portion 42b of the mating interface 38a. Alternatively still, the first portion 42a of the mating interface 38a can be configured to be received by the corresponding first portion 44a of the mating interface 40a, and the second portion 42b of the mating interface 38a can be configured to receive the corresponding second portion 44b of the mating interface 40a. Thus, the first portion 44a of the mating interface 40a can be configured to receive the corresponding first portion 42a of the mating interface 38a, and the second portion 44b of the mating interface 40a can be configured to be received by the corresponding second portion 42b of the mating interface 38a.

[0033] It will be understood that the first and second electrical connectors 22 and 24 can be shaped as desired. Referring to an alternative embodiment illustrated in Figs. 8A-D, a first electrical connector 22a and a second electrical connector can be mated with each other to define an alternative electrical connector assembly 20a. As shown, the mating interface 38a can be configured to receive, or be received by, the mating interface 40a. Thus, the mating interface 40a can be configured to receive, or be received by, the mating interface 38a. Furthermore, as shown, the first portion 42a of the mating interface 38a is configured to receive the corresponding first portion 44a of the mating interface 40a, and a second portion 42b of the

mating interface 38a can be configured to be received by a corresponding second portion 44b of the mating interface 40a. Thus, the first portion 44a of the mating interface 40a can be configured to be received by the corresponding first portion 42a of the mating interface 38a, and the second portion 44b of the mating interface 40a can be configured to receive the corresponding second portion 42b of the mating interface 38a. For instance, the connector housing 26 can define a housing body 26a, and the second portions 42b can project out from the housing body 26a along the mating direction a first distance. Similarly, the connector housing 30 can define a housing body 30a, and the first portions 44a can project out from the housing body 30a along the mating direction a second distance that is substantially equal to the first distance.

[0034] The first electrical connector 22 can include electrical contacts 28 that are constructed as desired so that the respective mating portions 28a are touch proof. Similarly, the second electrical connector can include electrical contacts 32 that are constructed as desired so that the respective mating portions 32a are touch proof. In accordance with an alternative embodiment, referring to Figs. 8A-D, the first electrical connector 22a includes electrical contacts 28' that include header and receptacle contacts. For instance, the second portions 42b of the first electrical connector 22a can be constructed so as to define a plurality of slots. The mating portions 28a of the electrical contacts 28 that are configured as headers of the first electrical connector 22a can be disposed within the slots. The mating portions 28a of the electrical contacts 28 configured as receptacles can be disposed within the first portions 42a of the first electrical connector 22a. Similarly, the first portions 44a of the second electrical connector 24a can be constructed so as to define a plurality of slots. The mating portions 32a of the electrical contacts 32 configured as headers of the second electrical connector 24a can be disposed within the slots. The mating portions 32a of the electrical contacts 32 configured as receptacles can be disposed within the second portions 44b of the second electrical connector 24a. As shown, the mating portions 28a of the receptacle contacts of the first electrical connector 22a can each include two fingers 52 spaced from each other along the lateral direction A. Similarly, the mating portions 32a of the receptacle contacts 32 of the second electrical connector 24a can each include two fingers 52 spaced apart from each other along the lateral direction A. The mating portions 28a of the plug contacts of the first electrical connector 22a can each define opposed broad surfaces that are configured to be received in between the two fingers 52 of the second electrical connector 24a when the first electrical connector 22a is mated with the second electrical connector 24a so that the each of the broad surfaces contacts a respective finger 52, so as to establish an electrical power connection between the first and

second electrical connectors 22a and 24a. The mating portions 32a of the plug contacts of the second electrical connector 24a can each define opposed broad surfaces that are configured to be received in between the two fingers 52 of the first electrical connector 22a when the first electrical connector 22a is mated with the second electrical connector 24a so that the each of the broad surfaces contacts a respective finger 52, so as to establish an electrical power connection between the first and second electrical connectors 22a and 24a.

[0035] Thus, it will be understood that the connector housing 30 can include a housing body 30a and a plurality of first portions 44a that extend from the housing body 30a along the mating direction. The electrical contacts 32 can each terminate at a mating portion 32a configured to mate with complementary electrical contacts of a complementary electrical connector. The mating portions 32a can be arranged in a plurality of columns that extend along a column direction, and the columns can be spaced from each other along a row direction that is substantially perpendicular to the column direction. The electrical contacts 32 include plug contacts and receptacle contacts, and the first portions 44a can extend farther from the housing body 30a relative to the mating portions 32a of the electrical contacts 32 along the mating direction such that each of the electrical contacts 32 is touch proof. In accordance with the illustrated embodiment, each column includes only one of plug contacts or receptacle contacts. Further, adjacent columns along the row direction can define an alternating pattern of plug and receptacle contacts such that no plug contacts are immediately adjacent to receptacle contacts along the row direction. The first portions 44a can be substantially diamond shaped. The first portions 44a can be sized to be received by complementary portions of a complementary connector housing of the complementary electrical power connector when the electrical power connector is mated with the complementary electrical power connector. The first portions 44a can define a plurality of slots, and the mating portions 32a of the plug contacts can be disposed within respective slots. As shown, the slots can be elongate along the column direction. The first portions 44a can define the second portions 44b. The second portions 44b can be sized to receive complementary portions of a complementary connector housing of the complementary electrical connector when the electrical power connector is mated with the complementary electrical power connector. Thus, still referring to Fig. 8, in accordance with the illustrated embodiment, the first portions 44a can be substantially diamond shaped and can be arranged so as to define the second portions 44b that are substantially diamond shaped. Referring also to Fig. 8D, the receptacle contacts can define fingers 52 that are spaced apart from each other along the row direction such that the fingers are configured to receive therebetween a complementary plug contact of the complementary electrical power connector when the electrical power connector is

mated with the complementary power connector. As shown, each of the receptacle contacts can be disposed immediately adjacent two first portions 44a along the row direction and two second portions 44b along the column direction.

[0036] The mating portions 28a of at least a portion up to all of the plurality of electrical contacts 28 of the first electrical connector 22 can be arranged in at least one row 46, such as at least a first row 46a and at least a second row 46b that is spaced from the first row 46a along the transverse direction T. Each mating portion 28a in the first row 46a can be aligned with a respective mating portion 28a in the second row 46b along the transverse direction T. Each of the first and second rows 46a and 46b can extend along the lateral direction A. Adjacent mating portions 28a in the rows 46 can be spaced apart any pitch as desired, for instance between 1 to 5 mm. In accordance with one embodiment, referring to Fig. 7A, adjacent mating portions 28a in the same row are spaced apart from each other approximately 2 mm along the lateral direction A. In accordance with another embodiment, referring to Fig. 2B, the mating portions 28a in the same row can be spaced apart from each other approximately 4 mm along the lateral direction A. The first row 46a can be disposed above the second row 46b, and can thus be referred to as an upper row, and the second row 46b can be disposed below the first row 46a and can thus be referred to as a lower row. Thus, it can be said that electrical contacts in the first row 46a are on top of electrical contacts in the second row 46b. For instance, when the first electrical connector 22 is configured as a right-angle electrical connector 22, the first row 46a can be spaced from the mounting interface 38b a distance along the transverse direction T that is greater than the distance along the transverse direction T that the second row 46b is spaced from the mounting interface 38b. The first portion 42a of the mating interface 38a can be disposed at the first row 46a, and the second portion 42b of the mating interface 38a can be disposed at the second row 46b.

[0037] Similarly, the mating portions 32a of at least a portion up to all of the plurality of electrical contacts 32 of the second electrical connector 24 can be arranged in at least one row 48, such as at least a first row 48a and at least a second row 48b that is spaced from the first row 48a along the transverse direction T. Each mating portion 32a in the first row 48a can be aligned with a respective mating portion 32a in the second row 48b along the transverse direction T. Each of the first and second rows 48a and 48b can extend along the lateral direction A. Adjacent mating portions 32a in the rows 48 can be spaced apart any pitch as desired, for instance between 1 to 5 mm. In accordance with one embodiment, referring to Fig. 7B, adjacent mating portions 32a in the same row are spaced apart from each other approximately 2 mm along the lateral direction A. In accordance with another embodiment, referring to Fig. 3A, the mating portions

32a in the same row can be spaced apart from each other approximately 4 mm along the lateral direction A. The first row 48a can be disposed above the second row 48b, and can thus be referred to as an upper row, and the second row 48b can be disposed below the first row 48a and can thus be referred to as a lower row. Thus, it can be said that electrical contacts in the first row 48a are on top of electrical contacts in the second row 48b. For instance, when the second electrical connector 24 is configured as a right-angle electrical connector, the first row 48a can be spaced from the mounting interface 40b a distance along the transverse direction T that is greater than the distance along the transverse direction T that the second row 48b is spaced from the mounting interface 40b. The first portion 44a of the mating interface 40a can be disposed at the first row 48a, and the second portion 44b of the mating interface 40a can be disposed at the second row 48b.

[0038] The mating portions 28a at the first row 46a of the first electrical connector 22 can be configured as plugs that are configured to be received by complementary receptacle mating portions 32a of the first row 48a of the second electrical connector 24, and the mating portions 28a of the second row 46b of the first electrical connector 22 can be configured as receptacles that are configured to receive complementary plug mating portions 32a of the second row 48b of the second electrical connector. Thus, the mating portions 28a of the plug contacts can be on top of the mating portions 28a of the receptable contacts. The mating portions 32a at the first row 48a of the second electrical connector 24 can be configured as receptacles that are configured to receive complementary plug mating portions 28a of the first row 46a of the first electrical connector 22, and the mating portions 32a of the second row 48b of the second electrical connector 24 can be configured as plugs that are configured to be received by complementary receptacle mating portions 28a of the second row 46b of the first electrical connector. Thus, the mating portions 32a of the receptacle contacts can be on top of the mating portions 32a of the plug contacts. Alternatively, the mating portions 28a at the first row 46a of the first electrical connector 22 can be configured as receptacles that are configured to receive by complementary plug mating portions 32a of the first row 48a of the second electrical connector 24, and the mating portions 28a of the second row 46b of the first electrical connector 22 can be configured as plugs that are configured to be received by complementary receptacle mating portions 32a of the second row 48b of the second electrical connector 24. Thus, the mating portions 32a at the first row 48a of the second electrical connector 24 can be configured as plugs that are configured to be received by complementary receptacle mating portions 28a of the first row 46a of the first electrical connector 22, and the mating portions 32a of the second row 48b of the second electrical connector can be configured as receptacles that are configured to receive by

complementary receptacle mating portions 28a of the second row 46b of the first electrical connector. Thus, the mating portions 28a of the receptacle contacts can be on top of the mating portions 28a of the plug contacts, and the mating portions 32a of the plug contacts can be on top of the mating portions 21a of the receptacle contacts.

[0039] Alternatively still, referring to Fig. 7A-B and 8A-D, at least one of mating portions 28a at the first row 46a of the first electrical connector 22 can be configured as a plug that is configured to be received by a complementary receptacle mating portions 32a of the first row 48a of the second electrical connector 24, and at least one of the mating portions 28a at the first row 46a of the first electrical connector 22 can be configured as a receptacle that is configured to receive a complementary plug mating portion 32a at the first row 48a of the second electrical connector 24. At least one of the mating portions 28a at the second row 46b of the first electrical connector 22 can be configured as a plug that is configured to be received by a complementary receptacle mating portions 32a of the second row 48b of the second electrical connector 24, and at least one of the mating portions 28a at the second row 46b of the first electrical connector 22 can be configured as a receptacle that is configured to receive a complementary plug mating portion 32a at the second row 48b of the second electrical connector 24. For instance, as shown in Fig. 7A, the first electrical connector 22 can include mating portions 28a that alternately are configured as plugs and receptacles along each of the rows 46. Thus, every other mating portion 28a can be configured as a plug along the first row 46a, and every other mating portion 28a can be configured as a receptacle along the second row 46b. Stated another way, the first row 46a can define a repeating pattern of plug-receptacle contacts, and the second row 46b can include a repeating pattern of receptacle-plug contacts. Similarly, the second electrical connector 24 can include mating portions 32a that alternately are configured as plugs and receptacles along each of the rows 48. Thus, every other mating portion 32a can be configured as a receptacle along the first row 48a, and every other mating portion 32a can be configured as a plug along the second row 46b. Stated another way, the first row 48a can define a repeating pattern of plug-receptacle contacts, and the second row 48b can include a repeating pattern of receptacle-plug contacts.

[0040] Further, the first plurality of electrical contacts 29a and the second plurality of electrical contacts 29b can be arranged in the first row 46a along the lateral direction A such that every other electrical contact 28 in the first row 46a is configured as a plug contact that is aligned with a receptacle contact, in particlar the mating portion 28a of the receptacle contact, along the transverse direction T that is substantially perpendicular to the lateral direction A and the mating direction of the electrical power connector 22 (e.g., see Fig. 7A). Similarly, the first plurality of

electrical contacts 33a and the second plurality of electrical contacts 33b can be arranged in the first row 48a along the lateral direction A such that every other electrical contact 32 in the first row 48a is configured as a plug contact that is aligned with a receptacle contact, in particular the mating portion 32a of the receptacle contact, along the longitudinal direction L that is substantially perpendicular to the lateral direction A and the transverse direction T (e.g., see Fig. 7B).

[0041] As used herein, electrical contacts having plug mating portions are often referred to as plug contacts, and electrical contacts having receptacle mating portions are often referred to as receptacle contacts. Thus, it should be appreciated that the electrical contacts 28 can include a first plurality of electrical contacts 29a supported by the connector housing 26, for instance such that their respective mating portions 28a are aligned along the first row 46a, the first plurality of electrical contacts 29a being of a first type. The first plurality of electrical contacts 29a can be spaced apart from each other along the lateral direction A that is substantially perpendicular to the mating direction. The electrical contacts 28 can include a second plurality of electrical contacts 29b supported by the connector housing 26, for instance such that their respective mating portions 28a are aligned along the second row 46b, the second plurality of electrical contacts 29b being of a second type. The second plurality of electrical contacts 29b can be spaced from each other along the lateral direction A. The second plurality of electrical contacts 29b can be spaced from the first plurality of electrical contacts 29a along the transverse direction T that is substantially perpendicular to both the mating and lateral directions. For example, the first type can be one of a plug and a receptacle, and the second type can be the other of a plug and a receptacle. Alternatively still, the first type can include both plugs and receptacles, such that a first group of the first plurality of electrical contacts 29a are plug contacts and a second group of the first plurality of electrical contacts 29a are receptacle contacts (e.g., see Figs. 7A and 7B). In accordance with the embodiment illustrated in Figs. 1-3B, the first plurality of electrical contacts 29a are configured as plug contacts, and the second plurality of electrical contacts 29b are configured as receptacle contacts.

[0042] Similarly, the electrical contacts 32 can include a first plurality of electrical contacts 33a supported by the connector housing 30, for instance such that their respective mating portions 32a are aligned along the first row 48a, the first plurality of electrical contacts 33a being of a first type. The electrical contacts 32 can include a second plurality of electrical contacts 33b supported by the connector housing 30, for instance such that their respective mating portions 32a are aligned along the second row 48b, the second plurality of electrical contacts 33b being of a second type. For example, the first type can be one of a plug and a

receptacle, and the second type can be the other of a plug and a receptacle. Alternatively still, the first type can include both plugs and receptacles, such that a first group of the first plurality of electrical contacts 29a are plug contacts and a second group of the first plurality of electrical contacts 29a are receptacle contacts. In accordance with the embodiment illustrated in Figs. 1-3B, the first plurality of electrical contacts 33a are configured as receptacle contacts, and the second plurality of electrical contacts 33b are configured as plug contacts.

[0043] With continuing reference to Figs. 1-3B, each of the first plurality of electrical contacts 29a of the first electrical connector 22 extends along a respective length to the mating portion 28a, and the connector housing 26 can extend beyond the mating portions 28a along the longitudinal direction L, such that each of the first plurality of electrical contacts 29a is touch proof with respect to the longitudinal direction L. Similarly, each of the second plurality of electrical contacts 29b extends along a respective length to the mating portion 28a, and the connector housing 26 extends beyond the mating portions 28a of the second plurality of electrical contacts 29b along the longitudinal direction L such that each of the second plurality of electrical contacts 29b is touch proof. With continuing reference to Figs. 1-3B, each of the first plurality of electrical contacts 33a of the second electrical connector 24 extends along a respective length to the mating portion 32a, and the connector housing 30 can extend beyond the mating portions 32a along the longitudinal direction L, such that each of the first plurality of electrical contacts 33a is touch proof. Similarly still, each of the second plurality of electrical contacts 33b of the second electrical connector 24 extends along a respective length to the mating portion 32a, and the connector housing 30 extends beyond the mating portions 32a of the second plurality of electrical contacts 33b along the longitudinal direction L such that each of the second plurality of electrical contacts 33b is touch proof.

[0044] As illustrated in Figs. 10A-C, reference to one or more of the electrical contacts 28 and 32 as touch proof can be as described in UL Standard 1977, Section 10.2, which is hereby incorporated by reference and requires that the mating devices intended for usage external to the end equipment shall not have exposed live contacts during engagement or withdrawal as determined by the use of a probe 102 shown in Figs. 10A-C. Descriptions of the probe 102 and how the probe 102 can be used to verify that the electrical contacts 28 and 32 are touch proof are included below. The electrical contacts 28 and 32, and in particular the mating portions 28a and 32a, can also be considered touch proof because the mating portions 28a and 32a are blocked from human contact or humans are otherwise prevented from touching the mating portions 28a and 32a with their fingers.

[0045] Referring in particular to Figs. 10A-C, the probe 102 can also be referred to as a test finger because the probe 102 simulates human finger movement. The probe 102 includes a finger portion 101, a rear portion 105, and a palm portion 103 disposed between the finger portion 101 and the rear portion 105. The finger portion 101, the rear portion 105, and the palm portion 103 can be made of any electrically conductive material as desired, for instance stainless steel. The rear portion 105 can include or be connected to a handle portion, which can be made of nylon. As shown, the finger portion 101 is in a fully extended position such the illustrated finger portion 101 defines a maximum length along the longitudinal direction L. The finger portion 101, and thus the probe 102, defines a distal or front end 106. The finger portion 101 further defines a rear end 112 opposite the distal end 106. When the finger portion 101 is in the fully extended position, as shown, the rear end 112 of the finger portion is spaced from the distal end 106 of the finger portion in a rearwardly longitudinal direction. The palm portion 103 includes a front end 114 and a rear end 116 spaced from the front end 114 along the longitudinal direction L. The rear end 112 of the finger portion 101 is disposed adjacent to the front end 114 of the palm portion 103. The rear portion 105 defines a front end 118 and a rear end 120 spaced from the front end 118 along the longitudinal direction L. The front end 118 of the rear portion 105 is disposed adjacent to the rear end 116 of the palm portion 103, and the rear end 120 of the rear portion 105 can be disposed adjacent to the handle.

[0046] As shown, referring in particular to Fig. 10A, the finger portion 101 defines a curved surface along the lateral direction A at the distal end 106. The curved surface defines a radius 104 that is equal to 3.5 millimeters (mm). As shown, referring in particular to Fig. 10B, the finger portion 101 further includes a first or top surface 202 and a second or bottom surface 204 that meets the top surface 202 at the distal end 106. The top and bottom surfaces 202 and 204 extend away from each other rearwardly along the longitudinal direction L to a first location 122. The top and bottom surfaces 202 and 204 are spaced from each along the transverse direction T a distance 123 at the first location 122, which is a location defined along the longitudinal direction L. The distance 123 is 5.8 mm. The first location 122 is a distance 124 from the distal end 106 along the longitudinal direction L. As shown, the distance 124 is 5 mm. Further, the top and bottom surfaces 202 and 204 define an angle 108 with respect to each other at the distal end 106. The angle 108 is approximately 60 degrees.

[0047] Still referring to Figs. 10A-C, the probe 102 defines joints 111, which enable the probe 102 to simulate a human finger. The joints 111 each include a gap that defines a gap distance 110 along the longitudinal direction L when the test finger is in the fully extended position, as shown. The gap distance 110 is 0.05 mm. Center points 113 are centered between

pairs of the joints 111 along the longitudinal direction L. A first center point 113a is a distance 136 from the distal end 106 along the longitudinal direction L when the probe 102 is in the fully extended position. The distance 136 is 30 mm. A second center point 113b is a distance 138 from the distal end 106 along the longitudinal direction L when the probe 102 is in the fully extended position. The distance 138 is 60 mm. A third center point 113c is a distance 140 from the distal end 106 along the longitudinal direction L when the probe 102 is in the fully extended position. The distance 140 is 100 mm.

[0048] As shown, the front end 114 of the palm portion 103 defines a width 130 along the lateral direction A. The width 130 is 50 mm. The front end 114 is spaced from the distal end 106 a distance 132 along the longitudinal direction L when the finger portion 101 is in the fully extended position. The distance 132 is 100 mm. The rear end 116 of the palm portion 103 defines a width 134 along the lateral direction A. The width 134 is 78 mm. The rear end 116 of the palm portion 103 is spaced from the distal end 106 a distance 142 along the longitudinal direction L when the finger portion 101 is in the fully extended position. The distance 142 is 154 mm.

[0049] In accordance with one embodiment, the connector housing 26 of the first electrical connector 22 defines a plurality of shrouds 50 that at least partially, for instance fully, surround respective ones of the second plurality of electrical contacts 29b, which can be configured as receptacle contacts whose mating portions 28a include one or more fingers 52 that are configured to receive therebetween a plug contact, for instance of the second electrical connector 24. The shrouds 50 can be elongate along the mating direction. Thus, each of the shrouds 50 can fully surround the receptacle mating portions 28a along a plane that is defined by the lateral direction A and the transverse direction T. The shrouds 50 can extend beyond the mating portions 28a of the second plurality of electrical contacts 29b along the longitudinal direction L, such that each of the second plurality of electrical contacts 29b is touch proof. For instance, the plurality of shrouds 50 of the connector housing 26 can terminate at a distal end 51 along the mating direction. The second plurality of electrical contacts 29b can be disposed in the second row 46b as illustrated in Figs. 1-3B and Fig. 6A, or can be disposed in the first row 46a as illustrated in Fig. 6B. At least a portion of each of the shrouds 50 can be aligned with respective ones of the first plurality of electrical contacts 29a along a select direction so as to render the respective ones of the first plurality of electrical contacts 29a touch proof with respect to the select direction. In accordance with one embodiment, the select direction can be upward along the transverse direction T as illustrated in Figs. 1-3B, though it should be appreciated that the select direction can be downward along the transverse direction as illustrated in Fig. 6B.

[0050] Similarly, the connector housing 30 of the second electrical connector 24 defines a plurality of shrouds 50 that at least partially, for instance fully, surround respective ones of the first plurality of electrical contacts 33a, which can be configured as receptacle contacts whose mating portions 32a include one or more fingers 52 that are configured to receive therebetween a plug contact, for instance of the first electrical connector 22. Thus, each of the shrouds 50 of the second electrical connector 24 can fully surround the receptacle mating portions 32a along a plane that is defined by the lateral direction A and the transverse direction T. The shrouds 50 can extend beyond the mating portions 32a of the first plurality of electrical contacts 33a along the longitudinal direction L, such that each of the first plurality of electrical contacts 33a is touch proof. For instance, the plurality of shrouds 50 of the connector housing 30 can terminate at a distal end 51 along the mating direction. The first plurality of electrical contacts 33a can be disposed in the first row 48a as illustrated in Figs. 1-3B, or can be disposed in the second row 48b as desired. At least a portion of each of the shrouds 50 can be aligned with respective ones of the second plurality of electrical contacts 33b along a select direction so as to render the respective ones of the second plurality of electrical contacts 33b touch proof with respect to the select direction. In accordance with one embodiment, the select direction can be downward along the transverse direction T as illustrated in Figs. 1-3B, though it should be appreciated that the select direction can be upward along the transverse direction T as desired.

[0051] With continuing reference to Figs. 1-3B, the connector housing 26 defines a plurality of beams 54 that are disposed between adjacent ones of the first plurality of electrical contacts 29a, and aligned with the first plurality of electrical contacts 29a, for instance in the lateral direction A along the first row 46a. Thus, the beams 54 can be spaced from each other along the lateral direction A. The beams 54 can be sized and shaped as desired, and can have a first height H_1 along the transverse direction T that is equal to or greater than a second height H_2 of the electrical contacts 28 along the transverse direction T that are adjacent the beams 54 along the lateral direction A. For instance, each beam 54 can have a body 54a and opposed terminal upper and lower ends 54b that project out with respect to the body 54a along the lateral direction A. Thus, the distance between adjacent terminal ends 54b along the lateral direction A of adjacent beams 54 is less than the distance between the bodies 54a of the adjacent beams along the lateral direction A. Because at least a portion of the terminal ends 54b is disposed out along the transverse direction with respect to the adjacent first plurality of electrical contacts 29a, the terminal ends 54b, and thus the beams 54 render the first plurality of electrical contacts 29a touch proof with respect to the transverse direction T, including in the downward direction. For instance, the plurality of beams 54 of the connector housing 26 can terminate at a distal end 55

along the mating direction. Thus, the plurality of beams 54 and the plurality of shrouds 50 can each terminate at a respective distal end. Each of the first plurality of electrical contacts 29a can terminate at a first distal end 31. Each of the first plurality of electrical contacts 29a can be disposed between a pair of adjacent beams 54. In accordance with an example embodiment, the distal end 55 of the beams 54 extends beyond the first distal end 31 of the first plurality of electrical contacts 29a along the mating direction, and the distal end 51 of the shrouds 50 extends beyond the distal end 31, which can also be referred to as the second distal end 31, of the second plurality of electrical contacts 29b along the mating direction.

[0052] Furthermore, the connector housing 30 defines a plurality of beams 54 that are disposed between adjacent ones of the second plurality of electrical contacts 33b, and aligned with the second plurality of electrical contacts 33b, for instance in the lateral direction A along the second row 48b. The beams 54 can be sized and shaped as desired, and can have a height along the transverse direction T that is equal to or greater than the height of the electrical contacts 32 along the transverse direction T that are adjacent the beams 54 along the lateral direction A. Because at least a portion of the terminal ends 54b is disposed out along the transverse direction with respect to the adjacent second plurality of electrical contacts 33b, the terminal ends 54b, and thus the beams 54 render the second plurality of electrical contacts 33b touch proof with respect to the transverse direction T, including in the downward direction. Each of the second plurality of electrical contacts 33b can be disposed between a pair of adjacent beams 54. In accordance with an example embodiment, the distal end 55 of the beams 54 extends beyond the second distal end 35 of the second plurality of electrical contacts 33b along the mating direction, and the distal end 51 of the shrouds 50 extends beyond the distal end 35 of the first plurality of electrical contacts 33a along the mating direction.

[0053] Accordingly, when the first and second electrical connectors 22 and 24 are mated with each other, the shrouds 50 of the each of the first and second electrical connectors 22 and 24 are received between adjacent ones of the beams 54 of the other of the first and second electrical connectors 22 and 24. Accordingly, the first portions of the mating interfaces of the first and second electrical connectors 22 and 24 can be disposed between adjacent beams 54. The second portions of the mating interfaces of the first and second electrical connectors 22 and 24 can be defined by the shrouds 50. The shrouds 50 of the first electrical connectors 22 surround the plug contacts 32 of the second electrical connector 24 when the first and second electrical connectors 22 and 24 are mated to each other. Similarly, when the first and second electrical connectors 22 and 24 are mated with each other, the shrouds 50 of the second electrical connectors 24 surround the plug contacts 28 of the first electrical connector 22. Thus, each of

the shrouds 50 surrounds the portions of respective ones of the mated plug and receptacle contacts. It should be appreciated that, in accordance with an alternative embodiment, that the shrouds 50 and the beams 54 can cooperate to surround the mating portions of respective ones of the mated receptacle contacts and plug contacts when the first electrical connectors are mated to each other. It should be appreciated that each of the connector housings 26 and 30 provides protection from creepage between adjacent ones of the respective first plurality of electrical contacts along the lateral direction A along the corresponding row, between adjacent ones of the respective second plurality electrical contacts along the lateral direction A along the corresponding row, and between adjacent ones of each of the first and second pluralities of electrical contacts along the transverse direction T between the corresponding rows.

[0054] Referring now to Figs. 7A and 7B, in accordance with an alternative embodiment, the mating portions 28a and 32a that are configured as plugs can be immediately adjacent to at least one shroud 54 along the lateral direction A such that none of the mating portions configured as plugs are immediately adjacent more than one beam 54. For instance, each of the mating portions 28a can be immediately adjacent only one beam 54, and each of the mating portions 32a can be immediately adjacent only one beam 54. The mating portions 28a and 32a that are configured as plugs can be disposed between two shrouds 54 along the lateral direction A. Furthermore, the mating portion 32a that is disposed between two shrouds 54 along the lateral direction A can also be immediately adjacent one of the beams, for instance a beam 54' along the longitudinal direction L such that beam 54' defines a width along the lateral direction A that is substantially equal to a width along the lateral direction A of a recess 59 defined by the connector housing 26. Thus, the recess 59 can be sized to receive the beam 54' when the first electrical connector 24 is mated with the second electrical connector 24.

[0055] Referring now to Fig. 4, each of the connector housings 26 and 30 can include at least one first alignment member carried by one or more up to all of the beams 54, and at least one second alignment member carried by one or more up to all of the shrouds 50. The first and second alignment members of the first and second connectors 22 and 24, respectively, are configured to engage each other so as to assist in maintaining alignment of the connector housings 26 and 30 when the first and second electrical connectors are mated. For instance, the first alignment members can be configured as ribs 56 that project from each of the beams 54 toward the respective adjacent electrical contacts. The ribs 56 can be elongate along the mating direction, which can be the longitudinal direction L, and open at the mating interface. The second alignment members can be configured as recesses 58 in respective outer surfaces of the shrouds 50, the recesses 58 sized to receive respective ones of the ribs of the other of the first and

second electrical connectors 22 and 24 when the first and second electrical connectors 22 and 24 are mated to each other. The recesses 58 can thus also be elongate along the longitudinal direction L. Of course, it should be appreciated that the first engagement members can define the recesses 58 that extend into an outer surface of the beams 54, and the second engagement members can define the ribs 54 that project out from the beams toward the respective adjacent electrical contacts. Referring in particular to Fig. 4, the beams 54 and the ribs 56 can extend beyond the distal end 35 of the second plurality of electrical contacts 33b such that each of the second plurality of electrical contacts 33b is touch proof. Similarly, the beams 54 and the ribs 56 can extend beyond the distal end 31 of the second plurality of electrical contacts 29b such that each of the second plurality of electrical contacts 29b is touch proof.

[0056] Referring now to Fig. 9, the mounting portions 32b of the electrical contacts 32 define a footprint 60 taken from a bottom plan view of the substrate 36 and the electrical connector 24 that is mounted to the substrate 36. The electrical connector 26 is illustrated as including three electrical contacts 32 that each include one mating portion 32b, though any number of contacts 32 and mating portions 32b can be included in the electrical connector as desired. While the footprint 60 is illustrated with respect to the electrical contacts 32, it will be understood that the footprint 60 can likewise be defined by the mounting portions 28b of the electrical contacts 28. As shown, the footprint 60 includes a plurality of columns. The mounting portions 32b are arranged in the plurality of columns. For instance, in accordance with the illustrated embodiment, the mounting portions 32b of two electrical contacts 32, for instance a first and a second mounting portion 32b, are arranged in a first column C_1. The mounting portions 32b of two electrical contacts 32, for instance a third and fourth mounting portion 32b' and 32b", respectively, can be arranged in a second column C_2. The mounting portions 32b of two electrical contacts 32, for instance a fourth and fifth mounting portion 32b, can be arranged in a third column C_3. The first, second, and third columns are spaced from each other along the lateral direction A. The second column C_2 is disposed between the first column C_1 and the third column C_3. Thus, the second column C_2 is adjacent to the first column C_1 and the third column C_3. The first, second, and third columns can each extend along a direction that is substantially parallel to each other. As shown, each of the first, second, and third columns extend and are elongate along the longitudinal direction L, and the plurality of columns are disposed laterally adjacent to each other.

[0057] The spacing between centerlines of adjacent columns C_1 and C_2 and adjacent columns C_2 and C_3 may be referred to as the column pitch CP. For instance, adjacent columns C_1 and C_2 can define a first column pitch CP1, and adjacent columns C_2 and C_3 can define a

second column pitch CP2. As illustrated, the first column pitch CP1 between columns C_1 and C_2 can be substantially equal to the second column pitch CP2 between columns C_2 and C_3. Furthermore, in accordance with the illustrated embodiment, adjacent mounting portions 32b can define respective column pitches that are substantially equal to a distance that the adjacent mating portions 32a are spaced from each along the lateral direction A. Thus, the first and second column pitches CP1 and CP2 can be between 1 and 5 mm. In one example embodiment, the first and second column pitches defined by the mounting portions 28b and 32b are approximately 4 mm. Referring to Fig. 7A and 7B, in accordance with another example embodiment, the first and second column pitches defined by the mounting portions 28b and 32b can be approximately 2 mm. It should be appreciated, however, that the first column pitch CP1 can alternatively be less than or greater than the second column pitch CP2 if desired. It should be further appreciated that any desired column pitch could be used as desired.

[0058] Still referring to Fig. 9, an equal number of mounting portions 32b can be disposed in each of the plurality of columns. For instance, two mounting portions 32b can be disposed in each of the plurality of columns. The mounting portions can be further arranged in a plurality of rows that are oriented substantially perpendicular to the orientation of the columns. For example, the plurality of rows can be are elongate in the lateral direction A that is substantially perpendicular to the longitudinal direction L. The rows can be longitudinally adjacent to each other. In accordance with the illustrated embodiment, one of the mounting portions 32b that is disposed in the second column C_2 is disposed in a first row R_1, and the other of the mounting portions 32b that is disposed in the second column C2 is disposed in a third row R_3. Furthermore, as shown, the mounting portions 32b that are disposed in the first column C_1 can be disposed in a second row R_2 and a fourth row R_4, and the mounting portions 32b that are disposed in the third column C_3 can be disposed in the second row R_2 and the fourth row R_4. The second row R_2 can be disposed between the first row R_1 and the third row R_3, and the third row R_3 can be disposed between the second row R_2 and the fourth row R_4. The spacing between adjacent rows may be referred to as the row pitch RP. For instance, the spacing between adjacent rows R_1 and R_2 can define a first row pitch RP1, the spacing between adjacent rows R_2 and R_3 can define a second row pitch RP2, and the spacing between rows R_3 and R_4 can define a third row pitch RP3. As illustrated, the first row pitch RP1 between rows R_1 and R_2 can be substantially equal to the second row pitch RP2 between rows R_2 and R_3, which can also be substantially equal to the third row pitch RP3 between rows R_3 and R_4. The rows can be spaced from each along the longitudinal direction. For instance, the rows R_{1-4} can each extend along a

direction that is substantially perpendicular to the direction that the columns C_{1-3} extend. As shown, each of the rows extend and are elongate along the lateral direction A.

[0059] Further, as illustrated, the mounting portions 32b disposed in adjacent columns can be offset in the longitudinal direction L with respect to each other. For instance, the third and fourth mounting portions 32b' and 32b" in the second column C_2 can be offset in the longitudinal direction L with respect to the first and second mounting portions 32b in the first column C_1 and the fourth and fifth mounting portions 32b in the third column C_3. The mounting portions 32b disposed in the first column C_1 can be aligned with the mounting portions 32b disposed in the third column C_3 along the longitudinal direction L. Otherwise stated, the first and third rows R_1 and R_3 defined by the mounting portions 32b of one column of the electrical contacts 32 are not aligned with the second and fourth rows R_2 and R_4 defined by the mounting portions 32b of two other columns of the electrical contacts 32. For example, the third mounting portion 32b' is disposed longitudinally between the adjacent mounting portions disposed in the second row R_2 and the fourth row R_4. It is further appreciated that no mounting portions are disposed between the mounting portions 32' and 32'' along the second column C_2. Otherwise stated, the second column C_2 is devoid of mounting portions that are in lateral alignment with mounting portions disposed in the first column C1 or the third column C3. Thus, as described above and in accordance with the illustrated embodiment, the mounting portions 32b can be arranged such that each of the mounting portions 32b define the vertices of at least one approximately equilateral triangle 62. The angles defined by the vertices of the triangles 62 can be approximately, for instance precisely, equal to 60 degrees. Thus, the mounting portions 32b can be arranged such that each of the mounting portions 32b define a vertex of at least one respective equilateral triangle 62 defined by three of the mounting portions 32b. As shown, the equilateral triangles 62 can be dependent on the row pitches being substantially equal to each other and the column pitches being substantially equal to each other. For instance, the first row pitch RP1, the second row pitch RP2, the third row pitch RP3, the first column pitch CP1, and the second column pitch CP2 can be substantially equal to each other. Further, at least one mounting portion 32b of one column can be disposed midway between the mounting portions 32b of at least one adjacent column with respect to the longitudinal direction L. In accordance with the illustrated embodiment, the mounting portions 32b of one column and the mounting portions 32b of an adjacent column define two equilateral triangles 62, though it be understood that the mounting terminals can be arranged to define any number of equilateral triangles 62 as desired.

[0060] Still referring to Fig. 9, the first and second mounting portions 32b can be disposed in the first column C_1, and the third mounting portion 32b can be disposed in the second column such that the first, second, and third mounting portions defining a first equilateral triangle 62. The first mounting portion 32b, the second mounting portion 32b, and the fourth mounting portion 32b" that is disposed in the second column C_2 can define a second equilateral triangle 62. The fifth and sixth mounting portions 32b can be disposed in the third column C_3 such that the fourth, fifth, and sixth mounting portions define a third equilateral triangle 62. The third mounting portion 32b', the fifth mounting portion 32b, and the sixth mounting portion 32b can define a fourth equilateral triangle 62. Thus, the third mounting portion 32b' can be a common vertex that is shared by at least four, for instance four, equilateral triangles defined by the mounting portions 32b.

[0061] Thus, as illustrated, the mounting portions of adjacent columns of a given electrical contact are spaced apart a greater distance than if they were not longitudinally offset (e.g., than if they were in lateral alignment). Accordingly, it can be said that a select pair of mounting portions disposed in adjacent columns are spaced apart a distance greater than the lateral distance between the adjacent columns. Conventional connectors with mounting terminals are not longitudinally offset in the manner described above. Therefore, the above-described electrical connectors provide increased spacing between the mounting portions without increasing the footprint of the mounting interface of the connector with respect to the similarly constructed connector. Otherwise stated, a conventional connector can be modified by offsetting the mounting portions along every other column such that each mounting terminal is a vertex of an equilateral triangle defined by adjacent columns, so as to increase the distance between adjacent mounting portions without increasing the footprint of the mounting interface of the electrical connector.

[0062] It should further be appreciated that the increased spacing between the mounting portions allows the electrical contacts to carry an increased working voltage (for instance 400V or greater) with respect to conventional mounting portions, while at the same time reducing or preventing voltage between mounting portions during operation. For instance, current generally follows a path of least resistance along the electrical contacts 32 to the mounting portions 32b and then into the printed circuit board 36. Accordingly, in conventional connectors, increased numbers of mounting portions generally allow for higher levels of current to flow through the contact. Unfortunately, increased numbers of mounting portions decreases the spacing, and thus the creepage distance, between mounting portions, which limits the working voltage. Accordingly, the electrical connectors 22 and 24 can define the footprint 60 that is configured to

increase the space, and thus the creepage distance, between two immediately adjacent mounting portions, without otherwise increasing the overall footprint at the mounting interface of the connector. While the footprint 60 and its alternative embodiments have been illustrated and described with respect to the mounting portions 32b of one or more electrical contacts 32, for instance power contacts 32, it should be appreciated that the footprint 60 can be defined by the mounting portions of any type of contacts, for instance single-beam AC power contacts, signal contacts, or DC power contacts. While various footprint embodiments have been described in combination with the electrical connector 24, it should be appreciated that the various structures and features described herein are applicable to differently constructed connectors, for instance the electrical connectors 22, 22a, and 24a described herein.

[0063] As illustrated in Figs. 1-3B, the first and second electrical connectors 22 and 24 can be configured such that when the first and second electrical connectors 22 and 24 are mounted to the respective first and second substrates and mated to each other, the first and second substrates are orthogonal to each other. Alternatively, as illustrated in Figs. 5-6B, the first and second electrical connectors 22 and 24 can each be configured as right-angle electrical connectors such that when the first and second electrical connectors 22 and 24 are mounted to the respective first and second substrates and mated to each other, the first and second substrates are coplanar with each other. It should be understood that the first and second electrical connectors 22 and 24 can be configured to carry any amount of power as desired, for instance 400 V of DC power.

[0064] As described above, in accordance with an example embodiment, the first and second electrical connectors 22 and 24 are touch proof as determined by the probe 102. In particular, when the probe 102 is applied to the mating interfaces of the electrical connectors 22 and 24, the distal end 106 of the probe 102 is prevented from touching the electrical contacts 28 and 32, regardless of the angle that the probe 102 is oriented with respect to the mating interfaces of connectors 22 and 24. In particular, a portion of the finger portion 101 of the probe 102 can be disposed within the connector housings 26 and 30 during a touch proof test, but the finger portion 101 can be prevented by the housings 26 and 30, in particular the distal ends 51 of the shroud 50 and the distal end 55 of the beams 54, from being able to touch the contacts 28 and 32. Thus, during a touch proof test using the probe 102, the probe 102 and the connector housing can define a point of largest ingress. The point of largest ingress can be defined as an inward distance from the distal end 51 of the shroud 50 to the distal end 106 of the probe along the mating direction. The point of largest ingress can be less than a distance from the distal end 51 of the shroud 50 to the distal ends of the electrical contacts disposed within the shrouds 50 along

the mating direction. Similarly, a point of largest ingress can be defined as an inward distance from the distal end 55 of the beams 54 to the distal end 106 of the probe along the mating direction. The point of largest ingress can be less than a distance from the distal ends 55 of the beams 54 to the distal ends of the electrical contacts disposed between the beams 54 along the mating direction.

[0065] A method can include any steps as described above. For instance, a method of mating can include the first and second electrical connectors to each other can include bringing the first and second electrical connectors toward each other. During the bringing step, the shrouds of each of the first and second electrical connectors can be inserted between adjacent ones of the beams of the other of the first and second electrical connectors. The method can further include inserting ones of the first plurality of electrical contacts of the each of the first and second electrical connectors between a pair of fingers of ones of the second plurality of electrical contacts of the other of the first and second electrical connectors so as to establish an electrical power connection between the first plurality of electrical contacts and the second plurality of electrical contacts.

[0066] The foregoing description is provided for the purpose of explanation and is not to be construed as limiting the invention. While the invention has been described with reference to preferred embodiments or preferred methods, it is understood that the words which have been used herein are words of description and illustration, rather than words of limitation. Furthermore, although the invention has been described herein with reference to particular structure, methods, and embodiments, the invention is not intended to be limited to the particulars disclosed herein, as the invention extends to all structures, methods and uses that are within the scope of the appended claims. For example, while the embodiments disclosed are two tiered, it should be understood that the features may be incorporated into single tiered connectors or other multi-tiered connectors. Furthermore, it should be appreciated that structures and features described above in connection with one or more embodiments can be included in all other embodiments, unless otherwise indicated. Those skilled in the relevant art, having the benefit of the teachings of this specification, may effect numerous modifications to the invention as described herein, and changes may be made without departing from the scope and spirit of the invention as defined by the appended claims.

What is Claimed:

1. An electrical power connector comprising:

an electrically insulative connector housing;

a first plurality of electrical contacts supported by the connector housing, the first plurality of electrical contacts being of a first type; and

a second plurality of electrical contacts supported by the connector housing, the second plurality of electrical contacts being of a second type and positioned adjacent to the first plurality of electrical contacts.

2. The electrical power connector as recited in claim 1, wherein each of the first plurality of electrical contacts extends along a respective length to a mating portion, and the housing extends beyond the mating portions of the first plurality of electrical contacts such that each of the first plurality of electrical contacts is touch proof.

3. The electrical power connector as recited in any one of the preceding claims, wherein each of the second plurality of electrical contacts extends along a respective length to a mating portion, and the housing extends beyond the mating portions of the second plurality of electrical contacts such that each of the second plurality of electrical contacts is touch proof.

4. The electrical power connector as recited in any one of the preceding claims, wherein the first plurality of electrical contacts are plug contacts, and the second plurality of electrical contacts are receptacle contacts.

5. The electrical power connector as recited in any one of the preceding claims, wherein the second plurality of electrical contacts includes one or more fingers configured to receive therebetween a plug contact, and the first plurality of electrical contacts are configured as plug contacts.

6. The electrical power connector as recited in any of claims 4 and 5, wherein the first plurality of electrical contacts is arranged along a first row and the second plurality of electrical contacts is arranged along a second row that is spaced from the first row along a transverse direction that is substantially perpendicular to a mating direction of the electrical power connector.

7. The electrical power connector as recited any of claims 4 and 5, wherein the first plurality of electrical contacts and the second plurality of electrical contacts are arranged in a first row along a lateral direction such that every other electrical contact in the first row is configured as a plug contact that is aligned with a receptacle contact along a transverse direction that is substantially perpendicular to the lateral direction and a mating direction of the electrical power connector.

8. The electrical power connector a recited in any one of the preceding claims, wherein the housing defines a plurality of shrouds that surround respective ones of the second plurality of electrical contacts, such that at least a portion of the shrouds is aligned with respective ones of the first type of electrical contacts along a select direction so as to render the first plurality of electrical contacts touch proof with respect to the select direction.

9. The electrical power connector as recited in any one of the preceding claims, wherein the housing provides creepage protection between adjacent ones of the first plurality of electrical contacts, adjacent ones of the second plurality electrical contacts, and adjacent ones of each of the first and second pluralities of electrical contacts.

10. The electrical power connector as recited in any one of the preceding claims, wherein the housing defines a plurality of beams that are disposed between adjacent ones of the first plurality of electrical contacts, and a plurality of shrouds that surround respective ones of the second plurality of electrical contacts.

11. The electrical power connector as recited in claim 10, wherein the housing further comprises ribs that project from each of the beams toward the respective adjacent one of the first plurality of electrical contacts.

12. The electrical power connector as recited in claim 11, wherein the housing defines recesses in respective outer surfaces of the shrouds, the recesses sized to receive respective ribs of a second electrical connector constructed as recited in claim 11 when mated.

13. The electrical power connector as recited in any one of the preceding claims, wherein the housing defines a mating interface configured to mate with a second electrical connector so as to place each of the first and second pluralities of electrical contacts in electrical communication with respective complementary second and first pluralities of electrical contacts of the second

electrical connector, and the housing defines a mounting interface configured to be mounted to a substrate so as to place the electrical contacts in electrical communication with the substrate.

14. The electrical power connector as recited in claim 13, wherein the mating interface is perpendicular to the mounting interface.

15. The electrical power connector as recited in any one of claims 13 to 14, wherein the mating interface is parallel with the mounting interface.

16. The electrical power connector as recited in any one of claims 13 to 15, wherein the first plurality of electrical contacts are aligned in a first row, and the second plurality of electrical contacts are aligned in a second row adjacent the first row.

17. The electrical power connector as recited in any one of the preceding claims, wherein each of the electrical contacts include a mounting portion, the mounting portions arranged such that each of the mounting portions define a vertex of at least one approximately equilateral triangle defined by three of the mounting portions.

18. An electrical power connector comprising:

a dielectric connector housing that includes a plurality of beams and a plurality of shrouds that each terminate at a respective distal end, the plurality of beams and the plurality of shrouds defining a mating interface configured to mate with a complementary electrical power connector along a mating direction;

a first plurality of electrical contacts supported by the connector housing spaced apart from each other along a lateral direction that is substantially perpendicular to the mating direction; and

a second plurality of electrical contacts supported by the connector housing spaced apart from each other along the lateral direction, the second plurality of electrical contacts spaced from the first plurality of electrical contacts along a transverse direction that is substantially perpendicular to both the mating and lateral directions,

wherein 1) the first plurality of electrical contacts terminate at a first distal end configured to mate with a complementary electrical contact of the complementary electrical connector, 2) the second plurality of electrical contacts terminate at a second distal end configured to mate with a complementary electrical contact of the complementary electrical connector, 3) the distal end of the beams extends beyond the first distal end of the first plurality

of electrical contacts along the mating direction, and 4) the distal end of the shrouds extends beyond the second distal end of second plurality of electrical contacts along the mating direction.

19. The electrical power connector as recited in claim 18, wherein the plurality of shrouds at least partially surround respective ones of the second plurality of electrical contacts from a plane defined by the lateral and transverse directions.

20. The electrical power connector as recited in any one of claims 18 to 19, wherein the plurality of shrouds fully surround a mating portion of the second plurality of electrical contacts, the mating portion including the distal end and configured to mate with the complementary electrical contact.

21. The electrical power connector as recited in claims 18 to 20, wherein the plurality of shrouds is elongate along the mating direction.

22. The electrical power connector as recited in any one of claims 18 to 19, wherein the plurality of beams are spaced from each other along the lateral direction.

23. The electrical power connector as recited in any one of claims 19 to 23, wherein the plurality of beams are disposed between adjacent ones of the first plurality of electrical contacts.

24. The electrical power connector as recited in any one of claims 18 to 23, wherein the beams extend beyond the second distal end of the second plurality of electrical contacts such that the second plurality of electrical contacts is touch proof.

25. The electrical power connector as recited in any one of claims 23 and 24, wherein the housing further comprises ribs supported by the beams, the ribs projecting out from the beams toward the respective adjacent one of the first plurality of electrical contacts.

26. The electrical power connector as recited in claim 25, wherein the ribs are elongate along the mating direction.

27. The electrical power connector as recited in any one of claims 25 and 26, wherein the beams and the ribs extend beyond the second distal end of the second plurality of electrical contacts such that each of the second plurality of electrical contacts is touch proof.

28. The electrical power connector as recited in any one of claims 18 to 27, wherein the first plurality of electrical contacts are plug contacts, and the second plurality of electrical contacts are receptacle contacts.

29. An electrical power connector assembly including first and second electrical connectors each as recited in any one of the preceding claims.

30. The electrical power connector assembly as recited in claim 29, wherein the shrouds of the each of the first and second electrical connectors surround respective ones of the first electrical contacts of the other of the first and second electrical connectors when the first and second electrical connectors are mated to each other.

31. The electrical power connector assembly as recited in any one of claims 28 and 29, wherein the shrouds of the each of the first and second electrical connectors are received between adjacent ones of the beams of the other of the first and second electrical connectors when the first and second electrical connectors are mated to each other.

32. The electrical power connector assembly as recited in any one of claims 29 to 31, wherein the mating interface of the second electrical connector is perpendicular to the mounting interface of the second electrical connector.

33. The electrical power connector assembly as recited in any one of claims 29 to 31, wherein the mating interface of the second electrical connector is parallel with the mounting interface of the second electrical connector.

34. The electrical power connector assembly as recited in any one of claims 29 to 33, wherein when the first and second electrical connectors are mounted to respective first and second substrates and mated to each other, the first and second substrates are coplanar with each other.

35. The electrical power connector as recited in any one of claims 29 to 33, wherein when the first and second electrical connectors are mounted to respective first and second substrates and mated to each other, the first and second substrates are orthogonal to each other.

36. A method of mating the first and second electrical connectors as recited in claim 29 to each other, the method comprising the steps of:

bringing the first and second electrical connectors toward each other; and

during the bringing step, inserting the shrouds of each of the first and second electrical connectors between adjacent ones of the beams of the other of the first and second electrical connectors.

37. The method as recited in claim 36, the method further comprising:

inserting ones of the first plurality of electrical contacts of the each of the first and second electrical connectors between a pair of fingers of ones of the second plurality of electrical contacts of the other of the first and second electrical connectors so as to establish an electrical power connection between the first plurality of electrical contacts and the second plurality of electrical contacts.

38. An electrical connector comprising:

an electrically insulative connector housing; and

a plurality of electrical contacts supported by the connector housing, each of the electrical contacts including a mounting portion configured to mount to a printed circuit board,

wherein the mounting portions are arranged such that each of the mounting portions define a vertex of at least one respective equilateral triangle defined by three of the mounting portions.

39. The electrical connector as recited in claim 38, wherein each of the electrical contacts includes only one mounting portion.

40. The electrical connector as recited in any one of claims 38 and 39, wherein the mounting portions are further arranged in a plurality of columns that are elongate in a longitudinal direction and are disposed laterally adjacent to each other, the columns comprising a first column, a second column that is spaced from the first column a first column pitch, and a third column that is spaced from the second column a second column pitch that is substantially equal to the first column pitch.

41. The electrical connector as recited in any one of claims 39 and 40, wherein a first and a second mounting portion are disposed in the first column, and a third mounting portion is disposed in the second column such that the first, second, and third mounting portions define a first equilateral triangle.

42. The electrical connector as recited in claim 41, wherein a fourth mounting portion is disposed in the second column such that the first, second, and fourth mounting portions define a second equilateral triangle.

43. The electrical connector as recited in claim 42, wherein a fifth and a sixth mounting portion are disposed in the third column such that the fourth, fifth, and sixth mounting portions define a third equilateral triangle.

44. The electrical connector as recited in claim 43, wherein the third, fifth, and sixth mounting portions define a fourth equilateral triangle.

45. The electrical connector as recited in any one of claims 41 to 43, wherein the third mounting portion is a common vertex shared by at least four equilateral triangles defined by the mounting portions.

46. The electrical connector as recited in any one of claims 40 to 45, wherein an equal number of mounting portions are disposed in each of the plurality of columns.

47. The electrical connector as recited in any of claims 40 to 46, wherein two mounting portions are disposed in each of the plurality of columns.

48. The electrical connector as recited in any one of claims 40 to 47, wherein the mounting portions are further arranged in a plurality of rows that are elongate in a lateral direction that is substantially perpendicular to the longitudinal direction, and are longitudinally adjacent to each other.

49. The electrical connector as recited in claim 48, wherein the mounting portions disposed in the second column are disposed in a first row and a third row, and the mounting portions in the first and third columns are disposed in a fourth row and a second row that is between the first row and the third row, the third row disposed between the second row and the fourth row.

50. The electrical connector as recited in claim 49, wherein the first row is spaced from the second row a first row pitch, the second row is spaced from the third row a second row, and the

third row is spaced from the fourth row a third row pitch that is substantially equal both the first row pitch and the second row pitch.

51. The electrical connector as recited in claim 50, wherein the first row pitch, the second row pitch, the third row pitch, the first column pitch, and the second column pitch are substantially equal to each other.

52. An electrical power connector configured to mate with a complementary electrical power connector along a mating direction, the electrical power connector comprising:

an electrically insulative connector housing that includes a housing body and a plurality of first portions that extend from the housing body along the mating direction; and

a plurality of electrical contacts supported by the connector housing, the electrical contacts each terminating at a mating portion configured to mate with complementary electrical contacts of the complementary electrical connector, the mating portions arranged in a plurality of columns that extend along a column direction, the columns spaced from each other along a row direction that is substantially perpendicular to the column direction,

wherein the electrical contacts include plug contacts and receptacle contacts, and the first portions extend farther from the housing body relative to the mating portions of the electrical contacts along the mating direction such that each of the electrical contacts is touch proof.

53. The electrical power connector as recited in claim 52, wherein each column includes only one of plug contacts or receptacle contacts.

54. The electrical power connector as recited in any of claims 52 and 53, wherein adjacent columns along the row direction define an alternating pattern of plug and receptacle contacts such that no plug contacts are immediately adjacent to receptacle contacts along the row direction.

55. The electrical power connector as recited in any one of claims 52 to 54, wherein the first portions are substantially diamond shaped.

56. The electrical power connector as recited in claim 55, wherein the first portions are sized to be received by complementary portions of a complementary connector housing of the

complementary electrical power connector when the electrical power connector is mated with the complementary electrical power connector.

57. The electrical power connector as recited in any one of claims 52 to 56, wherein the first portions define a plurality of slots, the mating portions of the plug contacts disposed within respective slots.

58. The electrical power connector as recited in claim 57, wherein the slots are elongate along the column direction.

59. The electrical power connector as recited in any one of claims 52 to 57, wherein the first portions define second portions sized to receive complementary portions of a complementary connector housing of the complementary electrical connector when the electrical power connector is mated with the complementary electrical power connector.

60. The electrical power connector as recited in claim 59, wherein the first portions are substantially diamond shaped and are arranged so as to define the second portions that are substantially diamond shaped.

61. The electrical power connector as recited in claim 60, wherein the receptacle contacts define fingers spaced apart from each other along the row direction such that the fingers are configured to receive therebetween a complementary plug contact of the complementary electrical power connector when the electrical power connector is mated with the complementary power connector.

62. The electrical power connector as recited in claim 61, wherein each of the receptacle contacts is disposed immediately adjacent two first portions along the row direction and two second portions along the column direction.

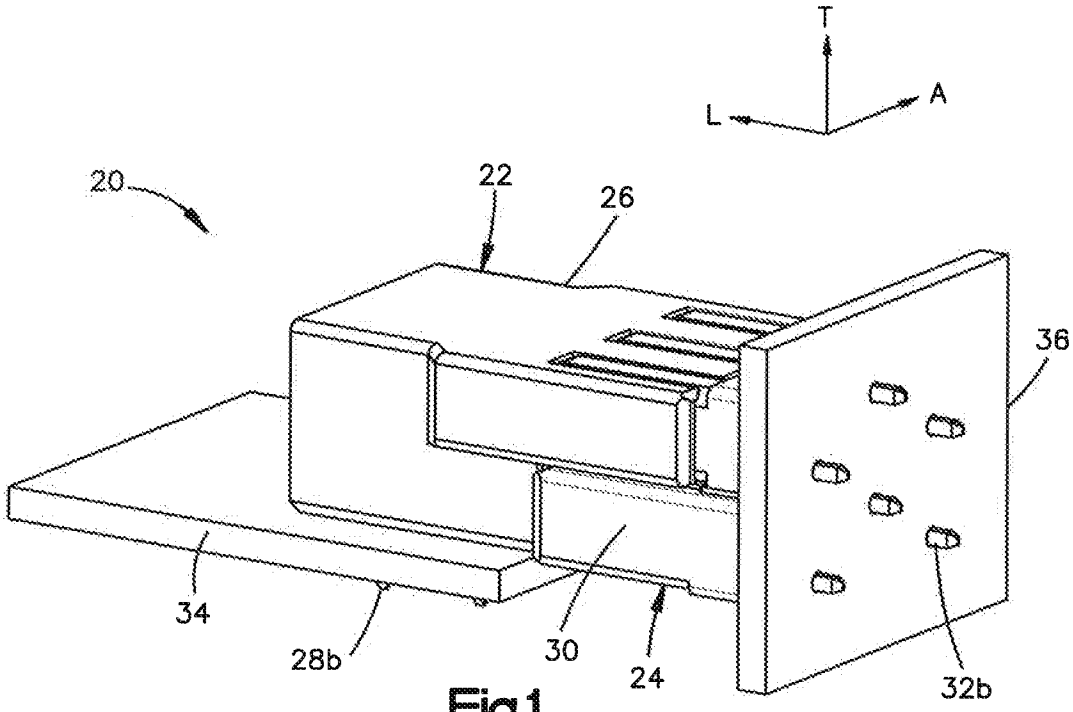

T
A
L
20
22
26
36
34
28b
30
24
32b

Fig.1

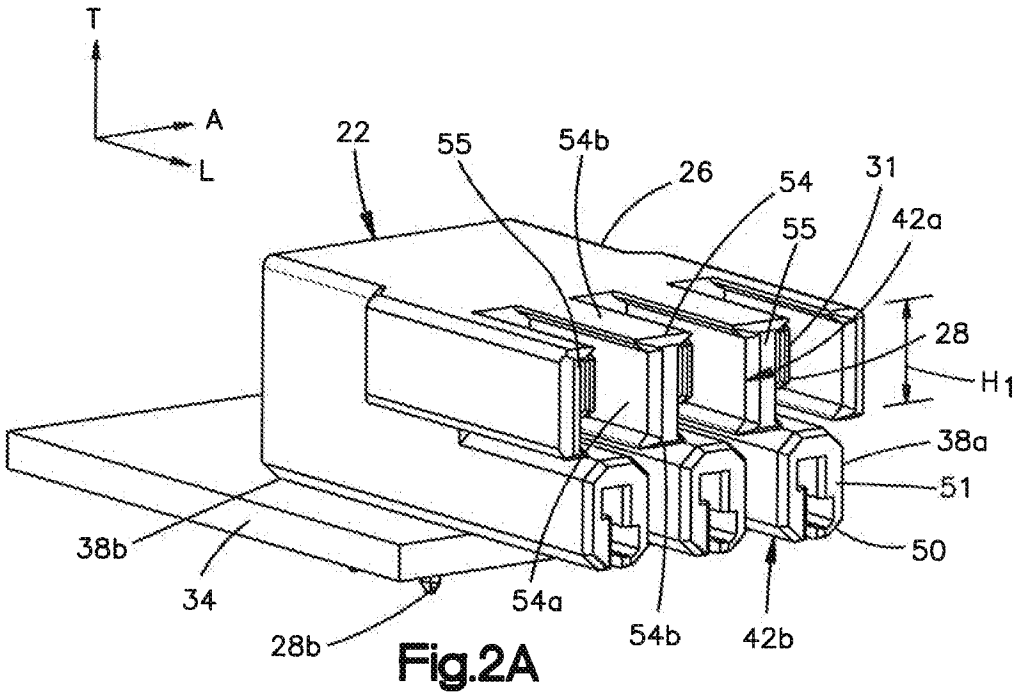

T
A
L
22
55
54b
26
54
31
55
42a
28
H1
38a
51
50
38b
34
28b
54a
54b
42b

Fig.2A

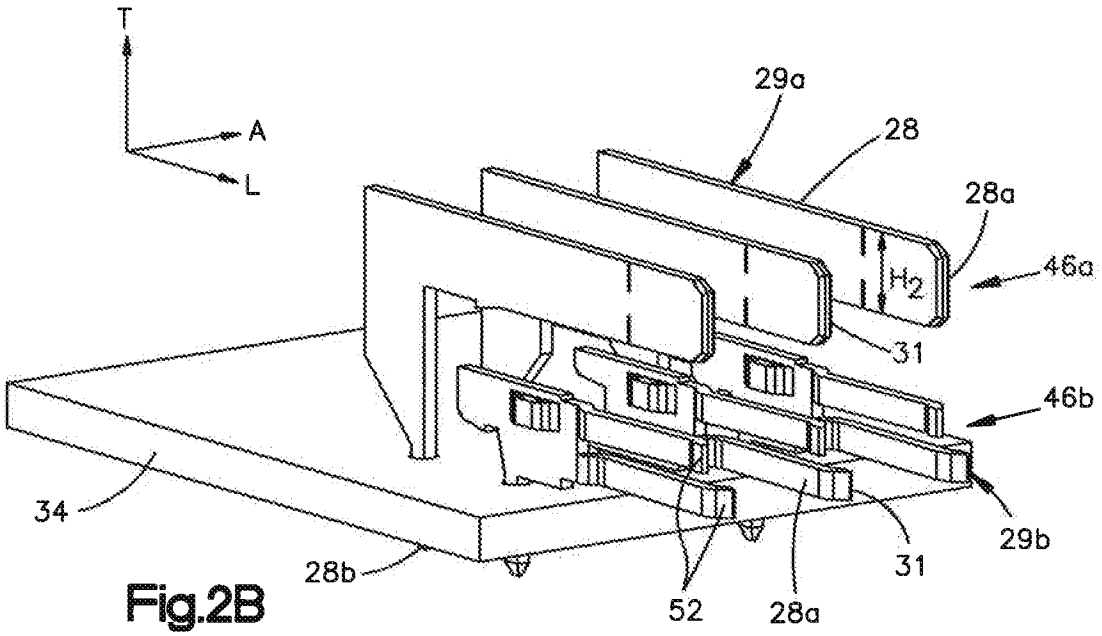

T
A
L
29a
28
28a
H_2
46a
31
46b
34
29b
28b
31
52
28a

Fig.2B

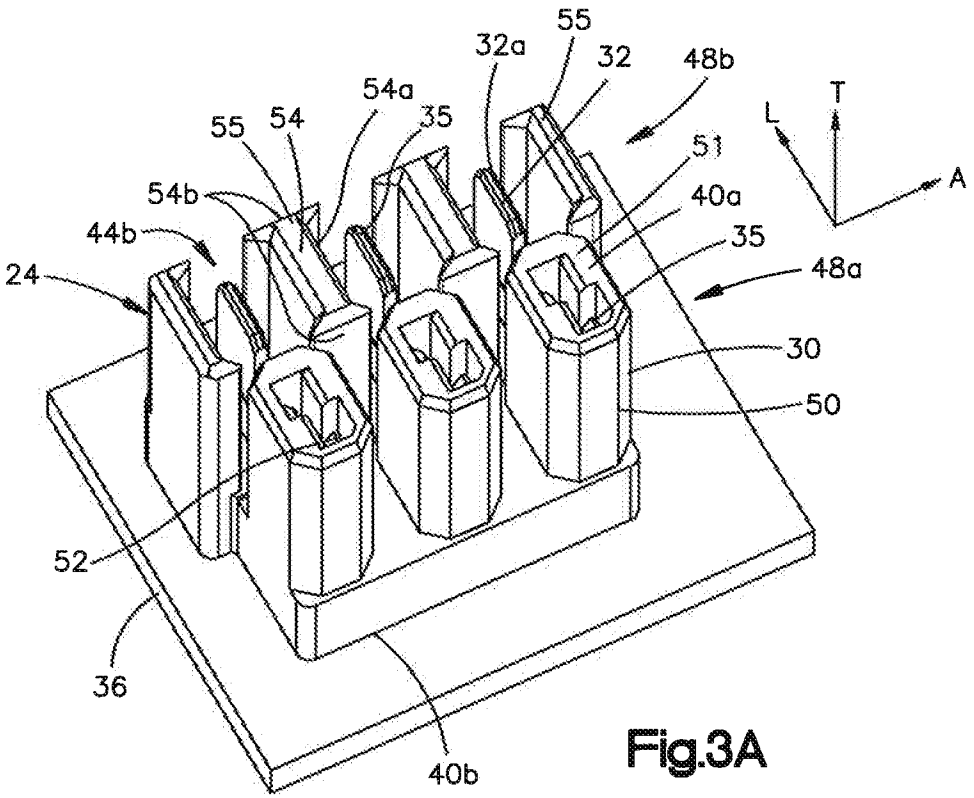

55
32a
32
48b
54a
55
54
35
T
L
A
51
54b
40a
44b
35
24
48a
30
50
52
36
40b

Fig.3A

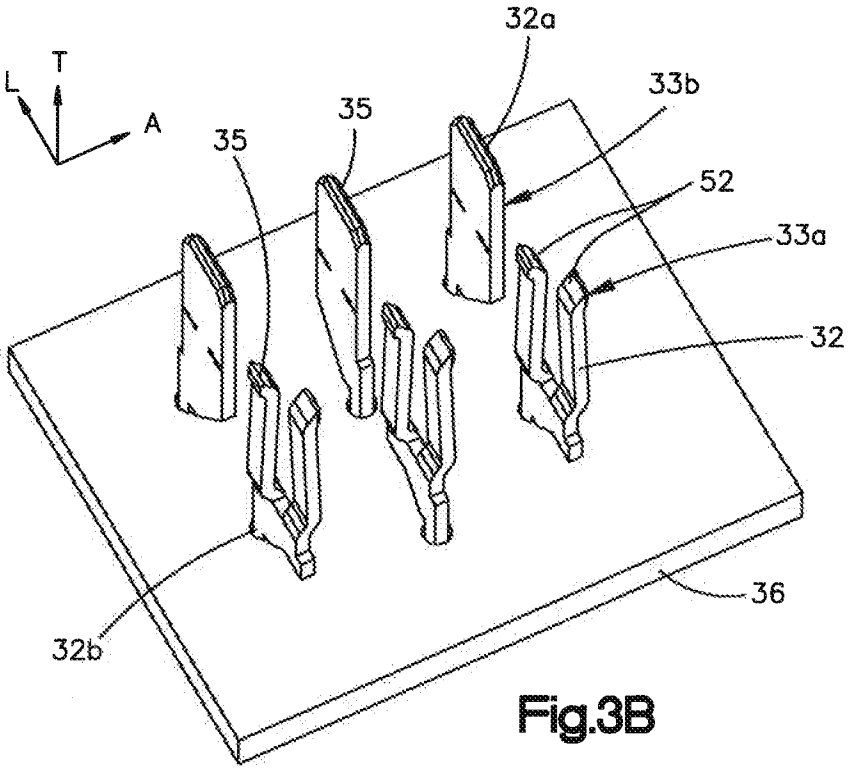


Fig.3B

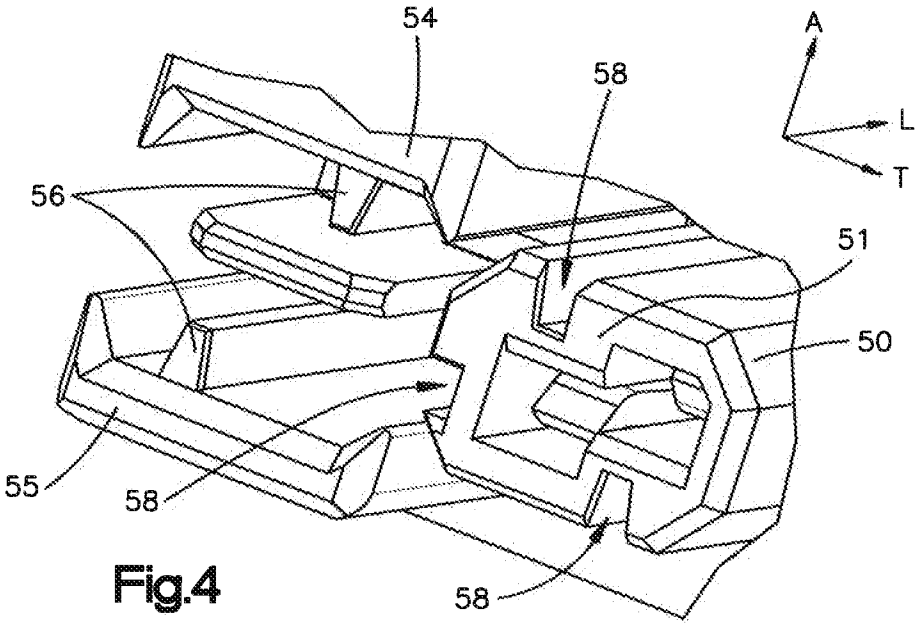
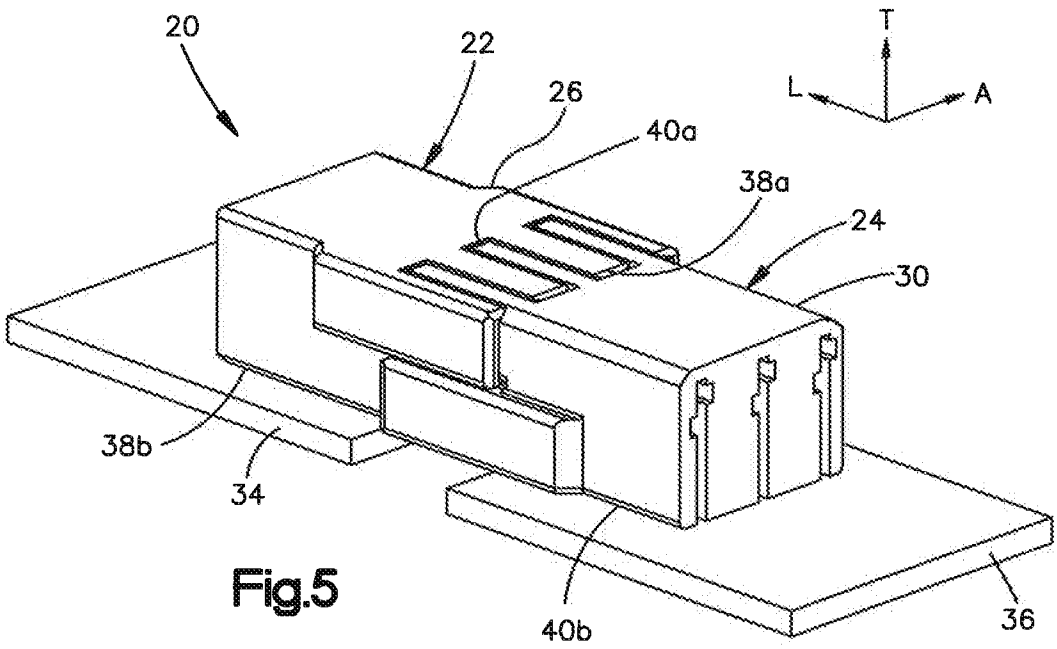


Fig.4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22
26
40a
38a
24
30
T
L
A
38b
34
40b
36

Fig.5

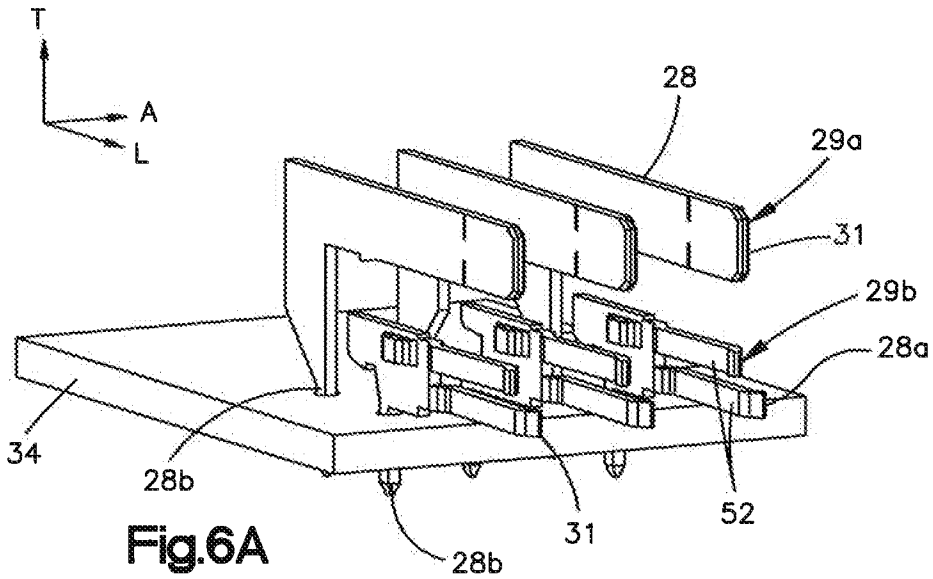

T
A
L
28
29a
31
29b
28a
34
28b
31
52
28b

Fig.6A

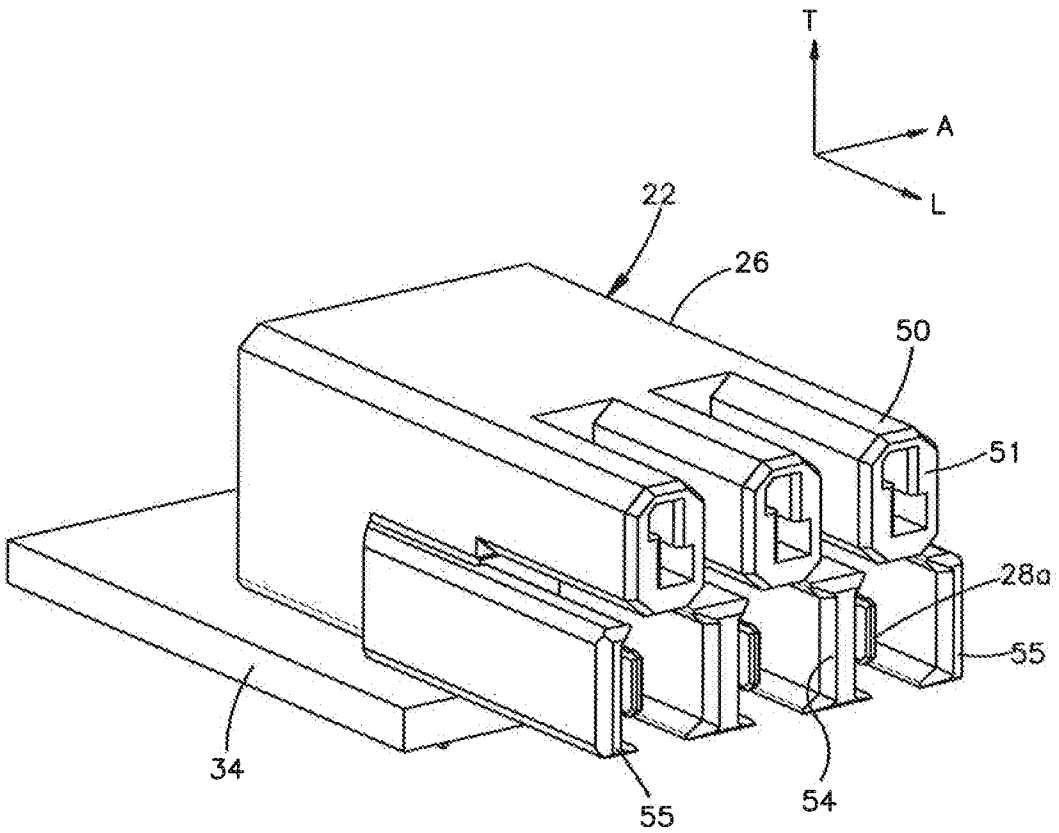
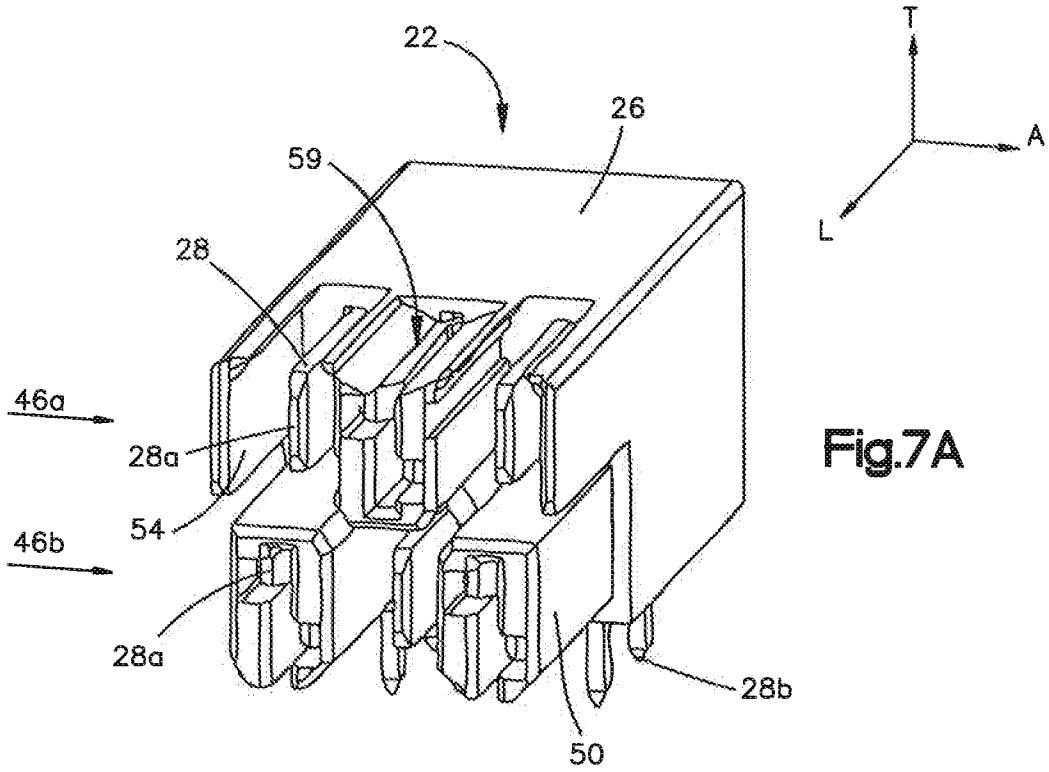


Fig.6B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26
59
28
46a
28a
54
46b
28a
28b
50
T
A
L

Fig.7A

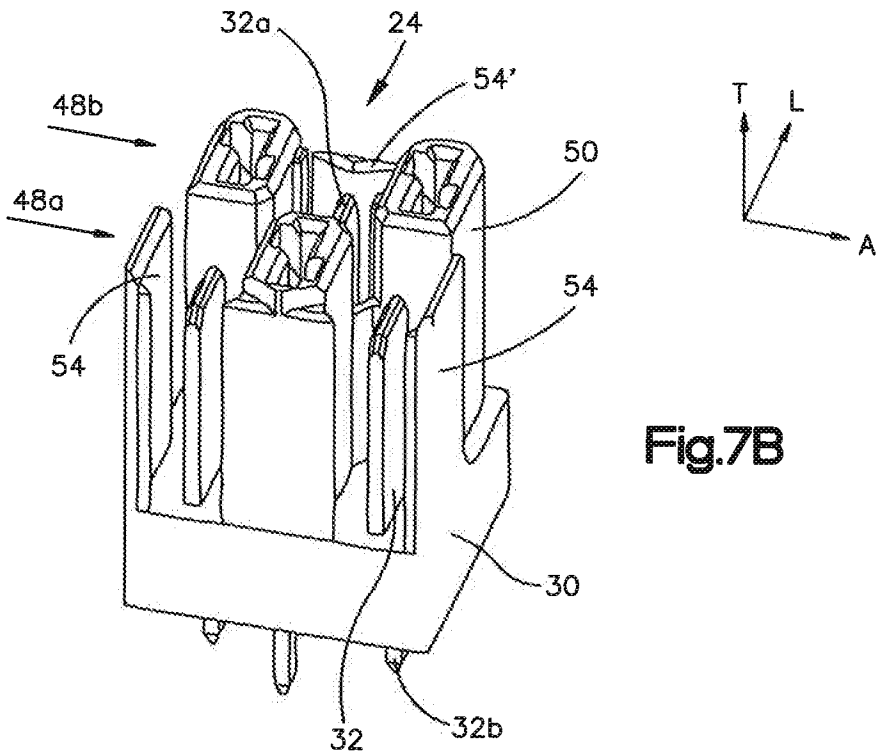

32a
24
54'
48b
48a
50
54
54
30
32
32b
T
L
A

Fig.7B

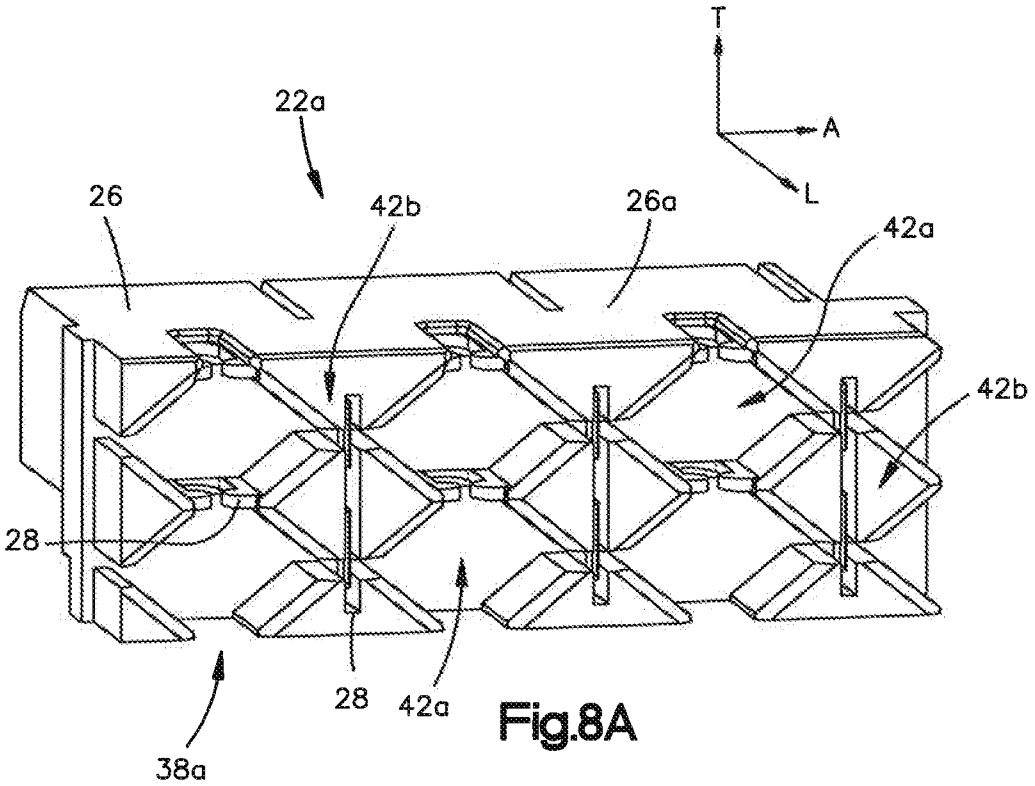

T
A
L
22a
26
42b
26a
42a
42b
28
28
42a
38a

Fig.8A

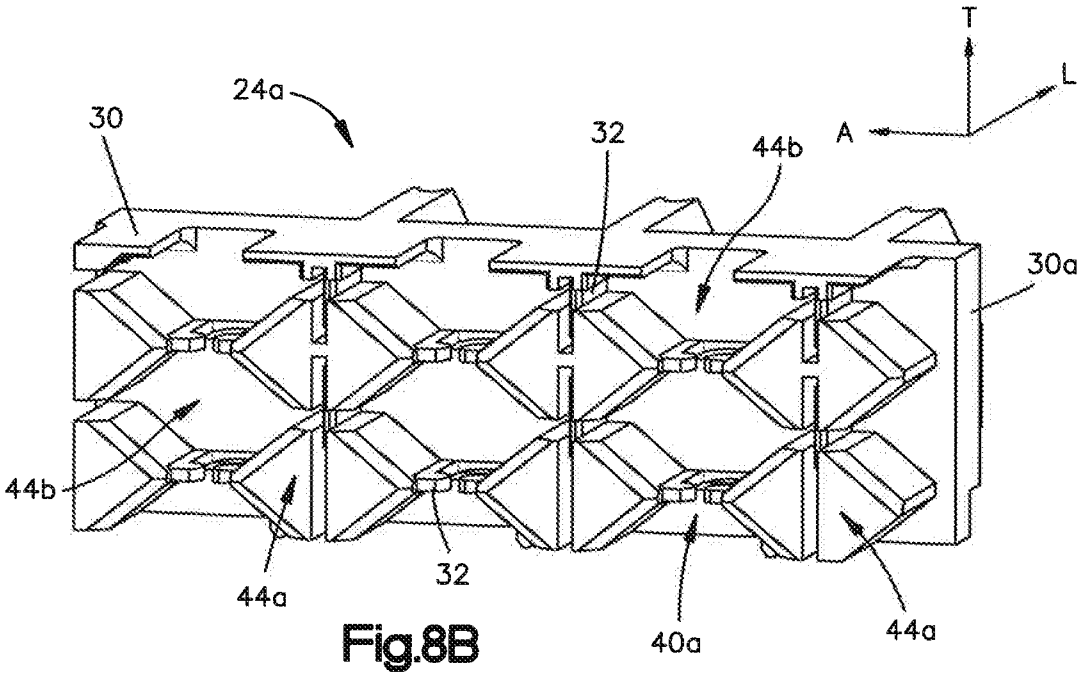

T
L
A
24a
30
32
44b
30a
44b
44a
32
40a
44a

Fig.8B

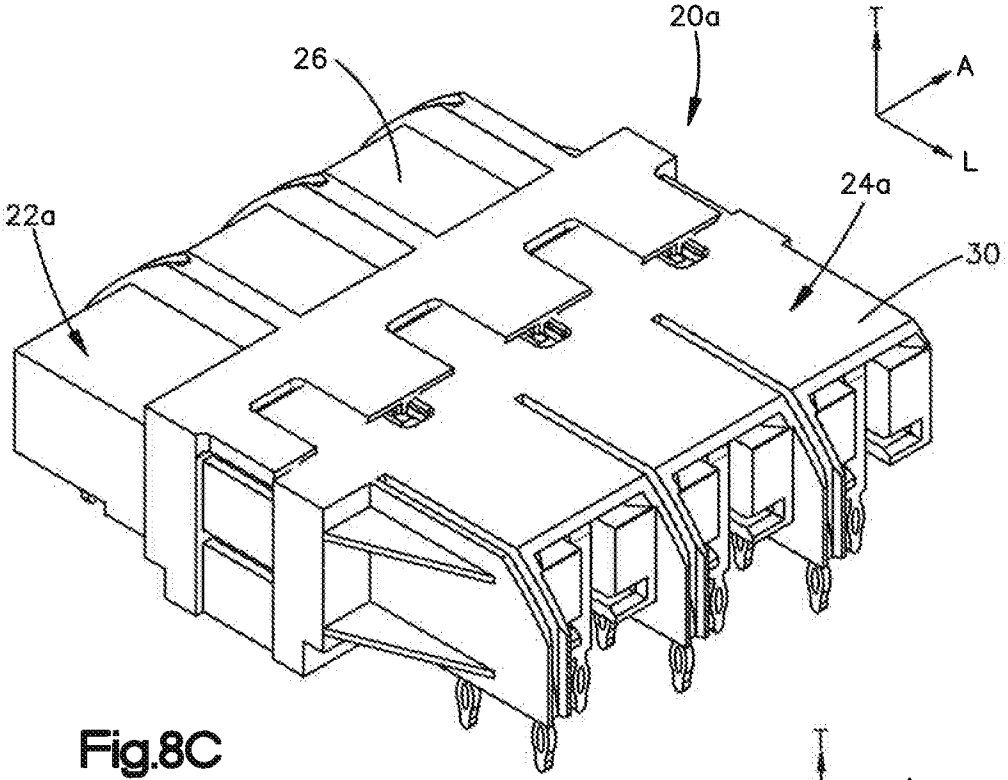


Fig.8C

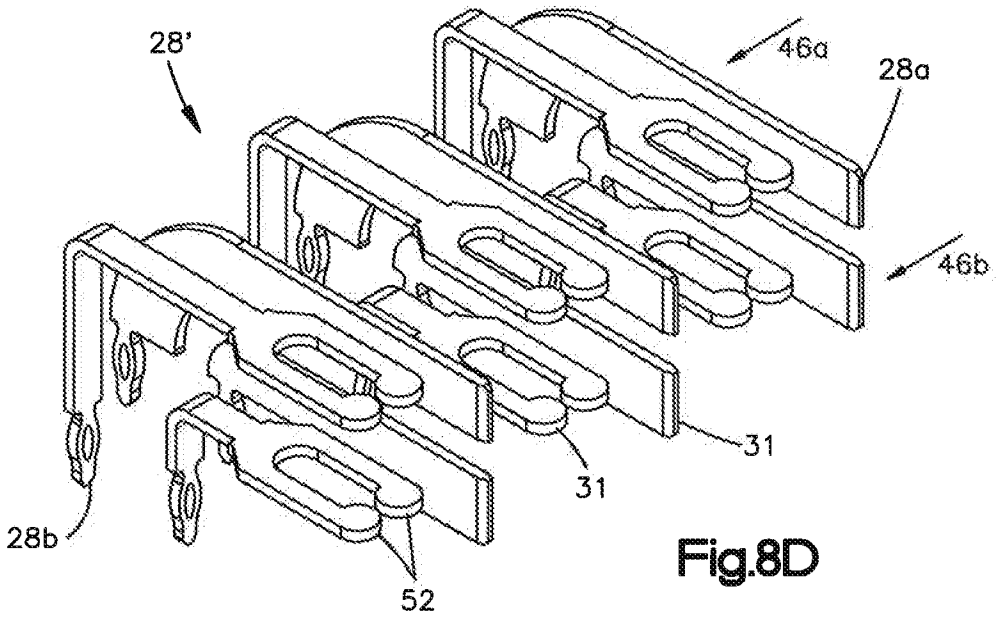
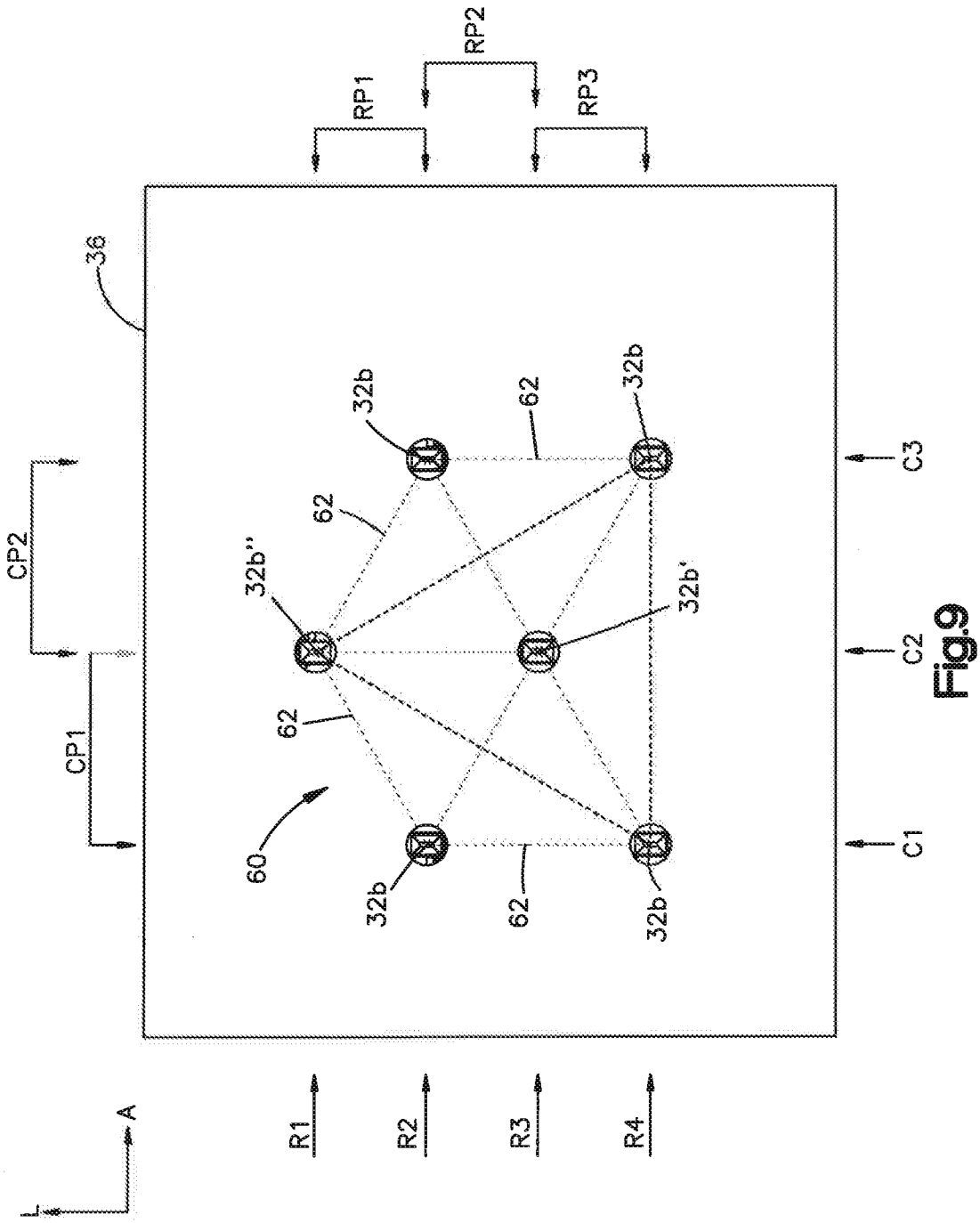


Fig.8D


RP1
RP2
RP3
36
32b
62
32b
32b''
32b'
62
62
60
32b
62
32b
CP2
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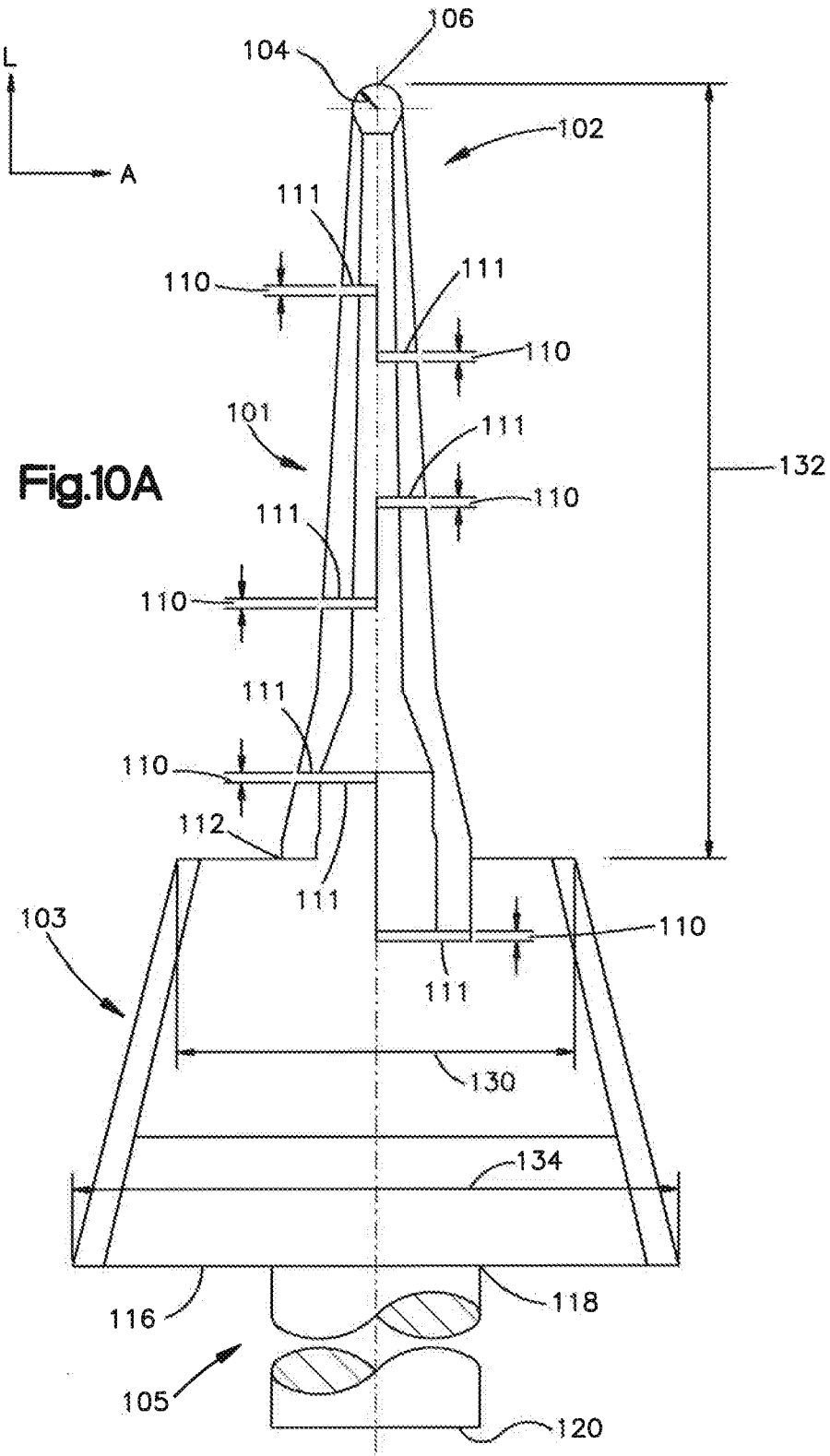
C3
C2
C1
R1
R2
R3
R4
A
L

Fig.9


L
A
106
104
102
111
110
111
110
101
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132
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118
105
120

Fig.10A

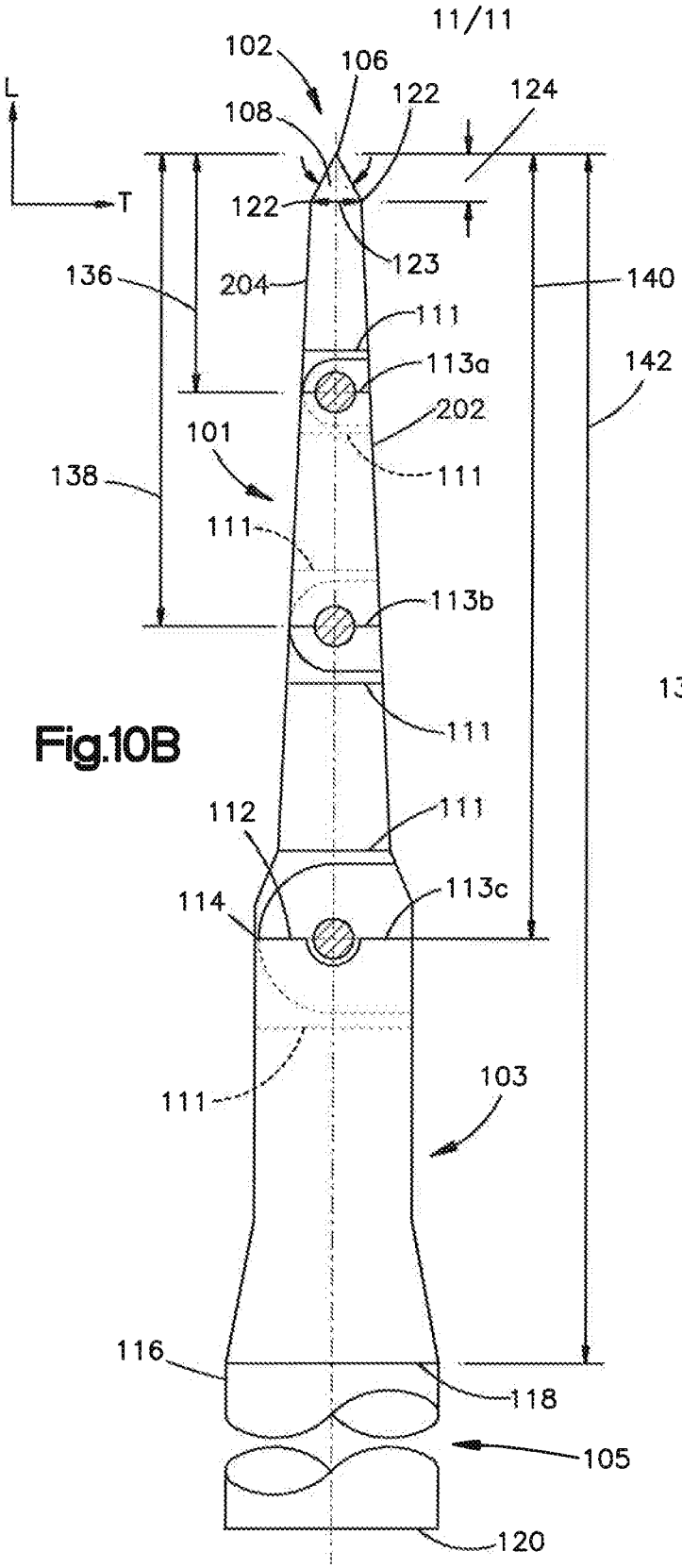

Fig.10B

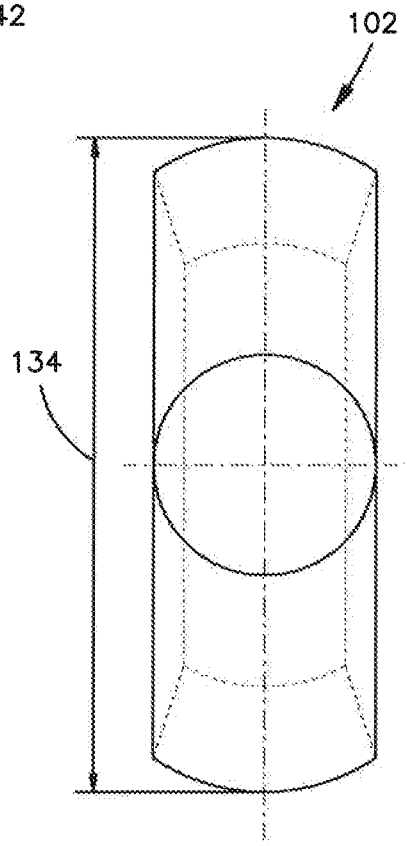

Fig.10C

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/067298

A. CLASSIFICATION OF SUBJECT MATTER

H01R 13/648(2006.01)i, H01R 12/73(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 13/648; none ; H01R 13/53; H01R 43/20; H01R 13/73; H01R 13/00; H01R 24/00; H01R 12/00; H01R 12/73

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:connector, contact, mate, housing, power, column, row

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012-0289071 A1 (JOHN DAVID DODDS et al.) 15 November 2012 See paragraphs [0002], [0037]-[0049], [0059]-[0077]; claim 2; and figures 1A-4B, 9A-10B, 14A.	1-3,18-20,38-40,52-54
A	US 2010-0048056 A1 (CHRISTOPHER G. DAILY et al.) 25 February 2010 See paragraphs [0013], [0042]-[0049]; and figures 1, 4.	1-3,18-20,38-40,52-54
A	US 2006-0194472 A1 (STEVEN E. MINICH et al.) 31 August 2006 See paragraphs [0026]-[0036], [0067]; and figures 1-2, 5.	1-3,18-20,38-40,52-54
A	US 2010-0304581 A1 (WAYNE SAMUEL DAVIS et al.) 02 December 2010 See paragraphs [0023]-[0034], [0084]; and figures 1, 13.	1-3,18-20,38-40,52-54
A	WO 2012-158616 A2 (MOLEX INCORPORATED) 22 November 2012 See paragraphs [0004]-[0005], [0027]-[0044]; and figure 2.	1-3,18-20,38-40,52-54

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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

Date of the actual completion of the international search	Date of mailing of the international search report
27 February 2015 (27.02.2015)	**27 February 2015 (27.02.2015)**

Name and mailing address of the ISA/KR
International Application Division
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/067298

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.: 11-12,14,26,30,36-37,42-44,49-51,56,58,60-62
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 11-12,14,26,30,36-37,42-44,49-51,56,58,60-62 are unclear because they refer to unsearchable claims, which do not comply with PCT Rule 6.4(a).

3. ☒ Claims Nos.: 4-10,13,15-17,21-25,27-29,31-35,41,45-48,55,57,59
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2014/067298

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2014/067298

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