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(54) **Broadside-coupled signal pair configurations for electrical connectors**

Breitseitengekoppelte Signalpaarkonfigurationen für elektrische Verbinder

Configurations de paires de signaux couplés latéralement pour connecteurs électriques

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Description

BACKGROUND

[0001] An electrical connector may provide signal connections between electronic devices using signal contacts. The electrical connector may include a leadframe assembly that has a dielectric leadframe housing and a plurality of electrical contacts extending therethrough. Typically, the electrical contacts within a leadframe assembly are arranged into a linear array that extends along a direction along which the leadframe housing is elongated. The contacts may be arranged edge-to-edge along the direction along which the linear array extends. The electrical contacts in one or more leadframe assemblies may form differential signal pairs. A differential signal pair may consist of two contacts that carry a differential signal. The value, or amplitude, of the differential signal may be the difference between the individual voltages on each contact. The contacts that form the pair may be broadside-coupled (*i.e.*, arranged such that the broadside of one contact faces the broadside of the other contact with which it forms the pair). Broadside or microstrip coupling is often desirable as a mechanism to control (e.g., minimize or eliminate) skew between the contacts that form the differential signal pair.

[0002] US 2005/0164555 discloses high-density electrical connectors with arrays of differential signal pairs and ground contacts.

[0003] When designing a printed circuit board (PCB), circuit designers typically establish a desired differential impedance for the traces on the PCB that form differential signal pairs. Thus, it is usually desirable to maintain the same desired impedance between the differential signal contacts in the electrical connector, and to maintain a constant differential impedance profile along the lengths of the differential signal contacts from their mating ends to their mounting ends. It may further be desirable to minimize or eliminate insertion loss (*i.e.*, a decrease in signal amplitude resulting from the insertion of the electrical connector into the signal's path). Insertion loss may be a function of the electrical connector's operating frequency. That is, insertion loss may be a greater at higher operating frequencies.

[0004] Therefore, a need exists for a high-speed electrical connector that minimizes insertion loss at higher operating frequencies while maintaining a desired differential impedance between differential signal contacts.

SUMMARY

[0005] The disclosed embodiments include an electrical circuit with an electrical connector having at least four electrical contacts that form two pairs of differential signal contacts. The first and second electrical contacts are arranged edge-to-edge along a first direction. The third electrical contact is adjacent to, and arranged broadside-to-broadside with, the first electrical contact along a sec-

ond direction substantially transverse to the first direction. The first and third electrical contacts define one of the pairs of differential signal contacts. The fourth electrical contact is adjacent to, and arranged broadside-to-broadside with, the second electrical contact along the second direction. The second and fourth electrical contacts define the other pair of differential signal contacts. The two pairs of differential signal contacts are offset from one another along the second direction.

[0006] The electrical connector may include one or more non-air dielectrics, such as a first non-air dielectric disposed between the first and third electrical contacts that form the one pair of differential signal contacts, and a second non-air dielectric disposed between the second and fourth electrical contacts that form the other pair of differential signal contacts.

[0007] The electrical connector may further include one or more ground contacts. For example, the electrical connector may include a first ground contact adjacent to, and arranged edge-to-edge with, the first electrical contact along the first direction. The electrical connector may also include second ground contact adjacent to, and arranged edge-to-edge with, the third electrical contact along the first direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIGs. 1A and 1B depict a portion of a prior-art connector system, in isometric and side views, respectively.

FIG. 1C depicts a contact arrangement of the prior-art connector system shown in FIGs. 1A and 1B.

FIGs. 2A and 2B depict a portion of a connector system, in isometric and side views, respectively, according to an embodiment not part of the present invention.

FIG. 2C depicts an example dielectric material that may be disposed between leadframe assemblies of a plug connector shown in FIGs. 2A and 2B.

FIG. 2D depicts an example contact arrangement of the plug connector shown in FIGs. 2A and 2B.

FIGs. 3A and 3B depict a portion of a connector system, in isometric and side views, respectively, according to another embodiment not part of the present invention.

FIG. 3C depicts an example contact arrangement of a plug connector shown in FIGs. 3A and 3B.

FIGs. 4A and 4B depict a portion of a connector system, in isometric and side views, respectively, according to another embodiment not part of the present invention.

FIG. 4C depicts an example contact arrangement of a plug connector shown in FIGs. 4A and 4B.

FIGs. 5A and 5B depict a portion of a connector, in isometric and rear views, respectively, according to an embodiment of the present invention.

FIG. 5C depicts an example contact arrangement of the connector shown in FIGs. 5A and 5B.

FIG. 6 is a comparison plot of differential insertion loss versus frequency exhibited by the connector shown in FIGs. 5A-5C.

FIG. 7 is a comparison plot of differential impedance versus time exhibited by the connector shown in FIGs. 5A-5C.

FIG. 8 is a table summarizing multi-active, worst-case crosstalk exhibited by the connector shown in FIGs. 5A-5C.

FIGs. 9A and 9B depict a portion of a connector, in isometric views, according to another embodiment of the present invention.

FIG. 9C depicts an example contact arrangement of the connector shown in FIGs. 9A and 9B.

FIG. 10 is a comparison plot of differential insertion loss versus frequency exhibited by the connector shown in FIGs. 9A-9C.

FIG. 11 is a comparison plot of differential impedance versus time exhibited by the connector shown in FIGs. 9A-9C.

FIG. 12 is a table summarizing multi-active, worst-case crosstalk exhibited by the connector shown in FIGs. 9A-9C.

FIGs. 13A and 13B depict a portion of a connector, in isometric views, according to another embodiment of the present invention.

FIG. 13C depicts a rear view of a portion of the connector shown in FIGs. 13A and 13B.

FIG. 13D depicts an example contact arrangement of the connector shown in FIGs. 13A-13C.

FIG. 14 is a comparison plot of differential insertion loss versus frequency exhibited by the connector shown in FIGs. 13A-13D.

FIG. 15 is a comparison plot of differential impedance versus time exhibited by the connector shown in FIGs. 13A-13D.

FIG. 16 is a table summarizing multi-active, worst-case crosstalk exhibited by the connector shown in FIGs. 13A-13D.

FIG. 17 depicts an example contact arrangement of an electrical connector according to another embodiment of the present invention in which differential signal contacts are arranged edge-to-edge.

DETAILED DESCRIPTION

[0009] FIGs. 1A and 1B depict isometric and side views, respectively, of a prior art connector system 100. The connector system 100 includes a plug connector 102 mated to a receptacle connector 104. The plug connector 102 may be mounted to a first substrate, such as a printed circuit board 106. The receptacle connector 104 may be mounted to a second substrate, such as a printed circuit board 108. The plug connector 102 and the receptacle connector 104 are shown as vertical connectors. That is, the plug connector 102 and the receptacle connector 104

each define mating planes that are generally parallel to their respective mounting planes.

[0010] The plug connector 102 may include a connector housing, a base 110, leadframe assemblies 126, and electrical contacts 114. The connector housing of the plug connector 102 may include an interface portion 105 that defines one or more grooves 107. As will be further discussed below, the grooves 107 may receive a portion of the receptacle connector 104 and, therefore, may help provide mechanical rigidity and support to the connector system 100.

[0011] Each of the leadframe assemblies 126 of the plug connector 102 may include a first leadframe housing 128 and a second leadframe housing 130. The first leadframe housing 128 and the second leadframe housing 130 may be made of a dielectric material, such as plastic, for example. The leadframe assemblies 126 may be insert molded leadframe assemblies (IMLAs) and may house a linear array of electrical contacts 114. For example, as will be further discussed below, the array of electrical contacts 114 may be arranged edge-to-edge in each lead frame assembly 126, i.e., the edges of adjacent electrical contacts 114 may face one another.

[0012] The electrical contacts 114 of the plug connector 102 may each have a cross-section that defines two opposing edges and two opposing broadsides. Each electrical contact 114 may also define at least three portions along its length. For example, as shown in FIG. 1B, each electrical contact 114 may define a mating end 116, a lead portion 118, and a terminal end 121. The mating end 116 may be blade-shaped, and may be received by a respective electrical contact 136 of the receptacle connector 104. The terminal end 121 may be "compliant" and, therefore, may be press-fit into an aperture 124 of the base 110. The terminal end 121 may electrically connect with a ball grid array (BGA) 125 on a substrate face 122 of the base 110. The lead portion 118 of the electrical contact 114 may extend from the terminal end 121 to the mating end 116.

[0013] The base 110 of the plug connector 102 may be made of a dielectric material, such as plastic, for example. The base 110 may define a plane having a connector face 120 and the substrate face 122. The plane defined by the base 110 may be generally parallel to a plane defined by the printed circuit board 106. As shown in FIG. 1A, the connector face 120 of the base 110 may define the apertures 124 that receive the terminal ends 121 of the electrical contacts 114. The substrate face 122 of the base 110 may include the BGA 125, which may electrically connect the electrical contacts 114 to the printed circuit board 106.

[0014] The receptacle connector 104 may include a connector housing, a base 112, leadframe assemblies 132, and electrical contacts 136. The connector housing of the receptacle connector 104 may include an interface portion 109 that defines one or more ridges 111. Upon mating the plug connector 102 and the receptacle connector 104, the ridges 111 on the connector housing of

the receptacle connector 104 may engage with the grooves 107 on the connector housing of the plug connector 102. Thus, as noted above, the grooves 107 and the ridges 11 may provide mechanical rigidity and support to the connector system 100.

[0015] Each of the leadframe assemblies 132 of the receptacle connector 104 may include a leadframe housing 133. The leadframe housing 133 may be made of a dielectric material, such as plastic, for example. Each of the leadframe assemblies 132 may be an insert molded leadframe assembly (IMLAs) and may house a linear array of electrical contacts 136. For example, the array of electrical contacts 136 may be arranged edge-to-edge in the leadframe assembly 132, *i.e.*, the edges of adjacent electrical contacts 136 may face one another.

[0016] Like the electrical contacts 114, the electrical contacts 136 of the receptacle connector 104 may have a cross-section that defines two opposing edges and two opposing broadsides. Each electrical contact 136 may define at least three portions along its length. For example, as shown in FIG. 1B, each electrical contact 136 may define a mating end 141, a lead portion 144, and a terminal end 146. The mating end 141 of the electrical contact 136 may be any receptacle for receiving a male contact, such as the blade-shaped mating end 116 of the electrical contact 114. For example, the mating end 141 may include at least two-opposing tines 148 that define a slot therebetween. The slot of the mating end 141 may receive the blade-shaped mating end 116 of the electrical contacts 114. The width of the slot (*i.e.*, the distance between the opposing tines 148) may be smaller than the thickness of the blade-shaped mating end 116. Thus, the opposing tines 148 may exert a force on each side of the blade-shaped mating end 116, thereby retaining the mating end 116 of the of the electrical contact 114 in the mating end 141 of the electrical contact 136. Alternatively, as shown in FIG. 1A, the mating end 141 may include a single tine 148 that is configured to make contact with one side of the blade-shaped mating end 116.

[0017] The terminal end 146 of the electrical contact 136 may be "compliant" and, therefore, may be press-fit into an aperture (not shown) of the base 112. The terminal end 146 may electrically connect with a ball grid array (BGA) 142 on a substrate face 140 of the base 112. The lead portion 144 of each electrical contact 136 may extend from the terminal end 146 to the mating end 141.

[0018] The base 112 of the receptacle connector 104 may be made of a dielectric material, such as plastic, for example. The base 112 may define a plane having a connector face 138 and the substrate face 140. The plane defined by the base 112 may be generally parallel to a plane defined by the printed circuit board 108. The connector face 138 may define apertures (not shown) for receiving the terminal ends 146 of electrical contacts 136. Although the apertures of the base 112 are not shown in FIGs. 1A and 1B, the apertures in the connector face 138 of the base 112 may be the same or similar to the apertures 124 in the connector face 120 of the base 110. The

substrate face 140 may include the BGA 142, which may electrically connect the electrical contacts 136 to the printed circuit board 108.

[0019] FIG. 1C depicts a contact arrangement 190, viewed from the face of the plug connector 102, in which the electrical contacts 114 are arranged in linear arrays. As shown in FIG. 1C, the electrical contacts 114 may be arranged in a 5 x 4 array, though it will be appreciated that the plug connector 102 may include any number of the electrical contacts 114 arranged in various configurations. As shown, the plug connector 102 may include contact rows 150, 152, 154, 156, 158 and contact columns 160, 162, 164, 166.

[0020] As noted above, each of the electrical contacts 114 may have a cross-section that defines two opposing edges and two opposing broadsides. The electrical contacts 114 may be arranged edge-to-edge along each of the columns 160, 162, 164, 166. In addition, the electrical contacts 114 may be arranged broadside-to-broadside along each of the rows 150, 152, 154, 156, 158. As shown in FIG. 1C, the broadsides of the electrical contacts 114 in the rows 150, 154, 158 may be smaller than the broadsides of the electrical contacts 114 in the rows 152, 156. Each of the electrical contacts 114 may be surrounded on all sides by a dielectric 176, which may be air.

[0021] The electrical contacts 114 in the plug connector 102 may include ground contacts G and signal contacts S. As shown in FIG. 1C, the rows 150, 154, 158 of the plug connector 102 may include all ground contacts G. The rows 152, 156 of the plug connector 102 may include both ground contacts G and signal contacts S. For example, the electrical contacts 114 in the rows 152, 156 may be arranged in a G-S-S-G pattern. As noted above, the electrical contacts 114 may be arranged broadside-to-broadside along each of the rows 150, 152, 154, 156, 158. Accordingly, adjacent signal contacts S in rows 152, 156 may form broadside coupled differential signal pairs, such as the differential signal pairs 174 shown in FIG. 1C.

[0022] FIGs. 2A and 2B depict isometric and side views, respectively, of a connector system 200 according to an embodiment not part of the present invention. The connector system 200 may include a plug connector 202 mated to the receptacle connector 104. The plug connector 202 may be mounted to the printed circuit board 106. The receptacle connector 104 may be mounted to the printed circuit board 108. The plug connector 202 and the receptacle connector 104 are shown as vertical connectors. However, it will be appreciated that either or both of the plug connector 202 and the receptacle connector 104 may be right-angle connectors in alternative embodiments.

[0023] The plug connector 202 may include the base 110, leadframe assemblies 126, and electrical contacts 114. As shown in FIG. 2B, the plug connector 202 may further include a non-air dielectric, such as a dielectric material 204, positioned between adjacent leadframe assemblies 126. In particular, the dielectric material 204

may be positioned between the adjacent leadframe assemblies that house one or more signal contacts S. The dielectric material 204 may be made from any suitable material, such as plastic, for example. The dielectric material 204 may be molded as part of the leadframe assemblies 126. Alternatively, the dielectric material 204 may be molded independent of the leadframe assemblies 126 and subsequently inserted therebetween.

[0024] FIG. 2C depicts a side view of the dielectric material 204. As shown in FIG. 2C, the dielectric material 204 may include header portions 205a, 205b, that extend substantially parallel to one another. The dielectric material may further include interconnecting portions 206a, 206b that extend substantially parallel to one another and substantially perpendicular to the header portions 205a, 205b. The interconnecting portions 206a, 206b may connect the header portion 205a to the header portion 205b.

[0025] As noted above with respect to FIGs. 2A and 2B, the dielectric material 204 may be disposed between adjacent leadframe assemblies 126 having signal contacts S (*i.e.*, the inner leadframe assemblies 126 shown in FIGs. 2A and 2B). More specifically, the header portion 205a of the dielectric material 204 may be adjacent to the first leadframe housing 128 and may extend along a length thereof. The header portion 205b of the dielectric material 204 may be adjacent to the second leadframe housing 130 and may extend along a length thereof. Thus, the header portions 205a, 205b may be disposed adjacent to at least a portion of each electrical contact 114 in the inner leadframe assemblies 126. The interconnecting portions 206a, 206b of the dielectric material 204 may extend substantially parallel to the electrical contacts 114 in the inner leadframe assemblies 126. In particular, as will be further discussed below, the interconnecting portions 206a, 206b may extend along the lengths of each signal contact housed in the inner leadframe assemblies 126.

[0026] FIG. 2D depicts a contact arrangement 290, viewed from the face of the plug connector 202, that includes the linear arrays of electrical contacts 114 and a portion of the dielectric material 204. Like the contact arrangement depicted in FIG. 1C, the electrical contacts 114 may be arranged in a 5 x 4 array and may define contact rows 150, 152, 154, 156, 158 and contact columns 160, 162, 164, 166. The electrical contacts 114 in the plug connector 202 may have a cross-section that defines two opposing edges and two opposing broadsides. The electrical contacts 114 may be arranged edge-to-edge along each of the columns 160, 162, 164, 166. In addition, the electrical contacts 114 may be arranged broadside-to-broadside along each of the rows 150, 152, 154, 156, 158. The broadsides of the electrical contacts 114 in the rows 150, 154, 158 may be smaller than the broadsides of the electrical contacts 114 in the rows 152, 156.

[0027] The electrical contacts 114 in the plug connector 202 may also include ground contacts G and signal contacts S. The rows 150, 154, 158 of the plug connector

202 may include all ground contacts G, and the rows 152, 156 may include both ground contacts G and signal contacts S. For example, the electrical contacts 114 in the rows 152, 156 may be arranged in a G-S-S-G pattern.

5 The electrical contacts 114 may be arranged broadside-to-broadside along each of the rows 150, 152, 154, 156, 158. Accordingly, adjacent signal contacts S in rows 152, 156 may form broadside coupled differential signal pairs 174.

10 **[0028]** As shown in FIG. 2D, the interconnecting portions 206a, 206b of the dielectric material 204 may define a generally rectangular cross-section and may be positioned between adjacent signal contacts S in the columns 162, 164. That is, the interconnecting portions 206a, 206b may be positioned between the signal contacts S of each broadside-coupled differential signal pair 174 in the plug connector 202. In addition, each of the electrical contacts 114 may be surrounded on all sides by the dielectric 176, which may be different than the dielectric material 204 disposed between the broadside-coupled differential signal pairs 174.

15 **[0029]** As further shown in FIG. 2D, the interconnecting portions 206a, 206b may extend a greater distance than each of the electrical contacts 114 in the direction of the rows 150, 152, 154, 156, 158 (*i.e.*, the interconnecting portions 206a, 206b may be wider than the electrical contacts 114), though it will be appreciated that the widths of the interconnecting portions 206a, 206b may be equal to or less than the widths of the electrical contacts 114 in other embodiments. In addition, the interconnecting portions 206a, 206b may extend substantially the same distance as each of the electrical contacts 114 in the direction of the contact columns 160, 162, 164, 166 (*i.e.*, the height of each of the interconnecting portions 206a, 206b may be substantially the same as the heights of the electrical contacts 114 in the contact rows 152, 156), though it will be appreciated that the heights of the interconnecting portions 206a, 206b may be greater than or less than the heights of the electrical contacts 114 in other embodiments.

20 **[0030]** FIGs. 3A and 3B depict isometric and side views, respectively, of a connector system 300 according to another embodiment not part of the present invention. The connector system 300 includes a plug connector 302 mated to the receptacle connector 104. The plug connector 302 may be mounted to the printed circuit board 106. The receptacle connector 104 may be mounted to the printed circuit board 108. The plug connector 302 and the receptacle connector 104 are shown as vertical connectors. However, it will be appreciated that either or both of the plug connector 302 and the receptacle connector 104 may be right-angle connectors in alternative embodiments.

25 **[0031]** The plug connector 302 may include the base 110, leadframe assemblies 126, and electrical contacts 114. As shown in FIG. 3A, the plug connector 302 may further include a commoned ground plate 178 housed in at least one of the leadframe assemblies 126. The com-

moned ground plate 178 may be a continuous, electrically conductive sheet that extends along an entire contact column and that is brought to ground, thereby shielding all electrical contacts 114 adjacent to the commoned ground plate 178. The commoned ground plate 178 may include a plate portion 180, terminal ends 182, and mating interfaces 184.

[0032] More specifically, the plate portion 180 of the commoned ground plate 178 may be housed within the leadframe assembly 126, and may extend from the terminal ends 182 to the mating interfaces 184. As shown in FIG. 3A, the commoned ground plate 178 may include terminal ends 182 extending from the plate portion 180, and extending from the second leadframe housing 130 of the leadframe assembly 126. The terminal ends 182 may be compliant and may, therefore, be press-fit into the apertures 124 of the base 110. The terminal ends 182 of the commoned ground plate 178 may electrically connect with the BGA 125 on the bottom side 122 of the base 110.

[0033] The commoned ground plate 178 may also include mating interfaces 184 extending from the plate portion 180, and extending above the first leadframe housing 128 of the lead frame assembly 126. The mating interfaces 184 may be blade-shaped, and may be received by the respective mating ends 141 of the electrical contacts 136.

[0034] FIG. 3C depicts a contact arrangement 390, viewed from the face of the plug connector 302, that includes linear arrays of electrical contacts 114 and commoned ground plates 178a, 178b. The electrical contacts 114 and the commoned ground plates 178a, 178b may be arranged in a 5 x 4 array and may define contact rows 150, 152, 154, 156, 158 and contact columns 160, 162, 164, 166. Like the contact arrangement depicted in FIG. 1C, the electrical contacts 114 in the plug connector 302 may have a cross-section that defines two opposing edges and two opposing broadsides. The electrical contacts 114 may be arranged edge-to-edge along each of the columns 162, 164. In addition, the electrical contacts 114 may be arranged broadside-to-broadside along each of the rows 150, 152, 154, 156, 158. The broadsides of the electrical contacts 114 in the rows 150, 154, 158 may be smaller than the broadsides of the electrical contacts 114 in the rows 152, 156.

[0035] The commoned ground plates 178a, 178b may be positioned adjacent to the contact columns 162, 164, respectively. Thus, as shown in FIG. 3C, the commoned ground plates 178a, 178c may replace the ground contacts G in the contact columns 160, 166 shown in FIG. 1C.

[0036] The electrical contacts 114 in the plug connector 302 may include ground contacts G and signal contacts S. The rows 150, 154, 158 of the plug connector 302 may include all ground contacts G, and the rows 152, 156 may include both ground contacts G and signal contacts S. For example, the commoned ground plates 178a, 178b and the electrical contacts 114 in the rows 152, 156 may be arranged in a G-S-S-G pattern. The electrical

contacts 114 may be arranged broadside-to-broadside along each of the rows 150, 152, 154, 156, 158. Accordingly, adjacent signal contacts S in rows 152, 156 may form broadside coupled differential signal pairs 174.

[0037] The commoned ground plates 178a, 178b may each have a cross-section that is generally rectangular in shape. As shown in FIG. 3C, the commoned ground plates 178a, 178b may each extend substantially the entire length of the contact columns 160, 162, 164, 166. The commoned ground plates 178a, 178b may also extend substantially the same distance as each of the electrical contacts 114 in the direction of the contact rows (i.e., each of the commoned ground plates 178a, 178b may have substantially the same width as the electrical contacts 114), though it will be appreciated that the widths of the commoned ground plates 178a, 178b may be less than or greater than the widths of the electrical contacts 114 in other embodiments. The electrical contacts 114 and the commoned ground plates 178a, 178b may be surrounded on all sides by the dielectric 176.

[0038] FIGs. 4A and 4B depict isometric and side views, respectively, of a connector system 400 according to another embodiment not part of the present invention. The connector system 400 may include a plug connector 402 mated to the receptacle connector 104. The plug connector 402 may be mounted to the printed circuit board 106. The receptacle connector 104 may be mounted to the printed circuit board 108. The plug connector 402 and the receptacle connector 104 are shown as vertical connectors. However, either or both of the plug connector 402 and the receptacle connector 104 may be right-angle connectors in alternative embodiments. The plug connector 402 may include the base 110, the leadframe assemblies 126, the electrical contacts 114, the commoned ground plates 178a, 178b, and the dielectric material 204.

[0039] FIG. 4C depicts a contact arrangement 490, viewed from the face of the plug connector 402, that includes linear arrays of electrical contacts 114, the commoned ground plates 178a, 178b and the dielectric material 204. As shown in FIG. 4C, the interconnecting portions 206a, 206b of the dielectric material 204 may define a generally rectangular cross-section and may be positioned between the signal contacts S in the contact columns 162, 164. That is, the interconnecting portions 206a, 206b may be positioned between the broadside-coupled differential signal pairs 174 in the contact columns 162, 164. In addition, each of the electrical contacts 114 and the commoned ground plates 178a, 178b may be surrounded on all sides by the dielectric 176, which may be different than the dielectric material 204 disposed between the broadside-coupled differential signal pairs 174.

[0040] As further shown in FIG. 4C, the commoned ground plates 178a, 178b may be positioned adjacent to the contact columns 162, 164, respectively. Thus, the commoned ground plates 178a, 178b may replace the ground contacts G in the contact columns 160, 166

shown in FIG. 1C. The commoned ground plates 178a, 178b may each have a cross-section that is generally rectangular in shape. As shown in FIG. 4C, the commoned ground plates 178a, 178b may each extend substantially the entire length of the contact columns 160, 162, 164, 166. The commoned ground plates 178a, 178b may also extend substantially the same distance as each of the electrical contacts 114 in the direction of the contact rows (*i.e.*, each of the commoned ground plates 178a, 178b may have the same width as the electrical contacts 114), though it will be appreciated that the widths of the of the commoned ground plates 178a, 178b may be less than or greater than the widths of the electrical contacts 114 in other embodiments.

[0041] It has also been found that the foregoing embodiments break up the coupling wave that moves up the connector causing a dB "suck out" about the 4 GHz region. An object of the plastic is to change the impedance slightly between signal and ground to minimize the coupling wave. The ground plane is to minimize the signal pair coupling to the ground individual pin edge and to provide a continuous ground plane.

[0042] FIGs. 5A and 5B depict isometric and rear views, respectively, of a connector 500 according to an embodiment of the present invention. The connector 500 may be a plug connector or a receptacle connector. The connector 500 may be devoid of ground plates and/or crosstalk shields. The connector 500 may be mounted to a printed circuit board 510, which may include one or more via holes 512. The connector 500 is shown as a right-angle connector. However, it will be appreciated that the connector 500 may be a vertical connector in alternative embodiments.

[0043] The connector 500 may include a connector housing (not shown), one or more leadframe assemblies (not shown), and electrical contacts 502. Each leadframe assembly may be an IMLA and may house a linear array of the electrical contacts 502. For example, the electrical contacts 502 in each linear array may be arranged edge-to-edge, *i.e.*, the edges of adjacent electrical contacts 502 may face one another.

[0044] Each electrical contact 502 may define at least three portions along its length. For example, each electrical contact 502 may define a mating end 544, a lead portion 546, and a terminal end 548. As shown in FIG. 5A, each mating end 544 may be blade-shaped and may be adapted to be received via a corresponding female contact (not shown). Alternatively, each mating end 544 may include one or more tines that are adapted to mate with one or more sides of a corresponding male contact (not shown). Each terminal end 548 may be configured to attach to the printed circuit board 510 in any suitable manner. For example, each terminal end 548 may be press-fit into one of the via holes 512 defined by the printed circuit board 510, or may be surface mounted to the printed circuit board 510 with fusible elements such as solder balls. Each lead portion 546 may extend from the terminal end 548 to the mating end 544. As will be further

discussed below, the electrical contacts 502 of the connector 500 may include signal contacts S and/or ground contacts G.

[0045] The connector 500 may further include a non-air dielectric, such as a dielectric material 508, positioned between adjacent leadframe assemblies. In particular, the dielectric material 508 may be positioned between adjacent signal contacts S housed by respective adjacent leadframe assemblies. The dielectric material 508 may be made from any suitable material, such as plastic, for example. The dielectric material 508 may be molded as part of the leadframe assemblies, or may be molded independent of the leadframe assemblies and subsequently inserted therebetween.

[0046] FIG. 5C depicts a contact arrangement 514, viewed from the face of the connector 500, that includes linear arrays of the electrical contacts 502. The electrical contacts 502 may be arranged in a 5 x 9 array and may define contact rows 516, 518, 520, 522, 524 and contact columns 526, 528, 530, 532, 534, 536, 538, 540, 542, though any suitable configuration is consistent with an embodiment. Each column 526, 528, 530, 532, 534, 536, 538, 540, 542 may correspond to an IMLA. As shown in FIG. 5C, each electrical contact 502 in the connector 500 may have a cross-section that defines two opposing edges and two opposing broadsides. As further shown in FIG. 5C, the broadsides of the ground contacts G may be larger than the broadsides of the signal contacts S. For example, the lengths of the broadsides of the ground contacts G in the direction of the columns 526, 528, 530, 532, 534, 536, 538, 540, 542 may be longer than the lengths of the signal contact S in the same direction. In an embodiment, the lengths of the broadsides of the ground contacts G may be approximately two times greater than the lengths of the broadsides of the signal contacts S.

[0047] The electrical contacts 502 may be arranged edge-to-edge along each of the columns 526, 528, 530, 532, 534, 536, 538, 540, 542. In addition, the electrical contacts 502 may be arranged broadside-to-broadside along each of the rows 516, 518, 520, 522, 524. Adjacent signal contacts S in each of the rows 516, 518, 520, 522, 524 may form a pair of differential signal contacts 504. A ground contact G may be disposed between each pair of differential signal contacts 504 in the rows 516, 518, 520, 522, 524. In addition, the dielectric material 508 may be disposed between the signal contacts S of each pair of differential signal contacts 504. The dielectric material 508 may be used to increase field strength within the pair of differential signal contacts 504 while not increasing pair-to-pair coupling, crosstalk, and/or noise. Moreover, the ground contacts G and the signal contacts S may be surrounded on all sides by a dielectric 506, which may be air.

[0048] Referring back to FIG. 5A, the dielectric material 508 may extend along a length of the respective signal contacts S in each pair of differential signal contacts 504 (*i.e.*, from approximately the mating end 544 to the ter-

minal end 548 of each signal contact S). Moreover, the signals contacts S of a respective pair of differential signal contacts 504 may have substantially equal lengths as measured between the mating ends 544 and the terminal ends 548 of the signal contacts S. Thus, each pair of differential signal contacts 504 may exhibit approximately zero signal skew.

[0049] Each of the contact columns 526, 528, 530, 532, 534, 536, 538, 540, 542 may define a contact pattern, *i.e.*, an arrangement of ground contacts G and signal contacts S. For example, the electrical contacts 502 in the column 526 may be arranged (moving from top to bottom) in a G-S-S-G-S pattern. The electrical contacts 502 in the column 528 may be arranged in a S-G-S-S-G pattern, though it will be appreciated that the contact pattern in the column 528 may be the same as the contact pattern in the column 526 when viewed from bottom to top. The electrical contacts 502 in the column 530 may be arranged in a S-S-G-S-S pattern, which may be different from the respective contact patterns in the columns 526, 528.

[0050] The contact patterns in the columns 526, 528, 530 may be repeated in the remaining columns, *i.e.*, the column 532 may have the same contact pattern as the column 526, the column 534 may have the same contact pattern as the column 528, the column 536 may have the same contact pattern as the column 530, and so on. Thus, each pair of differential signal contacts 504 in the row 518 may be offset (along the row-direction) by one full column pitch from the nearest pair of differential signal contacts 504 in the row 516. Similarly, each pair of differential signal contacts 504 in the row 520 may be offset (along the row-direction) by one full column pitch from the nearest pair of differential signal contacts 504 in the row 518. It will be appreciated that some of the signal contacts S may be neutral contacts, or "extra pins," and may not be needed for the formation of a pair of differential signal contacts 504.

[0051] As shown in FIG. 5C, one of the signal contacts S from each pair of differential signal contacts 504 in the rows 516, 518, 520, 522, 524 may form an array defined by an imaginary line 550. For example, the line 550 may extend from an approximate center point on a side of a signal contact S in the column 528 to an approximate center point on the same side of another signal contact S in the column 536. Similarly, the ground contacts G in rows 516, 518, 520, 522, 524 may also form an array defined by an imaginary line 552. For example, the line 552 may extend from an approximate center point on a side of a ground contact G in the column 532 to an approximate center point on the same side of another ground contact G in the column 540.

[0052] It will be appreciated that the imaginary lines 550, 552 may extend from any suitable point on the same sides of the signal contact S and the ground contacts G, respectively. It will be further appreciated that the imaginary lines 550, 552 may each define an oblique angle with respect to the direction of the columns 526, 528,

530, 532, 534, 536, 538, 540, 542. The oblique angles defined by the lines 550, 552 may be substantially the same or may differ from one another. As shown in FIG. 5C, the array formed along the line 550 by the pairs of differential signal contacts 504 may be disposed between two arrays formed along respective lines 552 by the ground contacts G.

[0053] The offset of the ground contacts G from row-to-row may be none, less than a column pitch, equal to a column pitch, or more than a column pitch. Similarly, the offset of the pairs of differential signal contacts 504 from row-to-row may be none, less than a column pitch, equal to a column pitch, or more than a column pitch. A row-to-row centerline spacing A may be about 1.4mm to 2.5mm, with approximately 2mm the preferred spacing. A column-to-column centerline spacing B may be about 1.3mm to 2.5mm, with approximately 1.8mm the preferred spacing. A ground-to-ground spacing C in each column may be about 3.9mm to 6mm, with approximately 5.4mm the preferred spacing. A signal-to-signal spacing D in each column may be about 1.2mm, but can be in a range of about 0.3mm to 2mm. A material thickness E of the ground contacts G and/or the signal contacts S may be in a range of 0.2mm to 0.4mm, with approximately 0.35mm the preferred thickness. A height F of each ground contact G is preferably about 2.4mm, but the height F may range from about 1mm to 2.9mm. A spacing J between a ground contact G and an adjacent signal contact S in a column may be about 0.4mm, but can be in a range of 0.2mm to 0.7mm. A gap distance H between signal contacts S that define a pair of differential signal contacts 504 is about 0.2mm to 2.5mm, with a gap distance of about 1.8mm preferred with the dielectric material 508 disposed between the signal contacts S that form the pair. However, the signal contacts S in a column may be offset from the array centerline spacing by a material stock thickness or more, with a approximate 0.2mm to 0.3mm offset in opposite directions preferred.

[0054] In the embodiment of the present invention, the column 528 includes a first signal contact S and a second signal contact S arranged edge-to-edge along the column 528. The column 526 includes a third signal contact S adjacent to the first signal contact S in the column 528. The column 530 includes a fourth signal contact S adjacent to the second signal contact S in the column 528. As shown in FIG. 5C, the first and third signal contacts are arranged broadside-to-broadside and the second and fourth signal contacts are arranged broadside-to-broadside in a direction substantially perpendicular to the column 528. The first and third signal contacts define a first pair of differential signal contacts 504 and the second and fourth signal contacts define a second pair of differential signal contacts 504. As further shown in FIG. 5C, the first and second pairs of differential signal contacts 504 are offset from one another in the direction substantially perpendicular to the column 528.

[0055] FIG. 6 is a comparison plot 600 of differential insertion loss versus frequency exhibited by four pairs of

differential signal contacts 504 in the connector 500. As shown in FIG. 6, the connector 500 may exhibit an insertion loss suck out of approximately - 1.5 dB in the 4 to 6 GHz frequency range.

[0056] FIG. 7 is a comparison plot 700 of differential impedance versus time exhibited by the four pairs of the differential signal contacts 504 in the connector 500. As shown in FIG. 7, the connector 500 may exhibit a differential impedance of approximately 100 ohms plus or minus 6%.

[0057] FIG. 8 is a table 800 summarizing multi-active, worst-case crosstalk exhibited by the four pairs of differential signal contacts 504 in the connector 500. As shown in FIG. 8, the connector 500 may exhibit a multi-active, worst case crosstalk in a range of about 2.6% to 5.5%. Far end crosstalk is shown in the upper two quadrants of FIG. 8, and near end crosstalk is shown in the lower two quadrants of FIG. 8. Although rise time is indicated as 50 (10-90%) picoseconds, the measurement may be between 35-1000 (10-90% or 20-80%) picoseconds. These values generally may correspond to data transfer rates of about ten or more Gigabits per second to less than 622 Megabits per second.

[0058] FIGs. 9A and 9B depict isometric views of a connector 900 according to another embodiment of the present invention. FIG. 9C depicts a contact arrangement 902, viewed from the face of the connector 900, that includes linear arrays of the electrical contacts 502. Like the connector 500, the connector 900 may be devoid of ground plates and/or crosstalk shields. The connector 900 may be a right-angle connector that is mounted to the printed circuit board 510, though it will be appreciated that the connector 900 may be a vertical connector in alternative embodiments.

[0059] The connector 900 generally may include the same features and/or elements as the connector 500, such as one or more leadframe assemblies (not shown) for housing linear arrays of the electrical contacts 502 and a dielectric material 508 disposed between adjacent signal contacts S. As shown in FIGs. 9A and 9B, the dielectric material 508 may extend along a length of the respective signal contacts S in each pair of differential signal contacts 504. In addition, the connector 900 may have the same or similar contact and contact spacing dimensions as the connector 500.

[0060] As shown in FIG. 9C, the connector 900 may differ from the connector 500 in that the connector 900 may be devoid of any ground contacts G. More specifically, the contact arrangement 902 may include one or more signal contacts S arranged edge-to-edge along each of the columns 526, 528, 530, 532, 534, 536, 538, 540, 542. In addition, the signal contacts S may be arranged broadside-to-broadside along each of the rows 516, 518, 520, 522, 524. Adjacent signal contacts S in each of the rows 516, 518, 520, 522, 524 may form pairs of differential signal contacts 504. Unlike the connector 500, a ground contact G may not be disposed between each pair of differential signal contacts 504 in the rows

516, 518, 520, 522, 524 of the connector 900.

[0061] FIG. 10 is a comparison plot 1000 of differential insertion loss versus frequency exhibited by four pairs of differential signal contacts 504 in the connector 900. As shown in FIG. 10, the connector 900 may exhibit an insertion loss suck out of approximately -0.5 dB in the 4 to 6 GHz frequency range.

[0062] FIG. 11 is a comparison plot 1100 of differential impedance versus time exhibited by the four pairs of the differential signal contacts 504 in the connector 900. As shown in FIG. 11, the differential impedance for all but one of the pairs of differential signal contacts 504 may be approximately 100 ohms plus or minus 10%. It will be appreciated that the differential impedance may be adjusted (*i.e.*, matched to a system impedance) by moving the signal contacts S that form a pair of differential signal contacts 504 closer together or farther apart, by increasing or decreasing the width of the signal contacts S, and/or by increasing or decreasing a dielectric constant in the gap between the signal contacts S.

[0063] FIG. 12 is a table 1200 summarizing multi-active, worst-case crosstalk exhibited by the four pairs of differential signal contacts 504 in the connector 900. As shown in FIG. 12, the connector 900 may exhibit a multi-active, worst case crosstalk in a range of about 2.7% to 4.1 %. Far end crosstalk is shown in the upper two quadrants of FIG. 12, and near end crosstalk is shown in the lower two quadrants of FIG. 12.

[0064] FIGs. 13A and 13B depict isometric views of a connector 1300 according to another embodiment of the present invention. FIG. 13C depicts a rear view of the connector 1300. FIG. 13D depicts a contact arrangement 1302, viewed from the face of the connector 1300, that includes linear arrays of the electrical contacts 502. Like the connector 500, the connector 1300 may be devoid of ground plates and/or crosstalk shields. The connector 1300 may be a right-angle connector that is mounted to the printed circuit board 510, though it will be appreciated that the connector 1300 may be a vertical connector in alternative embodiments.

[0065] The connector 1300 generally may include the same features and/or elements as the connector 500, such as one or more leadframe assemblies (not shown) for housing linear arrays of the electrical contacts 502. Each linear array may include the ground contacts G and the signal contacts S. In addition, the connector 1300 may have the same or similar contact and contact spacing dimensions as the connector 500 as well as the same or similar contact arrangements.

[0066] As shown in FIG. 13D, the connector 1300 may differ from the connector 500 in that the connector 1300 may not include the dielectric material 508 disposed between adjacent signal contacts S that form a pair of differential signal contacts 504. Moreover, a row-to-row centerline spacing K may be about 1.4mm to 3, with 1.65mm to 2mm being the preferred spacing. A column-to-column centerline spacing L is about 1.3mm to 2.5mm, with 1.4mm to 1.5mm being the preferred spacing.

[0067] FIG. 14 is a comparison plot 1400 of differential insertion loss versus frequency exhibited by four pairs of differential signal contacts 504 in the connector 1300. As shown in FIG. 14, the connector 1300 may exhibit an insertion loss of less than -0.5 dB up to 20 GHz and approximately zero suck out in a 0 to 20 GHz frequency range. In addition, the insertion loss values demonstrate minimal tapering in the 0 to 20 GHz frequency range. Consequently, the insertion loss for one or more of the pairs of differential signal contacts 504 may remain below -2 dB or less up to at least 40 GHz.

[0068] FIG. 15 is a comparison plot 1500 of differential impedance versus time exhibited by the four pairs of the differential signal contacts 504 in the connector 1300. As shown in FIG. 15, the differential impedance for all but one of the pairs of differential signal contacts 504 may be approximately 100 ohms plus or minus 10%. As noted above, the differential impedance may be adjusted (*i.e.*, matched to a system impedance) by moving the signal contacts S that form a pair of differential signal contacts 504 closer together or farther apart, by increasing or decreasing the width of the signal contacts S, and/or by increasing or decreasing a dielectric constant in the gap between the signal contacts S.

[0069] FIG. 16 is a table 1600 summarizing multi-active, worst-case crosstalk exhibited by the four pairs of differential signal contacts 504 in the connector 1300. As shown in FIG. 16, the connector 1300 may exhibit a multi-active, worst case crosstalk in a range of about 0.3% to 2.1%. Far end crosstalk is shown in the upper two quadrants of FIG. 16, and near end crosstalk is shown in the lower two quadrants of FIG. 16.

[0070] In one or more of the foregoing embodiments, at least a portion of the electrical contacts may be insert molded in plastic. Moreover, the electrical connectors may be configured for flat rock PCB press-fit insertion. For example, one or more linear arrays of electrical contacts may be laminated. Each laminated linear array may then be combined together to form a solid body or a collection of individual wafers. Alternatively, a four, five, or six sided box may be created around the electrical contacts. The interior of the box may then be filled with air, plastic, PCB material, or any combination thereof. The electrical connector may be mounted to a printed circuit board via solder balls, fusible elements, solder fillets, and the like.

[0071] FIG. 17 depicts a contact arrangement 1700 viewed from the face of an electrical connector according to another embodiment not part of the present invention in which differential signal contracts are arranged edge-to-edge. The contact arrangement 1700 may include linear arrays of electrical contacts 1732, which may include the ground contacts G and the signal contacts S. As shown in FIG. 17, the electrical contacts 1732 may be arranged in a 6 x 9 array and may define contact rows 1702, 1704, 1706, 1708, 1710, 1712 and contact columns 1714, 1716, 1718, 1720, 1722, 1724, 1726, 1728, 1730, though any suitable configuration is consistent with

an embodiment. Each column 1714, 1716, 1718, 1720, 1722, 1724, 1726, 1728, 1730 may correspond to an IM-LA. As shown in FIG. 17, each electrical contact 1732 in the connector may have a cross-section that defines two opposing edges and two opposing broadsides. As further shown in FIG. 17, the broadsides of the ground contacts G may be larger than the broadsides of the signal contacts S. For example, in an embodiment, the broadsides of the ground contacts G may be approximately two times greater than the broadsides of the signal contacts S.

[0072] The electrical contacts 1732 may be arranged edge-to-edge along each of the columns 1714, 1716, 1718, 1720, 1722, 1724, 1726, 1728, 1730. In addition, at least a portion of the electrical contacts 1732 may be arranged broadside-to-broadside along each of the rows 1702, 1704, 1706, 1708, 1710, 1712. Adjacent signal contacts S in each of the columns 1714, 1716, 1718, 1720, 1722, 1724, 1726, 1728, 1730 may form a pair of differential signal contacts 1734. A ground contact G may be disposed between each pair of differential signal contacts 1734 in the columns 1714, 1716, 1718, 1720, 1722, 1724, 1726, 1728, 1730. The ground contacts G and the signal contacts S may be surrounded on all sides by the dielectric 506.

[0073] Each of the contact columns 1714, 1716, 1718, 1720, 1722, 1724, 1726, 1728, 1730 may define a contact pattern. For example, the electrical contacts 1732 in the column 1714 may be arranged (moving from top to bottom) in a G-S-S-G-S-S pattern. The electrical contacts 1732 in the column 1716 may be arranged in a S-S-G-S-S-G pattern, though it will be appreciated that the contact pattern in the column 1716 may be the same as the contact pattern in the column 1714 when viewed from bottom to top. The electrical contacts 1732 in the column 1718 may be arranged in a S-G-S-S-G-S pattern, which may be different from the respective contact patterns in the columns 1714, 1716.

[0074] The contact patterns in the columns 1714, 1716, 1718 may be repeated in the remaining columns, *i.e.*, the column 1720 may have the same contact pattern as the column 1714, the column 1722 may have the same contact pattern as the column 1716, the column 1724 may have the same contact pattern as the column 1718, and so on. It will be appreciated that some of the signal contacts S may be neutral contacts, or "extra pins," and may not be needed for the formation of a pair of differential signal contacts 1734.

[0075] As shown in FIG. 17, the ground contacts G in rows 1702, 1704, 1706, 1708, 1710, 1712 may form one or more arrays defined by an imaginary line 1736. For example, one of the lines 1736 may extend from an approximate center point on a side of a ground contact G in the column 1716 to an approximate center point on the same side of another ground contact G in the column 1726. It will be appreciated that the imaginary lines 1736 may extend from any suitable point on the same sides of the ground contacts G. Each imaginary line 1736 may define an oblique angle with respect to the direction of

the columns 1714, 1716, 1718, 1720, 1722, 1724, 1726, 1728, 17302. The oblique angles defined by each line 1736 may be substantially the same or may differ from one another.

Claims

1. An electrical circuit with an electrical connector (500) comprising:

a first electrical contact (502) and a second electrical contact arranged edge-to-edge along a first direction (526, 528, 530, 532, 534, 536, 538, 540, 542);

a third electrical contact adjacent the first electrical contact along a second direction (516, 518, 520, 522, 524) substantially transverse to the first direction, wherein the first and third electrical contacts are arranged broadside-to-broadside; and

a fourth electrical contact adjacent the second electrical contact along the second direction, wherein the second and fourth electrical contacts are arranged broadside-to-broadside, **characterized in that** the first and third electrical contacts define a first pair (504) of differential signal contacts (S), the second and fourth electrical contacts, define a second pair (504) of differential signal contacts, and the first and second pairs of differential signal contacts are offset from one another along the second direction.

2. The electrical circuit of claim 1 further comprising a first non-air dielectric (508) disposed between the first and third electrical contacts of the first pair (504) of differential signal contacts and a second non-air dielectric disposed between the second and fourth electrical contacts of the second pair of differential signal contacts.

3. The electrical circuit of claim 2, wherein at least one of the first or second non-air dielectrics (508) include a plastic material.

4. The electrical circuit of claim 2, wherein the first and third electrical contacts (504) are housed in a first leadframe assembly and a second leadframe assembly, respectively, and wherein the first non-air dielectric (508) is molded independent of the first and second leadframe assemblies.

5. The electrical circuit of claim 1 further comprising:

a first ground contact (G) adjacent the first electrical contact, wherein the first ground contact and the first electrical contact (502) are arranged

edge-to-edge along the first direction;

a second ground contact (G) adjacent the third electrical contact, wherein the second ground contact and the third electrical contact are arranged edge-to-edge along the first direction.

6. The electrical circuit of claim 5, wherein a broadside of at least one of the first and second ground contacts (G) is longer along the first direction than a broadside of at least one of the first and third electrical contacts (504).

7. The electrical circuit of claim 1, wherein the first electrical contact of the first pair of differential signal contacts and the second electrical contact of the second pair of differential signal contacts form at least a portion of a contact array that defines an oblique angle with respect to the first direction.

8. The electrical circuit of claim 1, wherein the electrical connector (500) is devoid of shields.

9. The electrical circuit of claim 1, wherein the first electrical contact (502) includes a first mating end and a first terminal end and defines a first contact length therebetween, wherein the third electrical contact (502) includes a second mating end and a second terminal end and defines a second contact length therebetween, and wherein the first and second contact lengths are substantially equal.

10. The electrical circuit of claim 1, wherein at least one of the first and second pairs (504) of differential signal contacts has less than a -0.5 dB insertion loss up to a frequency of 20 GHz.

11. The electrical circuit of claim 1, wherein at least one of the first and second pairs (504) of differential signal contacts has approximately zero suck out in a range of 0 to 20 GHz.

Patentansprüche

1. Elektrische Schaltung mit einem elektrischen Verbinder (500) aufweisend:

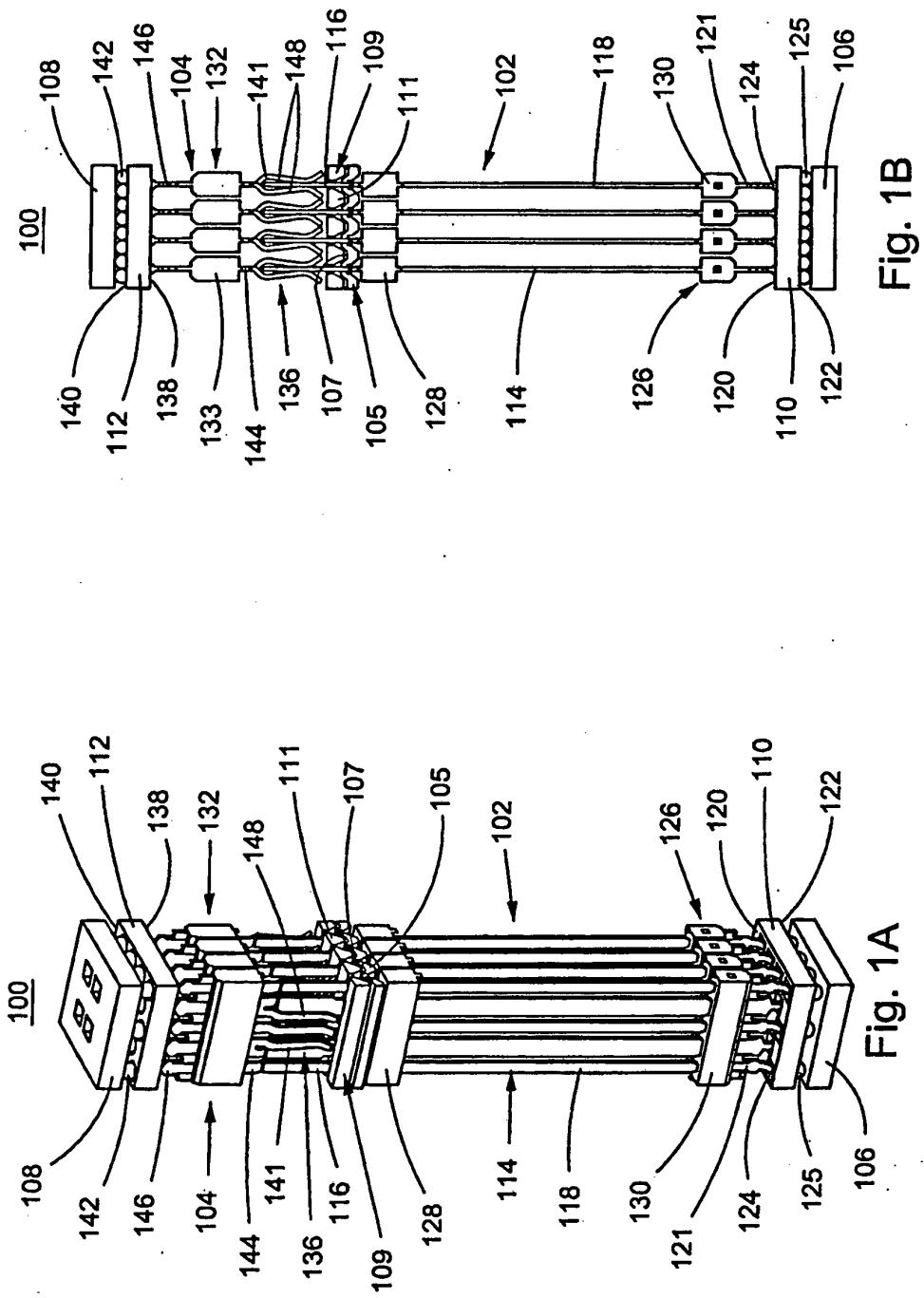
einen ersten elektrischen Kontakt (502) und einen zweiten elektrischen Kontakt, welche Kante-an-Kante (edge-to-edge) entlang einer ersten Richtung (526, 528, 530, 532, 534, 536, 538, 540, 542) angeordnet sind;

einen dritten elektrischen Kontakt benachbart zu dem ersten elektrischen Kontakt entlang einer zweiten Richtung (516, 518, 520, 522, 524), welche im Wesentlichen transversal zu der ersten Richtung ist, wobei die ersten und dritten

- elektrischen Kontakte Breitseite-zu-Breitseite (broadside-to-broadside) angeordnet sind und ein vierter elektrischer Kontakt benachbart zu dem zweiten elektrischen Kontakt entlang der zweiten Richtung, wobei die zweiten und vierten elektrischen Kontakte Breitseite-zu-Breitseite angeordnet sind,
- dadurch gekennzeichnet, dass** die ersten und dritten elektrischen Kontakte ein erstes Paar (504) von differenziellen Signalkontakten (S) definieren, die zweiten und vierten elektrischen Kontakte ein zweites Paar (504) von differenziellen Signalkontakten definieren, und die ersten und zweiten Paare von differenziellen Signalkontakten voneinander entlang der zweiten Richtung versetzt sind.
2. Elektrische Schaltung nach Anspruch 1 weiterhin aufweisend ein erstes Nicht-Luft-Dielektrikum (508), welches zwischen den ersten und dritten elektrischen Kontakten des ersten Paares (504) von differenziellen Signalkontakten angeordnet ist, und ein zweites Nicht-Luft-Dielektrikum, welches zwischen den zweiten und vierten elektrischen Kontakten des zweiten Paares von differenziellen Signalkontakten angeordnet ist.
 3. Elektrische Schaltung nach Anspruch 2, wobei zumindest einer der ersten oder zweiten Nicht-Luft-Dielektrika (508) ein Kunststoffmaterial umfasst.
 4. Elektrische Schaltung nach Anspruch 2, wobei die ersten und dritten elektrischen Kontakte (504) in einer ersten Leitrahmenanordnung bzw. einer zweiten Leitrahmenanordnung untergebracht sind und wobei das erste Nicht-Luft-Dielektrikum (508) unabhängig von den ersten und zweiten Leitrahmenanordnungen gegossen ist.
 5. Elektrische Schaltung nach Anspruch 1 weiterhin aufweisend:
 - einen ersten Massekontakt (G) benachbart zu dem ersten elektrischen Kontakt, wobei der erste Massekontakt und der erste elektrische Kontakt (502) Kante-zu-Kante entlang der ersten Richtung angeordnet sind;
 - einen zweiten Massekontakt (G) benachbart zu dem dritten elektrischen Kontakt, wobei der zweite Massekontakt und der dritte elektrische Kontakt Kante-zu-Kante entlang der ersten Richtung angeordnet sind.
 6. Elektrische Schaltung nach Anspruch 5, wobei eine Breitseite des zumindest einen der ersten und zweiten Massekontakte (G) länger entlang der ersten Richtung ist als eine Breitseite des zumindest einen der ersten und dritten elektrischen Kontakte (504).
 7. Elektrische Schaltung nach Anspruch 1, wobei der erste elektrische Kontakt des ersten Paares von differenziellen Signalkontakten und der zweite elektrische Kontakt des zweiten Paares von differenziellen Signalkontakten zumindest einen Abschnitt eines Kontakt-Arrays bilden, welcher einen schrägen Winkel in Bezug auf die erste Richtung definiert.
 8. Elektrische Schaltung nach Anspruch 1, wobei der elektrische Verbinder (500) frei von Abschirmungen ist.
 9. Elektrische Schaltung nach Anspruch 1, wobei der erste elektrische Kontakt (502) ein erstes Steckende und ein erstes Anschlussende umfasst und eine erste Kontaktlänge dazwischen definiert, wobei der dritte elektrische Kontakt (502) ein zweites Steckende und ein zweites Anschlussende umfasst und eine zweite Kontaktlänge dazwischen definiert, und wobei die ersten und zweiten Kontaktlängen im Wesentlichen gleich sind.
 10. Elektrische Schaltung nach Anspruch 1, wobei zumindest eines der ersten und zweiten Paare (504) von differenziellen Signalkontakten weniger als eine -0.5 db Einfügungsdämpfung bis zu einer Frequenz von 20 GHz aufweist.
 11. Elektrische Schaltung nach Anspruch 1, wobei zumindest eines der ersten und zweiten Paare (504) von differenziellen Signalkontakten ungefähr Null suck-out in einem Bereich von 0-20 GHz aufweist.
- ### Revendications
1. Circuit électrique présentant un connecteur électrique (500) qui comprend :
 - un premier contact électrique (502) et un deuxième contact électrique agencés bord à bord le long d'une première direction (526, 528, 530, 532, 534, 536, 538, 540, 542) ;
 - un troisième contact électrique adjacent au premier contact électrique le long d'une seconde direction (516, 518, 520, 522, 524) sensiblement transversale à la première direction, dans lequel les premier et troisième contacts électriques sont agencés flanc à flanc ; et
 - un quatrième contact électrique adjacent au deuxième contact électrique le long de la deuxième direction, dans lequel les deuxième et quatrième contacts électriques sont agencés flanc à flanc ;

caractérisé en ce que les premier et troisième contacts électriques définissent une première paire (504) de contacts de signaux différentiels

- (S), les deuxième et quatrième contacts électriques définissent une seconde paire (504) de contacts de signaux différentiels, et les première et seconde paires de contacts de signaux différentiels sont décalées l'une de l'autre le long de la seconde direction.
2. Circuit électrique selon la revendication 1, comprenant en outre un premier diélectrique qui n'est pas de l'air (508) disposé entre les premier et troisième contacts électriques de la première paire (504) de contacts de signaux différentiels, et un second diélectrique qui n'est pas de l'air disposé entre les deuxième et quatrième contacts électriques de la seconde paire de contacts de signaux différentiels. 10
 3. Circuit électrique selon la revendication 2, dans lequel au moins l'un du premier ou du second diélectrique qui n'est pas de l'air (508), comprend un matériau de matière plastique. 20
 4. Circuit électrique selon la revendication 2, dans lequel les premier et troisième contacts électriques (504) sont logés dans un premier ensemble de grille de connexion et dans un second ensemble de grille de connexion, respectivement ; et dans lequel le premier diélectrique qui n'est pas de l'air (508) est moulé indépendamment des premier et second ensembles de grille de connexion. 25
30
 5. Circuit électrique de la revendication 1, comprenant en outre :
un premier contact de masse (G) adjacent au premier contact électrique, dans lequel le premier contact de masse et le premier contact électrique (502) sont agencés bord à bord le long de la première direction ;
un second contact de masse (G) adjacent au troisième contact électrique, dans lequel le second contact de masse et le troisième contact électrique sont agencés bord à bord le long de la première direction. 35
40
 6. Circuit électrique selon la revendication 5, dans lequel un flanc d'au moins l'un des premier et second contacts de masse (G) est plus long le long de la première direction qu'un flanc d'au moins l'un des premier et troisième contacts électriques (504). 45
50
 7. Circuit électrique selon la revendication 1, dans lequel le premier contact électrique de la première paire de contacts de signaux différentiels et le deuxième contact électrique de la seconde paire de contacts de signaux différentiels, forment une partie au moins d'un réseau de contacts qui définit un angle oblique par rapport à la première direction. 55
 8. Circuit électrique selon la revendication 1, dans lequel le connecteur électrique (500) est dépourvu de blindages.
 9. Circuit électrique selon la revendication 1, dans lequel le premier contact électrique (502) comprend une première extrémité d'accouplement et une première extrémité terminale, et définit entre elles une première longueur de contact ;
dans lequel le troisième contact électrique (502) comprend une seconde extrémité d'accouplement et une seconde extrémité terminale, et définit entre elles une seconde longueur de contact ; et dans lequel les première et seconde longueurs de contact sont sensiblement égales. 5
 10. Circuit électrique selon la revendication 1, dans lequel au moins l'une de la première et de la seconde paires (504) de contacts de signaux différentiels, présente un affaiblissement d'insertion inférieur à -0,5 dB jusqu'à une fréquence de 20 GHz. 15
 11. Circuit électrique selon la revendication 1, dans lequel au moins l'une de la première et de la seconde paires (504) de contacts de signaux différentiels, présente une extraction sensiblement nulle dans une plage de fréquences comprise entre 0 et 20 GHz. 20



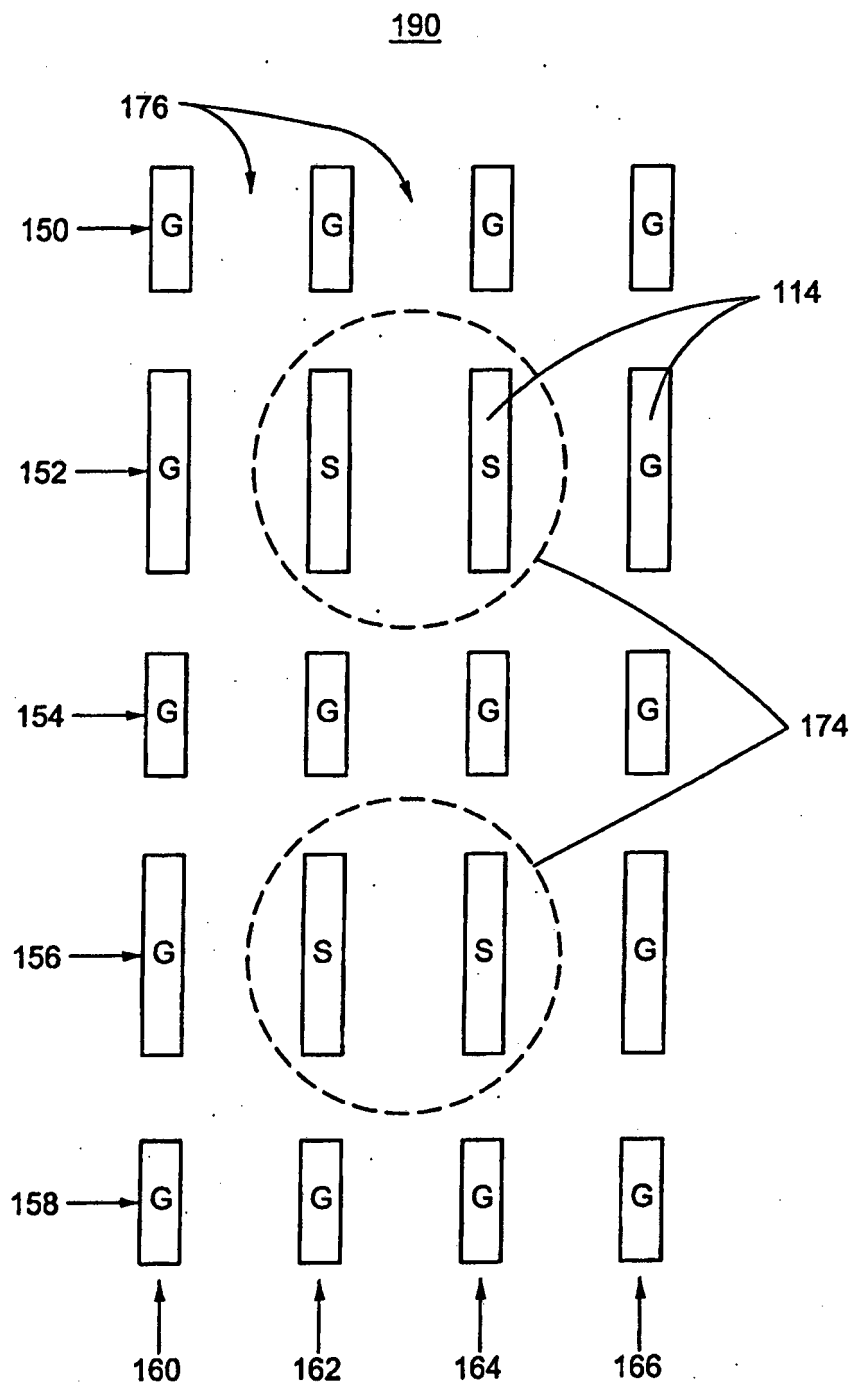


Fig. 1C

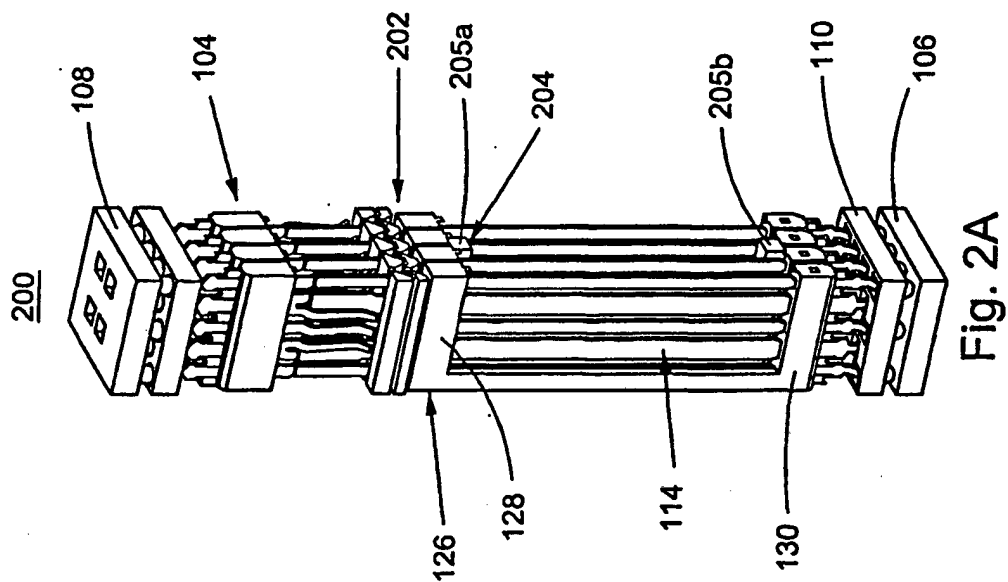


Fig. 2A

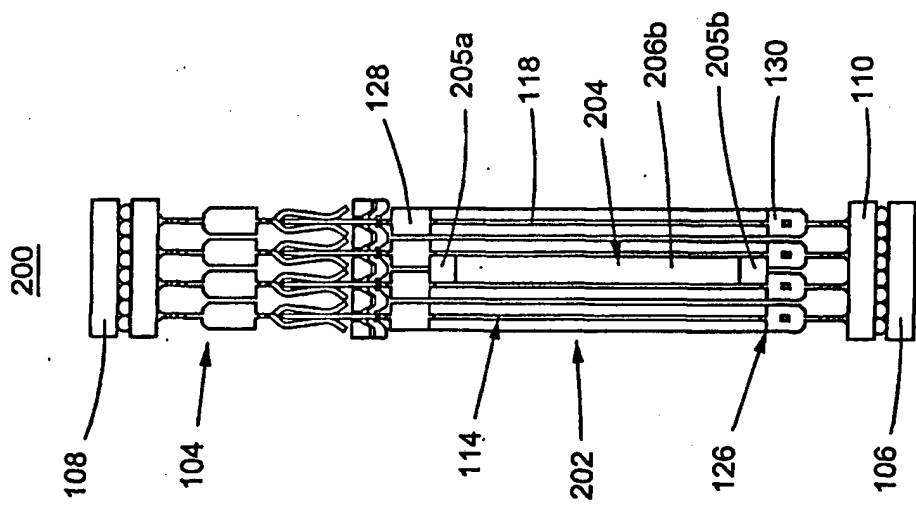


Fig. 2B

204

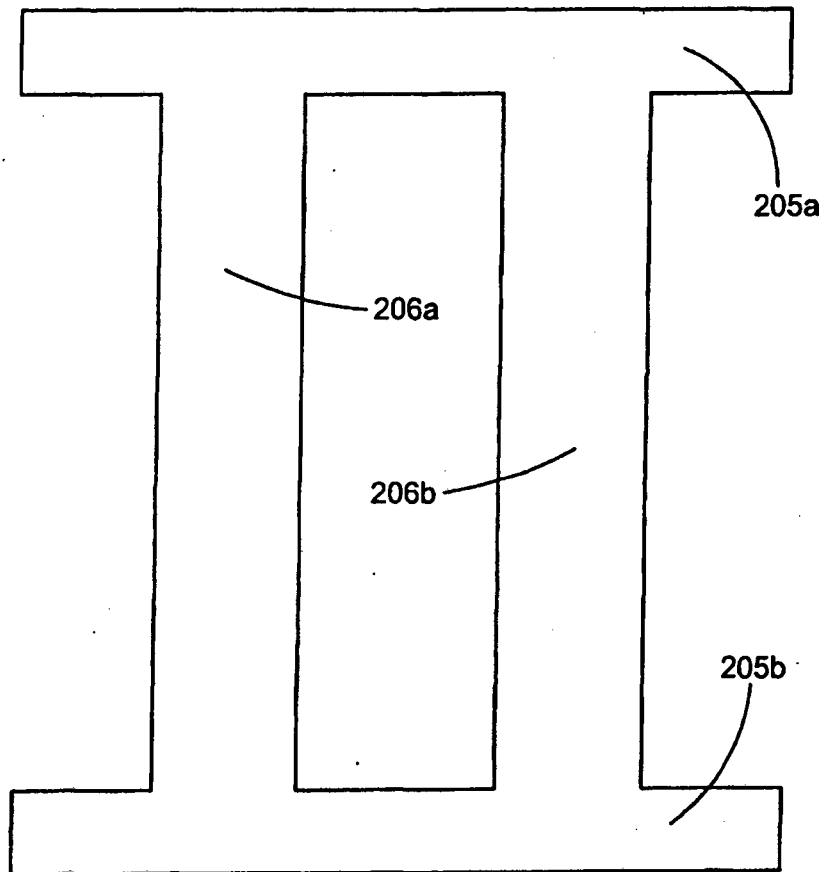


Fig. 2C

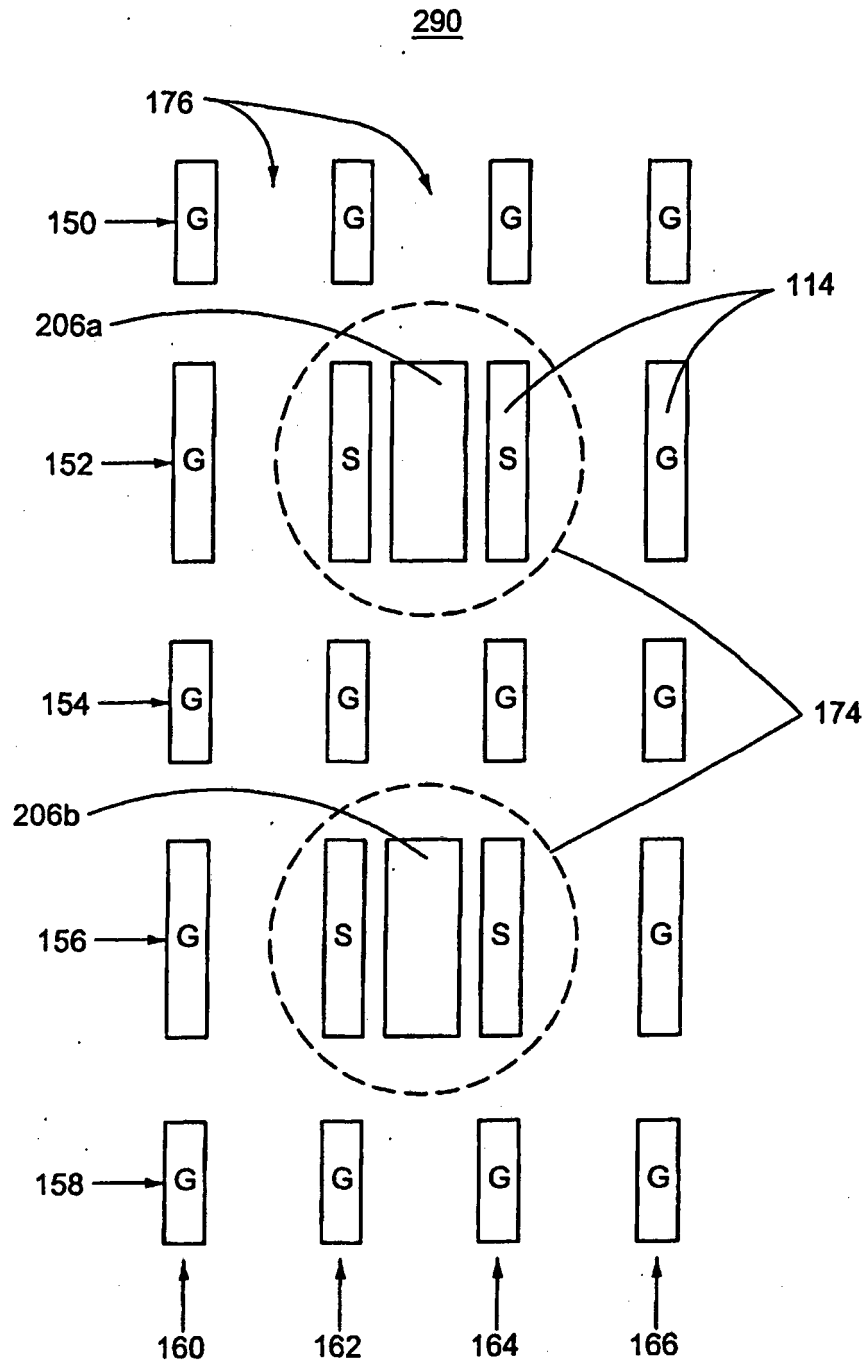


Fig. 2D

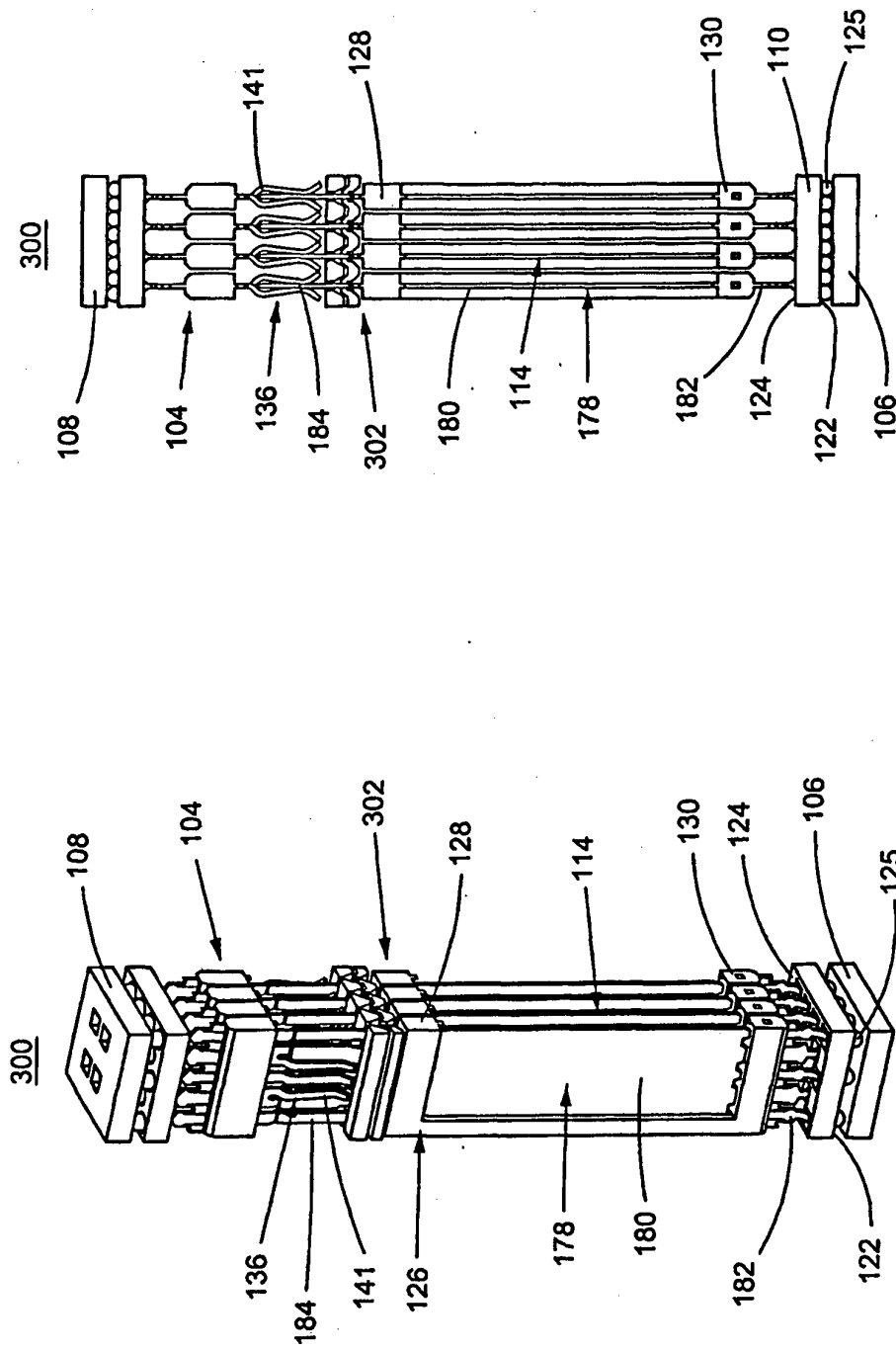


Fig. 3B

Fig. 3A

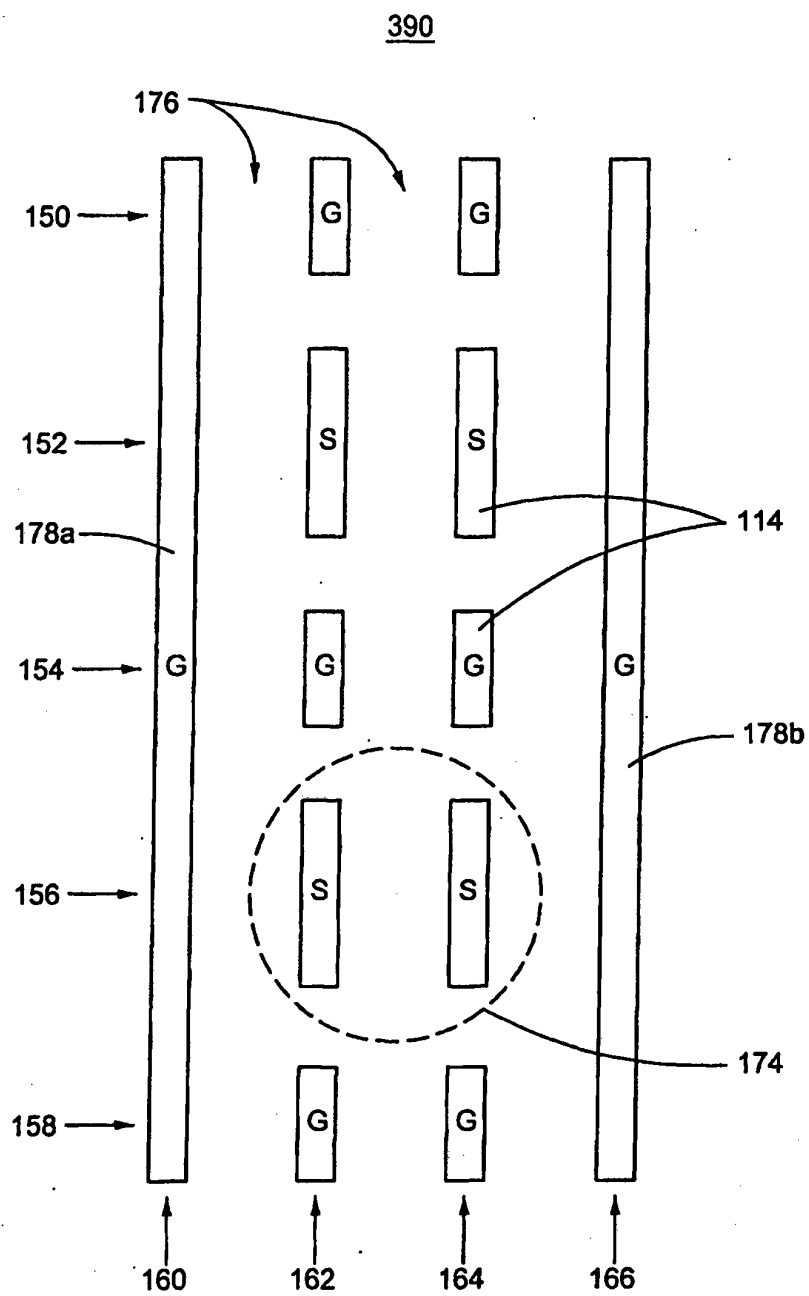


Fig. 3C

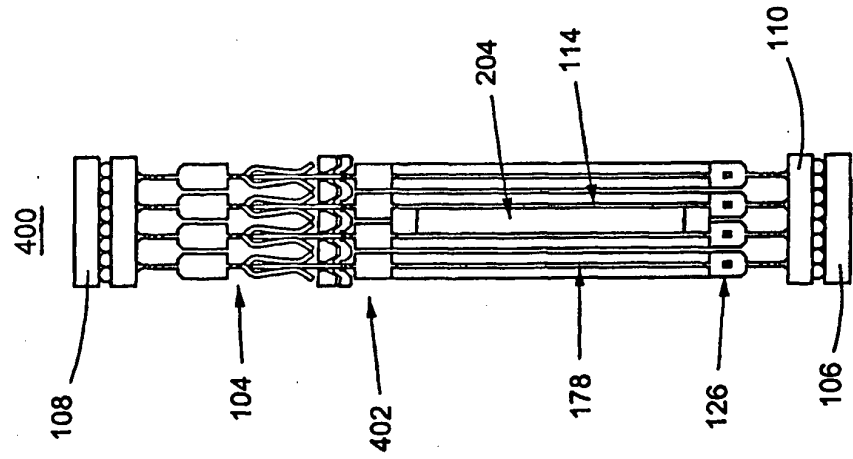


Fig. 4A

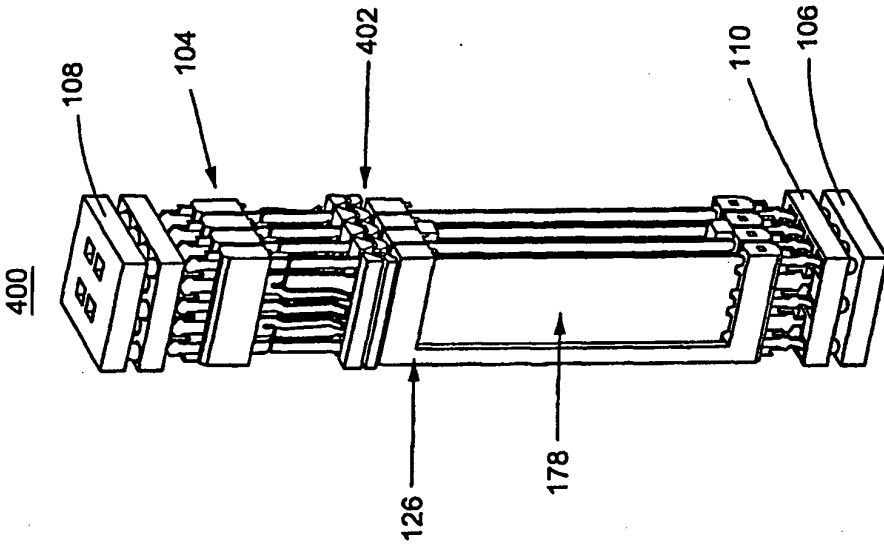


Fig. 4B

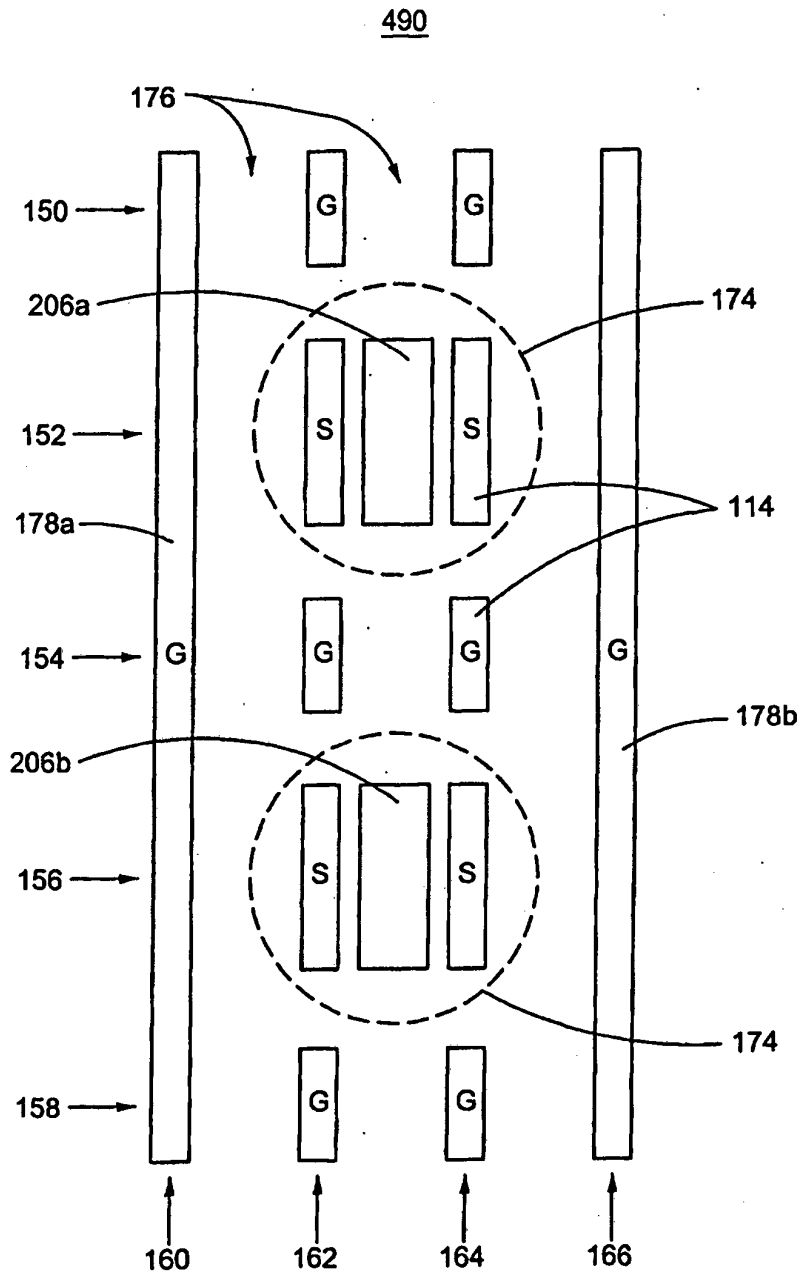


Fig. 4C

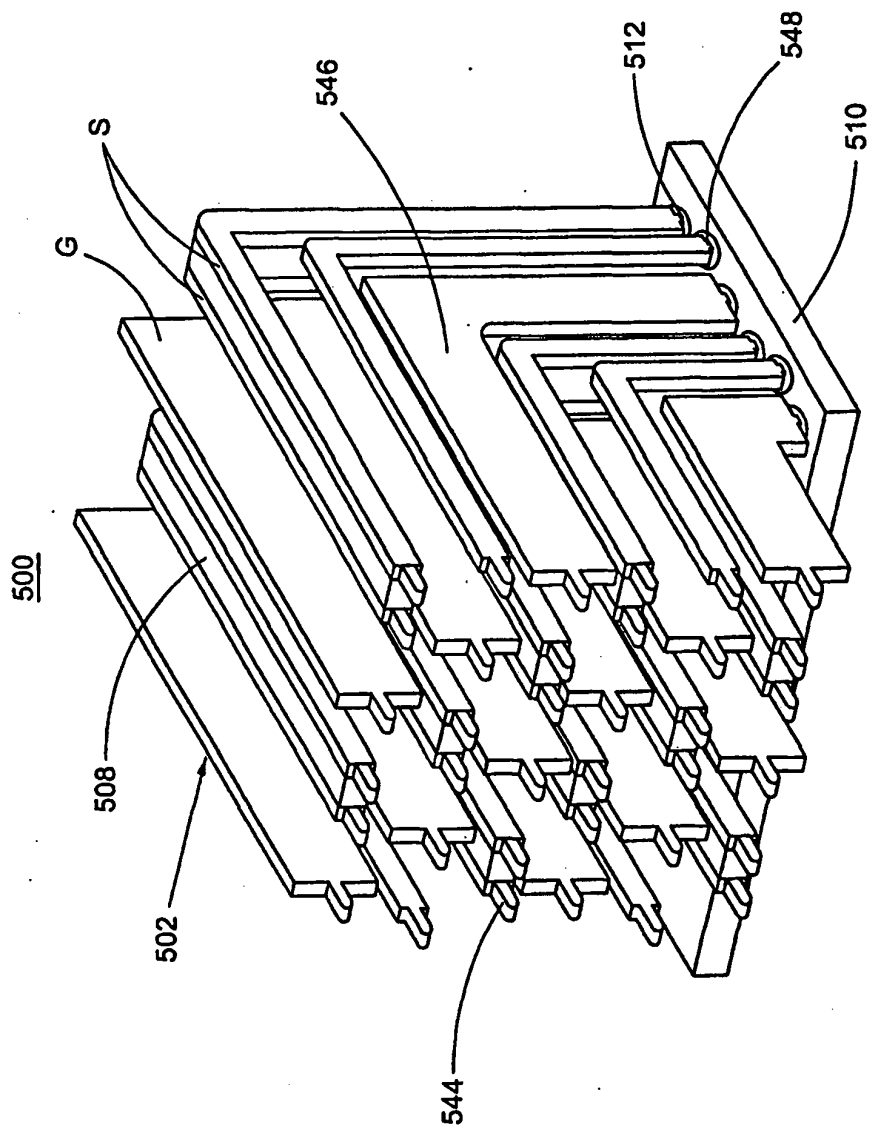


Fig. 5A

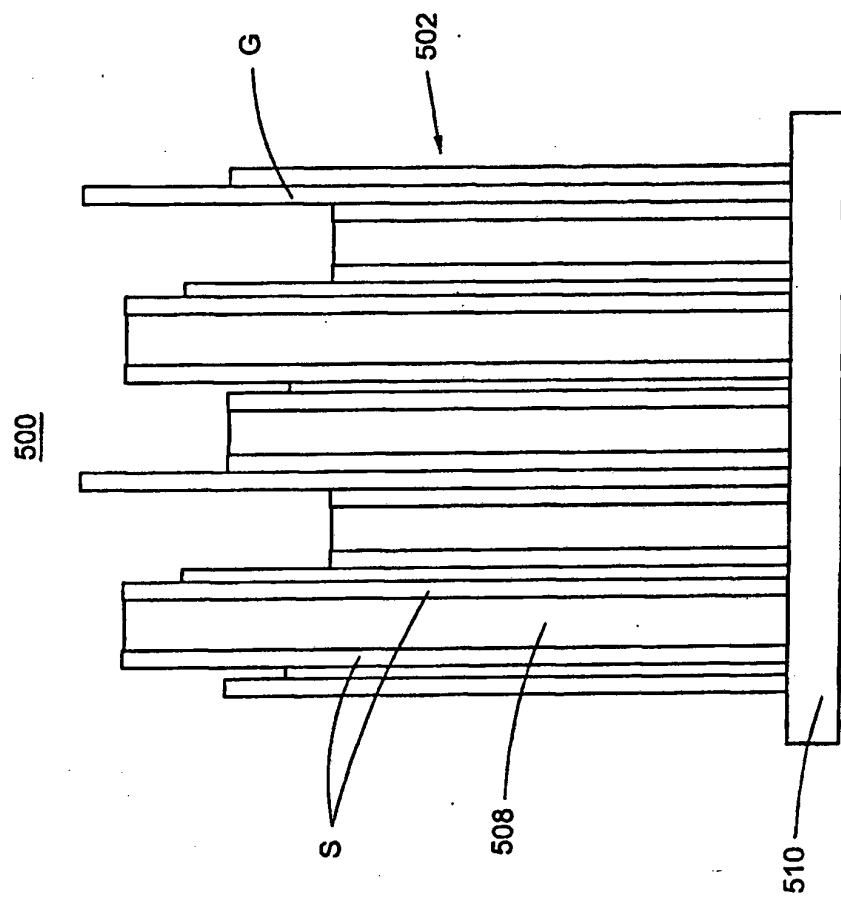
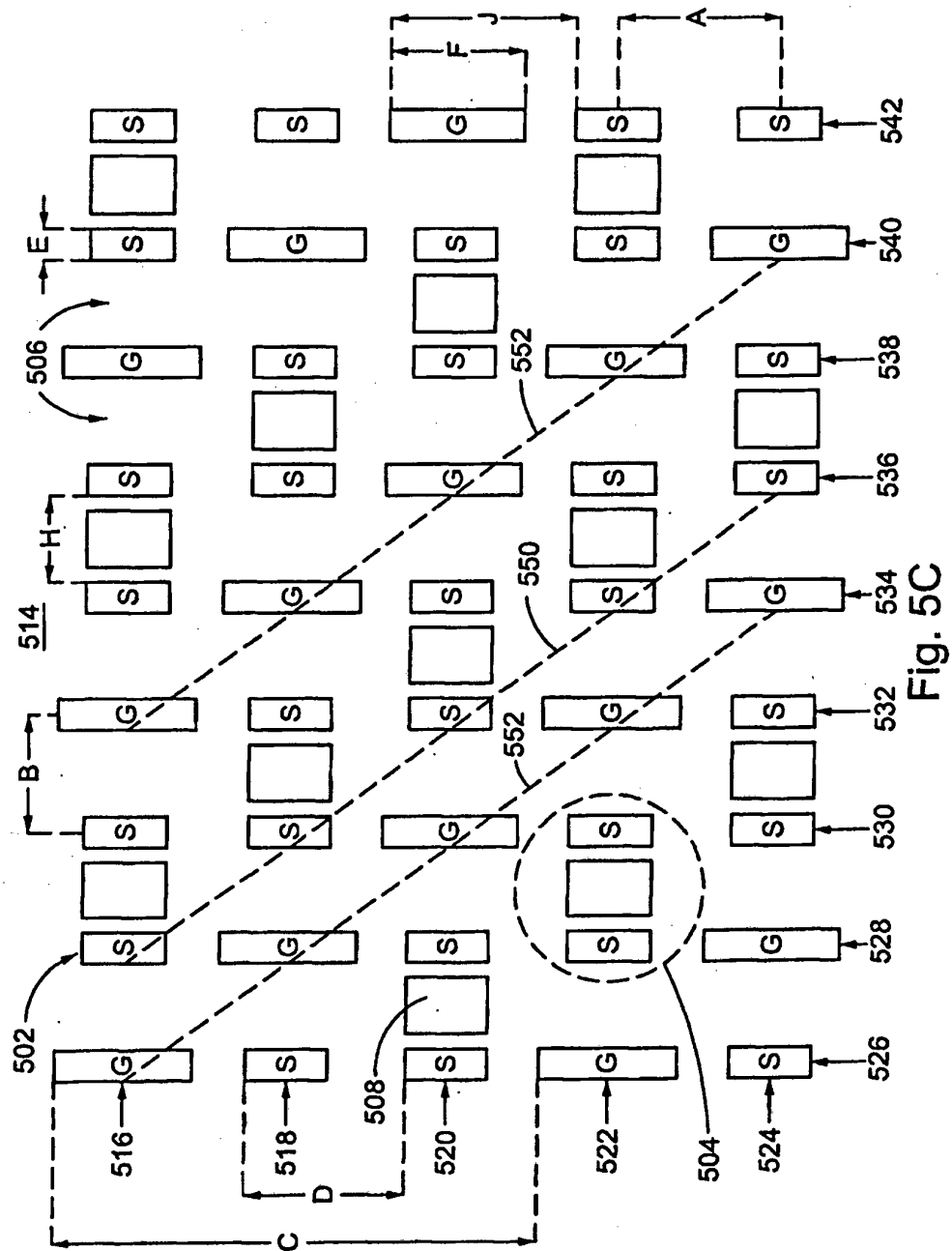


Fig. 5B



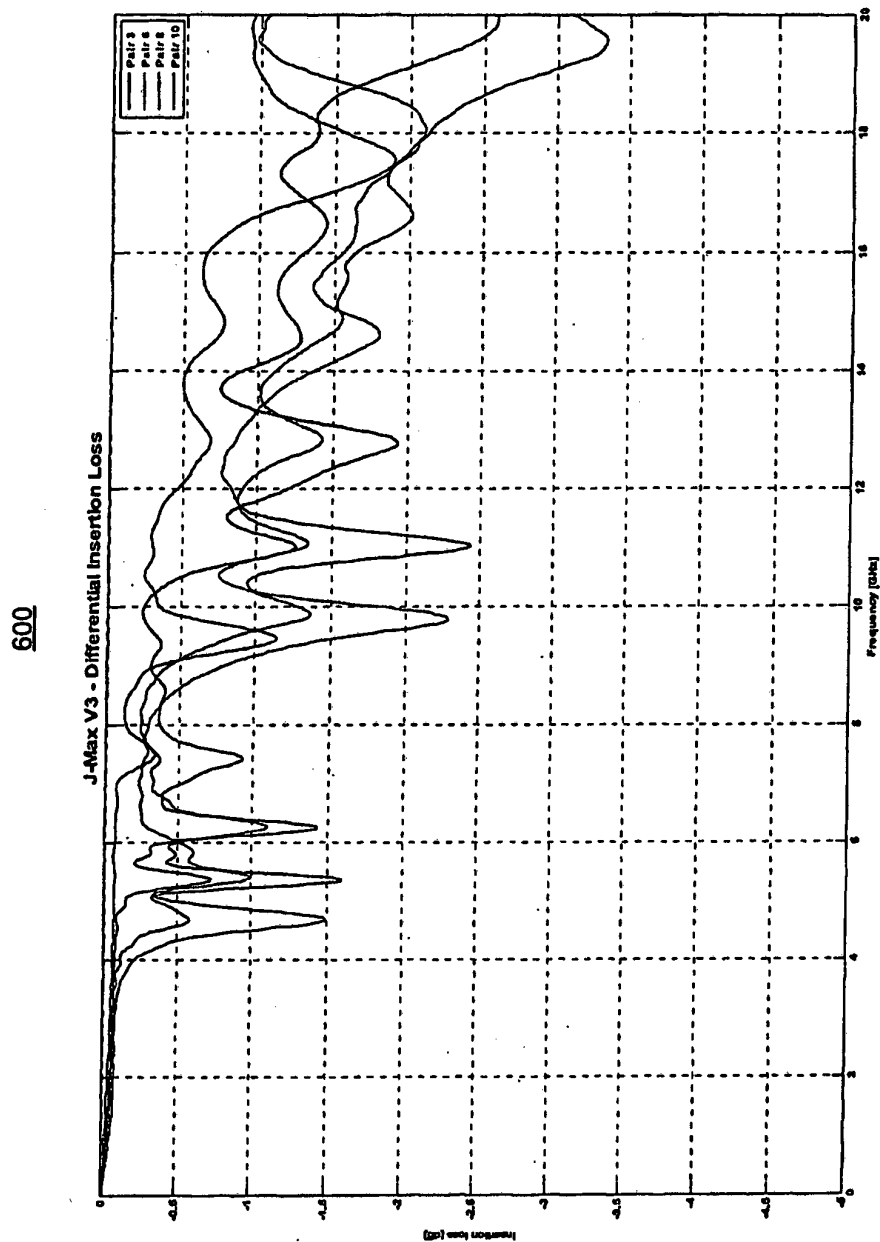


Fig. 6

700

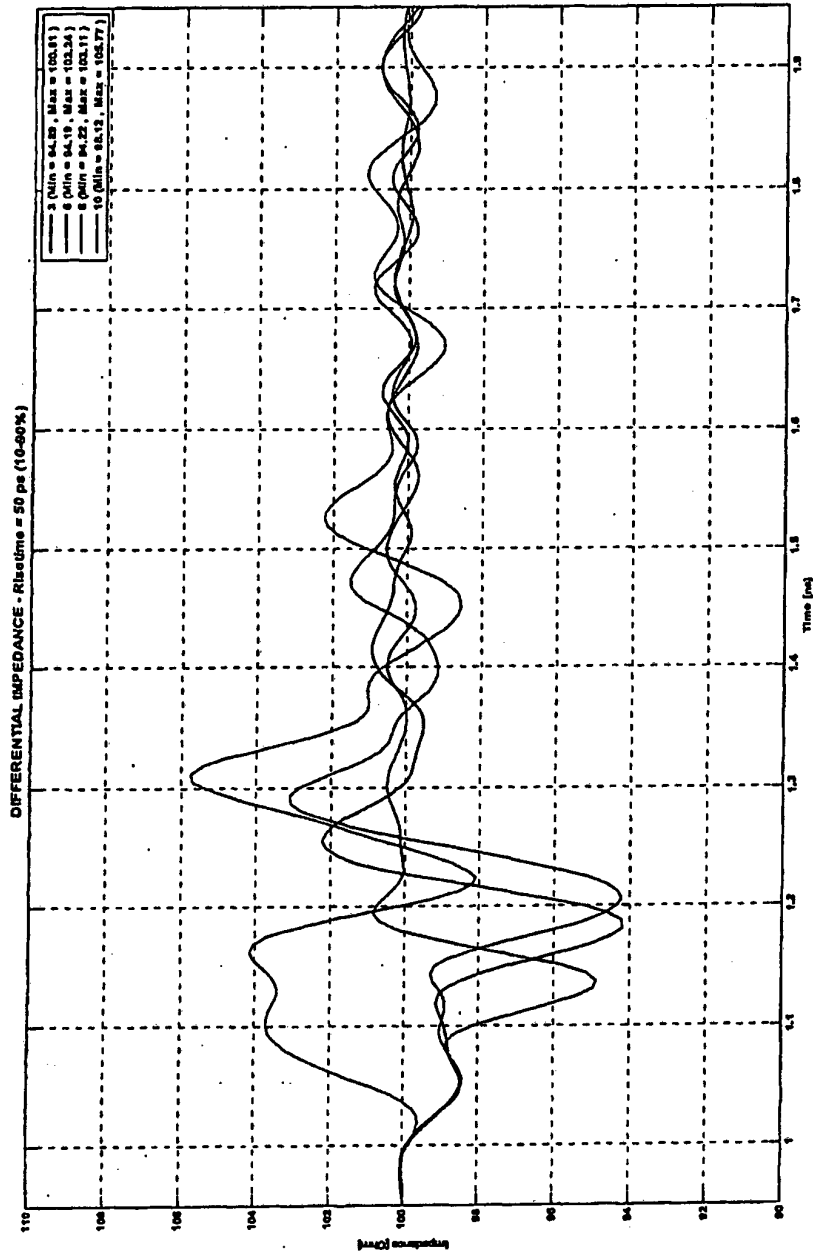


Fig. 7

800

CROSSTALK [%]			CROSSTALK [%]		
From	To	Risetime=50 ps (10-90%)	From	To	Risetime=50 ps (10-90%)
Port 3	Port 11	0.58	Port 6	Port 11	-0.10
Port 3	Port 12	-0.11	Port 6	Port 12	-0.05
Port 3	Port 14	0.19	Port 6	Port 13	0.23
Port 3	Port 15	0.73	Port 6	Port 14	0.86
Port 3	Port 16	0.27	Port 6	Port 15	0.34
Port 3	Port 17	0.21	Port 6	Port 17	0.33
Port 3	Port 18	-0.27	Port 6	Port 18	1.15
Port 3	Port 19	-0.08	Port 6	Port 19	-0.40
Port 3	Port 20	-0.18	Port 6	Port 20	-0.34

CROSSTALK [%]			CROSSTALK [%]		
From	To	Risetime=50 ps (10-90%)	From	To	Risetime=50 ps (10-90%)
Port 3	Port 1	-1.28	Port 6	Port 1	-0.10
Port 3	Port 2	-0.10	Port 6	Port 2	0.04
Port 3	Port 4	-0.23	Port 6	Port 3	-0.25
Port 3	Port 5	-1.24	Port 6	Port 4	-1.67
Port 3	Port 6	-0.25	Port 6	Port 5	-0.36
Port 3	Port 7	-0.22	Port 6	Port 7	-0.32
Port 3	Port 8	-0.17	Port 6	Port 8	-2.06
Port 3	Port 9	-0.08	Port 6	Port 9	0.33
Port 3	Port 10	-0.14	Port 6	Port 10	-0.33

Fig. 8

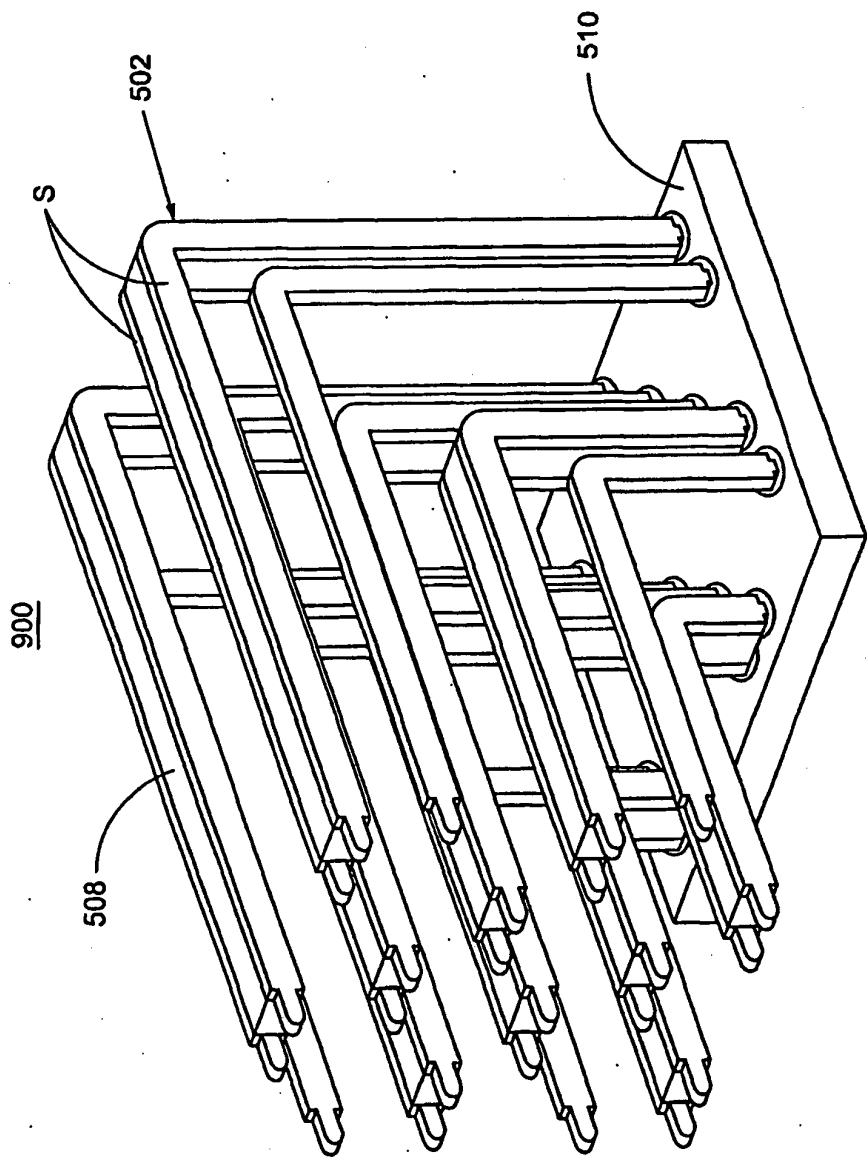


Fig. 9A

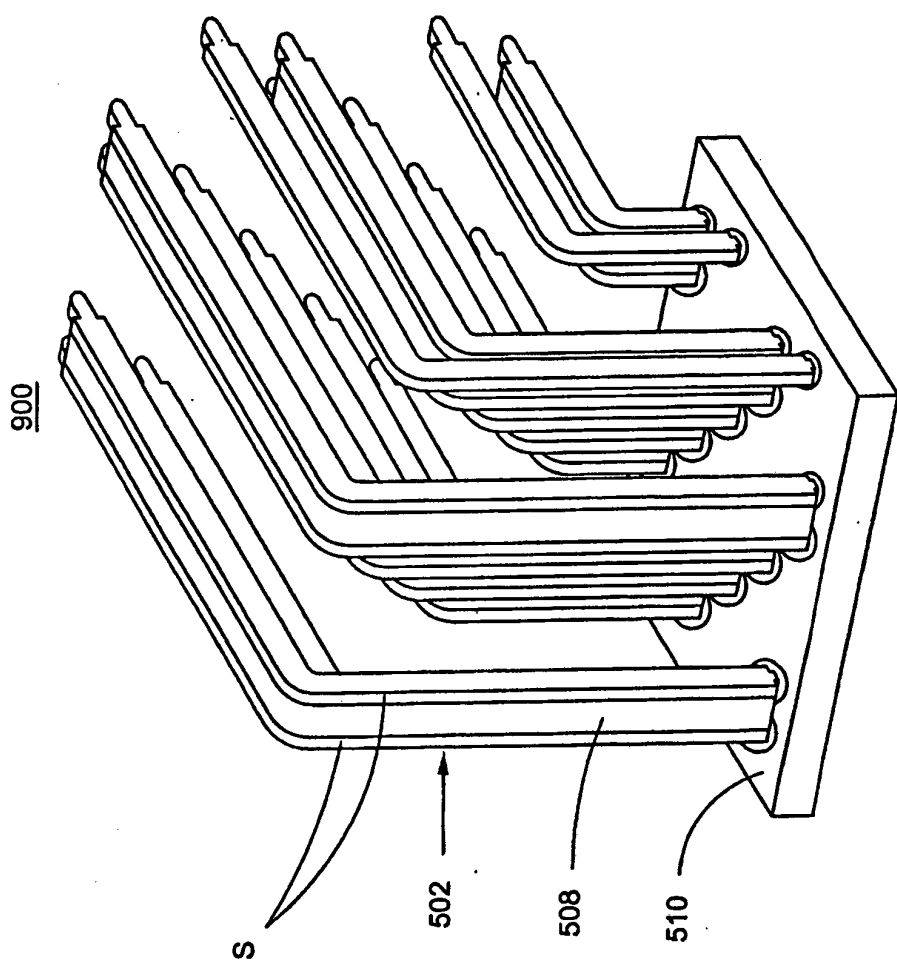


Fig. 9B

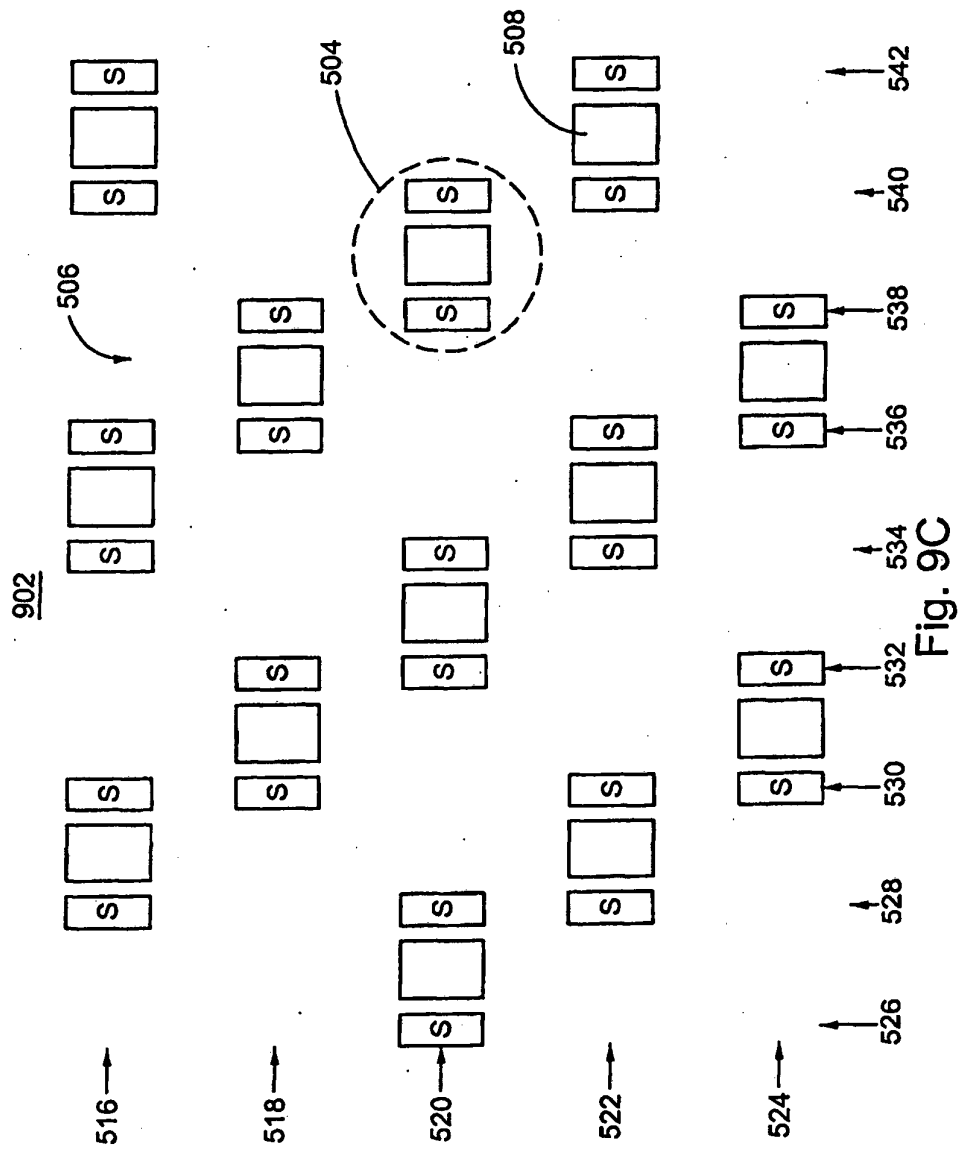


Fig. 9C

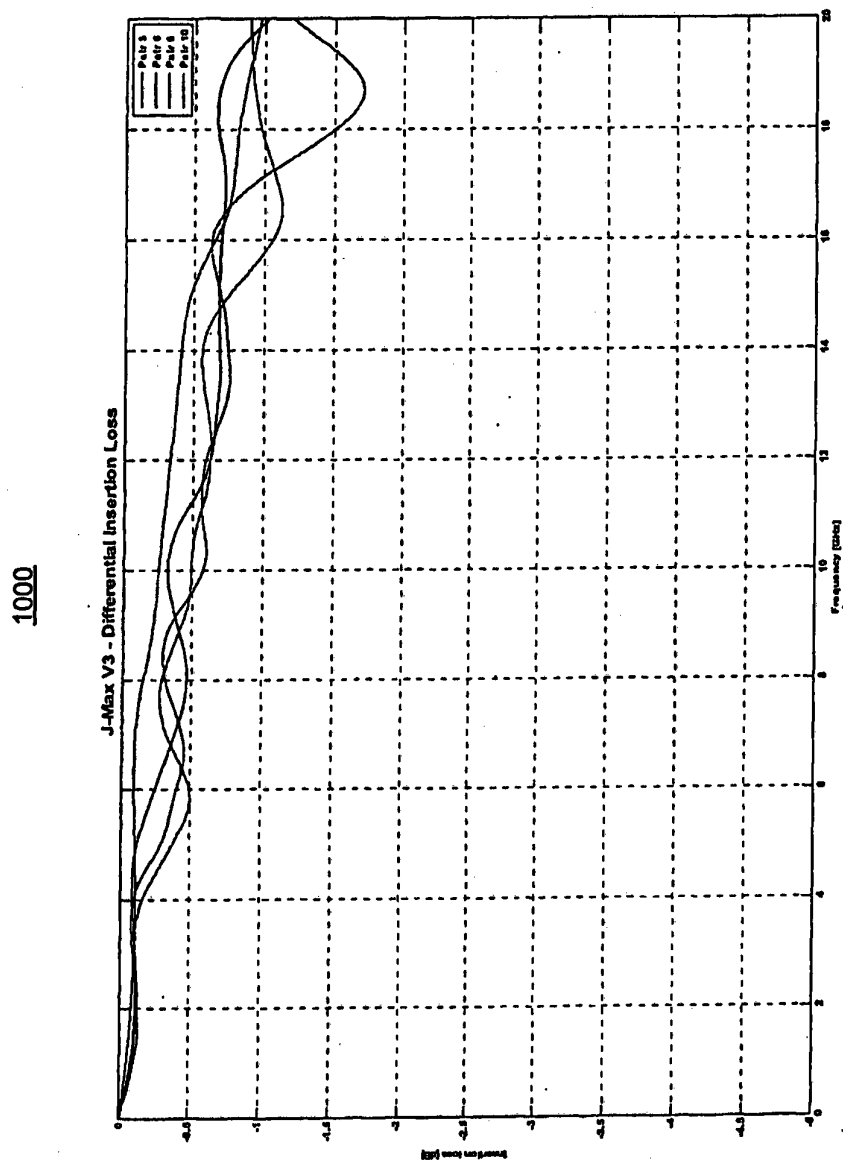


Fig. 10

1100

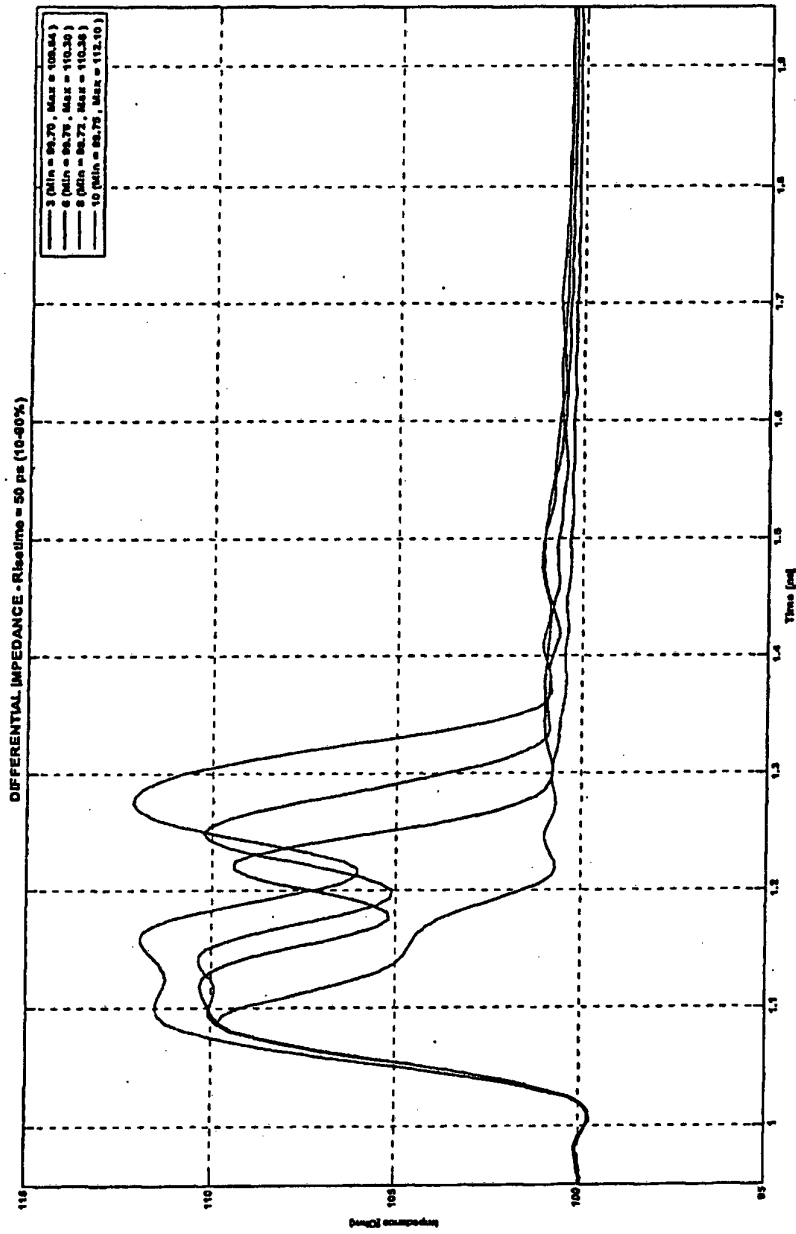


Fig. 11

1200

CROSSTALK [%]			CROSSTALK [%]		
From	To	Risetime=50 ps (10-90%)	From	To	Risetime=50 ps (10-90%)
Port 3	Port 11	-0.23	Port 6	Port 11	-0.18
Port 3	Port 12	0.53	Port 6	Port 12	-0.04
Port 3	Port 14	0.64	Port 6	Port 13	-0.34
Port 3	Port 15	0.22	Port 6	Port 14	-0.36
Port 3	Port 16	-0.42	Port 6	Port 15	0.84
Port 3	Port 17	0.10	Port 6	Port 17	0.68
Port 3	Port 18	-0.27	Port 6	Port 18	0.42
Port 3	Port 19	-0.10	Port 6	Port 19	-0.78
Port 3	Port 20	-0.14	Port 6	Port 20	0.18

CROSSTALK [%]			CROSSTALK [%]		
From	To	Risetime=50 ps (10-90%)	From	To	Risetime=50 ps (10-90%)
Port 3	Port 1	-0.33	Port 6	Port 1	0.19
Port 3	Port 2	-0.93	Port 6	Port 2	0.03
Port 3	Port 4	-0.90	Port 6	Port 3	0.41
Port 3	Port 5	-0.44	Port 6	Port 4	-0.39
Port 3	Port 6	0.41	Port 6	Port 5	-0.94
Port 3	Port 7	-0.08	Port 6	Port 7	-0.56
Port 3	Port 8	0.23	Port 6	Port 8	-0.65
Port 3	Port 9	0.09	Port 6	Port 9	0.68
Port 3	Port 10	0.11	Port 6	Port 10	-0.22

Fig. 12

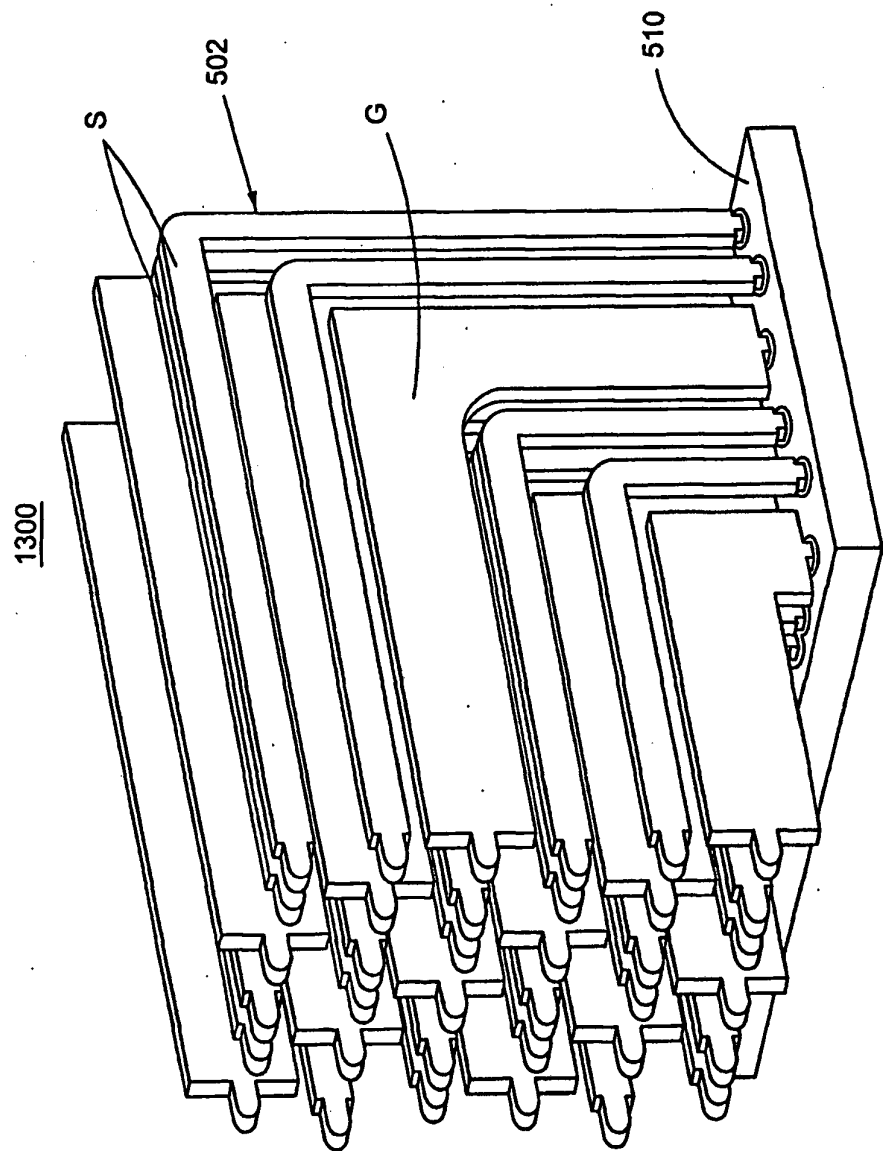


Fig. 13A

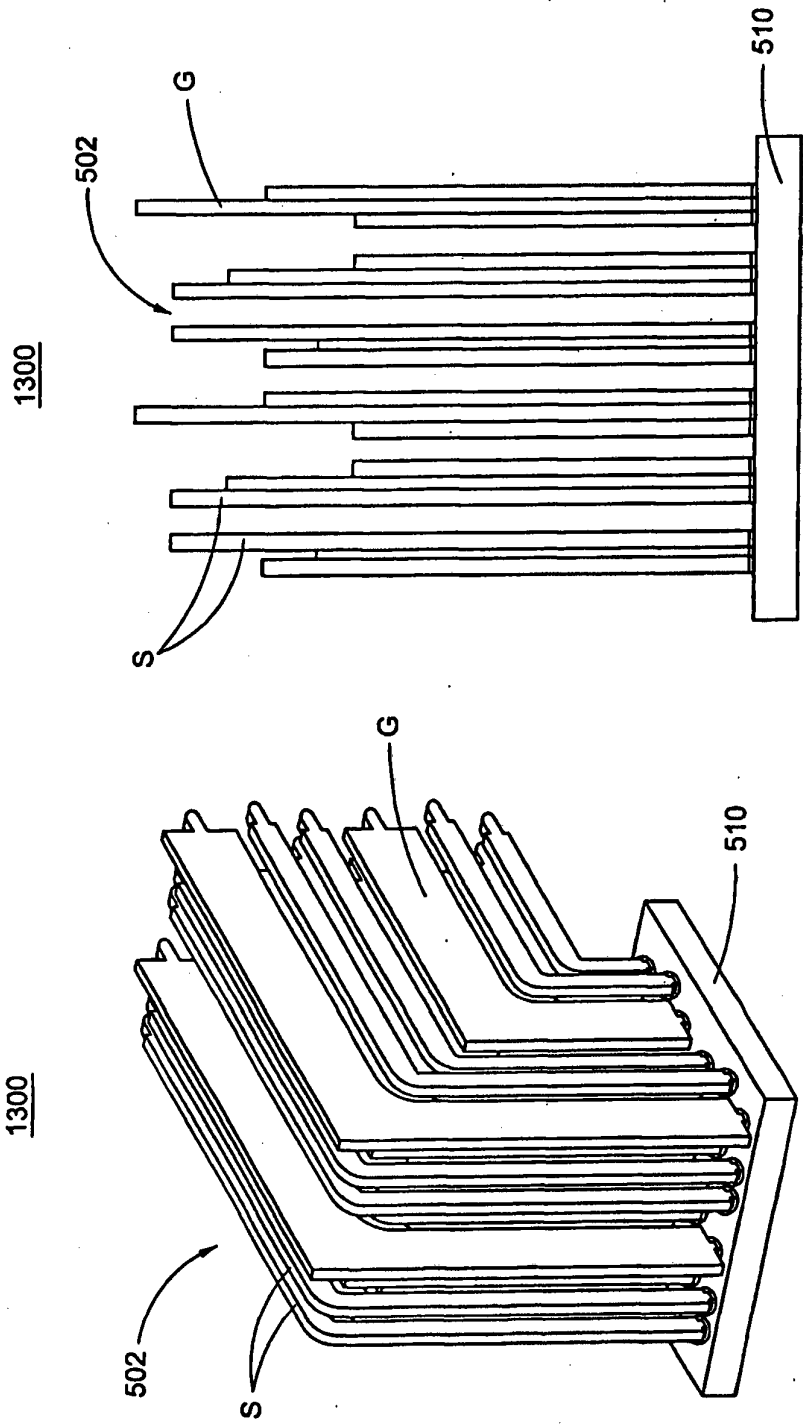


Fig. 13C

Fig. 13B

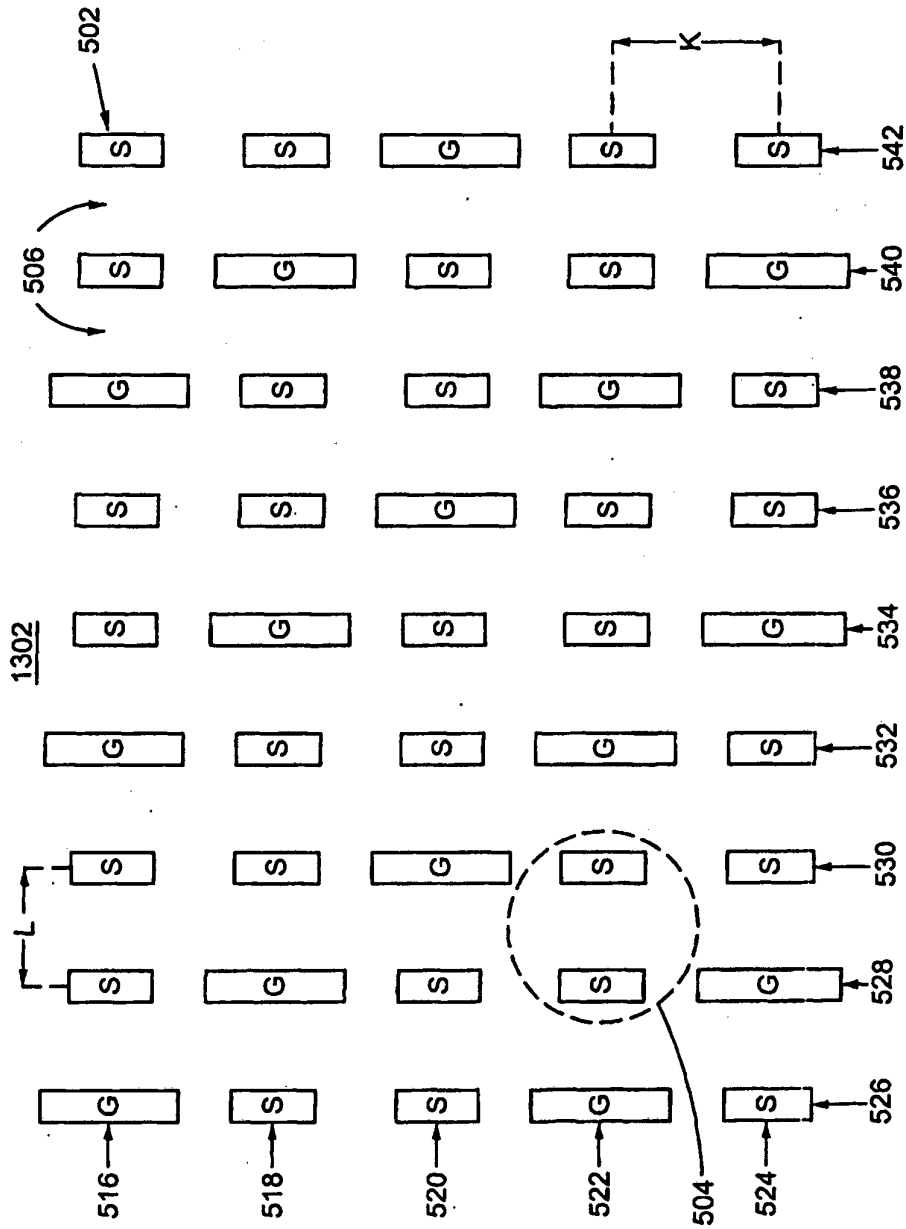


Fig. 13D

1400

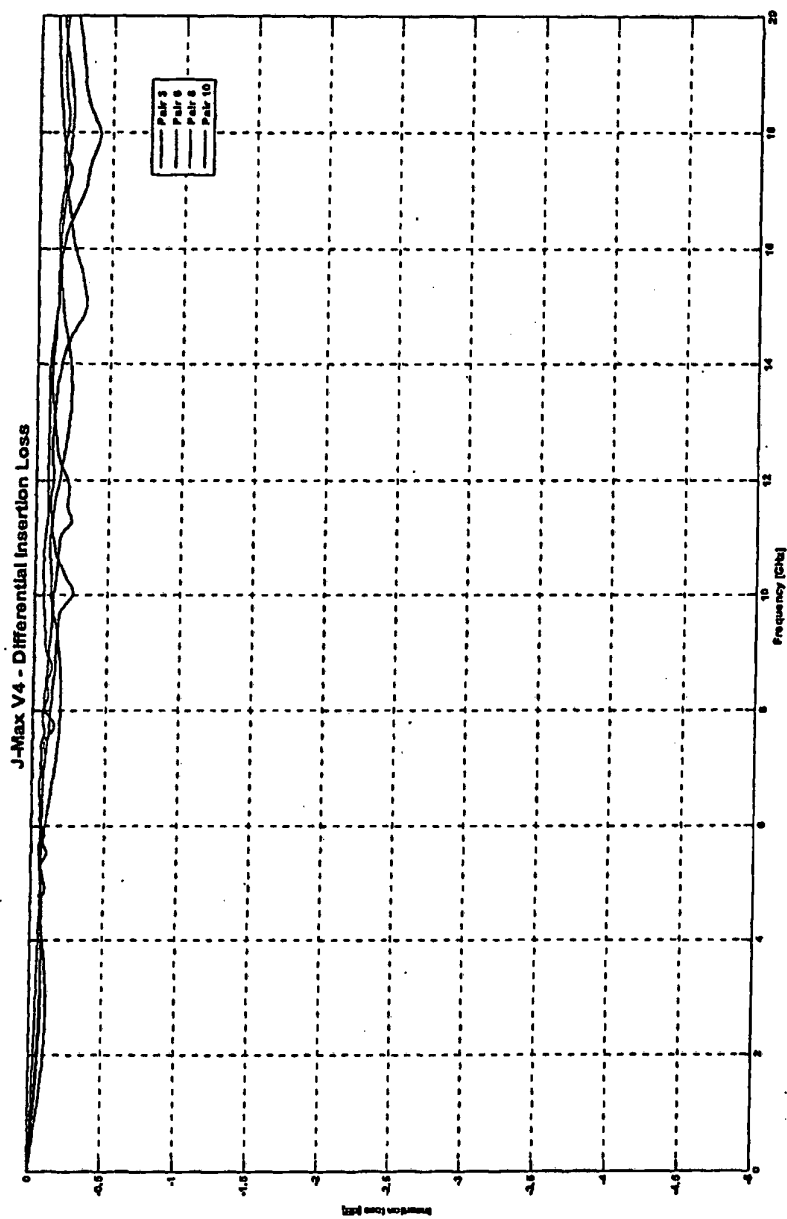


Fig. 14

1500

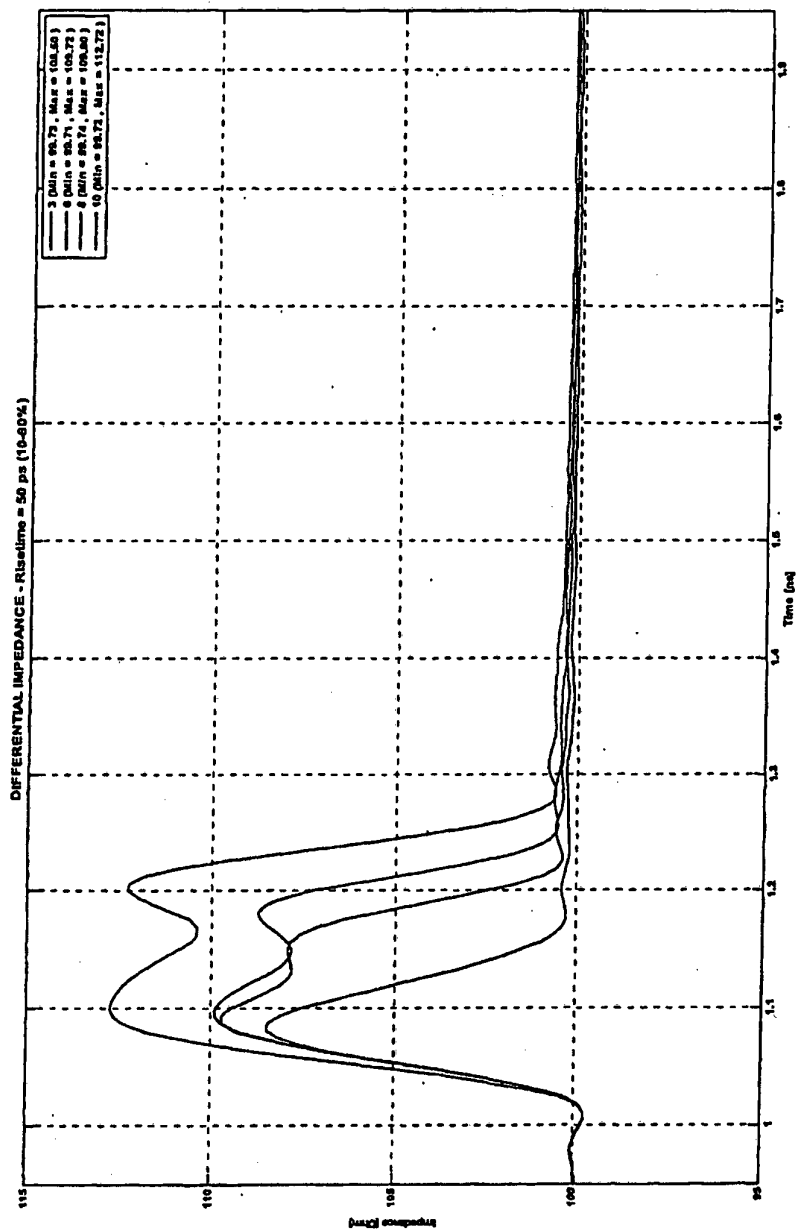


Fig. 15

1600

CROSSTALK [%]			CROSSTALK [%]		
From	To	Risetime=50 ps (10-90%)	From	To	Risetime=50 ps (10-90%)
Port 3	Port 11	0.14	Port 6	Port 11	-0.01
Port 3	Port 12	0.02	Port 6	Port 12	-0.01
Port 3	Port 14	-0.03	Port 6	Port 13	-0.01
Port 3	Port 15	0.07	Port 6	Port 14	0.08
Port 3	Port 16	-0.02	Port 6	Port 15	0.03
Port 3	Port 17	0.03	Port 6	Port 17	-0.02
Port 3	Port 18	0.01	Port 6	Port 18	0.08
Port 3	Port 19	-0.01	Port 6	Port 19	-0.04
Port 3	Port 20	0.00	Port 6	Port 20	0.03

CROSSTALK [%]			CROSSTALK [%]		
From	To	Risetime=50 ps (10-90%)	From	To	Risetime=50 ps (10-90%)
Port 3	Port 1	-0.92	Port 6	Port 1	0.01
Port 3	Port 2	-0.04	Port 6	Port 2	-0.01
Port 3	Port 4	-0.05	Port 6	Port 3	0.01
Port 3	Port 5	-0.92	Port 6	Port 4	-0.96
Port 3	Port 6	0.01	Port 6	Port 5	-0.05
Port 3	Port 7	-0.02	Port 6	Port 7	0.02
Port 3	Port 8	0.01	Port 6	Port 8	-0.99
Port 3	Port 9	0.01	Port 6	Port 9	0.03
Port 3	Port 10	-0.00	Port 6	Port 10	-0.02

Fig. 16

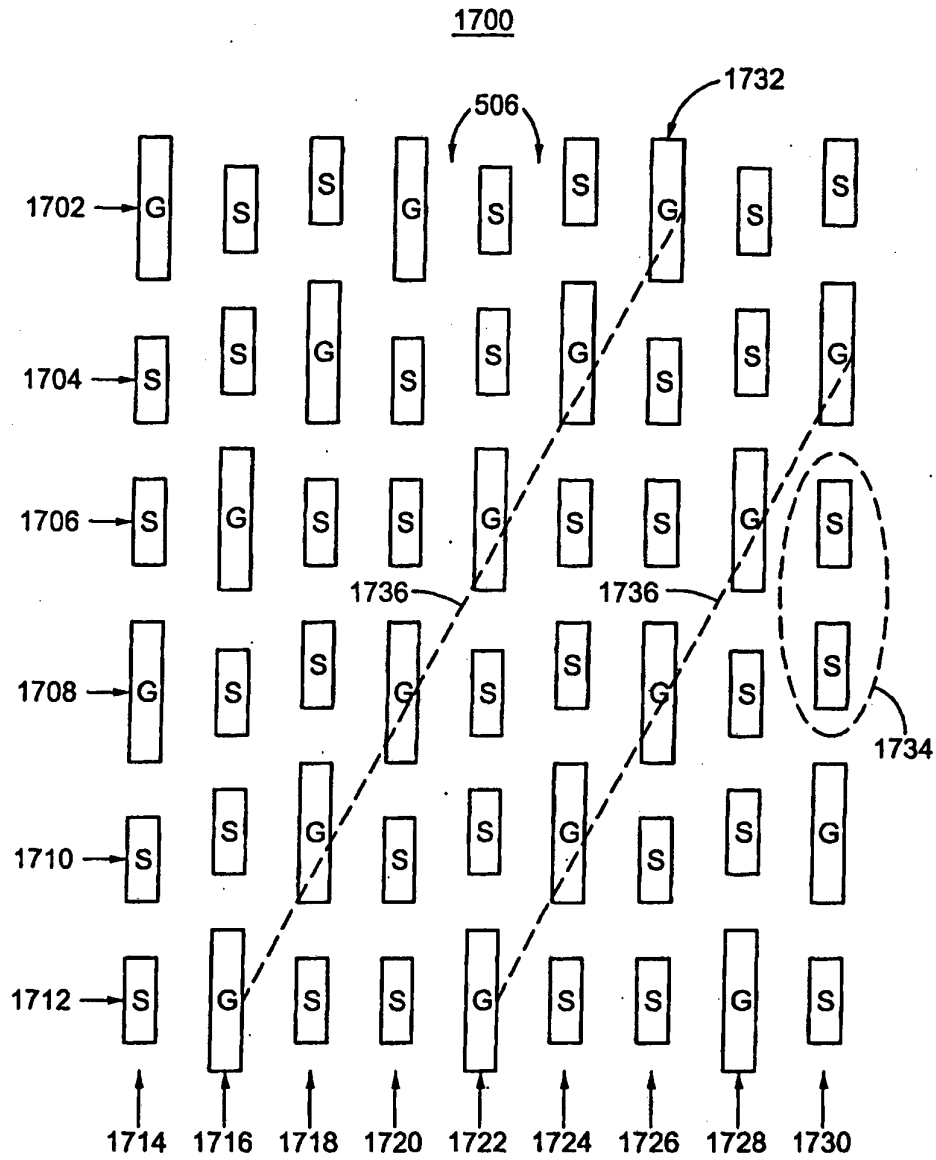


Fig. 17

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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