



(51) International Patent Classification:
H01R 12/71 (2011.01) *H01R 13/646* (2011.01)

(21) International Application Number:
PCT/US2011/045375

(22) International Filing Date:
26 July 2011 (26.07.2011)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/367,481 26 July 2010 (26.07.2010) US

(71) Applicant (for all designated States except US):
MOLEX INCORPORATED [US/US]; 2222 Wellington Court, Lisle, Illinois 60532 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **REGNIER, Kent E.** [US/US]; c/o Molex Incorporated, 2222 Wellington Court, Lisle, Illinois 60532 (US).

(74) Agent: **SHELDON, Stephen L.**; Molex Incorporated, 2222 Wellington Court, Lisle, Illinois 60532 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: CONNECTOR WITH IMPEDANCE CONTROLLED INTERFACE

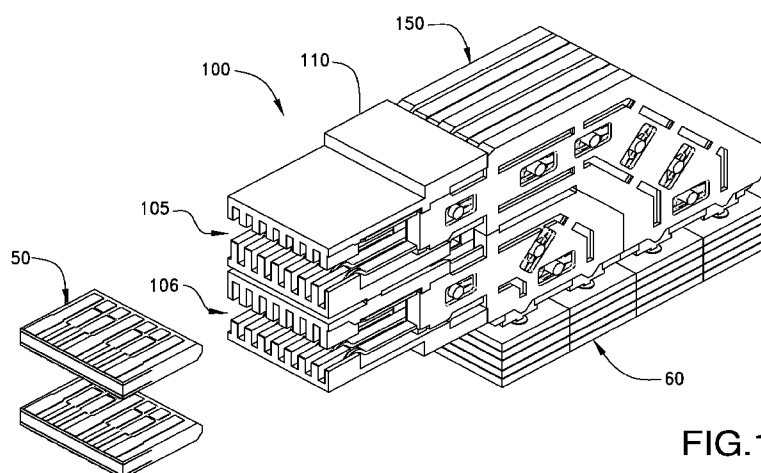


FIG.1

(57) Abstract: A connector is provided for receiving a mating connector, the mating connector including an edge-card. The connector includes terminals positioned in a card slot and support by frame that provide a wafer construction. Terminals are positioned so as to provide a broad-side coupled differential coupling between wafers and transition to an edge-coupled configuration at the edge-card interface.



Connector With Impedance Controlled Interface

BACKGROUND OF THE INVENTION

RELATED APPLICATIONS

[001] This application claims priority to United States Provisional Application No. 61/367,481, filed July 26, 2010, which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[002] The present invention relates to the field of connectors, more specifically to connectors suitable for high data rates.

DESCRIPTION OF RELATED ART

[003] Connectors are commonly used to provide a link between two circuit boards or between a circuit board and a cable. For example, input/output (I/O) connectors are often used to couple a first circuit board to a second circuit board via a cable. As Moore's observation about the ability to double the number of transistors approximately every two years at minimum costs has held true for the past half a century, this has resulted in exponential increases in processing power and memory capacity. This has resulted in a desire to transmit information from point to point at ever increasing data rates.

[004] Backplane connectors have been used to provide relatively high data rates but tend to be expensive and difficult to manufacture. I/O connectors, while much less expensive, have heretofore been unable to provide data rates approaching 15 Gbps when using a non-return-to-zero encoding. However, the increased ability to store and process information has resulted in a desire for an improved I/O connector that can offer very high data rates. Consequentially, certain individuals would appreciate an improved I/O connector that could offer improved performance at higher signaling frequencies.

BRIEF SUMMARY OF THE INVENTION

[005] A connector is provided for receiving a mating connector, the mating connector including an edge card. The connector can be a board-mounted connector with terminals that are arranged in a wafer-like construction. Terminals are positioned so as to provide a broad-side coupled differential coupling between wafers and transition to an edge-coupled configuration at the edge-card interface. In an embodiment, the interface can be configured to engage contacts provided on two opposing sides of the card edge.

BRIEF DESCRIPTION OF THE DRAWINGS

[006] The present invention is illustrated by way of example and not limited in the accompanying figures in which like reference numerals indicate similar elements and in which:

[007] Figure 1 illustrates a perspective simplified view of an embodiment of a connector.

[008] Figure 2 illustrates an elevated side view of the connector depicted in Figure 1.

[009] Figure 3 illustrates a perspective partially exploded view of the connector depicted in Figure 1.

[010] Figure 4 illustrates a perspective partially exploded view of an embodiment of several wafers.

[011] Figure 5 illustrates a perspective view of one of the wafer depicted in Figure 4.

[012] Figure 6 illustrates a perspective view of an embodiment of ground terminals suitable for use in a wafer as depicted in Figure 5.

[013] Figure 7 illustrates a perspective view of one of the signal wafers depicted in Figure 4.

[014] Figure 8 illustrates a perspective view of another of the signal wafers depicted in Figure 4.

[015] Figure 9 illustrates a perspective view of an embodiment of terminals suitable for use in the wafer depicted in Figure 7.

[016] Figure 10 illustrates a perspective view of an embodiment of terminals suitable for use in the wafer depicted in Figure 8.

[017] Figure 11 illustrates an elevated side view of an embodiment of signal and ground terminals.

[018] Figure 12 illustrates a perspective view of an embodiment of a plurality of terminals that could be supported by four wafers.

[019] Figure 13 illustrates a perspective simplified view of another embodiment of a connector.

[020] Figure 14 illustrates an elevated side view of the connector depicted in Figure 13.

[021] Figure 15 illustrates a partially exploded perspective view of the connector depicted in Figure 13.

[022] Figure 16 illustrates a perspective, partially exploded view of the wafers suitable for use with the connector depicted in Figure 13.

[023] Figure 17 illustrates a perspective view of a plurality of terminals suitable for use in the connector depicted in Figure 13.

[024] Figure 18 illustrates a perspective view of a ground terminal suitable for use with the connector depicted in Figure 13.

[025] Figure 19 illustrates an elevated side view of an embodiment of signal and a ground terminal suitable for use with the connector depicted in Figure 13.

[026] Figure 20 illustrates a perspective view of an embodiment of a plurality of beams that can be supported by a wafer such as is depicted in Figure 13.

[027] Figure 21 illustrates a perspective enlarged view of an embodiment of a connector.

[028] Figure 22 illustrates a perspective enlarged view of another embodiment of a connector.

[029] Figure 23 illustrates a perspective view of an embodiment that includes four terminal beams positioned in an adjacent manner.

[030] Figure 24 illustrates a perspective view of an embodiment of terminals in two adjacent wafers.

[031] Figure 25 illustrates a perspective view of another embodiment of a connector.

[032] Figure 26 illustrates a perspective view of a cross-section of the connector depicted in Figure 25 taken along line 26-26.

[033] Figure 27 illustrates a perspective view of a cross-section of the connector depicted in Figure 25 taken along line 27-27.

[034] Figure 28 illustrates a perspective view of a cross-section of the connector depicted in Figure 25 taken along line 28-28.

[035] Figure 29 illustrates a perspective view of a cross-section of the connector depicted in Figure 25 taken along line 29-29.

[036] Figure 30 illustrates a perspective partially simplified view of the cross section depicted in Figure 27.

[037] Figure 31 illustrates a perspective further simplified view of the connector depicted in Figure 30.

DETAILED DESCRIPTION OF THE INVENTION

[038] The detailed description that follows describes exemplary embodiments and is not intended to be limited to the expressly disclosed combination(s). Therefore, unless otherwise noted, features disclosed herein may be combined together to form additional combinations that were not otherwise shown for purposes of brevity.

[039] As depicted in Figures 1-13, in a first embodiment, a connector can be provided that provides improved impedance in the mating interface. It has been determined that as signal frequencies and data rates increase, it becomes increasingly beneficial to control impedance of the terminals. Controlling both common mode impedance and difference impedance turns out to be beneficial so as to minimize reflection and losses in the system (as changes in impedance tend to cause reflection of some portion of the energy being transmitted along a transmission line).

[040] Differential coupling is often chosen as a desirable method to transmit signals at high data rates because the differential coupling tends to make the system more resistant to noise. However, this can cause problems when transferring from a waferized channel (such as can be provided by two broad-side coupled terminals positioned in adjacent wafers) to a card edge. For one thing, there is a desire to ensure there is sufficient mechanical force so as to reliably engage contacts on an edge card with the terminals provided by the connector. On the other hand, the force cannot be so high that inserting a mating connector becomes difficult or potentially damages other systems.

[041] Therefore, due to various manufacturing issues, terminals in wafer systems tend to be blanked (or stamped). This allows for good control of the position of the terminals as an array of terminals can be blanked and molded into a wafer (and then the terminals can be singulated). Blanked terminals can provide good width control, thus helping to ensure consistent electrical performance. Furthermore, this type of construction allows for good control of spacing between terminals in adjacent wafers (along with the ability to change the dielectric value between two adjacent terminals) so as to provide a desired and controlled

differential coupling between signal terminals. However, when the terminals reach the point where they need to deflect, they tend to have their width modified so that they can deflect with a reasonable level of force. This typically results in a thinner terminal at the contact area. In addition, unlike backplane connectors that have terminals engaging terminals, because the terminals engage contact pads on a card edge that have relatively narrow spacing (typically contact pads are at a pitch of 0.8 mm or less) and due to dimensional variations, the terminals need to be thin enough and positioned far enough apart to ensure they engage only the appropriate pad. Thus, at the card edge interface the terminals that otherwise provided a relatively constant impedance become inductive.

[042] Figures 1-12 illustrate embodiments of connector system that have terminals that are blanked and formed. This increases cost and complexity of the terminals (and the overall system) but provides the ability to improve performance at the interface. In particular, it has been determined that insertion loss can be substantially reduced. Consequentially, a connector that might otherwise have been suitable for 14-18 Gbps data rates as acceptable insertion losses can be suitable for data rates of 25 Gbps.

[043] In addition to providing a less inductive interface (compared to conventional terminals/edge card connectors), the terminals also have thin contact. This allows the terminals to engage the contacts on the card edge without creating a large stub, thus avoiding reflection losses as the signal is transmitted from terminal to contact pad. The depicted embodiments can offer less than 1.4 dB of insertion loss at signal frequencies greater than 8 GHz.

[044] More specifically, a connector 100 is provided that can be mounted on a circuit board 60. Circuit board 60 can have plated vias, as is conventional, and may be constructed as desired. The connector 100 includes a housing 110 that supports a wafer set 150, the housing as depicted is a partial simplified housing for purposes of depiction (it being understood that a typical housing would normally extend around additional the sides of wafer set 150). The depicted housing 110 provides card slots 105, 106 in a stacked configuration, however in certain applications a single card slot or additional card slots may be desired. In general,

however, increasing the number of card slots tends to make the depth of the connector 100 increase (thus causing the connector 100 to take up more circuit board area) and thus the number of card slots would need to be balanced with the desired board space. In addition, the top card slot would be a longer channel and with sufficient difference the top card slot may begin to provide undesirable differences in performance characteristics compared to the bottom card slot. As can be appreciated, a mating connector has one or more circuit cards 50 that are inserted into the appropriate card slot.

[045] The card slots can each provide contacts on two sides of the card slots, labeled generally as contacts 164, and the contacts can oppose each other and be inserted into terminal channels formed in the housing 110. The contacts 164 are part of terminals that are supported by a frame 154 (which may be insulative) and the terminals and frame 154 comprise the wafers. Wafers can also have additional features as desired and may be formed of different materials in different areas (such as including conductive or somewhat conductive materials in desired locations). In addition, in certain applications two or more wafers may be configured to be pressed together to form a wafer group.

[046] The contacts are coupled to beams 163 which extend to a transition and then the terminal continues as a body 162 and the terminal ends as a tail 161. Thus, for many applications the terminals can extend continuously between the contact and the tail.

[047] As can be appreciated, the wafer set is depicted as including a first pair 151 and a second pair 152 of signal wafers that are surrounded by ground wafers 153. In an embodiment, ground wafers can be configured with terminals that include a commoning feature 166 and are commoned together with pins 190. In addition, bodies 162a' and 162b' of the ground terminals are depicted as being wider than corresponding bodies of the signal wafers. However, in alternative embodiments, the terminals in each wafer (the ground and the signal wafers) can be substantially the same (for example, similar to the terminals provided in the signal wafers depicted). Furthermore, the pins can be omitted if the channel is sufficiently tuned or if lossy plastic is used to help dampen resonances. The advantage of

using pins is that there is more flexibility in designing the channel and tolerance do not have to be as well controlled, thus potentially making the system easier to manufacture.

[048] The first pair 151 comprises a wafer 151a and 151b. As can be appreciated, beams 136a-163h extend forward of the insulative frame 154a, 154b provided for the corresponding wafer. The beams 163 are formed and configured so that they do not become excessively inductive as they extend from the corresponding transition provided on each corresponding body 162a-162h. Thus, beams 163a, 163b provide a desirable continuation of the controlled impedance that was provided by the corresponding body 162a, 162b of the terminals. As can be appreciated, this is accomplished, in part, by going for a broad-side coupled orientation to an edge-coupled orientation at the transition. To ensure the contacts 164 are the appropriate size for mating with circuit cards, the contacts are not as wide as the beams 163. Thus, unlike typical IO interfaces, the beam 163 (which is intended to flex) is wider than the contact 163.

[049] It should be noted that the depicted embodiment also has the bodies of the terminals transition toward an edge-coupled configuration right before the tails. While not required, this allows for a reduced pitch between terminals (supporting 0.75 or even 0.70 mm pitch) without the need to have the terminals formed so that they extend sidewise in the wafer (from a first distance apart to a second greater distance apart). Furthermore, the depicted configuration may be useful for certain routing of traces in the circuit board. However, any other desirable via pattern could be used.

[050] It should be noted that the tails 161 are depicted in a truncated fashion. Tails can be configured as desired and may be configured to solder or press-fit (or a combination). An example is provided in the embodiment depicted in Figures 25-30. As the design to the tails can be varied, however, the depicted tails are truncated so as to make the other details easier to appreciate.

[051] As can be appreciated from Figure 12, the body of the terminal transitions at transition T1 or T2 to a beam. Thus, rows 121a-121d of beams can be provided. The transitions T1 and T2 can be configured so that they are helpful in aligning a wafer into the

housing (a portion of the corresponding transition can extend out of the frame). In an embodiment, the transition T1 and the transition T2 can be configured so as to have the beam on the same side of the body (in effect, having the beam deformed up from T1 and deformed down from T2).

[052] An embodiment similar to the first embodiment is provided in Figures 13-24. A connector 200 includes a housing 210, a wafer set 250 and may be mounted on a circuit board 60. Ground wafers 253 can be positioned on both sides of signal pairs 151. As before, optional pins 290 can be used to engaging commoning feature 266 so as to help common the ground terminals if the commoning is determined to be useful in improving the performance of the connector.

[053] The signal pairs can include a first wafer 251a with a frame 254a and a second wafer 251b with a frame 254b that each support a plurality of terminals (as depicted, four terminals each to provide a total of up to for signal pairs, although some other number of terminals may be provided). The signal wafers may include apertures 257 that allow pins 290 to extend past the signal terminals. As depicted above, the signal pair provides beams 263a-263h so as to enable provision of four differential pairs P1-P4 where the impedance is desirably controlled through the body portion (such as body 262a, 262a' or body 262b, 262b') into the interface portion and the contacts 264, 264' (which are providing in an opposing manner) are still suitable for engaging a circuit card at a pitch of 0.8 or less.

[054] As above, the tails 261a, 261b of the signal terminals can be configured so that they are positioned forward and rearward of each other. In addition, as can be appreciated from Figure 19, transition T1 places the beam toward (or at) the bottom of the terminal body while transition T2 places the beam toward (or at) the top of the body. As can be appreciated from Figures 21 and 22, the contact 264, 264' can be offset with respect to the corresponding beam 263 so that there is distance 269, 269' between an edge of the contact and an edge of the beam. This allows the contact to be formed so that it is offset with respect to the body of the corresponding terminal, which can be useful in distributing forces. It should be noted that

such an alignment is not required and the contact could also be substantially aligned with the body.

[055] As can be appreciated from Figure 23, the body 262a and 262a' are a first distance D1 apart in the frame, the beams 263a, 263b extending from the body are a second distance D2 apart and the contacts 264a, 264b are a third distance D3 apart. In an embodiment, D1 and D3 can be slightly difference. If desired, for example, D1 could be about 0.62 mm and D2 could be about 0.25 mm and D3 could be about 0.55 mm. In general, however, D1 will be greater than D3 and D3 will be greater than D2. In an embodiment, D1 can be at least twice D2.

[056] It should be noted, as can be appreciated from Figure 24, that the body of each of the signal terminals has a side face and an edge face, the side face being at twice as wide as the edge face, and the side faces of adjacent terminals are facing each other (thus providing a broad-side coupled configuration). Conversely, the beam of each signal terminal has a top face and an edge face and the top face is at least twice as wide as the edge face and the edge faces of adjacent terminals are facing each other. It should also be noted that while the depicted terminals are intended to be signal terminals, the same shape could also be used for a ground terminal (and in certain embodiments the ground and signal terminals may be all similar to the terminals depicted in Figure 24 but ground terminals may have varying tail positions (e.g., in between the current tail portions).

[057] As can be appreciated from Figures 25-30, an embodiment of a connector 300 is disclosed with a housing 310 that includes a first opening 311 that provides a first card slot 305 and includes a second opening 312 that provides a second card slot 306. Contacts 364 are positioned in terminal channels 314 provided in the card slots. As above, beams 363 extend from transition T1 and T2. The signal tails 361a, 361b and ground tail 361c are depicted as press-fit tails but, as discussed above, other tail configurations can be used as desired.

[058] The connector 300 can provide a terminal that uses the transition as a securing flange that extend into the slot (potentially to a notch in the rear wall of slot as depicted) while allowing the terminals to be unsupported between a terminal tip and the transition. Furthermore, the terminals can be configured so that there is an air channel between adjacent terminals from the contact to the rear wall. This can help provide a desirable impedance such that there is reduced loss in the connector (e.g., reflection and/or insertion loss can be reduced). For example, the signal terminals of adjacent wafers can be configured so that the adjacent pair of terminals are configured to provide a differential signal transmission channel that provides an insertion loss of not more than 1.4 dB at a signaling frequency of greater than 8 GHz. If the channels are well managed, the insertion loss can be not more than 1.4 dB at signaling frequencies greater than 10 GHz. As can be appreciated, this can also help reduce cross talk as there will be less undesired modes of energy traveling along the terminals that could potentially resonate and create spikes in noise (e.g., cross-talk).

[059] The disclosure provided herein describes features in terms of preferred and exemplary embodiments thereof. Numerous other embodiments, modifications and variations within the scope and spirit of the appended claims will occur to persons of ordinary skill in the art from a review of this disclosure.

We claim:

1. A connector, comprising:
 - a housing having a slot with a first and second side;
 - a first and second signal wafer adjacently positioned in the housing, each signal wafer supporting a first and second terminal, the terminals each having a tail, a contact, a beam and a body extending between the tail and the beam, wherein the body of the terminals has a side face that is at least twice as wide as a first edge face and the body of the terminals of adjacent wafers are aligned so as to provide broad-side coupled configuration with the side faces facing each other, and wherein the beam of the terminals has a top face that is at least twice as wide as a second edge face and the beams of adjacent wafers are in an edge-coupled configuration with the second edge faces of adjacent beams facing each other.
2. The connector of claim 1, wherein the first terminal in each wafer is positioned on the first side of the slot and the second terminal in each wafer is position on the second side of the slot and an orientation of the contact of the first terminal is opposite an orientation of the contact of the second terminal.
3. The connector of claim 1, wherein the first terminal includes a first securing flange that extends in a first direction and the second terminal includes a second securing flange that extends in a second direction that is opposite the first direction, the first and second securing flanges respectfully engaging an upper and a lower notch in the housing so as to secure the wafer to the housing.
4. A connector, comprising:
 - a housing with a slot that includes a first side and a second side;
 - a set of four terminals supported by the housing, each terminal having a tail, a curved contact configured to engage a flat contact on a mating connector, a beam supporting the contact, a transition and a body extending between the tail and the transition, wherein the body of the terminals has a side face that is at least twice as wide as a top face and the body of the terminals are aligned so as to provide broad-side coupled configuration, and wherein

the beam of the terminals has a top face that is at least twice as wide as an edge face of the beam, wherein the beam is configured to be edge-coupled and wherein the housing does not extend between adjacent beams between the transition and the contact.

5. A connector, comprising:

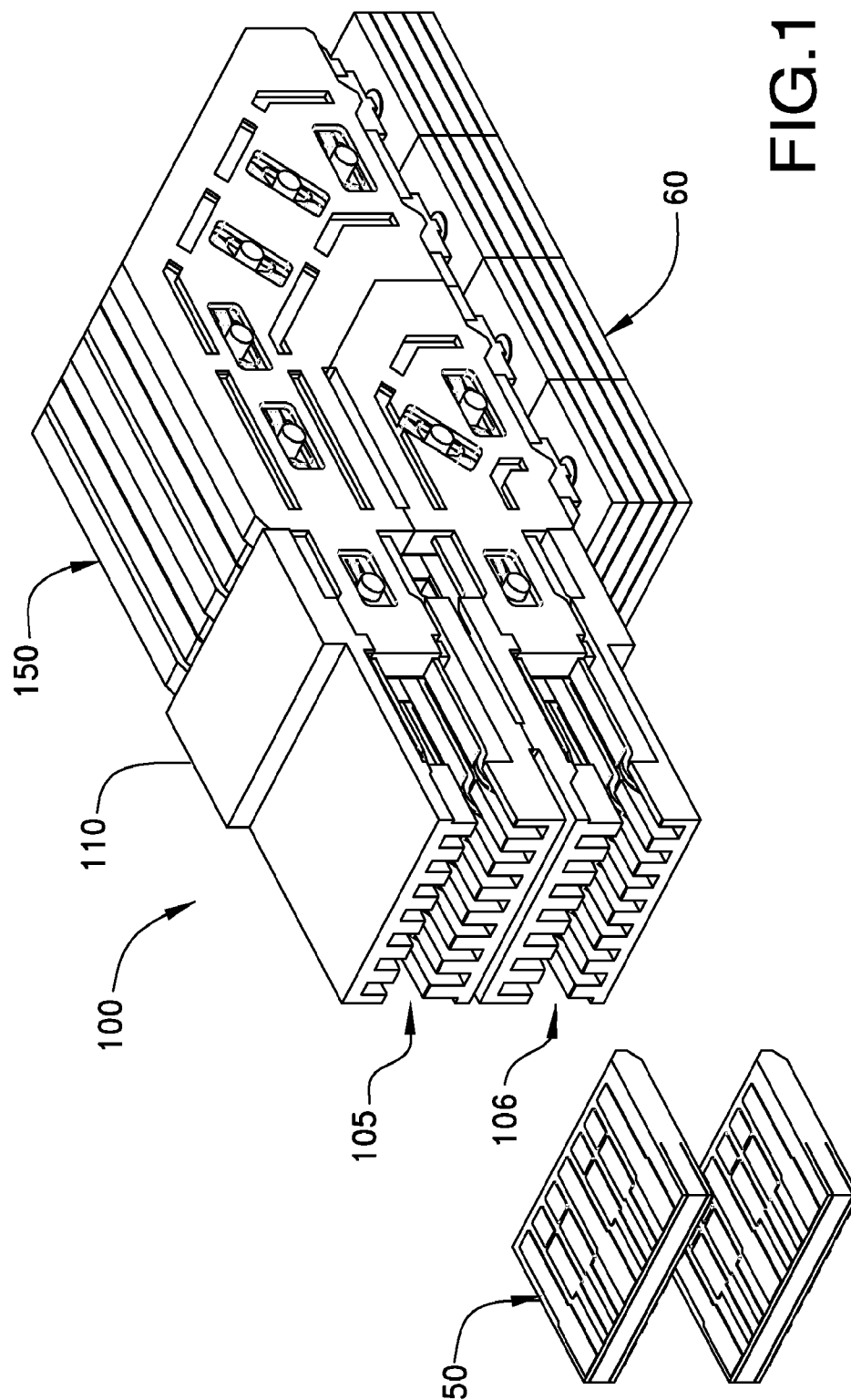
a housing with a slot that includes a first side and a second side;

a first and second signal wafer adjacently positioned in the housing, the first wafer support a first signal wafer terminal and the second wafer supporting a second signal terminal, the terminals each having a press-fit tail, a contact, a beam coupled to the contact and a body extending between the tail and the beam, wherein the body of the terminals has a side face that is at least twice as wide as a top face and the body of the terminals are aligned so as to provide broad-side coupled configuration, and wherein the beam has a top face that is at least twice as wide as a side face of the interface portion and housing is not provided over between the interface portion of the terminals, wherein the first and second terminal are configured to provide a differential signal transmission channel that provides an insertion loss of not more than 1.4 dB at a frequency of greater than 8 GHz.

6. The connector of claim 5, wherein the first terminal in each wafer is positioned on the first side of the slot and the second terminal in each wafer is position on the second side of the slot and the contacts of each terminal are offset with respect to the beam.

7. The connector of claim 6, wherein the offset of the contact of the first terminal is opposite the offset of the contact of the second terminal.

8. The connector of claim 6, wherein the first and second terminal are configured to provide the insertion loss of not more than 1.4 dB at a frequency of greater than 10 GHz.



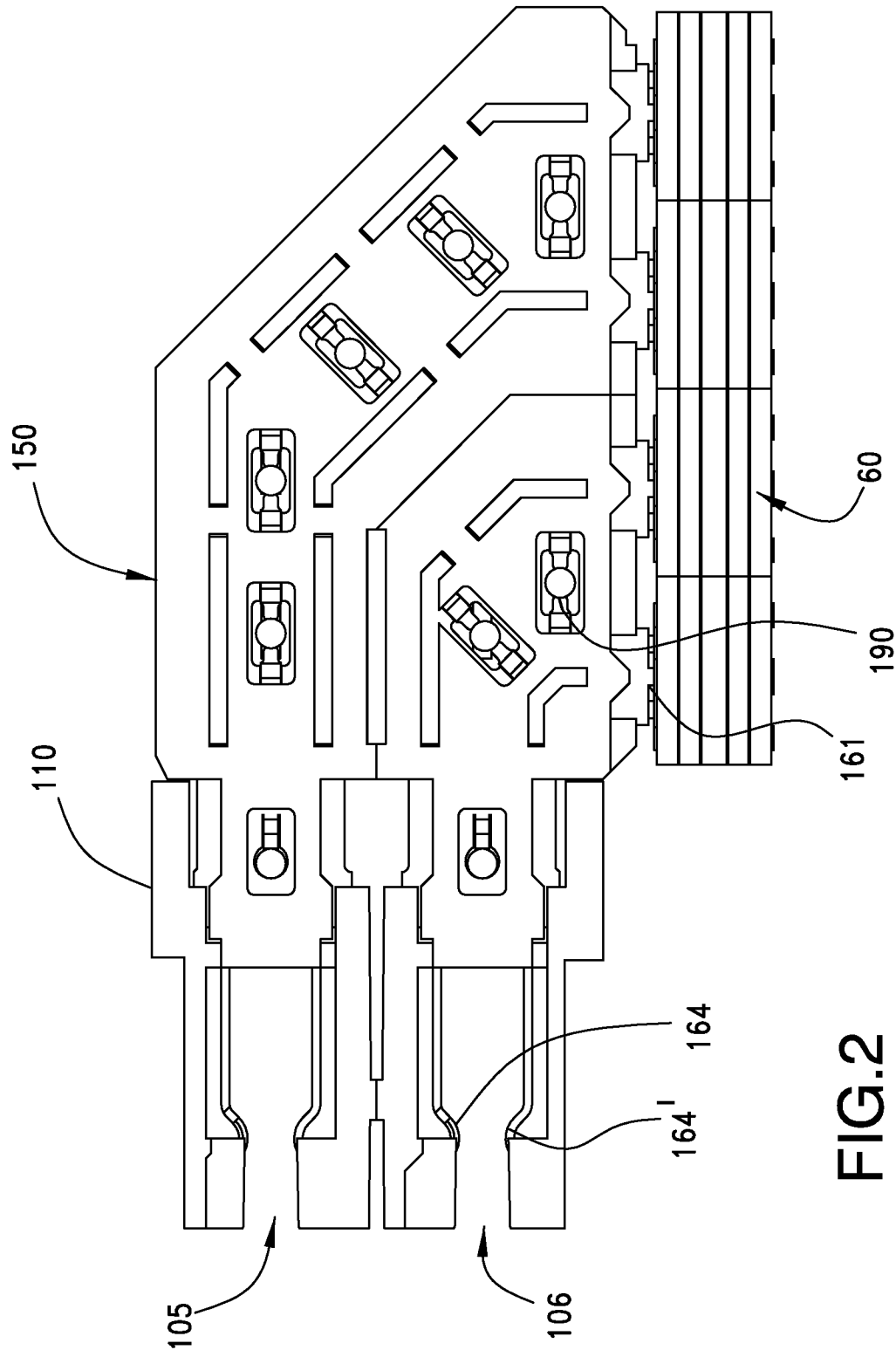


FIG.2

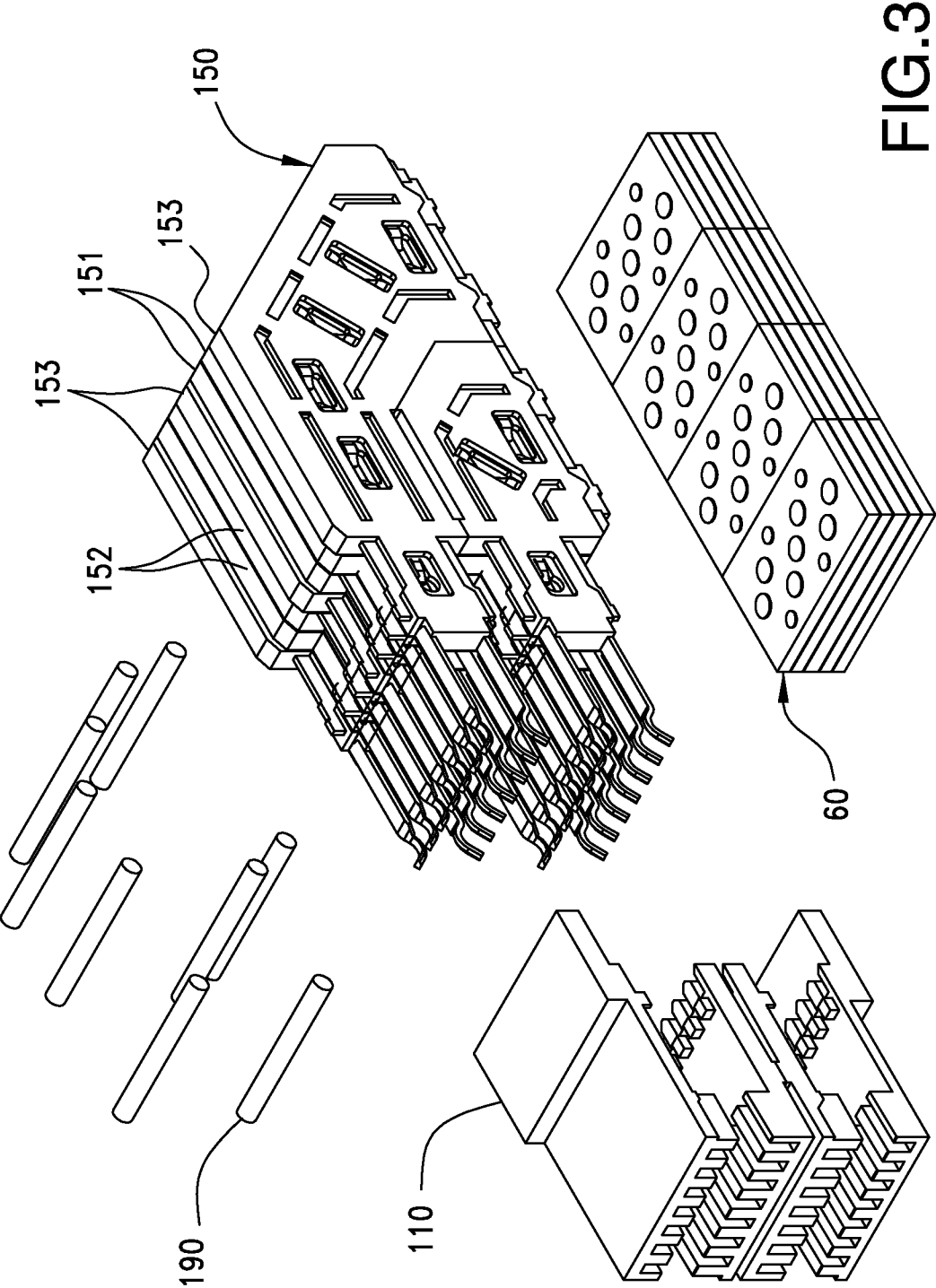


FIG.3

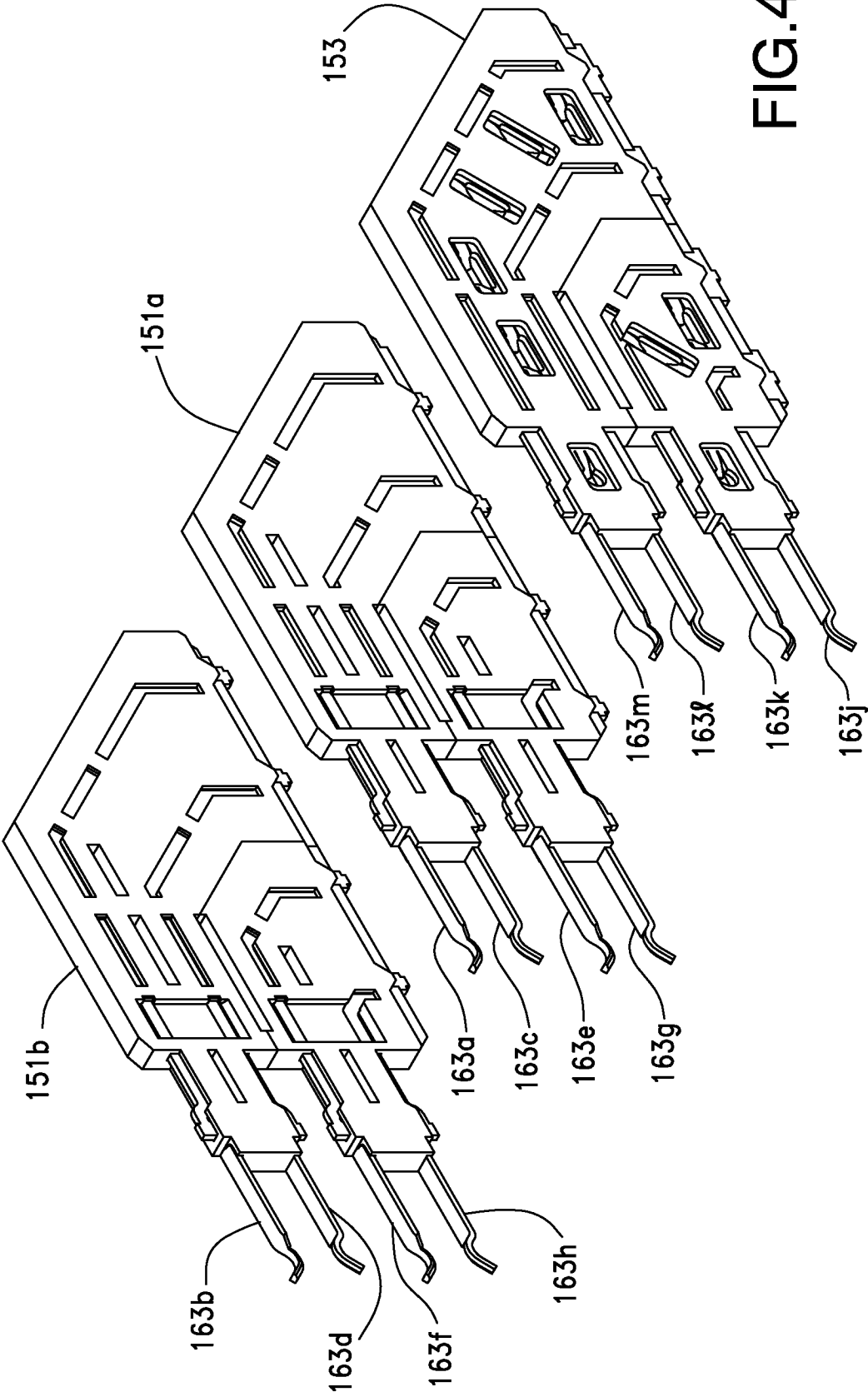


FIG. 4

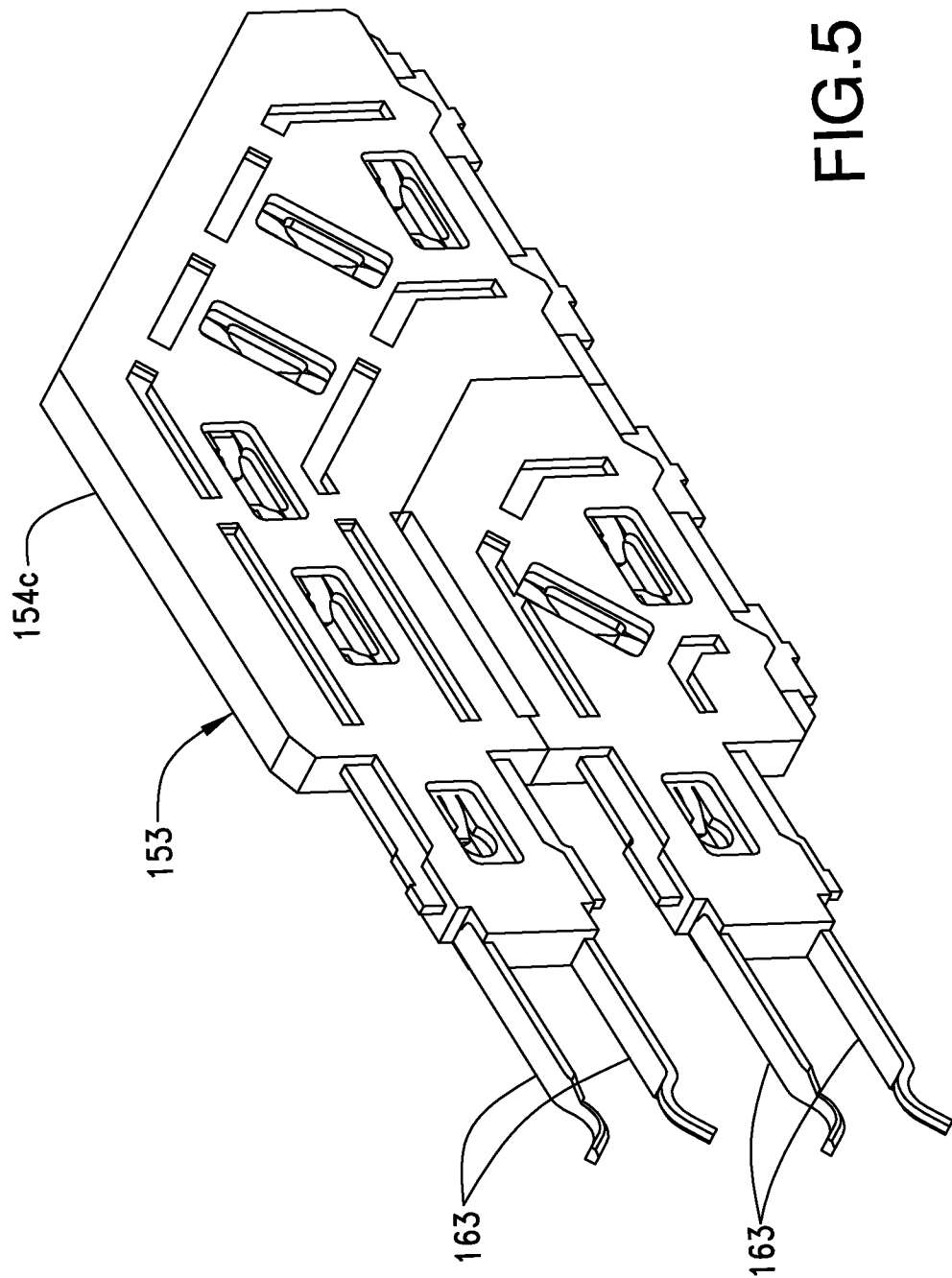


FIG. 5

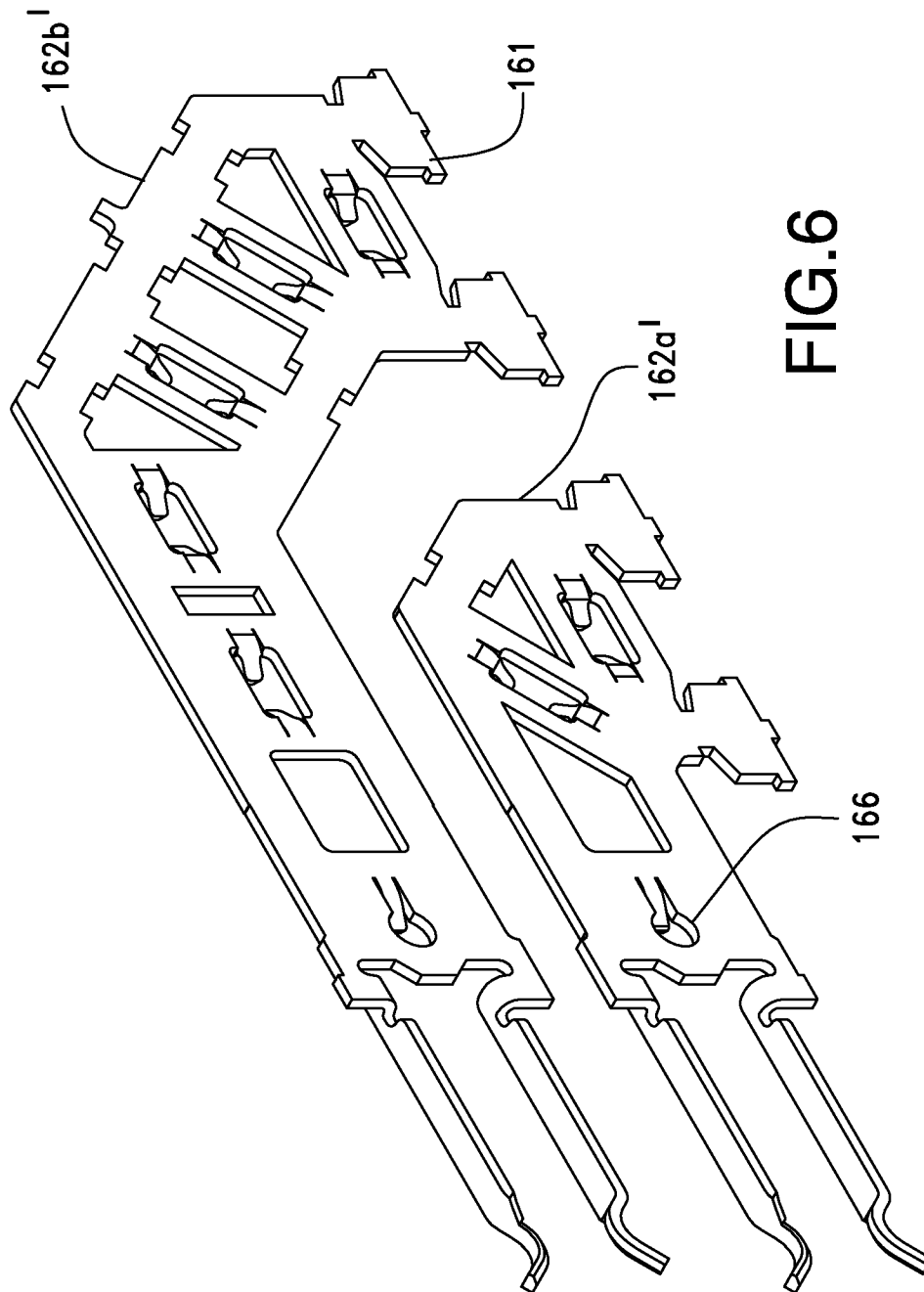
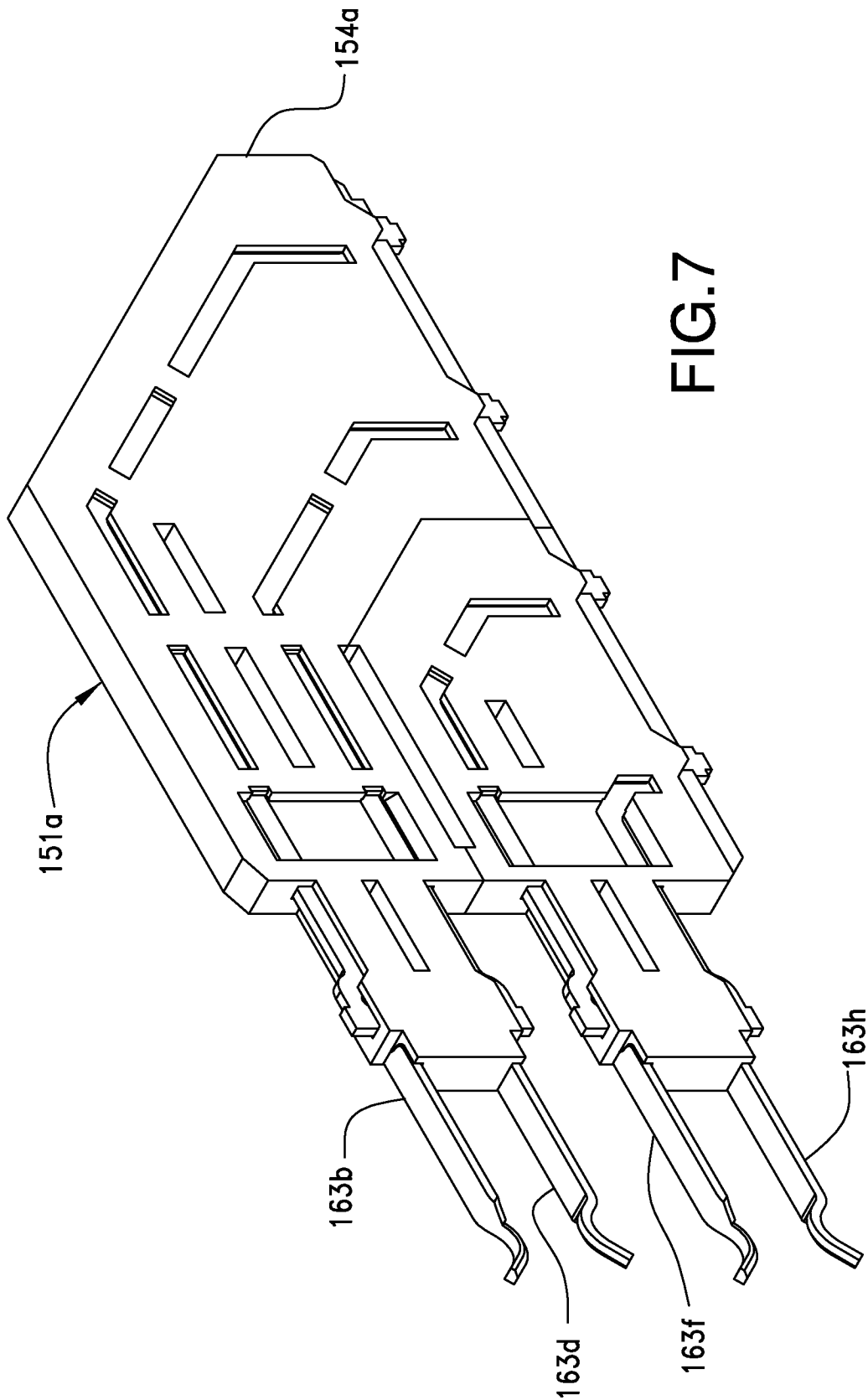


FIG. 6



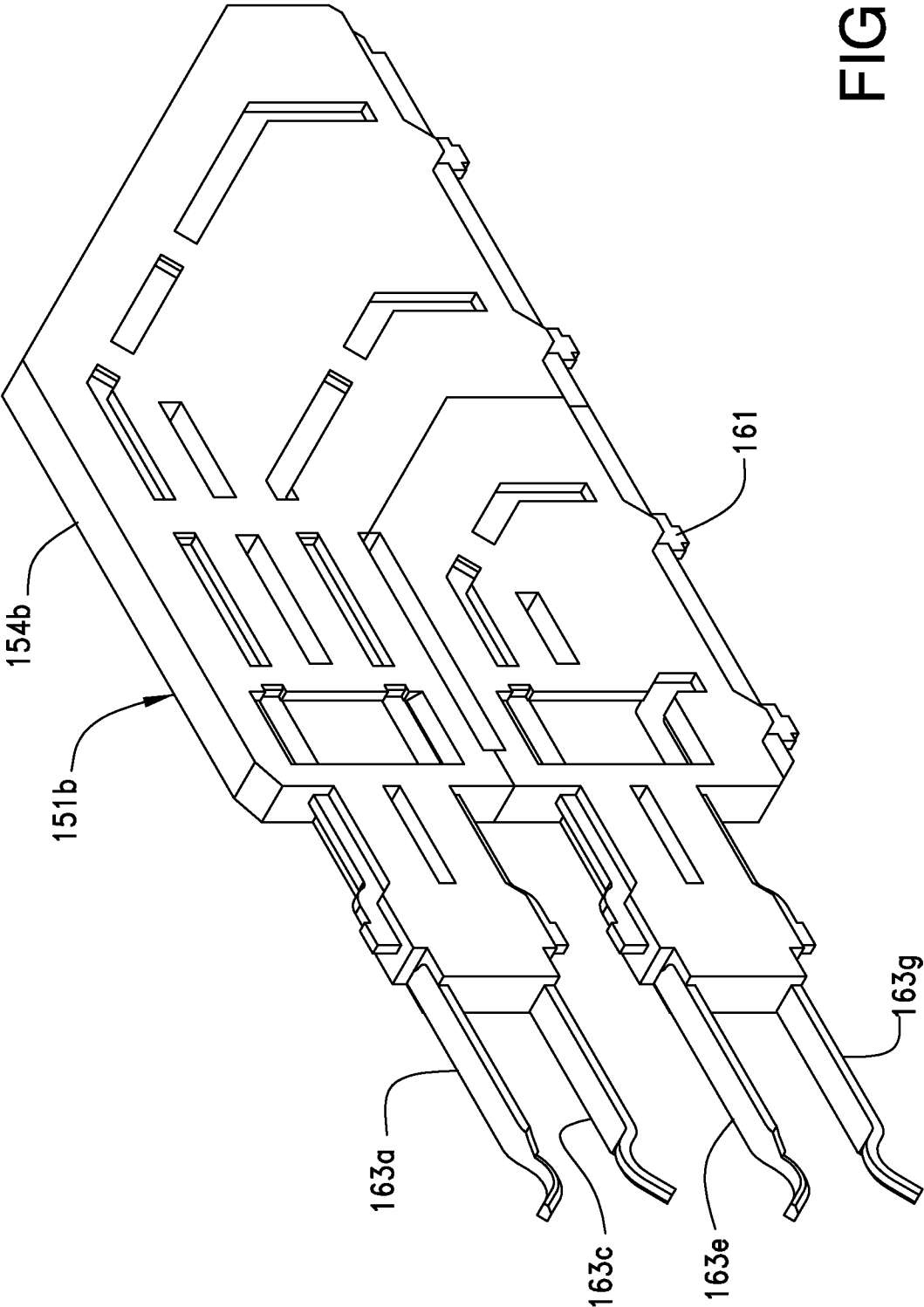
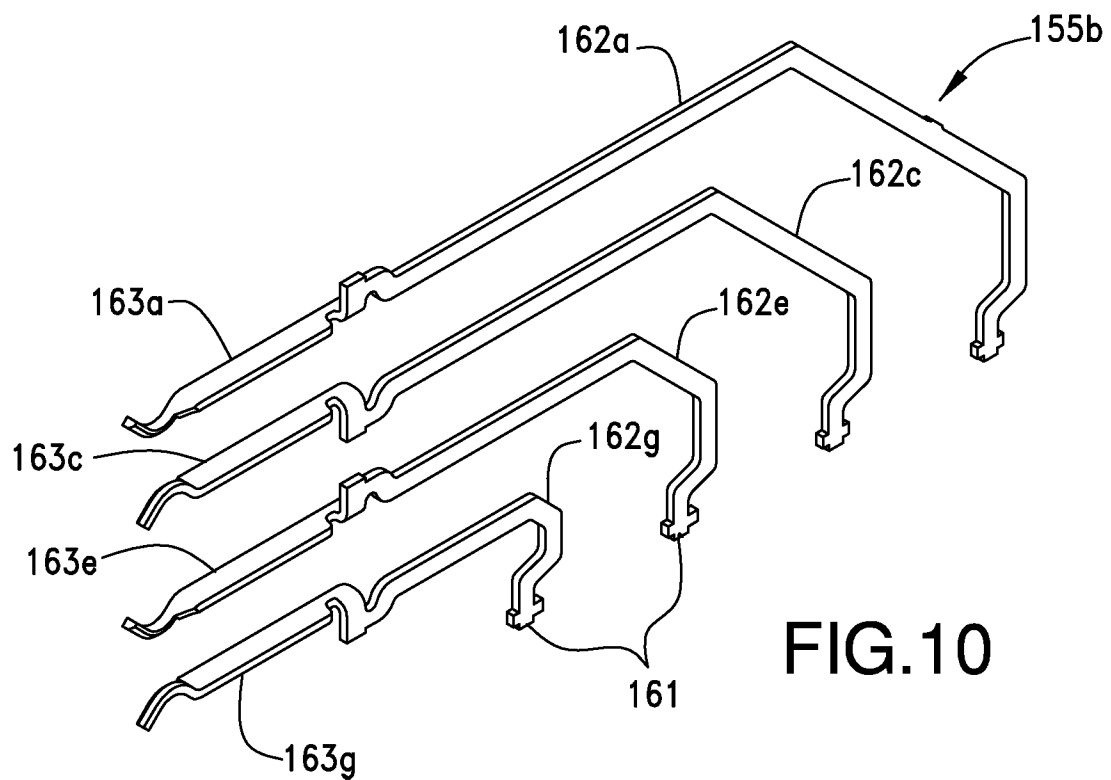
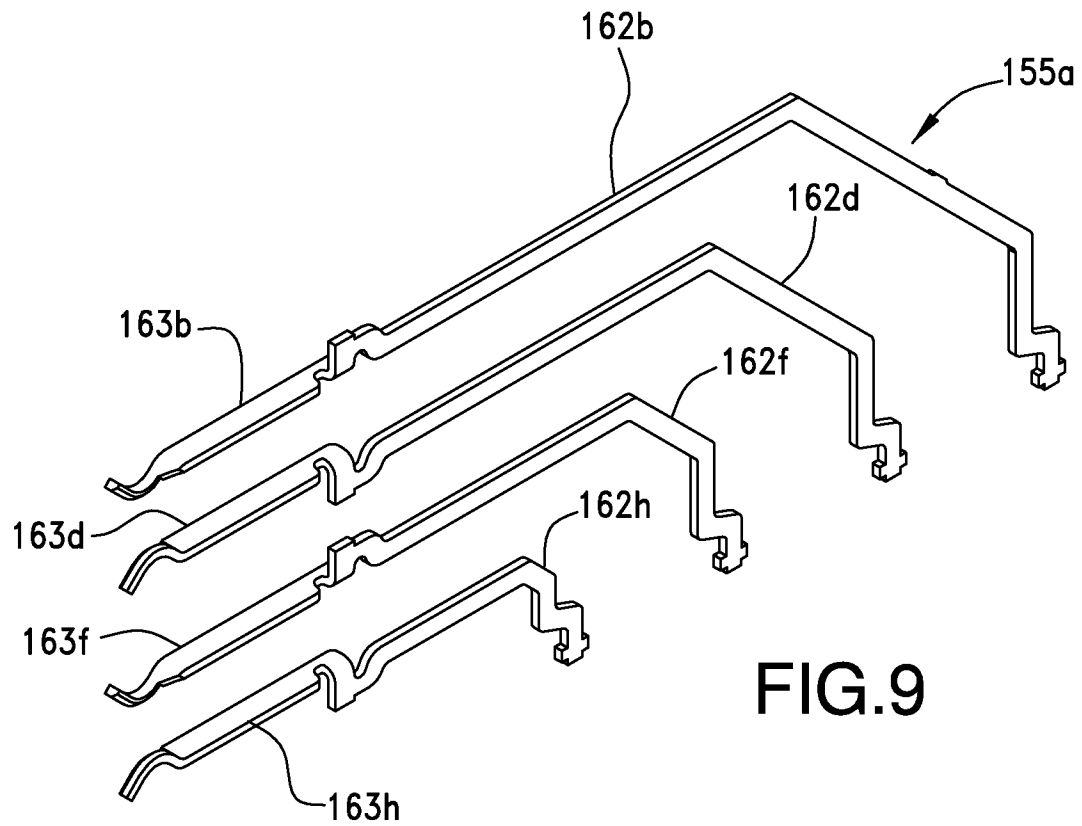
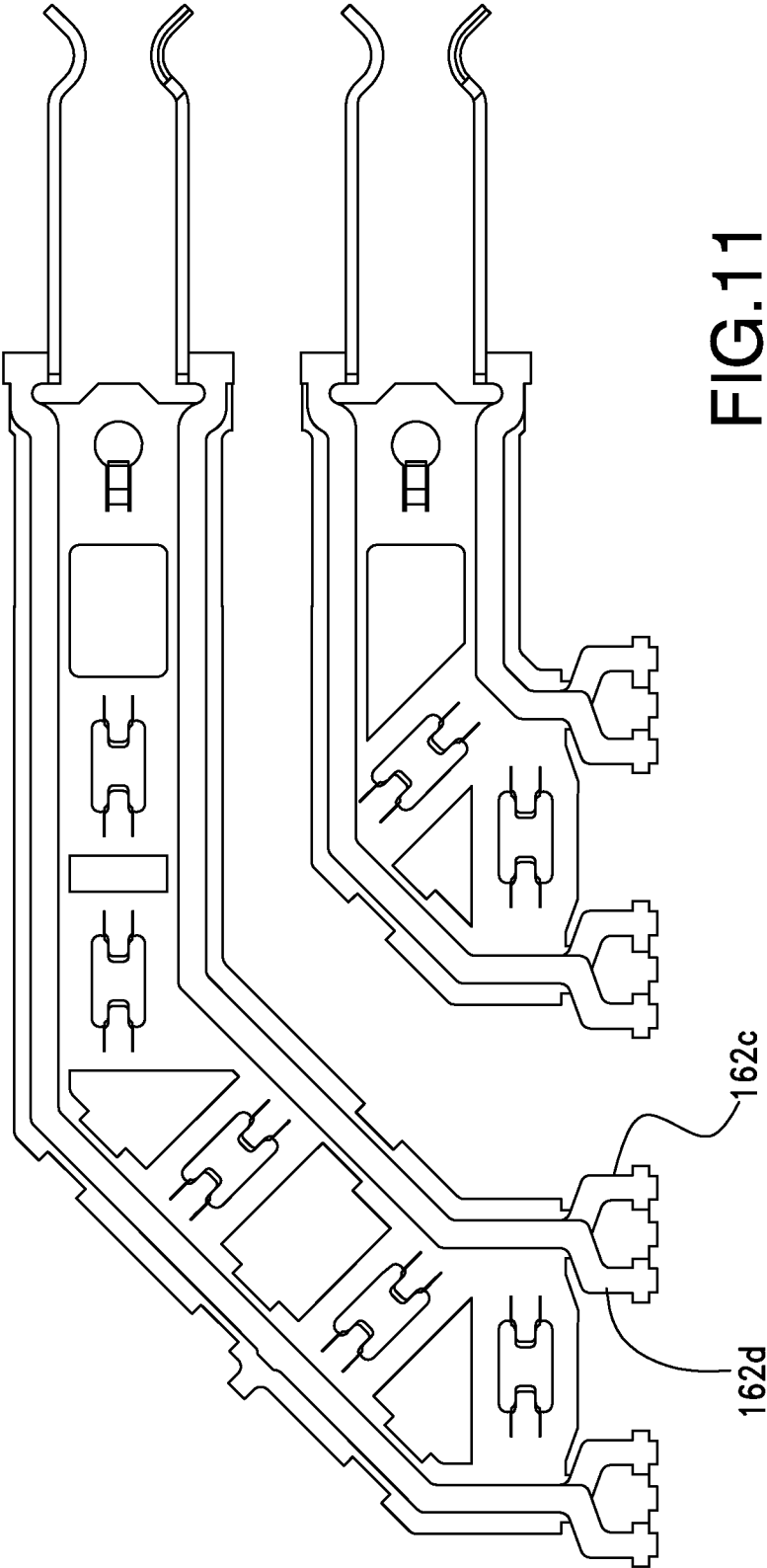


FIG. 8





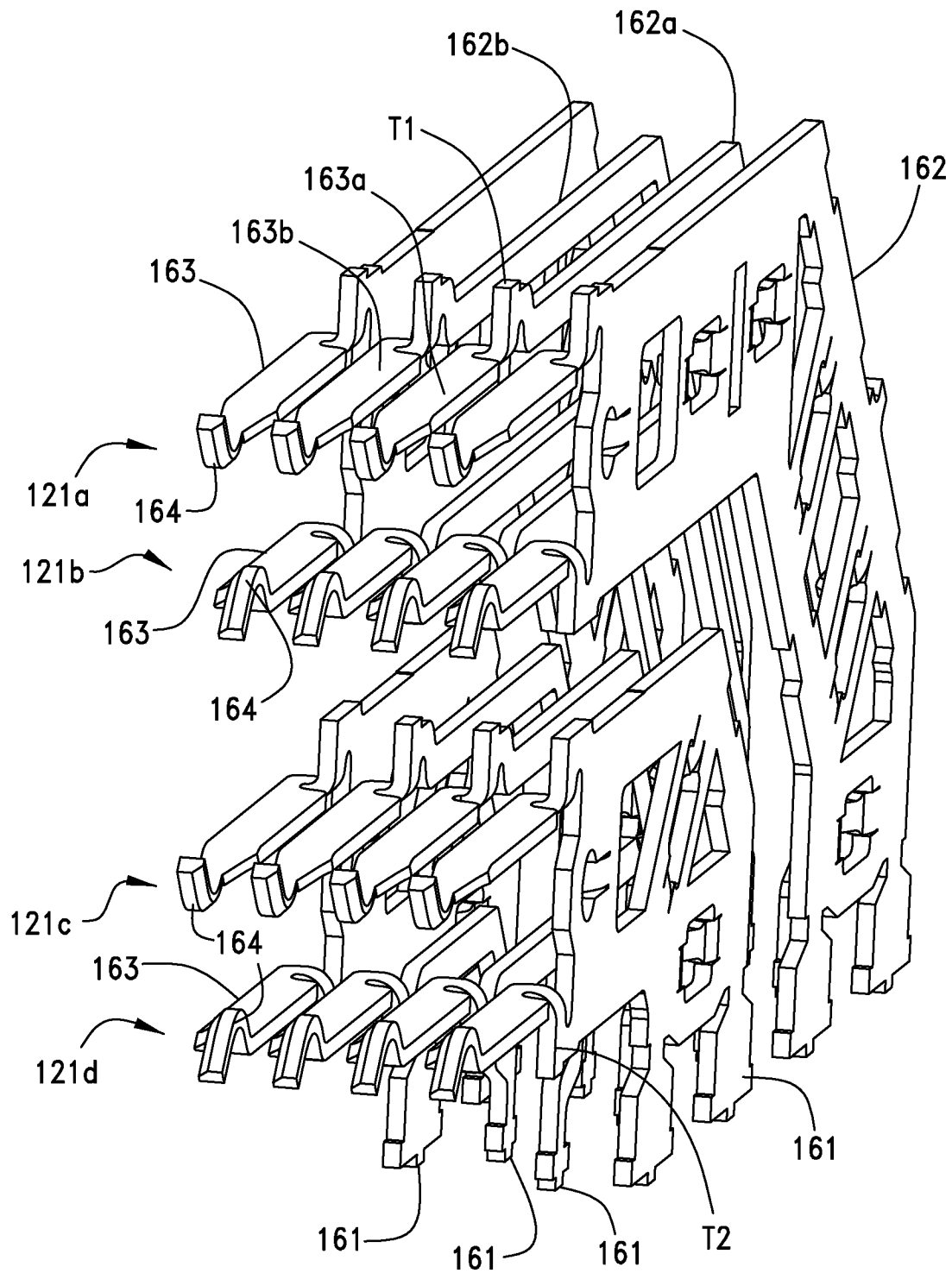


FIG.12

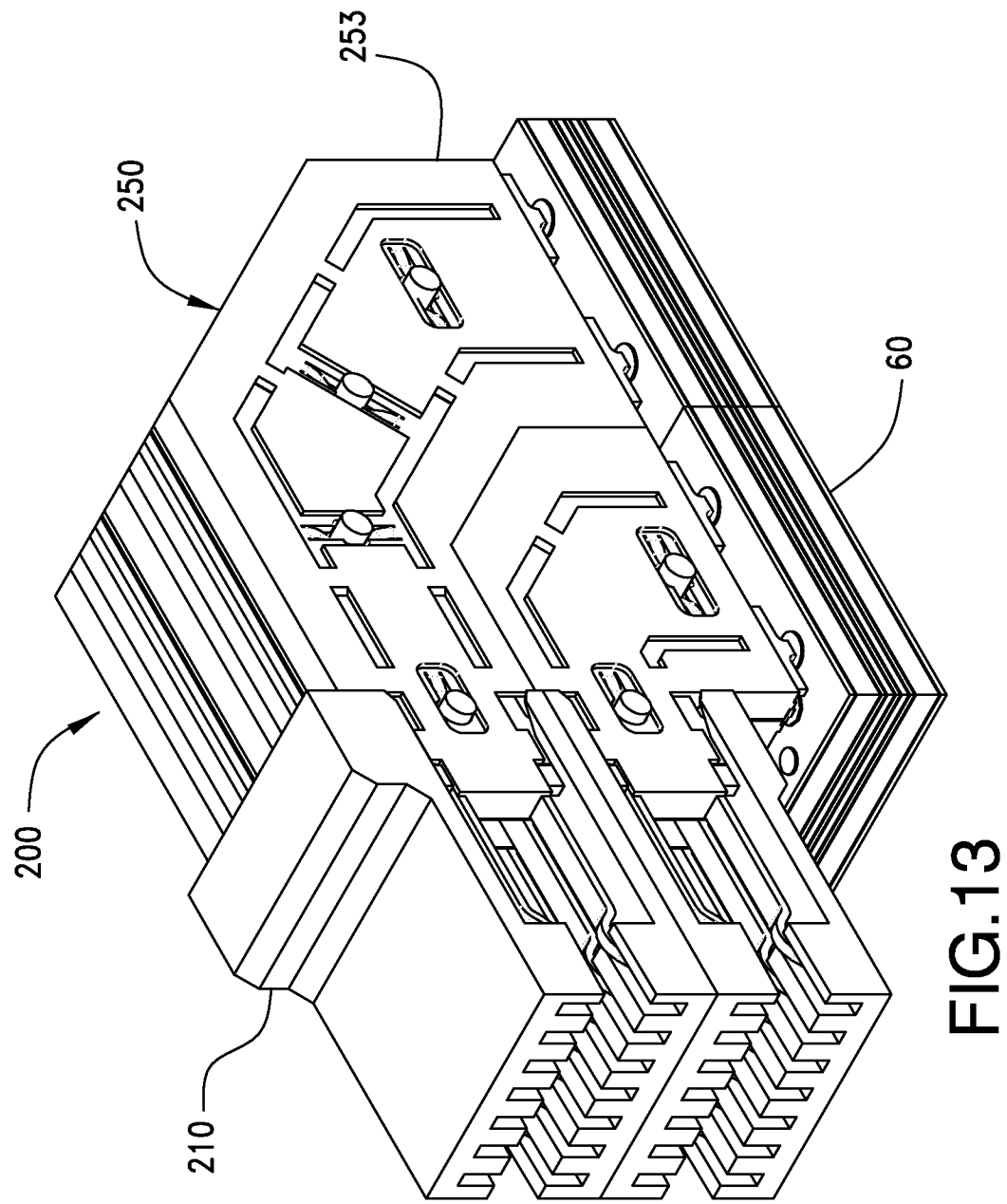


FIG.13

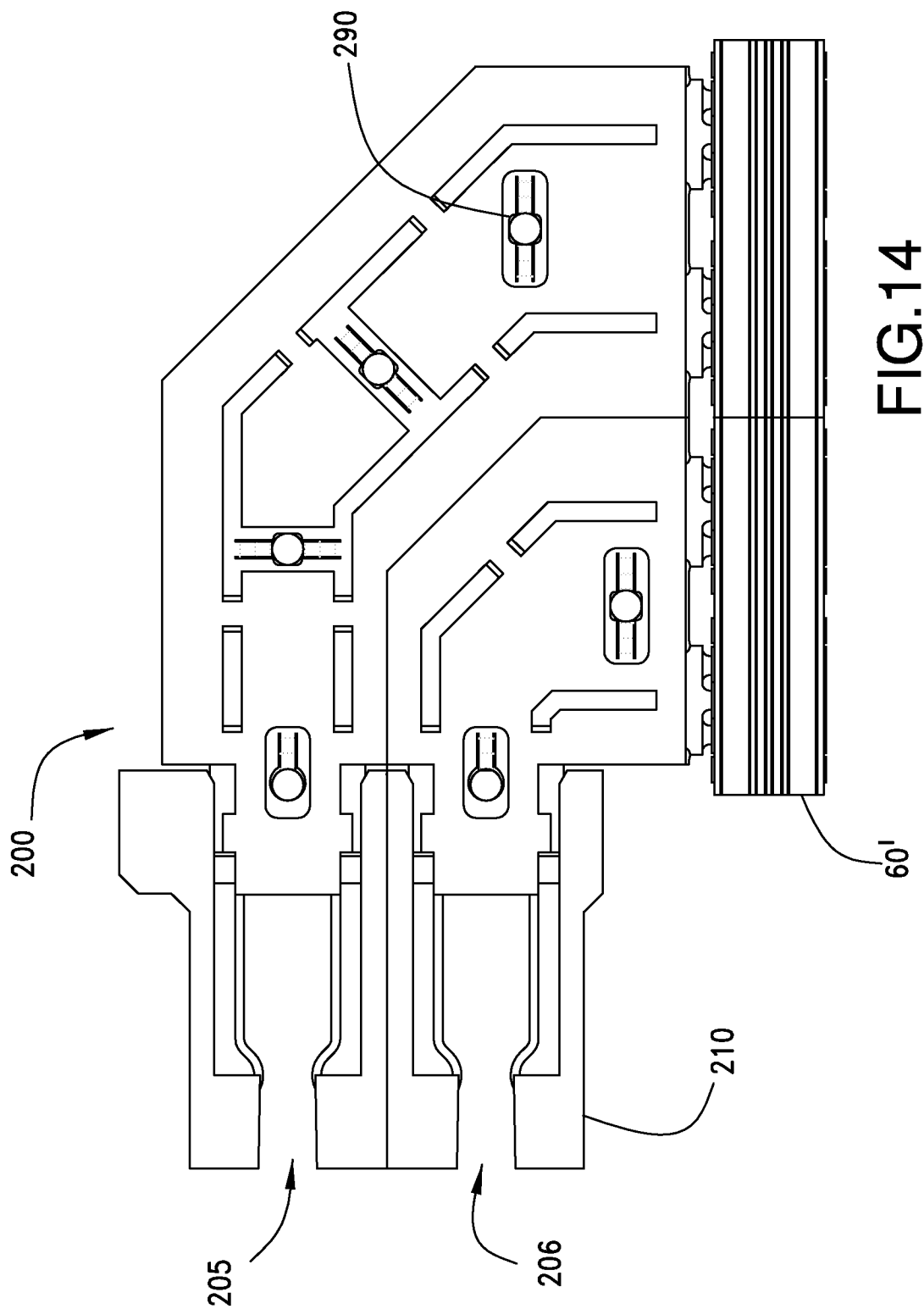
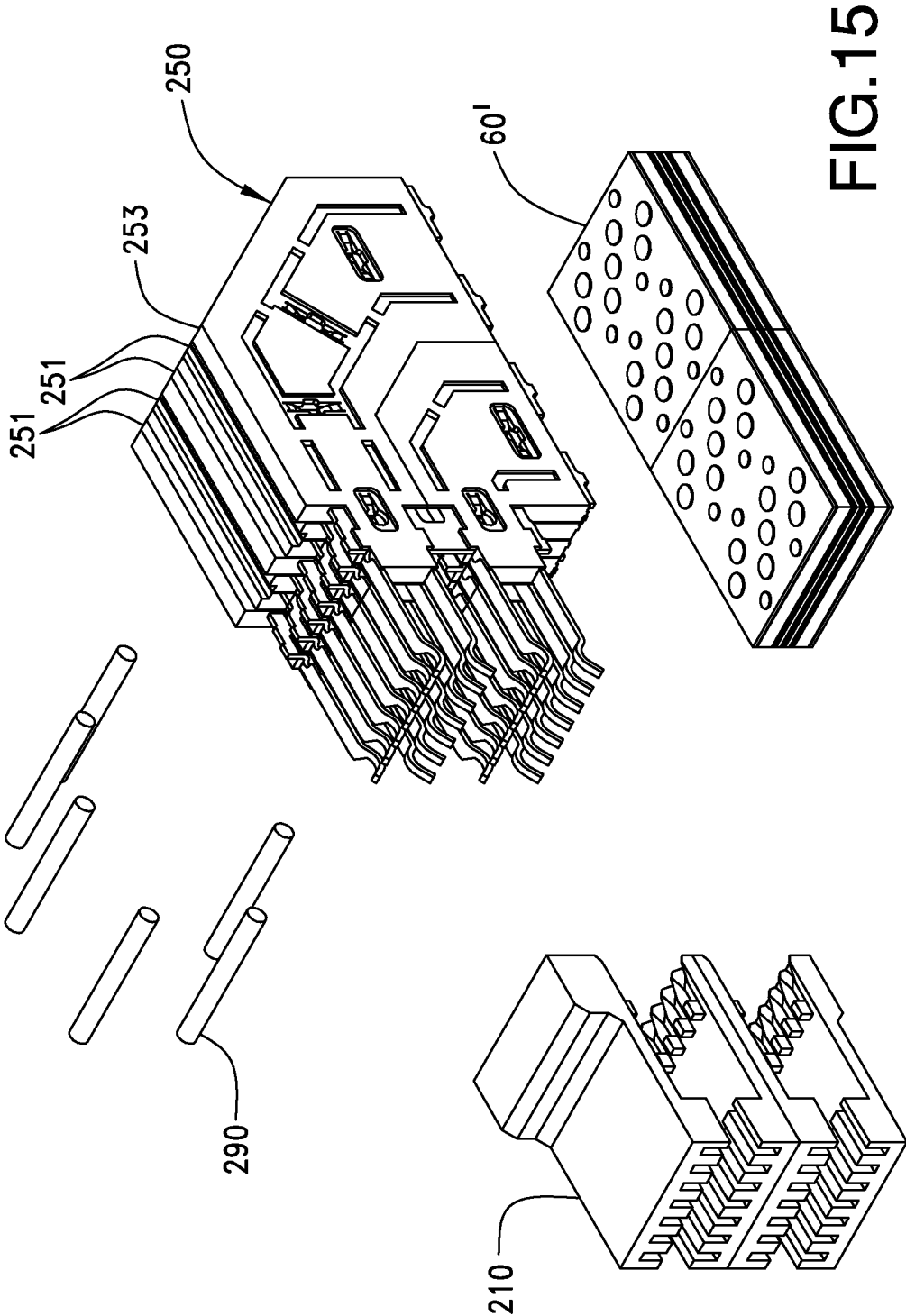


FIG.14



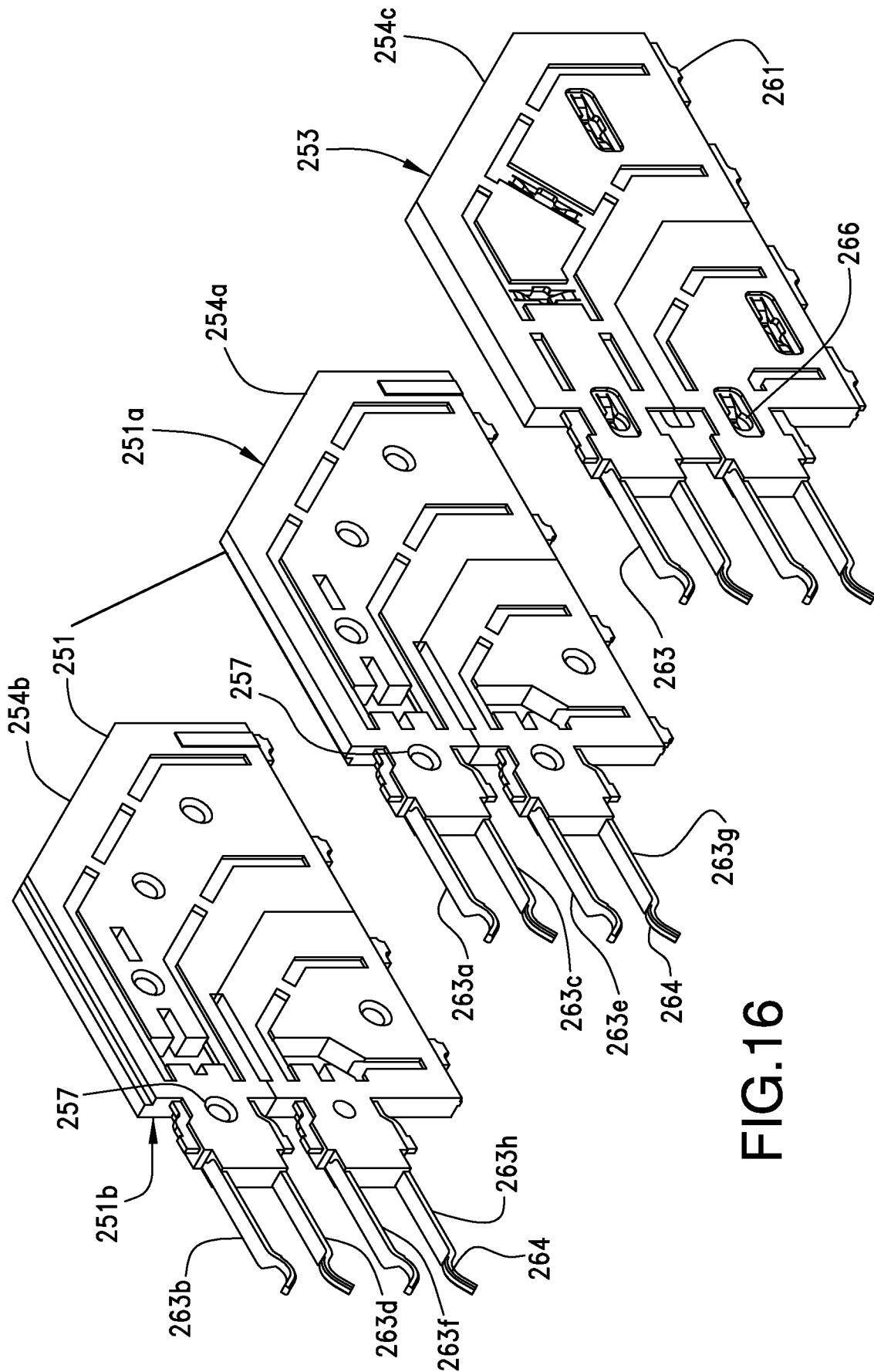


FIG. 16

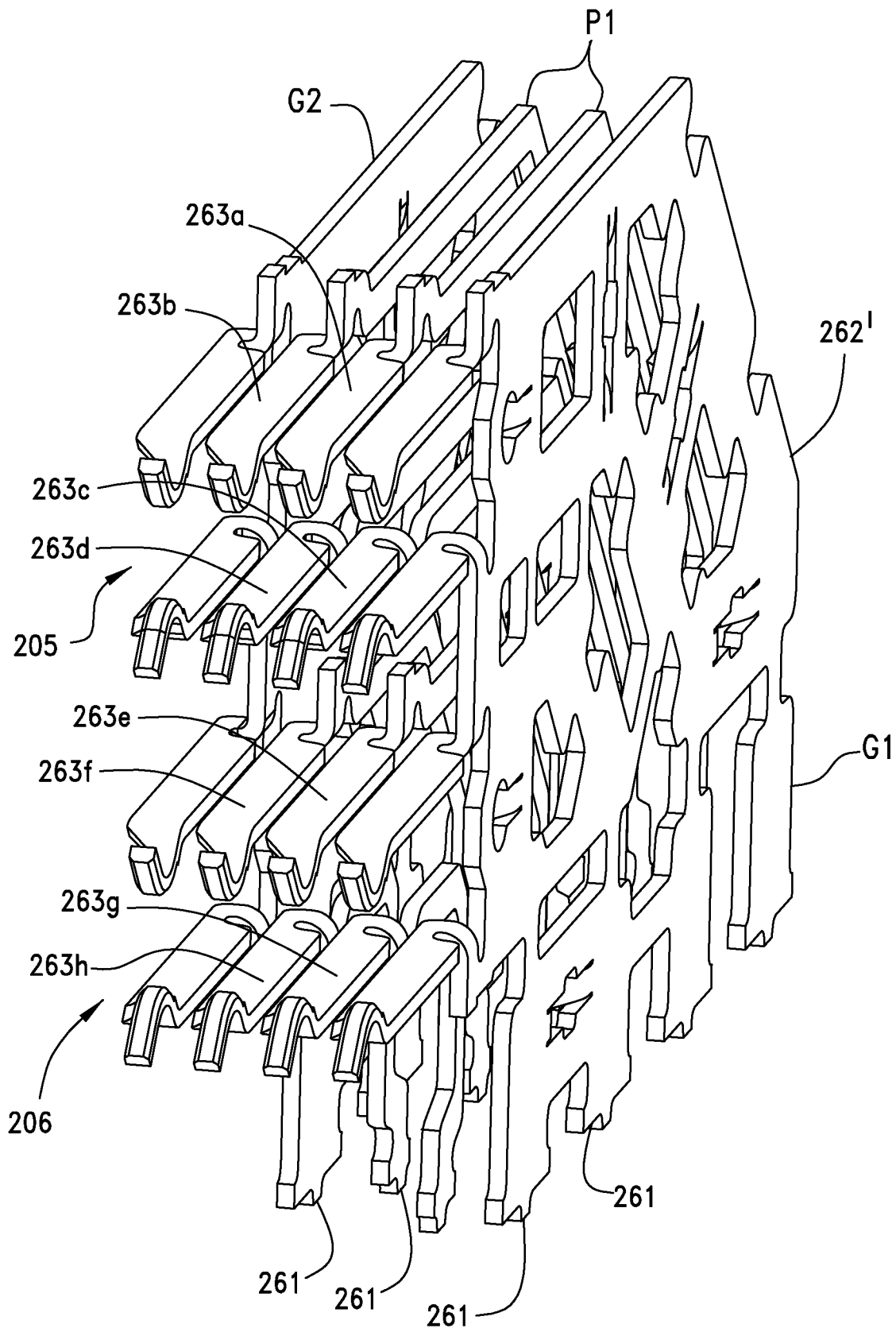


FIG.17

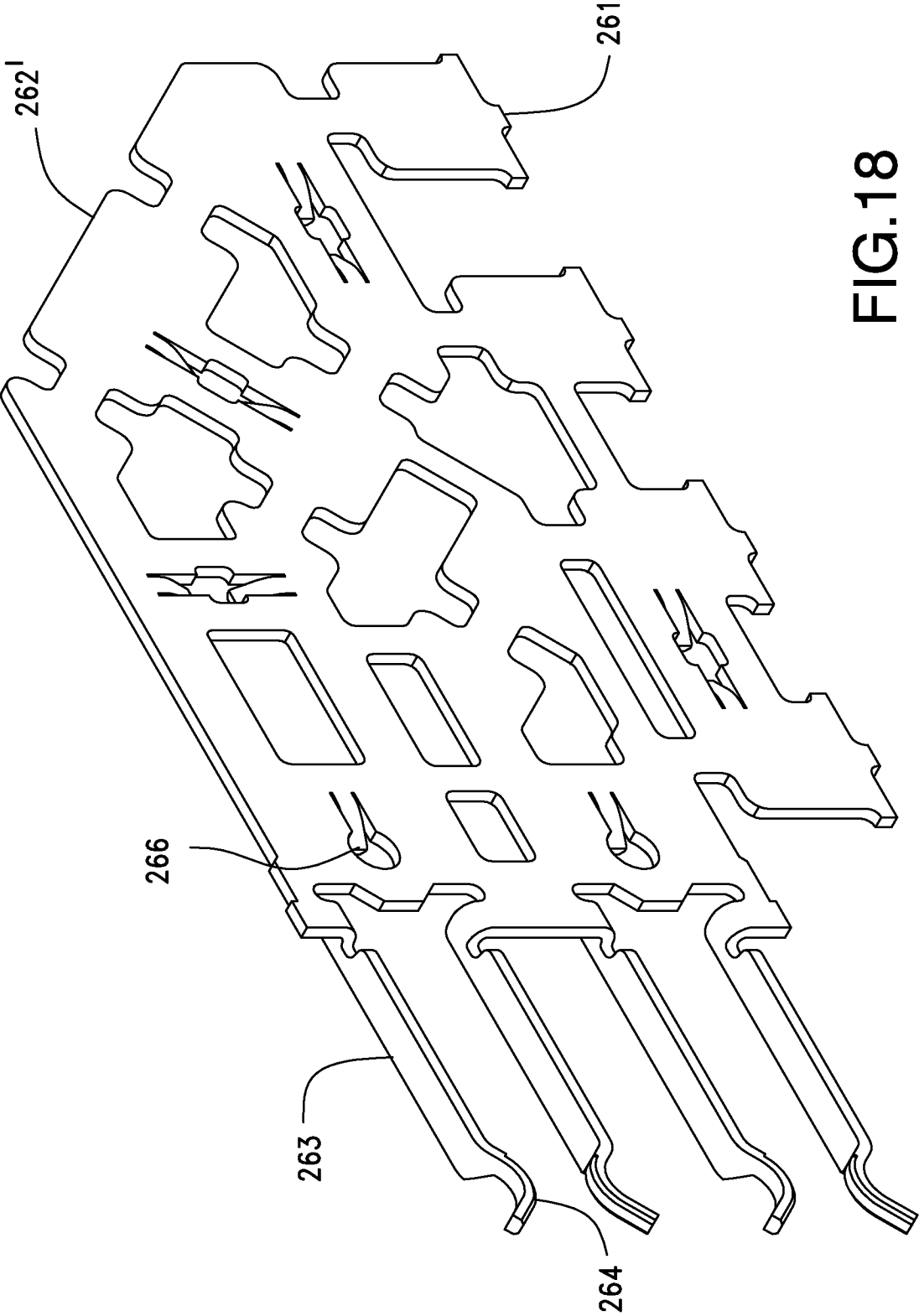


FIG.18

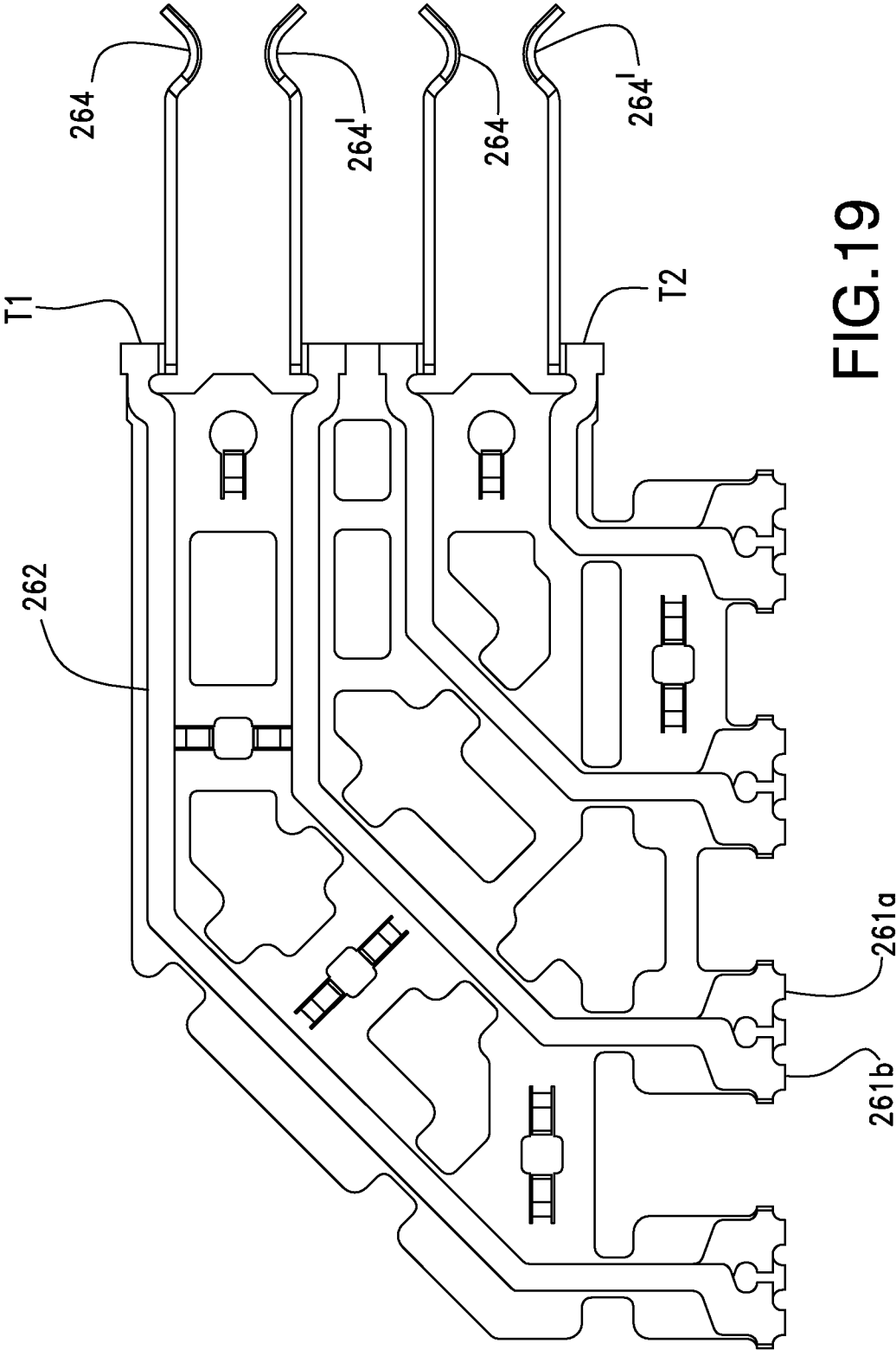


FIG.19

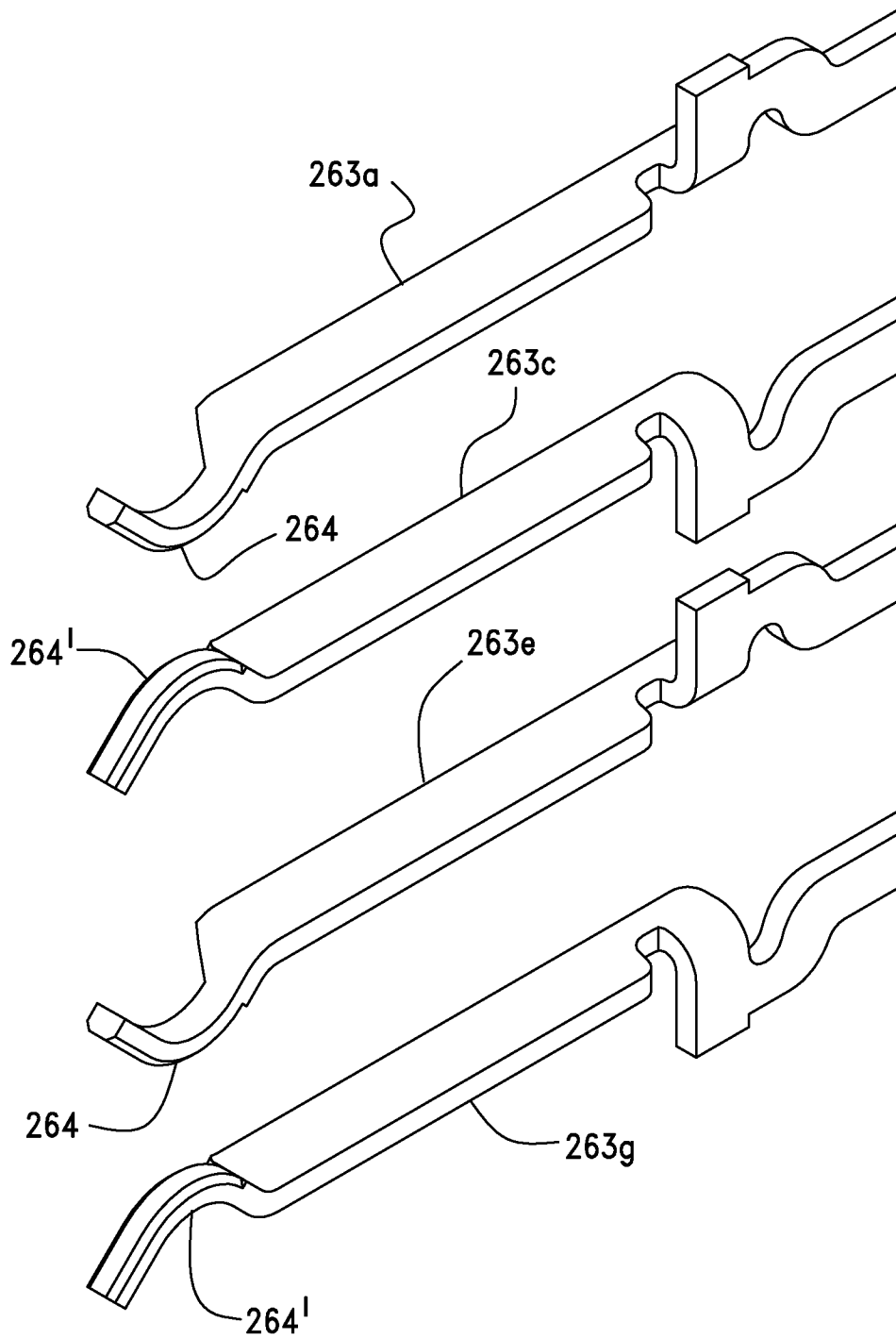
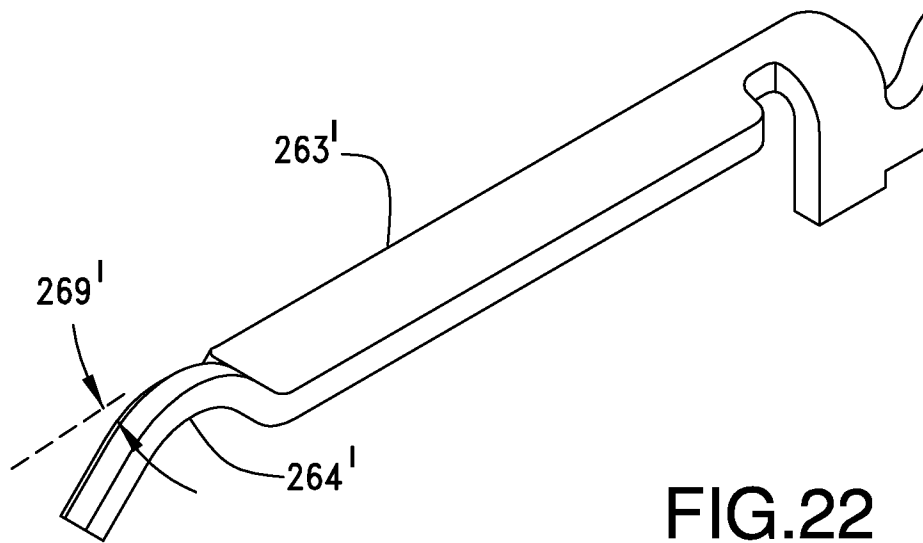
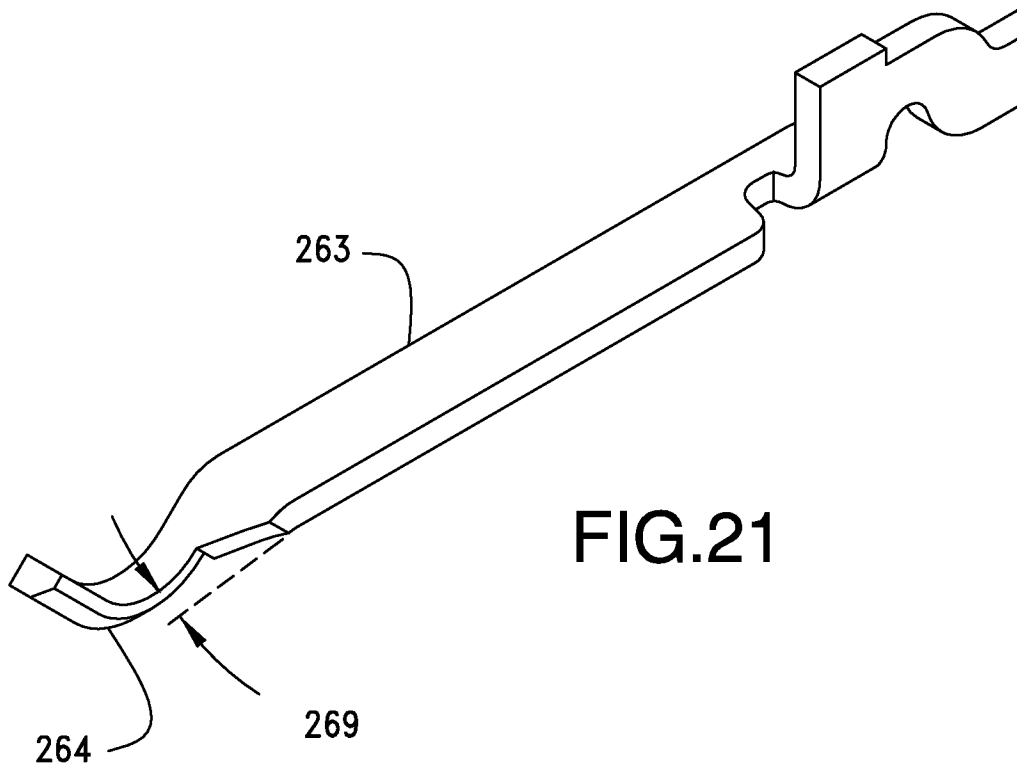


FIG.20



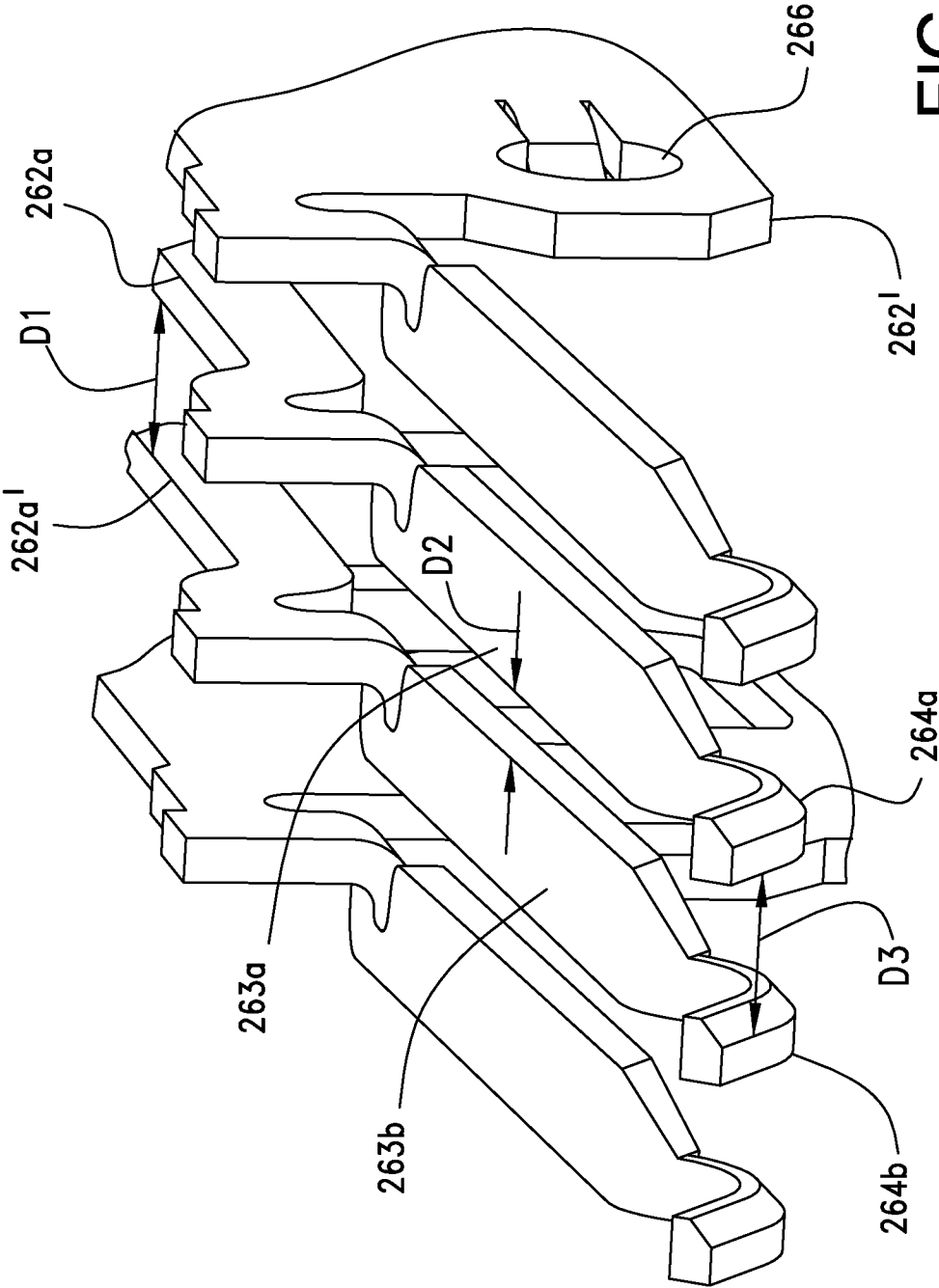


FIG. 23

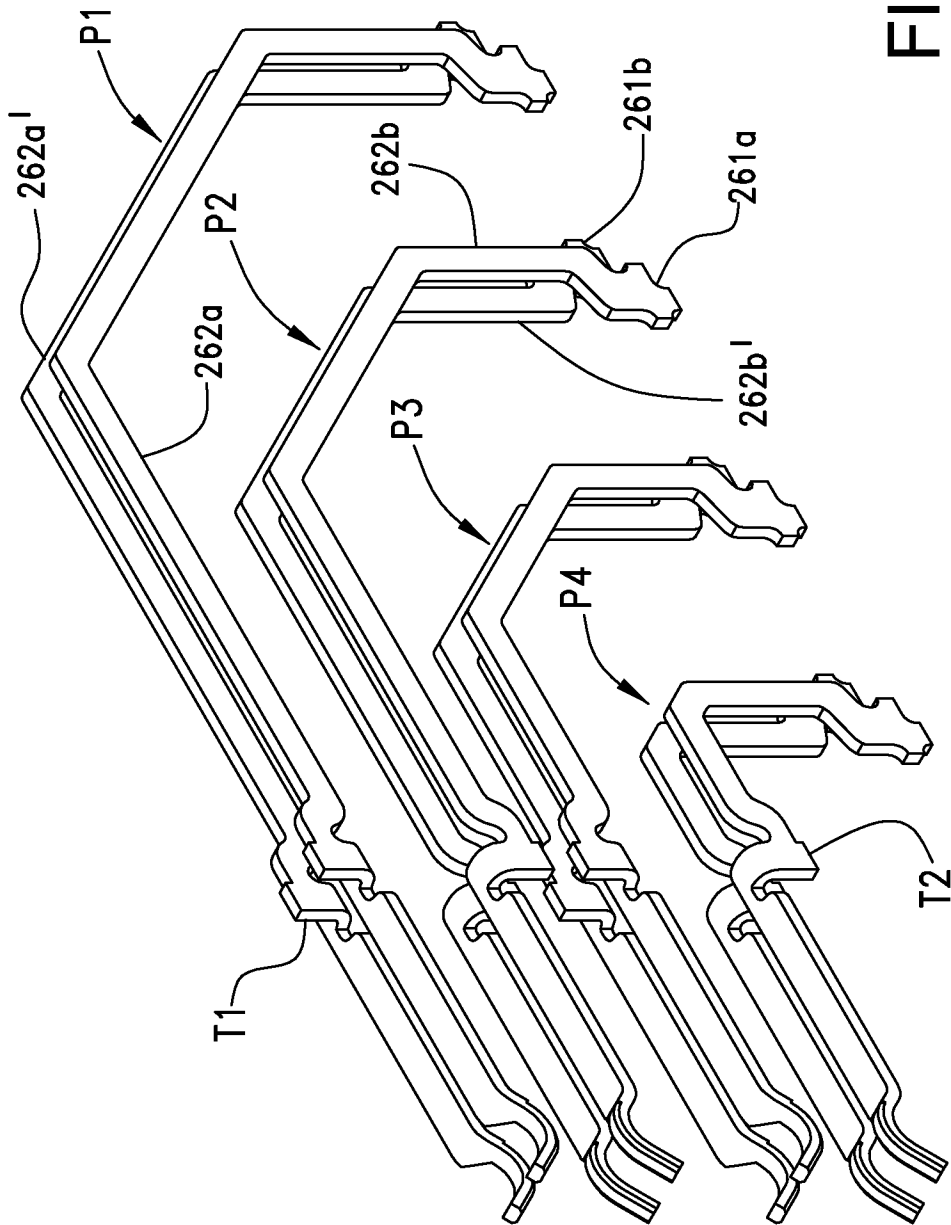


FIG. 24

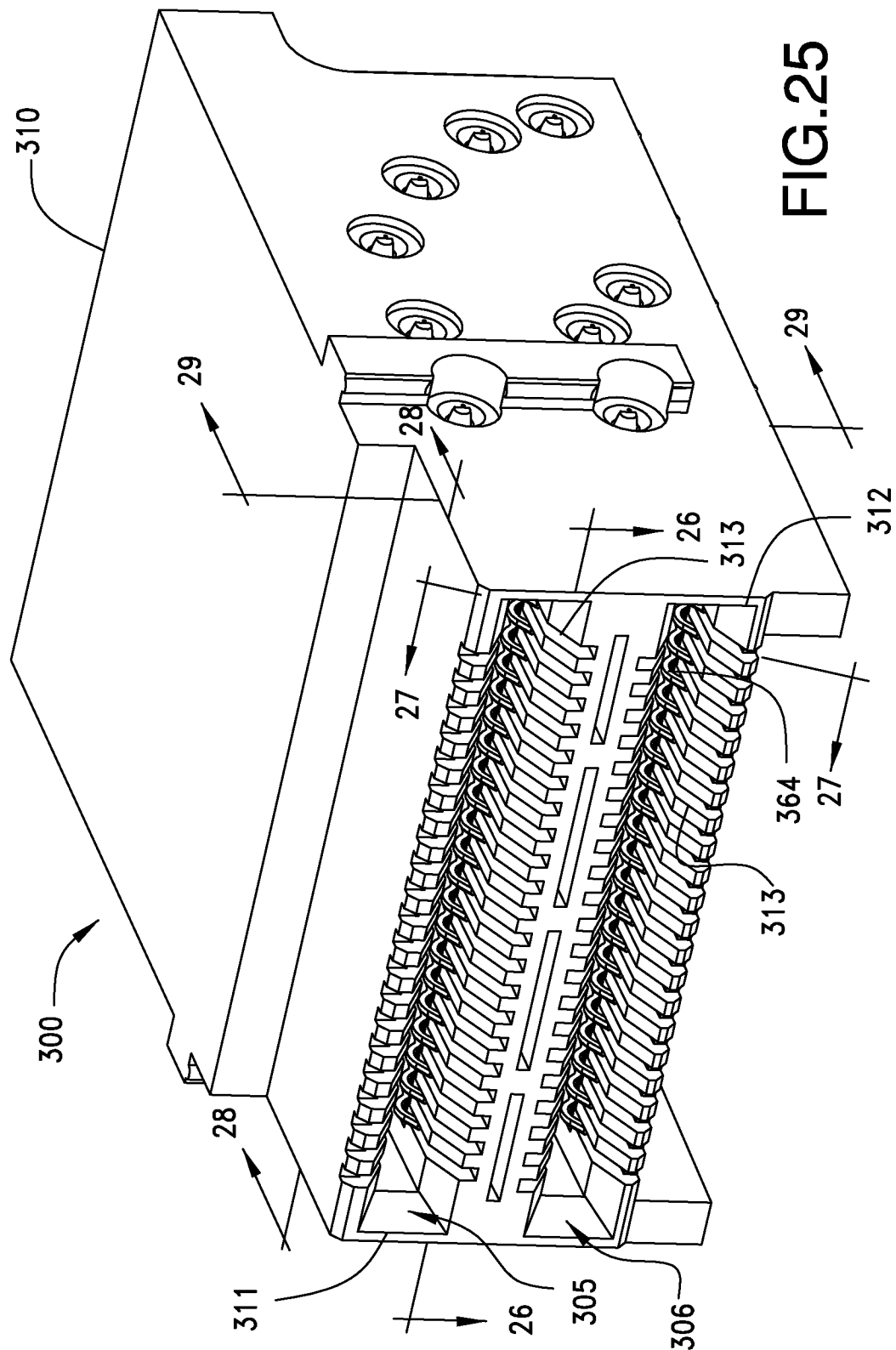


FIG. 25

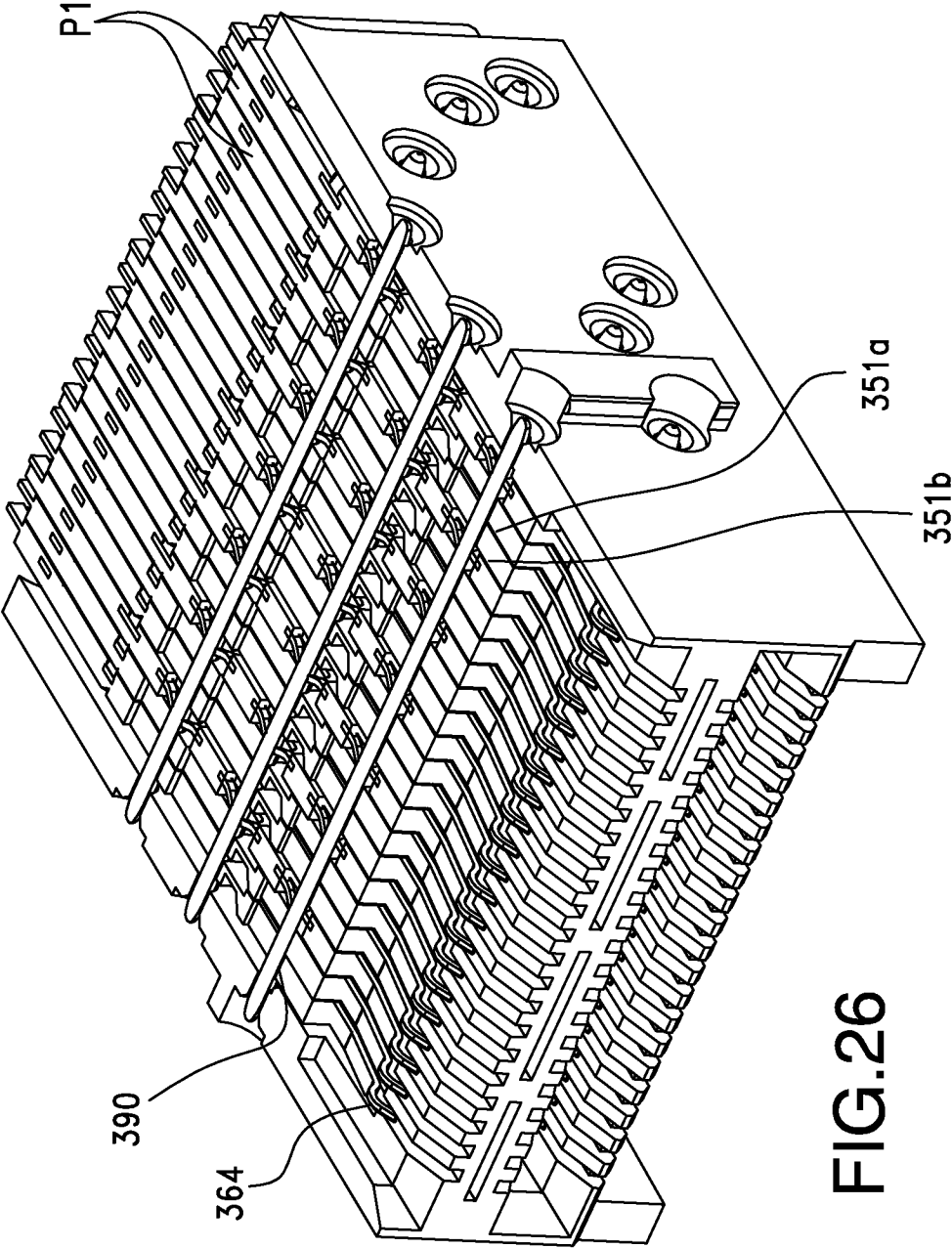


FIG. 26

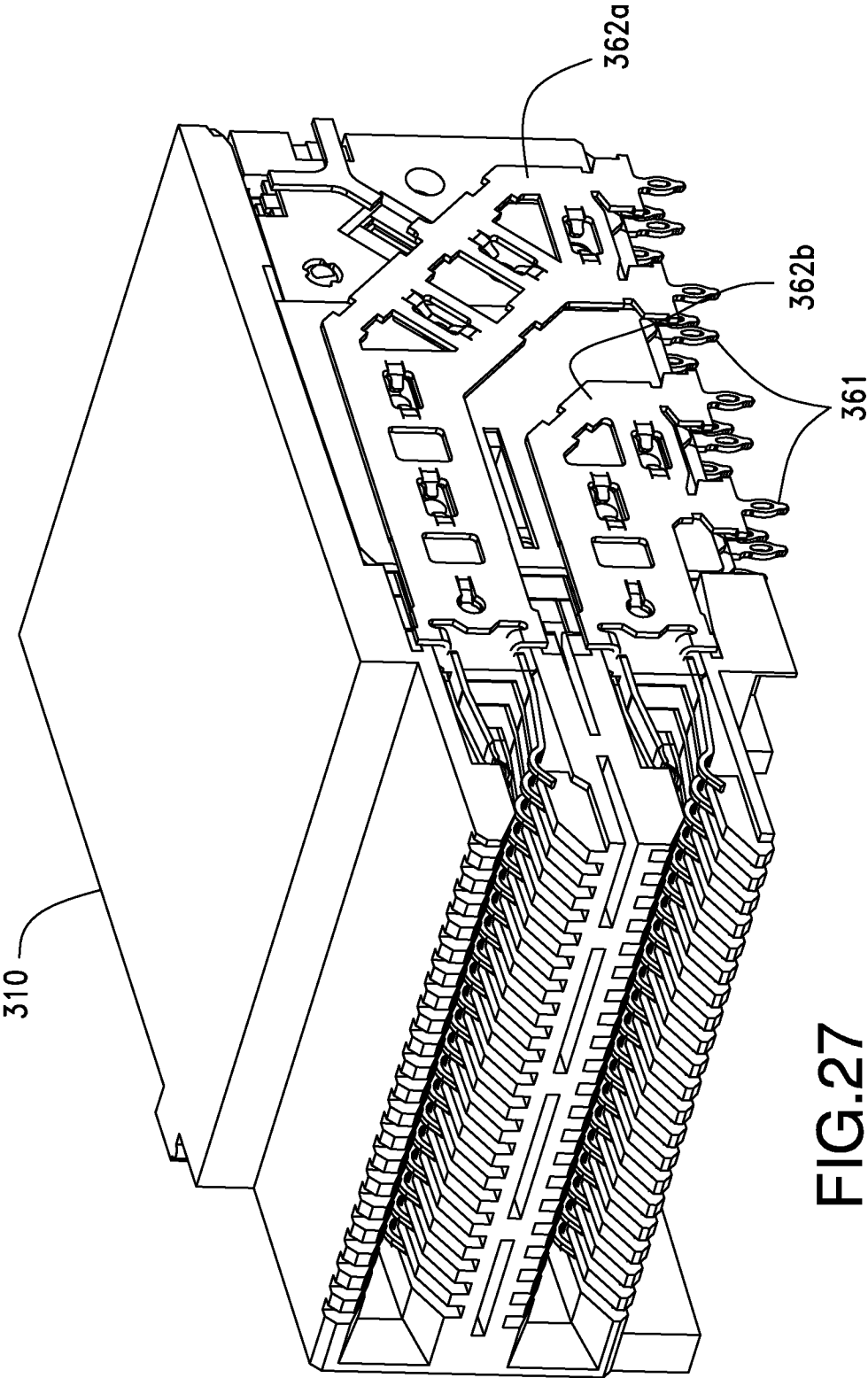
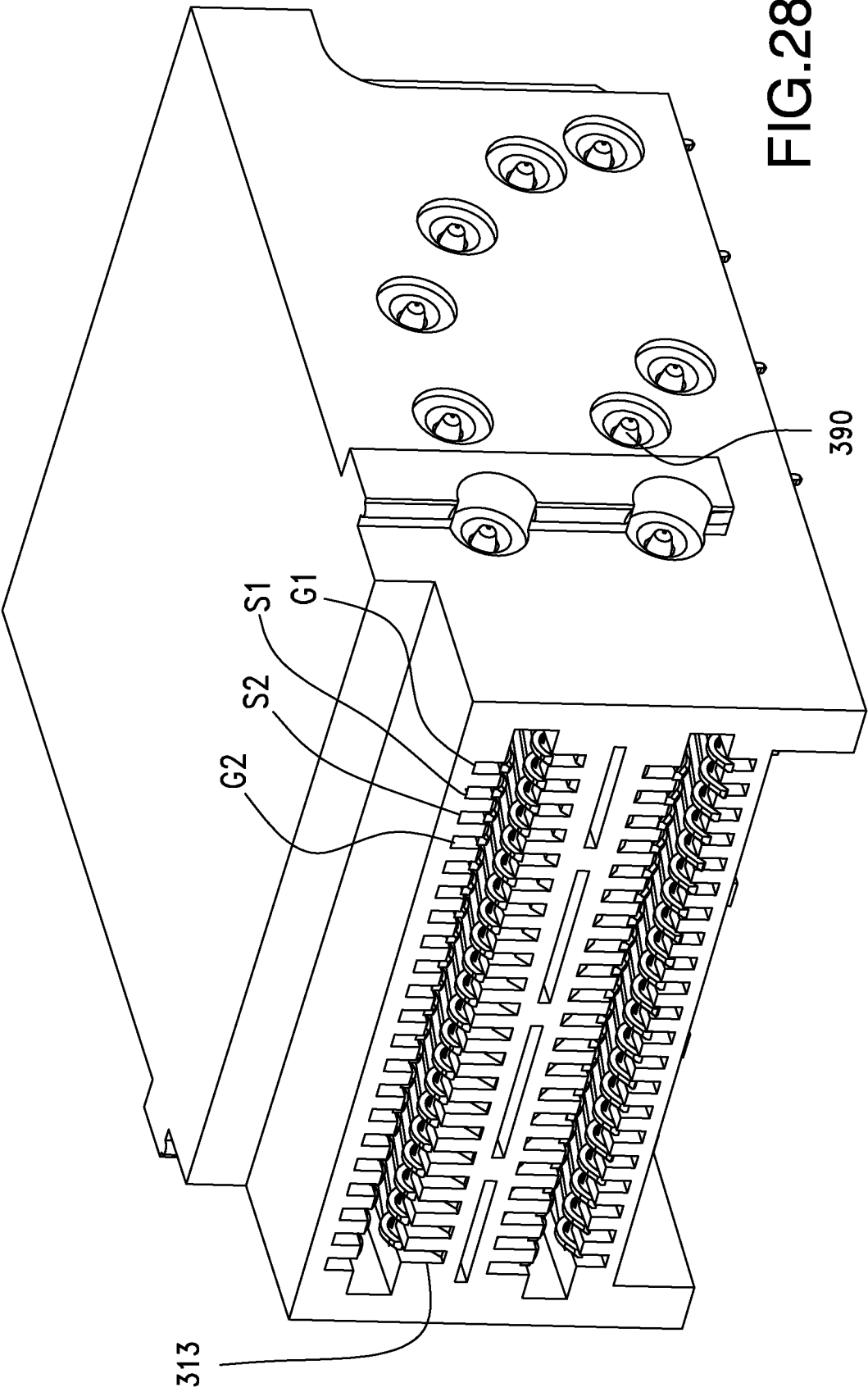


FIG. 27



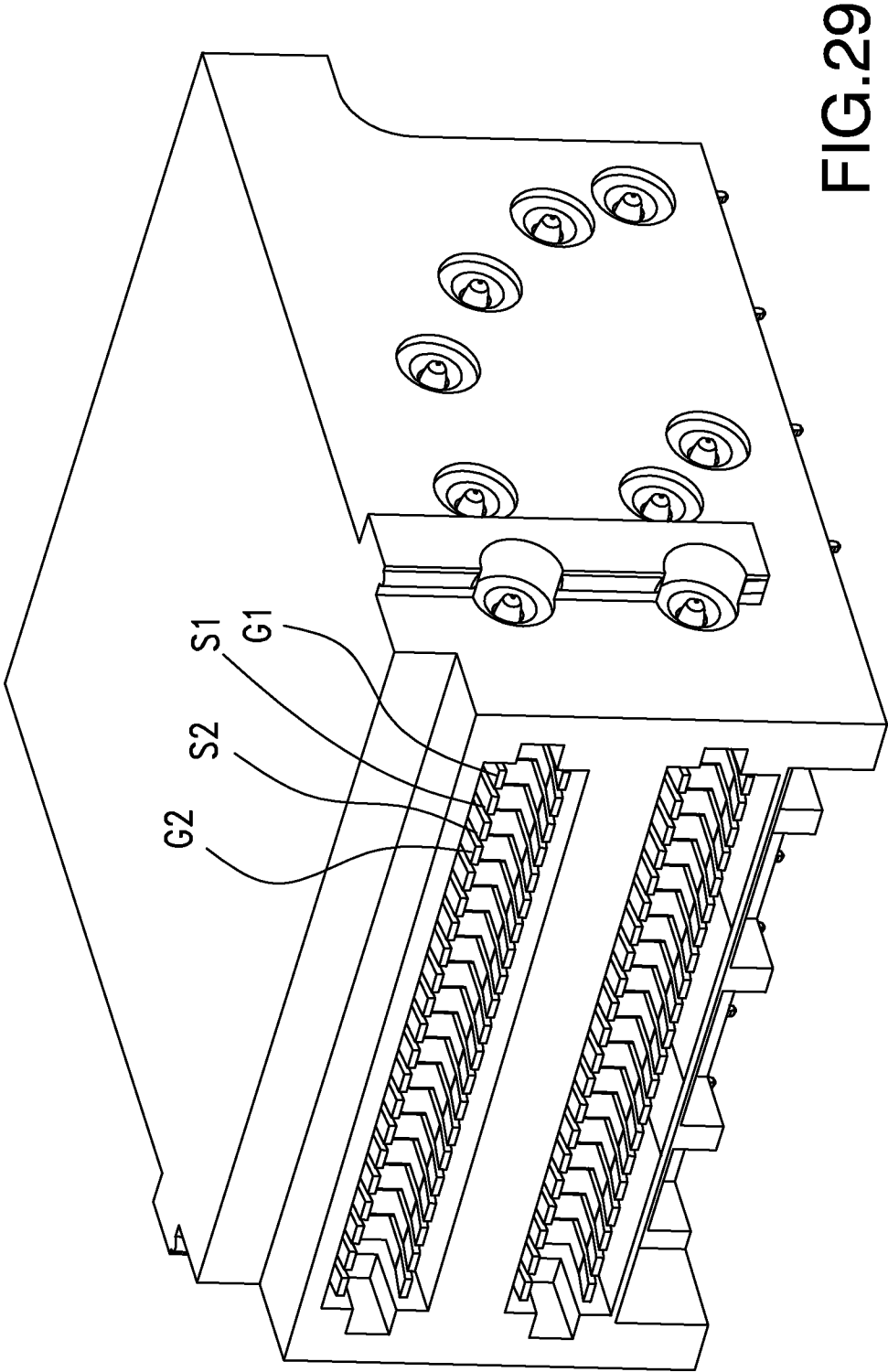


FIG.29

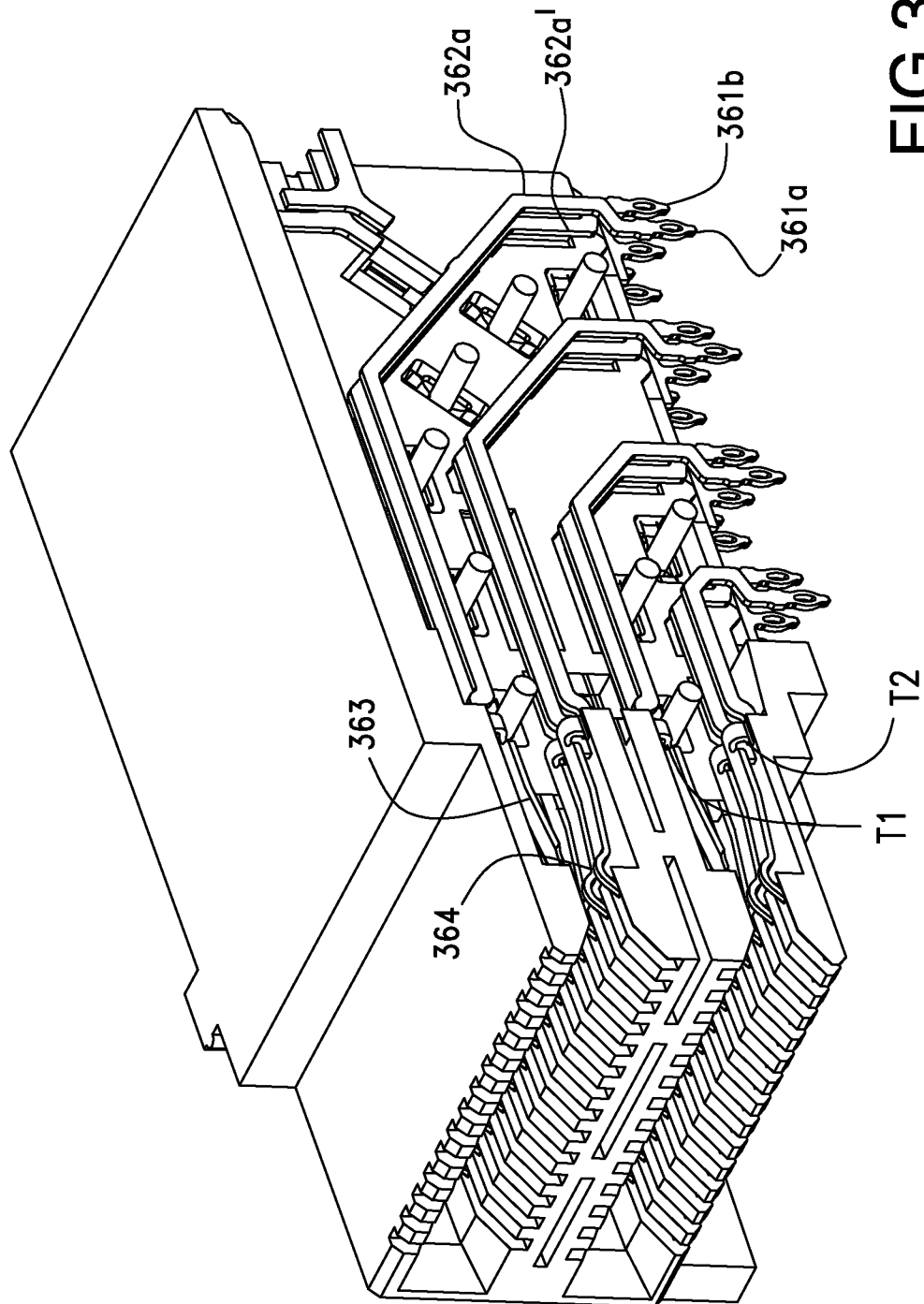


FIG. 30

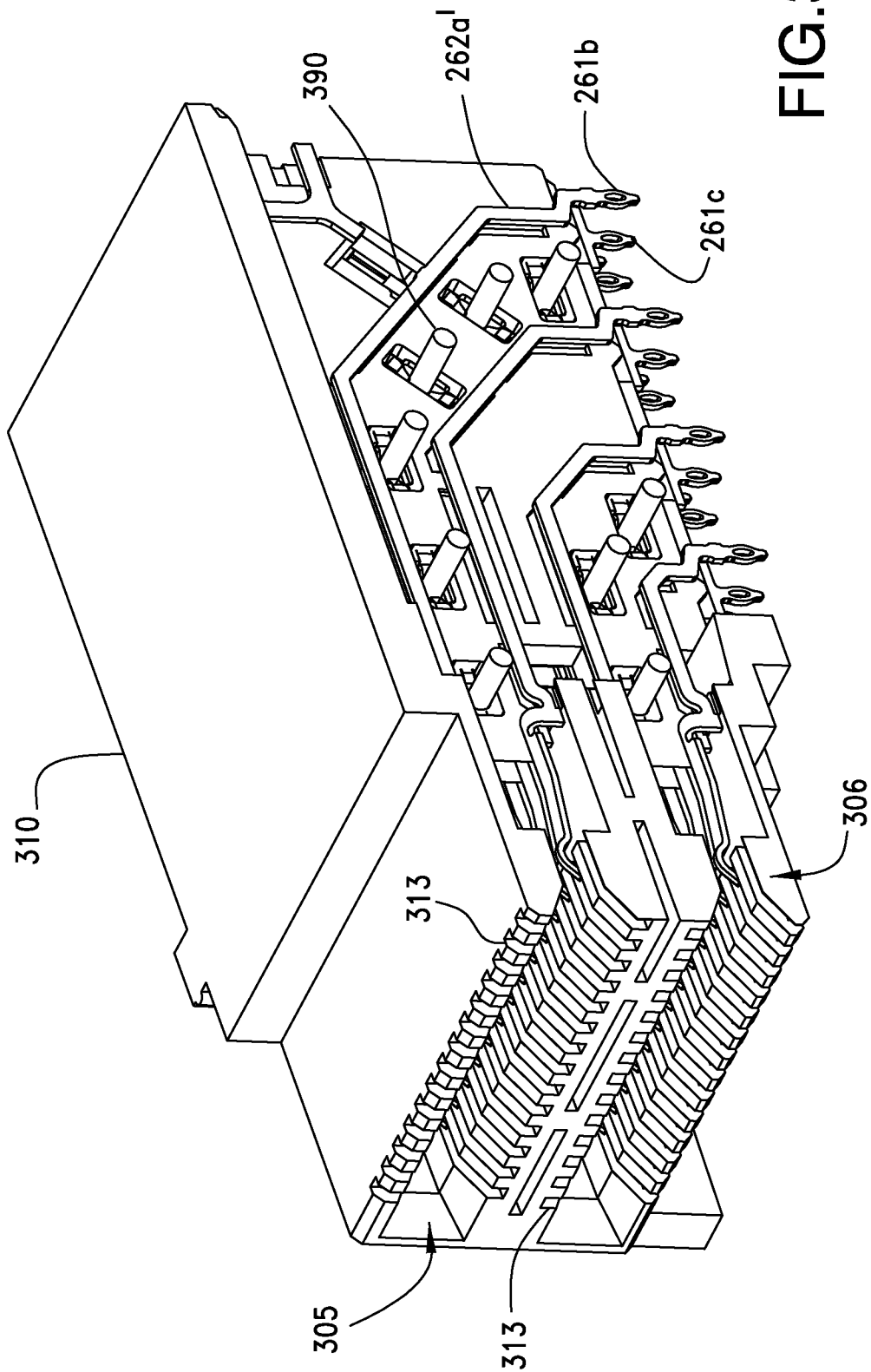


FIG. 31

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2011/045375**A. CLASSIFICATION OF SUBJECT MATTER*****H01R 12/71(2011.01)i, H01R 13/646(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 12/71; H01R 13/658; H01R 13/648; H01R 12/24; H01R 12/20

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,impedance,slot,wafer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2003-0186580 A1 (PHILIP, J. DAMBACH et al.) 02 October 2003 See paragraph [0025] - paragraph [0029] and figures 1-2.	1-8
A	EP 1356550 B1 (TERADYNE, INC.) 13 December 2006 See paragraph [0013] - paragraph [0017] and figures 1-2.	1-8
A	US 6394822 B1 (MCNAMARA; DAVID M.) 28 May 2002 See column 2, line 52 - column 4, line 7 and figures 1-4.	1-8



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 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

27 DECEMBER 2011 (27.12.2011)

Date of mailing of the international search report

28 DECEMBER 2011 (28.12.2011)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
Government Complex-Daejeon, 189 Cheongsu-ro,
Seo-gu, Daejeon 302-701, Republic of Korea

Facsimile No. 82-42-472-7140

Authorized officer

KIM, Sung Hee

Telephone No. 82-42-481-5889



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2011/045375

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003-0186580 A1	02.10.2003	US 6786755 B2	07.09.2004
EP 1356550 B1	13.12.2006	AU 2002-251809 A1	06.08.2002
		AU 2002-251809 A8	06.08.2002
		CA 2435759 A1	01.08.2002
		CN 1502151 A	02.06.2004
		CN 1502151 C0	17.01.2007
		DE 60216728 D1	25.01.2007
		DE 60216728 T2	08.11.2007
		EP 1356550 A2	29.10.2003
		JP 04-221466 B2	12.02.2009
		JP 2004-521448 A	15.07.2004
		JP 2004-521448 T	15.07.2004
		MX PA03006690 A	31.05.2004
		TW 595052 A	21.06.2004
		TW 595052 B	21.06.2004
		US 2002-0098738 A1	25.07.2002
		US 2002-0111069 A1	15.08.2002
		US 6409543 B1	25.06.2002
		US 6602095 B2	05.08.2003
		WO 02-060011 A2	01.08.2002
		WO 02-060011 A3	01.08.2002
		WO 0206-0011 A3	24.07.2003
		WO 0206-0011 B1	06.11.2003
US 6394822 B1	28.05.2002	AT 262739 T	15.04.2004
		AU 2000-17414 A1	13.06.2000
		CN 1139151 C0	18.02.2004
		CN 1328715 A0	26.12.2001
		DE 69915882 D1	29.04.2004
		DE 69915882 T2	03.03.2005
		EP 1145386 A1	17.10.2001
		EP 1145386 B1	24.03.2004
		JP 04-098958 B2	11.06.2008
		JP 2002-530840 A	17.09.2002
		JP 2002-530840 T	17.09.2002
		WO 00-31833 A1	02.06.2000