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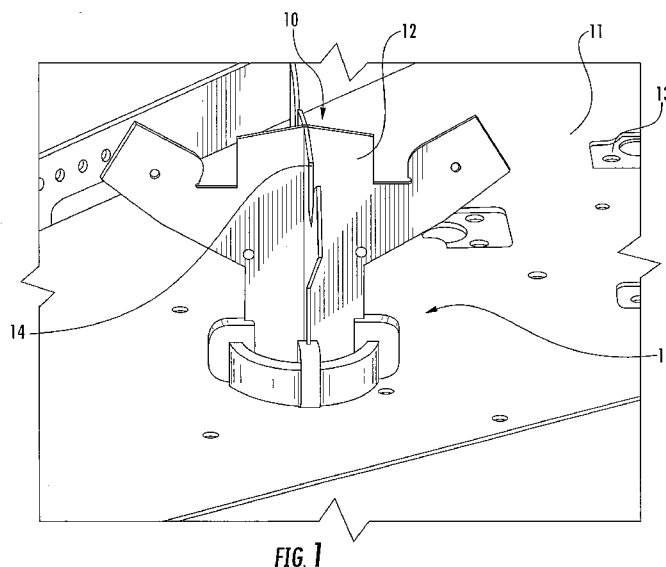
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(54) Title: SOLDERLESS DIPOLE CLIP WITH CAPACITIVE COUPLING



(57) Abstract: An antenna includes a feedboard, a radiating element that includes a printed circuit board that extends perpendicular to the feedboard, and a clip that receives the printed circuit board and mounts the printed circuit board on the feedboard. The printed circuit board is electrically connected to the feedboard via a solderless connection.

SOLDERLESS DIPOLE CLIP WITH CAPACITIVE COUPLING

BACKGROUND

[0001] Antenna for wireless voice and/or data communications typically include an array of radiating elements that are connected to one or more feed networks. For quality transmission and reception of Radio Frequency (RF) signals, one or more diversity techniques may be employed. One such diversity technique is polarization diversity, which may be particularly effective in combating multi-path fading. Crossed-dipole members (forming a radiating element) may be used to employ polarization diversity. Each of the crossed dipole members may include a printed circuit board (PCB). Solder and/or adhesives are typically used to attach the dipole PCBs to a feedboard of an antenna. However these attachment techniques may be costly, insecure, and may affect RF performance of the radiating element, and, in turn, the overall performance of the antenna.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] Fig. 1 is a perspective view of a crossed-dipole radiating element retained in a clip mounted on a feedboard according to an aspect of the present disclosure;

[0003] Fig. 2 is a perspective view of a top side of the clip of Fig. 1;

[0004] Fig. 3 is a perspective view of an underside of the clip of Fig. 1;

[0005] Fig. 4 is a perspective view of a top side of a clip according to another aspect of the present disclosure;

[0006] Fig. 5 is a perspective view of the underside of the clip of Fig. 4;

[0007] Fig. 6 is a cross-sectional view of a first half of the clip of Fig. 4;

[0008] Fig. 7 is a cross-sectional view of the second half of the clip of Fig. 4;

[0009] Fig. 8 is a perspective view of a crossed-dipole radiating element connected to the clip of Fig. 4;

[0010] Fig. 9 is a perspective view of a clip according to aspects of the present disclosure being used to mount a crossed-dipole radiating element on a feedboard; and

[0011] Fig. 10 is an illustration of the locking members of clips according to aspects of the present disclosure that may be used to lock the clips to a reflector.

[0012] Figs. 11A and 11B are front views of first and second dipole printed circuit boards that may be used in the feedboard assemblies and antennas according to embodiments of the present invention.

DETAILED DESCRIPTION

[0013] The words "lower," "bottom," "upper" and "top" designate directions in the drawings to which reference is made. Unless specifically set forth herein, the terms "a," "an" and "the" are not limited to one element, but instead should be read as meaning "at least one." The terminology includes the words noted above, derivatives thereof and words of similar import. It should also be understood that the terms "about," "approximately," "generally," "substantially" and like terms, used herein when referring to a dimension or characteristic of a component of the disclosure, indicate that the described dimension/characteristic is not a strict boundary or parameter and does not exclude minor variations therefrom that are functionally similar. At a minimum, such references that include a numerical parameter would include variations that, using mathematical and industrial principles accepted in the art (e.g., rounding, measurement or other systematic errors, manufacturing tolerances, etc.), would not vary the least significant digit.

[0014] Fig. 1 is a perspective view of a crossed-dipole radiating element 10 that is mounted on a feedboard 11 according to an aspect of the present disclosure. The crossed-dipole radiating element 10 may include a first dipole printed circuit board (PCB) 12 and a second dipole PCB 14. Each dipole PCB 12, 14 may have a conductive plane, a feed line, and a dipole. The dipole PCBs 12, 14 may be mounted on the feedboard 11 via a clip 16. The clip 16 may act as a socket for the PCBs 12, 14. While the crossed dipole radiating element 10 of Fig. 1 includes first and second dipole PCBs 12, 14, it will be appreciated that other dipole radiating elements may be used. For example, in other embodiments, the dipole PCBs 12, 14 may be replaced with metal plated plastic dipole radiating elements, sheet metal dipole radiating elements and the like. Thus, it will be appreciated that the embodiments disclosed herein may use any appropriate form of dipole radiating elements. It will also be appreciated that radiating elements other than dipole radiating elements may be used in some embodiments.

[0015] The dipole PCB's 12, 14 may fit together such that the dipoles are at approximately right angles to each other. When combined, the first and second dipole PCBs 12, 14 may comprise a cross-polarized radiating element.

[0016] Fig. 2 is a perspective view of a top side of the clip 16. Fig. 3 is a perspective view of an underside of the clip 16. Referring to Figs. 2 and 3, the clip 16 may be generally ring shaped when viewed from above, although other shapes may be used. A plurality of tabs 18 may be positioned radially from the center of the clip 16 and may aid in the installation of the dipole PCBs 12, 14 into the clip 16. The tabs 18 include retaining members 20. The retaining members may be molded as a part of the tabs 18 in some embodiments, and may be attached to the tabs 18 in other embodiments. Each of the retaining members 20 may define a slot 22 that is dimensioned to receive a dipole PCB 12, 14. The four retaining members 20 may intersect each other at a center of an aperture of the clip 16 and together the four retaining members 20 may form an "X" shape. Molded on, or otherwise attached to, a portion of each of the retaining members 20, is an RF capacitive coupling pad having a dipole PCB capacitive coupling surface 24a (see Fig. 2) and a feedboard capacitive coupling surface 24b (see Fig. 3). Each of the surfaces 24a, 24b of the RF capacitive coupling pad may include a metal trace, or a formed metal surface, to enable capacitive coupling. As best seen in Fig. 2, in the depicted embodiment, each dipole PCB capacitive coupling surface 24a extends upwardly and substantially perpendicular to a plane defined by the intersecting retaining members 20, and may be capacitively coupled to a metal trace or surface on a respective one of the dipole PCBs 12, 14. As best seen in Fig. 3, the feedboard capacitive coupling surface 24b may form a substantially right angle with the dipole PCB capacitive coupling surface 24a of the RF capacitive coupling pad, and may be capacitively coupled to traces, pads or the like on the feedboard 11. It should be noted that the feedboard capacitive coupling surface 24b may form other angles with the dipole PCB capacitive coupling surface 24b in other embodiments. As shown in Figs. 2 and 3, the clip 16 may include a first dipole PCB capacitive coupling surface 24a and a first feedboard capacitive coupling surface 24b that together form a first RF capacitive coupling pad that is used to capacitively couple a first metal trace/pad on the feedboard 11 to a corresponding metal trace/pad on the first dipole PCB 12, and a second dipole PCB capacitive coupling surface 24a and a second feedboard capacitive coupling surface 24b that together form a second RF capacitive coupling pad that is used to capacitively couple a second metal trace/pad on the feedboard 11 to a corresponding metal trace/pad on the second dipole PCB 14. Each dipole PCB capacitive coupling surface 24a is electrically connected to a respective feedboard capacitive coupling surface 24b.

[0017] The clip 16 may include one or more locking members 25 that are positioned on a bottom surface of the clip 16. The locking members 25 may be configured to lock the clip 16 onto the feedboard 11 and/or onto a reflector 13 (see Fig. 1) that may be, for example, underneath the feedboard 11, as will be discussed in more detail below with respect to Figs. 9 and 10. As such, when the dipole PCBs 12, 14 are inserted into the clip 16, and the clip 16 is locked onto the feedboard 11 and/or the reflector 13, the clip 16 may capacitively couple the RF feedlines of the dipole PCBs 12, 14 to respective RF connections of the feedboard 11 without the use of any solder. It also should be noted that a thin insulating member, such as solder mask or the like, may be used on one or more surfaces of one or more of the PCBs discussed hereinthroughout (e.g., the dipole PCBs 12, 14 and/or the feedboard 11) so as to reduce or prevent any potential generation of passive intermodulation products.

[0018] According to another aspect of the present disclosure, in addition to coupling the RF feedlines of the crossed-dipole radiating element 10 to the RF connections of the feedboard 11, a clip 26 may include capacitive coupling pads for coupling one or more conductive ground planes of the dipole radiating element 10 to the ground of the feedboard 11. Figs. 4-10 illustrate a clip 26 that includes such capacitive coupling pads for coupling conductive ground planes of the dipole radiating element 10 to the ground of the feedboard 11.

[0019] Referring now to Figs. 4 and 5, a perspective view of a top side of the clip 26, and a perspective view of the underside of the clip 26 are shown, respectively. Similar to the clip 16, the clip 26 may be generally ring shaped when viewed from the top. A plurality of tabs 28 may be positioned radially from the center of the clip 26 and may aid in the installation of the dipole PCBs 12, 14 into the clip 26. The tabs 28 include retaining members 30. The retaining members may be molded as a part of the tabs 28 in some embodiments, and may be attached to the tabs 28 in other embodiments. The retaining members 30 may define a pair of slots 31-1, 31-2 that are dimensioned to receive the respective dipole PCBs 12, 14. The four retaining members 30 may intersect each other at the center of an aperture of the clip 26. Molded on, or otherwise attached to, a portion of each of the retaining members 30, are capacitive coupling pads 32 and/or 34. The capacitive coupling pads 32, 34 include ground capacitive coupling pads 32-1 through 32-3 and feed capacitive coupling pads 34-1 and 34-2. In example embodiments, one of the retaining members 30 may include two capacitive coupling pads 32, 34 while the other of the retaining members 30 may include a single capacitive coupling pad 32, 34 each. It should be understood,

however, that the retaining members 30 may include different numbers of capacitive coupling pads 32, 34 in other embodiments.

[0020] The capacitive coupling pads 32, 34 may be configured to couple RF signals between each of the dipole PCBs 12, 14 and the feedboard 11. Each of the ground capacitive coupling pads 32 may include a surface extending upwardly and substantially perpendicular to the plane defined by the retaining members 30 ("dipole ground coupling surfaces 32a"). These dipole ground coupling surfaces 32a may be capacitively coupled to a conductive ground planes on respective ones of the dipole PCBs 12, 14. Further, each of the ground capacitive coupling pads 32 may include a surface extending substantially perpendicular to the dipole ground coupling surfaces 32a that is referred to herein as a feedboard ground coupling surface 32b. These feedboard ground coupling surfaces 32b may be capacitively coupled to a ground plane on the feedboard 11. Because the dipole ground coupling surfaces 32a are connected to, or otherwise in contact with, the respective feedboard ground coupling surfaces 32b, the ground capacitive coupling pads 32 may capacitively couple the conductive ground plane of each of the dipole PCBs 12, 14 to the ground plane on the feedboard 11.

[0021] Each of the feed capacitive coupling pads 34 may include a surface extending upwardly and substantially perpendicular to the plane defined by the retaining members ("dipole PCB capacitive coupling surfaces 34a"). Each dipole PCB capacitive coupling surface 34a may be capacitively coupled to an RF feedline of a respective one of the dipole PCBs 12, 14. Further, each of the feed capacitive coupling pads 34 may include a surface extending substantially perpendicular to the dipole PCB capacitive coupling surfaces 34a that is referred to herein as a feedboard capacitive coupling surface 34b. The feedboard capacitive coupling surfaces 34b may be capacitively coupled to RF connections of the feedboard 11. Because the dipole PCB capacitive coupling surfaces 34a are connected to, or otherwise in contact with, the respective feedboard capacitive coupling surfaces 34b, the feed capacitive coupling pads 34 may capacitively couple RF feedlines of each of the dipole PCBs 12, 14 to RF connections of the feedboard 11.

[0022] Fig. 6 is a cross-sectional view of half of the clip 26 of Figs. 4-5. As shown in Fig. 6, the dipole PCB capacitive coupling surface 34a of the feed capacitive coupling pad 34 is in contact with, or otherwise coupled to, the feedboard capacitive coupling surface 34b of the feed capacitive coupling pad 34. On an opposing side of one of the slots 31 is a capacitive

coupling pad 32. As shown, the dipole ground coupling surface 32a of the ground capacitive coupling pad 32 is in contact with, or otherwise coupled to, feedboard ground coupling surface 32b of the ground capacitive coupling pad 32.

[0023] Fig. 7 is a cross-sectional view of the other half of the clip 26. As shown, two of the ground capacitive coupling pads 32 may include respective dipole ground coupling surfaces 32a, extending upwardly from the retaining members 30. Between the ground capacitive coupling pads 32 and connected to an intersecting retaining member 30, the dipole PCB capacitive coupling surface 34a of the feed capacitive coupling pad 34 is shown.

[0024] Figs. 11A and 11B are front views of the first and second dipole PCBs 100, 150 that may be used to implement the above-described dipole PCBs 12, 14. It will be understood that the dipole PCBs 100, 150 could also be replaced with other types of dipoles such as plated plastic dipoles, sheet metal dipoles and the like.

[0025] As shown in FIG. 11A, the first dipole PCB 100 comprises a generally T-shaped substrate 110 that has a base 112, a crossbar 114 and a vertical slot 116 that bisects the crossbar 114 structure and extends about halfway down the base 112 of the T-shaped substrate 110. Metal plating 120 is provided on the surface of the substrate 110. The metal plating 120 may comprise two generally upside-down L-shaped metal plated areas 122, 124. A horizontal plated metal connector 126 connects the two metal plated areas 122, 124. Metal plating on the other side of the substrate 110 (not shown in Fig. 11A) is provided that couples to one of the feed capacitive coupling pads 34 when the first dipole PCB 100 is received within a slot 31 of the clip 26.

[0026] As shown in FIG. 11B, the second dipole PCB 150 comprises a generally T-shaped substrate 160 that has a base 162, a crossbar 164 and a vertical slot 166 that bisects the bottom of the T-shaped substrate 160 and extends about halfway up down the base 162 of the T-shaped substrate 160. Metal plating is provided on the surface of the substrate 160. The metal plating may comprise two generally upside-down L-shaped metal plated areas 172, 174. The metal-plated areas 172, 174 are not connected to each other. Metal plating on the other side of the substrate 160 (not shown in Fig. 11B) is provided that couples to one of the feed capacitive coupling pads 34 when the second dipole PCB 150 is received within a slot 31 of the clip 26.

[0027] Referring to Figs. 4, 11A and 11B, a method of installing the first and second dipole PCBs 100, 150 in the clip 26 will be described that will provide the appropriate

connections. Dipole 100 may be placed in slot 31-1 so that the metal plating 120 couples to the ground coupling surface 32a of ground capacitive coupling pad 32-3 and the metal plating on the other side of the substrate 110 contacts the dipole PCB capacitive coupling surface 34a of feed capacitive coupling pad 34-1. Since the horizontal plated metal connector 126 connects the two metal plated areas 122, 124, both legs of the dipole may be connected to ground through the ground capacitive coupling pad 32-3. Next, dipole 150 may be rotated 90 degrees with respect to dipole PCB 100 and placed in slot 31-2 so that vertical slot 166 of dipole PCB 150 is received within the vertical slot 116 of dipole PCB 100. Once in place, the metal plated area 172 on dipole PCB 150 couples to the ground coupling surface 32a of ground capacitive coupling pad 32-1 and the metal plated area 174 on dipole PCB 150 couples to the ground coupling surface 32a of ground capacitive coupling pad 32-2. The metal plating on the other side of the substrate 160 contacts the dipole PCB capacitive coupling surface 34a of feed capacitive coupling pad 34-2. Here, connections to two ground capacitive coupling pads 32-1, 32-2 are provided since the metal plated areas 172, 174 are not connected to each other.

[0028] Fig. 8 is a perspective view of the dipole radiating element 10 connected to the clip 26. As discussed above, each of the clips 16, 26 may include locking members 25 positioned on the bottom surface of the clips 16, 26. As shown in Figs. 9 and 10, each of the locking members 25 may be dimensioned to fit through openings in the feedboard 11 and reflector 13. After the locking members 25 are fit through the openings of the feedboard 11 and reflector 13, the clip 16, 26 may be rotated so that the locking members 25 may abut another portion of the reflector 26 so as to lock the clip 16, 26 to the feedboard 11 and reflector 13. Once twisted and locked into position, the capacitive coupling surfaces of the clip 16, 26 may line up and be capacitively coupled to the feedboard traces, without the use of any solder, an example of which is illustrated in Fig. 10. It also should be noted that a thin insulating member, such as solder mask or the like, may be used on one or more surfaces of one or more of the PCBs discussed hereinthroughout, so as to reduce or prevent any potential generation of passive intermodulation products.

[0029] It will be appreciated that numerous modifications may be made to the above-described clips and feedboard assemblies and antennas using the same without departing from the scope of the present invention. For example, while the dipole radiating elements depicted in the drawings are fully implemented on PCBs, in other embodiments the radiating elements may

comprise PCB-based feed stalks with non-PCB dipoles mounted thereon. As another example, the radiating elements need not be cross-polarized radiating elements. Additionally, radiating elements other than dipole-based radiating elements may be used in other embodiments such as, for example, patch radiating elements that are mounted on PCB feed stalks.

[0030] It will also be appreciated that the shape of the clip 16, 26, the shapes of the retaining members 20, 30 and slots 31 may likewise be changed as can the shapes and locations of the various capacitive coupling surfaces. Other locking members 25 may also be used to lock the clips 16, 26 to an underlying surface. The tabs 18, 28 may have different shapes and/or configurations, and may be omitted in some embodiments. Thus, it will be appreciated that the clips 16, 26 are provided merely so this specification will fully disclose example embodiments and it will be understood that the disclosed clips 16, 26 are not intended to be limiting with respect to the broader scope of the invention to solderless attachment mechanisms for radiating elements having one or more PCB-based feed stalks.

[0031] Various embodiments of the disclosure have now been discussed in detail; however, the disclosure should not be understood as being limited to these embodiments. It should also be appreciated that various modifications, adaptations, and alternative embodiments thereof may be made within the scope and spirit of the present disclosure.

That Which is Claimed is:

1. A feedboard assembly, comprising:
a feedboard having a radio frequency (RF) connection;
a radiating element having a feedline;
a clip that includes:
a first capacitive coupling surface that is configured to capacitively couple to the RF connection on the feedboard;
a second capacitive coupling surface that is configured to capacitively couple to the feedline of the radiating element;
wherein the first capacitive coupling surface is electrically connected to the second capacitive coupling surface.
2. The feedboard assembly of Claim 1, wherein the clip further includes a first retaining member that is configured to receive an edge of the radiating element.
3. The feedboard assembly of Claim 1 or 2, wherein the radiating element includes at least one dipole.
4. The feedboard assembly of Claim 1, wherein the radiating element comprises a crossed-dipole radiating element.
5. The feedboard assembly of Claim 4, wherein the radiating element includes a printed circuit board that has the feedline thereon.
6. The feedboard assembly of Claim 1 or 2, wherein the clip further includes at least one locking member that is configured to mate with a corresponding locking member of an external structure.
7. The feedboard assembly of Claim 6, wherein the external structure is a reflector of an antenna that includes the feedboard assembly.
8. The feedboard assembly of Claim 1 or 2, wherein the first capacitive coupling surface extends in a first plane and the second capacitive coupling surface extends in a second plane that is substantially perpendicular to the first plane.

9. The feedboard assembly of Claim 5, wherein the feedboard further comprises a second RF connection and the radiating element further comprises a second printed circuit board having a second feedline thereon, wherein the clip further comprises:

a third capacitive coupling surface that is configured to capacitively couple to the second RF connection on the feedboard; and

a fourth capacitive coupling surface that is configured to capacitively couple to the second feedline of the radiating element,

wherein the third capacitive coupling surface is electrically connected to the fourth capacitive coupling surface.

10. The feedboard assembly of Claim 1 or 2, wherein the clip further comprises a third capacitive coupling surface that is configured to capacitively couple to a conductive ground plane on the printed circuit board;

a fourth capacitive coupling surface that is configured to capacitively couple to a ground connection on the feedboard;

wherein the third capacitive coupling surface is electrically connected to the fourth capacitive coupling surface.

11. The feedboard assembly of Claim 6, wherein the at least one locking member is configured to lock the clip to the external structure when the at least one locking member is inserted into the corresponding locking member and the clip is rotated with respect to the external structure.

12. The feedboard assembly of Claim 1 or 2, wherein the feedline is electrically connected to the feedboard via a solderless connection.

13. The feedboard assembly of Claim 2, wherein the first retaining member includes a vertically extending tab.

14. The feedboard assembly of Claim 2, wherein the first retaining member includes a slot that is configured to receive the edge of the radiating element.

15. The feedboard assembly of Claim 5, wherein the crossed-dipole radiating element includes a second printed circuit board, and wherein the clip further includes a second retaining

member that is configured to receive an edge of the second printed circuit board of the crossed-dipole radiating element.

16. An antenna, comprising:
 - a feedboard;
 - a radiating element that includes a stalk that extends perpendicular to the feedboard;
 - a clip that receives the stalk and mounts the stalk on the feedboard, the stalk electrically connected to the feedboard via a solderless connection.
17. The antenna of Claim 16, wherein the clip further includes:
 - a first capacitive coupling surface that is configured to capacitively couple to an RF connection on the feedboard;
 - a second capacitive coupling surface that is configured to capacitively couple to a feedline on the stalk of the radiating element;
 - wherein the first capacitive coupling surface is electrically connected to the second capacitive coupling surface.
18. The antenna of Claim 16, wherein the clip further includes a retaining member that is configured to receive an edge of the stalk.
19. The antenna of Claim 16 or 17, wherein the radiating element includes at least one dipole.
20. The antenna of Claim 16 or 17, wherein the radiating element comprises a crossed-dipole radiating element.
21. The antenna of Claim 17, wherein the first capacitive coupling surface extends in a first plane and the second capacitive coupling surface extends in a second plane that is substantially perpendicular to the first plane.
22. The antenna of Claim 17, wherein the clip further comprises
 - a third capacitive coupling surface that is configured to capacitively couple to a conductive ground plane on the stalk; and

a fourth capacitive coupling surface that is configured to capacitively couple to a ground connection on the feedboard,

wherein the third capacitive coupling surface is electrically connected to the fourth capacitive coupling surface.

23. The antenna of Claim 18, wherein the retaining member includes a slot that is configured to receive the edge of the stalk of the radiating element.

24. The antenna of Claim 16, wherein the stalk comprises a printed circuit board.

25. The antenna of Claim 16, wherein the stalk comprises a plated plastic substrate.

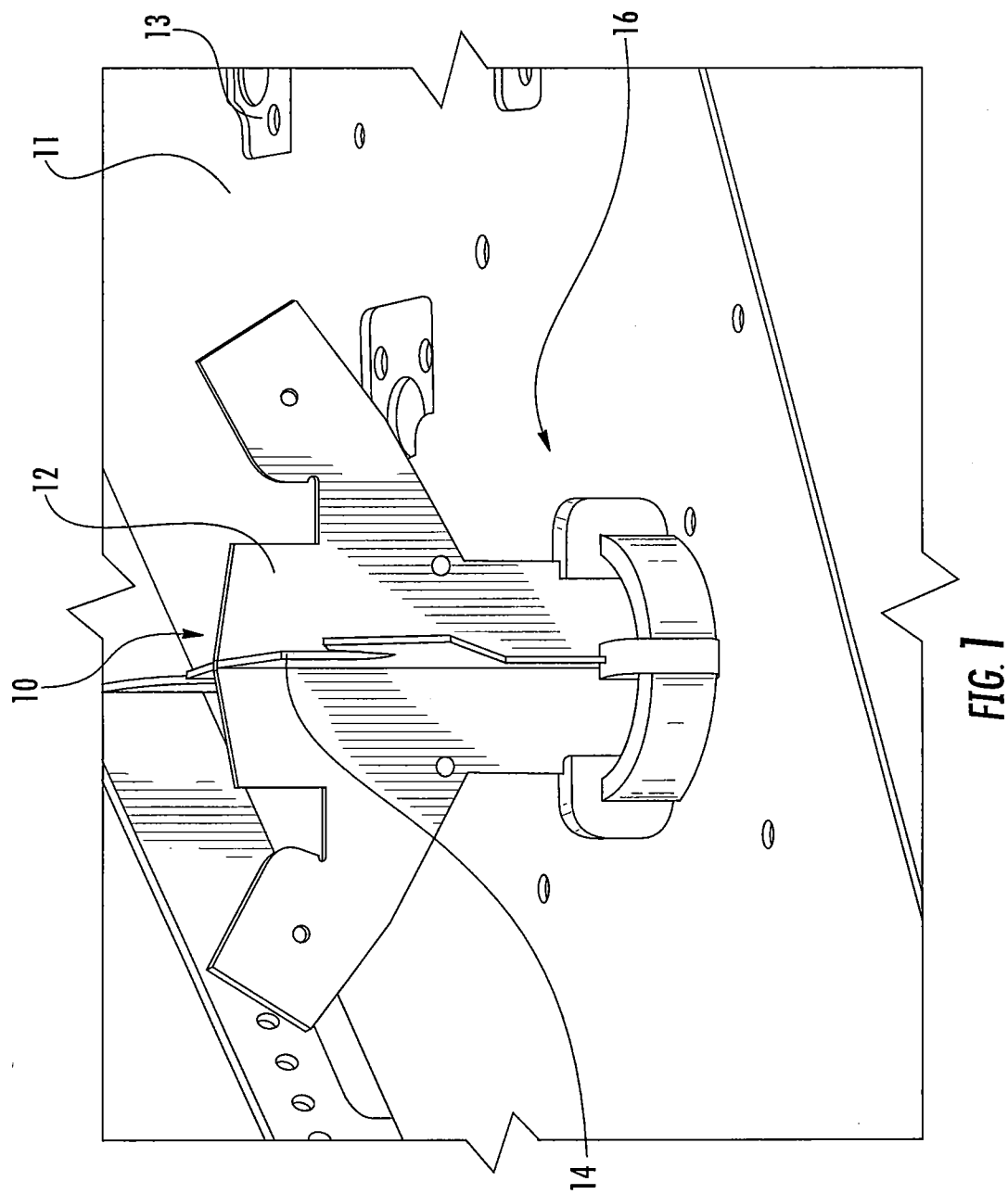
26. An antenna, comprising:
a feedboard;
a clip that includes a retaining member that has a slot, the clip mounted on the feedboard;
a radiating element that includes a printed circuit board, the printed circuit board mounted in the slot to extend outwardly from the feedboard;
wherein the printed circuit board is in radio frequency communication with the feedboard.

27. The antenna of Claim 26, wherein the printed circuit board is connected to the feedboard via a solderless connection.

28. The antenna of Claim 27, wherein the clip further includes:
a first capacitive coupling surface that is configured to capacitively couple to an RF connection on the feedboard;
a second capacitive coupling surface that is configured to capacitively couple to a feedline on the printed circuit board of the radiating element;
wherein the first capacitive coupling surface is electrically connected to the second capacitive coupling surface.

29. The antenna of Claim 28, wherein the first capacitive coupling surface extends in a first plane and the second capacitive coupling surface extends in a second plane that is substantially perpendicular to the first plane.

30. The antenna of Claim 26, 27 or 28, wherein the printed circuit board extends perpendicularly from the feedboard.



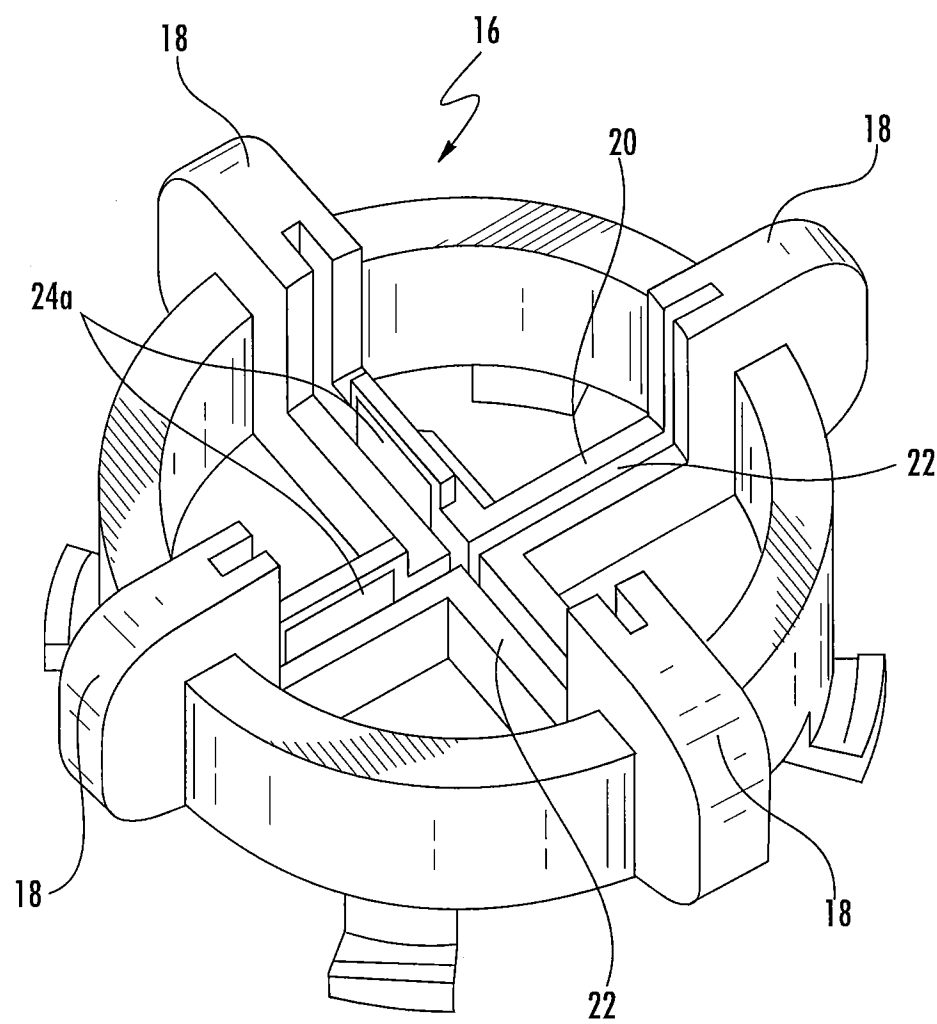
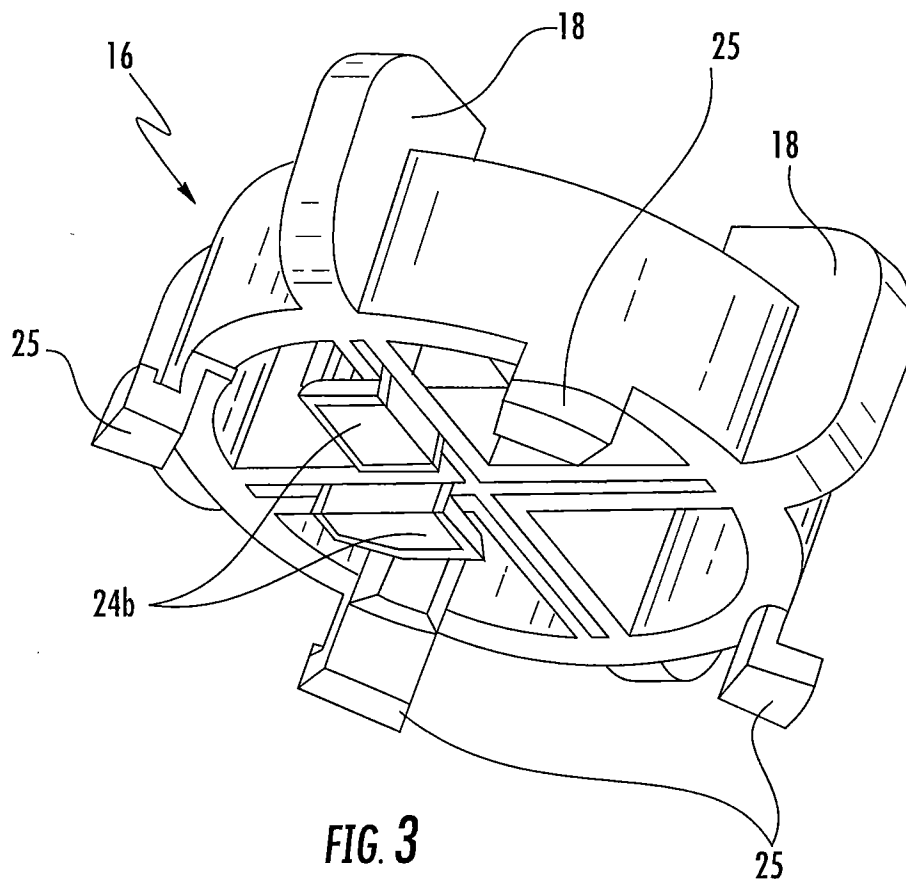


FIG. 2



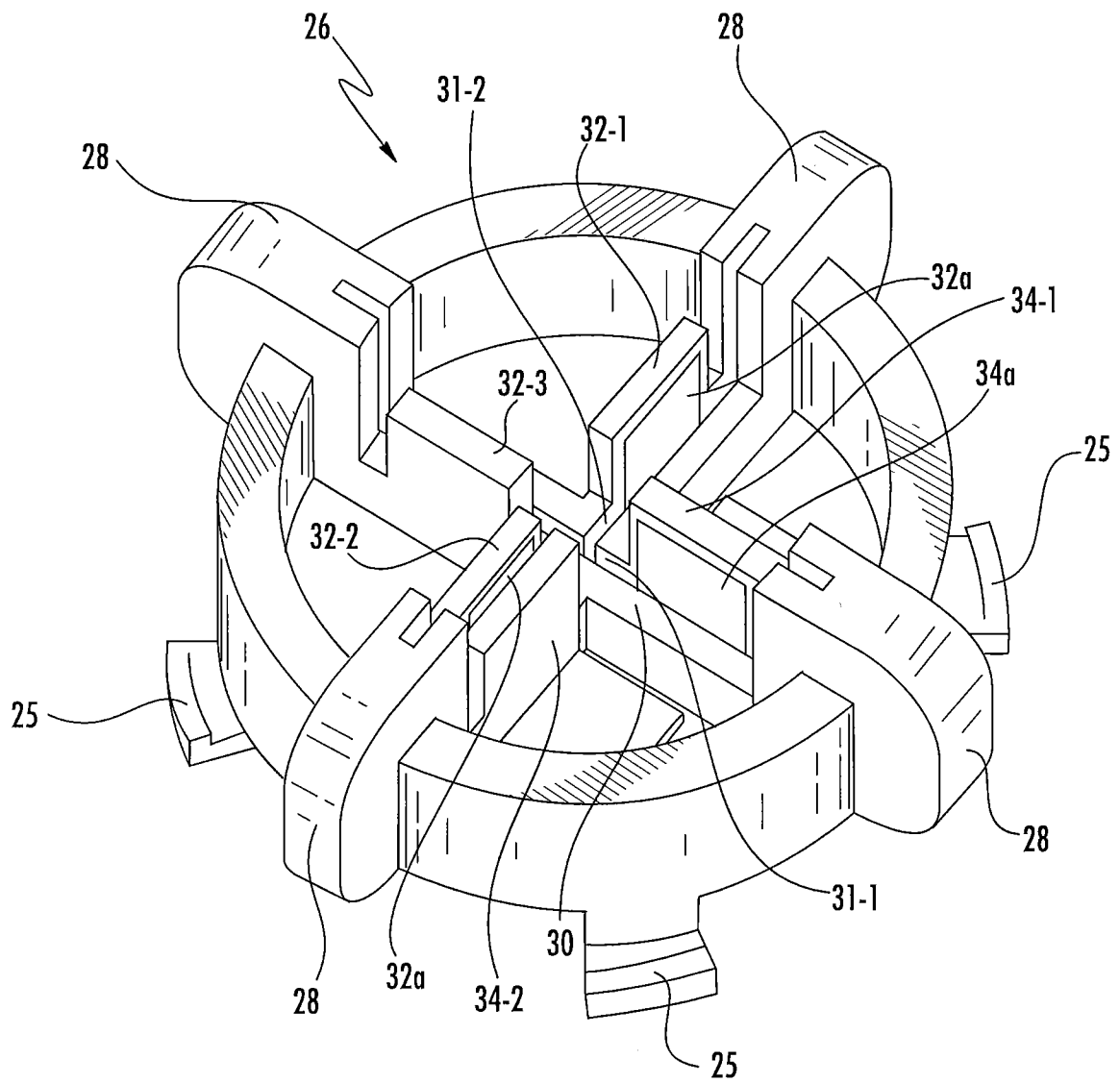


FIG. 4

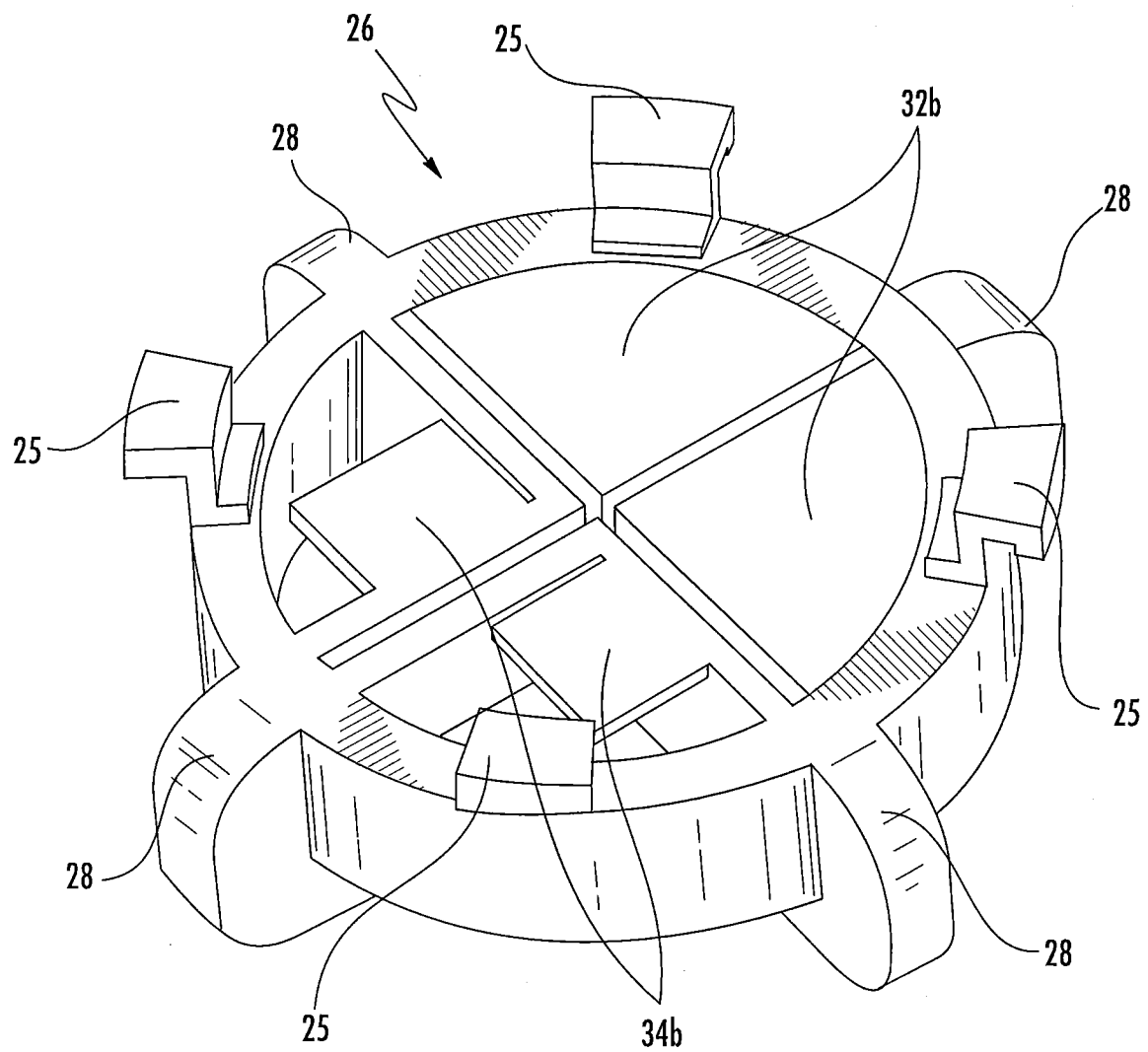


FIG. 5

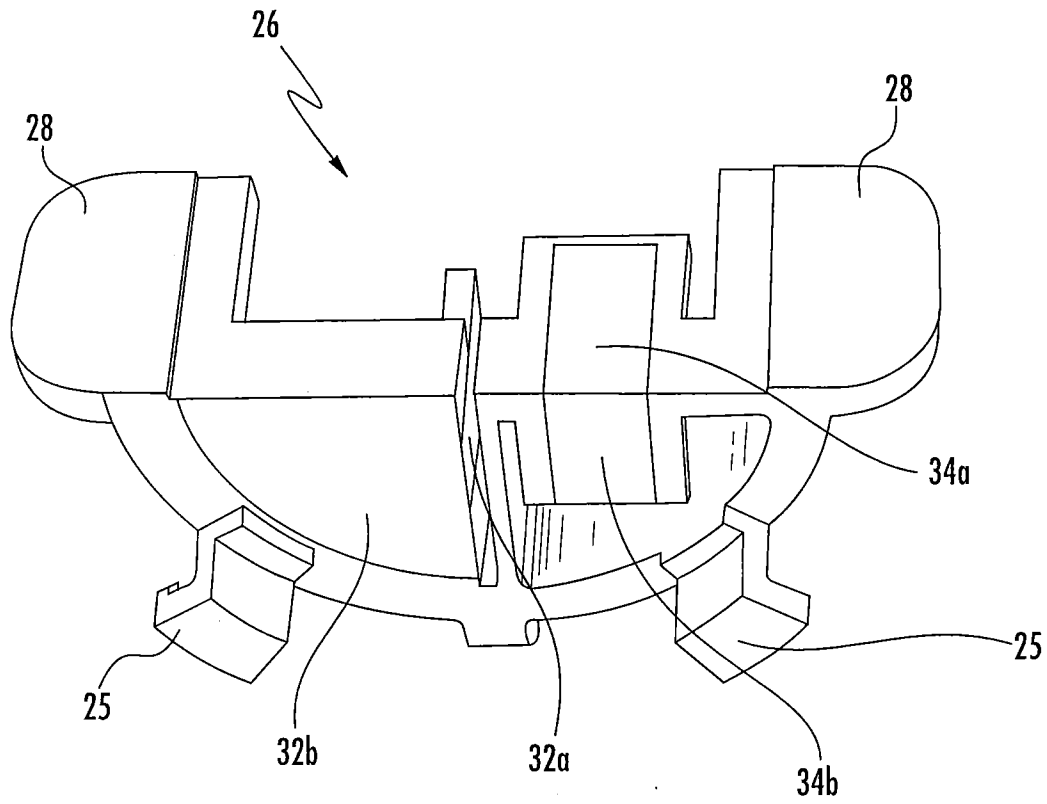
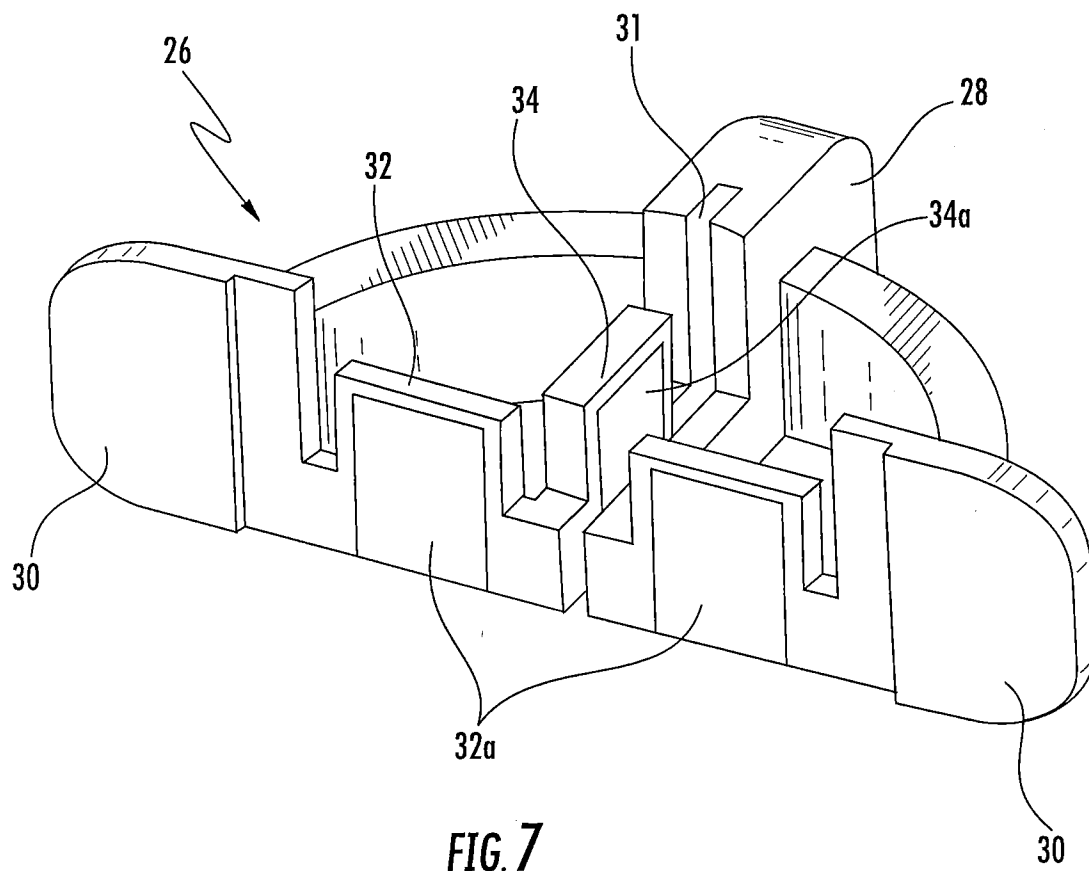


FIG. 6



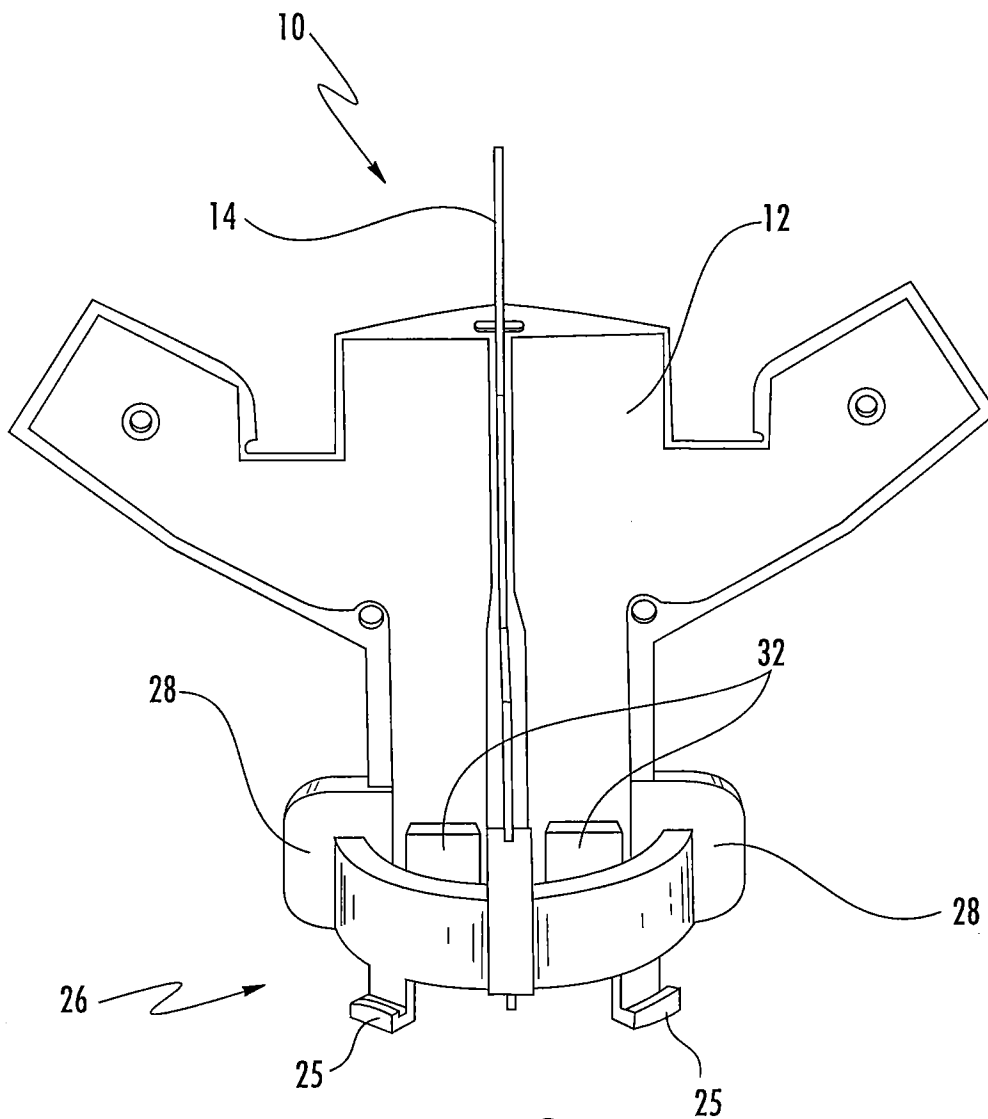


FIG. 8

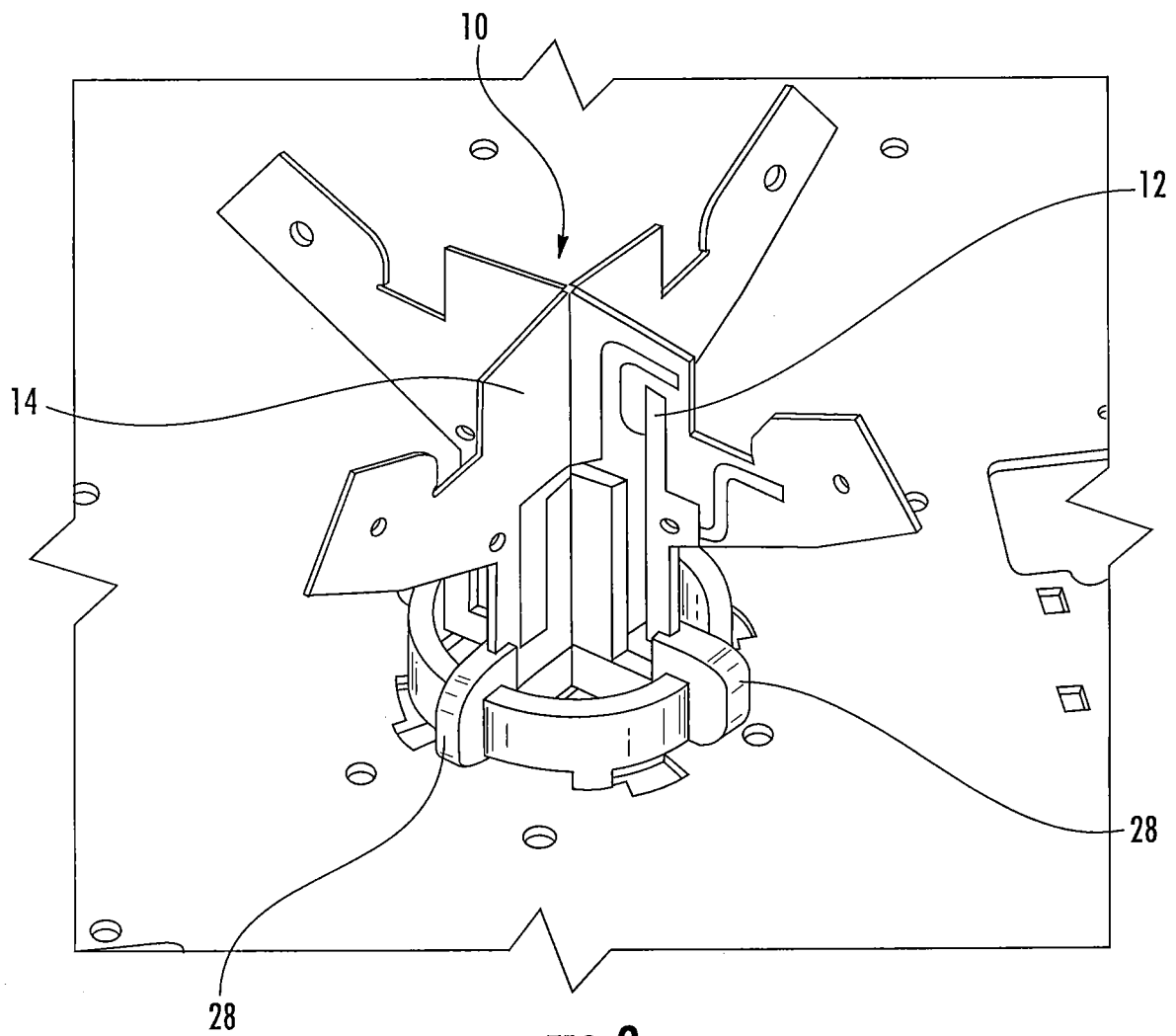
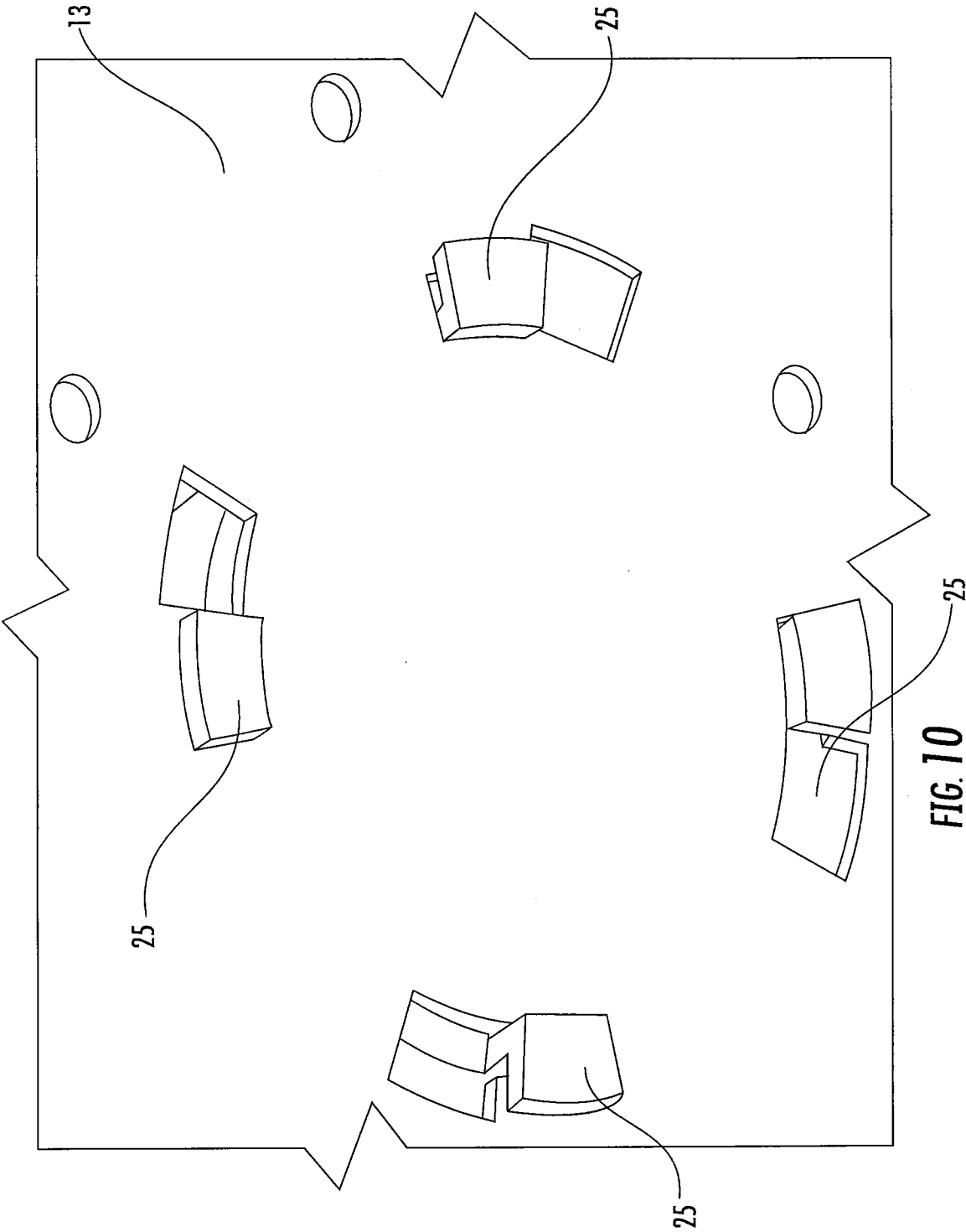


FIG. 9



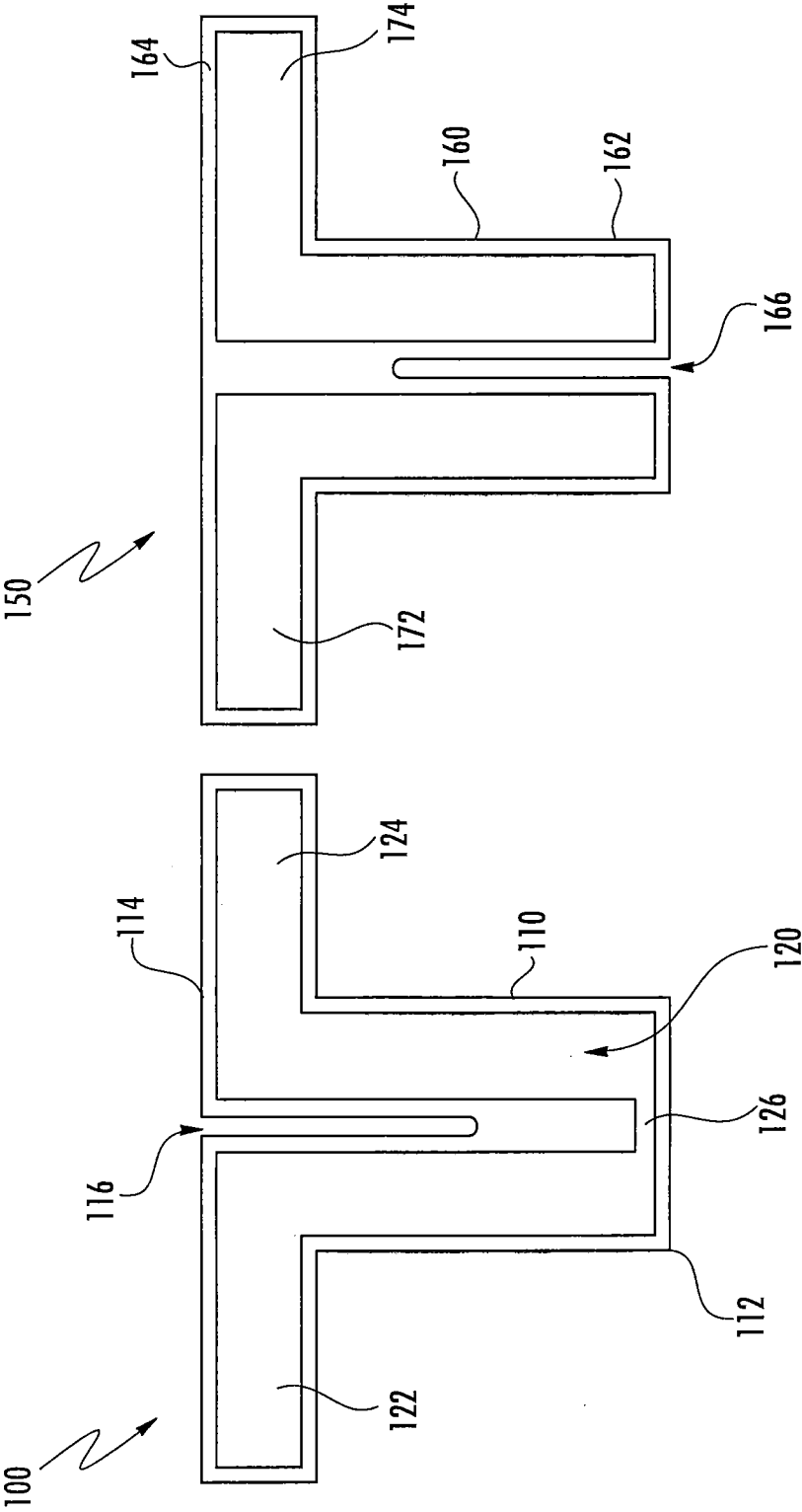


FIG. 11B

FIG. 11A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/028607**A. CLASSIFICATION OF SUBJECT MATTER****H01Q 1/12(2006.01)i, H01Q 1/20(2006.01)i, H01Q 1/36(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01Q 1/12; H01Q 9/16; H01Q 1/38; H01Q 13/08; H01Q 9/44; H01Q 21/26; H01Q 13/10; H01Q 1/20; H01Q 1/36

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: antenna, crossed dipole, clip, capacitive

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2013-0314292 A1 (GREGORY JOSEPH MALEY) 28 November 2013 See paragraphs [0021]–[0026], claim 1 and figures 1–12.	1–30
Y	US 2004-0201537 A1 (MANFRED STOLLE et al.) 14 October 2004 See paragraphs [0027]–[0028], claims 1–2 and figures 1–3.	1–30
A	KR 10-2013-0112518 A (LS CABLE & SYSTEM LTD.) 14 October 2013 See claims 1–5 and figures 1–4.	1–30
A	KR 10-2006-0099061 A (K.M.W. INC.) 19 September 2006 See abstract and figures 1–4.	1–30
A	US 2004-0217910 A1 (MARK MONTGOMERY et al.) 04 November 2004 See figures 2–4.	1–30



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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