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(54) **Title**: A METHOD OF MANUFACTURING ANTENNAS

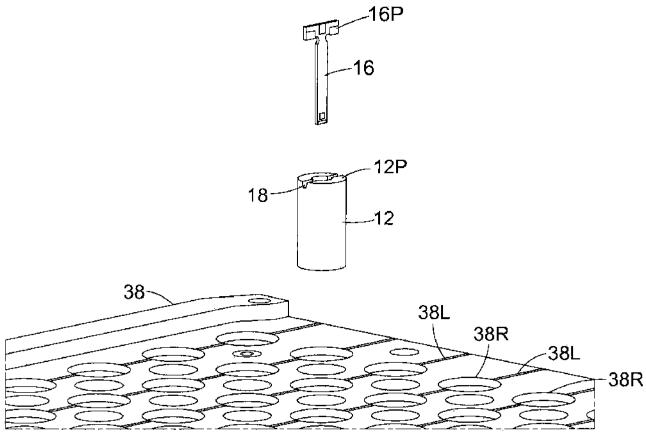

Fig. 2F

(57) **Abstract**: In a method of manufacturing dielectrically loaded antennas, a first step comprises providing a printed circuit panel (30) having a plurality of disc-shaped laminate boards (20) supported in apertures in a body of the panel. The panel is secured to a carrier plate (38) forming part of a pallet assembly so that the disc-shaped boards (20) are in registry with respective antenna core receptacles (38R) in the carrier plate. Next, cylindrical insulative antenna cores each having an axial passage are placed in the receptacles with distal end surfaces of the cores abutting the disc-shaped boards and elongate feeder boards are inserted in the core passages from the core proximal end surfaces. The pallet assembly, panel body, boards and cores are then heated to melt solder paste on the core end surfaces to form electrical connections between the boards and between the core and the boards to form a plurality of antennas. Lastly the antennas are separated from the panel body by pushing the disc-shaped boards (20) out of the apertures in the printed circuit panel body.

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A Method of Manufacturing Antennas

This invention relates to a method of manufacturing dielectrically loaded antennas, particularly backfire antennas having an insulative antenna core, antenna elements on the surface of the core, a feeder housed in a passage in the core, and a laminate board for connecting the feeder to the antenna elements.

In US2011/0221650A1 (filed on January 27, 2011 as U.S. Patent Application No. 13/014,962), there is disclosed a backfire dielectrically loaded helical antenna for operation at UHF, particularly for use in a portable radio communication device such as a cellphone, a satellite telephone, or a handheld positioning unit. The antenna has a cylindrical ceramic core with a relative dielectric constant of at least 5, the outer surface of the core bearing an antenna element structure in the form of helical conductive tracks. Housed in a bore extending through the antenna core is an axial feeder in the form of an elongate laminate feeder board having a transmission line section which is housed in the core passage, a distal section which projects from a distal end face of the core, and an antenna connection section projecting from the core proximal end face. The laminate board has three conductive layers which, in the transmission line section, form a shielded line. The proximal antenna connection section, being wider than the transmission line section and wider than the passage, abuts the plated proximal end face of the core, conductors on this proximal section being electrically connected to a balun sleeve encircling the core. Forming part of the coupling between the shielded line and the helical elements on the core is a distal laminate board which overlies the distal end face of the core in a region around the core passage. In effect, the board has a slot dimensioned to receive the distal end section of the feeder board. This distal laminate board forms a bridge between conductors of the feeder and conductors plated on the core distal end face which, in turn, are connected to the helical antenna elements. Also disclosed is a method of manufacturing antennas such as that described above, including placing the distal laminate boards in an array in holes in a base plate, securing a ceramic locator plate on the base plate, placing antenna cores in apertures in the locator plate so that they abut the distal laminate boards, inserting the elongate feeder boards into the passages in the cores, applying solder preforms to the cores and subjecting the assembly of the above-described components to a reflow soldering process to join the antenna components together. Finished antennas are then pushed out of the base plate. The entire disclosure of the above-mentioned U.S. patent application is expressly incorporated in the present application by reference.

It is an object of the invention to provide an improved method of manufacturing dielectrically loaded antennas.

According to a first aspect of the invention, there is provided a method of manufacturing dielectrically located antennas for operating at a frequency above 200MHz, the antennas each having an insulative antenna core with a proximal surface portion, a distal surface portion, a side surface portion extending between the proximal and distal surface portions, and a passage extending through the core from the distal surface portion to the proximal surface portion, an antenna element structure comprising a plurality of elongate conductive antenna elements on the core side surface portion and conductive connection elements on the distal surface portion coupled to the antenna elements, an elongate feeder housed in the core passage, and a distal laminate board on the core distal surface portion interconnecting the feeder and the conductive connection elements, wherein the method comprises providing a printed circuit panel comprising a panel body and a plurality of said distal laminate boards each supported in the panel body in a respective aperture in the panel body and each having an exposed conductor layer on a connection surface; providing a pallet assembly comprising a carrier plate with a plurality of antenna core receptacles in a spaced-apart arrangement corresponding to the arrangement of the distal laminate boards in the printed circuit panel, the assembly further comprising a panel support structure for supporting and locating the printed circuit panel relative to the carrier plate; securing the printed circuit panel to the carrier plate using the panel support structure in a face-to-face juxtaposition in which the exposed conductive layer faces the carrier plate and with each distal laminate board in registry with a respective said antenna core receptacle; placing a plurality of the said insulative antenna cores in the antenna core receptacles; inserting a plurality of the said elongate feeders in the core passages of the placed cores; heating the assembled combination of the pallet assembly, the printed circuit panel, the cores and the feeders to form electrical connections between the feeders and the distal laminate boards and between the distal laminate boards and the conductive connection elements on the cores; and urging the distal laminate boards out of the panel body to separate the antennas formed by the assembly of the cores, the distal laminate boards and the feeders from the panel body. In the preferred method, the panel support structure is a base plate or frame shaped and configured to be attached to the carrier plate in a position parallel to the carrier plate. Location elements, preferably in the form of pillars or pins adjacent edge of the frame, locate the frame, the pins being received in recesses in the carrier plate. The printed circuit panel has cut-outs, typically holes adjacent its edges, which locate the panel on the pins when the latter is sandwiched between the frame and the carrier plate. The frame has openings arranged to expose a major part of the face of the panel which is directed away from the carrier plate to allow circulation of hot air to the panel face when the assembly is heated in an oven.

In order further to promote the circulation of hot air, the carrier plate has spacers for spacing the printed circuit panel from the carrier plate. In this case, the antenna cores, when they are placed in the carrier plate, project from the receptacles into the space between the carrier plate and the panel where they are exposed to air circulating in the space.

Although the method of the invention may be used with feeders having various constructions, it is particularly applicable to antennas with feeders in the form of elongate laminate boards such as those described above with reference to US2011/0221650A1. In this case, the step of inserting the feeders in the core passage is performed with the elongate laminate feeder boards in a predetermined rotational orientation relative to the antenna cores. Where the distal laminate board has a slot for connecting the feeder board, the feeder boards are aligned with the slots so that, during the insertion step, the distal end portion of the feeder board is received in the slot. In the case of the distal laminate boards being arranged in a two-dimensional matrix in the printed circuit panel, the matrix having a plurality of rows, the slots in the distal laminate boards are typically oriented to lie parallel to the rows.

The antennas may have plated diametrical grooves in their proximal surface portions to locate the rotational positions of the feeder boards. In this case each feeder board has a proximal section which is wider than other parts of the feeder board so that when each feeder board is inserted in the respective core passage in a predefined orientation aligned with the groove, the proximal section is received in the groove. Whether or not the core has a groove, the longitudinal position of the feeder board in the core is defined by the engagement of the wider proximal section with a proximal part of the core. The preferred antenna has a conductive covering or layer over this proximal core part to act as a balun sleeve and the proximal section of the feeder board has a conductive surface for engaging the conductive layer. The preferred method includes applying a conductive bonding material, typically solder paste or a solder preform, to either the core conductive layer or the feeder board conductive surface so that, following the insertion of the board, an electrical connection can be formed between the feeder board and the core conductive layer. Advantageously, solder paste or at least one solder preform is applied to a part of the conductive layer on the proximal surface portion of the core after the core has been placed in its carrier plate receptacle and before the feeder board is inserted. Where the core has a groove, solder paste or at least one solder preform may be applied in the groove before the feeder board is inserted.

The preferred method also includes applying a conductive bonding material, e.g. solder paste or solder preforms, to the core distal surface portions and/or to the distal laminate boards in order to connect the distal laminate boards to the core distal surface portions, e.g. during the heating step. It is preferred that the above-mentioned heating step is the only heating step in the method of manufacture insofar as it relates to the assembly of the feeder board, the distal laminate board and the core (as opposed to steps performed on the two boards before they are placed in the pallet assembly).

The above-described method allows the antenna cores to remain upright with their proximal surface portions uppermost during the period starting with their placement in the carrier plate receptacles and finishing with the separation of the antennas from the printed circuit panel. The groove in each core precludes leaning of the feeder board before the electrical connections are formed. In an alternative antenna recesses in the form of e.g., notches are provided in the core, instead of the groove. Accordingly, another aspect of the invention provides an antenna for operation at a frequency in excess of 200MHz comprising:

an insulative substrate having a central axis, an axial passage extending therethrough and an outer substrate surface which extends around the axis;

a three-dimensional antenna element structure including at least one pair of axially coextensive elongate conductive antenna elements on or adjacent the outer substrate surface; and

an axial feeder structure which extends through the passage and comprises an elongate laminate board having a proximal end portion for connection to host equipment circuitry, an intermediate portion including a transmission line, and a distal end portion coupled to the antenna elements;

wherein the laminate board proximal end portion is wider than the intermediate portion in that it includes lateral extensions projecting in opposite lateral directions, and wherein, adjacent the laminate board proximal end portion, the substrate has notches on opposite sides of the axis which receive distally directed projections of said lateral extensions of the laminate board proximal end portion.

Each notch preferably lies on a diameter passing through the central axis and is separated from the core passage by a non-recessed part of the core proximal end portion, the laminate board proximal end portion having stepped distal edge parts on opposite sides of the axis, each edge part incorporating an outer projection and an inner cut-out, the latter being of a size sufficient to receive the non-recessed part of the core proximal end portion when the laminate board is fully received in the core with the outer projections fully received in the notches.

The invention will now be described by way of example with reference to the drawings in which:

Figures 1A to 1C are, respectively, a perspective view of an antenna produced using a method in accordance with the invention, and first and second exploded views of the antenna from proximal and distal viewpoints;

Figure 2A is a perspective view of a printed circuit panel containing a matrix of laminate boards, the panel being shown prior to location on the base plate of a pallet assembly;

Figure 2B is a perspective view of the printed circuit panel and base plate of Figure 2A, together with an apertured spacer plate;

Figure 2C is a perspective view of a core carrier plate prior to its location on the assembly of Figure 2B;

Figure 2D is a perspective view of the underside of the carrier plate;

Figure 2E is a perspective view of the assembly of the base plate, printed circuit panel and carrier plate;

Figure 2F is an exploded view representing the placement of an antenna core in the carrier plate, and the insertion of a feeder board into the core;

Figure 2G is a perspective view showing the antenna core and the feeder board in their assembled condition in the carrier plate;

Figure 3 is a flow diagram of a manufacturing method in accordance with the invention; and

Figures 4A and 4B are, respectively, a perspective view and an exploded perspective view of an alternative antenna produced using a method in accordance with the invention.

Referring to Figures 1A to 1C, a dielectrically-loaded backfire helical antenna which may be manufactured in accordance with the method of the invention has an antenna element structure with four axially coextensive helical tracks 10A, 10B, 10C, 10D as antenna elements which are plated or otherwise metallised on the cylindrical side outer surface portion 12S of a cylindrical ceramic core 12. The relative dielectric constant of the ceramic material of the core is typically greater than 20. A barium-samarium-titanate-based material, having a relative dielectric constant of 82 is especially suitable. With a total core length of 12mm and a diameter of 7.5mm, the antenna has frequencies of operation at 1575MHz and 2450MHz, as explained in co-pending British Patent Application No. 1220203.2 filed November 9, 2012 and corresponding U.S. Patent Application No. 13/682,557 filed November 20, 2012, the contents of which are expressly incorporated herein by reference.

The core 12 has a central passage, centred on the axis of the cylinder and in the form of a bore 12B extending through the core from a distal end surface portion 12D to a proximal end surface portion 12P. Both of these end surface portions are planar faces extending transversely and perpendicularly with respect to the core axis. They are oppositely directed in that one is directed distally and the other proximally.

On the distal end surface portion 12D of the core, the antenna element structure includes four plated or otherwise metallised radial connection elements 10AR, 10BR, 10CR, 10DR, each connected to one of the antenna elements 10A-10D. Arcuate metallised connection elements 10AB, 10CD interconnect the radial connection elements.

Encircling a proximal part of the core 12 is a plated or otherwise metallised conductive sleeve 14 which is conductively continuous with a plated or otherwise metallised conductive covering of the proximal end surface portion 12P of the core. The rim 14R of the sleeve 14 forms an annular interconnection of the proximal ends of the helical antenna elements 10A-10D.

Housed in the axial bore 12B of the core is a feeder in the form of an elongate laminate board 16 having a plurality of conductive layers and a plurality of insulative layers, as will be described below. At the proximal end of the bore 12B, the laminate board 16 is received in a groove 18 opening out in the core proximal end surface portion 12P. In this example the groove 18 also intersects the cylindrical outer surface 12S. At the other, distal end of the bore 12B, the laminate board 16 projects beyond the distal end surface portion 12D and is received in a slot 20S of a disc-shaped laterally extending distal laminate board 20. The distal laminate board 20 is perpendicular to the axis of the core 12 and overlies the core distal end surface portion 12D. It is of a lateral extent sufficient to overlie, as well, the connecting elements formed by the arcuate interconnecting conductors 10AB, 10CD of the antenna element structure.

Referring to Figures 1B and 1C, the elongate feeder board 16 has a proximal end portion 16P for connection to host equipment circuitry, an intermediate portion 16I which forms a shielded transmission line, and a distal end portion 16D to be received in the slot 20S of the distal laminate board 20. The feeder board 16 has three conductive layers, only of which appears in Figures 1B and 1C. This first conductive layer is exposed on an upper surface 16U of the board 16. The first conductive layer 16-1 extends the full length of the intermediate portion 16I and substantially the full width, too. On the proximal end portion 16P of the board 16, this conductive layer forms proximal contact areas 16C. These contact areas 16C are electrically continuous with that part of the conductive layer which is on the intermediate portion 16I.

The second, intermediate conductive layer of the laminate feeder board 16, separated from the first conductive layer by an insulative layer, is formed as a narrow elongate feed line conductor (not shown) positioned centrally between the edges of the intermediate portion 16I. The third, lower conductive layer has a similar configuration to the upper conductive layer in that it extends the full length of the intermediate portion 16I and is electrically continuous with contact areas 16C on the proximal end portion 16P. It is insulated from the intermediate conductive layer by a second insulative layer. Adjacent each edge of the board intermediate portion 16I is a line of plated vias (not shown) interconnecting the upper conductive layer and the lower conductive layer along opposite sides of the inner conductor formed by the intermediate layer. As a result, the combination of the three conductive layers forms a quasi-coaxial shielded transmission line in the laminate intermediate portion 16I. In this instance, the characteristic impedance of the transmission line is 50 ohms.

Plated vias between the contact areas 16C on opposite faces of the board proximal end portion 16P interconnect these contact areas. (Note only the contact areas 16C on one face of the board proximal portion are visible in Figures 1B and 1C.)

At each end of the inner conductor formed by intermediate layer, there is a plated via connecting the inner conductor to proximal and distal feed line connection areas 27P, 27D on the upper surface 16U (see Figure 1B) of the elongate feeder board 16.

In a variant (not shown), the feeder board 16 may have an impedance matching network on or near the distal end portion 16D. These and other features of the feeder board are disclosed in US2011/0221650A1 and the above-referenced British Patent Application No. 1220203.2 and U.S. Patent Application No. 13/682,557.

Referring generally to Figures 1B and 1C, it will be noted that the laminate board proximal end portion 16P is significantly wider than the intermediate portion 16I in that it includes lateral extensions or ears projecting in opposite lateral directions with respect to the central axis. Each ear has a proximal edge 16PE on a line perpendicular to the central axis. The upper and lower contact areas 16C on the board proximal end portion 16P extend right to the proximal edges 16PE. Referring to Figure 1B, the groove 18 is fully plated inasmuch as both the base 18B and the side walls 18S of the groove are conductively coated and electrically continuous with the conductive sleeve 14.

Connections between the shielded transmission line formed by the intermediate portion 16I of the elongate feeder board 16 and the antenna element structure are completed by the distal laminate board 20. The slot 20S in the distal laminate board 20 has elongate side walls 20SW which are each plated (only one such plated wall 20SW being visible in Figure 1B), each plated side wall 20SW being connected to a respective segment-shaped inner plated area 20I on the proximal face 20PF of the laminate board part 20.

On each side of the slot, the distal laminate board 20 has arcuate peripheral conductor areas 20P extending over the side edges of the board 20. Embodied in and/or carried by the lateral laminate board 20 are circuit elements (not shown) interconnecting the conductors associated with the slot side walls 20SW and the peripheral conductor areas 20P. In the absence of an impedance matching network on the elongate laminate board 16, these circuit elements may constitute an impedance matching network of the kind disclosed in U.S. 7,439,934, the entire contents of which are incorporated herein by reference.

In the assembled antenna, solder joints are formed between the distal connection areas 27D, 29 of the feed line inner conductor and shield conductors, respectively, the side walls 20SW of the slot 20S. Solder joints between the peripheral conductor areas 20P of the lateral laminate board 20 and the conductors on the distal end surface portion 12D of the core, specifically the arcuate interconnections 10AB, 10CD, together with the above-described connections between the feeder board 16 and the perpendicular distal laminate board 20, result in the connection of the shielded transmission line formed by the feeder board intermediate portion 16I to the antenna element structure. Further features of the antenna, including its electrical operation, are described in the above-referenced British Patent Application No. 1220203.2 and U.S. Patent Application No. 13/682,557.

A method of manufacturing antennas as described above will be described below with reference to Figures 2A to 2G, in conjunction with the flow chart of Figure 3.

The main components of the antennas are the plated ceramic cores 12, the plated T-shaped feeder boards 16, and the plated disc-shaped distal laminate boards 20, as shown in Figures 1A to 1C. The method to be described is a method of assembling these components and securing them together.

Referring to Figure 2A, the disc-shaped distal laminate boards 20 are supplied as part of a printed circuit panel 30 in which they are arranged spaced apart in a regular matrix. Each disc-shaped board 20 lies in a respective circular aperture, supported in the aperture by two diametrically opposite narrow webs formed from the insulative material of the panel. The webs may be continuous in the sense that they each constitute an unbroken frangible connection between the body 30B of the panel 30 and the disc-shaped laminate boards 20. Alternatively, the webs are broken and the disc-shaped laminate boards 20 are supported by frictional and/or interfering contact between the boards 20 and the panel body 30B. Preferably, the disc-shaped boards 20 and the body 30B of the printed circuit panel 30 are all initially monolithically formed with frangible webs between the boards and the panel body. Then, before the process for assembling the antennas begins, the disc-shaped boards 20 are punched out of the panel body 30B and returned to their respective co-planar locations in their respective apertures in the panel body 30B, the boards 20 being held in the apertures by frictional, interfering contact between the broken-apart webs portions, the original orientation of the disc-shaped boards 20 being maintained. The board slots 20S (see Figures 1B and 1C) are all aligned with the centre-line of the matrix row in which they are located and the disc-shaped boards 20 and the body 30B of the printed circuit panel 30 are co-planar. Tightly toleranced location holes 30H are positioned near the edges of the panel 30.

At this stage, each disc-shaped board 20 has a conductor pattern as shown in Figure 1B, the slot 20S having plated sides, as well. In addition, referring to Figure 3, solder paste has been screen-printed on these boards (step 101). Assembly of the disc-shaped boards 20 and the other antenna components is performed in a jig hereinafter referred to as a pallet assembly. As shown in Figure 2A, this pallet assembly includes a base plate 32 in the form of a rectangular frame which is largely open in the sense that it has large apertures 32A which, when the printed circuit panel 30 is laid on the frame 32, expose the major part of the underside area of the panel 30. This is to promote the free circulation of hot air to the lower face of the panel 30 during a subsequent heating step. Frame 32 is made of a refractory plastics material.

The frame 32 incorporates location pillars 34 sized and positioned so as to match the size and position of the location holes 30H in the printed circuit panel 30, as shown. Semi-circular recesses 32R are provided in the edges of the frame 32 to assist disassembly.

Referring to Figure 2B, in a first assembly step 102 (Figure 3), the printed circuit panel 30 is laid on the base plate or frame 32, the panel 30 being lowered onto the frame 32 in a position such that the location pillars 34 pass through the location holes 30H in the panel, as shown.

Next, a carrier plate 38 is fitted over the printed circuit panel 30, as shown in Figures 2C, 2D and 2E. The carrier plate is a rectangular component of the pallet assembly, made of a refractory plastics material. It has a matrix of core receptacles 38R each in the form of a tapered or stepped hole so that an antenna core, placed from above, can be guided into a lower part of the hole having a diameter slightly greater than that of the core to locate the core accurately in the receptacle. In order that the cores, when fitted in the receptacles 38R, are accurately located over respective disc-shaped distal laminate boards 20, the receptacles 38 are spaced apart in a pattern exactly corresponding to the pattern of the boards 20 in the printed circuit panel 30 beneath, and accurately positioned location holes 38H are provided to receive the upper end portions of the location pillars 34 of the frame 32. As shown in Figure 2D, the carrier plate 38 has a number of spacing pillars 38P on its underside so that when assembled to the combination of the frame 32 and printed circuit panel, the lower face 38L (Figure 2D) of the carrier plate 38 is spaced from the printed circuit panel 30, as shown in Figure 2E. This spacing serves to promote the flow of hot air around the cores which, when they are received in the receptacles 38R, pass through the carrier plate 38 into the space between the carrier plate 38 and the printed circuit panel 30 to abut the respective disc-shaped distal laminate boards 20. In order further to promote circulation of air, the carrier plate has extra holes 38V in the spaces between the core receptacles 38R. Like the receptacles 38R, these ventilation holes 38V pass fully through the carrier plate 38. Score lines 38L on the top face of the carrier plate 38 are provided to allow manual alignment of the ceramic cores when needed.

Assembly of the carrier plate 38 to the components beneath completes the assembly step 103 of the flow chart of Figure 3.

With the carrier plate 38 secured to the base plate or frame 32, the pallet assembly is moved to a pick-and-place machine where, in carrying out a pick-and-place step (step 104), antenna cores are picked from a supply station with their proximal end surface portions 12P (Figure 1B) uppermost, automatically rotated about their cylindrical axes to a predetermined alignment using optical position-sensing, and lowered into the carrier plate receptacles 38R, as shown in Figures 2F and 2G. In this instance, the alignment of the cores prior to lowering them into the receptacles 38R is such that the grooves 18 are aligned with the rows of the receptacle matrix and with the score lines 38L.

Next, with the cores 12 fully lowered into the receptacles 38R with their distal end surface portions abutting the disc-shaped distal laminate boards 20, solder paste is extruded or screen printed in the grooves 18 and/or on the plated planar part of the core proximal end surface portion 12P (step 105, Figure 3).

The T-shaped feeder boards 16 are then aligned and inserted in respective cores, as shown in Figures 2F and 2G, with the proximal end portions 16P of the boards 16 lying in the core grooves 18 (step 106, Figure 3). Before this, solder paste has been, e.g., screen printed on conductive areas of the board 16 which are to receive surface-mount components or, e.g., an impedance matching network (step 106A), such components then being picked from a respective supply station and placed on the board (step 106B) before being heated (step 106C) to solder the components to the feeder board 16. These preliminary steps 106A - 106C do not form part of the assembly process whereby the boards 16, the cores 12 and the distal laminate boards 20 are assembled to form an antenna. Typically the preliminary steps are performed simultaneously on a plurality of feeder boards 16 forming, at that stage, part of a respective printed circuit panel (not shown). It is only when the individual feeder boards 16 have been separated from the panel (singulation step 106D, Figure 3) that they are mechanically picked, aligned, and placed in the antenna cores 12 in the carrier plate 38 of the pallet assembly (step 106).

With the antenna components now assembled together in the pallet assembly, they and the pallet assembly are moved from the pick-and-place station to a reflow station (step 107) where the complete assembly is heated to melt the solder at the distal and proximal end surface portions of each core 12 to form electrical connections between, firstly, conductive areas on the proximal end portion of the respective feeder board 16 and the proximal end surface portion 12P of the core 12 to form solder fillets 32 which extend into the grooves 18 to reach the base 18B of the groove, as shown in Figure 1A, and, secondly, between conductive areas 27D on the distal end of the feeder board 16 and the plated walls 20SW of the slot 20S in the respective distal laminate board 20. Thirdly, electrical connections are formed between the peripheral conductor areas 20P (Figure 1B) on the distal laminate boards 20 and the accurate interconnections 10AB, 10CD on the core distal end surface portion 12D (Figure 1C).

The pallet assembly is then moved from the reflow station and allowed to cool, whereupon the antenna cores 12 and the laminate boards 16, 20, now bonded to the cores, are mechanically pushed upwardly (step 108) to release the disc-shaped boards 20 from the body 30B of the printed circuit panel 30 so that the individual assembled antennas can be collected (step 109).

The above process is described as producing an antenna in which the elongate laminate feeder board 16 has a proximal end portion 16P located in a diametrical groove 18 in the core 12, as shown in Figures 1A to 1C. The process may be used for a variety of antennas. In one alternative antenna, as shown in Figures 4A and 4B, the proximal end portion 16P of the feeder board 16 is located instead in recesses formed as truncated groove portions or notches 118A, 118B in the proximal end surface portion 12P of the core 12. Each notch 118A, 118B lies on a diameter of the core 12 and extends radially inwardly from the cylindrical surface 12S of the core and terminates short of the bore 12B housing the feeder board 16. In this antenna each lateral extension or ear of the feeder board proximal end portion 16P has a stepped proximal edge 16PE to match the profile of the core 12 on the diameter of the notches 118A, 118B. More specifically, each proximal edge 16PE has a distally directed projection 16PEP, as shown in Figure 4B, in registry with one of the notches 118A, 118B. Between the projection 16PEP and the intermediate portion 16I of the feeder board 16, there is a portion of the proximal edge 16PEP which is nearer the proximal edge 16PP of the board 16 to form a cut-out of a width and depth sufficient to receive the inner part 12PI of the core proximal surface portion 12P when the board 16 is received in the core 12 with the projections 16PEP fully inserted in the notches 118A, 118B.

Claims

1. A method of manufacturing dielectrically loaded antennas for operation at a frequency above 200MHz, the antennas each having an insulative antenna core with a proximal surface portion, a distal surface portion, a side surface portion extending between the proximal and distal surface portions, and a passage extending through the core from the distal surface portion to the proximal surface portion, an antenna element structure comprising a plurality of elongate conductive antenna elements on the core side surface portion and conductive connection elements on the distal surface portion coupled to the antenna elements, an elongate feeder housed in the core passage, and a distal laminate board on the core distal surface portion interconnecting the feeder and the conductive connection elements, wherein the method comprises:

providing a printed circuit panel comprising a panel body and a plurality of said distal laminate boards each supported in the panel body in a respective aperture in the panel body and each having an exposed conductor layer on a connection surface;

providing a pallet assembly comprising a carrier plate with a plurality of antenna core receptacles in a spaced-apart arrangement corresponding to the arrangement of the distal laminate boards in the printed circuit panel, the assembly further comprising a panel support structure for supporting and locating the printed circuit panel relative to the carrier plate;

securing the printed circuit panel to the carrier plate using the panel support structure in a face-to-face juxtaposition in which the exposed conductive layer faces the carrier plate and with each distal laminate board in registry with a respective said antenna core receptacle;

placing a plurality of the said insulative antenna cores in the antenna core receptacles;

inserting a plurality of the said elongate feeders in the core passages of the placed cores;

heating the assembled combination of the pallet assembly, the printed circuit panel, the cores and the feeders to form electrical connections between the feeders and the distal laminate boards and between the distal laminate boards and the conductive connection elements on the cores; and urging the distal laminate boards out of the panel body to separate the antennas formed by the assembly of the cores, the distal laminate boards and the feeders from the panel body.

2. A method according to claim 1, wherein the panel support structure is a frame shaped and configured to be attached to the carrier plate in a position parallel thereto, the pallet assembly further comprising location elements to locate the frame relative to the carrier plate, wherein securing the printed circuit panel to the carrier plate results in sandwiching the panel between the frame and the carrier plate, the frame having openings to expose a major part of the face of the panel which is directed away from the carrier plate.

3. A method according to claim 2, wherein the pallet assembly has location pillars on one of the frame and the carrier plate, the printed circuit panel having cut-outs which receive the pillars to locate the panel relative to the carrier plate and the frame.

4. A method according to any preceding claim, wherein the carrier plate has spacers for spacing the printed circuit panel therefrom, and wherein the antenna cores, when they are placed in the carrier plate, project from the receptacles into the space between the carrier plate and the panel to abut the distal laminate boards.

5. A method according to any preceding claim, including placing an apertured cover plate between the printed circuit panel and the carrier plate, the cover plate having a plurality of apertures in a spaced-apart arrangement corresponding to the arrangement of the distal laminate boards in the panel.

6. A method according to any preceding claim, wherein each feeder is an elongate laminate board, and wherein the insertion of the feeders in the core passages is performed with the elongate laminate feeder boards in a predetermined rotational orientation relative to the cores.

7. A method according to claim 6, wherein each distal laminate board has a slot, and wherein, during the insertion step, the feeder boards are aligned with the slots so that each slot receives a distal end portion of the respective feeder board.

8. A method according to claim 7, wherein the distal laminate boards are arranged in a two-dimensional matrix in the printed circuit panel, the matrix having a plurality of rows, and wherein the slots in the distal laminate boards are oriented to lie parallel to the rows.

9. A method according to any of claims 6 to 8 for manufacturing antennas in which each antenna core has a groove in the proximal surface portion and each feeder board has a proximal section which is wider than other parts thereof, wherein the feeder insertion step comprises inserting each elongate laminate feeder board in an orientation in which it is aligned with the groove so that it is received in the groove.

10. A method according to any preceding claim, including applying solder paste or preforms to the conductive connection elements on the core distal surface portion before the heating step.

11. A method according to any of claims 1 to 9, including the step of applying solder paste or preforms to the distal laminate boards before securing the printed circuit panel to the carrier plate.

12. A method according to any preceding claim for manufacturing antennas in each of which the antenna core has a proximal part with a conductive layer and in each of which the feeder has a conductive surface for engaging the conductive layer, wherein the method comprises applying solder paste or at least one solder preform to one of the conductive layer on the core proximal part and the feeder conductive surface, and wherein, during the heating step, an electrical connection is formed between the feeder and the conductive layer on the proximal core part.

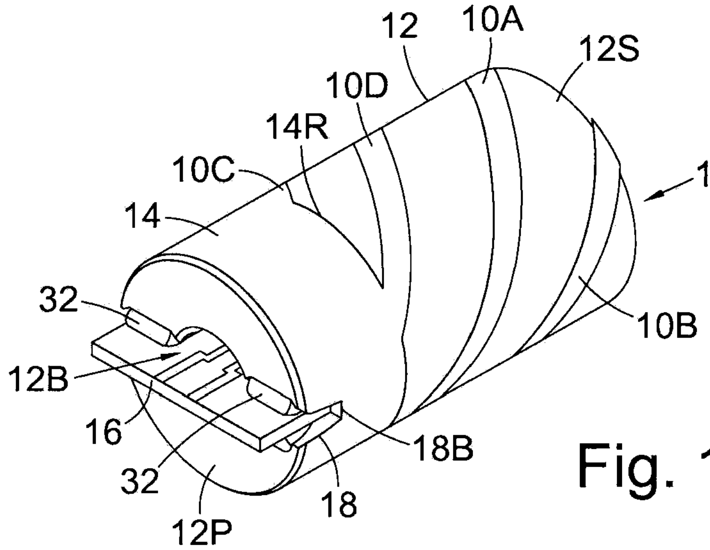
13. A method according to claim 12, including applying solder paste or at least one solder preform to a conductive layer on the proximal surface portion of the core after it has been placed in the carrier plate receptacle and before insertion of the feeder.

14. A method according to claim 9, including, before the insertion step, applying solder paste at least one solder preform in the groove.

15. A method according to any preceding claim, wherein all electrical connections between the assembled antenna parts are made in a single heating step.

16. A method according to any preceding claim, wherein the antenna cores remain upright with their proximal surface portions uppermost during the period starting with their placement in the carrier plate receptacles and finishing with the separation of the antennas from the printed circuit panel.

17. A method according to any preceding claim, wherein the carrier plate is made of a refractory plastics material.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10B
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18B
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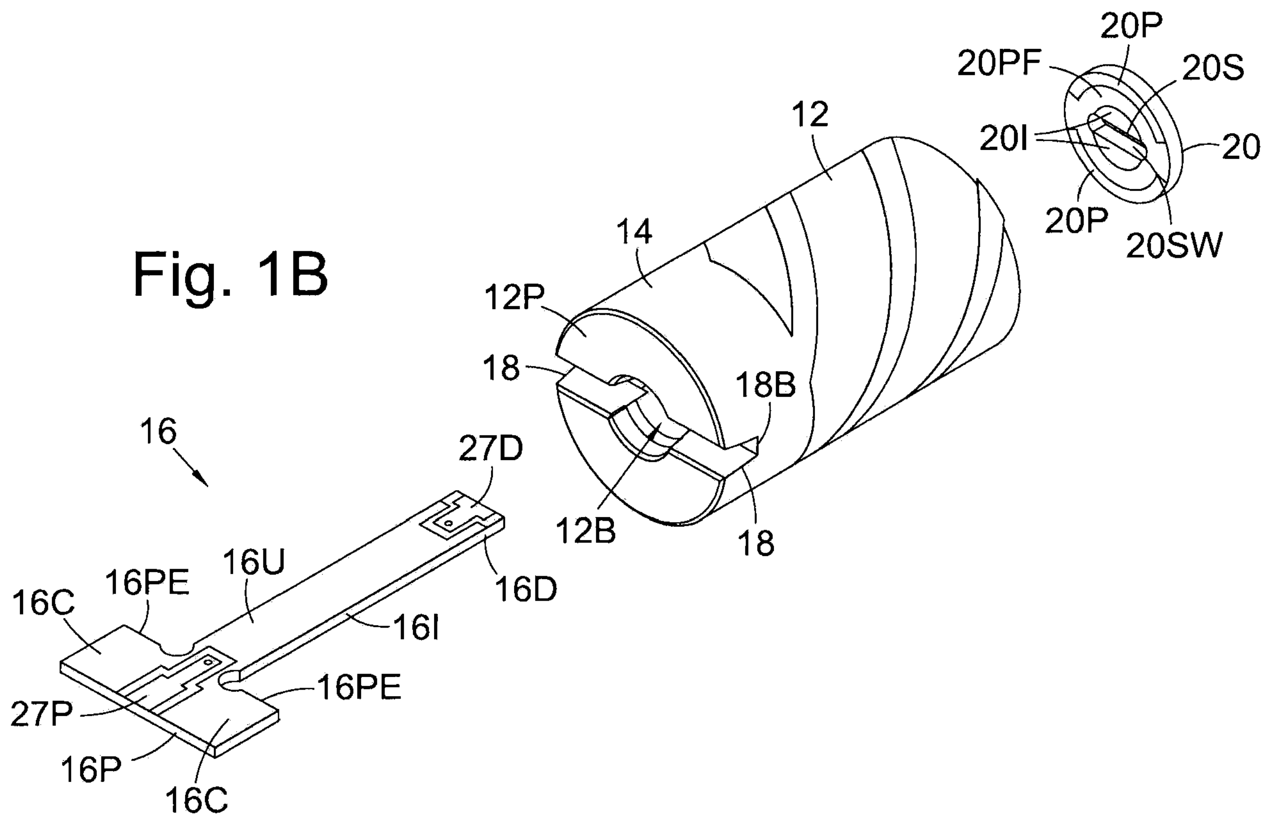
12P

Fig. 1A

Fig. 1B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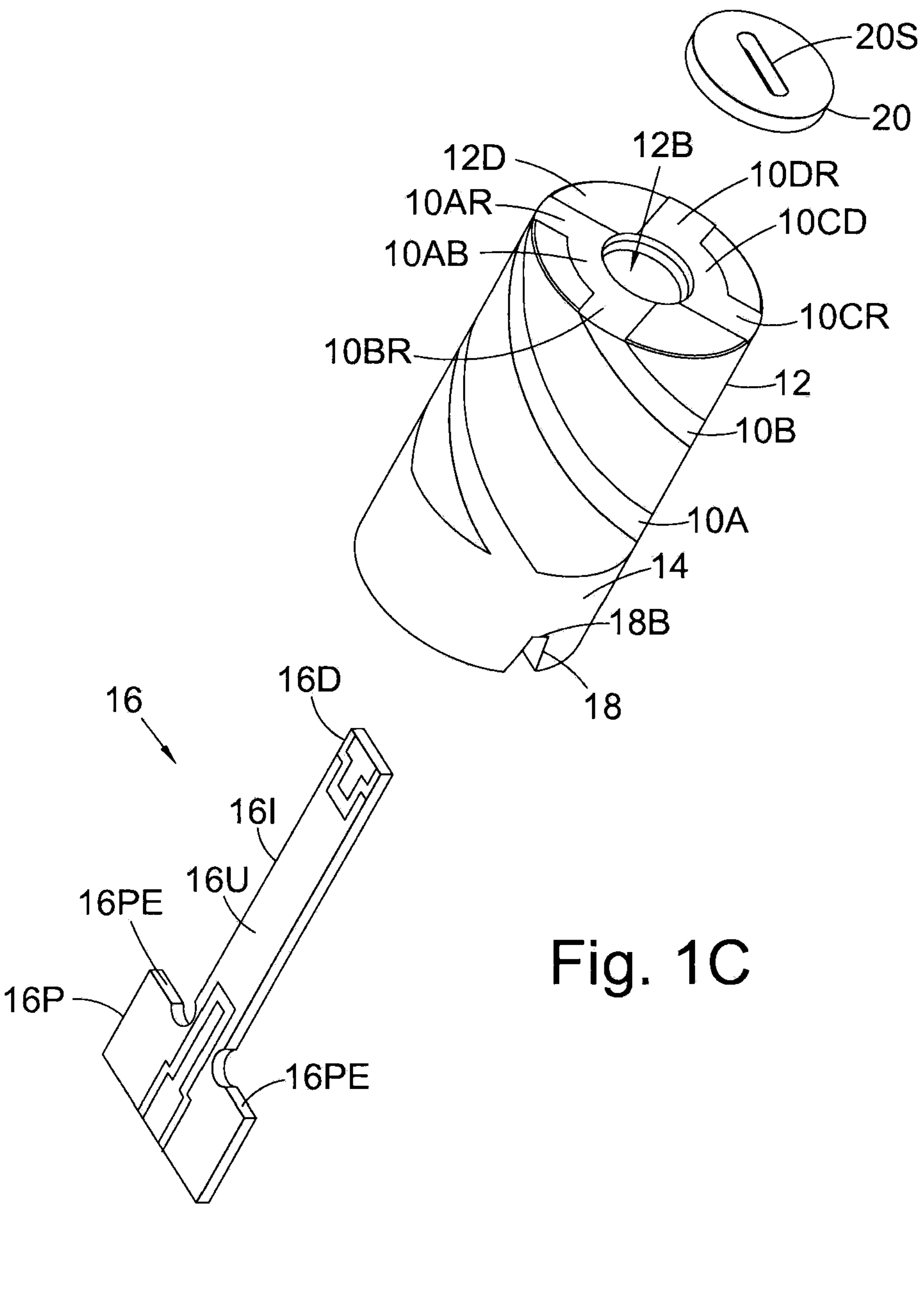
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Fig. 1C

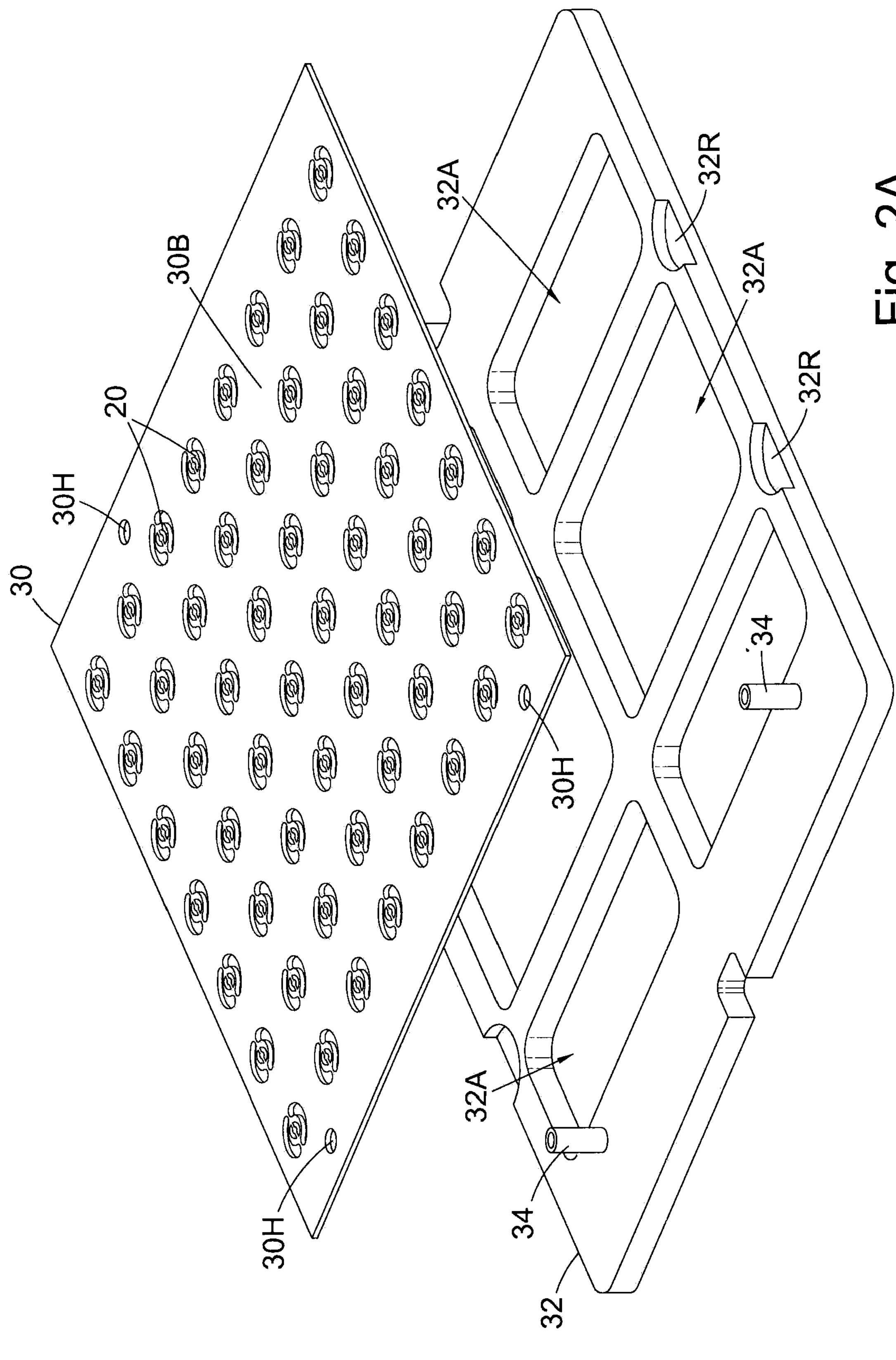


Fig. 2A

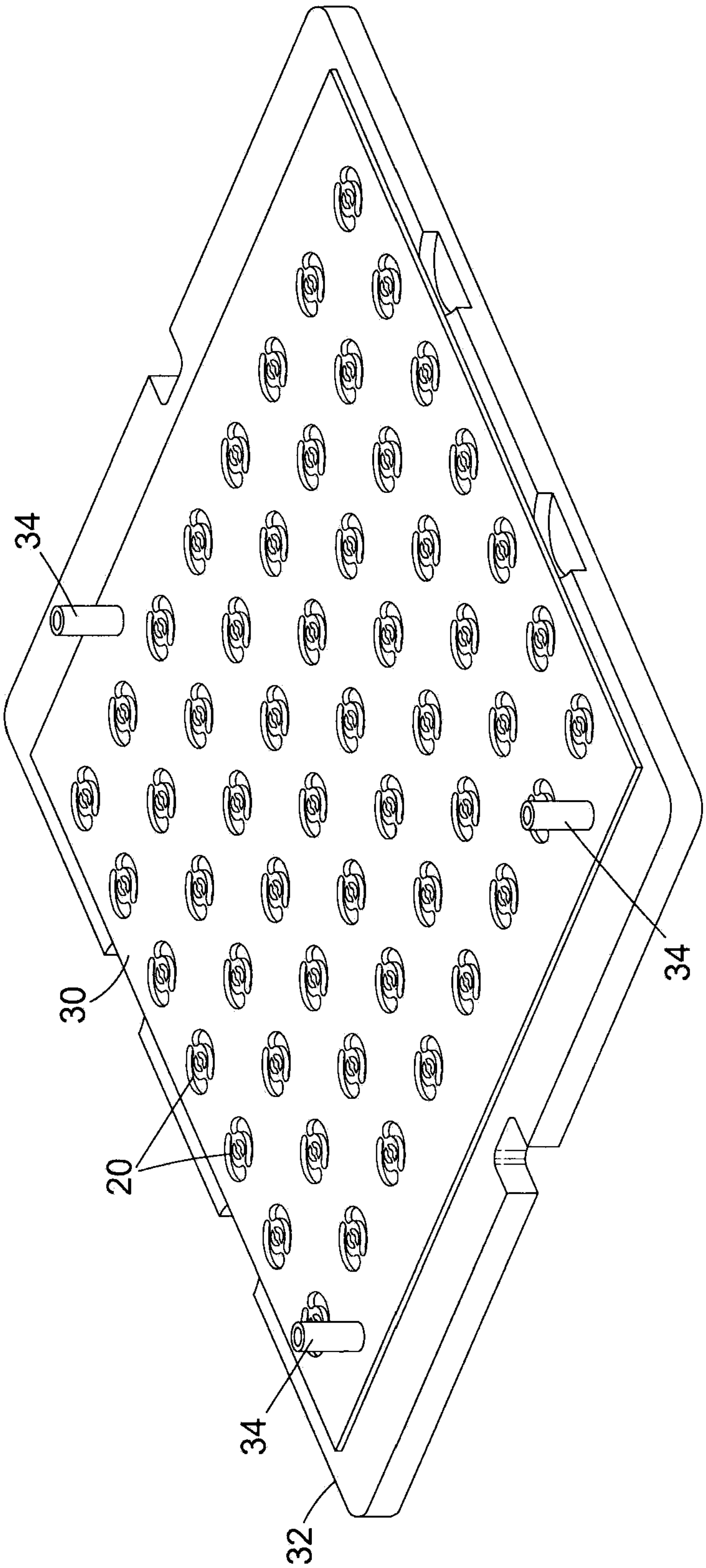


Fig. 2B

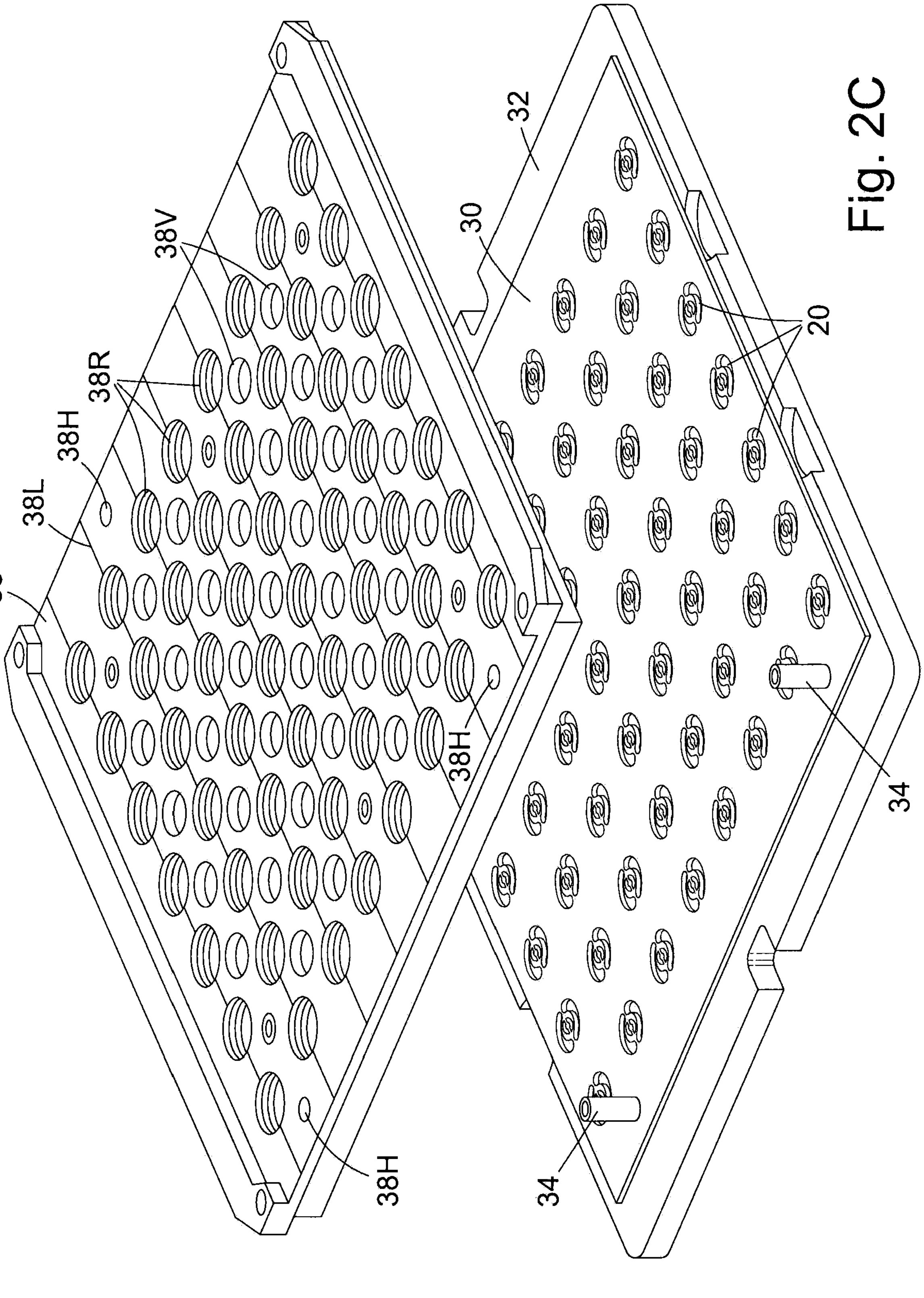
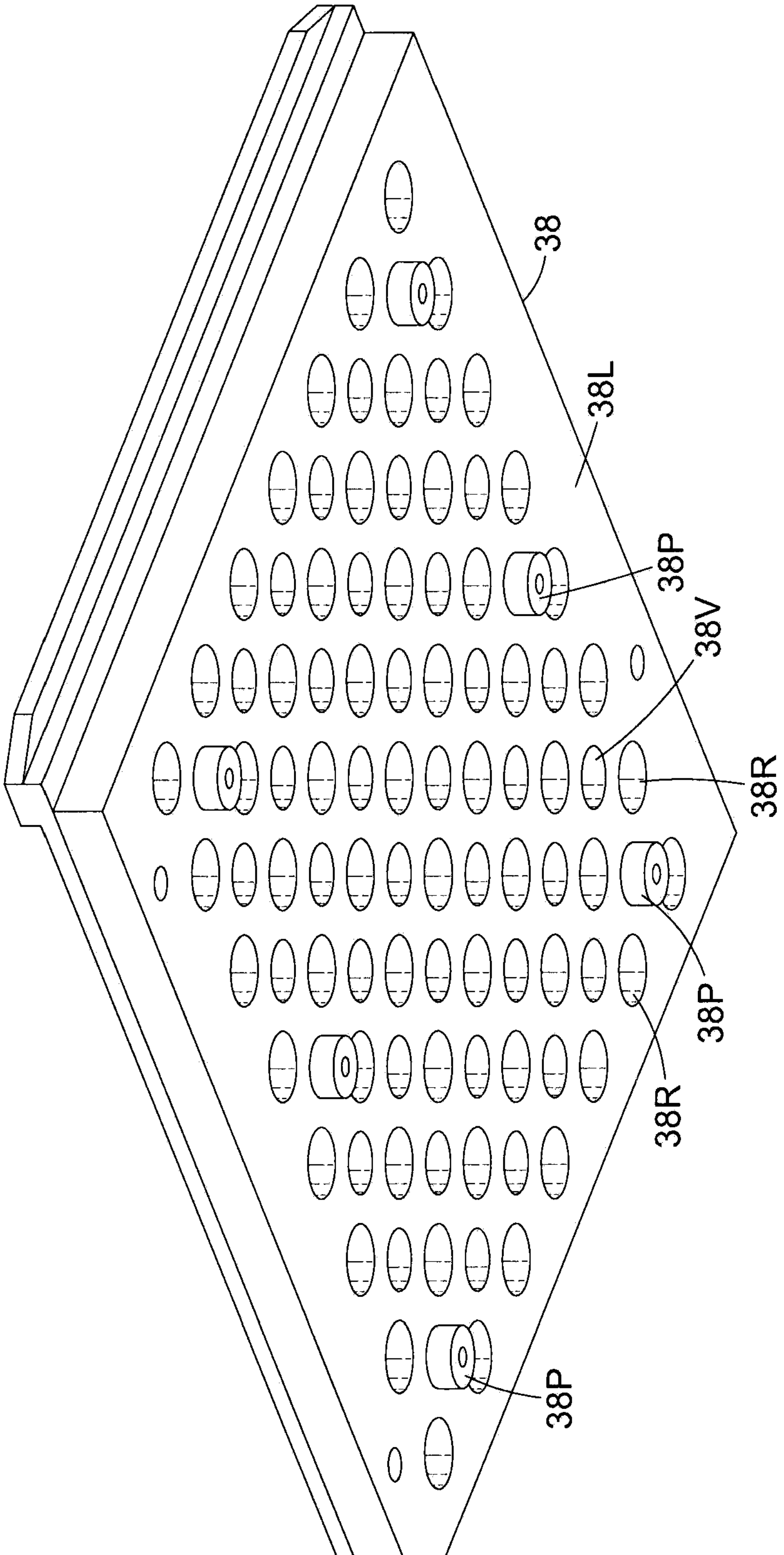


Fig. 2C



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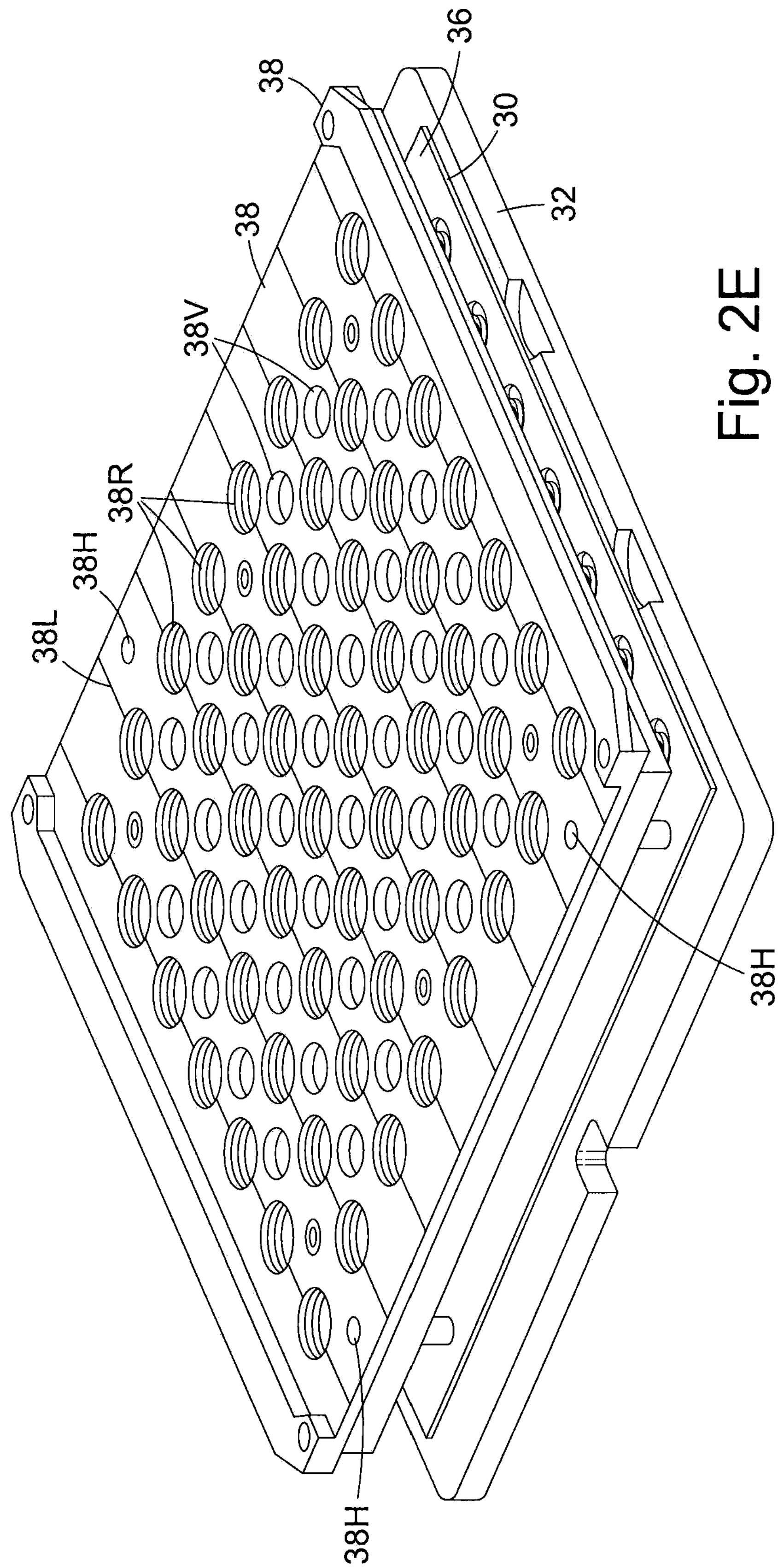

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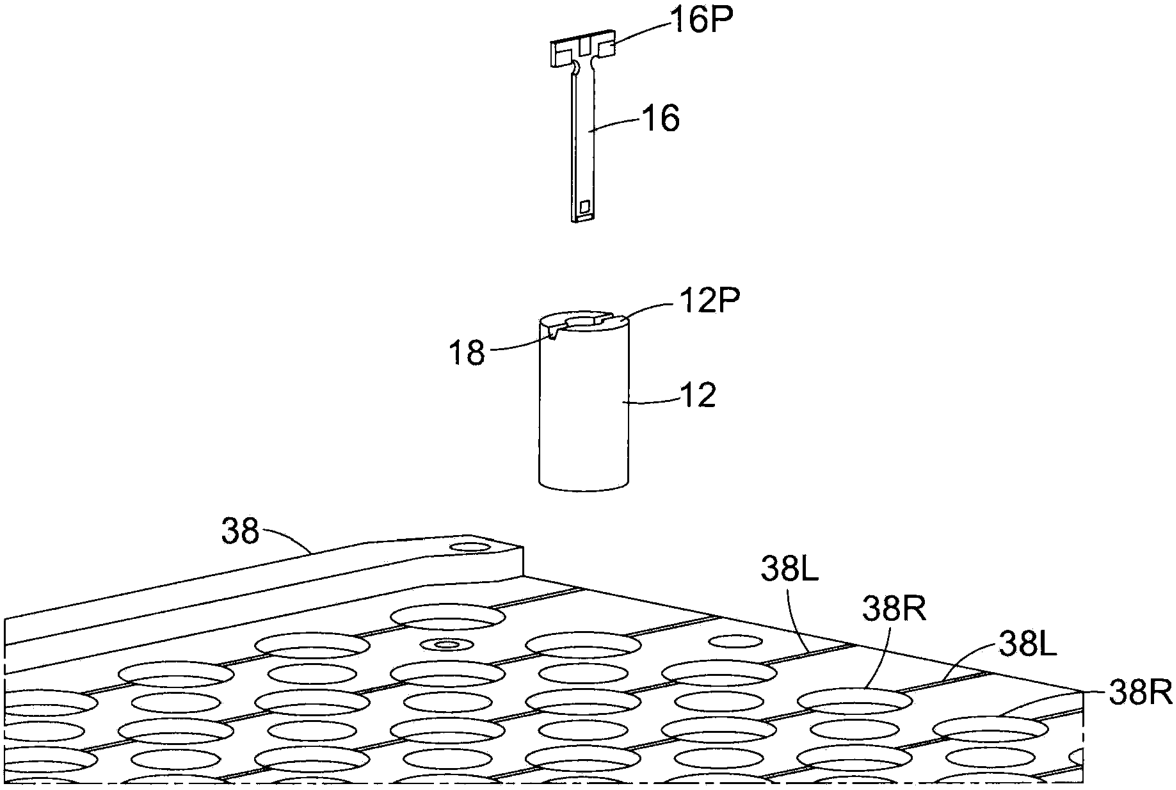
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38R

Fig. 2F

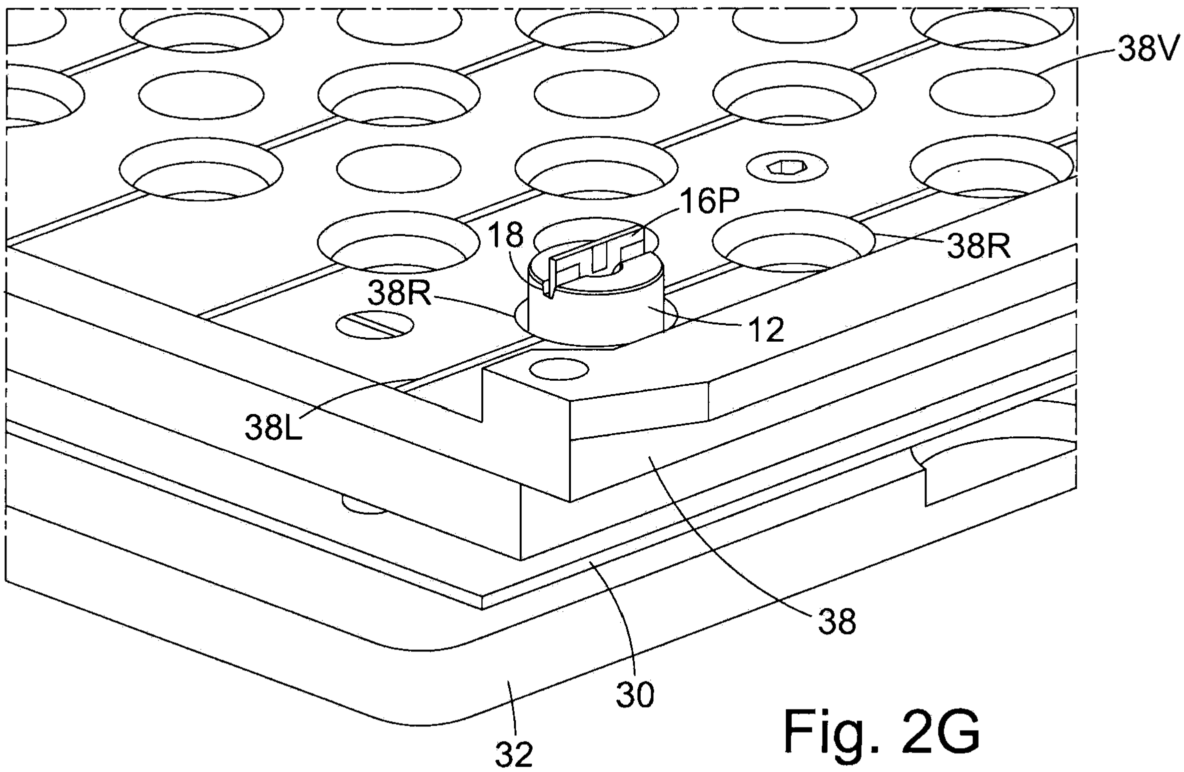
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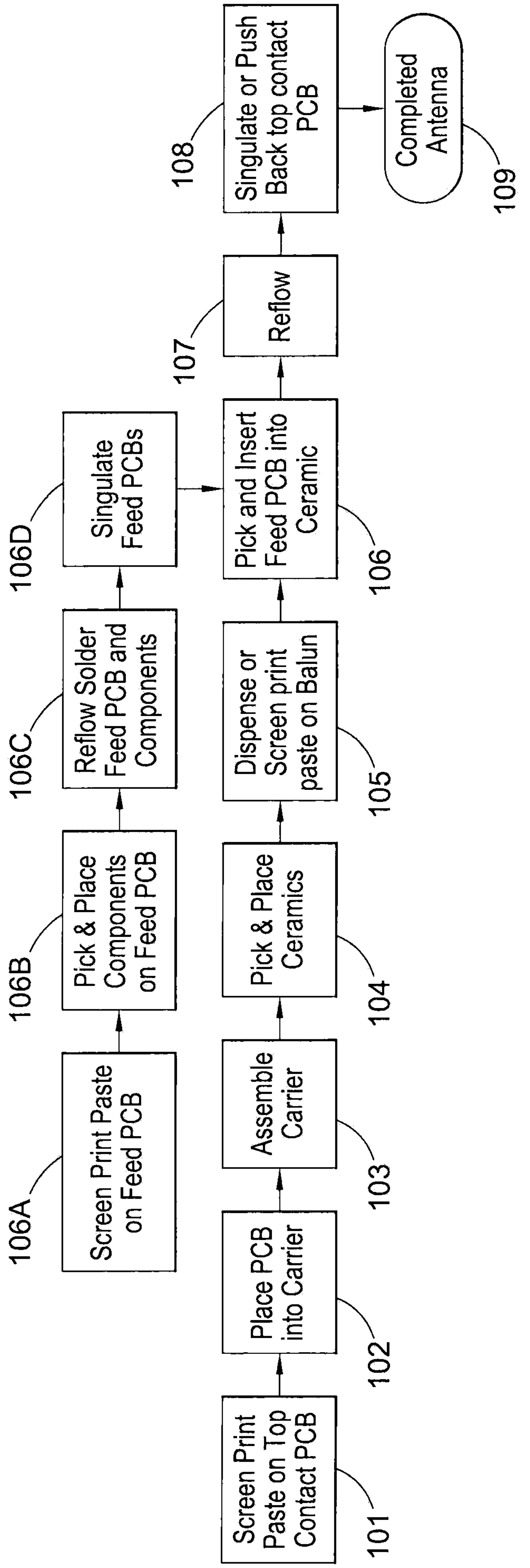
Fig. 2G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Place PCB into Carrier
102
Assemble Carrier
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Pick & Place Ceramics
104
Dispense or Screen print paste on Balun
105
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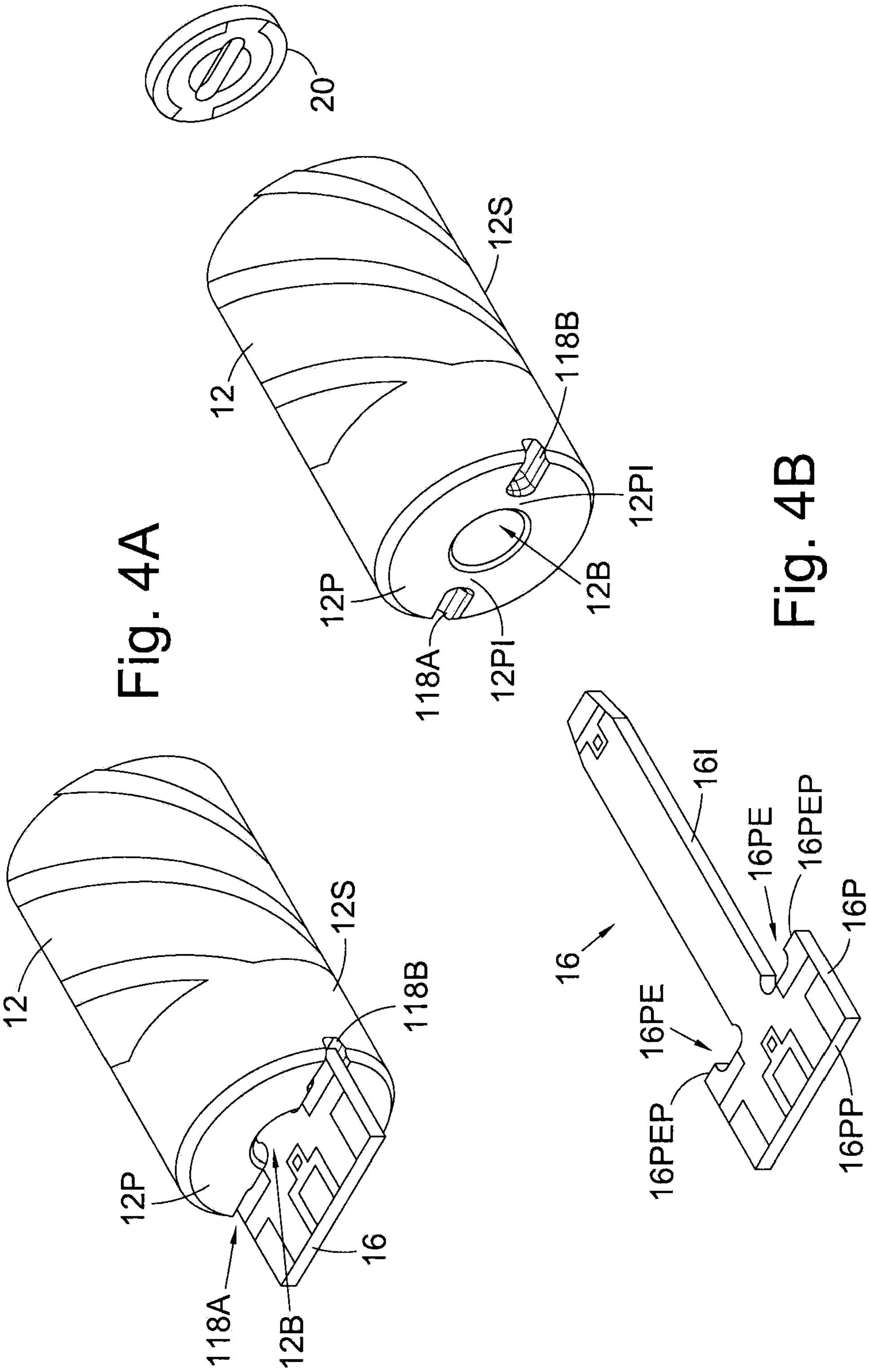
106
Screen Print Paste on Feed PCB
106A
Pick & Place Components on Feed PCB
106B
Reflow Solder Feed PCB and Components
106C
Singulate Feed PCBs
106D
Reflow
107
Singulate or Push Back top contact PCB
108
Completed Antenna
109

Fig. 3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16PP
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118B
12P
16
118A
12B

Fig. 4A

Fig. 4B

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2013/050292

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01Q11/08
ADD.

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

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/221650 A1 (CHRISTIE ANDREW ROBERT [GB] ET AL) 15 September 2011 (2011-09-15) cited in the application abstract sentences 3-27, 49-109; figures 1a, 1b, 17a-17e -----	1-3,6-17
A	WO 2006/136809 A1 (SARANTEL LTD [GB]; LEISTEN OLIVER PAUL [GB]; CHRISTIE ANDREW ROBERT [G) 28 December 2006 (2006-12-28) abstract page 1, line 3 - page 9, line 27 page 11, line 7 - page 24, line 24 -----	1-17

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

☒ See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 June 2013	17/06/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Sidoti, Filippo

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2013/050292

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		WO 2006136809 A1	28-12-2006
		WO 2006136810 A1	28-12-2006