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(54) Multi-band monopole antenna for a mobile communications device

Mehrband-monopolantenne für ein Mobilfunkgerät

Antenne unipolaire multibande pour dispositif de communications mobile

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EP 2 273 611 B1

Description

FIELD OF THE INVENTION

[0001] This invention relates generally to the field of multi-band monopole antennas. More specifically, a multi-band monopole antenna is provided that is particularly well-suited for use in mobile communications devices, such as Personal Digital Assistants, cellular telephones, and pagers.

BACKGROUND OF THE INVENTION

[0002] Multi-band antenna structures for use in a mobile communications device are known in this art. For example, one type of antenna structure that is commonly utilized as an internally-mounted antenna for a mobile communications device is known as an "inverted-F" antenna. When mounted inside a mobile communications device, an antenna is often subject to problematic amounts of electromagnetic interference from other metallic objects within the mobile communications device, particularly from the ground plane. An inverted-F antenna has been shown to perform adequately as an internally mounted antenna, compared to other known antenna structures. Inverted-F antennas, however, are typically bandwidth-limited, and thus may not be well suited for bandwidth intensive applications.

[0003] EP 1 237 224 A1 discloses an antenna and a method for fabricating such antenna for application in a mobile radio.

[0004] US 2002/0000940 A1 discloses an antenna device, a method for manufacturing an antenna device and a radio communication device including an antenna device.

[0005] US 6111545. discloses an external antenna particularly suited for mobile stations.

[0006] US 6307511 B1 discloses a clamshell-type cellular telephone.

SUMMARY

[0007] The invention is defined in claim 1. Some embodiments are defined in the dependent claims.

[0008] A multi-band monopole antenna for a mobile communications device includes a common conductor coupled to both a first radiating arm and a second radiating arm. The common conductor includes a feeding port for coupling the antenna to communications circuitry in a mobile communications device. In one embodiment, the first radiating arm includes a space-filling curve. In another embodiment, the first radiating arm includes a meandering section extending from the common conductor in a first direction and a contiguous extended section extending from the meandering section in a second direction.

[0009] A mobile communications device having a multi-band monopole antenna includes a circuit board, communications circuitry, and the multi-band monopole antenna. The circuit board includes an antenna feeding point and a ground plane. The communications circuitry is coupled to the antenna feeding point of the circuit board. The multi-band monopole antenna includes a common conductor, a first radiating arm and a second radiating arm. The common conductor includes a feeding port that is coupled to the antenna feeding point of the circuit board. The first radiating arm is coupled to the common conductor and includes a space-filling curve. The second radiating arm is coupled to the common conductor. In one embodiment, the circuit board is mounted in a first plane within the mobile communications device and the multi-band monopole antenna is mounted in a second plane within the mobile communications device.

[0010] Some aspects of the invention are the following aspects A1-A34:

A1. A multi-band monopole antenna for a mobile communications device, comprising:

a common conductor having a feeding port for coupling the antenna to circuitry in the mobile communications device;
a first radiating arm coupled to the common conductor, the first radiating arm including a space-filling curve; and
a second radiating arm coupled to the common conductor.

A2. The multi-band monopole antenna of aspect A1, wherein the first radiating arm further
includes an extended section that is contiguous with the space-filling curve.

A3. The multi-band monopole antenna of aspect A2, wherein space-filling curve extends from the common feeding port in a first direction and the extended section extends from the spacefilling curve in a second direction.

A4. The multi-band monopole antenna of aspect A3, wherein the first direction is parallel to the second direction.

A5. A multi-band monopole antenna for a mobile communications device, comprising:

a common conductor having a feeding port for coupling the antenna to circuitry in the mobile communications device;
a first radiating arm coupled to the common conductor and having a meandering section extending from the common conductor in a first direction and a contiguous extended section extending from the meandering section in a second direction; and
a second radiating arm coupled to the common

conductor.

A6. The multi-band monopole antenna of aspect A5, wherein the first direction is parallel to the second direction.

A7. The multi-band monopole antenna of aspect A5, wherein the meandering section of the first radiating arm forms a space-filling curve.

A8. The multi-band monopole antenna of any of aspects A2 to A7, wherein the extended section is linear.

A9. The multi-band monopole antenna of any of aspects A2 to A7, wherein the extended section forms an arc.

A10. The multi and monopole antenna of any of aspects A2 to A7, wherein the extended section includes a polygonal portion.

A11. The multi-band monopole antenna of any of aspects A2 to A7, wherein the extended section includes a portion with an arcuate longitudinal edge.

A12. The multi-band monopole antenna of any of aspects A1 to A11, wherein the second radiating arm includes a linear section adjacent to the first radiating arm.

A13. The multi-band monopole antenna of any of aspects A1 to A12, wherein the total length of the first radiating arm is greater than the total length of the second radiating arm.

A14. The multi-band monopole antenna of aspect A13, wherein the total length of the first radiating arm is selected to tune the first radiating arm to a first frequency band and the total length of the second radiating arm is selected to tune the second radiating arm to a second frequency band.

A15. The multi-band monopole antenna of any of aspects A1 to A14, wherein the antenna is fabricated on a substrate.

A16. The multi-band monopole antenna of aspect A15, wherein the substrate is a flex-film material.

A17. The multi-band monopole antenna of aspect A15, wherein the substrate is a dielectric material.

A18. The multi-band monopole antenna of any of aspects A1 to A17, wherein the mobile communications device is a cellular telephone.

A19. The multi-band monopole antenna of any of aspects A1 or A17, wherein the mobile communications device is a personal digital assistant (PDA).

A20. The multi-band monopole antenna of aspect A18, wherein the mobile communications device is a clamshell-type cellular telephone that includes a hinge, and wherein the antenna is mounted within the mobile communication device adjacent to the hinge of the clamshell-type cellular telephone.

A21. A mobile communications device, comprising:

a circuit board having an antenna feeding point and a ground plane;
communications circuitry coupled to the antenna feeding point of the circuit board; and
a multi-band monopole antenna having a common conductor that includes a feeding port coupled to the antenna feeding point of the circuit board, a first radiating arm coupled to the common conductor and including a space-filling curve, and a second radiating arm coupled to the common conductor.

A22. The mobile communications device of aspect A21, wherein the circuit board is mounted in a first plane within the mobile communications device and the multi-band monopole antenna is mounted in a second plane within the mobile communications device.

A23. The mobile communications device of aspect A21 or A22, wherein the antenna feeding point is located at a position on the circuit board corresponding to a corner of the ground plane.

A24. The mobile communications device of aspect A21 or A22, wherein an edge of the antenna is laterally aligned with an edge of the circuit board.

A25. The mobile communications device of aspect A21 or A22, wherein the antenna is offset laterally from the ground plane.

A26. The mobile communications device of aspect A25, wherein the amount of lateral offset between the antenna and the ground plane is such that a projection of the antenna footprint on the plane of the circuit board does not intersect with the ground plane.

A27. The mobile communications device of aspect A25, wherein the amount of lateral offset between the antenna and the ground plane is such that a projection of the antenna footprint onto the plane of the circuit board intersects with the ground plane by no-more than fifty (50) percent.

A28. The mobile communications device of any of aspects A21 to A27, wherein the first radiating arm further includes an extended section that is contiguous with the space-filling curve.

A29. The mobile communications device of aspect A28, wherein the space-filling curve extends in a first direction from the common feeding port and the contiguous extended section extends in a second direction from the space-filling curve.

A30. The mobile communications device of aspect A29, wherein the first direction is parallel to the second direction.

A31. The mobile communications device of any of aspects A21 to A30, wherein the second radiating arm includes a linear section.

A32. The mobile communications device of any of aspects A21 to A31, wherein the mobile communications device is a cellular telephone.

A33. The mobile communications device of any of aspects A21 to A31, wherein the mobile communications device is a personal digital assistant (PDA).

A34. The mobile communications device of aspect A32, wherein the mobile communications device is a clamshell-type cellular telephone that includes a hinge, and wherein the antenna is mounted within the mobile communication device adjacent to the hinge of the clamshell-type cellular telephone.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a top view of an exemplary multi-band monopole antenna for a mobile communications device;
Fig. 2 is a top view of an exemplary multi-band monopole antenna including one alternative space-filling geometry;
Figs. 3-9 illustrate several alternative multi-band monopole antenna configurations;
Fig. 10 is a top view of the exemplary multi-band monopole antenna of Fig. 1 coupled to a circuit board for a mobile communications device;
Figs. 11 shows an exemplary mounting structure for securing a multi-band monopole antenna within a mobile communications device;
Fig. 12 is an exploded view of an exemplary clamshell-type cellular telephone having a multi-band monopole antenna;
Fig. 13 is an exploded view of an exemplary candybar-style cellular telephone having a multi-band monopole antenna; and
Fig. 14 is an exploded view of an exemplary personal digital assistant (PDA) having a multi-band monopole antenna.

DETAILED DESCRIPTION

[0012] Referring now to the drawing figures, Fig. 1 is a top view of an exemplary multi-band monopole antenna 10 for a mobile communications device. The multi-band monopole antenna 10 includes a first radiating arm 12 and a second radiating arm 14 that are both coupled to a feeding port 17 through a common conductor 16. The antenna 10 also includes a substrate material 18 on which the antenna structure 12, 14, 16 is fabricated, such as a dielectric substrate, a flex-film substrate, or some other type of suitable substrate material. The antenna structure 12, 14, 16 is preferably patterned from a conductive material, such as a metallic thick-film paste that is printed and cured on the substrate material 18, but may alternatively be fabricated using other known fabrication techniques.

[0013] The first radiating arm 12 includes a meandering section 20 and an extended section 22. The meandering section 20 is coupled to and extends away from the common conductor 16. The extended section 22 is contiguous with the meandering section 20 and extends from the end of the meandering section 20 back towards the common conductor 16. In the illustrated embodiment, the meandering section 20 of the first radiating arm 12 is formed into a geometric shape known as a space-filling curve, in order to reduce the overall size of the antenna 10. A space-filling curve is characterized by at least ten segments which are connected in such a way that each segment forms an angle with its adjacent segments, that is, no pair of adjacent segments define a larger straight segment. It should be understood, however, that the meandering section 20 may include other space-filling curves than that shown in Fig. 1, or may optionally be arranged in an alternative meandering geometry. Figs. 2-6, for example, illustrate antenna structures having meandering sections formed from several alternative geometries. The use of shape-filling curves to form antenna structures is described in greater detail in the co-owned PCT Application WO 01/54225, entitled Space-Filling Miniature Antennas.

[0014] The second radiating arm 14 includes three linear portions. As viewed in Fig. 1, the first linear portion extends in a vertical direction away from the common conductor 16. The second linear portion extends horizontally from the end of the first linear portion towards the first radiating arm. The third linear portion extends vertically from the end of the second linear portion in the same direction as the first linear portion and adjacent to the meandering section 20 of the first radiating arm 14.

[0015] As noted above, the common conductor 16 of the antenna 10 couples the feeding port 17 to the first and second radiating arms 12, 14. The common conductor 16 extends horizontally (as viewed in Fig. 1) beyond the second radiating arm 14, and may be folded in a

perpendicular direction (perpendicularly into the page), as shown in Fig. 10, in order to couple the feeding port 17 to communications circuitry in a mobile communications device.

[0016] Operationally, the first and second radiating arms 12, 14 are each tuned to a different frequency band, resulting in a dual-band antenna. The antenna 10 may be tuned to the desired dual-band operating frequencies of a mobile communications device by pre-selecting the total conductor length of each of the radiating arms 12, 14. For example, in the illustrated embodiment, the first radiating arm 12 may be tuned to operate in a lower frequency band or groups of bands, such as PDC (800 MHz), CDMA (800 MHz), GSM (850 MHz), GSM (900 MHz), GPS, or some other desired frequency band. Similarly, the second radiating arm 14 may be tuned to operate in a higher frequency band or group of bands, such as GPS, PDC (1500 MHz), GSM (1800 MHz), Korean PCS, CDMA/PCS (1900 MHz), CDMA2000/UMTS, IEEE 802.11 (2.4 GHz), or some other desired frequency band. It should be understood that, in some embodiments, the lower frequency band of the first radiating arm 12 may overlap the higher frequency band of the second radiating arm 14, resulting in a single broader band. It should also be understood that the multi-band antenna 10 may be expanded to include further frequency bands by adding additional radiating arms. For example, a third radiating arm could be added to the antenna 10 to form a triband antenna.

[0017] Fig. 2 is a top view of an exemplary multi-band monopole antenna 30 including one alternative space-filling geometry. The antenna 30 show in Fig. 2 is similar to the multi-band antenna 10 shown in Fig. 1, except the meandering section 32 in the first radiating arm 12 includes a different space-filling curve than that shown in Fig. 1.

[0018] Figs. 3-9 illustrate several alternative multiband monopole antenna configurations 50, 70, 80, 90, 93, 95, 97. Similar to the antennas 10, 30 shown in Figs. 1 and 2, the multiband monopole antenna 50 illustrated in Fig. 3 includes a common conductor 52 coupled to a first radiating arm 54 and a second radiating arm 56. The common conductor 52 includes a feeding port 62 on a linear portion of the common conductor 52 that extends horizontally (as viewed in Fig. 3) away from the radiating arms 54, 56, and that may be folded in a perpendicular direction (perpendicularly into the page) in order to couple the feeding port 62 to communications circuitry in a mobile communications device.

[0019] The first radiating arm 54 includes a meandering section 58 and an extended section 60. The meandering section 58 is coupled to and extends away from the common conductor 52. The extended section 60 is contiguous with the meandering section 58 and extends from the end of the meandering section 58 in an arcing path back towards the common conductor 52.

[0020] The second radiating arm 56 includes three linear portions. As viewed in Fig. 3, the first linear portion extends diagonally away from the common conductor 52. The second linear portion extends horizontally from the end of the first linear portion towards the first radiating arm. The third linear portion extends vertically from the end of the second linear portion away from the common conductor 52 and adjacent to the meandering section 58 of the first radiating arm 54.

[0021] The multi-band monopole antennas 70, 80, 90 illustrated in Figs. 4-6 are similar to the antenna 50 shown in Fig. 3, except each includes a differently-patterned meandering portion 72, 82, 92 in the first radiating arm 54. For example, the meandering portion 92 of the multiband antenna 90 shown in Fig. 6 meets the definition of a space-filling curve, as described above. The meandering portions 58, 72, 82 illustrated in Figs. 3-5, however, each include differently-shaped periodic curves that do not meet the requirements of a space-filling curve.

[0022] The multi-band monopole antennas 93, 95, 97 illustrated in Figs. 7-9 are similar to the antenna 30 shown in Fig. 2, except in each of Figs. 7-9 the expanded portion 22 of the first radiating arm 12 includes an additional area 94, 96, 98. In Fig. 7, the expanded portion 22 of the first radiating arm 12 includes a polygonal portion 94. In Figs. 8 and 9, the expanded portion 22 of the first radiating arm 12 includes a portion 96, 98 with an arcuate longitudinal edge.

[0023] Fig. 10 is a top view 100 of the exemplary multiband monopole antenna 10 of Fig. 1 coupled to the circuit board 102 of a mobile communications device. The circuit board 102 includes a feeding point 104 and a ground plane 106. The ground plane 106 may, for example, be located on one of the surfaces of the circuit board 102, or may be one layer of a multi-layer printed circuit board. The feeding point 104 may, for example, be a metallic bonding pad that is coupled to circuit traces 105 on one or more layers of the circuit board 102. Also illustrated, is communication circuitry 108 that is coupled to the feeding point 104. The communication circuitry 108 may, for example, be a multi-band transceiver circuit that is coupled to the feeding point 104 through circuit traces 105 on the circuit board.

[0024] In order to reduce electromagnetic interference from the ground plane 106, the antenna 10 is mounted within the mobile communications device such that the projection of the antenna footprint on the plane of the circuit board 102 does not intersect the metalization of the ground plane 106 by more than fifty percent. In the illustrated embodiment 100, the antenna 10 is mounted above the circuit board 102. That is, the circuit board 102 is mounted in a first plane and the antenna 10 is mounted in a second plane within the mobile communications device. In addition, the antenna 10 is laterally offset from an edge of the circuit board 102, such that, in this embodiment 100, the projection of the antenna footprint on the plane of the circuit board 102 does not intersect any of the metalization of the ground plane 106.

[0025] In order to further reduce electromagnetic interference from the ground plane 106, the feeding point 104

is located at a position on the circuit board 102 adjacent to a corner of the ground plane 106. The antenna 10 is preferably coupled to the feeding point 104 by folding a portion of the common conductor 16 perpendicularly towards the plane of the circuit board 102 and coupling the feeding port 17 of the antenna 10 to the feeding point 104 of the circuit board 102. The feeding port 17 of the antenna 10 may, for example, be coupled to the feeding point 104 using a commercially available connector, by bonding the feeding port 17 directly to the feeding point 104, or by some other suitable coupling means. In other embodiments, however, the feeding port 17 of the antenna 10 may be coupled to the feeding point 104 by some means other than folding the common conductor 16.

[0026] Fig. 11 shows an exemplary mounting structure 111 for securing a multi-band monopole antenna 112 within a mobile communications device. The illustrated embodiment 110 employs a multi-band monopole antenna 112 having a meandering section similar to that shown in Fig. 2. It should be understood, however, that alternative multi-band mo nopole antenna configurations, as described in Figs 1-9, could also be used.

[0027] The mounting structure 111 includes a flat surface 113 and at least one protruding section 114. The antenna 112 is secured to the flat surface 113 of the mounting structure 111, preferably using an adhesive material. For example, the antenna 112 may be fabricated on a flex-film substrate having a peel-type adhesive on the surface opposite the antenna structure. Once the antenna 112 is secured to the mounting structure 111, the mounting structure 111 is positioned in a mobile communications device with the protruding section 114 extending over the circuit board. The mounting structure 111 and antenna 112 may then be secured to the circuit board and to the housing of the mobile communications device using one or more apertures 116, 117 within the mounting structure 111.

[0028] Fig. 12 is an exploded view of an embodiment of the invention, a clamshell-type cellular telephone 120 having a multi-band monopole antenna 121. The cellular telephone 120 includes a lower circuit board 122, an upper circuit board 124, and the multi-band antenna 121 secured to a mounting structure 110. Also illustrated are an upper and a lower housing 128, 130 that join to enclose the circuit boards 122, 124 and antenna 121. The illustrated multi-band monopole antenna 121 is similar to the multi-band antenna 30 shown in Fig. 2. It should be understood, however, that alternative antenna configurations, as describe above with reference to Figs. 1-9, could also be used.

[0029] The lower circuit board 122 is similar to the circuit board 102 described above with reference to Fig. 10, and includes a ground plane 106, a feeding point 104, and communications circuitry 108. The multi-band antenna 121 is secured to a mounting structure 110 and coupled to the lower circuit board 122, as described above with reference to Figs. 10 and 11. The lower circuit board 122 is then connected to the upper circuit board 124 with a hinge 126, enabling the upper and lower circuit boards 122, 124 to be folded together in a manner typical for clamshell-type cellular phones. In order to further reduce electromagnetic interference from the upper and lower circuit boards 122, 124, the multiband antenna 121 is preferably mounted on the lower circuit board 122 adjacent to the hinge 126.

[0030] Fig. 13 is an exploded view of an exemplary candy-bar-type cellular telephone 200 having a multi-band monopole antenna 201. The cellular telephone 200 includes the multi-band monopole antenna 201 secured to a mounting structure 110, a circuit board 214, and an upper and lower housing 220, 222. The circuit board 214 is similar to the circuit board 102 described above with reference to Fig. 10, and includes a ground plane 106, a feeding point 104, and communications circuitry 108. The illustrated antenna 201 is similar to the multiband monopole antenna shown in Fig. 3, however alternative antenna configurations, as described above with reference to Figs. 1-9, could also be used.

[0031] The multi-band antenna 201 is secured to the mounting structure 110 and coupled to the circuit board 214 as described above with reference to Figs. 10 and 11. The upper and lower housings 220, 222 are then joined to enclose the antenna 212 and circuit board 214.

[0032] Fig. 14 is an exploded view of an exemplary personal digital assistant (PDA) 230 having a multi-band monopole antenna 231. The PDA 230 includes the multi-band monopole antenna 231 secured to a mounting structure 110, a circuit board 236, and an upper and lower housing 242, 244. Although shaped differently, the PDA circuit board 236 is similar to the circuit board 102 described above with reference to Fig. 10, and includes a ground plane 106, a feeding point 104, and communications circuitry 108. The illustrated antenna 231 is similar to the multi-band monopole antenna shown in Fig. 5, however alternative antenna configurations, as described above with reference to Figs. 1-9, could also be used.

[0033] The multi-band antenna 231 is secured to the mounting structure 110 and coupled to the circuit board 214 as described above with reference to Figs. 10 and 11. In slight contrast to Fig. 10, however, the PDA circuit board 236 defines an L-shaped slot along an edge of the circuit board 236 into which the antenna 231 and mounting structure 110 are secured in order to conserve space within the PDA 230. The upper and lower housings 242, 244 are then joined together to enclose the antenna 231 and circuit board 236.

[0034] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to make and use the invention. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art.

Claims

1. A clamshell-type cellular telephone (120) comprising:

an upper circuit board (124);
a lower circuit board (122) comprising a ground plane (106), a feeding point (104); and communications circuitry (108), the feeding point being (104) coupled to the communications circuitry (108);
a multi-band monopole antenna (121, 30, 10, 50, 70, 80, 90, 93, 95, 97) secured to a mounting structure (111);
a hinge (126) connecting the lower circuit board (122) to the upper circuit board (124) and enabling the upper circuit board (124) and the lower circuit board (122) to be folded together;
an upper housing (128) enclosing the upper circuit board (124); and
a lower housing (130) enclosing the lower circuit board (122) and the multi-band monopole antenna (121),
wherein the multi-band monopole antenna (121, 30, 10, 50, 70, 80, 90, 93, 95, 97) - comprises:
a common conductor (16, 52) having a feeding port (17, 62) for coupling the antenna to the communications circuitry (108);
a first radiating arm (12, 54) coupled to the common conductor and having a meandering section (20, 32, 58, 72, 82, 92) extending from the common conductor in a first direction and a contiguous extended section (22, 60) extending from the meandering section in a second direction; and
a second radiating arm (14, 56) coupled to the common conductor;
wherein the multi-band monopole antenna is mounted on the lower circuit board (122) adjacent to the hinge (126) such that the orthogonal projection of the antenna footprint on the plane of the lower circuit board does not intersect the metallization of the ground plane by more than 50%; and
wherein the feeding point (104) is located at a position on the lower circuit board (122) adjacent to a corner of the ground plane (106).

2. The clamshell-type cellular telephone of claim 1, wherein the first direction is parallel to the second direction.

3. The clamshell-type cellular telephone of claim 1, wherein the meandering section of the first radiating arm is shaped as a space-filling curve.

4. The clamshell-type cellular telephone of any of claims 1 to 3, wherein:
the extended section is linear (22); or
the extended section forms an arc (60); or
the extended section includes a polygonal portion (94); or
the extended section includes a portion with an arcuate longitudinal edge (96, 98).

5. The clamshell-type cellular telephone of any of claims 1 to 4, wherein the second radiating arm (14, 56) includes three linear portions, and wherein one of said three linear portions is adjacent to the first radiating arm.

6. The clamshell-type cellular telephone of any of claims 1 to 5, wherein the total length of the first radiating arm (12, 54) is greater than the total length of the second radiating arm (14, 56).

7. The clamshell-type cellular telephone of claim 6, wherein the total length of the first radiating arm is selected to tune the first radiating arm to a first frequency band and the total length of the second radiating arm is selected to tune the second radiating arm to a second frequency band.

8. The clamshell-type cellular telephone of any of claims 1 to 7, wherein the antenna. (121) is fabricated on a substrate (18), and wherein the substrate preferably is a flex-film material or a dielectric material.

9. The clamshell-type cellular telephone of any of claims 1 to 8, wherein the lower circuit board (122) is mounted on a first plane within the clamshell-type cellular telephone and the multi-band monopole antenna is mounted on a second plane within the clamshell-type cellular telephone.

10. The clamshell-type cellular telephone of any of claims 1 to 9, wherein an edge of the antenna is laterally aligned with an edge of the lower circuit board.

11. The clamshell-type cellular telephone of any of claims 1 to 9, wherein the antenna is offset laterally from the ground plane; and wherein
the amount of lateral offset between the antenna and the ground plane is such that an orthogonal projection of the antenna footprint on the plane of the lower circuit board does not intersect with the ground plane.

12. The clamshell-type cellular telephone of any of claims 1 to 11, wherein the multi-band monopole antenna operates in a lower frequency band and in a higher frequency band.

13. The clamshell-type cellular telephone of claim 12, wherein the lower frequency band is GSM (900

MHz).

14. The clamshell-type cellular telephone of claim 12 or 13, wherein the higher frequency band is GSM (1800 MHz).

15. The clamshell-type cellular telephone of claim 12, wherein the lower frequency band is CDMA (800 MHz) and the higher frequency band CDMA/PCS (1900 MHz).

16. The clamshell-type cellular telephone of any of claims 12 to 15, wherein the multi-band monopole antenna includes a third radiating arm and operates in three frequency bands.

17. The clamshell-type cellular telephone of any of claims 1 to 15, wherein the mounting structure (111) includes a flat surface (113) and at least one protruding section (114), and wherein the mounting structure (111) is positioned in the clamshell-type cellular telephone (120) with the protruding section (114) extending over the lower circuit board (122).

Patentansprüche

1. Klappbares Mobiltelefon (120), mit:

einer oberen Schaltungsplatte (124);
einer unteren Schaltungsplatte (122) mit einer Grundebene (106), einem Zuführpunkt (104) und einer Kommunikationsschaltung (108), wobei der Zuführpunkt (104) mit der Kommunikationsschaltung (108) verbunden ist;
einer Mehrband-Monopolantenne (121,30,10, 50,70,80,90,93,95,97), die an einer Anbringungsstruktur (111) befestigt ist;
einem Scharnier (126), das die untere Schaltungsplatte (122) mit der oberen Schaltungsplatte (124) verbindet und ein Zusammenklappen der oberen Schaltungsplatte (124) und der unteren Schaltungsplatte (122) ermöglicht;
einem oberen Gehäuse (128), das die obere Schaltungsplatte (124) umschließt; und
einem unteren Gehäuse (130), das die untere Schaltungsplatte (122) und die Mehrband-Monopolantenne (121) umschließt,
wobei die Mehrband-Monopolantenne (121,30, 10,50,70,80,90,93,95, 97) aufweist:
einen gemeinsamen Leiter (16,52) mit einem Zuführport (17,62) zum Verbinden der Antenne mit der Kommunikationsschaltung (108);
einen ersten Strahlungsarm (12,54), der mit dem gemeinsamen Leiter verbunden ist und einen mäandernden Abschnitt (20,32,58,72, 82,92), der von dem gemeinsamen Leiter in einer ersten Erstreckung absteht, und einen angrenzenden verlängerten Abschnitt (22,60) aufweist, der von dem mäandernden Abschnitt in einer zweiten Erstreckung absteht; und
einen zweiten Strahlungsarm (14,56), der mit dem gemeinsamen Leiter verbunden ist;
wobei die Mehrband-Monopolantenne an der unteren Schaltungsplatte (122) nahe dem Scharnier (126) derart befestigt ist, dass die orthogonale Projektion des Antennen-Fußabdrucks auf die Ebene der unteren Schaltungsplatte die Metallisierung der Grundebene um nicht mehr als 50% schneidet; und
wobei der Zuführpunkt (104) an einer nahe einer Ecke der Grundebene (106) gelegenen Position an der unteren Schaltungsplatte (122) angeordnet ist.

2. Klappbares Mobiltelefon nach Anspruch 1, bei dem die erste Erstreckung parallel zu der zweiten Erstrekkung verläuft.

3. Klappbares Mobiltelefon nach Anspruch 1, bei dem der mäandernde Abschnitt des ersten Strahlungsarms als raumfüllende Kurve geformt ist.

4. Klappbares Mobiltelefon nach einem der vorhergehenden Ansprüche, bei dem:

der verlängerte Abschnitt linear ist (22); oder
der verlängerte Abschnitt einen Bogen (60) bildet; oder
der verlängerte Abschnitt einen polygonalen Teil (94) aufweist; oder
der verlängerte Abschnitt einen Teil mit einem bogenförmigen Längsrand (96,98) aufweist.

5. Klappbares Mobiltelefon nach einem der Ansprüche 1 bis 4, bei dem der zweite Strahlungsarm (14,56) drei lineare Abschnitte aufweist, und bei dem einer der drei linearen Abschnitte dem zweiten Strahlungsarm benachbart ist.

6. Klappbares Mobiltelefon nach einem der Ansprüche 1 bis 5, bei dem die Gesamtlänge des ersten Strahlungsarms (12,54) größer als die Gesamtlänge des zweiten Strahlungsarms (14,56) ist.

7. Klappbares Mobiltelefon nach Anspruch 6, bei dem die Gesamtlänge des ersten Strahlungsarms derart gewählt ist, dass der erste Strahlungsarm auf ein erstes Frequenzband getunt ist, und die Gesamtlänge des zweiten Strahlungsarms derart gewählt ist, dass der zweite Strahlungsarm auf ein zweites Frequenzband getunt ist.

8. Klappbares Mobiltelefon nach einem der Ansprüche 1 bis 7, bei dem die Antenne (121) auf einem Substrat (18) ausgebildet ist, und bei dem das Substrat

vorzugsweise ein Flexfilm-Material oder ein dielektrisches Material ist.

9. Klappbares Mobiltelefon nach einem der Ansprüche 1 bis 8, bei dem die untere Schaltungsplatte (122) auf einer ersten Ebene innerhalb des klappbaren Mobiltelefons angeordnet ist und die Mehrband-Monopolantenne auf einer zweiten ersten Ebene innerhalb des klappbaren Mobiltelefons angeordnet ist.

10. Klappbares Mobiltelefon nach einem der Ansprüche 1 bis 9, bei dem ein Rand der Antenne seitlich mit dem Rand der unteren Schaltungsplatte ausgerichtet ist.

11. Klappbares Mobiltelefon nach einem der Ansprüche 1 bis 9, bei dem die Antenne seitlich von der Grundebene versetzt ist; und bei dem
der Betrag der seitlichen Versetzung zwischen der Antenne und der Grundebene derart bemessen ist, dass eine orthogonale Projektion des Antennen-Fußabdrucks auf die Ebene der unteren Schaltungsplatte die Grundebene um nicht schneidet.

12. Klappbares Mobiltelefon nach einem der Ansprüche 1 bis 11, bei dem die Mehrband-Monopolantenne in einem niedrigeren Frequenzband und in einem höheren Frequenzband arbeitet.

13. Klappbares Mobiltelefon nach Anspruch 12, bei dem das niedrigere Frequenzband GSM (900 MHz) ist.

14. Klappbares Mobiltelefon nach Anspruch 12 oder 13, bei dem das höhere Frequenzband GSM (1800 MHz) ist.

15. Klappbares Mobiltelefon nach Anspruch 12, bei dem das niedrigere Frequenzband CDMA (800 MHz) ist und das höhere Frequenzband CDMA/PCS (1900 MHz) ist.

16. Klappbares Mobiltelefon nach einem der Ansprüche 12 bis 15, bei dem die Mehrband-Monopolantenne einen dritten Strahlungsarm aufweist und in drei Frequenzbändern arbeitet.

17. Klappbares Mobiltelefon nach einem der Ansprüche 1 bis 15, bei dem die Anbringungsstruktur (111) eine flache Fläche (113) und mindestens einen vorstehenden Abschnitt (114) aufweist, und bei dem die Anbringungsstruktur (111) in dem klappbaren Mobiltelefon (120) derart angeordnet ist, dass der vorstehende Abschnitt (114) über die untere Schaltungsplatte (122) hinausragt.

Revendications

1. Téléphone cellulaire de type rabattable (120) comprenant:

une carte de circuit supérieure (124);
une carte de circuit inférieure (122) comprenant un plan de masse (106), un point d'alimentation (104) et des circuits de communication (108), le point d'alimentation (104) étant couplé aux circuits de communication (108);
une antenne unipolaire multi-bandes (121, 30, 10, 50, 70, 80, 90, 93, 95, 97) fixée sur une structure de montage (111);
une articulation (126) reliant la carte de circuit inférieure (122) à la carte de circuit supérieure (124) et permettant que la carte de circuit supérieure (124) et la carte de circuit inférieure (122) soient pliées ensemble;
un boîtier supérieur (128) renfermant la carte de circuit supérieure (124); et
un boîtier inférieur (130) renfermant la carte de circuit inférieure (122) et l'antenne unipolaire à bandes multiples (121),
où l'antenne unipolaire à bandes multiples (121, 30, 10, 50, 70, 80, 90, 93, 95, 97) comprend:
un conducteur commun (16, 52) ayant un port d'alimentation (17, 62) pour le couplage de l'antenne aux circuits de communication (108);
un premier bras rayonnant (12, 54) couplé au conducteur commun et ayant une section en méandre (20, 32, 58, 72, 82, 92) s'étendant du conducteur commun dans une première direction et une section contiguë étendue (22, 60) s'étendant de la section en méandre dans une seconde direction; et
un deuxième bras de rayonnement (14, 56) couplé au conducteur commun;
où l'antenne unipolaire à bandes multiples est montée sur la carte de circuit inférieure (122) d'une manière adjacente à l'articulation (126) de sorte que la projection orthogonale de l'empreinte de l'antenne sur le plan de la carte de circuit inférieure ne se croise pas avec la métallisation du plan de masse selon plus que 50%; et
où le point d'alimentation (104) se situe à une position sur la carte de circuit inférieure (122) adjacente à un coin du plan de masse (106).

2. Téléphone cellulaire de type rabattable selon la revendication 1, dans lequel la première direction est parallèle à la seconde direction.

3. Téléphone cellulaire de type rabattable selon la revendication 1, dans lequel la section en méandre du premier bras de rayonnement est configurée comme une courbe de remplissage d'espace.

4. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 1 à 3, dans lequel:

la section étendue est linéaire (22); ou
la section étendue forme un arc (60); ou
la section étendue comprend une portion polygonale (94); ou
la section étendue comprend une portion avec un bord longitudinal arqué (96, 98).

5. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 1 à 4, dans lequel le deuxième bras de rayonnement (14, 56) comprend trois portions linéaires, et où une desdites trois portions linéaires est adjacente au premier bras de rayonnement.

6. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 1 à 5, dans lequel la longueur totale du premier bras de rayonnement (12, 54) est plus grande que la longueur totale du deuxième bras de rayonnement (14, 56).

7. Téléphone cellulaire de type rabattable selon la revendication 6, dans lequel la longueur totale du premier bras de rayonnement est sélectionnée pour accorder le premier bras de rayonnement à une première bande de fréquences, et la longueur totale du second bras de rayonnement est sélectionnée pour accorder le deuxième bras de rayonnement à une seconde bande de fréquences.

8. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 1 à 7, dans lequel l'antenne (121) est fabriquée sur un substrat (18), et où le substrat est de préférence un matériau de film flexible ou un matériau diélectrique.

9. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 1 à 8, dans lequel la carte de circuit inférieure (122) est montée sur un premier plan dans le téléphone cellulaire de type rabattable, et l'antenne unipolaire à bandes multiples est montée sur un second plan dans le téléphone cellulaire de type rabattable.

10. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 1 à 9, dans lequel un bord de l'antenne est aligné latéralement avec un bord de la carte de circuit inférieure.

11. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 1 à 9, dans lequel l'antenne est décalée latéralement du plan de masse; et où
la quantité de décalage latéral entre l'antenne et le plan de masse est telle qu'une projection orthogonale de l'empreinte de l'antenne sur le plan de la carte de circuit inférieure ne se croise pas avec le plan de masse.

12. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 1 à 11, dans lequel l'antenne unipolaire à bandes multiples fonctionne dans une bande de fréquences plus basses et dans une bande de fréquences plus élevées.

13. Téléphone cellulaire de type rabattable selon la revendication 12, dans lequel la bande de fréquences inférieures est GSM (900 MHz).

14. Téléphone cellulaire de type rabattable selon la revendication 12 ou 13, dans lequel la bande de fréquences plus élevées est GSM (1800 MHz).

15. Téléphone cellulaire de type rabattable selon la revendication 12, dans lequel la bande de fréquences plus basses est CDMA (800 MHz), et la bande de fréquences plus élevées CDMA/PCS (1900 MHz).

16. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 12 à 15, dans lequel l'antenne unipolaire à bandes multiples comprend un troisième bras de rayonnement et fonctionne dans trois bandes de fréquences.

17. Téléphone cellulaire de type rabattable selon l'une quelconque des revendications 1 à 15, dans lequel la structure de montage (111) comprend une surface plate (113) et au moins une section saillante (114), et où la structure de montage (111) est positionnée dans le téléphone cellulaire de type rabattable (120) avec la section saillante (114) s'étendant sur la carte de circuit inférieure (122).

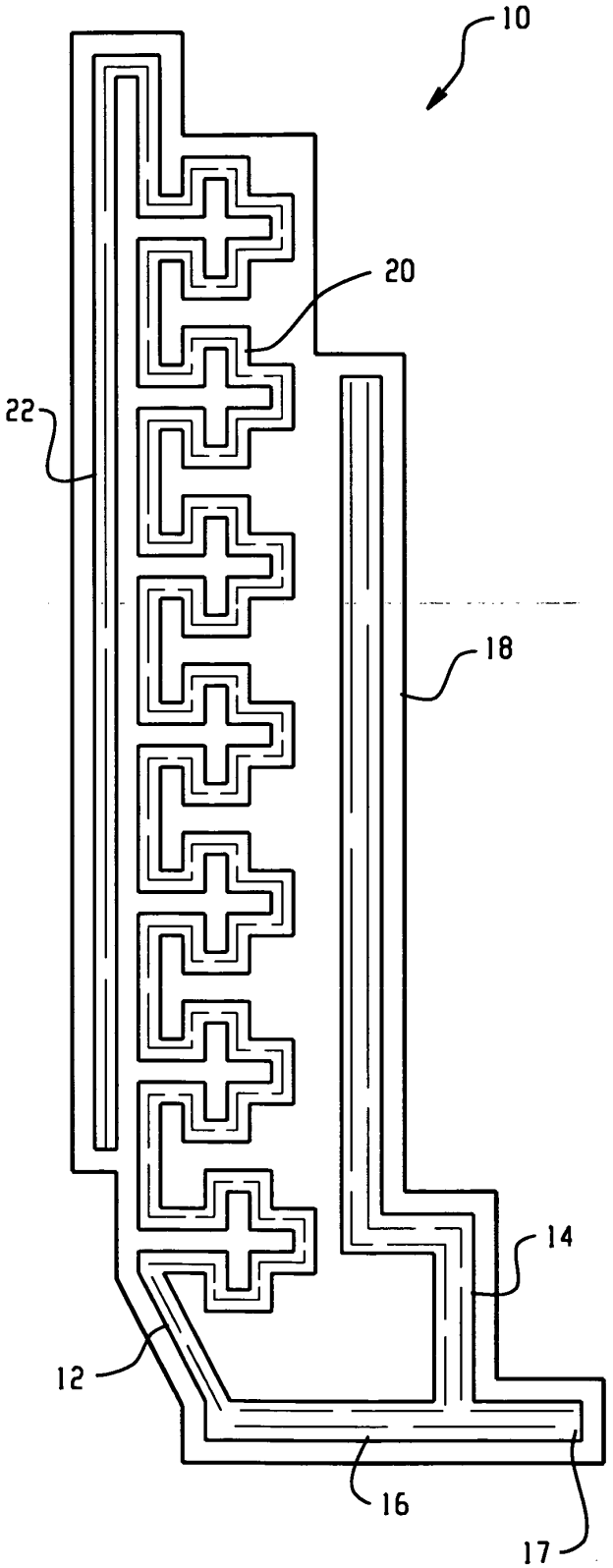


Fig. 1

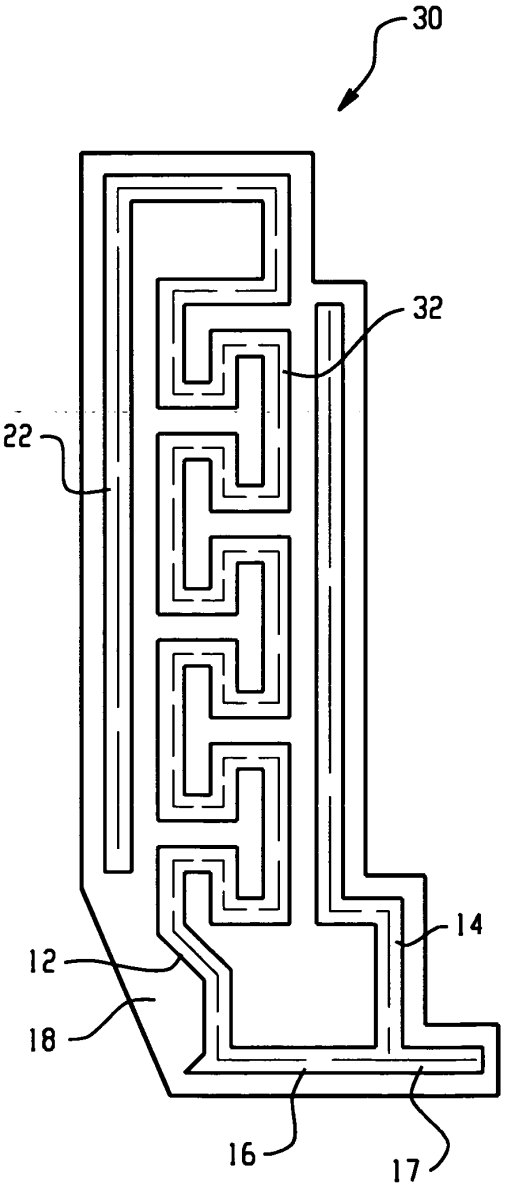


Fig. 2

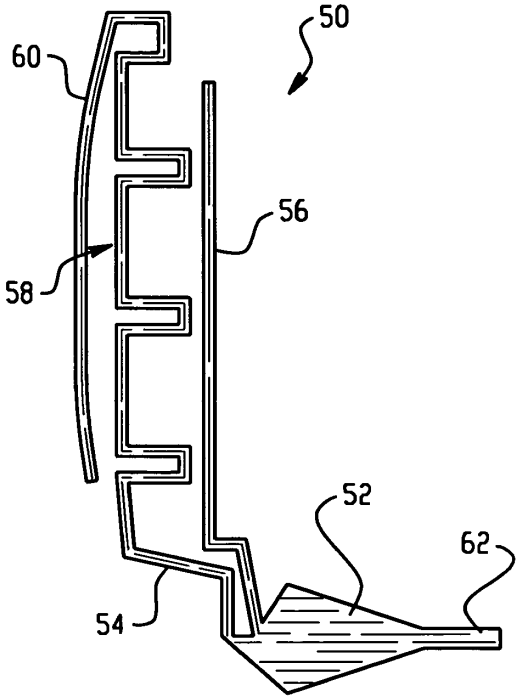


Fig. 3

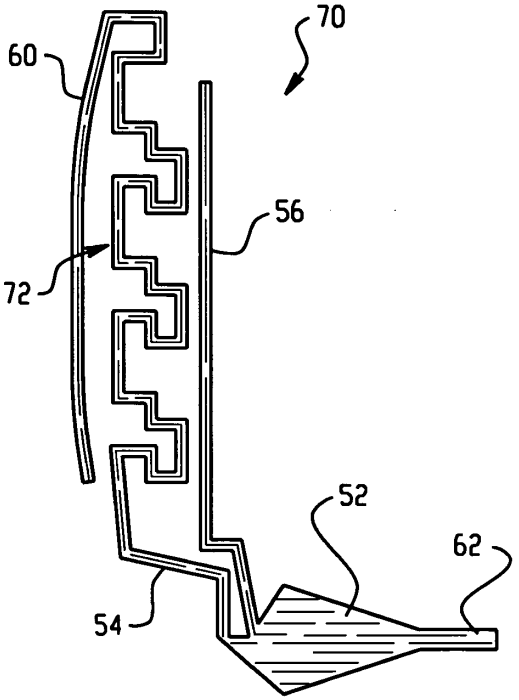


Fig. 4

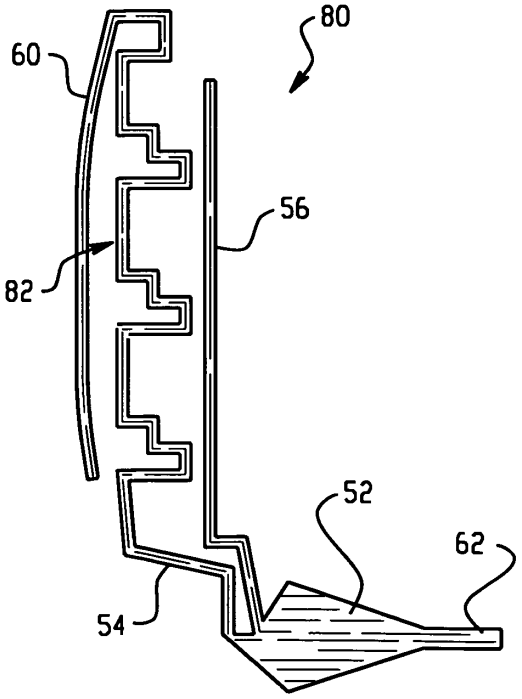


Fig. 5

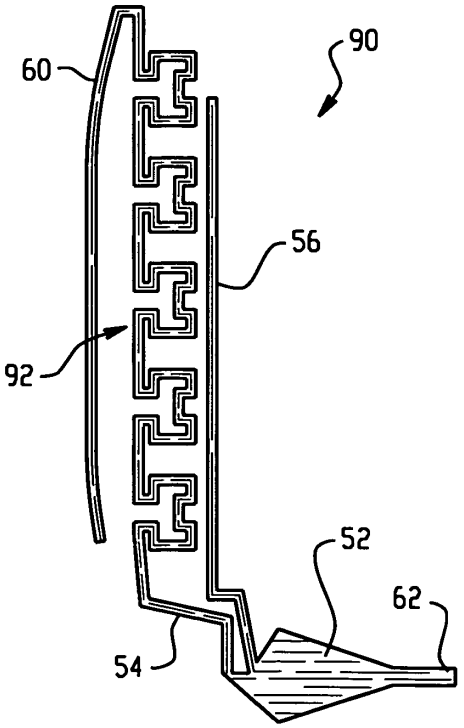


Fig. 6

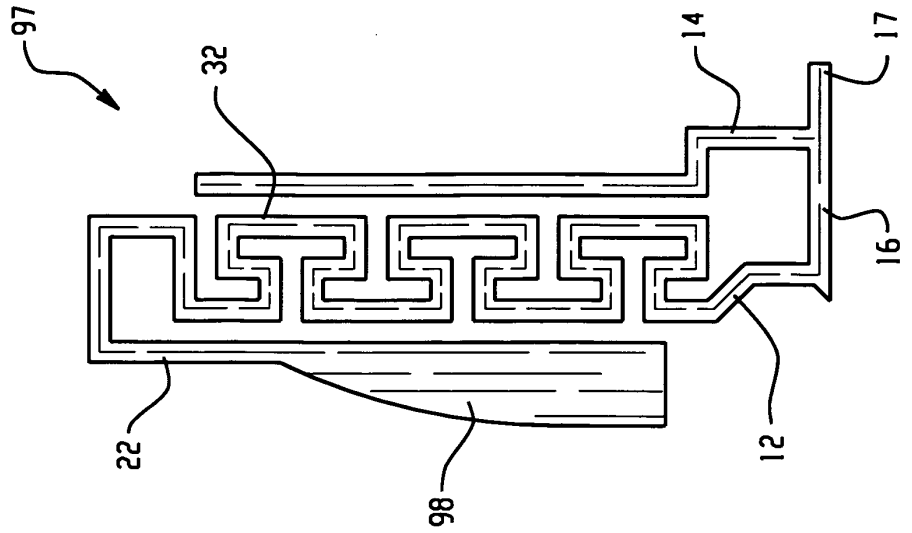


Fig. 9

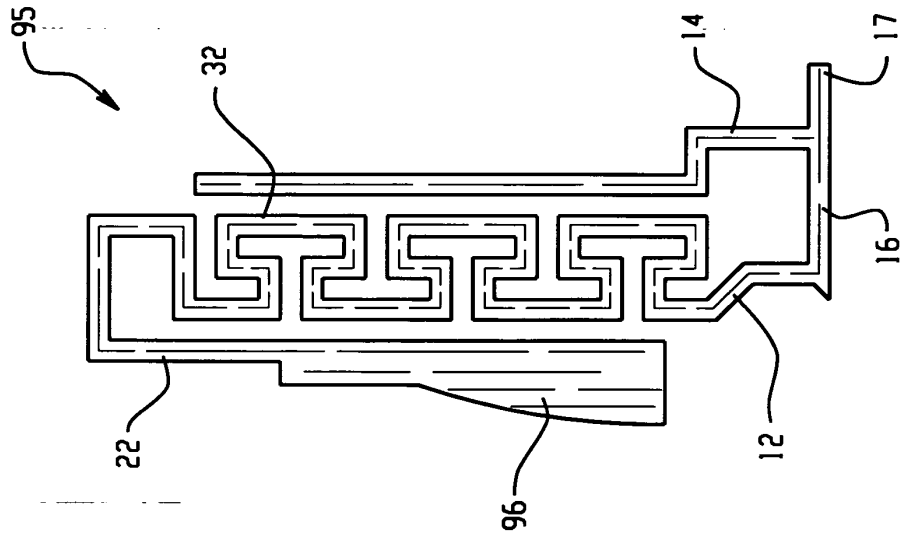


Fig. 8

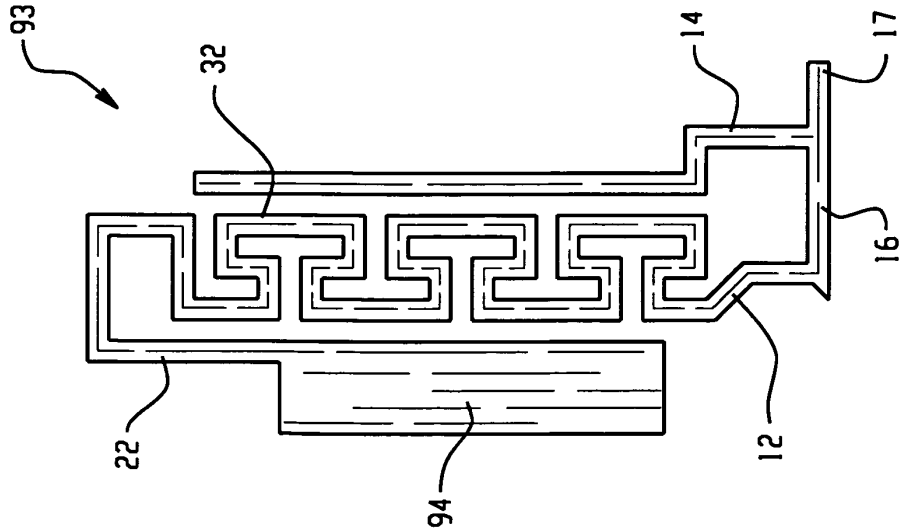


Fig. 7

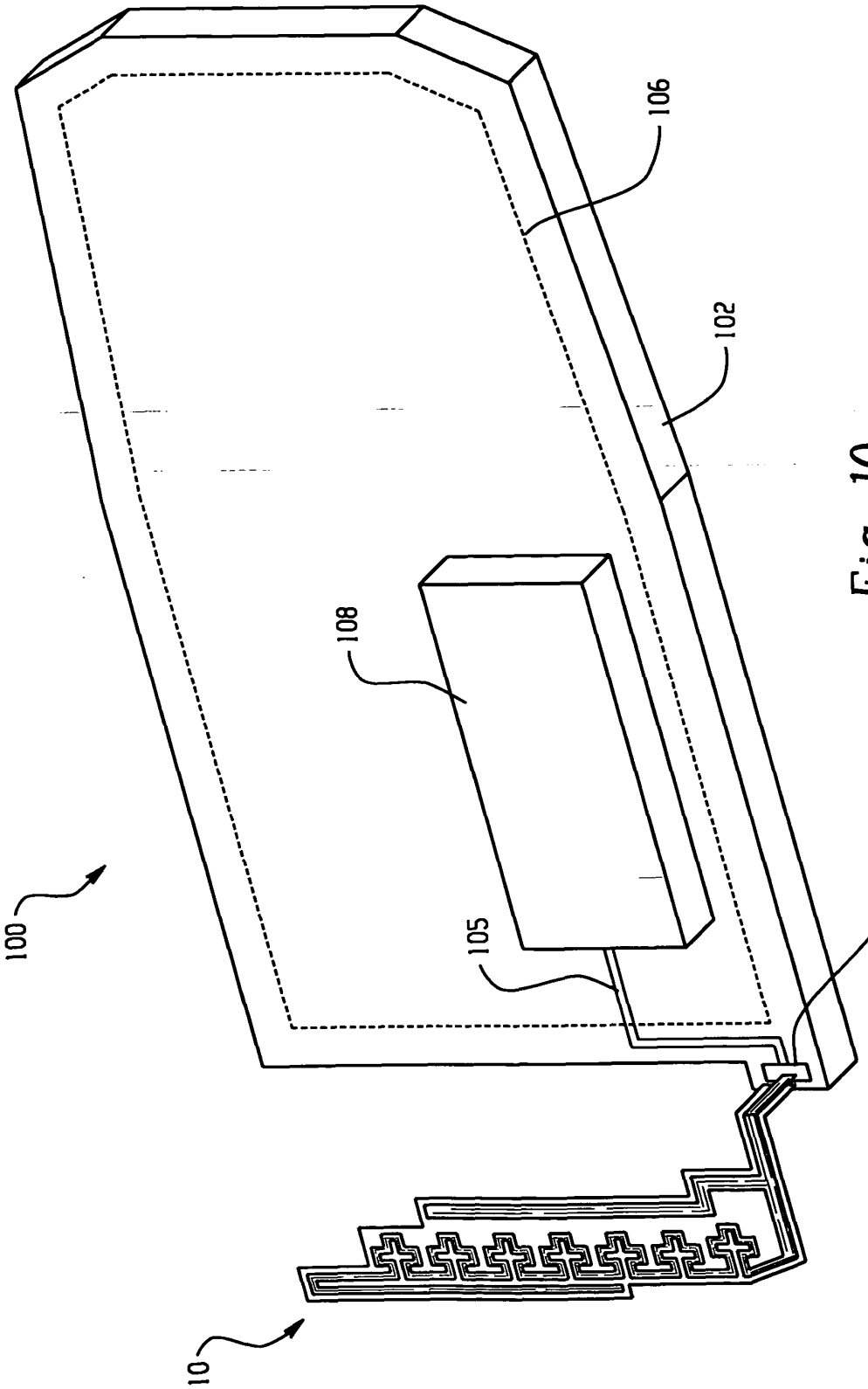
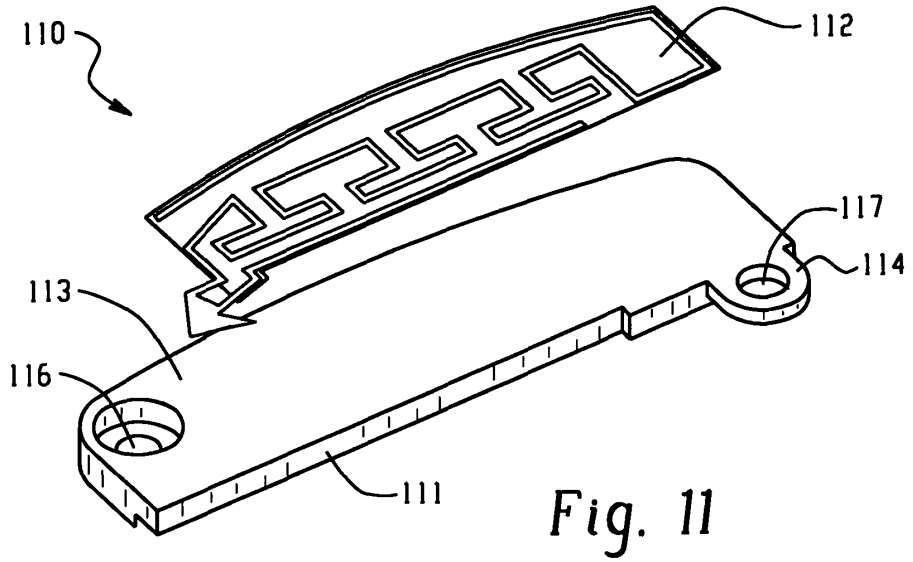


Fig. 10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113
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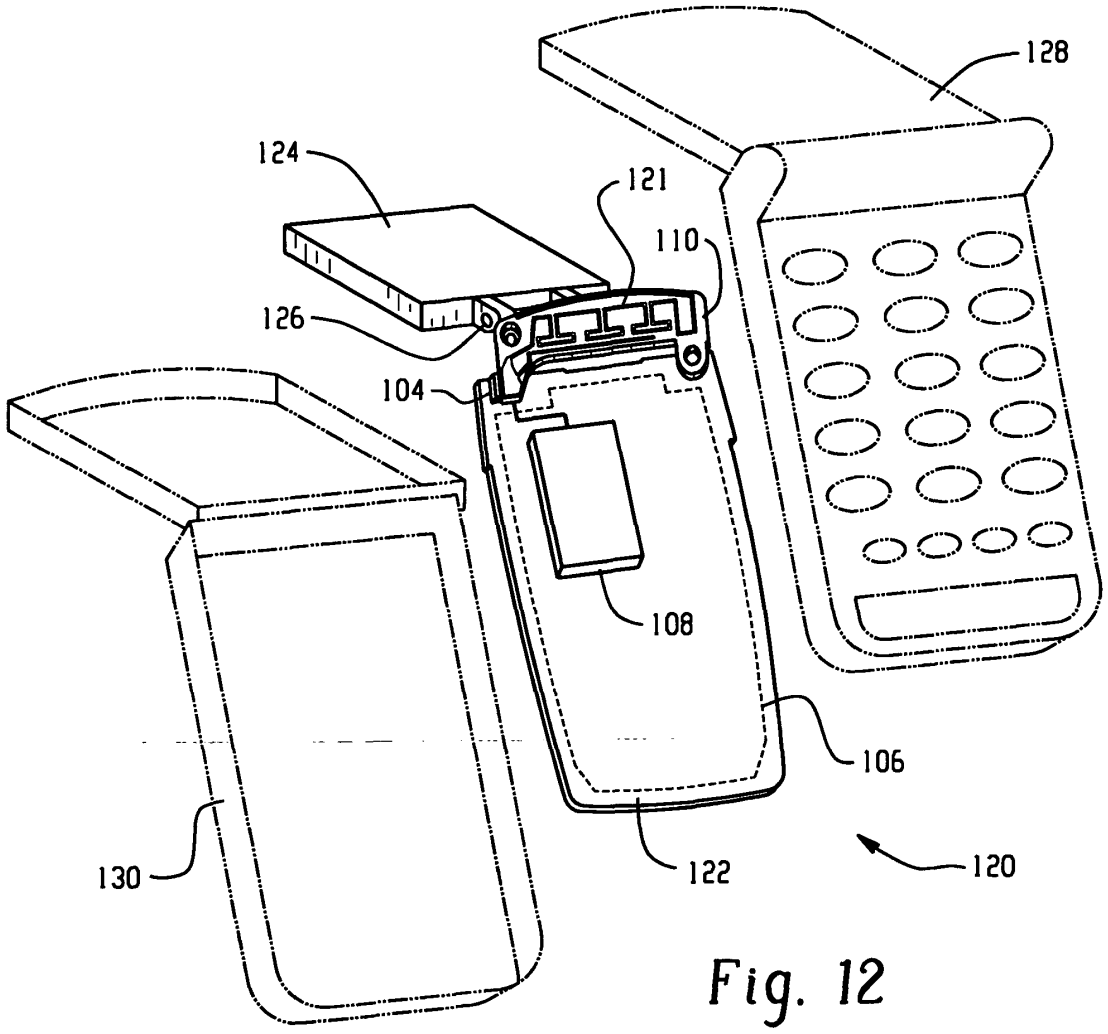
111

Fig. 11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122
120

Fig. 12

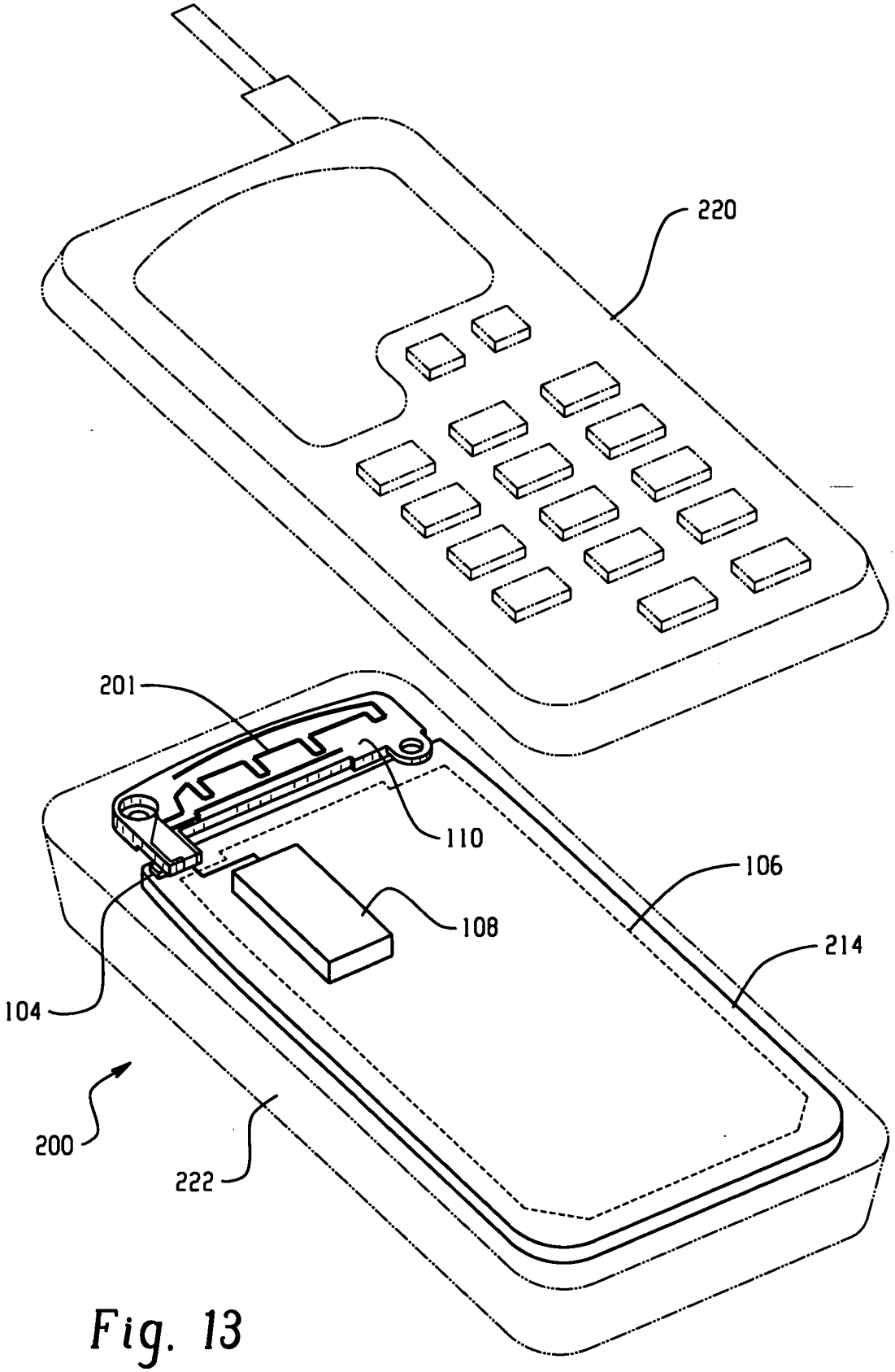

Fig. 13

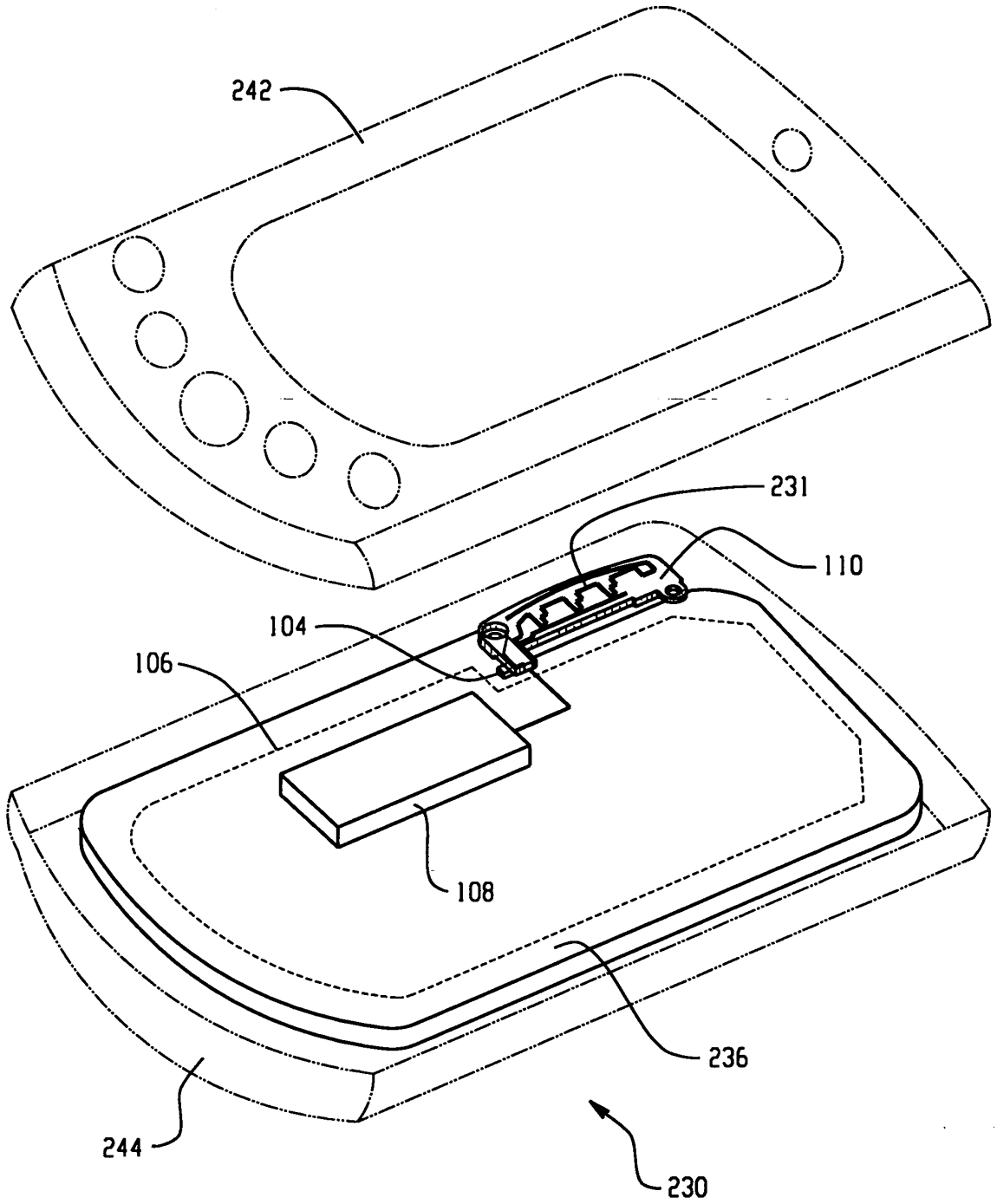

Fig. 14

REFERENCES CITED IN THE DESCRIPTION

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