



US009774071B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.:** **US 9,774,071 B2**
(45) **Date of Patent:** **Sep. 26, 2017**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventors: **Yi-Chieh Lee**, New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 225 days.

(21) Appl. No.: **14/024,842**

(22) Filed: **Sep. 12, 2013**

(65) **Prior Publication Data**

US 2014/0320349 A1 Oct. 30, 2014

(30) **Foreign Application Priority Data**

Apr. 30, 2013 (TW) 102115373 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/392 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/371**
(2015.01); **H01Q 5/392** (2015.01); **H01Q 9/42**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/00; H01Q 1/243
USPC 343/700
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

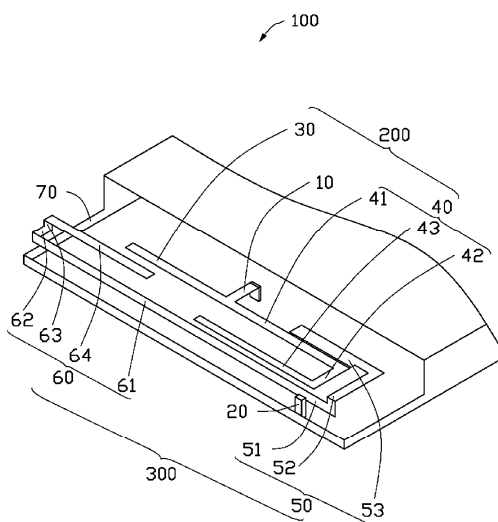
Assistant Examiner — Walter Davis

(74) *Attorney, Agent, or Firm* — Steven Reiss

(57) **ABSTRACT**

An antenna structure includes a feed portion, a ground portion, a primary antenna, a secondary antenna, and a metal portion connected to the ground portion. The primary antenna includes first and second radiating portions. The first radiating portion and the second radiating portion are both connected to the feed portion and are positioned at opposite sides of the feed portion. The secondary antenna includes third and fourth radiating portions. The third radiating portion and the fourth radiating portion are connected to the ground portion and positioned at two sides of the ground portion.

13 Claims, 3 Drawing Sheets





US009774072B2

(12) **United States Patent**
Chung et al.

(10) **Patent No.:** **US 9,774,072 B2**

(45) **Date of Patent:** **Sep. 26, 2017**

(54) **HOUSING, HANDHELD DEVICE, AND
MANUFACTURING METHOD OF HOUSING**

(71) Applicant: **HTC Corporation**, Taoyuan County
(TW)

(72) Inventors: **Cheng-Han Chung**, Taoyuan County
(TW); **Chih-Kuang Wang**, Taoyuan
County (TW); **Yen-Liang Kuo**,
Taoyuan County (TW)

(73) Assignee: **HTC Corporation**, Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 287 days.

(21) Appl. No.: **14/154,199**

(22) Filed: **Jan. 14, 2014**

(65) **Prior Publication Data**

US 2014/0191910 A1 Jul. 10, 2014

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/768,736,
filed on Apr. 28, 2010, now Pat. No. 8,665,159.

(30) **Foreign Application Priority Data**

Oct. 9, 2009 (TW) 98134312 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/40 (2006.01)
H01Q 1/44 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/40**
(2013.01); **H01Q 1/44** (2013.01); **Y10T**
29/49016 (2015.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/40; H01Q 1/44
(Continued)

(56) **References Cited**

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343/700 MS
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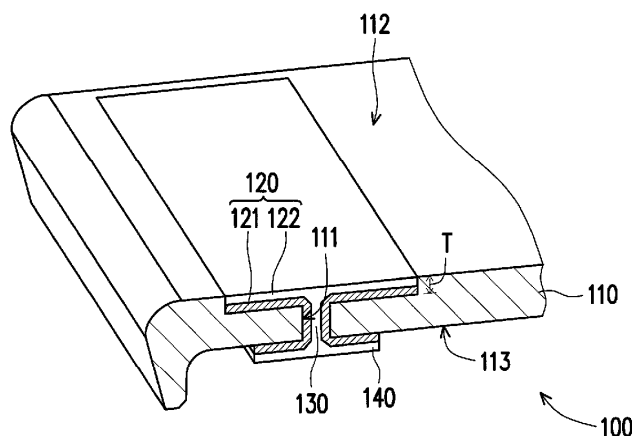
Primary Examiner — Khai M Nguyen

(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**

A housing, a handheld device and a manufacturing method of a housing are provided. The housing includes a body, a metal antenna layer, and a conductive element. The body includes a through hole and an outer surface and an inner surface opposite to the outer surface. The metal antenna layer is disposed on the outer surface and covers the through hole, wherein an edge of the metal antenna layer is connected to the outer surface seamlessly, and a surface of the metal antenna layer is at least partially exposed by the body. The conductive element is disposed in the through hole and directly contacts the metal antenna layer to transmit signals received by the metal antenna layer.

18 Claims, 6 Drawing Sheets





US009774073B2

(12) **United States Patent**
Tsai et al.

(10) **Patent No.:** **US 9,774,073 B2**

(45) **Date of Patent:** **Sep. 26, 2017**

(54) **MOBILE DEVICE AND MULTI-BAND ANTENNA STRUCTURE THEREIN**

USPC 343/700 MS, 702, 767
See application file for complete search history.

(71) Applicant: **HTC Corporation**, Taoyuan, Taoyuan County (TW)

(56) **References Cited**

(72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);
Chien-Pin Chiu, Taoyuan (TW);
Hsiao-Wei Wu, Taoyuan (TW);
Ying-Chih Wang, Taoyuan (TW)

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343/700 MS

(73) Assignee: **HTC CORPORATION**, Taoyuan (TW)

(Continued)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 228 days.

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(21) Appl. No.: **14/157,126**

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(22) Filed: **Jan. 16, 2014**

(Continued)

(65) **Prior Publication Data**

US 2015/0200448 A1 Jul. 16, 2015

Primary Examiner — Tho G Phan

Assistant Examiner — Patrick Holecsek

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 13/10 (2006.01)
H01Q 5/371 (2015.01)
H05K 1/16 (2006.01)

(57) **ABSTRACT**

A mobile device includes a ground plane, a grounding branch, a connection element, a first radiation branch, and a second radiation branch. The grounding branch is coupled to the ground plane. A first open slot is formed and substantially surrounded by the grounding branch and the ground plane. The first radiation branch is coupled through the connection element to the grounding branch. A second open slot is formed and is substantially surrounded by the first radiation branch and the grounding branch. The second radiation branch is disposed in the second open slot and is coupled to the grounding branch. A multi-band antenna structure is formed by the grounding branch, the connection element, the first radiation branch, and the second radiation branch.

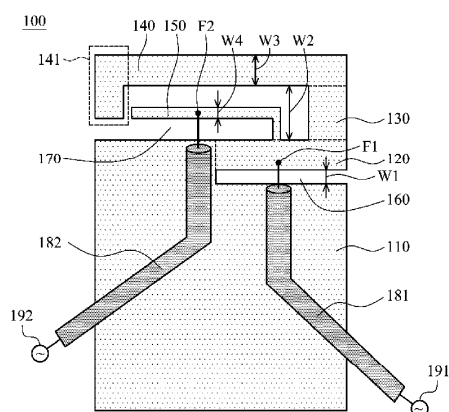
(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01); **H05K 1/165** (2013.01); **H05K 2201/10098** (2013.01); **Y10T 29/49018** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 13/106; H01Q 5/30; H01Q 5/307; H01Q 5/342; H01Q 5/35; H01Q 5/378; H01Q 1/2258-1/243; H01Q 5/50; H01Q 9/30; H01Q 9/42; H01Q 13/10; H01Q 21/29; H01Q 21/30; H01Q 1/44; H01Q 19/22; H01Q 19/26

22 Claims, 10 Drawing Sheets





US009774074B2

(12) **United States Patent**
Tsai et al.

(10) **Patent No.:** **US 9,774,074 B2**

(45) **Date of Patent:** **Sep. 26, 2017**

(54) **MOBILE DEVICE AND MANUFACTURING METHOD THEREOF**

USPC 343/702, 752, 846, 876, 750
See application file for complete search history.

(71) Applicant: **HTC Corporation**, Taoyuan, Taoyuan County (TW)

(56) **References Cited**

(72) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);
Chien-Pin Chiu, Taoyuan (TW);
Li-Yuan Fang, Taoyuan (TW);
Hsiao-Wei Wu, Taoyuan (TW)

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343/700 MS

(73) Assignee: **HTC CORPORATION**, Taoyuan (TW)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 317 days.

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(21) Appl. No.: **14/487,958**

(22) Filed: **Sep. 16, 2014**

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(65) **Prior Publication Data**

US 2016/0079656 A1 Mar. 17, 2016

The ARRL Antenna Book, Gerald (Jerry) Hall, 1988.*

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 9/42 (2006.01)

H01Q 5/335 (2015.01)

H01Q 5/321 (2015.01)

H01Q 5/328 (2015.01)

(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 5/335**
(2015.01); **H01Q 9/42** (2013.01); **H01Q 1/241**
(2013.01); **H01Q 1/242** (2013.01); **H01Q**
1/244 (2013.01); **H01Q 5/321** (2015.01);
H01Q 5/328 (2015.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/24; H01Q 3/44; H01Q 5/00; H01Q
5/314; H01Q 5/335; H01Q 5/50; H01Q
9/42; H01Q 5/328; H01Q 5/321; H01Q
1/241–1/244; H01Q 9/0421; H01Q 9/14;
H01Q 9/0442

Primary Examiner — Hoang Nguyen

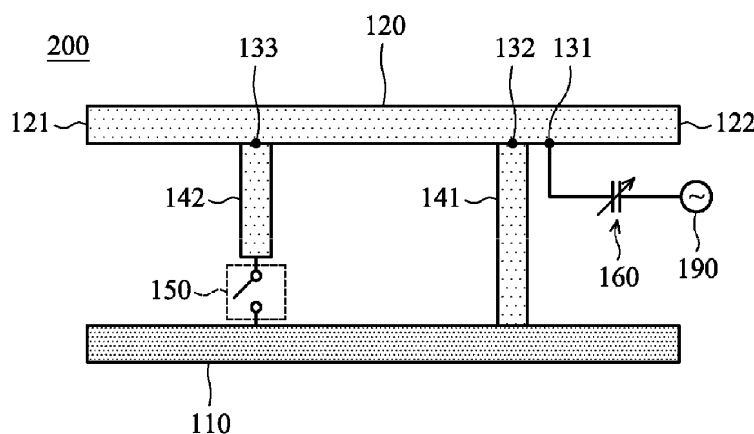
Assistant Examiner — Awat Salih

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch
& Birch, LLP

(57) **ABSTRACT**

A mobile device includes a ground element, a radiation element, a first short-circuited element, a second short-circuited element, and a switch element. The radiation element has a feeding point, a fixed grounding point, and a switchable grounding point. The fixed grounding point is coupled through the first short-circuited element to the ground element. The switchable grounding point is coupled through the second short-circuited element and the switch element to the ground element. An antenna structure is formed by the radiation element, the first short-circuited element, the second short-circuited element, and the switch element.

18 Claims, 6 Drawing Sheets





US009774075B2

(12) **United States Patent**
Nishizaka et al.

(10) **Patent No.:** **US 9,774,075 B2**

(45) **Date of Patent:** **Sep. 26, 2017**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **KYOCERA CORPORATION**,
Kyoto-shi, Kyoto (JP)

(72) Inventors: **Naoki Nishizaka**, Sagamihara (JP);
Daisuke Togashi, Yokohama (JP);
Motonori Imamura, Yokohama (JP)

(73) Assignee: **KYOCERA CORPORATION**, Kyoto
(JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/761,615**

(22) PCT Filed: **Dec. 25, 2013**

(86) PCT No.: **PCT/JP2013/084627**

§ 371 (c)(1),

(2) Date: **Jul. 16, 2015**

(87) PCT Pub. No.: **WO2014/115473**

PCT Pub. Date: **Jul. 31, 2014**

(65) **Prior Publication Data**

US 2015/0349407 A1 Dec. 3, 2015

(30) **Foreign Application Priority Data**

Jan. 22, 2013 (JP) 2013-009302

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/371**
(2015.01); **H01Q 9/42** (2013.01); **H01Q 13/10**
(2013.01); **H05K 5/0247** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 1/2266;
H01Q 5/328; H01Q 13/106; H01Q
1/2291; H01Q 1/42

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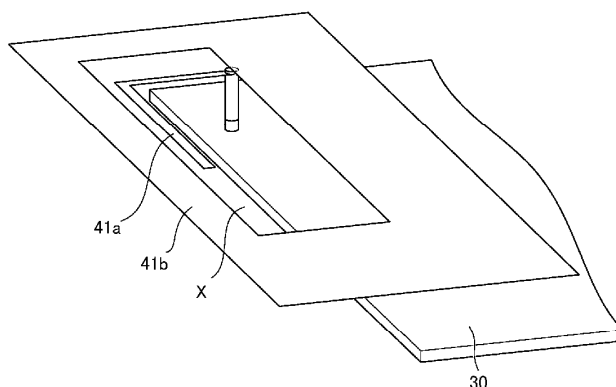
Primary Examiner — Linh Nguyen

(74) *Attorney, Agent, or Firm* — Hauptman Ham, LLP

(57) **ABSTRACT**

Provided is an electronic device in which, if an antenna
element is formed on the surface of a housing, restrictions on
the formation of the antenna element are less likely to arise.
The following are provided: a rear case, an antenna element,
and a power supply unit that supplies power to the antenna
element. The antenna unit comprises a first section that is
formed by applying a conductive material onto a first main
surface of the rear case, and a second section. A dielectric or
an insulator is interposed between the first section and the
second section.

9 Claims, 18 Drawing Sheets





US009774083B2

(12) **United States Patent**
Liu et al.

(10) **Patent No.:** **US 9,774,083 B2**

(45) **Date of Patent:** **Sep. 26, 2017**

(54) **SWITCHABLE PI SHAPE ANTENNA**

(56) **References Cited**

(71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)

U.S. PATENT DOCUMENTS

(72) Inventors: **Hongwei Liu**, San Diego, CA (US);
Ning Ma, San Diego, CA (US)

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(73) Assignee: **FUTUREWEI TECHNOLOGIES, INC.**, Plano, TX (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Sep. 1, 2015**

(65) **Prior Publication Data**

US 2015/0372384 A1 Dec. 24, 2015

Primary Examiner — David Q Nguyen

(74) *Attorney, Agent, or Firm* — Futurewei Technologies, Inc.

Related U.S. Application Data

(63) Continuation of application No. 14/274,474, filed on May 9, 2014, now Pat. No. 9,184,494.

(51) **Int. Cl.**
H04W 72/00 (2009.01)
H01Q 5/335 (2015.01)
(Continued)

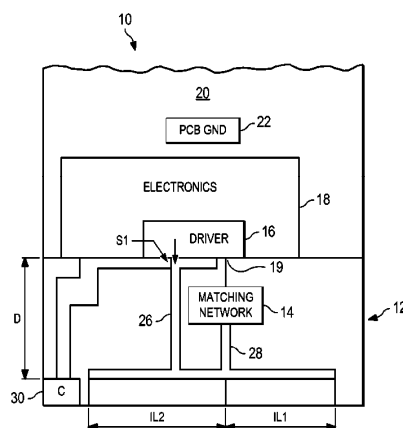
(52) **U.S. Cl.**
CPC **H01Q 5/335** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/50** (2013.01);
(Continued)

(58) **Field of Classification Search**
USPC 455/450; 343/845, 702, 906
See application file for complete search history.

(57) **ABSTRACT**

A mobile device including a housing having a distal end, and electronics disposed in the housing configured to operate the mobile device. A connector is coupled to the electronics, and a Pi-shaped antenna has a coupling coupled to the connector to create a resonance using the connector. The Pi-shaped antenna and the connector are configured to wirelessly send and receive the wireless signals. An impedance matching network matches the impedance of the electronics to the Pi-shaped antenna. In some embodiments, the impedance matching network is switchable by the electronics and is configured to match an impedance of the electronics to the Pi-shaped antenna in at least two states, over multiple RF bands.

29 Claims, 7 Drawing Sheets





US009780436B2

(12) **United States Patent**
Lai et al.

(10) **Patent No.:** **US 9,780,436 B2**
(45) **Date of Patent:** **Oct. 3, 2017**

(54) **TRANSFORMABLE MOBILE DEVICE**

(71) Applicant: **Quanta Computer Inc.**, Taoyuan (TW)

(72) Inventors: **Chun-Nan Lai**, Taoyuan (TW); **Chun-I Lin**, Taoyuan (TW); **Hui Lin**, Taoyuan (TW)

(73) Assignee: **QUANTA COMPUTER INC.**,
Guishan Dist., Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 67 days.

(21) Appl. No.: **14/838,765**

(22) Filed: **Aug. 28, 2015**

(65) **Prior Publication Data**

US 2017/0012342 A1 Jan. 12, 2017

(30) **Foreign Application Priority Data**

Jul. 9, 2015 (TW) 104122257 A

(51) **Int. Cl.**
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H01Q 1/22 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/2266** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 9/0421; H01Q 1/42
USPC 343/702, 700 MS, 872, 878
See application file for complete search history.

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Primary Examiner — Dameon E Levi

Assistant Examiner — Collin Dawkins

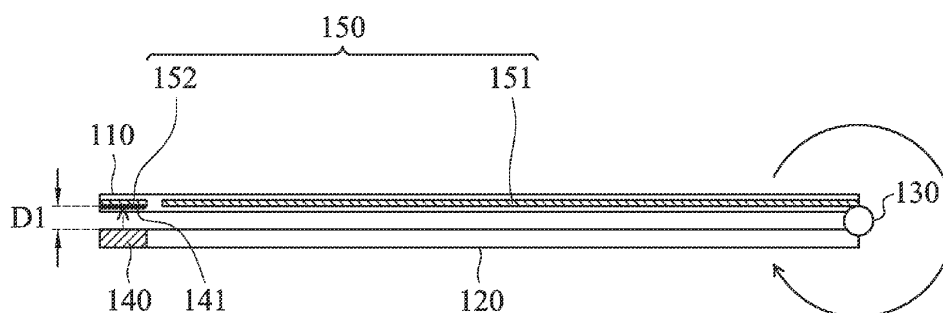
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A transformable mobile device operating in a notebook mode or a tablet mode is provided. The transformable mobile device includes a base, an upper cover, a hinge, a main antenna, and a ground metal plane. The hinge is connected between the base and the upper cover. The main antenna is disposed in the upper cover. The ground metal plane is disposed in the base, or on an outer surface of the base. The ground metal plane includes a main portion and a float portion. The float portion is completely separate from the main portion.

9 Claims, 8 Drawing Sheets

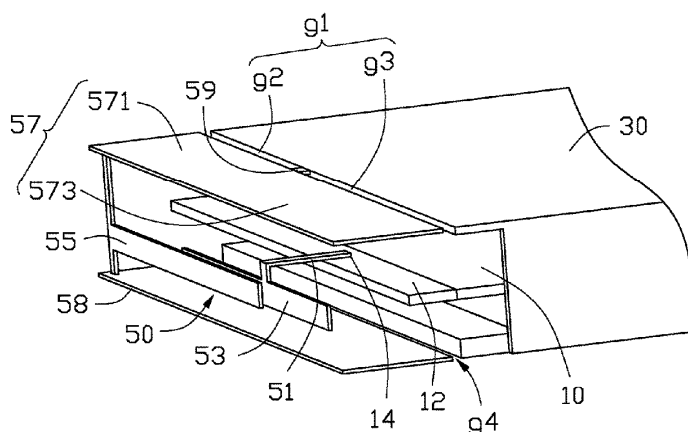
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(12) **United States Patent**
Liou et al.

- (54) **ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE USING THE SAME**
- (71) Applicant: **Chiun Mai Communication Systems, Inc.,** New Taipei (TW)
- (72) Inventors: **Geng-Hong Liou,** New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)
- (73) Assignee: **Chiun Mai Communication Systems, Inc.,** New Taipei (TW)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 154 days.
- (21) Appl. No.: **14/510,530**
- (22) Filed: **Oct. 9, 2014**
- (65) **Prior Publication Data**
US 2015/0155617 A1 Jun. 4, 2015
- (30) **Foreign Application Priority Data**
Nov. 30, 2013 (CN) 2013 1 0622125
- (51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/335 (2015.01)
H01Q 5/371 (2015.01)





US009780441B2

(12) **United States Patent**
Komaki et al.

(10) **Patent No.:** **US 9,780,441 B2**
(45) **Date of Patent:** **Oct. 3, 2017**

(54) **ANTENNA AND WIRELESS
COMMUNICATION DEVICE**

(75) Inventors: **Kunihiro Komaki**, Kyoto-fu (JP);
Masayuki Atokawa, Kyoto-fu (JP);
Masahiro Izawa, Kyoto-fu (JP); **Yuji**
Kaminishi, Kyoto-fu (JP); **Tsuyoshi**
Mukai, Kyoto-fu (JP)

(73) Assignee: **Murata Manufacturing Co., Ltd.**,
Kyoto-fu (JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 663 days.

(21) Appl. No.: **13/584,601**

(22) Filed: **Aug. 13, 2012**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No.
PCT/JP2010/068887, filed on Oct. 26, 2010.

(30) **Foreign Application Priority Data**

Feb. 16, 2010 (JP) 2010-031249

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/42 (2006.01)

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(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/2283**
(2013.01); **H01Q 5/371** (2015.01); **H01Q**
5/378 (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 5/371; H01Q 1/2283;
H01Q 9/42

See application file for complete search history.

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Primary Examiner — Robert Karacsony

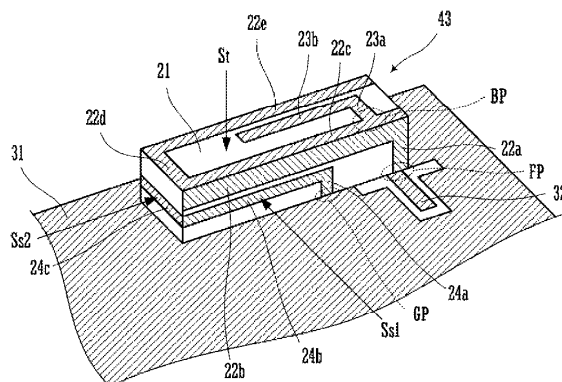
Assistant Examiner — Amal Patel

(74) *Attorney, Agent, or Firm* — Studebaker & Brackett
PC

(57) **ABSTRACT**

This disclosure provides an antenna and a wireless commu-
nication device that includes the antenna in which a high-
order mode can be controlled while maintaining good radia-
tion characteristics in both the fundamental mode and high-
order mode. The antenna has a radiation electrode provided
on a surface of a dielectric substrate and a branch electrode
portion that branches from the radiation electrode portion at
a branch point near the feeding port toward a vicinity of a
position of the radiation electrode at which a maximum
voltage of a high-order mode is generated.

14 Claims, 3 Drawing Sheets





US009780445B2

(12) **United States Patent**
Hwang et al.

(10) **Patent No.:** **US 9,780,445 B2**

(45) **Date of Patent:** **Oct. 3, 2017**

(54) **ANTENNA ASSEMBLY WITH HIGH ISOLATION**

(71) Applicant: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(72) Inventors: **Tzu-Yao Hwang**, New Taipei (TW);
Lung-Sheng Tai, New Taipei (TW)

(73) Assignee: **HON HAI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(h) by 475 days.

(21) Appl. No.: **14/477,892**

(22) Filed: **Sep. 5, 2014**

(65) **Prior Publication Data**

US 2015/0070237 A1 Mar. 12, 2015

(30) **Foreign Application Priority Data**

Sep. 9, 2013 (TW) 102132333

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/526** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/065** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/48; H01Q 1/243; H01Q 1/526
USPC 343/841
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

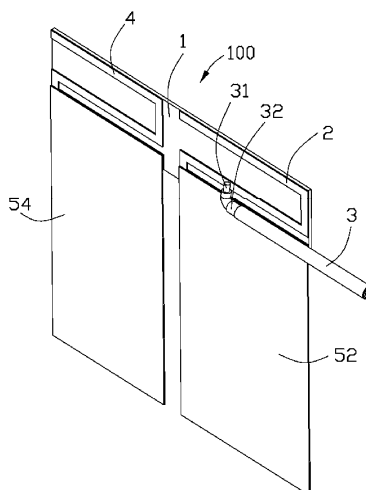
Assistant Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — Wei Te Chung; Ming Chieh Chang

(57) **ABSTRACT**

An antenna assembly includes a main body, a coaxial cable connecting the main body and an isolating member located beside the main body. The main body includes a grounding portion extending in a longitudinal direction, a radiating portion extending in the longitudinal direction and a connecting portion connecting the grounding portion and the radiating portion. The coaxial cable includes an inner conductor connecting the connecting portion and an outer conductor surrounding the inner conductor and connecting the grounding portion. The isolating member located beside the main body in a side by side manner and defined a gap therebetween.

19 Claims, 6 Drawing Sheets





US009780452B2

(12) **United States Patent**
Tanaka et al.

(10) **Patent No.:** **US 9,780,452 B2**

(45) **Date of Patent:** **Oct. 3, 2017**

(54) **COMMUNICATION TERMINAL**

(56) **References Cited**

(71) Applicant: **SONY CORPORATION**, Tokyo (JP)

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(72) Inventors: **Masato Tanaka**, Chiba (JP); **Shinichi Kuroda**, Tokyo (JP); **Takanori Nakazawa**, Tokyo (JP)

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343/700 MS
2013/0201067 A1 8/2013 Hu et al.
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(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications Inc.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 49 days.

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(21) Appl. No.: **14/589,480**

EP 2 498 336 A2 9/2012
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JP 2008-219840 9/2008

(22) Filed: **Jan. 5, 2015**

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(65) **Prior Publication Data**

US 2016/0197407 A1 Jul. 7, 2016

Extended European Search Report issued Jun. 1, 2016 in Patent Application No. 15157717.8.

Primary Examiner — Dameon E Levi

Assistant Examiner — David Lotter

(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/14 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/328 (2015.01)

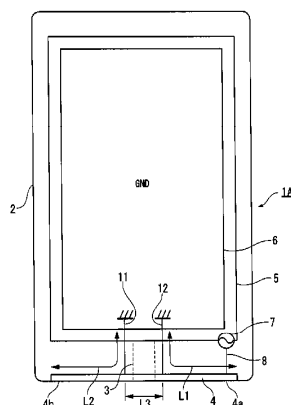
(57) **ABSTRACT**

Embodiments include a communication device, having a wireless communication processor. The communication device includes an antenna connected to a feeding point of the wireless communication processor. The communication device also includes a metal component disposed proximal the antenna and a circuit board including a ground plane. The communication device further includes a first conductive line and a second conductive line which connect the ground plane to two locations on the antenna, on one end and the other end of a location proximal the metal component.

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 9/145** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/0407
USPC 343/700 MS
See application file for complete search history.

23 Claims, 13 Drawing Sheets





US009780455B2

(12) **United States Patent**
Miyake

(10) **Patent No.:** **US 9,780,455 B2**

(45) **Date of Patent:** **Oct. 3, 2017**

(54) **ANTENNA DEVICE AND COMMUNICATION EQUIPMENT**

(71) Applicant: **Funai Electric Co., Ltd.**, Daito-shi, Osaka (JP)

(72) Inventor: **Yasunari Miyake**, Daito (JP)

(73) Assignee: **Funai Electric Co., Ltd.**, Daito-shi (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 282 days.

(21) Appl. No.: **14/370,667**

(22) PCT Filed: **Dec. 10, 2012**

(86) PCT No.: **PCT/JP2012/081920**

§ 371 (c)(1),

(2) Date: **Jul. 3, 2014**

(87) PCT Pub. No.: **WO2013/103067**

PCT Pub. Date: **Jul. 11, 2013**

(65) **Prior Publication Data**

US 2014/0375508 A1 Dec. 25, 2014

(30) **Foreign Application Priority Data**

Jan. 5, 2012 (JP) 2012-000525

(51) **Int. Cl.**
H01Q 5/00 (2015.01)
H01Q 9/42 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 9/045** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/378** (2015.01);

(Continued)

(58) **Field of Classification Search**

CPC .. H01Q 5/20; H01Q 5/25; H01Q 5/30; H01Q 5/378; H01Q 5/392; H01Q 5/50;

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Primary Examiner — Tho G Phan

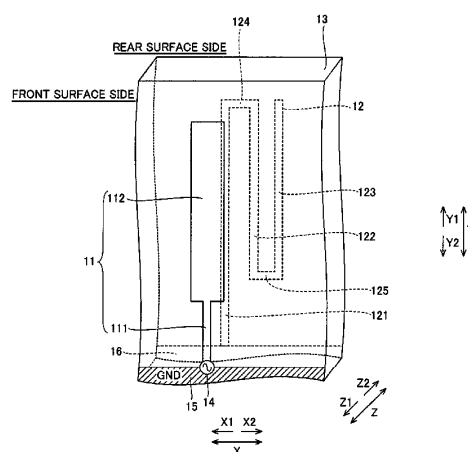
Assistant Examiner — Patrick Holecek

(74) *Attorney, Agent, or Firm* — Crowell & Moring LLP

(57) **ABSTRACT**

An antenna device (10) includes a feed element (11) including a first portion (111) and a second portion (112) and a non-feed element (12) including a plurality of folded back portions (121 to 125). The width (W2) of the second portion of the feed element is rendered larger than the width (W3) of the non-feed element, and at least the second portion of the feed element is configured to be coupled to the plurality of folded back portions of the non-feed element.

15 Claims, 11 Drawing Sheets





US009780862B2

(12) **United States Patent**
Liou et al.

(10) **Patent No.:** **US 9,780,862 B2**
(45) **Date of Patent:** **Oct. 3, 2017**

(54) **ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE USING THE SAME**

H01Q 19/005; H01Q 9/0421; H01Q 9/0442; H01L 2924/0002; H03G 1/0023; H03F 3/45179; H03F 1/56; H01F 2021/125

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

See application file for complete search history.

(72) Inventors: **Geng-Hong Liou**, New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)

(56) **References Cited**

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(73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

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343/700 MS
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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 205 days.

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(21) Appl. No.: **14/642,091**

(22) Filed: **Mar. 9, 2015**

Primary Examiner — Ping Hsieh

Assistant Examiner — James Yang

(65) **Prior Publication Data**

US 2016/0112113 A1 Apr. 21, 2016

(74) *Attorney, Agent, or Firm* — Steven Reiss

(30) **Foreign Application Priority Data**

Oct. 21, 2014 (CN) 2014 1 0560732

(57) **ABSTRACT**

An antenna structure includes a feed end, a ground end, a main radiator, a coupling portion, a matching circuit, a switching circuit, and a diplexer. The main radiator is coupled to the feed end. The coupling portion is coupled to the ground end and is spaced apart from the main radiator to allow current to flow from the main radiator to the coupling portion. The switching circuit is coupled to the ground end. The diplexer includes a first port, a second port, and a third port, the first port is coupled to the feed end, the second port is coupled to a transceiver via the matching circuit, and the third port is coupled to the transceiver. The diplexer separates high frequency current from low frequency current output from the feed end, the matching circuit and the switching circuit adjust the high frequency current and the low frequency current.

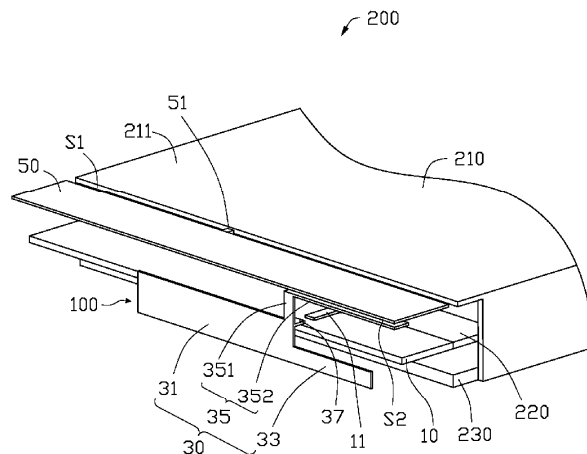
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H04B 7/10 (2017.01)
H01Q 5/335 (2015.01)
H01Q 5/328 (2015.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H04B 7/10** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/335** (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/335; H01Q 1/243; H01Q 9/42;

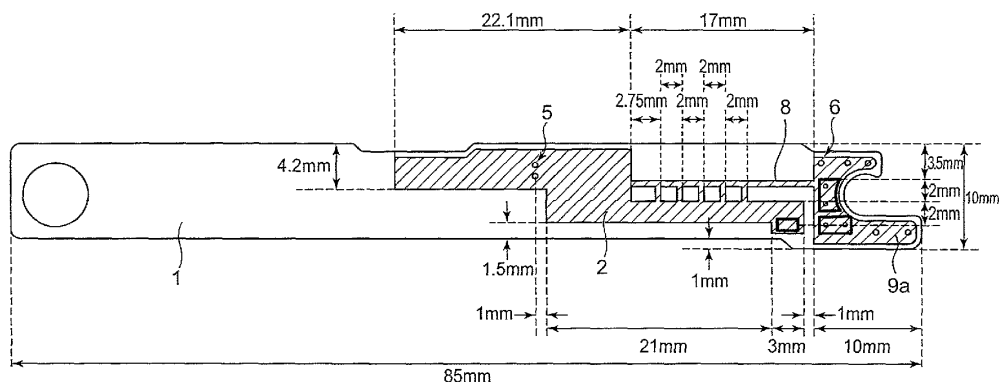
12 Claims, 7 Drawing Sheets





(45) **Date of Patent:** **Oct. 10, 2017**

CPC *H01Q 5/0024* (2013.01); *H01Q 1/2266*
(2013.01); *H01Q 5/321* (2015.01); *H01Q*
5/385 (2015.01); *H01Q 9/42* (2013.01)





US009786994B1

(12) **United States Patent**
Lee et al.

(10) **Patent No.:** **US 9,786,994 B1**
(45) **Date of Patent:** **Oct. 10, 2017**

(54) **CO-LOCATED, MULTI-ELEMENT ANTENNA STRUCTURE**

(71) Applicant: **AMAZON TECHNOLOGIES, INC.**,
Reno, NV (US)

(72) Inventors: **Tzung-I Lee**, San Jose, CA (US);
Cheol Su Kim, San Jose, CA (US); **In Chul Hyun**, San Jose, CA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Reno, NV
(US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 256 days.

(21) Appl. No.: **14/221,136**

(22) Filed: **Mar. 20, 2014**

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 5/342 (2015.01)
H01Q 25/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/0006** (2013.01); **H01Q 5/342** (2015.01); **H01Q 25/04** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/0006; H01Q 5/342; H01Q 25/04
USPC 343/702, 833, 834, 853
See application file for complete search history.

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Primary Examiner — Dameon E Levi

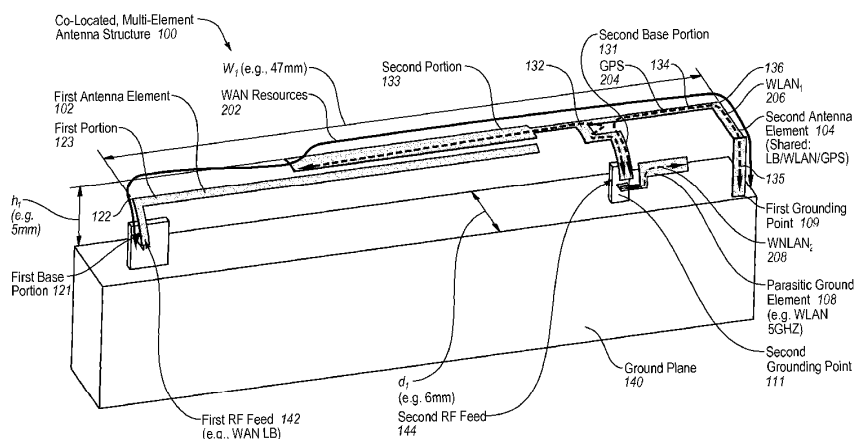
Assistant Examiner — Ab Salam Alkassim, Jr.

(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

Antenna structures and methods of operating the same of an electronic device are described. One apparatus includes a first radio frequency (RF) feed, a second RF feed and an antenna structure. The antenna structure includes a ground plane, a first antenna element coupled to the first RF feed, a second antenna element coupled to the second RF feed and coupled to the ground plane at a first grounding point located at a distal end of the second antenna element. The first antenna element operates as a first directly-fed element and the second antenna element operates as a first parasitic ground element when RF signals in a first frequency range are applied to the first RF feed. The second antenna element operates as a second directly-fed element when RF signals in a second frequency range are applied to the second RF feed, the second frequency range being higher than the first frequency range. The first antenna element is grounded by the RF short circuit when the RF signals in the second frequency range are applied to the second RF feed.

20 Claims, 10 Drawing Sheets





US009793598B2

(12) **United States Patent**
Hobson et al.

(10) **Patent No.:** **US 9,793,598 B2**

(45) **Date of Patent:** **Oct. 17, 2017**

(54) **WIRELESS HANDHELD ELECTRONIC DEVICE**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(72) Inventors: **Phillip M. Hobson**, Menlo Park, CA (US); **Stephen P. Zadesky**, Portola Valley, CA (US); **Erik L. Wang**, Cupertino, CA (US); **Tang Yew Tan**, Palo Alto, CA (US); **Richard Hung Minh Dinh**, San Jose, CA (US); **Adam D. Mittleman**, San Francisco, CA (US); **Kenneth A. Jenks**, Capitola, CA (US); **Robert J. Hill**, Salinas, CA (US); **Robert W. Schlub**, Cupertino, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 436 days.

(21) Appl. No.: **14/612,187**

(22) Filed: **Feb. 2, 2015**

(65) **Prior Publication Data**

US 2015/0214602 A1 Jul. 30, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/773,010, filed on Feb. 21, 2013, now Pat. No. 8,952,853, which is a (Continued)

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01);
(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/273; H01Q 7/00; H01Q 13/10; H01Q 1/38; H01Q 1/46; H01R 2201/02

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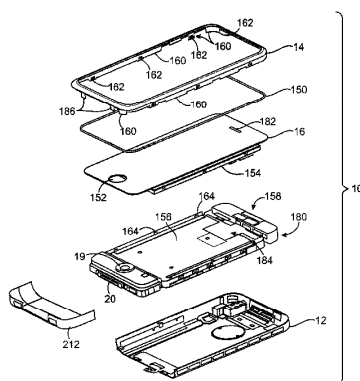
Primary Examiner — Joseph Lauture

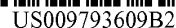
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

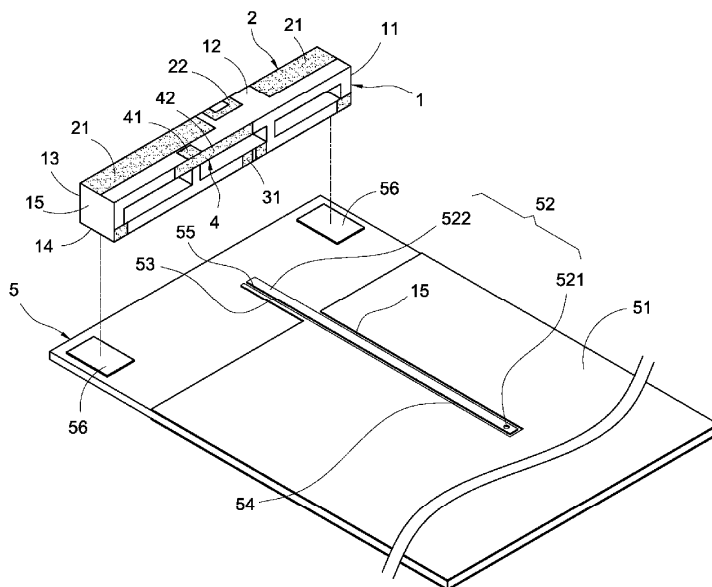
A handheld electronic device may be provided that contains a conductive housing and other conductive elements. The conductive elements may form an antenna ground plane. One or more antennas for the handheld electronic device may be formed from the ground plane and one or more associated antenna resonating elements. Transceiver circuitry may be connected to the resonating elements by transmission lines such as coaxial cables. Ferrules may be crimped to the coaxial cables. A bracket with extending members may be crimped over the ferrules to ground the coaxial cables to the housing and other conductive elements in the ground plane. The ground plane may contain an antenna slot. A dock connector and flex circuit may overlap the slot in a way that does not affect the resonant frequency of the slot. Electrical components may be isolated from the antenna using isolation elements such as inductors and resistors.

20 Claims, 38 Drawing Sheets





(45) **Date of Patent:** **Oct. 17, 2017**



6 Claims, 4 Drawing Sheets