(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
31 August 2017 (31.08.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/147459 A4

(51) International Patent Classification:
H02J 7/00 (2006.01) *H02J 50/10* (2016.01)
H02J 7/02 (2016.01) *H01F 38/14* (2006.01)

(21) International Application Number:
PCT/US2017/019408

(22) International Filing Date:
24 February 2017 (24.02.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/299,942 25 February 2016 (25.02.2016) US
62/399,179 23 September 2016 (23.09.2016) US

(71) Applicant: **APPLE INC.** [US/US]; 1 Infinite Loop, Cupertino, California 95014 (US).

(72) Inventors: **KALLMAN, Benjamin J.**; MS 305-1PH, 1 Infinite Loop, Cupertino, California 95014 (US). **WITTENBERG, Michael B.**; MS 305-1DR, 1 Infinite Loop, Cupertino, California 95014 (US). **GRAHAM, Christopher S.**; MS 305-1PH, 1 Infinite Loop, Cupertino, California 95014 (US).

(74) Agent: **ZIGMANT, John Matthew** et al.; Kilpatrick Townsend and Stockton LLP, Mailstop IP Docketing - 22, 1100 Peachtree Street, Suite 2800, Atlanta, Georgia 30309 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,

(54) Title: INDUCTIVE CHARGING PORTS FOR PORTABLE COMPUTING DEVICES

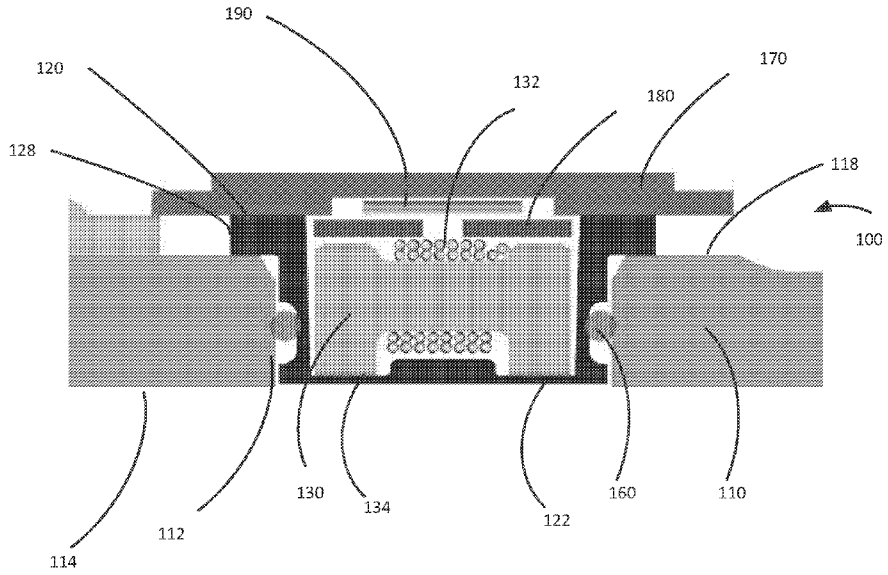

Figure 1

(57) Abstract: Connector assemblies may be space efficient, have a high corrosion resistance, are difficult to damage, reduce or prevent moisture leakage into an electronic device housing the connector assembly, are readily assembled, and are reliable. One example may provide an inductive charging port for transferring electrical energy from a first electric device to a second electronic device. As compared to conventional connector inserts and connector receptacles, these inductive charging ports may have a smaller form factor and consume a reduced volume in an electronic device. Corrosion resistance may be provided by including a protective layer or cover portion over what would otherwise be exposed surfaces of a transformer core. Orings, gaskets, or other structures may be included to reduce moisture leakage into a device. The inductive charging port may include a low number of parts for a simplified assembly, and thermal management of various types may be used to improve reliability.

WO 2017/147459 A4

[Continued on next page]

MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

Published:

— *with international search report (Art. 21(3))*

— *with amended claims (Art. 19(1))*

(88) Date of publication of the international search report:
21 September 2017 (21.09.2017)

Date of publication of the amended claims:
23 November 2017 (23.11.2017)

WHAT IS CLAIMED IS:

1. An inductive charging port for an electronic device, the inductive charging port comprising:

a first housing located in a first opening of an enclosure of the electronic device; and

an inductive coil around a transformer core, the transformer core fixed to the first housing and the enclosure such that a surface of the transformer core is exposed at the first opening of the enclosure,

wherein a cover portion of the first housing covers the surface of the transformer core.

2. The inductive charging port of claim 1 wherein the inductive charging port is sealed by a sealing structure between the enclosure and a sidewall of the first housing.

3. The inductive charging port of claim 2 wherein the sealing structure is an O-ring.

4. The inductive charging port of claim 1 further comprising a flexible circuit board electrically connected to the inductive coil.

5. The inductive charging port of claim 4 further comprising a bracket such that the flexible circuit board is between the bracket and the transformer core.

6. The inductive charging port of claim 4 further comprising a compliant piece such that the compliant piece is between the flexible circuit board and the transformer core.

7. An inductive charging port for an electronic device, the inductive charging port comprising:

a first housing located in a first opening of an enclosure of the electronic device;

an inductive coil around a transformer core, the transformer core fixed to the first housing, wherein the first housing and first inductive coil are movable relative to the enclosure;

a second housing fixed to the enclosure; and

a first resilient member having a first end around a first tail portion of the first housing and a second end in a first supporting cavity formed by sidewalls of the second housing, such that the first resilient member biases the transformer in a direction out of the electronic device when the electronic device is not mated to a second device, and such that the first resilient member compresses such that the transformer core is moved in a direction into the electronic device when the electronic device is mated to a second device.

8. The inductive charging port of claim 7 further comprising a second resilient member having a first end around a second tail portion of the first housing and a second end in a second supporting cavity formed by sidewalls in the second housing.

9. The inductive charging port of claim 8 wherein the first and second resilient members are springs.

10. The inductive charging port of claim 9 wherein the springs bias the inductive core towards a surface of the enclosure when the electronic device is not mated to a second device and the springs compress allowing the inductive core to retract behind the surface of the enclosure when the electronic device is mated to a second device.

11. The inductive charging port of claim 10 wherein the second device mates with the electronic device by moving laterally along a surface of the enclosure, wherein

the first housing includes a front surface having sloped lead-in features on each side of the transformer core such that as the second device moves laterally along the surface of the enclosure, one of the lead-in features encounters the second device and pushes the first housing into the electronic device.

12. The inductive charging port of claim 11 wherein a leading surface of the transformer core is recessed below peaks of the sloped lead-in features.

13. The inductive charging port of claim 7 wherein the inductive charging port is sealed by a sealing structure between the enclosure and a sidewall of the second housing.

14. The inductive charging port of claim 13 wherein the sealing structure is an O-ring.

15. An inductive charging port for an electronic device, the inductive charging port comprising:

a first housing located in a first opening of an enclosure of the electronic device;

an inductive coil around a transformer core, the transformer core fixed to the first housing, wherein the first housing and first inductive coil are movable relative to the enclosure;

a first magnetic element fixed to the first housing; and

a proximity sensor fixed to the enclosure, wherein when the electronic device is not mated to a second device, the first housing and the first magnetic element move away from the proximity sensor, and

wherein when the electronic device is mated to a second electronic device, the first housing and the first magnetic element move towards the proximity sensor,

wherein the proximity sensor uses the movement of the first magnetic element to detect a presence of the second electronic device.

16. The inductive charging port of claim 15 further comprising a second magnetic element fixed to the enclosure.

17. The inductive charging port of claim 16 further comprising a second housing fixed to the enclosure, wherein the proximity sensor and the second magnetic element are attached to the second housing.

18. The inductive charging port of claim 16 wherein the proximity sensor is a Hall-effect sensor.

19. The inductive charging port of claim 18 further comprising a first spring and a second spring each having a first end around a corresponding tail portion of the first housing and a second end in a corresponding supporting cavity formed by sidewalls of the second housing.

20. The inductive charging port of claim 19 wherein when the electronic device is not mated to a second device, the first spring and the second spring push the first housing and the first magnetic element away from the proximity sensor.