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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
8 October 2015 (08.10.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/154050 A1

(51) International Patent Classification: *H02N 1/08* (2006.01)

(21) International Application Number: PCT/US2015/024376

(22) International Filing Date: 3 April 2015 (03.04.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data: 61/995,159 3 April 2014 (03.04.2014) US

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(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, 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, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, 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))*

(54) Title: BATTERY CHARGER FOR PORTABLE ELECTRONIC DEVICES AND PORTABLE ELECTRONIC DEVICE USING THE SAME

(57) Abstract: A battery charger (10) for portable electronic devices and a portable electronic device (12) are disclosed. In one embodiment, a housing (30) forms a portion of an outer case (16) of the portable electronic device (12). Capacitors are located within the housing (30) that include opposing spaced plates (66, 68, 70, 72) having contact segments (74, 76, 78, 80) thereon. An output power increasing, electrically resistive fluid (82) is held within and partially fills an enclosed chamber that is boundaried by the contact segments (74, 76, 78, 80).

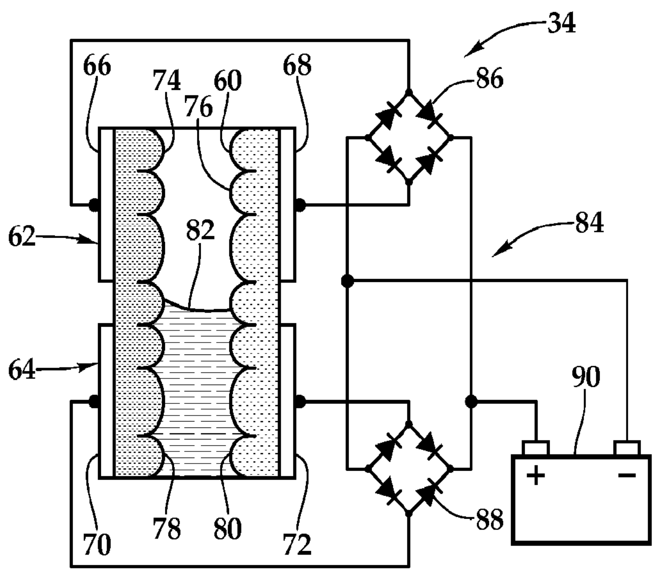

Fig.3

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BATTERY CHARGER FOR PORTABLE ELECTRONIC DEVICES AND PORTABLE ELECTRONIC DEVICE USING THE SAME

TECHNICAL FIELD OF THE INVENTION

This invention relates, in general, to battery chargers, and, more particularly, to battery chargers which generate an electrical charge which restores energy to the battery of a portable electronic device, such as a smart phone or the like.

BACKGROUND OF THE INVENTION

All portable electronic devices such as smart phones and the like rely on a storage battery for operating power. Since the physical dimensions and weight of the portable electronic device must be limited to permit acceptable portability, the battery capacity is likewise severely limited. Accordingly, there is a need for improved systems and methods for providing improved battery capacity.

SUMMARY OF THE INVENTION

It would be advantageous to improve battery capacity in portable electronic devices, such as smart phones. It would also be desirable to enable a mechanical-to-electrical conversion solution that would convert motion to electrical energy, which would be thereafter be transferred to the battery of the portable electronic device. To better address one or more of these concerns, a battery charger for a portable electronic device and a portable electronic device using the same are disclosed. In one embodiment of the battery charger, a housing forms a portion of an outer case of the portable electronic device. Capacitors, which may be supercapacitors, are located within the housing and each of the pair of capacitors includes opposing spaced plates having contact segments thereon. An output power increasing, electrically resistive fluid is held within and partially fills an enclosed chamber that is boundaried by the contact segments. In response to movement of the portable electronic device, induced relative motion between the output power increasing, electrically resistive fluid and contact segments varies the fluid-contact segment contact within the enclosed chamber, thereby inversely alternating the capacitance between the pair of capacitors and triboelectrically generating an electrical charge. An electronic circuit coupled to the opposing spaced plates is configured to transfer the electrical charge to a battery associated with the portable electronic device.

In another aspect, a portable electronic device includes an outer case, an interactive display interface mounted thereto, and a battery housed within the outer case. The aforementioned battery charger is located within the outer case. The kinetic motion of the portable electronic device causes the physical displacement of an output power increase, electrically resistive fluid relative to a pair of capacitors, thereby utilizing triboelectrical generation to create a charge stored in an electrical accumulator, which is connected to the battery. These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the features and advantages of the present invention, reference is now made to the detailed description of the invention along with the accompanying figures in which corresponding numerals in the different figures refer to corresponding parts and in which:

Figure 1A is front perspective view of one embodiment of a portable electronic device employing a battery charger according to the teachings presented herein;

Figure 1B is a side elevation view of the portable electronic device employing the battery charger depicted in figure 1A;

Figure 2 is a schematic perspective diagram of one embodiment of the battery charger depicted in figure 1A;

Figure 3 is a side elevation, in cross section, of one embodiment of an electrostatic energy generator, which forms a portion of the battery charger of figure 2, in further detail;

Figure 4 is a side elevation, in cross section, of another embodiment of the electrostatic energy generator, which forms a portion of the battery charger; and

Figure 5 is a process state diagram depicting one embodiment of the electrical energy generation process.

DETAILED DESCRIPTION OF THE INVENTION

While the making and using of various embodiments of the present invention are discussed in detail below, it should be appreciated that the present invention provides many applicable inventive concepts, which can be embodied in a wide variety of specific contexts.

The specific embodiments discussed herein are merely illustrative of specific ways to make and use the invention, and do not delimit the scope of the present invention.

Referring initially to figures 1A and 1B, therein is depicted one embodiment of battery charger, which is schematically illustrated and designated 10. The battery charger 10 generates an electrical charge which restores energy to a portable electronic device, such as a smart phone 12, which has a battery 14. The smart phone 12 also includes an outer case 16, interactive display interface 18, and user button 20. As shown, the battery charger (10) forms a portion of the outer case 16 and, in one embodiment, may be integral therewith or therein. It should be appreciated that although a smart phone is depicted, the portable electronic device may be a smart watch, tablet computer, or cellular telephone, for example.

Referring now to figure 2, one embodiment of the battery charger 10 is depicted. A housing 30 forms a portion of the outer case 16 of the portable electronic device 12 and a liquid triboelectrical generator 32 includes multiple electrostatic energy generators, for example, electrostatic energy generators 34, 36, 38, 40, 42 coupled to electrical circuitry (not shown) and separated by physical separators 44, 46, 48, 50. As will be discussed in further detail hereinbelow, the capacitors utilized in the electrostatic energy generators 34, 36, 38, 40, 42 may be supercapacitors or variable capacitors. The liquid tribolectrical generator 32 utilizes the tribolectric effect in generating an electric charge which may recharge the battery 14, for example, associated with the portable electronic device 12.

The triboelectric effect is known as a transfer of charge between two contacting materials, which become electrically charged in opposite signs. Though the triboelectric effect is known for many centuries, its fundamental mechanism is still under investigation. Only recently was it applied in energy harvesting for fabrication of triboelectric generators converting small-scale mechanical energy into electricity that paves the way for simple and low-cost green-energy technology. However, most of the proposed triboelectric generators are limited in efficiency by indispensable requirement for constant change of cavity volume and/or utilization of sliding surfaces. Also these work best only under dry conditions. However, triboelectricity is known to exist when liquids flow through insulators. For example, a voltage variation of 0.3 V was observed upon water flow through a one meter-long millimeter-diameter rubber pipe and surface charge density of over 5 μC/m2 was measured on each water droplet dispensed from a teflon-coated pipette tip.

The present battery charger 10 may include a design of a liquid triboelectric generator comprising a liquid-filled capacitor or supercapacitor as the key element enabling the increase of the efficiency of generation of electricity. The proposed approach is based on the relation between the electrical charge Q and voltage V and capacitance C:

$$Q = CV \qquad \text{[Equation (1)]}$$

Therefore the generated electrical current I (which is the time derivative of the triboelectrical charge) appears to be proportional to the capacitance and its variation in time:

$$I = \frac{dQ}{dt} = C\frac{\partial V}{\partial t} + V\frac{\partial C}{\partial t} \qquad \text{[Equation (2)]}$$

where d/dt and ∂/∂t represent total and partial derivative with time correspondingly.

With a supercapacitor which is not fully filled with liquid and separated into more than one individually contacted segments, flow of liquid inside the cavity or series of enclosed chambers causes generation of the triboelectric charge. Therefore the first term in Equation (2) is the variation of the potential across the opposite electrodes owing to the triboelectrically-generated charges, while the second term is the variation of the capacitance due to the local change of capacitance in the segments of the supercapacitor due to the flow of liquid. From Equation (2) one can see that utilization of such triboelectricity-enabled supercapacitor makes it possible to increase the efficiency of triboelectrical generation by a factor of the ratio of electrical capacitance C of the supercapacitor to that of the conventional triboelectrical generator, which can be many orders of magnitude. Supercapacitors are known to feature extremely high capacitance, up to a few kilofarads.

The triboelectricity-enabled liquid-filled capacitor or supercapacitor may feature the internal volume (cavity) which is only partially filled with liquid thus enabling for the movement of the liquid inside the cavity. The triboelectricity-enabled supercapacitor also features two or more individually contacted segments that enable the outflow of the electrical charge, which is triboelectrically-generated by the movement of the liquid inside the cavity.

Referring now to figure 3, one embodiment of the electrostatic energy generator 34 is depicted in further detail. As discussed, the housing 30 forms a portion of the outer case 16 of the portable electronic device 12. The housing 30 includes an enclosed chamber 60. A pair of variable capacitors 62, 64 which may be supercapacitors or variable capacitors, are located within the housing 30 and each of the pair of capacitors 62, 64 includes opposing spaced plates 66, 68, 70, 72 which act as electrodes, having respective contact segments 74, 76, 78, 80 thereon. As shown, in one embodiment, the contact segments 74, 76, 78, 80 form at least a portion of the enclosed chamber 60.

An output power increasing, electrically resistive fluid 82 is held within the enclosed chamber 60 and the output power increasing, electrically resistive fluid 82 partially fills the enclosed chamber 60 such that fluid motion varies the fluid-contact segment contact within the enclosed chamber. As will be discussed in further detail hereinbelow, in response to movement of the portable electronic device 12, induced relative motion between the output power increasing, electrically resistive fluid 82 and contact segments 74, 76, 78, 80 varies the fluid-contact segment contact within the enclosed chamber 60, thereby inversely alternating the capacitance between the pair of capacitors 62, 64 and triboelectrically generating an electrical charge.

An electronic circuit 84 is coupled to the opposing spaced plates 66, 68, 70, 72 of the pair of variable capacitors. In one embodiment, the electronic circuit 84 may include diode bridges 86, 88 and an electrical accumulator 90. The electronic circuit 84 may be configured to transfer the electrical charge to the battery 14 associated with the portable electronic device 12. In one event, the electrical accumulator 90 may be at least partially integrated with the battery 14.

Referring now to figure 4, another embodiment of the electrostatic energy generator 34 is depicted. In this embodiment, the plates 66, 68, 70, 72 feature an electret material 100. Electret is a dielectric with a quasi-permanent electric charge or dipole polarization and therefore generates internal and external electric fields. Therefore, utilization of the electret material facilitates generation of the electrical double-layers on the liquid-plate interface (which are crucial for high capacitance of the supercapacitors) without a voltage applied to the electrodes of the triboelectricity-enabled capacitor. Additionally, as shown, the enclosed chamber 60 may include a dielectric material 102, 104 interposed within the contact segments 74, 76, 78, 80 between the opposing spaced plates 66, 68, 70, 72.

Referring now to figure 5, a process state diagram depicting one embodiment of the electrical energy generation process is shown. In general, in a fluid inflow cycle, movement of the output power increasing, electrically resistive fluid 82 occurs proximate to the opposing spaced plates 66, 68 such that the fluid 82 is physically occupying the enclosed chamber 60. The fluid 82 inflow cycle causes electrostatic charges with opposite signs to be triboelectrically generated and distributed proximate the opposing spaced plates 66, 68. A temporary electrical circuit is created across the opposing spaced plates 68, 70 thereby generating a voltage/current peak. Thereafter, in a fluid outflow cycle, wherein movement of the output power increasing, electrically resistive fluid 82 moves away from the opposing spaced plates 66, 68 and physically evacuating that portion of the enclosed chamber 60, neutralization of the electrostatic charges occurs. Electrons flow to the electronic circuit 84 until equilibrium is reached between the opposing spaced plates 66, 68.

More specifically, at State (a), which may be the initial state of the triboelectricity-enabled liquid-filled capacitor or supercapacitor, the enclosed chamber 60, which is not fully filled with the output power increasing, electrically resistive fluid 82, includes a pair of capacitors 62, 64 each including the opposing spaced plates 66, 68, 70, 72 having the contact segments thereon. For purposes of illustration, it should be appreciated that with respect to figure 5, the process of the triboelectrical generation is described for the contact segments 74, 76 proximate the spaced plates 66, 68. It should be further appreciated that a similar description and process applies to the contact segments 78, 80 proximate the spaced plates 70, 72 as well.

At State (b), with respect to the fluid inflow cycle, with the movement of the fluid 82 inside the enclosed chamber 60, electrostatic charges with opposite signs are triboelectrically generated and distributed on the two internal surfaces of the plates 66, 68 of the supercapacitor segment represented by the opposing spaced plates 66, 68. At State (c), the neutral metal electrodes associated with the spaced plates 66, 68 are charged via the triboelectric effect. At State (d), continuing the fluid inflow cycle, electrons flow across the electrical circuit 84 generating a voltage/current peak. At State (e), a temporary potential equilibrium forms in the supercapacitor segment. Beginning the fluid outflow cycle, at State (f), most of the electrostatic charges on the internal surfaces are neutralized during the fluid outflow process prior to, at State (g), electrons flow back via the electrical circuit 84 until the potential equilibrium forms between the two metal electrodes associated with the plates 66, 68. This enables unidirectional flow of the electrical current out of the triboelectrical generator to the electrical circuit 84, including the electrical accumulator 90 and/or battery 14 to be charged.

In another embodiment, the battery charger 10 may be a motion-activated charger for portable electronic devices that includes a housing defining an enclsoed chamber. An element movable within the housing coacts with the housing to generate an electrical charge. This emboidment of the battery charger 10 includes electrical circuitry that is configured to transfer the electicl charge generated to a storage battery. In a further embodiment, a charging system for portable electronic device batteries is disclosed that includes a housing defining an enclosed chamber and a convertor contained within the housing which converts body heat of the user to electrical energy. This emboidment of the battery charger 10 also includes electrical circuitry that is configured to transfer the electicl charge generated to a storage battery. These embodiments are discussed further in United States Patent Application Serial No. 61/995,159 entitled "Battery Charger for Portable Electronic Devices" filed on April 3, 2014 in the name of Laslo Olah; which is hereby incorporated by reference in its entirity for all purposes.

The order of execution or performance of the methods and data flows illustrated and described herein is not essential, unless otherwise specified. That is, elements of the methods and data flows may be performed in any order, unless otherwise specified, and that the methods may include more or less elements than those disclosed herein. For example, it is contemplated that executing or performing a particular element before, contemporaneously with, or after another element are all possible sequences of execution.

While this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to the description. It is, therefore, intended that the appended claims encompass any such modifications or embodiments.

What is claimed is:

1. A battery charger for a portable electronic device, the battery charger comprising:

a housing forming a portion of an outer case of the portable electronic device, the housing including an enclosed chamber;

a pair of capacitors located within the housing, each of the pair of capacitors including opposing spaced plates having contact segments thereon;

the contact segments forming at least a portion of the enclosed chamber;

an output power increasing, electrically resistive fluid held within the enclosed chamber, the output power increasing, electrically resistive fluid partially filling the enclosed chamber such that fluid motion varies the fluid-contact segment contact within the enclosed chamber;

in response to movement of the portable electronic device, induced relative motion between the output power increasing, electrically resistive fluid and contact segments varies the fluid-contact segment contact within the enclosed chamber, thereby inversely alternating the capacitance between the pair of capacitors and triboelectrically generating an electrical charge; and

an electronic circuit coupled to the opposing spaced plates of the pair of capacitors, the electronic circuit configured to transfer the electrical charge to a battery associated with the portable electronic device.

2. The battery charger as recited in claim 1, wherein the portable electronic device further comprises a smart phone.

3. The battery charger as recited in claim 1, wherein the portable electronic device further comprises a device selected from the group consisting of smart phones, tablet computers, smart watches, and cellular telephones.

4. The battery charger as recited in claim 1, further comprising the kinetic motion of the portable electronic device causing the physical displacement of the output power increase, electrically resistive fluid relative to the pair of capacitors.

5. The battery charger as recited in claim 1, wherein opposing spaced plates further comprise an electret material, the opposing spaced plates generating an internal electric field about the contact segments and an external electric field about the enclosed chamber, thereby enhancing the electrical charge generated through tribolelectricity.

6. The battery charger as recited in claim 1, wherein the enclosed chamber further comprises dielectric material interposed within the contact segments between the opposing spaced plates.

7. The battery charger as recited in claim 1, further comprising each pair of variable capacitors being configured for,

a fluid inflow cycle wherein movement of the output power increasing, electrically resistive fluid proximate to the opposing spaced plates and physically occupying enclosed chamber thereto;

the fluid inflow cycle causing electrostatic charges with opposite signs to be triboelectrically generated and distributed proximate the opposing spaced plates;

a temporary electrical circuit created across the opposing spaced plates and generating a voltage/current peak;

a fluid outflow cycle wherein movement of the output power increasing, electrically resistive fluid away from the opposing spaced plates and physically evacuating the enclosed chamber;

the fluid outflow cycle causing the neutralization of the electrostatic charges; and

electrons flow via the electrical circuit to the electronic circuit until equilibrium is reached between the opposing spaced plates.

8. A battery charger for a portable electronic device, the battery charger comprising:

a housing forming a portion of an outer case of the portable electronic device, the housing including an enclosed chamber;

a pair of supercapacitors located within the housing, each of the pair of supercapacitors including opposing spaced plates having contact segments thereon;

the opposing spaced plates include an electret material, the opposing spaced plates generating an internal electric field about the contact segments and an external electric field about the enclosed chamber, thereby enhancing the electrical charge generated through tribolelectricity;

the contact segments forming at least a portion of the enclosed chamber;

an output power increasing, electrically resistive fluid held within the enclosed chamber, the output power increasing, electrically resistive fluid partially filling the enclosed chamber such that fluid motion varies the fluid-contact segment contact within the enclosed chamber;

in response to movement of the portable electronic device, induced relative motion between the output power increasing, electrically resistive fluid and contact segments varies the fluid-contact segment contact within the enclosed chamber, thereby inversely alternating the capacitance between the pair of supercapacitors and triboelectrically generating an electrical charge;

an electronic circuit coupled to the opposing spaced plates of the pair of supercapacitors, the electronic circuit configured to transfer the electrical charge to a battery associated with the portable electronic device;

a fluid inflow cycle wherein movement of the output power increasing, electrically resistive fluid proximate to the opposing spaced plates and physically occupying enclosed chamber thereto;

the fluid inflow cycle causing electrostatic charges with opposite signs to be triboelectrically generated and distributed proximate the opposing spaced plates;

a temporary electrical circuit created across the opposing spaced plates and generating a voltage/current peak;

a fluid outflow cycle wherein movement of the output power increasing, electrically resistive fluid away from the opposing spaced plates and physically evacuating the enclosed chamber;

the fluid outflow cycle causing the neutralization of the electrostatic charges; and

electrons flow via the electrical circuit to the electronic circuit until equilibrium is reached between the opposing spaced plates.

9. The battery charger as recited in claim 8, wherein the portable electronic device further comprises a device selected from the group consisting of smart phones, tablet computers, smart watches, and cellular telephones.

10. A portable electronic device comprising:

an outer case, an interactive display interface mounted thereto, and a battery housed within the outer case;

a battery charger comprising:

a housing forming a portion of the outer case, the housing including an enclosed chamber, a pair of capacitors located within the housing, each of the pair of capacitors including opposing spaced plates having contact segments thereon,

the opposing spaced plates include an electret material, the opposing spaced plates generating an internal electric field about the contact segments and an external electric field about the enclosed chamber, thereby enhancing the electrical charge generated through tribolelectricity,

the contact segments forming at least a portion of the enclosed chamber,

an output power increasing, electrically resistive fluid held within the enclosed chamber, the output power increasing, electrically resistive fluid partially filling the enclosed chamber such that fluid motion varies the fluid-contact segment contact within the enclosed chamber,

in response to movement of the portable electronic device, induced relative motion between the output power increasing, electrically resistive fluid and contact segments varies the fluid-contact segment contact within the enclosed chamber, thereby inversely alternating the capacitance between the pair of capacitors and triboelectrically generating an electrical charge,

an electronic circuit coupled to the opposing spaced plates of the pair of capacitors, the electronic circuit configured to transfer the electrical charge to the battery,

a fluid inflow cycle wherein movement of the output power increasing, electrically resistive fluid proximate to the opposing spaced plates and physically occupying enclosed chamber thereto,

the fluid inflow cycle causing electrostatic charges with opposite signs to be triboelectrically generated and distributed proximate the opposing spaced plates,

a temporary electrical circuit created across the opposing spaced plates and generating a voltage/current peak,

a fluid outflow cycle wherein movement of the output power increasing, electrically resistive fluid away from the opposing spaced plates and physically evacuating the enclosed chamber,

the fluid outflow state causing the neutralization of the electrostatic charges, and

electrons flow via the electrical circuit to the electronic circuit until equilibrium is reached between the opposing spaced plates; and the kinetic motion of the portable electronic device causing the physical displacement of the output power increase, electrically resistive fluid relative to the pair of variable capacitors.

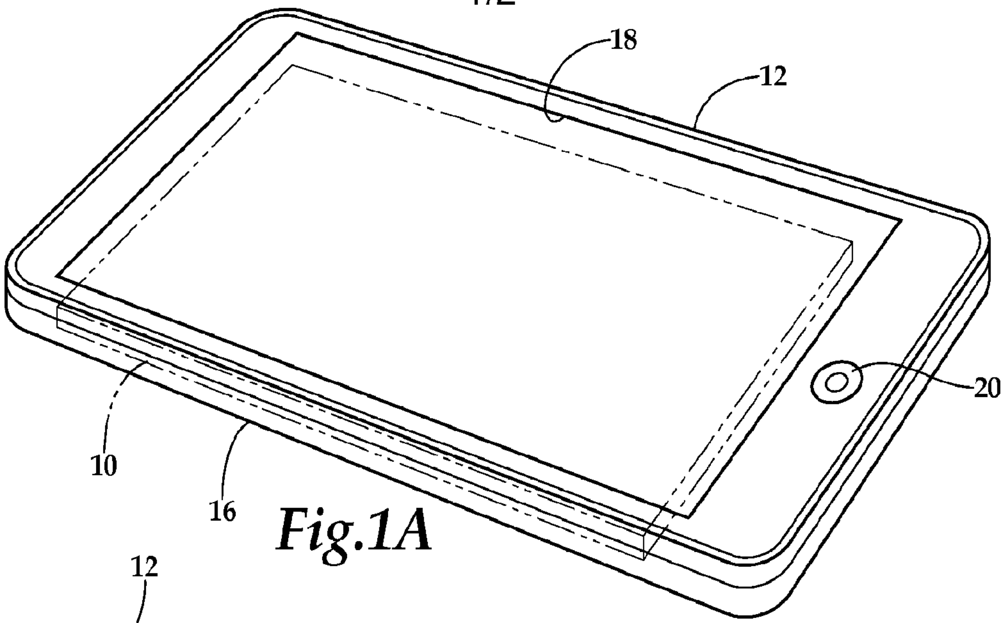

Fig.1A

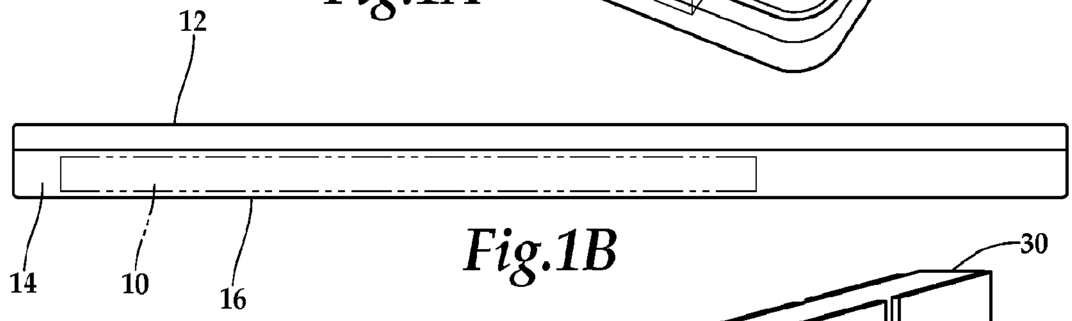

Fig.1B

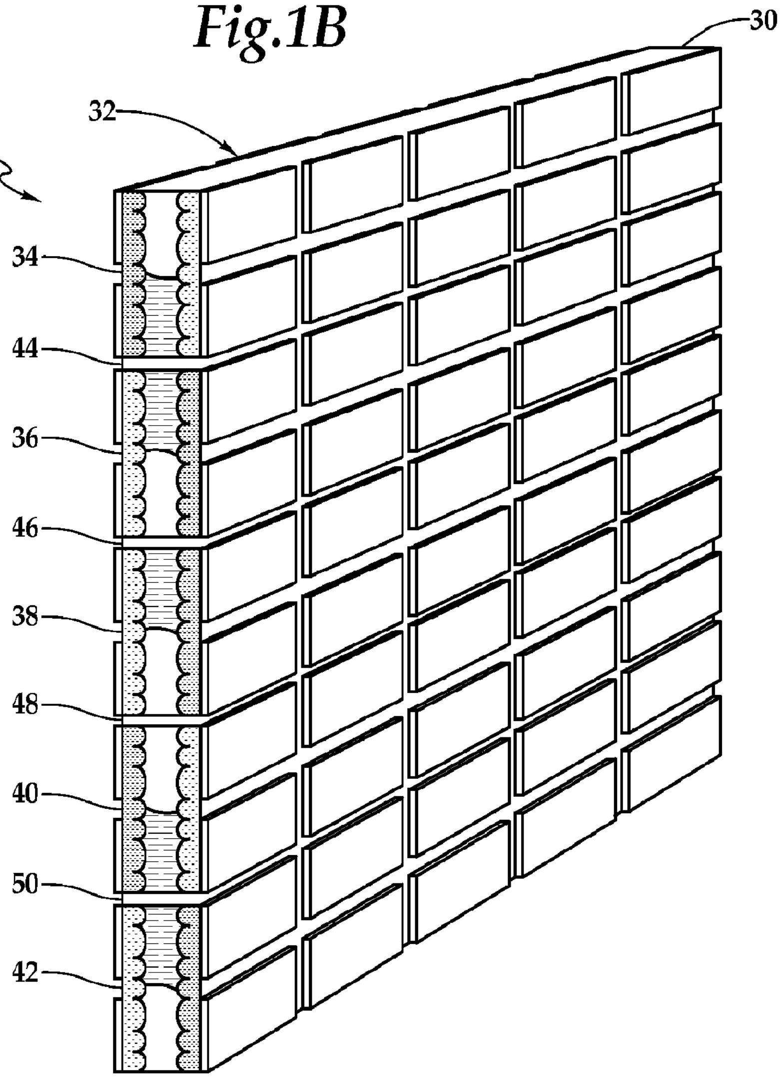

Fig.2

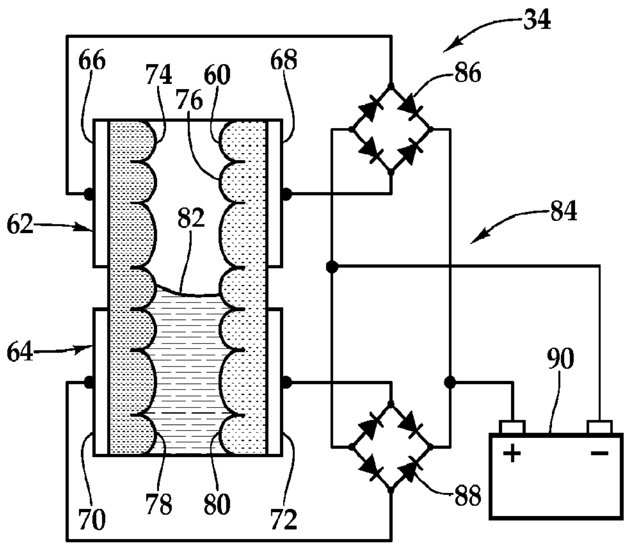

Fig.3

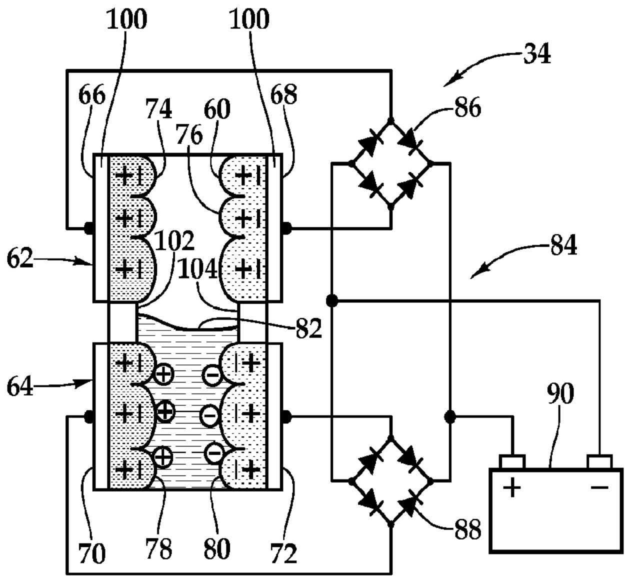

Fig.4

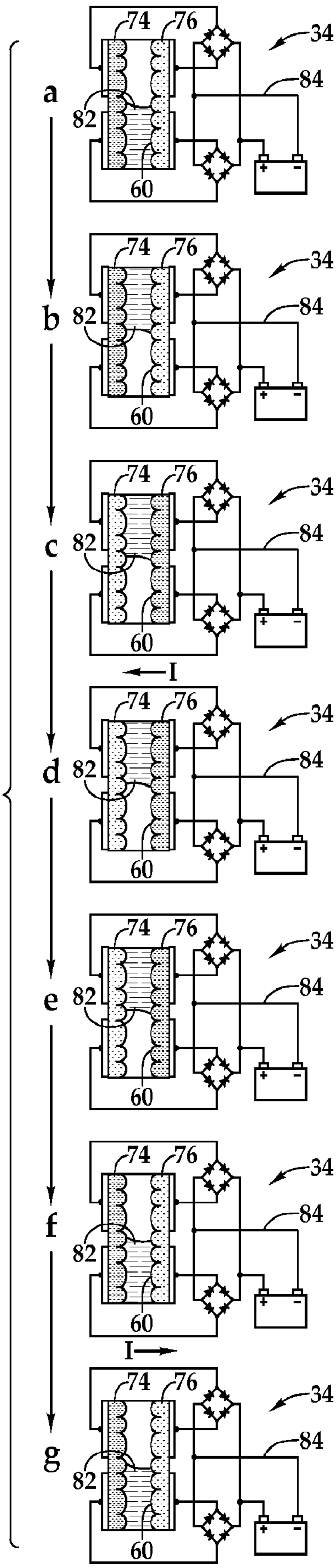

Fig.5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/024376

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H02N 1/08 (2015.01)
CPC - H02N 1/08 (2015.04)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - H02N 1/08 (2015.01)
USPC - 310/309; 322/2A; 968/503

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - H02N 1/00, 04, 06, 08, 10 (2015.04) (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Orbit, Google Patents, Google Scholar.
Search terms used: triboelectric, resistive, fluid, battery, charge, capacitor, portable device, smartphone, supercapacitor, kinetic, mechanical, energy

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,126,822 A (WAHLSTROM) 21 November 1978 (21.11.1978) entire document	1-10
A	US 7,898,096 B1 (KRUPENKIN) 01 March 2011 (01.03.2011) entire document	1-10
A	US 2006/0077762 A1 (BOLAND et al) 13 April 2006 (13.04.2006) entire document	1-10
A	CN 203377111 U (XU et al) 01 January 2014 (01.01.2014) see machine translation	1-10

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Date of the actual completion of the international search	Date of mailing of the international search report
11 June 2015	06 JUL 2015

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