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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
06 December 2018 (06.12.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/220627 A1

(51) International Patent Classification:
H01F 27/24 (2006.01) *H01F 27/30* (2006.01)
H01F 27/26 (2006.01) *H01F 41/00* (2006.01)

(21) International Application Number:
PCT/IL2018/050585

(22) International Filing Date:
29 May 2018 (29.05.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/512,087 29 May 2017 (29.05.2017) US

(71) Applicant: **THIN ENERGY LTD.** [IL/IL]; 1 Bat Sheva Street, 7120101 Lod (IL).

(72) Inventors: **ASSIS, Daniel**; 98 Shir HaShirim Street, 4481400 Elqana (IL). **HASID, Itay**; 44 Yisha'ayahu Street, 6249433 Tel Aviv (IL). **NEMENMAN, Ilya**; 38/8 HaNevi'im Street, 7175480 Modi'in-Maccabim-Re'ut (IL).

(74) Agent: **BARKAI, Yosi** et al.; Pearl Cohen Zedek Latzer Baratz, P.O. Box 7198, 6107121 Tel Aviv (IL).

(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, JO, JP, KE, KG, KH, KN, KP, KR, KW, 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))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) **Title:** THIN TRANSFORMER AND METHOD OF PRODUCTION OF SAME

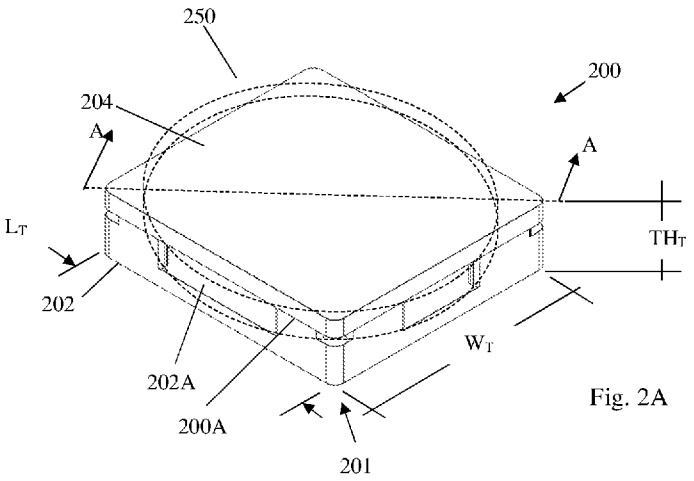


Fig. 2A

(57) **Abstract:** An ultra-thin transformer (UTT) is disclosed. The UTT is comprised of an ultra-thin core (UTC), which comprises a base unit comprising a central core branch, at least one side branch, a plurality of dents forming a toroidic space in the base unit around the central core branch, and an open face. The UTC also comprises a cover unit adapted to match the open face of the base unit. The UTT also comprises a primary winding and a secondary winding. A method for production of thin helical winding is also disclosed. The method comprises obtaining a wire adapted to form a helical layer, winding the wire of certain transformer's layer between two flat plates, and removing the flat plates when the layer is finished.

WO 2018/220627 A1

THIN TRANSFORMER AND METHOD OF PRODUCTION OF SAME

BACKGROUND OF THE INVENTION

[001] Power supplier and battery chargers are widely used. Many of them are designed to be fed from home power grid, ranging for example between 110VAC to 220VAC. Charger and power supplier that are fed from home power grid and designed to supply output DC voltage ranging between, for example, 20VDC and 5VDC. Such voltage step-down is dealt with typically using at least one stage of step-down transformer.

[002] Transformers convert electrical AC current in a primary winding to magnetic flux which is then converted back to electrical AC current in a secondary winding of the transformer. The voltage ratio between the input voltage at the terminals of the primary winding and the output voltage at the terminals of the secondary winding is directly proportional to the ration between the number of windings N1 of the primary to the number of windings N2 of the secondary. Thus, a step-down transformer will have $N1/N2 > 1$.

[003] In order to efficiently transform the electrical energy by a transformer, the electrical resistance of the windings should be kept as low as possible, and the resistance to the magnetic flux should also be kept as low as possible. Both types of resistances will be decreased as the cross section of the respective conduit, electrical wires and magnetic core, respectively, will grow bigger, irrespective of the material they are made of. This basic physical rule dictates that a given amount of power that needs to be transferred limits the ability to decrease the size, or volume of the transformer. On the other hand, users of many portable electronic devices, such as cellular phones and smartphones, portable computing devices (laptop computers, tablets, and the like) rely on availability of a handy power charger, and for the sake of comfort and appearance, would prefer the charger to be as small as possible, preferably as small as a credit card with thickness no bigger than twice or three times the thickness of the credit card, which would make that charger almost unnoticeable.

[004] There is a need to provide very thin transformers for use in super thin chargers and power suppliers.

SUMMARY OF THE INVENTION

[005] An ultra-thin transformer (UTT) is presented comprising an ultra-thin magnetic core (UTC) that comprises a base unit, a cover unit, a primary winding and a secondary winding. The base unit comprising a central core branch, at least one side branch, a plurality of dents forming a toroidic space in the base unit around the central core branch and an open face.

[006] In some embodiments, the UTT comprises a windings toroid adapted to substantially cover the primary winding and the secondary winding.

[007] In some embodiments, the primary winding further comprises two layers of windings disposed at opposite ends, wherein the secondary winding is disposed in at least one layer between the two primary winding's layers, each of the winding layers comprises a flat helical continuous wire. In further embodiments, the primary winding's layers are made of an electrical wire having a triple insulation adapted to conform with high voltage insulation requirements. In still further embodiments, the primary winding's layers conform with the standard defined by IEC/UL 60950.

[008] In some embodiments the, UTT comprises four side branches forming a substantially rectangular prism-shaped UTC, wherein at least one of the primary winding and the secondary winding may protrude from four faces of the UTC.

[009] In some embodiments, the UTT comprises three side branches forming a substantially triangular prism-shaped UTC, wherein at least one of the primary winding and the secondary winding may protrude from three faces of the UTC.

[0010] In some embodiments, the UTC is substantially cylindrical, wherein the toroidic space and the UTC have a common axis of symmetry.

[0011] In some embodiments, the UTC is made of a magnetic permeable material.

[0012] In some embodiments, the UTT is operable in operation frequencies in the range of 50kHz-5MHz.

[0013] In some embodiments, the maximal thickness of the UTT is 3.95 mm, wherein the maximal thickness of the base unit's face is 1.1 mm, wherein the maximal thickness of the cover unit is 1.1 mm, leaving space of at least 1.75 mm for the primary winding and the secondary winding.

[0014] A method for production of thin helical winding is also disclosed. The method comprises obtaining a wire adapted to form a helical layer, winding the wire of certain transformer's layer between two flat plates and removing the flat plates when the layer is finished.

[0015] In some embodiments, the helical layer is made of a wire having diameter of 0.42 mm or less.

[0016] In some embodiments, the wire is coated with very thin polymeric coating, wherein the coating's melting point is lower than that of the wire insulating coating.

[0017] The method for the production of a thin transformer further comprising, after the step of winding the wire, heating the coating to its melting point temperature, thereby melting the coating and stopping the heating after a pre-determined heating time, allowing the coil to cool down, thereby to solidify the coil.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with objects, features, and advantages thereof, may best be understood by reference to the following detailed description when read with the accompanying drawings in which:

[0019] Figs. 1A and 1B are schematic illustrations of configurations of transformers of the prior art;

[0020] Fig. 1C is a schematic isometric illustration of a transformer core, including arrows that indicate the magnetic flux according to the configuration of Fig. 1B;

[0021] Fig. 2A is a schematic isometric illustration of an ultra-thin transformer according to embodiments of the present invention;

[0022] Fig. 2B is a schematic three-dimensional (3D) blown illustration of the thin transformer of Fig. 2A, according to embodiments of the present invention;

[0023] Fig. 2C is a cross section view of the thin transformer of Fig. 2A;

[0024] Fig. 2D is a schematic cross section view of transformer windings, showing the primary winding's layers and the secondary winding's layer in between, according to embodiments of the present invention;

[0025] Fig. 3A schematically depicts three helical windings in a blown view, according to embodiments of the present invention; and

[0026] Fig. 3B is a schematic illustration of a method for producing very thin helical winding using a flat plate, according to embodiments of the present invention.

[0027] It will be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated, relative to other elements, for clarity. Further, where considered appropriate,

reference numerals may be repeated among the figures to indicate corresponding or analogous elements.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

[0028] In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

[0029] Reference is made now to **Figs. 1A** and **1B**, which are schematic illustrations of configurations 100 and 150, respectively, of transformers as known in the prior art. Transformer configuration 100 depicts embodiment in which the magnetic core 102 comprises two adjacent magnetic loops and the windings of the primary 104 and the secondary 106 windings are located on the outer branches of the core 102. As a result, the main magnetic flux flows through the external path 102A while the middle path is substantially not in use for flowing magnetic flux. Fig. 1B depicts a schematic illustration of transformer configuration 150 in which the shape of the magnetic core is similar to that of transformer 100, but both the primary and the secondary windings 154, 156, are wound around the central branch of the magnetic core 152. As a result, the magnetic flux flows through all branches of the magnetic core 152, as depicted by arrows 152A. In this configuration, the total cross section of magnetic core available for the magnetic flux is higher than that of configuration 100, thereby enabling transforming of higher power with lower magnetic resistance of the core.

[0030] Reference is made now to **Fig. 1C**, which is a schematic isometric illustration of a transformer core 180. For transformer windings configuration as in Fig. 1B, the magnetic flux would flow as depicted by the arrows of Fig. 1C. The cross section available for the magnetic flux flowing in the vertical branches is depicted by the cross section-like grey areas 180A, 180B and 180C. The cross section available for the magnetic flux flowing in the horizontal branches is depicted by the cross section-like grey areas 182A, 182B. Any attempt to reduce the physical dimensions of the transformer is deemed to affect the cross section available for the magnetic flux flow, which in turn will limit the amount of electrical power that may be transformed via the transformer.

[0031] Refence is made to **Fig. 2A** which is a schematic isometric illustration of an ultra-thin transformer 200, according to embodiments of the present invention. Ultra-thin transformer (UTT) 200 comprises an ultra-thin core (UTC) 201 comprising base unit 202 and cover unit 204, adapted to match the open face of base unit 202. UTC 201 may be made of magnetic permeable material that may be selected to have the magnetic parameters (such as magnetic field [H], magnetic flux density

[B], core losses, operating frequency, permeability, and the like) that meet the overall design requirements of the transformer. For example – operability in operation frequencies in the range of 50kHz-5MHz, etc. UTC 201 is formed to accommodate windings toroid 250 that may be utilized to host primary and secondary windings of UTT 200, with turns ratio as required and high voltage in-to-out isolation as required.

[0032] Reference is made now also to **Fig. 2B** which is a schematic three-dimensional (3D) blown illustration of ultra-thin transformer 200 of Fig. 2A, according to embodiments of the present invention. As shown in Fig. 2B, base unit 202 comprises a plurality of dents, or engraving, 202A forming toroidic space in base unit 202 formed around central core branch 202B. Cover unit 204 is made to fit onto and fully cover base unit 202, thereby completing a four-way magnetic path around core branch 202B and via four side branches 202C (as depicted by the grey arrows). As shown in Fig. 2B, at least one of the primary winding and the secondary winding may protrude from four faces of the UTC. However, the rectangular prism-shaped UTC of Fig. 2B is just a non-limiting example, whereas triangular prism-shaped UTCs (in which at least one of the primary winding and the secondary winding may protrude from three faces of the UTC) and substantially cylindrical UTCs (in which the toroidic space and the UTC have a common axis of symmetry) are possible as well. The hollow space defined between base unit 202 and cover unit 204 is depicted by toroid or a toroidic space 250, which schematically defines the volume available for the transformer's windings (toroid windings).

[0033] Reference is now made to **Fig. 2C**, which is a schematic cross section view of UTT 200 along cross section line AA in Fig. 2A. As can be seen in Fig. 2C, base unit 202 is covered by cover unit 204. The core 201 formed by base unit 202 and cover unit 204 forms magnetic flux paths, inter alia, as depicted by the arrows running through central core branch 202B and via side core branches 202C. The magnetic flux surrounds winding volume 250 which is adapted to accommodate the transformer's primary and secondary windings. In some embodiments of the present invention, the thickness TH_T of the transformer may be no more than 3.95 mm (maximal thickness), the thickness of the base unit basis TH_B may be no more than 1.1 mm and the thickness TH_C of the cover unit may be no more than 1.1 mm, leaving at least 1.75 mm for the windings of the transformer (SOL_H).

[0034] Reference is now made to **Fig. 2D**, which is a schematic cross section view of the primary windings 251A, 251B and of the secondary winding 252, according to embodiments of the present invention. The primary winding may be embodied using two layers of windings, disposed at the external opposite ends of transformer's winding 250. The secondary winding may be embodied in one or more adjacent layers disposed between the primary windings layers. Each of the windings layers may comprise a flat helical continuous wire, as explained in details below.

[0035] The primary winding layers may be made of electrical wire having triple insulation, to conform with high voltage insulation requirements, such as UL 60950. Typically, but not limited to, the number of turns of the primary will be higher than that of the secondary, to provide voltage step-down transformation. In other embodiments, the transformer may be designed for voltage step-up function or simply for galvanic isolation with, for example 1:n transformation ratio.

[0036] The production of the transformer stage with the higher number of turns may raise some production difficulties, for example when producing the flat helical layer with a wire having diameter of 0.42 mm or less. It may be convenient to wound the helical winding of a certain transformer layer between two flat plates and remove the plates when the winding is finished. See one such support plate 370 in **Fig. 3B**, which is a schematic illustration of a method for producing very thin helical winding. Yet, due to the small size / diameter of the wire and its low stiffness figure, when the support plates are removed the helical coil may collapse. According to some embodiments, the winding of such small size helical coil may be carried out using electrical wires coated, around the insulation layer, with very thin polymeric coating. The coating may have melting point CT_M (°C) lower than that of the wire insulating coating. When the preparation of the helical coil between the support plates terminates, the coil may be heated to the CT_M temperature thereby melting the polymeric coating. After a pre-determined heating time the heating may be stopped allowing the coil to cool down and the polymeric coating to solidify, thereby to solidify the coil. The heating may be carried out using any known means and methods, such as direct heating (e.g., hot air), induction heating, ultrasonic heating, and the like. The support plates may be selected from material that has low tendency to solidify with the polymeric material, to ease the separation of the plates after the polymeric costing has solidified. The windings of the primary stage may be embodied by performing a helical winding layer running from the outer perimeter inbound, crossing next to the navel (or center) of the transformer from an external primary winding layer to the external primary layer on the other side of the transformer and being wound from the inner perimeter outbound thereby creating a single winding of the primary stage embodied in two layers formed at two opposing external layers.

[0037] Between the helical coils layers, insulation layers 253, 255 may be placed if needed. However, when low thickness is a goal of design and the regulation does not require such insulation, such insulation layers may be avoided.

[0038] Reference is made now to Fig. 3A which schematically depicts three helical windings 352, 354 and 356 in a blown view, according to embodiments of the present invention. Each of the helical windings may have external diameter D350, internal diameter d350 and helical coil thickness T352, T354 and T356, respectively. The thickness of the coils may be selected to optimally utilize the available coils volume while considering the currents flowing in each of the coils, to arrive at an

optimal utilization of the volume, or – to arrive at a minimal transformer thickness for a given available width and length and required transformation power. The UTT may further comprise two input terminals and two output terminals, wherein the input terminals may be connected to the primary winding and the output terminals may be connected to the secondary winding. According to some embodiments, in order to enable high number of windings of the secondary coil, two layers or more of coils may be connected electrically in series. For example, coils 352 and 356 may be connected in series, and the direction of turns is set to provide unified magnetic flux in the same direction. The connection may be carried out by a via connector (not shown in the drawing), which may be embodied with the same insulation requirements applied to the windings. According to some embodiments, the diameter of the wire of the secondary winding may be changed along the helical winding in order to ensure that each of the turns has the same internal resistance per full turn, i.e., the diameter of the external windings may be larger than that of internal winding in order to compensate for longer winding length. In other embodiments, the change in external resistance may be achieved in other ways, such as change in the purity of the wire material along the winding. In some embodiments, the winding of the secondary stage may be of a wire that has same diameter along the entire winding.

[0039] According to some embodiments, in order to achieve very low impedance of the secondary stage, secondary terminals of two or more transformers may be connected in parallel.

[0040] According to some embodiments the terminals of the secondary windings may be positioned rotated in 90 degrees with respect to the orientation of the terminals of the primary windings, in order to optimize the utilization of the volume around the windings and allow for better minimization of the transformer.

[0041] The ferromagnetic material(s) for the production of the transformer core may be selected according to considerations such as work frequency, required / limitation of power losses, energy storage capability, and the like.

[0042] While certain features of the invention have been illustrated and described herein, many modifications, substitutions, changes, and equivalents will now occur to those of ordinary skill in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

CLAIMS

What is claimed is:

1. An ultra-thin transformer (UTT), the UTT comprising:
   an ultra-thin magnetic core (UTC), the UTC comprising:
   a base unit comprising:
   a central core branch;
   at least one side branch;
   a plurality of dents forming a toroidic space in the base unit around the central core branch; and
   an open face;
   a cover unit adapted to match the open face of the base unit;
   a primary winding; and
   a secondary winding.
2. The UTT of claim 1, wherein the primary winding further comprises two layers of windings disposed at opposite ends, wherein the secondary winding is disposed in at least one layer between the two primary winding's layers, each of the winding layers comprises a flat helical continuous wire.
3. The UTT of claim 2, wherein a first primary winding's layer is a helical winding layer that is wound from the UTC's perimeter inbound, crossing next to the center of the UTT from the first primary winding's layer to a second primary winding's layer positioned opposite to the side of the first primary winding's layer, wherein the second primary winding's layer is wound from the UTC's perimeter outbound, thereby creating a single winding of the primary winding via two opposing layers.
4. The UTT of claim 3, wherein the primary winding's layers are made of an electrical wire having a triple insulation adapted to conform with high voltage insulation requirements.
5. The UTT of claim 1 further comprising a windings toroid adapted to substantially cover the primary winding and the secondary winding
6. The UTT of claim 1 comprising four side branches forming a substantially rectangular prism-shaped UTC, wherein at least one of the primary winding and the secondary winding may protrude from four faces of the UTC.
7. The UTT of claim 1 comprising three side branches forming a substantially triangular prism-shaped UTC, wherein at least one of the primary winding and the secondary winding may protrude from three faces of the UTC.

8. The UTT of claim 1, wherein the UTC is substantially cylindrical, wherein the toroidic space and the UTC have a common axis of symmetry.
9. The UTT of claim 1, wherein the UTC is made of a magnetic permeable material.
10. The UTT of claim 1, wherein it is operable in operation frequencies in the range of 50kHz-5MHz.
11. The UTT of claim 1, wherein the maximal thickness of the UTT is 3.95 mm, wherein the maximal thickness of the base unit's face is 1.1 mm, wherein the maximal thickness of the cover unit is 1.1 mm, leaving space of at least 1.75 mm for the primary winding and the secondary winding.
12. The UTT of claim 1 further comprising:

    two input terminals; and

    two output terminals,

    wherein the input terminals may be connected to the primary winding and the output terminals may be connected to the secondary winding.
13. The UTT of claim 1, wherein the UTT is adapted to connect to at least one selected from the group comprising of a power supplier, a battery charger, a thin battery, a laptop, and to a smartphone.
14. The UTT of claim 1, wherein the UTT is utilized as a step-down transformer.
15. The UTT of claim 1, wherein the UTT is utilized as a step-up transformer.
16. The UTT of claim 1, wherein the UTT is used for galvanic isolation.
17. The UTT of claim 1, wherein the transformation ratio is 1:n.
18. A method for production of thin helical winding, the method comprising:

    obtaining a wire adapted to form a helical layer;

    winding the wire of certain transformer's layer between two flat plates; and

    removing the flat plates when the layer is finished.
19. The method of claim 18, wherein the helical layer is made of a wire having diameter of 0.42 mm or less.
20. The method of claim 18, wherein the wire is coated with very thin polymeric coating, wherein the coating's melting point is lower than that of the wire insulating coating.
21. The method of claim 20 further comprising after winding the wire:

    heating the coating to its melting point temperature, thereby melting the coating; and

    stopping the heating after a pre-determined heating time, allowing the coil to cool down, thereby to solidify the coil.
22. The method of claim 21, wherein the heating is performed using a mean selected from the group comprising of direct heating, hot air, induction heating, and ultrasonic heating.

23. The method of claim 21, wherein the flat plates are made of a material that has low tendency to solidify with the polymeric material.
24. The UTT of claim 1 further comprising a plurality of insulation layers, wherein each insulation layer is placed between two helical coil layers.
25. The UTT of claim 1, wherein two layers or more of coils are connected electrically in series, wherein the direction of turns is set to provide a unified magnetic flux in the same direction.
26. The UTT of claim 1, wherein the diameter of the wire of the secondary winding is changed along the helical winding.
27. The UTT of claim 1, wherein the change in resistance is achieved by changing the purity of the wire material.
28. A plurality of UTTs according to claim 12, wherein the secondary terminals of two or more UTTs are connected in parallel.
29. The UTT of claim 12, wherein the terminals of the secondary winding are positioned rotated in 90 degrees with respect to the orientation of the terminals of the primary winding.

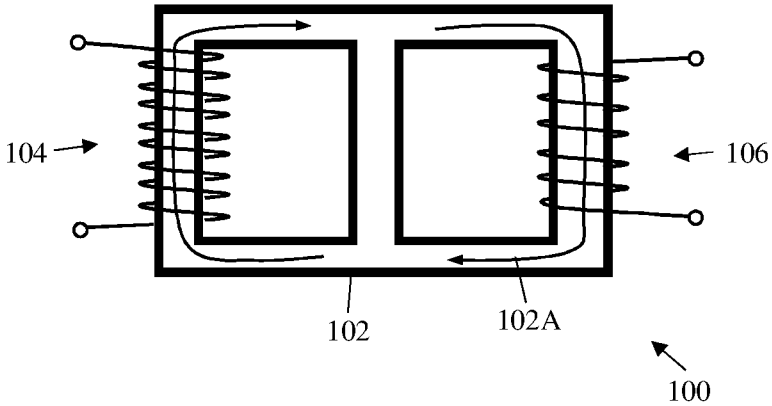


Fig. 1A

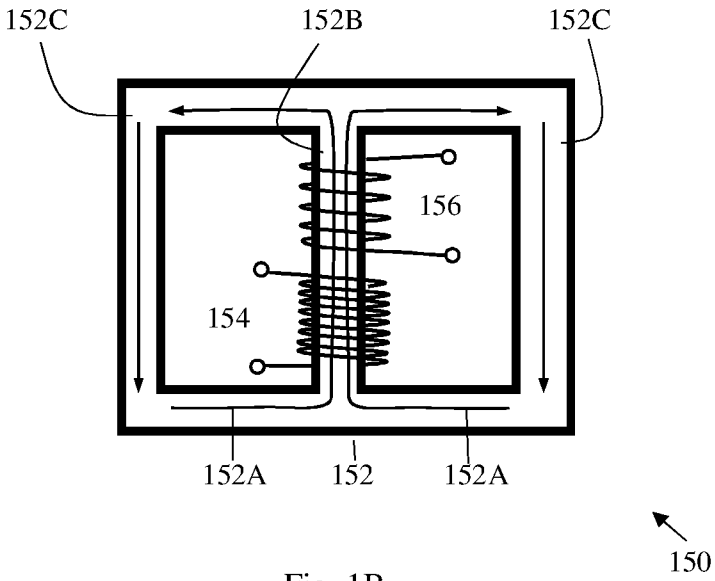


Fig. 1B

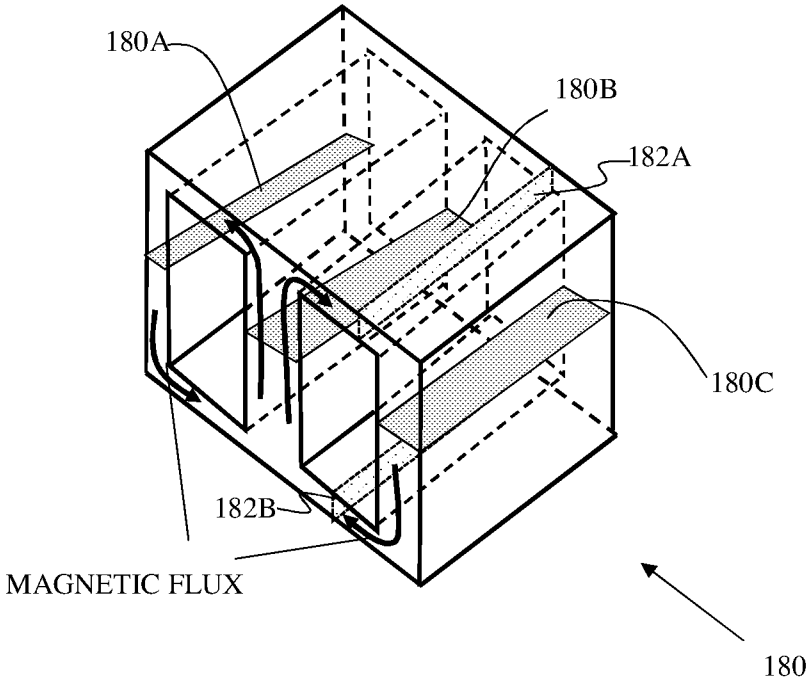


Fig. 1C

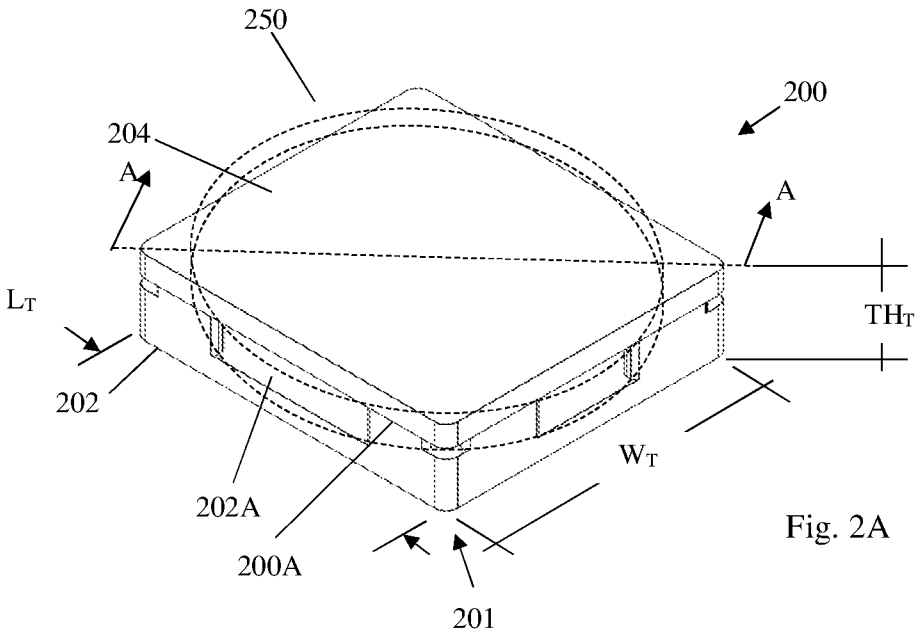

250
200
204
A
A
L_T
TH_T
202
W_T
202A
200A
201

Fig. 2A

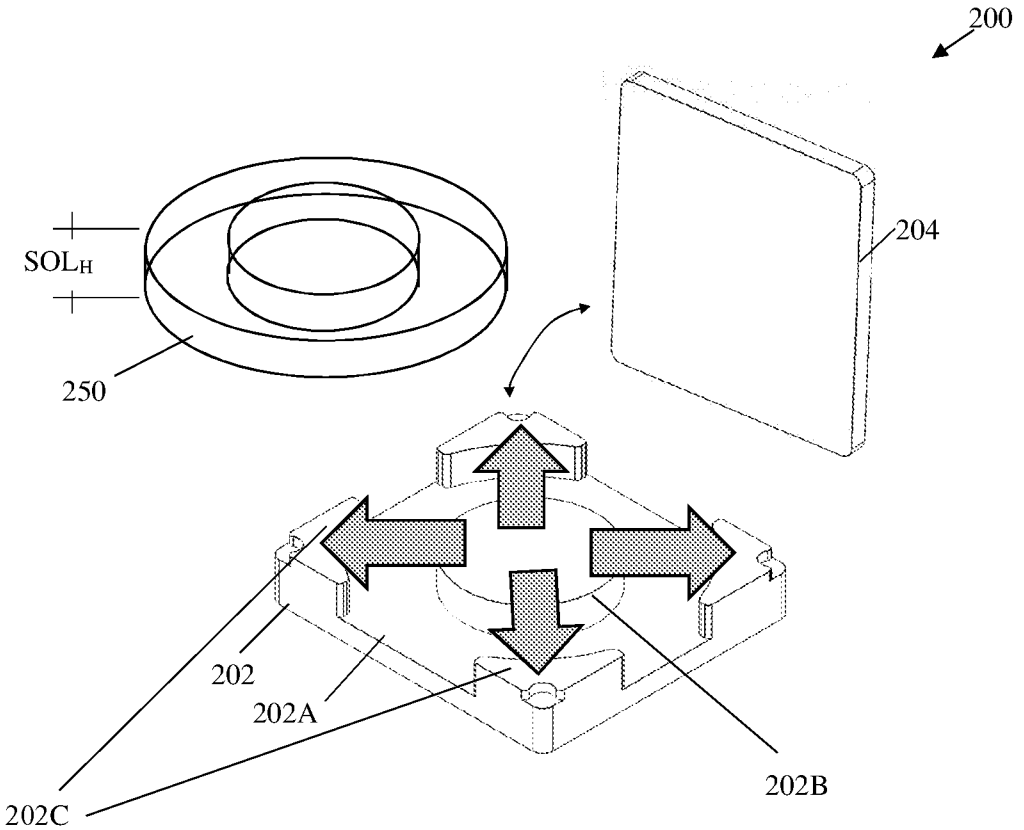

200
204
SOL_H
250
202
202A
202C
202B

Fig. 2B

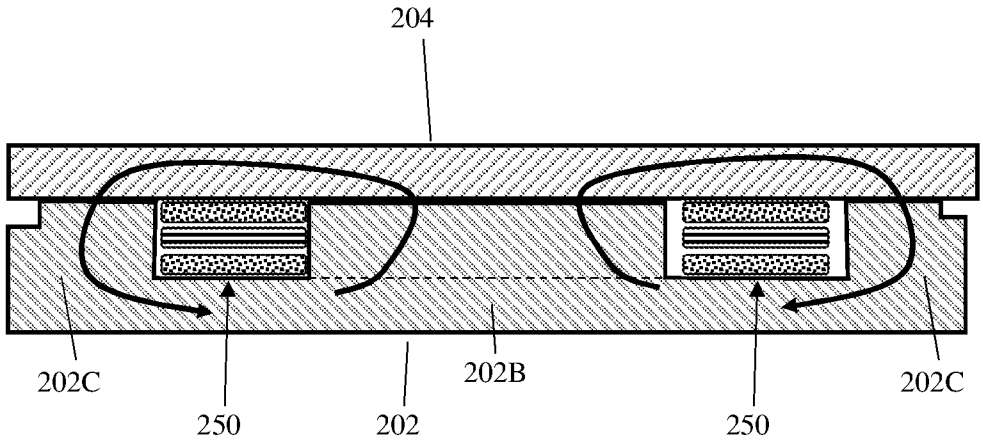

204
202C
250
202
202B
250
202C

Fig. 2C

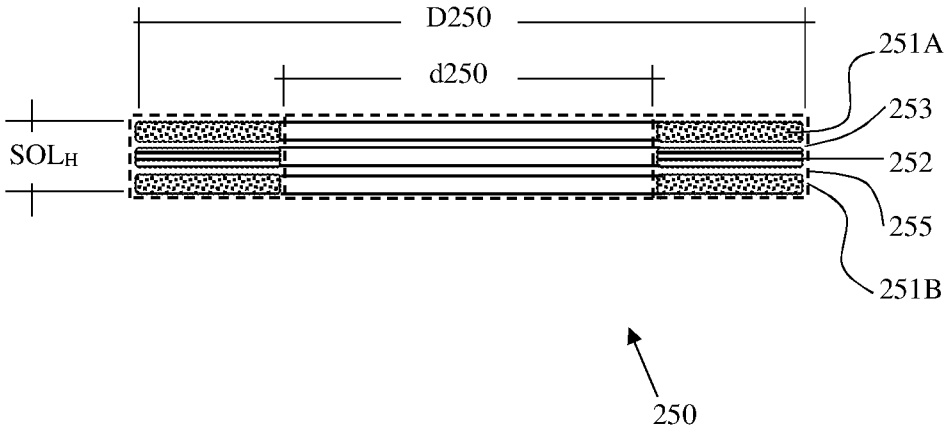

D250
d250
SOLH
251A
253
252
255
251B
250

Fig. 2D

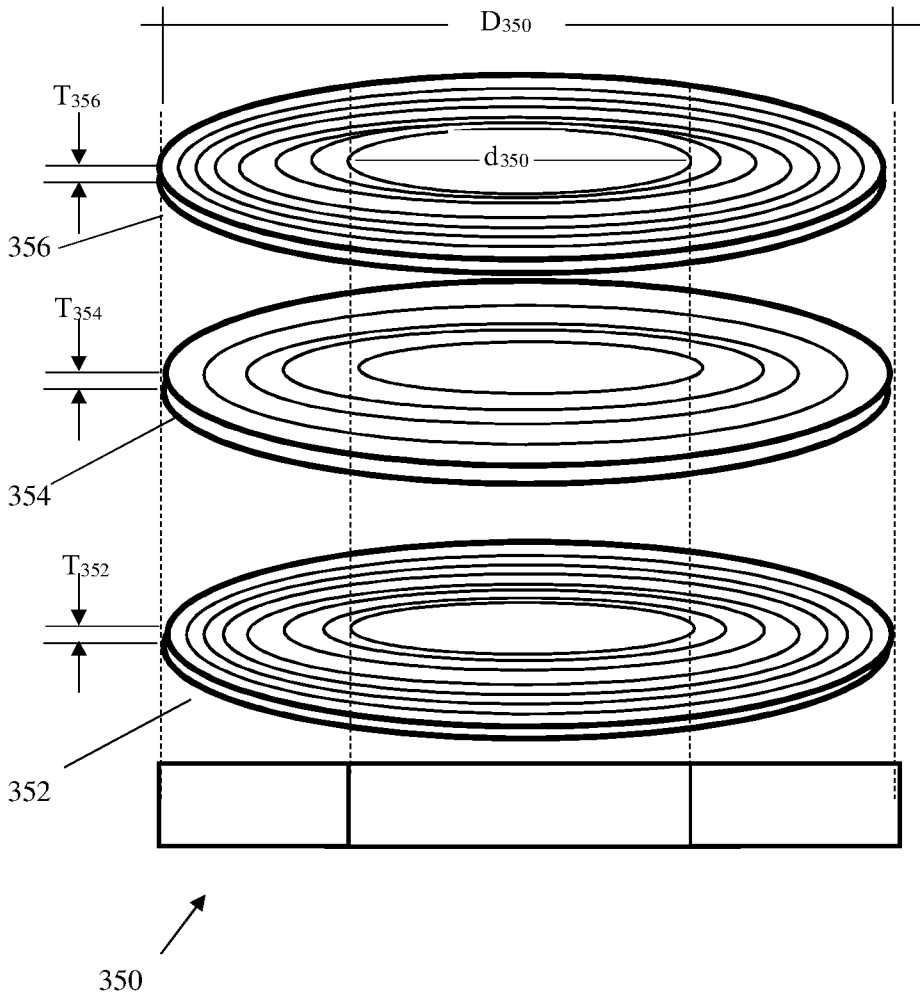


Fig. 3A

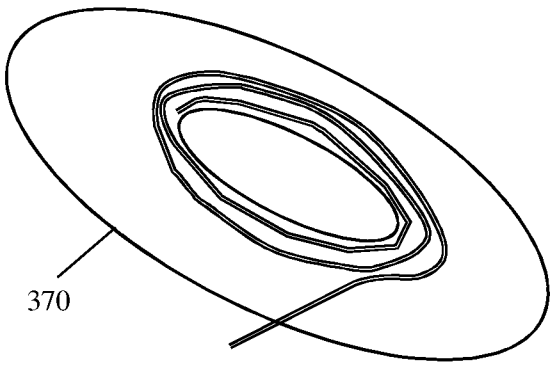


Fig. 3B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2018/050585

A. CLASSIFICATION OF SUBJECT MATTER
IPC (2018.01) H01F 27/24, H01F 27/26, H01F 27/30, H01F 41/00

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 (2018.01) H01F

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP H0521244 A 29 Jan 1993 (1993/01/29) Entire Document	1,2,5,8-10,12,13,25
Y	Entire Document	3,4,11,14,17-24
X	CN 101996759 A 30 Mar 2011 (2011/03/30) Entire Document	1-29
A	DE 4117878 A1 12 Dec 1991 (1991/12/12) Entire Document	1-29
A	DE 202005008757 U1 12 Oct 2006 (2006/10/12) Entire Document	1-29

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 Nov 2018	01 Nov 2018

Name and mailing address of the ISA:	Authorized officer
Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. 972-2-5651616	ABU RABIA Nizar Telephone No. 972-2-5651765

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2018/050585

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2004070480 A1 15 Apr 2004 (2004/04/15) Entire Document	1-29
A	US 2008186121 A1 07 Aug 2008 (2008/08/07) Entire Document	1-29

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2018/050585

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
JP H0521244 A	29 Jan 1993	JP H0521244 A	29 Jan 1993
CN 101996759 A	30 Mar 2011	CN 101996759 A	30 Mar 2011
DE 4117878 A1	12 Dec 1991	DE 4117878 A1	12 Dec 1991
		DE 4117878 C2	26 Sep 1996
		JP 2001102235 A	13 Apr 2001
		JP 3382215 B2	04 Mar 2003
		JP H04363006 A	15 Dec 1992
		JP 3441082 B2	25 Aug 2003
		JP 2001110639 A	20 Apr 2001
		JP 3540733 B2	07 Jul 2004
		KR 960006848 B1	23 May 1996
		US 5583474 A	10 Dec 1996
		US 5801521 A	01 Sep 1998
		US 6404317 B1	11 Jun 2002
		US 6593841 B1	15 Jul 2003
DE 202005008757 U1	12 Oct 2006	DE 202005008757 U1	12 Oct 2006
		AT 381766 T	15 Jan 2008
		AT 451703 T	15 Dec 2009
		DE 502006000228 D1	31 Jan 2008
		DE 502006005568 D1	21 Jan 2010
		DK 1729310 T3	05 May 2008
		DK 1772877 T3	26 Apr 2010
		EP 1729310 A1	06 Dec 2006
		EP 1729310 B1	19 Dec 2007
		EP 1772877 A1	11 Apr 2007
		EP 1772877 B1	09 Dec 2009
		ES 2299118 T3	16 May 2008
		ES 2337279 T3	22 Apr 2010

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IL2018/050585

Patent document cited search report	Publication date	Patent family member(s)	Publication Date
US 2004070480 A1	15 Apr 2004	US 2004070480 A1	15 Apr 2004
		US 6859130 B2	22 Feb 2005
		CN 1491423 A	21 Apr 2004
		CN 100403462 C	16 Jul 2008
		EP 1439553 A1	21 Jul 2004
		EP 1439553 A4	24 Dec 2008
		JP WO2003036665 A1	17 Feb 2005
		WO 03036665 A1	01 May 2003
US 2008186121 A1	07 Aug 2008	US 2008186121 A1	07 Aug 2008
		US 7443278 B2	28 Oct 2008
		CN 101258567 A	03 Sep 2008
		CN 101258567 B	04 Jul 2012
		EP 1933340 A1	18 Jun 2008
		EP 1933340 A4	15 Jun 2011
		EP 1933340 B1	01 Aug 2012
		JP WO2007029594 A1	19 Mar 2009
		KR 20080042923 A	15 May 2008
		KR 101044373 B1	29 Jun 2011
		TW 200715312 A	16 Apr 2007
		TW I317956 B	01 Dec 2009
		WO 2007029594 A1	15 Mar 2007