(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 811 495 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
11.01.2017 Bulletin 2017/02

(51) Int Cl.:
H01F 38/00 *(2006.01)* ***H01F 3/12*** *(2006.01)*

(21) Application number: **13170704.4**

(22) Date of filing: **05.06.2013**

(54) **Transformer**

Wandler

Transformateur

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(43) Date of publication of application:
10.12.2014 Bulletin 2014/50

(73) Proprietor: **Delphi Automotive Systems Luxembourg SA**
4940 Bascharage (LU)

(72) Inventors:
- **Heise, Volker**
  54292 Trier (DE)
- **Aye, Andreas**
  8033 Strassen (LU)
- **Kneppers, Gerard J.**
  6760 Virton (BE)

(74) Representative: **Delphi France SAS**
Patent Department
22, avenue des Nations
CS 65059 Villepinte
95972 Roissy CDG Cedex (FR)

(56) References cited:
EP-A1- 0 283 354
EP-A1- 0 913 841
EP-A1- 2 518 740
EP-A2- 2 498 266
CN-U- 202 258 665
US-A1- 2004 085 173
US-A1- 2004 085 174

EP 2 811 495 B1

Description

TECHNICAL FIELD

[0001] This disclosure relates to a transformer and has particular, but not exclusive application, to a transformer for an ignition apparatus or coil, such as for, but not limited to, automotive applications.

BACKGROUND OF THE INVENTION

[0002] Conventional ignition coils are realized with gapped transformers. The transformers generally include a core of magnetic highly permeable material, around which primary and secondary windings are located. A closed magnetic return path is provided by a generally C or U shaped magnetic return path element, the magnetic core being located between two end faces of the return path element. Preferred materials for the magnetic core and for the magnetic return path element are laminated metal sheets.

[0003] Typically, one end of the magnetic core directly abuts or contacts one end face of the magnetic return path element. Between the other end face of the magnetic return path element and the other end of the core is typically located a magnet or simply an air-gap. During the operation of such a coil transformer, heat is created dominantly by ohmic losses in the primary and secondary winding.

[0004] Magnetic saturation zones can be created at interfaces between the magnetic return path element and the magnetic core. Saturation is built-up inside the magnetic return path element, around the interface region to the magnetic core. Generally such saturation causes a problem in that it limits the performance of the entire magnetic circuit. Known solutions are to increase the cross-sections of the magnetic path element or use magnetic material with higher magnetic permeability. Either solution is not desired because it increases weight, volume and/or cost. Documents US 2004/085174A1 and US 2004/085173A1 disclose a transformer device comprising bulk amorphous metal.

[0005] It is an object of the invention to provide an improved transformer that overcomes such problems.

SUMMARY OF THE INVENTION

[0006] According to the present invention there is provided a transformer according to present claim 1. Preferred features are specified in dependent claims 2 to 13.

[0007] Further features, uses and advantages of the invention will appear more clearly on a reading of the following detailed description of the embodiments of the invention, which is given by way of non-limiting example only and with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] This invention will be further described by way of example and with reference to the accompanying drawings in which:

Figure 1 shows a schematic longitudinal section through transformer of an ignition coil, in accordance with one basic example of the invention.

Figure 2 shows a schematic longitudinal section through transformer of an ignition coil, in accordance with a further example of the invention.

Figure 3 shows a schematic longitudinal section through transformer of an ignition coil, in accordance with another example of the invention.

DETAILED DESCRIPTION OF THE PREFFERED EMBODIMENTS

[0009] Figure 1 shows a simple transformer according to one embodiment of the invention. The transformer comprises a magnetic core 12, a primary winding 14 and secondary winding 16, a magnetic return path element 18 and a first gap component 30. The magnetic core 12 extending along a longitudinal axis 'A' is generally cylindrical in overall shape and includes two ends 20 and 22. The magnetic return path element 18 is configured to provide a high permeability magnetic return path, and has a base section 24 and two end faces 26 and 28. The typical width for gap component 30 is 0.5 to 2 mm. Gap components could have different thickness.

[0010] A second gap component 34 is located symmetrically to the first gap component 30. More precisely, the first and the second gap component 30 and 34 are located between each end faces of section 26 and 28 of the magnetic return path element 18 and the respective ends 20 and 22 of the magnetic core 12. The magnetic core 12 in combination with the magnetic return path element 18, and gap components form a magnetic circuit having a high magnetic permeability.

[0011] The two gap components 30 and 34 may be formed from ceramic or other material. Preferably this material has a heat conductivity greater than 1 W/m/K. The choice of using heat conducting material for one or two gap components 30 and 34 can be selected to dissipate heat generated by the primary winding 14 and the secondary winding 16 from the magnetic core 12 to the magnetic return path element 18 either with a preferential direction or symmetrically. Preferably the gap components 30 and 34 are formed from materials such as ceramics; for example ceramics including aluminum-oxide, aluminum-nitrides or any similar materials. The additional second gap component 34, arranged symmetrically about the transverse axis 'B' to the first gap component 30 in the magnetic core 12, allows balancing of the magnetic circuit and by this allows an increase the total flux of the circuit. As an example, one gap component could be realized by a permanent magnetic material, whereas

the second gap could be made out of any filling material, preferably with high thermal conductivity. This transformer topology increases the output performance of the transformer 10 and provides for a smaller more compact transformer.

[0012] Figure 2 shows a transformer according to another embodiment of the invention. The transformer comprises again a magnetic core 12, a primary winding 14 and secondary winding 16, a magnetic return path element 18 and two gap components 30 and 34. The transformer is encapsulated within e.g. an epoxy material 32 with typical heat conductivities in the range of 0.1 to 1 W/m/K, to provide electrical insulation. The two gap components 30 and 34 encapsulated inside the epoxy 32 potting material may be provided by spacers. The two gap components allow balancing of the magnetic circuit and by this allow an increase the total flux of the circuit. The spacers provide the advantage of a lighter transformer.

[0013] The epoxy potting material 32 also provides protection from environmental factors which may be encountered during the service life of the transformer. During the operation of the transformer 10, heat is created dominantly by ohmic losses of the primary winding 14 and secondary winding 16. This heat is conducted through the epoxy 32 encapsulation of the transformer to the surface. The transformer 10 mays have an insulating plastic housing 38 in order to attach, for instance, connectors. This transformer topology increases the output performance of the transformer 10 or to further miniaturize its magnetic circuit.

[0014] Figure 3 illustrates a further refined and preferred embodiment of the invention. The drawing shows similar components and reference numerals as before. The embodiment further however includes a heat sink 36 and an electronic circuit board 40.

[0015] The heat sink 36 may be attached to the magnetic return path element 18 providing a large surface to reduce the internal temperature of the primary winding 14 and secondary winding 16 during transformer operation. The heat sink 36 can be attached by means of an over-mold, welding, clamping directly or any similar method, to the magnetic return path element18. The heat sink 36 is preferably made of magnetic or non-magnetic metal material and allows heat to flow outside of the plastic housing 38. The heat sink 36 may have additional means to attach to an integrated electronic circuit board 40 and serves by this for dissipating the heat from the electronic circuit board 40. The electronic circuit board is preferably used as an electronic control board for the ignition coil comprising the transformer 10.

[0016] The heat sink 36 may further be formed as a bracket that can be fixed to a vehicle chassis. Optionally the bracket can be split into at least two individual elements. The thickness and contact surface of the heat sink 36 can be varied so as to provide desired heat dissipation requirements. The shape of the heat sink 36 is preferably conforms to the shape of the outer surface of the magnetic return path element 18. Within the invention, ignition coil topology allows balancing the magnetic circuit and by this allows increasing the total flux of the circuit. This can be used either to increase the output performance or to further miniaturize the magnetic circuit

Claims

1. A transformer (10) comprising:

   a magnetic core (12) extending along a longitudinal axis (A), being cylindrical in overall shape and including two ends (20, 22) forming two opposite radial surfaces;
   a U shaped magnetic return path element (18) having a base (24) and two legs and providing a magnetic return path for the magnetic core (12); said magnetic core (12) being located between two internal end faces (26,28) of the two legs of the U shaped magnetic return path element (18);
   a primary coil or winding (14), surrounding the magnetic core (12);
   a secondary coil or winding (16) surrounding the primary winding/coil (14);
   a first gap component (30) located between one end (20) of the magnetic core (12) and one corresponding internal end face (26) of the magnetic return path element (18);
   a second gap component (34) is located between the other end (22) of the magnetic core (12) and the corresponding other internal end face (28) of the magnetic return path element (18).

2. A transformer (10) as claimed in claim 1 wherein said second gap component (34) is located symmetrically to the first gap component (30) in the magnetic core (12) about an axis perpendicular to the core axis.

3. A transformer (10) as claimed in any previous claims wherein the magnetic core (12), the magnetic return path element (18), the primary winding (14) and the secondary winding (16) are encapsulated.

4. A transformer (10) as claimed in claim 3 wherein the encapsulating material is an epoxy resin (32).

5. A transformer (10) as claimed in any previous claims wherein at least one of the gap components (30, 34) is formed from an electrical isolating material.

6. A transformer (10) as claimed in any previous claims wherein at least one of the gap components (30, 34) are formed from a material with a thermal conductivity greater than 1 W/m/K.

7. A transformer (10) as set in any of previous claims wherein the two gap components (30, 34) are formed from a ceramic material.

8. A transformer (10) as claimed in claim 7 wherein said ceramic material includes aluminum-oxide or aluminum-nitrides.

9. A transformer (10) as claimed in any of previous claims further including a heat sink (36) surrounding a substantial portion of said transformer (10).

10. A transformer (10) as claimed in claim 9 wherein said heat sink includes a bracket.

11. A transformer (10) as claimed in claims 9 or 10 wherein an electronic board (40) is attached to the heat sink (36).

12. A transformer (10) as claimed in any of previous claims including an insulating housing (38).

13. An ignition coil including a transformer (10) as claimed in any preceding claim.

Patentansprüche

1. Ein Wandler (10), der aufweist:

einen Magnetkern (12), der sich entlang einer Längsachse (A) erstreckt, eine zylinderförmige Gesamtform hat und zwei Enden (20, 22) umfasst, die zwei gegenüberliegende radiale Oberflächen bilden;
ein U-förmiges magnetisches Rückpfadelement (18), das eine Basis (24) und zwei Schenkel hat und einen magnetischen Rückpfad für den Magnetkern (12) vorsieht; wobei sich der Magnetkern (12) zwischen zwei internen Endflächen (26, 28) der zwei Schenkel des U-förmigen magnetischen Rückpfadelements (18) befindet;
eine Primärspule oder -wicklung (14), die den Magnetkern (12) umgibt;
eine Sekundärspule oder -wicklung (16), die die Primärwicklung/spule (14) umgibt;
eine erste Spaltkomponente (30), die sich zwischen einem Ende (20) des Magnetkerns (12) und einer entsprechenden internen Endfläche (26) des magnetischen Rückpfadelements (18) befindet;
eine zweite Spaltkomponente (34) befindet sich zwischen dem anderen Ende (22) des Magnetkerns (12) und der entsprechenden anderen internen Endfläche (28) des magnetischen Rückpfadelements (18).

2. Ein Wandler (10) gemäß Anspruch 1, wobei die zweite Spaltkomponente (34) symmetrisch zu der ersten Spaltkomponente (30) in dem Magnetkern (12) um eine Achse senkrecht zu der Kernachse angeordnet ist.

3. Ein Wandler (10) gemäß einem der vorhergehenden Ansprüche, wobei der Magnetkern (12), das magnetische Rückpfadelement (18), die Primärwicklung (14) und die Sekundärwicklung (16) eingekapselt sind.

4. Ein Wandler (10) gemäß Anspruch 3, wobei das Einkapselungsmaterial ein Epoxidharz (32) ist.

5. Ein Wandler (10) gemäß einem der vorhergehenden Ansprüche, wobei zumindest eine der Spaltkomponenten (30, 34) aus elektrisch isolierendem Material gebildet ist.

6. Ein Wandler (10) gemäß einem der vorhergehenden Ansprüche, wobei zumindest eine der Spaltkomponenten (30, 34) aus einem Material mit einer Wärmeleitfähigkeit von mehr als 1 W/m/K gebildet ist.

7. Ein Wandler (10) gemäß einem der vorhergehenden Ansprüche, wobei die zwei Spaltkomponenten (30, 34) aus einem keramischen Material gebildet sind.

8. Ein Wandler (10) gemäß Anspruch 7, wobei das keramische Material Aluminium-Oxid oder Aluminium-Nitride umfasst.

9. Ein Wandler (10) gemäß einem der vorhergehenden Ansprüche, der weiter eine Wärmesenke (36) umfasst, die einen wesentlichen Teil des Wandlers (10) umgibt.

10. Ein Wandler (10) gemäß Anspruch 9, wobei die Wärmesenke eine Klammer umfasst.

11. Ein Wandler (10) gemäß Anspruch 9 oder 10, wobei eine elektronische Platine (40) an der Wärmesenke (36) angebracht ist.

12. Ein Wandler (10) gemäß einem der vorhergehenden Ansprüche, der ein isolierendes Gehäuse (38) umfasst.

13. Eine Zündspule mit einem Wandler (10) gemäß einem vorhergehenden Anspruch.

Revendications

1. Transformateur (10) comprenant:

un noyau magnétique (12) s'étendant le long d'un axe longitudinal (A), ayant une forme glo-

bale cylindrique et incluant deux extrémités (20, 22) formant deux surfaces radiales opposées ;
un élément formant trajet de retour magnétique (18) en forme de U ayant une base (24) et deux branches et réalisant un trajet de retour magnétique pour le noyau magnétique (12) ; ledit noyau magnétique étant placé entre deux faces d'extrémité internes (26, 28) des deux branches de l'élément formant trajet de retour magnétique (18) en forme de U ;
un bobinage ou enroulement primaire (14) qui entoure le noyau magnétique (12) ;
un bobinage ou enroulement secondaire (16) qui entoure le bobinage/enroulement primaire (14) ;
un premier composant formant intervalle (30) placé entre une extrémité (20) du noyau magnétique (12) et une face d'extrémité interne correspondante (26) de l'élément formant trajet de retour magnétique (18) ;
un second composant formant intervalle (34) placé entre l'autre extrémité (22) du noyau magnétique (12) et l'autre face d'extrémité interne correspondante (28) de l'élément formant trajet de retour magnétique (18).

2. Transformateur (10) selon la revendication 1, dans lequel ledit second composant formant intervalle (34) est situé symétriquement au premier composant formant intervalle (30) dans le noyau magnétique (12) par rapport à un axe perpendiculaire à l'axe du noyau.

3. Transformateur (10) selon l'une quelconque des revendications précédentes, dans lequel le noyau magnétique (12), l'élément formant trajet de retour magnétique (18), l'enroulement primaire (14) et l'enroulement secondaire (16) sont encapsulés.

4. Transformateur (10) selon la revendication 3, dans lequel le matériau d'encapsulation est une résine époxy (32).

5. Transformateur (10) selon l'une quelconque des revendications précédentes, dans lequel l'un au moins des composants formant intervalle (30, 34) est formé d'un matériau électriquement isolant.

6. Transformateur (10) selon l'une quelconque des revendications précédentes, dans lequel l'un au moins des composants formant intervalle (30, 34) est formé d'un matériau avec une conductivité thermique plus élevée que 1 W/m/K.

7. Transformateur (10) selon l'une quelconque des revendications précédentes, dans lequel les deux composants formant intervalle (30, 34) sont formés d'un matériau céramique.

8. Transformateur (10) selon la revendication 7, dans lequel ledit matériau céramique inclut un oxyde d'aluminium ou des nitrures d'aluminium.

9. Transformateur (10) selon l'une quelconque des revendications précédentes, incluant en outre un puits de chaleur (36) entourant une portion substantielle dudit transformateur (10).

10. Transformateur (10) selon la revendication 9, dans lequel ledit puits de chaleur inclut une monture.

11. Transformateur (10) selon les revendications 9 ou 10, dans lequel une carte électronique (40) est attachée au puits de chaleur (36).

12. Transformateur (10) selon l'une quelconque des revendications précédentes, incluant un boîtier isolant (38).

13. Bobine d'allumage incluant un transformateur (10) selon l'une quelconque des revendications précédentes.

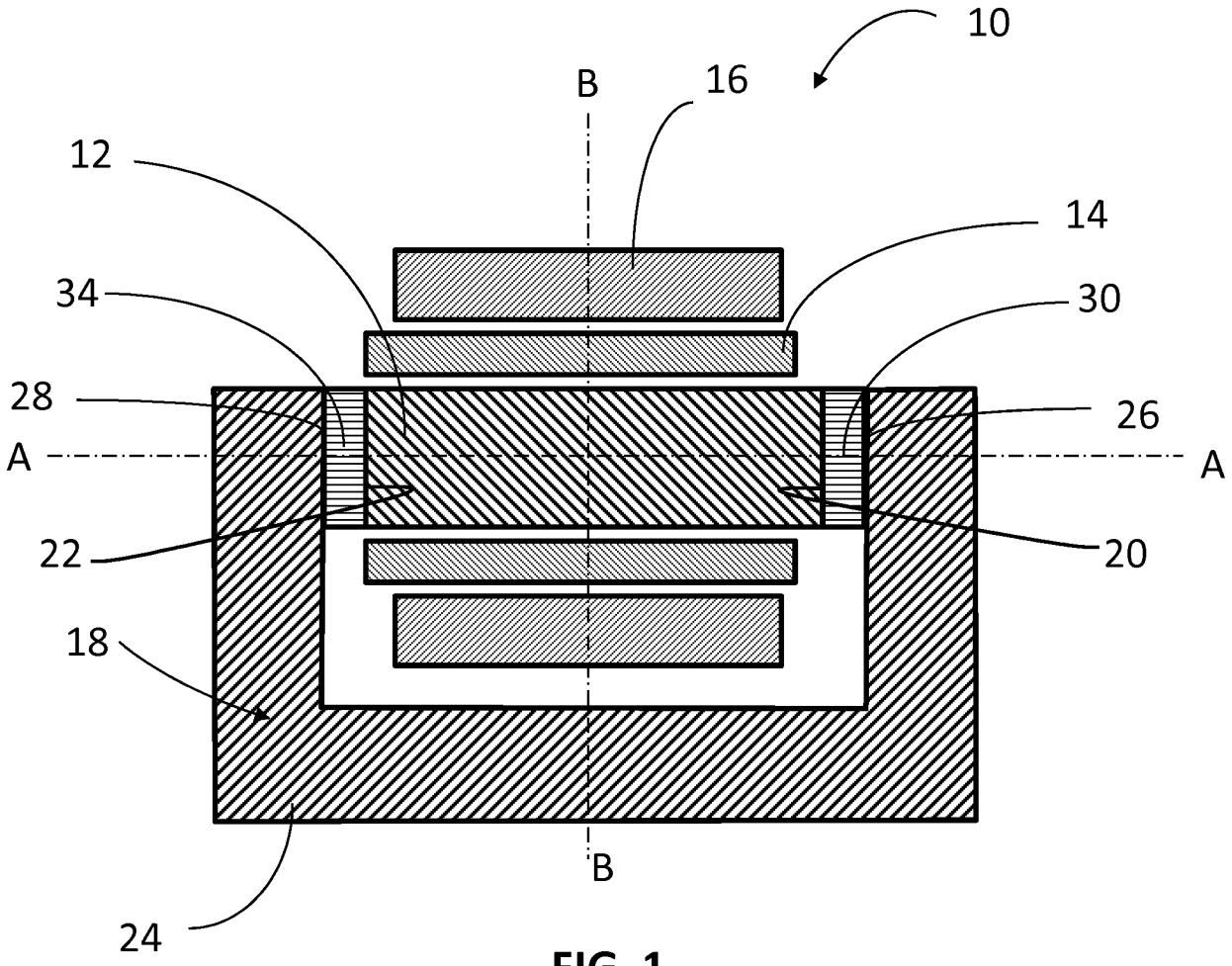

FIG. 1

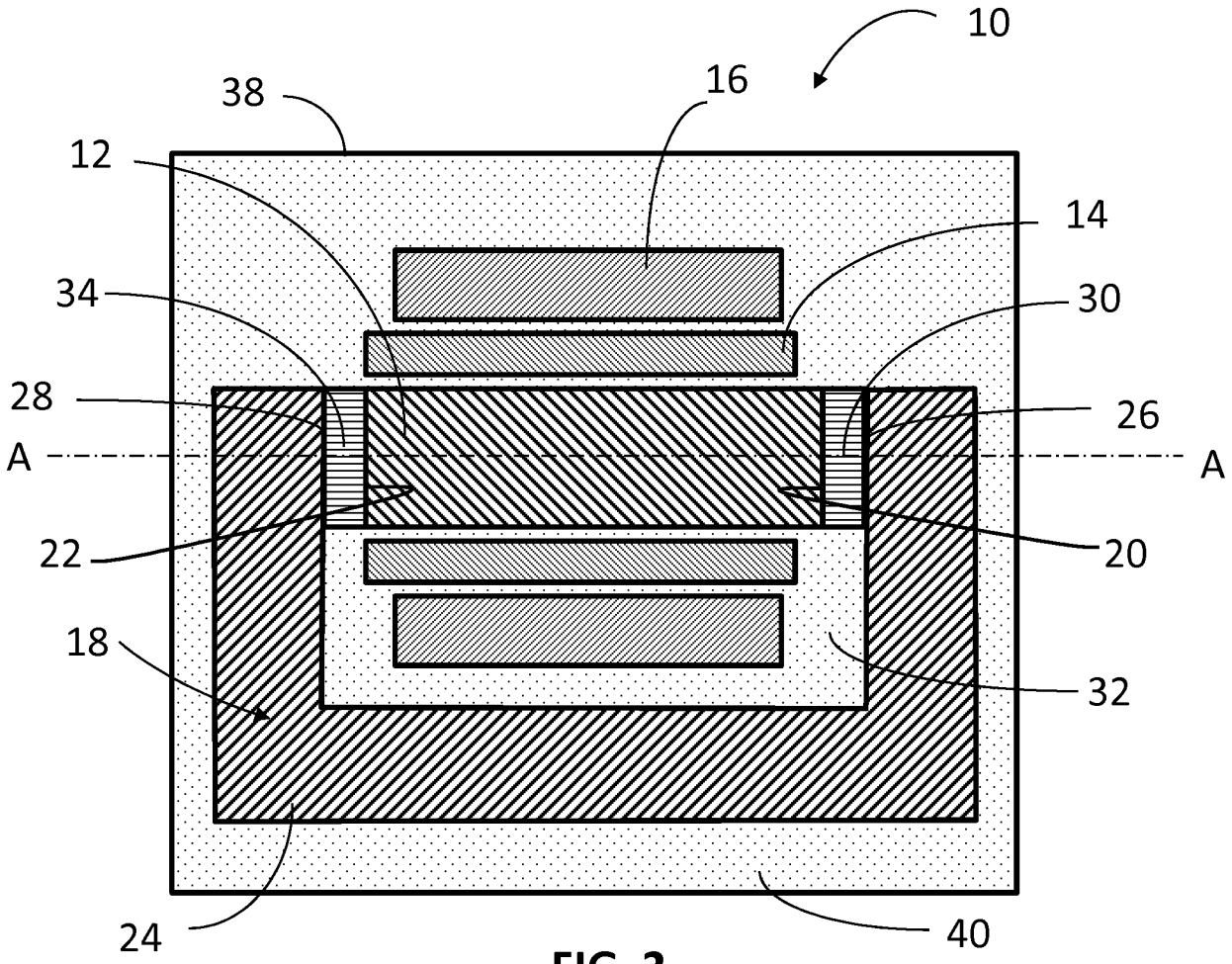

FIG. 2

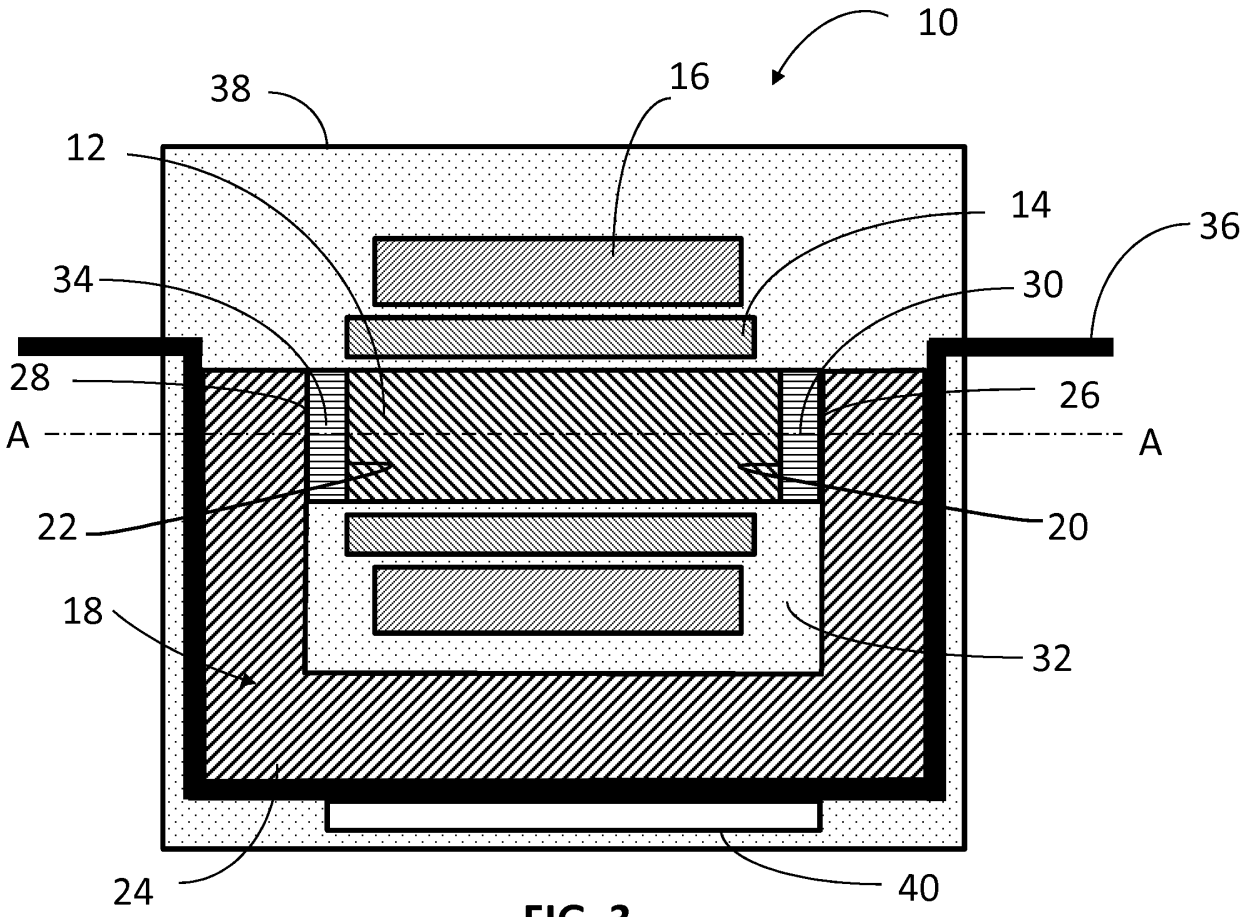

FIG. 3

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 2004085174 A1 **[0004]**
- US 2004085173 A1 **[0004]**