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(54) HIGH-VOLTAGE TRANSFORMER

HOCHSPANNUNGSTRANSFORMATOR

TRANSFORMATEUR HAUTE TENSION

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Description

[0001] The present invention relates to a high-voltage transformer according to the preamble of claim 1. The ends of the primary winding are connected to a low voltage direct electric current source, there being further provided means for interrupting the direct current intended to periodically interrupt the direct current supply to said primary winding.

[0002] The one just described is the common configuration of a high-voltage transformer known in the prior art, particularly the invention relates to high-voltage transformers used as igniters for gas, Diesel fuel and the like, that is for making an electric pulse for igniting a fuel.

[0003] Documents US2009/071454 and EP0297487 disclose a transformer according to the preamble of claim 1. Document EP2065907 discloses a coil assembly of a resonant circuit.

[0004] The transformer of the present invention is addressed to all the high-voltage transformers, particularly to transformers based on the Ruhmkorff coil, intended to generate high voltage and characterized by an open magnetic circuit.

[0005] Moreover it is specified that the term low voltage particularly refers to a rectified mains voltage, equal to about 250V.

[0006] The term low, that is the voltage at which the ends of the primary windings are connected has to be intended as "low" with respect to the output voltage at the ends of the secondary winding.

[0007] Therefore low voltage means a primary voltage, namely the voltage between the ends of the primary winding, about one hundred times lower than a secondary voltage, a high-voltage, that is the voltage between the ends of the secondary winding.

[0008] Currently almost all the high-voltage igniters are based on the Ruhmkorff coil where an induction coil, known also as Ruhmkorff coil, is characterized by a disruptive discharge coil.

[0009] It is a type of transformer particularly used for producing high-voltage pulses starting from a low-voltage direct current source. To produce the flux changes necessary to induce the electromotive force in the secondary winding, the direct current flowing in the primary winding is repeatedly interrupted by interruption means, such as for example vibrating contacts.

[0010] This type of transformer is also called as induction coil.

[0011] Its operation is quite simple, the transformer is composed of two solenoids, the primary one and the secondary one, wound around a single core made of a suitable magnetic material, such as for example ferrite. The first solenoid is called as primary winding and it is composed of few tens of insulated enamelled copper wire, with a large dimension, from few tens of millimeter to some millimeters. On the contrary the secondary one is composed of thousands of turns of copper wire suitably insulated, enamelled, with a dimension of few hundredths

of millimeter.

[0012] An electric current that passes through the primary winding creates a magnetic field, where the secondary winding is magnetically coupled by the magnetic core. The primary winding acts therefore as an inductor by storing energy in the associated magnetic field. When the electric current passing through the primary winding is suddenly interrupted, the magnetic field rapidly collapses with a consequent generation of a high voltage pulse through the secondary winding caused by the electromagnetic induction.

[0013] Due to the large number of turns of the secondary winding the generated pulse has a voltage of many thousands of Volt. This voltage is then sufficient to generate a pulse, an electric spark or discharge whatever it may be called, sufficient for igniting gases and/or liquid fuels.

[0014] In the modern and prior art known transformers the vibrating contact for interrupting the direct current present in the Ruhmkorff coil is replaced by modern electronic circuits.

[0015] As said above the modern high voltage igniters in most cases are composed of circuits obtained from the Ruhmkorff coil that optimize the interruption intervals and allow them to be adjusted.

[0016] Although the improvements made on the part upstream of the transformers, the several components of the transformers have remained practically unchanged in the last years.

[0017] This is due to the fact that it is not possible to increase the amount of magnetic flux by changing the components known in the prior art composing the transformer, since these latter are the result of some compromises.

[0018] If the amount of the generated magnetic flux depends on the characteristics of the low voltage applied at the ends of the primary winding, the amount of collected magnetic flux depends on the goodness and dimension of the magnetic core and on the distance of the turns of the secondary winding from the magnetic core. The most distant turns, although the greater amount of material with which they are made with respect to the turns closest to the magnetic core, collect a lower amount of flux.

[0019] From such evident dichotomy derives the need of obtaining a balance between the distance of the windings and their dimension allowing the magnetic flux to increase.

[0020] Moreover in the transformers known in the prior art, the turns of the primary winding are free to move and to shift along the magnetic core and to be deformed for example upon the assembly with the circuit. This leads to an uneven distribution of the magnetic flux and consequently, above all in the case of several secondary windings, this leads to a difference in the performances due to the different output voltage between the two or more secondary windings.

[0021] Therefore there is the unsatisfied need in the

prior art known devices to provide a high-voltage transformer allowing the generation of the magnetic flux to be optimized, while maintaining the production costs low and the constructional simplicity of the components.

[0022] The present invention achieves the above aims by providing a high-voltage transformer according to the preamble of claim 1, further comprising the combination of features according to the characterizing part of claim 1.

[0023] Preferably it is possible to provide also the secondary winding to be contained at least partially within the outer profile of the magnetic core.

[0024] According to the invention, the magnetic core has at least one housing seat obtained in the thickness of the outer walls of the magnetic core intended to house the primary winding and/or the secondary winding.

[0025] Therefore the shape of the magnetic core is modified in order to contain within the overall dimension thereof at least one of the two windings of the transformer.

[0026] In addition to an optimization of the magnetic flux, such arrangement allows transformers with a volume reduction to be obtained with a consequent saving in materials and therefore costs, not only maintaining, but also increasing the performances of the transformer of the present invention.

[0027] The best performances of the transformer of the present invention are also achieved since the solution just described allows the distance of the secondary winding from the magnetic core to be reduced by increasing its performance, while reducing the amount of material used and therefore the cost.

[0028] According to the invention, said housing seat is composed of a coiled channel bored in the thickness of the outer walls of the magnetic core, such to form turns housing the turns of the primary winding.

[0029] According to a variant embodiment the magnetic core has at least two radial enlargements placed at the end sides of the magnetic core.

[0030] The presence of the radial enlargements increases the overall dimension of the magnetic core, but it allows not only the primary winding but also the secondary winding to be easily housed.

[0031] According to one improvement the magnetic core is divided into two parts connectable to each other.

[0032] The advantages of such arrangement are obvious and they are mainly about a greater easiness in mounting and assembling the components of the transformer of the present invention.

[0033] Moreover such last arrangement described is particularly advantageous in combination with the variant providing the presence of at least two radial enlargements.

[0034] This solution that at the state of the art is slightly more expensive, however allows an amount of flux as large as possible to be collected and therefore allowing the transformer to be optimized as much as possible while reducing its dimensions as much as possible.

[0035] Advantageously the turns of the primary winding are wound around the magnetic core such to guar-

antee an even distribution along the magnetic core.

[0036] The secondary winding is preferably placed at the primary winding.

[0037] The particular forms that will be described by some shown embodiments disclose how the magnetic core belonging to the transformer of the present invention allows the turns of the primary winding to be kept constantly and uniformly spaced apart, such to always guarantee a perfect balance of the secondary winding or windings.

[0038] In order to obtain further advantages as regards the constructional perspective and as regards the assembling perspective it is possible to provide the magnetic core to have at least one passage area obtained in the thickness of the magnetic core, intended for the insertion of at least one of the two ends of the primary winding.

[0039] Finally the turns of the primary winding and the turns of the secondary winding are advantageously covered by a sheath made of insulating material.

[0040] These and other characteristics and advantages of the present invention will be more clear from the following description of some embodiments shown in the annexed drawings wherein:

[0041] Fig.1 is a section of a high-voltage transformer known in the prior art;

[0042] Fig. 2a relates to a section of a variant embodiment of the magnetic core belonging to the transformer of the invention. Figs. 2b and 2c are two sections of two examples of a magnetic core not belonging to the transformer of the present invention.

[0043] Fig. 2d is a perspective view of the magnetic core of the embodiment of fig. 2a; Fig. 2e is a perspective view of the magnetic core of Fig. 2c;

[0044] Fig.3 is a section of one embodiment of the transformer of the present invention;

[0045] Fig.4 is a section of a transformer not belonging to the present invention;

[0046] Fig.5 is a principle diagram of a possible embodiment of the low voltage circuit connected to the ends of the first winding belonging to the transformer of the present invention.

[0047] It is specified that in the figures shown here below some possible embodiments of the transformer of the present invention are disclosed, but such embodiments are to be intended for a mere explanatory reason and for better understanding the claimed characteristics.

[0048] Such embodiments therefore have not to be intended as a limitation of the inventive concept of the present patent application, that consists in a modification of the magnetic core of a high-voltage transformer in order to obtain a positioning of at least a part of the turns of the primary winding within the overall dimension of the magnetic core.

[0049] Figure 1 shows the section of a high-voltage transformer known in the prior art.

[0044] The transformer comprises at least one primary winding 1 wound around a magnetic core 2 and at least one secondary winding 3.

[0045] The ends of the primary winding 1 are connected to a low voltage direct electric current source, there being further provided means for interrupting the direct current intended to periodically interrupt the direct current supply to the primary winding.

[0046] According to a possible embodiment, the low voltage circuit and the interruption means are shown in figure 5 and they will be described below.

[0047] The magnetic core 2 generally is made of ferrite or another suitable electromagnetic material.

[0048] The secondary winding 3 is generally composed of some thousands of turns, suitably separated into grooves made of insulating material.

[0049] Figure 1 further shows the insulating supports 5 of the turns belonging to the secondary winding 3.

[0050] Such as described above, the current passing through the primary winding 1, generates a magnetic field conveyed by the magnetic core 2, upon its termination a high voltage is generated in the secondary winding by electromagnetic induction.

[0051] Figures 2a to 2c show three sections of the magnetic core 2. Fig. 2a shows a section of the magnetic core 2 belonging to the transformer of the present invention.

[0052] Such examples or embodiment allow the primary winding 1 to be placed around the magnetic core 2 such to be contained at least partially within the outer profile of the magnetic core 2.

[0053] The magnetic core 2 shown in the figures 2a to 2c has at least one housing seat 21 inside which the turns of the primary winding 1 are wound.

[0054] The housing seat 21 is obtained in the thickness of the outer walls of the magnetic core 2 and therefore it is intended to house the primary winding.

[0055] With a particular reference to figure 2a, the housing seat 21 is composed of a coiled channel bored in the thickness of the outer walls of the magnetic core 2, such to form turns intended to house the turns of the primary winding 1.

[0056] Such configuration allows also the primary winding to be constrained in a rigid position.

[0057] Therefore the magnetic core 2 has a coil recessed with respect to the diameter D1 namely the greatest diameter of the magnetic core 2, with the recess decreasing up to the diameter D2, that is the smallest diameter of the magnetic core 2.

[0058] Preferably the difference between the diameter D1 and the diameter D2 is equal to the dimension of the diameter of the wire composing the turns of the primary winding 1 that therefore is embedded into the ferrite.

[0059] Moreover the coil drawn in the core 2 is also coincident with the number of turns of the primary winding 1 and therefore it guarantees an effective and perfect distribution thereof.

[0060] The magnetic core 2 of figure 2a is shown in figure 3 in combination with the primary winding 1 and

the secondary winding 3.

[0061] Firstly it has to be noted how the turns of the primary winding 1 are contained within the outermost border 22 of the magnetic core 2 and how they are wound around the magnetic core such to guarantee an even distribution along the magnetic core 2.

[0062] The turns of the secondary winding 3 are then placed at the primary winding 1.

[0063] The secondary winding 3 rests directly on the magnetic core 2 decreasing both the diameter of the wire and the distance between the turns of the secondary winding 3 and the magnetic core 2.

[0064] With a particular reference to figures 2a to 2c, the length L1 of the magnetic core 2 is proportional to the number of secondary windings provided in the transformer.

[0065] Moreover also the number of turns of the primary winding 1 and of the secondary winding 3 and the distance therebetween is adjusted according to the design data.

[0066] Like figure 2a, figures 2b and 2c show two sections of two examples of the magnetic core 2 not belonging to the transformer of the present invention.

[0067] The magnetic core 2 has one or more housing seats 21 such to obtain a diameter D1 greater than the diameter D2 and where the difference between the diameters is at least equal to the outer diameter of the primary winding 1 and where the length part of the diameter D2 is studied such to house the provided number of turns. In the case of several primary windings 1, the turns are evenly distributed under each corresponding secondary winding, figure 2c.

[0068] Preferably the passage of the wire on the diameter D1 of the magnetic core 2 is guaranteed by suitable channels inscribed therein with a depth equal to the diameter of the primary winding 1.

[0069] Moreover according to a preferred embodiment, the magnetic core 2 has at least one passage area obtained in the thickness of the magnetic core 2, intended for the insertion of at least one of the two ends of the primary winding 1.

[0070] The return of one of the two ends of the primary winding 1 can be facilitated by means of suitable geometrical changes made to the magnetic core 2.

[0071] For example it is possible to provide the return of one of the two ends of the primary winding 1 to take place through a hole 25 at the center of the magnetic core 2. The hole 25 is shown in figure 2d, where a perspective view of the variant embodiment of figure 2a is shown, particularly a perspective view and a section thereof, such to highlight the hole 25 all along the length of the magnetic core 2.

[0072] As an alternative figure 2e shows a perspective view of the example of figure 2c, where the passage area for the return of one of the two ends of the primary winding is obtained through one or more recesses 26 bored in the thickness of the magnetic core 2.

[0073] Moreover it is specified that even if the annexed

figures are only about the use of a primary winding 1 and a secondary winding 3, it is possible to provide to use also two or more secondary windings 3 on the same primary winding 1, by changing the mechanical dimensions of the several components, such as for example the length of the magnetic core 2, the number of turns and the spacing of the primary winding 1.

[0074] Figure 4 shows a transformer not belonging to the present invention, according to which also the secondary winding 3 is contained at least partially within the outer profile of the magnetic core 2.

[0075] Advantageously the magnetic core 2 has two radial enlargements 23 and 24 placed at the end sides of the magnetic core 2.

[0076] Such as shown in figure 4 the radial enlargements 23 and 24 define a space within which the secondary winding 3 is completely placed with all its turns.

[0077] In this case therefore not only the turns of the primary winding 1 are contained within the overall dimension of the magnetic core 2, but also the turns of the secondary winding 3, due to an enlarged extension of the ends of the magnetic core 2.

[0078] The magnetic core 2 is divided into two parts connectable with each other.

[0079] Particularly in order to help the components to be mounted, at least one of the two parts in which the magnetic core 2 is divided corresponds to the radial enlargement 23 that is fastened to the remaining part of the magnetic core 2 after introducing the secondary winding 3 within the space defined by the two radial enlargements 23 and 24.

[0080] Advantageously, the turns of the primary winding 1 and the turns of the secondary winding 3 are covered by a sheath made of an insulating material.

[0081] Figure 5 shows a possible embodiment of the low voltage circuit connected to the ends of the primary winding 1.

[0082] In this case starting from the normal mains voltage the limiting resistor R1 and the diode D1 provide to generate a direct component from the mains alternating one. This component charges in a given time the capacitor C1, time dependent on the time constant $R1 \cdot C1$.

[0083] Once a predetermined value is reached at the input of the SIDAC assembly, the capacitor is drastically discharged generating the change of magnetic flux necessary for operating a Ruhmkorff coil.

[0084] Now the capacitor is discharged and therefore the voltage at its ends is equal to 0, the SIDAC assembly closes and the capacitor charges again for a new discharge.

Claims

1. High-voltage transformer comprising at least one primary winding (1) wound around a magnetic core (2) and at least one secondary winding (3), the ends of the primary winding (1) being connecta-

ble to a low voltage direct electric current source, there being further provided means for interrupting the direct current intended to periodically interrupt the direct current supply to said primary winding (1), wherein the primary winding (1) is at least partially contained within the outer profile of the magnetic core (2) ;

the magnetic core (2) has at least one housing seat (21) formed in the thickness of the outer walls of the magnetic core (2) intended to house the primary winding (1) and/or the secondary winding (3) and **characterized in that** said housing seat (21) comprises a coiled channel bored in the thickness of the outer walls of the magnetic core (2), such to form turns housing the turns of the primary winding (1).

2. Transformer according to claim 1, wherein the secondary winding (3) is contained at least partially within the outer profile of the magnetic core (2).
3. Transformer according to claim 1 or 2, wherein said magnetic core (2) has at least two radial enlargements (23, 24) placed at the end sides of the magnetic core (2).
4. Transformer according to one or more of the preceding claims, wherein the magnetic core (2) is divided into two parts connectable with each other.
5. Transformer according to one or more of the preceding claims, wherein the turns of the primary winding (1) are wound around the magnetic core (2) such to guarantee an even distribution along the magnetic core, the secondary winding (3) being placed at the primary winding.
6. Transformer according to one or more of the preceding claims, wherein said magnetic core (2) has at least one passage area formed into the thickness of the magnetic core (2), adapted for the insertion of at least one of the two ends of said primary winding (1).
7. Transformer according to one or more of the preceding claims, wherein the turns of the primary winding (1) and the turns of the secondary winding (3) are covered by a sheath of insulating material.

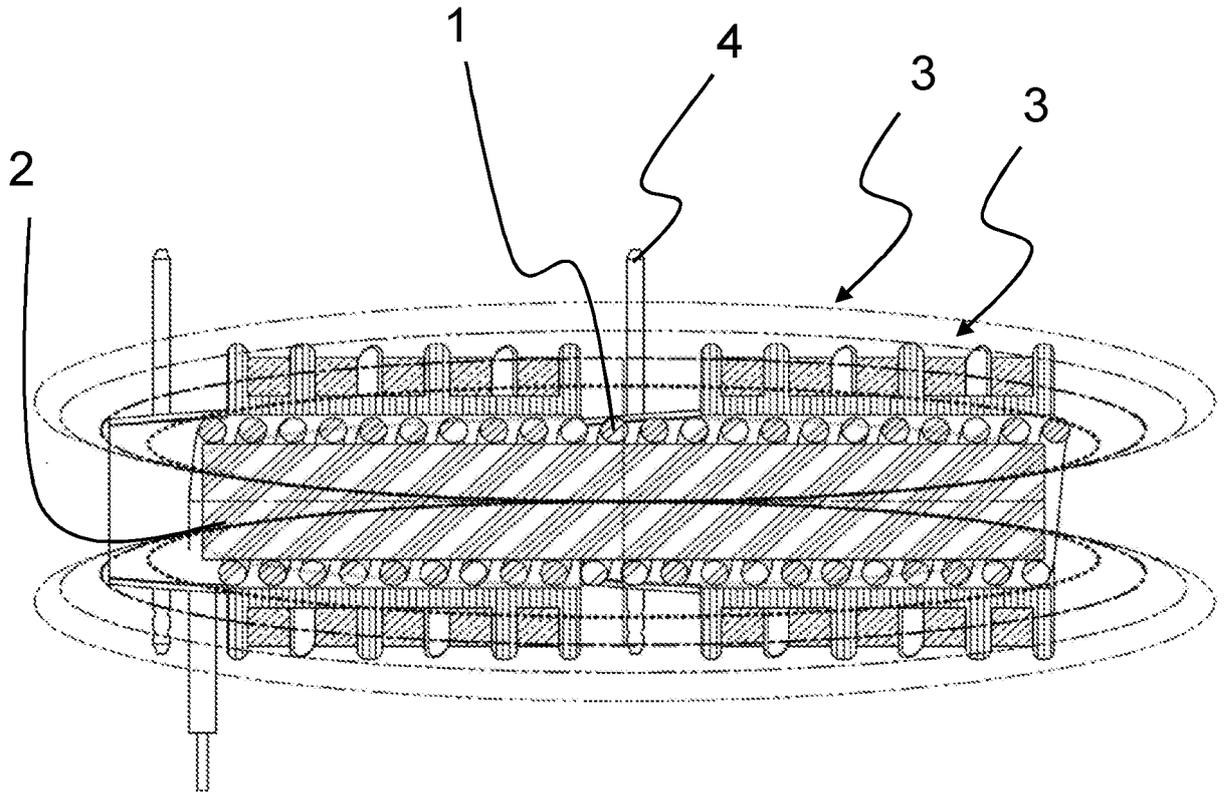
Patentansprüche

1. Hochspannungstransformator mit mindestens einer um einen Magnetkern (2) gewickelten Primärwicklung (1) und mindestens einer Sekundärwicklung (3), wobei die Enden der Primärwicklung (1) mit einer Niederspannungsgleichstromquelle verbindbar sind, wobei ferner Mittel zum Unterbrechen des Gleichstroms vorgesehen sind, die dazu vorgese-

- hen sind, die Gleichstromversorgung der Primärwicklung (1) periodisch zu unterbrechen, wobei die Primärwicklung (1) zumindest teilweise innerhalb des Außenprofils des Magnetkerns (2) enthalten ist; der Magnetkern (2) zumindest einen in der Dicke der Außenwände des Magnetkerns (2) ausgebildeten Gehäusesitz (21) aufweist, der dazu bestimmt ist, die Primärwicklung (1) und/oder die Sekundärwicklung (3) aufzunehmen, **dadurch gekennzeichnet, dass** der Gehäusesitz (21) einen gewendelten Kanal aufweist, der in die Dicke der Außenwände des Magnetkerns (2) eingearbeitet ist, so dass Windungen gebildet werden, die die Windungen der Primärwicklung (1) aufnehmen.
2. Transformator nach Anspruch 1, wobei die Sekundärwicklung (3) zumindest teilweise innerhalb des Außenprofils des Magnetkerns (2) enthalten ist.
3. Transformator nach Anspruch 1 oder 2, wobei der Magnetkern (2) mindestens zwei an den Stirnseiten des Magnetkerns (2) angeordnete radiale Erweiterungen (23, 24) aufweist.
4. Transformator nach einem oder mehreren der vorhergehenden Ansprüche, wobei der Magnetkern (2) in zwei miteinander verbindbare Teile unterteilt ist.
5. Transformator nach einem oder mehreren der vorhergehenden Ansprüche, wobei die Windungen der Primärwicklung (1) um den Magnetkern (2) gewickelt sind, so dass eine gleichmäßige Verteilung entlang des Magnetkerns gewährleistet ist, wobei die Sekundärwicklung (3) an der Primärwicklung angeordnet ist.
6. Transformator nach einem oder mehreren der vorhergehenden Ansprüche, wobei der Magnetkern (2) mindestens einen Durchgangsbereich aufweist, der in die Dicke des Magnetkerns (2) eingeformt ist und zum Einstecken wenigstens eines der beiden Enden der Primärwicklung (1) eingerichtet ist.
7. Transformator nach einem oder mehreren der vorhergehenden Ansprüche, wobei die Windungen der Primärwicklung (1) und die Windungen der Sekundärwicklung (3) von einem Mantel aus Isoliermaterial bedeckt sind.
- 5 basse tension,
des moyens d'interruption du courant continu, destinés à interrompre périodiquement l'alimentation en courant continu dudit premier enroulement (1), étant en outre prévus,
dans lequel
le premier enroulement (1) est au moins partiellement contenu dans le profil extérieur du noyau magnétique (2);
le noyau magnétique (2) a au moins un siège de logement (21) formé dans l'épaisseur des parois extérieures du noyau magnétique (2), destiné à loger l'enroulement primaire (1) et/ou l'enroulement secondaire (3) et **caractérisé en ce que** ledit siège de logement (21) comprend un canal en spirale percé dans l'épaisseur des parois extérieures du noyau magnétique (2), tel que pour former des spires logeant les spires de l'enroulement primaire (1).
- 20 2. Transformateur selon la revendication 1, dans lequel l'enroulement secondaire (3) est contenu au moins partiellement dans le profil extérieur du noyau magnétique (2).
- 25 3. Transformateur selon la revendication 1 ou 2, dans lequel ledit noyau magnétique (2) a au moins deux élargissements radiaux (23, 24) placés sur les côtés d'extrémité du noyau magnétique (2).
- 30 4. Transformateur selon l'une ou plusieurs des revendications précédentes, dans lequel le noyau magnétique (2) est divisé en deux parties pouvant être connectées entre elles.
- 35 5. Transformateur selon l'une ou plusieurs des revendications précédentes, dans lequel les spires de l'enroulement primaire (1) sont enroulés autour du noyau magnétique (2) afin de garantir une distribution uniforme le long du noyau magnétique, l'enroulement secondaire (3) étant placé en correspondance de l'enroulement primaire.
- 40 6. Transformateur selon l'une ou plusieurs des revendications précédentes, dans lequel ledit noyau magnétique (2) a au moins une zone de passage formée dans l'épaisseur du noyau magnétique (2), adaptée à l'insertion d'au moins une des deux extrémités dudit enroulement primaire (1).
- 50 7. Transformateur selon l'une ou plusieurs des revendications précédentes, dans lequel les spires de l'enroulement primaire (1) et les spires de l'enroulement secondaire (3) sont recouvert d'une gaine en matériau isolant.
- 55

Revendications

1. Transformateur à haute tension comprenant au moins un enroulement primaire (1) enroulé autour d'un noyau magnétique (2) et au moins un enroulement secondaire (3), les extrémités de l'enroulement primaire (1) pouvant être connectées à une source de courant continu à



PRIOR ART

Fig. 1

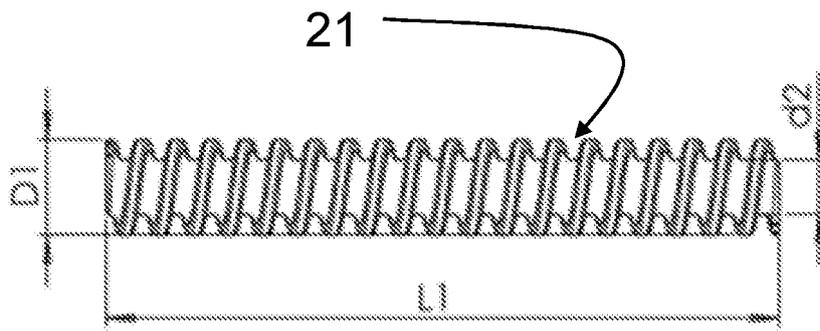


Fig. 2a

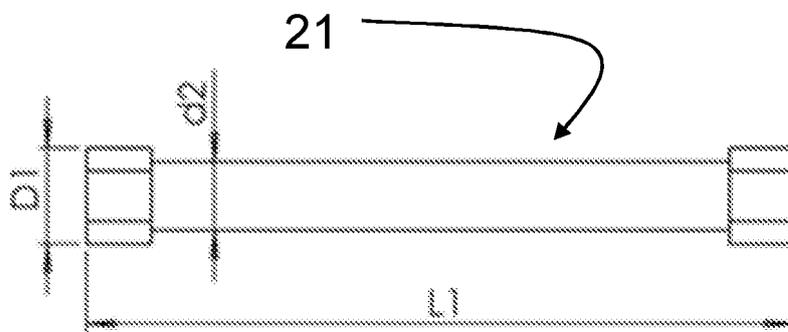


Fig. 2b

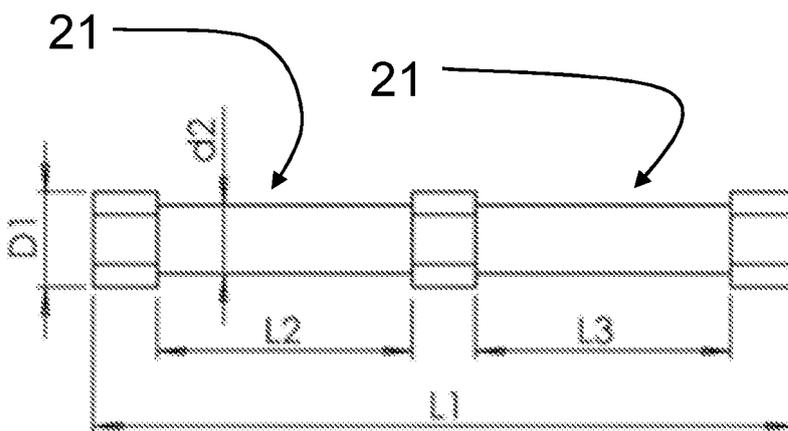


Fig. 2c

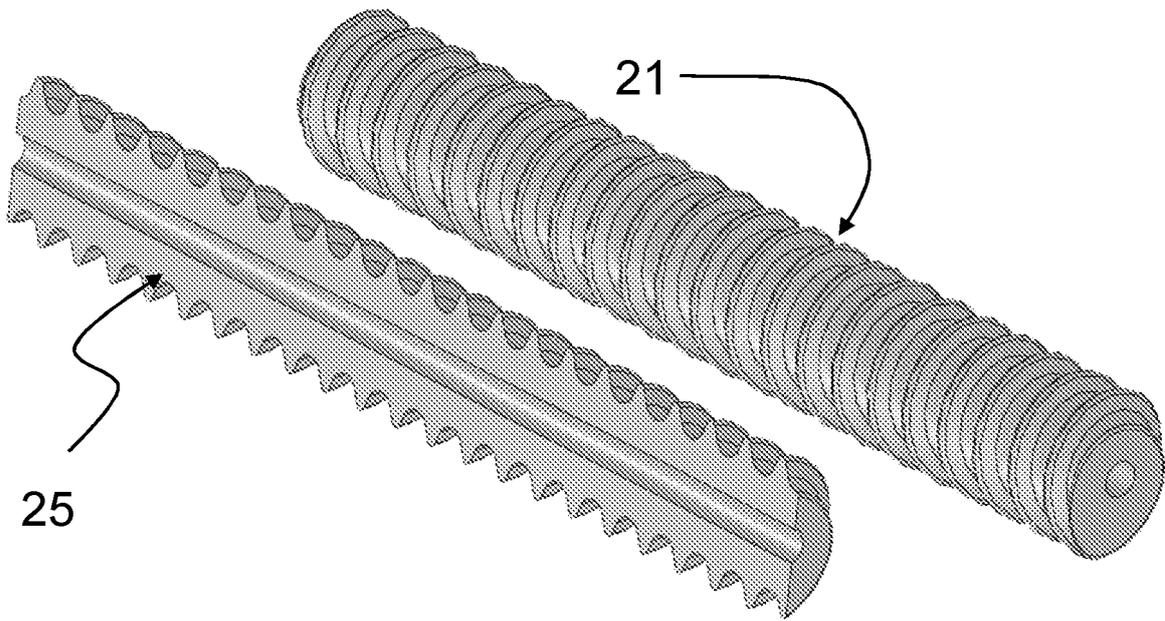


Fig. 2d

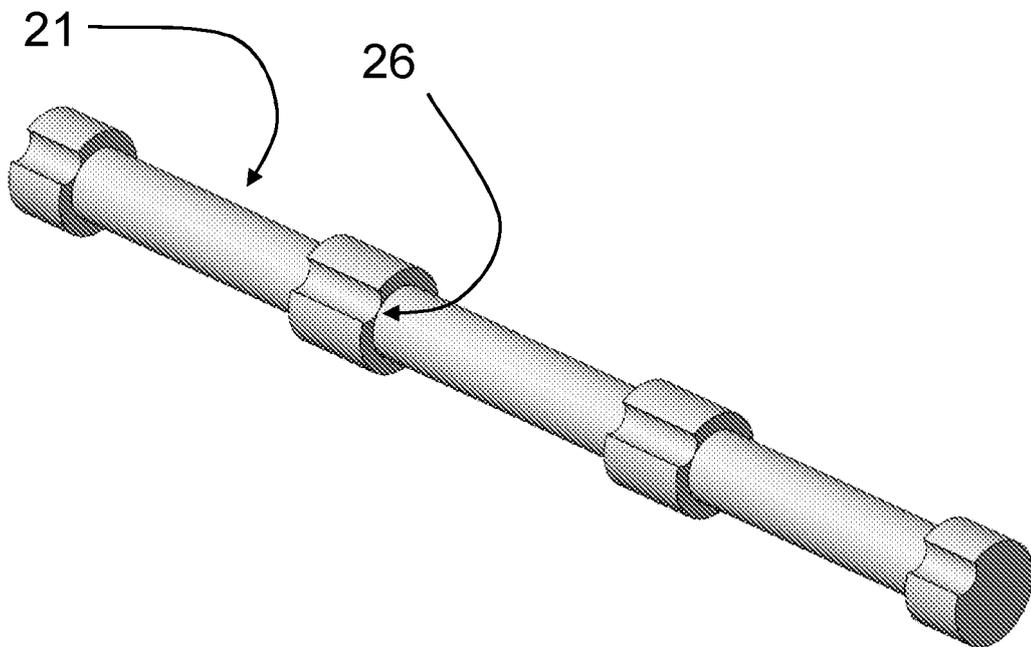


Fig. 2e

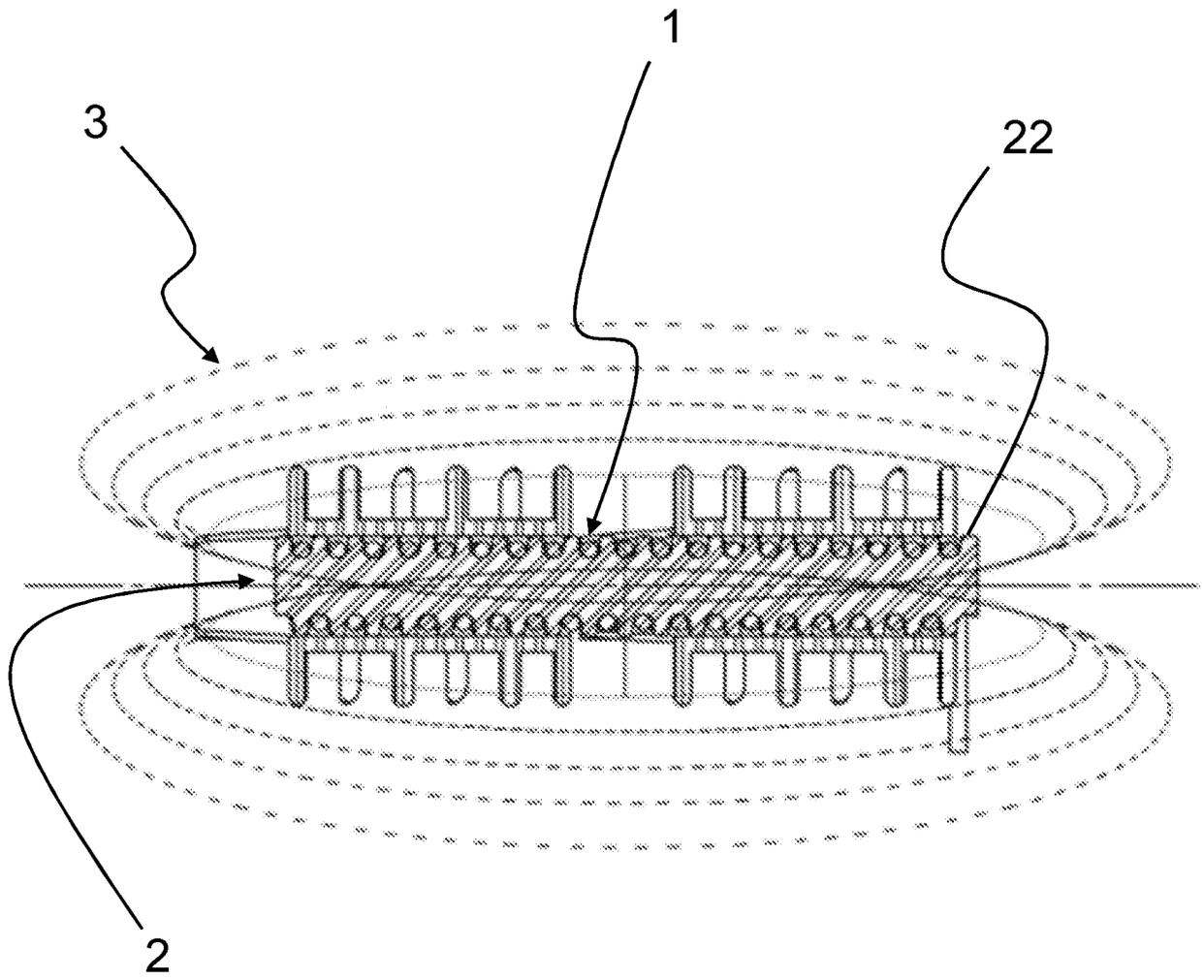


Fig. 3

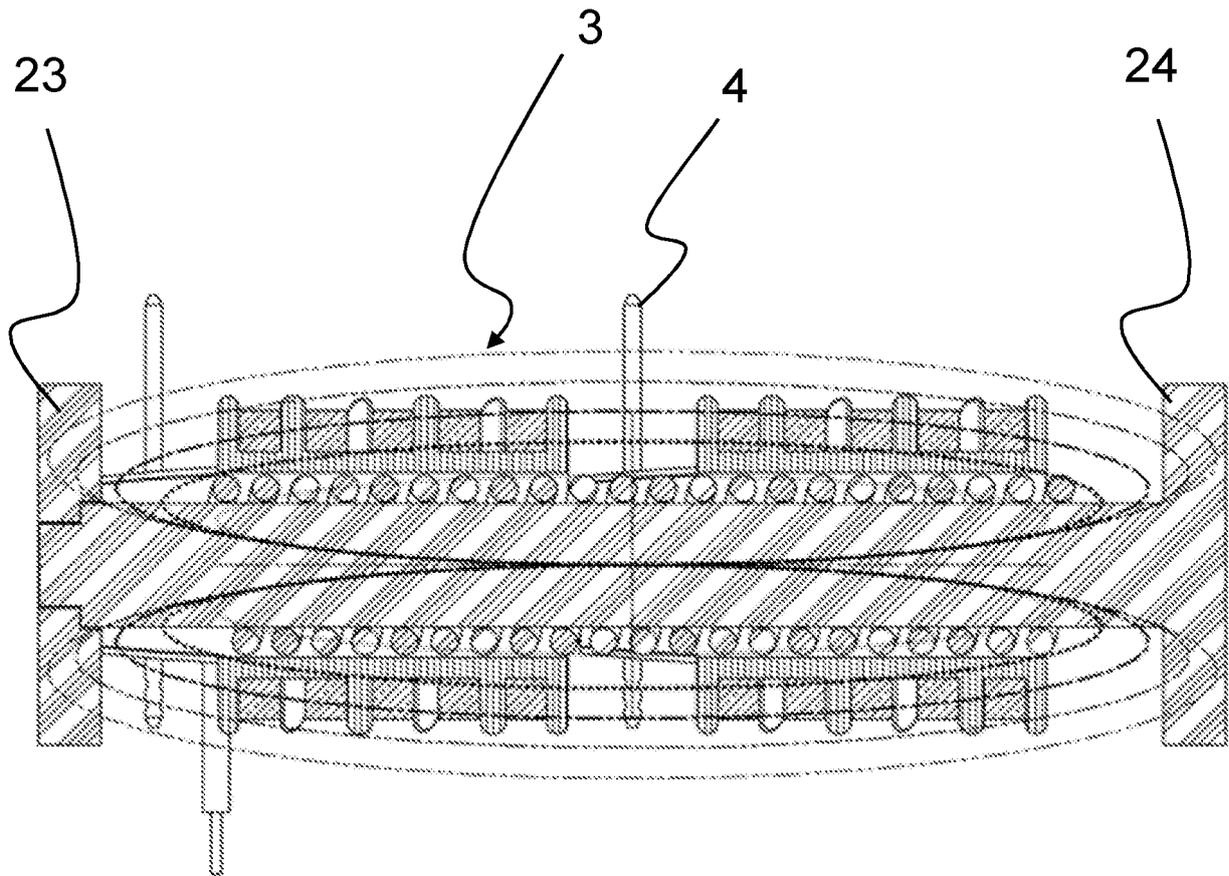


Fig. 4

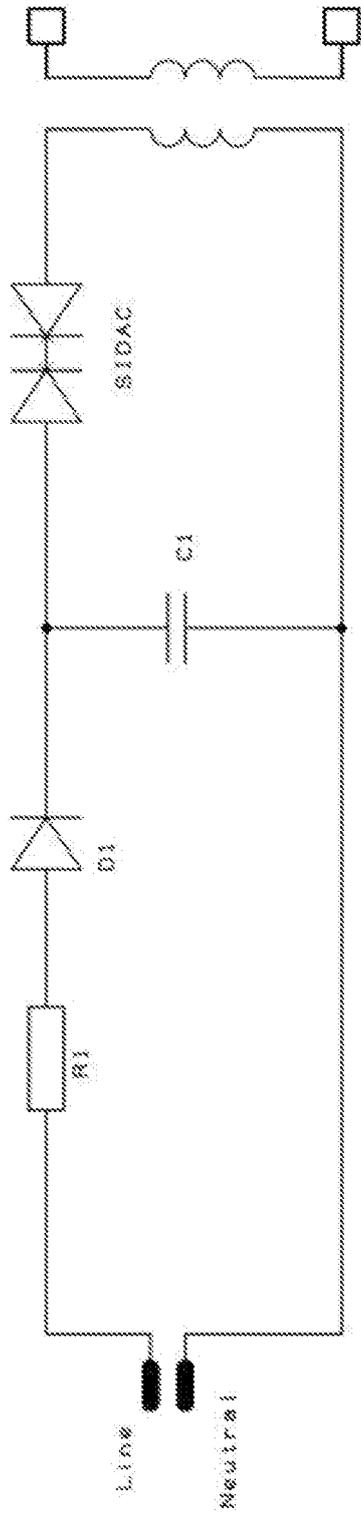


Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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