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(54) HIGH-FREQUENCY TRANSFORMER

(57) Transformer, comprising at least one pair of juxtaposed bearing tubular elements (1,7), rigidly connected to one another at least at one end, being at the opposite end connected to appropriate support means, and being arranged on each of said bearing tubular elements a plurality of annular ferromagnetic elements (3) sized to cooperate with said tubular elements and adapted to form the core of said transformer, the windings (4) of said transformer being arranged coaxially with said tubular elements.

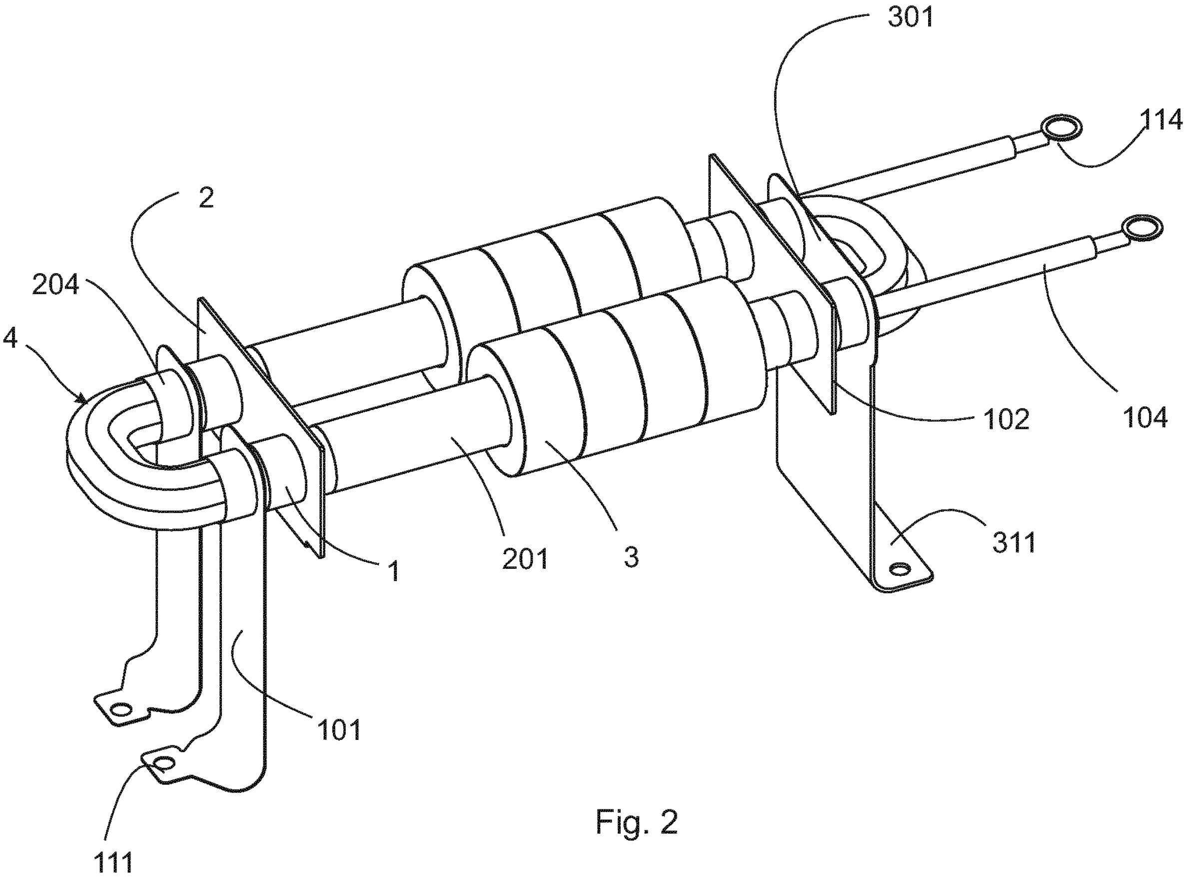

Fig. 2

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Description

[0001] The present invention relates to electrical transformers, and in particular concerns high-frequency transformers.

[0002] High frequency transformers have application fields mainly aimed at obtaining high-value currents from an energy source, such as an inverter; one of the main characteristics of high-frequency transformers is that of having small dimensions compared to low-frequency transformers, a feature that favors their use in modular structures.

[0003] The features of a high-frequency transformer must take into account the needs related to its structure, which must be able to better absorb the generated vibrations, and which must adequately dissipate the heat, as well as being able to minimize the parasitic currents.

[0004] For this purpose, the usual transformer structures, having cores of stacks of iron laminates E-shaped or with toroidal cores with the coils wound on the toroid, do not often meet the expected results in this area, except with an increase in the size of the transformer and therefore with a significant loss of the advantages related to the use of high frequency transformers.

[0005] In document GB1385867 a high-voltage and high-frequency transformer with ferrite core is disclosed, which has at least two parallel portions comprising a plurality of conductors connected to each other at their respective ends, and at least one ferrite core of suitable dimensions, arranged on each of the two portions. In a preferred embodiment, one of the conductors of each group of conductors is tubular, and the remaining conductors are arranged within the same. This solution presents, from the structural point of view, both the strength and the constructive simplicity, since the connection of the conductors of one group to those of the other group is made by means of plates to which said conductors must be connected. The plates are therefore on one side the structural supporting element of the transformer, and also the most complex one to be realized.

[0006] A different solution in an extremely specific field of application such as that of electric arc welding is provided in document EP1496527, which describes a transformer module for modular transformers in which the use of a pair of conductive tubular elements is provided, connected to each other, inside which the windings of a primary can be arranged, the tubular elements being each surrounded by a magnetic core, which preferably consists of a plurality of annular elements. This structure, which is constructively simpler than the one described above, also needs a strong support, which complicates its construction and increases its size in use.

[0007] In document EP1675139 B1 a matrix transformer for a plasma soldering apparatus is described; in this context a basic module is proposed that is very similar to that of the document cited above, not by chance belonging to the same applicant, but whose structural characteristics do not give it the required strength, probably also in relation to the fact that It has been designed for use in a matrix transformer.

[0008] The aim of the present invention is therefore to provide a high frequency transformer which is made with a simple, modular structure, and which is provided with a minimum encumbrance, having at the same time a solidity which allows optimal operation, limiting noise and dispersions thereto associated.

[0009] An object of the present invention is therefore a transformer comprising at least one pair of juxtaposed supporting tubular elements, rigidly connected to each other at a respective end, being at the opposite end connected to appropriate support means, and being arranged on each of said tubular elements a plurality of ferromagnetic annular elements sized to cooperate with said tubular elements and adapted to form the core of said transformer, the windings of said transformer being arranged coaxially with said tubular elements.

[0010] In a first embodiment, said supporting tubular elements are conductors, which constitute the primary of the transformer, preferably tubes with a wall of a thickness not less than 15% of the tube section, and more preferably with a thickness of not less than 20% of the tube section; the tubular elements are preferably made of copper, and are connected to one end by a bridge in the same material, to which they are welded, while at the opposite end each one has a support provided with means for connecting to the supply line. Inside the conductive tubular element, the turns of at least one secondary winding of the transformer are disposed, duly insulated.

[0011] In another embodiment, the supporting tubular elements are extruded in insulating plastic material, which have an outer diameter corresponding to the inner diameter of the cores, and show on the outer wall a plurality of axial grooves angularly equidistant from each other, suitable for housing the turns of the primary, a central duct being provided for each tubular element designed to house the turns of at least one secondary winding. The ends of said tubular elements are coupled to insulating plates, preferably of the same material as said tubular elements.

[0012] Advantageously, the transformer according to the present invention can be inserted into a metal box-like body, preferably made of steel or the like, substantially parallelepipedal-shaped, and of appropriate size to contain the transformer, in which is poured a thermoconductive resin so as to completely cover the transformer; preferably the resin is an epoxy resin.

[0013] Further advantages and characteristics of the transformer according to the present invention will be apparent from the following description of some embodiments thereof, given by way of non-limiting example with reference to the attached drawings, in which:

Figure 1 is a perspective view of a first embodiment of the transformer according to the present invention;

Figure 2 is a partially exploded perspective view of the transformer of Figure 1;

Figure 3 is a perspective view of a second embodiment of the transformer according to the present invention;

Figure 4 is a partially exploded perspective view of the transformer of Figure 3;

Figure 5 is a cross-sectional view of a variant embodiment of the transformer of Figures 1 and 2;

Figure 6 is a cross-sectional view of a variant embodiment of the transformer of Figures 3 and 4.

[0014] Figure 1 shows a first embodiment of the transformer according to the present invention; two juxtaposed series of ferromagnetic rings 3 constitute the core of the transformer, which has the secondary winding 4 arranged inside an insulation sheath 204 which protrudes from the conductive supporting tubular elements, not visible in the figure and shown in Figure 2. At one end the conductive tubular elements are connected to the legs 101 provided with the connecting feet 111, while the other end is connected in the manner better described and illustrated. The rings 3 are comprised between two walls 2 and 102 of insulating material; the foot 311 of the bridge connecting the two tubular elements, not visible in the figure, provides another support for the transformer. The winding 4 is provided with an insulating sheath 104 and the connecting terminals 114.

[0015] In Figure 2 the transformer is shown in an exploded configuration; the conductive tubular elements 1 constitute the load-bearing structure of the transformer and on them, with the interposition of the sheath 201, the rings 3 forming the core are placed. Inside the tubular elements, connected to each other by the bridge 301, the winding 4 is arranged; consequently the tubular elements 1 constitute the primary of the transformer, while the winding 4 constitutes the secondary one. The bridge 301 is provided with the foot 311, and both are made of the same conductive material as the tubular elements 1 and the stems 101.

[0016] Figure 3 shows a second embodiment of the transformer according to the present invention; to the equal parts correspond equal numerals. The supporting tubular elements 7, better visible in Figure 4, support the ferromagnetic rings 3, and allow the arrangement of both the primary winding 5 and the secondary winding 6. The windings are provided with the respective insulating sheaths 105 and 106, and the terminals of connections 115 and 116. At the ends of the two columns of rings 3 the plates 2 and 202 are arranged. The two tubular elements 7 are connected to each other by means of the two bridges 207, as it appears better visible in Figure 4.

[0017] In the exploded perspective of Figure 4, rotated through 180 ° with respect to Figure 3, the equal parts correspond to the same numerals. The figure highlights the fact that each tubular element provides housing in its outer surface to the primary winding 5 and in its inner conduit to the secondary 6. The two bridges 207 connect the two tubular elements together.

[0018] Figure 5 shows a section of a variant embodiment of the transformer according to the embodiment of Figures 1 and 2; to the equal parts correspond equal numerals. The figure shows the transformer inserted in a box-like container body 8, filled with a resin 108; moreover, the fact that the two columns of the annular elements 3 that make up the core of the transformer are connected to each other by means of a bead 103 of resin deposited in the construction of the transformer itself is also highlighted. The winding conductor 4 is a multi-stranded cable 114.

[0019] Figure 6 shows a section of a similar embodiment of the transformer according to the embodiment illustrated in Figures 3 and 4; to the equal parts correspond equal numerals. The figure shows the structure of the tubular elements 7, which have a plurality, in this case six, longitudinal grooves angularly equidistant to each other, in which the turns of the primary winding 5 are arranged, while the turns of the secondary winding are located in the conduit 307, formed coaxially with the tubular carrier element 7. Both the cable 115 of the primary winding 5 and the cable 116 of the secondary winding 6 are multi-stranded.

[0020] The structure and operation of the transformer according to the present invention will be apparent from the following. As it results from the state of the art discussed in the premises, high frequency transformers are known in which the core is formed by a plurality of annular ferromagnetic elements juxtaposed in at least two columns, inside which the turns of the windings are conducted. This structure, given the reduced overall section required for high-frequency transformers, guarantees its compact dimensions compared to the more usual type structures, and minimizes the parasitic currents, given the substantially coaxial positioning of the primary and secondary turns.

[0021] However, as is also clear from the analysis of the state of the art, it is not at all simple to provide this type of transformer with a stable and simple construction, given that normally the transformers with the E, or C cores, or even with toroidal cores they provide directly support for the windings, whereas in this case the annular elements of the two juxtaposed columns must also be adequately supported.

[0022] In the first embodiment of the present invention illustrated in Figures 1 and 2, and in the variant of Figure 5, the problem is solved by providing a pair of conductive tubular elements 1 which on the one hand can perform the function of primary of the transformer, and on the other they have sufficient consistency to constitute the load-bearing structure of the transformer itself. The two tubular elements, connected together at one end by the bridge 301, made of the same material as the tubular elements, present at the opposite end the stems 101, which complete the support for the structure. The tubular elements, made of copper or an alloy thereof, have a wall thickness such as to ensure carrying capacity to the same; in particular, the wall thickness will not be less than 15% of the section of the tubular element, and preferably will not be less than 20% of the section of the tubular element.

[0023] The transformer thus realized can be placed on an appropriate thermal dissipation system, that is on the thermal dissipation system of the apparatus in which the transformer is used; the stems 101 with their feet 111 and the bridge 301 with its foot 311 themselves constitute the thermal dissipation means for the transformer in this embodiment.

[0024] In the executive variant of Figure 5, and likewise also in the embodiment variant of Figure 6, the transformer is inserted into a container body made of metallic material, preferably steel or the like, then filled with a thermoconductive resin, generally bicomponent epoxy resins. In this way, on the one hand, transformer insulation is implemented, on the other, its thermal dissipation capacity is favored.

[0025] The ferromagnetic annular elements which make up the core of the transformer according to the invention will preferably be made of high permeability ferrite, permalloy, or ferrocarbonyl. The connecting cord between the two columns of annular elements is preferably in epoxy glue such as Araldite®. The windings will preferably be made of Litz wire, i.e. a multi-strand wire in which the different strands are insulated from each other; this wire is designed to reduce losses caused by the skin effect and by the proximity effect in conductors used at frequencies up to about 1 MHz.

[0026] In the embodiment of Figures 3 and 4, the supporting tubular elements 7 are extruded in plastic material, provided with the appropriate mechanical properties and a reasonably high glass transition temperature, higher than 100 ° C, which are formed with a central duct and a plurality of longitudinal grooves angularly equidistant from each other. In particular, polycarbonate, which has a glass transition temperature in the order of 147 ° C, was taken into consideration as a material and can therefore be used up to temperatures in the order of 130 ° C. This thermoplastic resin has excellent mechanical properties and is well suited for extrusion.

[0027] The grooves allow the windings of the transformer primary to be positioned and distributed properly, while the secondary can be placed inside the central duct. The tubular elements also act in this way as isolation between primary and secondary; the ends of the two tubular elements are connected to each other with two bridges of plastic material, preferably of the same material in which the tubular elements are made.

Claims

1. Transformer, comprising at least one pair of juxtaposed bearing tubular elements, rigidly connected to one another at least at one end, being at the opposite end connected to appropriate support means, and being arranged on each of said bearing tubular elements a plurality of annular ferromagnetic elements sized to cooperate with said tubular elements and adapted to form the core of said transformer, the windings of said transformer being arranged coaxially with said tubular elements.

2. Transformer according to claim 1, in which said bearing tubular elements are conductors which constitute the primary of the transformer, with the wall having a thickness of not less than 15% of the section of the tubular element.

3. Transformer according to claim 2, wherein the tubular elements are connected at one end by welding to a bridge made of the same conductive material of the tubular elements and provided with a support integral to it, whereas at the opposite end they are welded each to a support, also in the same conductive material, provided with means for connection to the supply line.

4. Transformer according to claim 2 or 3, wherein said conductive material is Cu or an alloy thereof.

5. Transformer according to anyone of the preceding claims 2 to 4, in which inside the conductive tubular element, the turns of at least one secondary winding of the transformer are disposed, duly insulated.

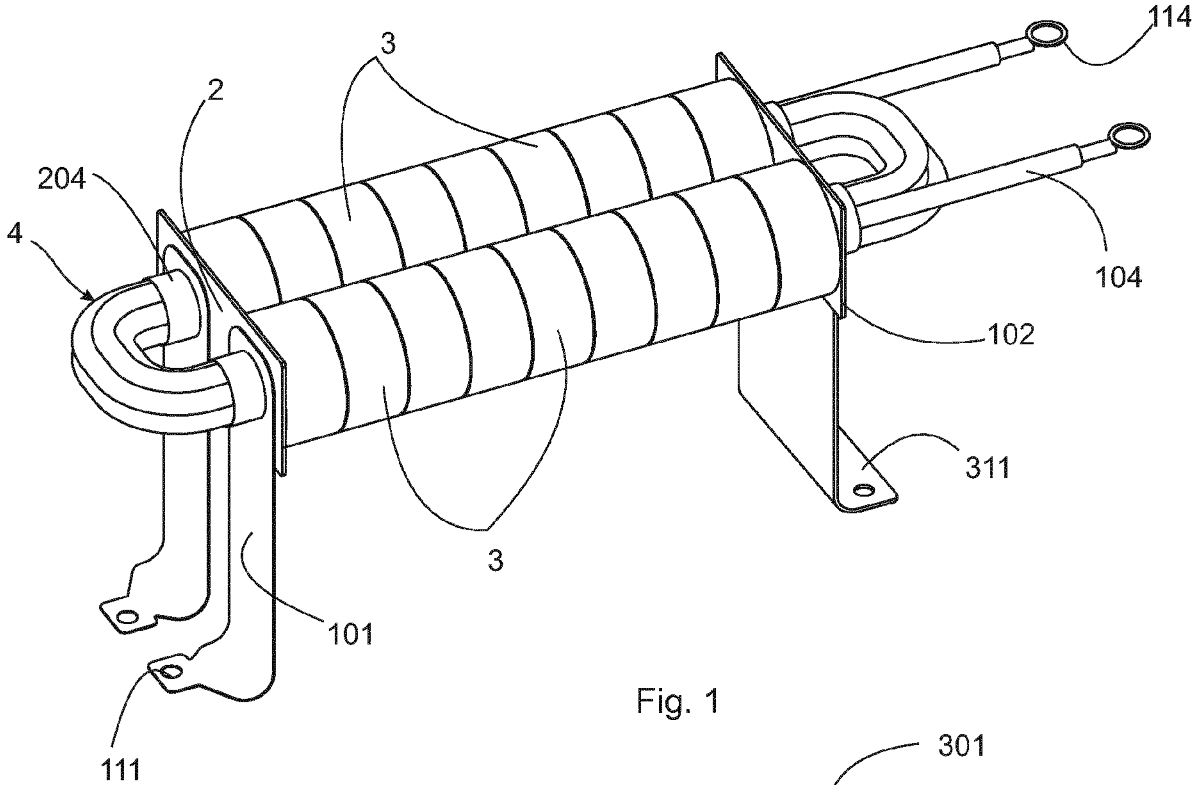
6. Transformer according to claim 1, in which the bearing tubular elements are extruded in insulating plastic material, which have an outer diameter corresponding to the inner diameter of the cores, and present on the outer wall a plurality of axial grooves equidistant from each other angularly, suitable for housing the turns of the primary, being provided a central duct for each tubular element designed to house the turns of at least one secondary winding.

7. Transformer according to claim 6, wherein the ends of said tubular elements are coupled to insulating plates, preferably of the same plastic material as said tubular elements.

8. Transformer according to claim 6 or 7, wherein the plastic material is polycarbonate.

9. Transformer according to anyone of the preceding claims from 1 to 8, wherein said transformer inserted in a metal box-like body, preferably made of steel or the like, substantially parallelepipedal in shape, and of appropriate size to contain the transformer, in which a thermo-conductive resin is cast, that completely covers the transformer.

10. Transformer according to anyone of the preceding claims from 1 to 9, wherein said annular ferromagnetic elements are made of ferrite with high magnetic permeability.


114
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2
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4
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102
311
3
101
111

Fig. 1

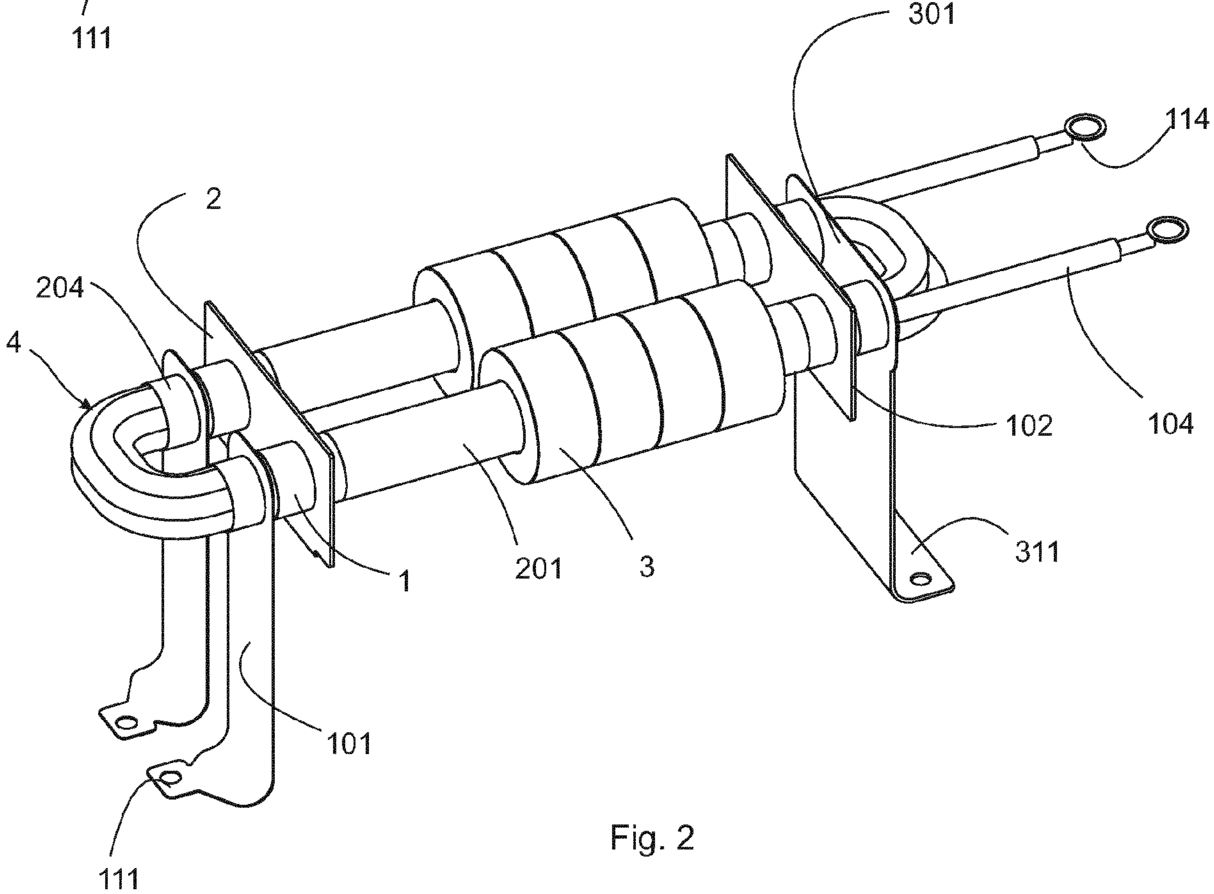
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Fig. 2

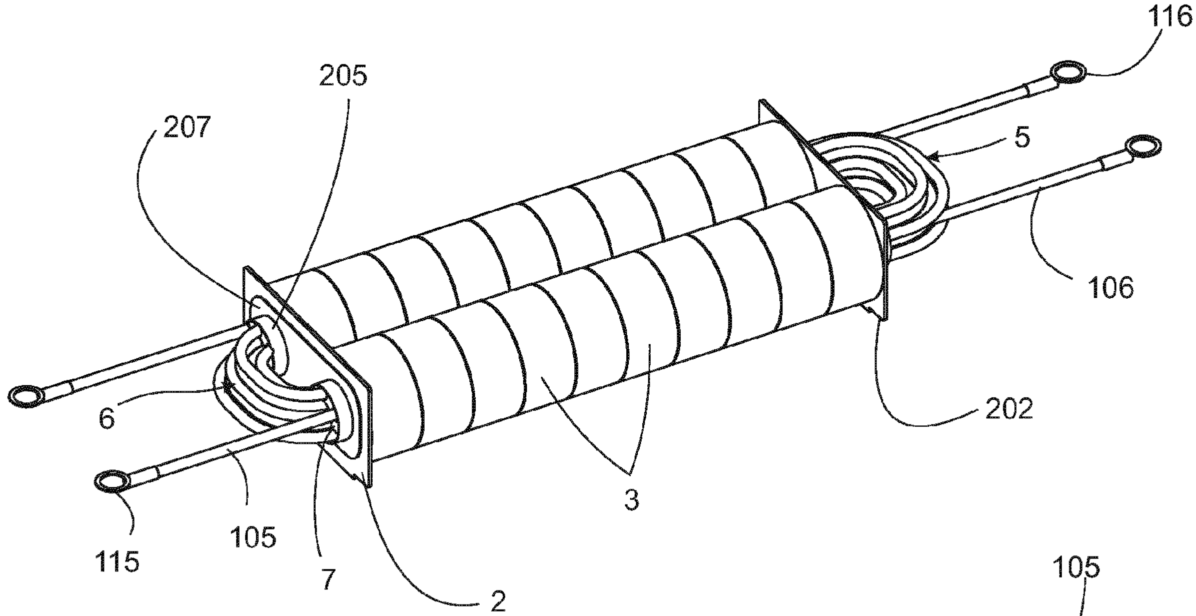
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Fig. 3

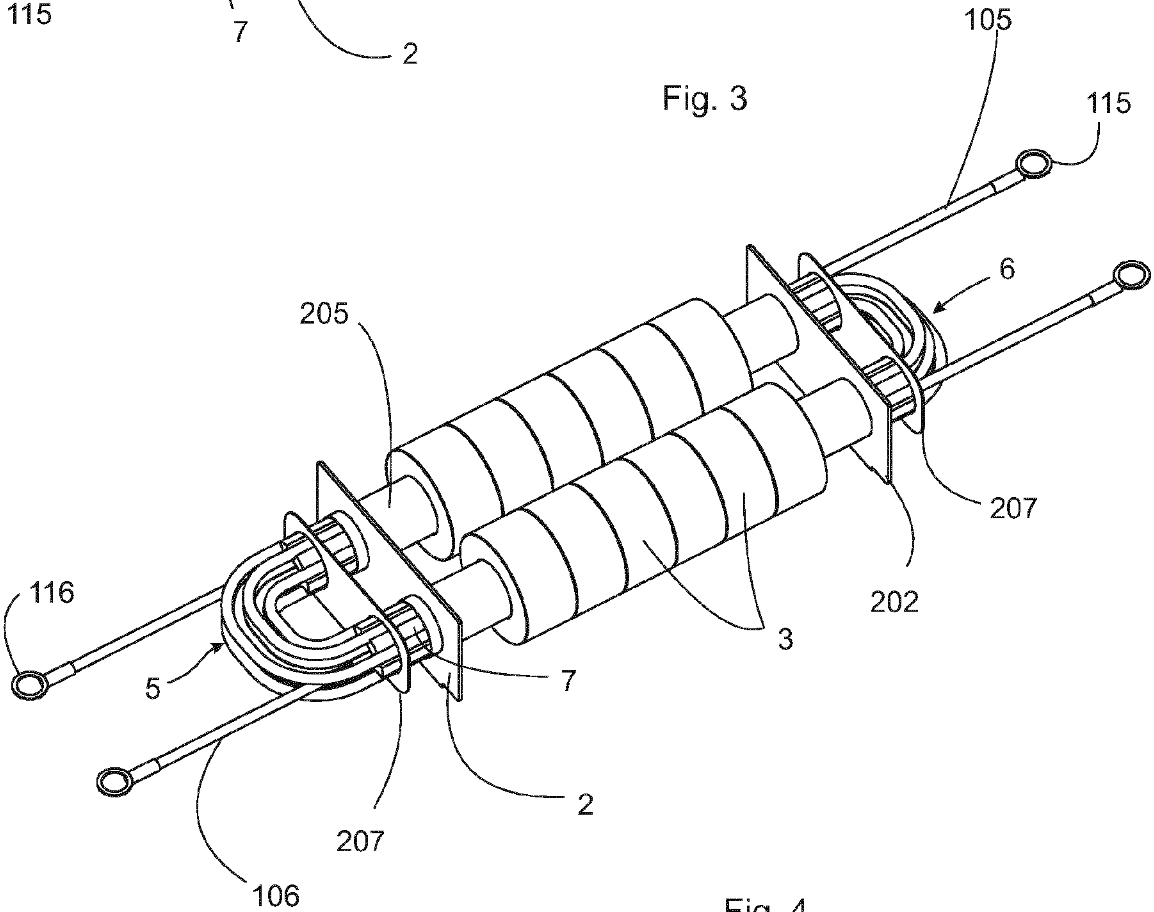
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Fig. 4

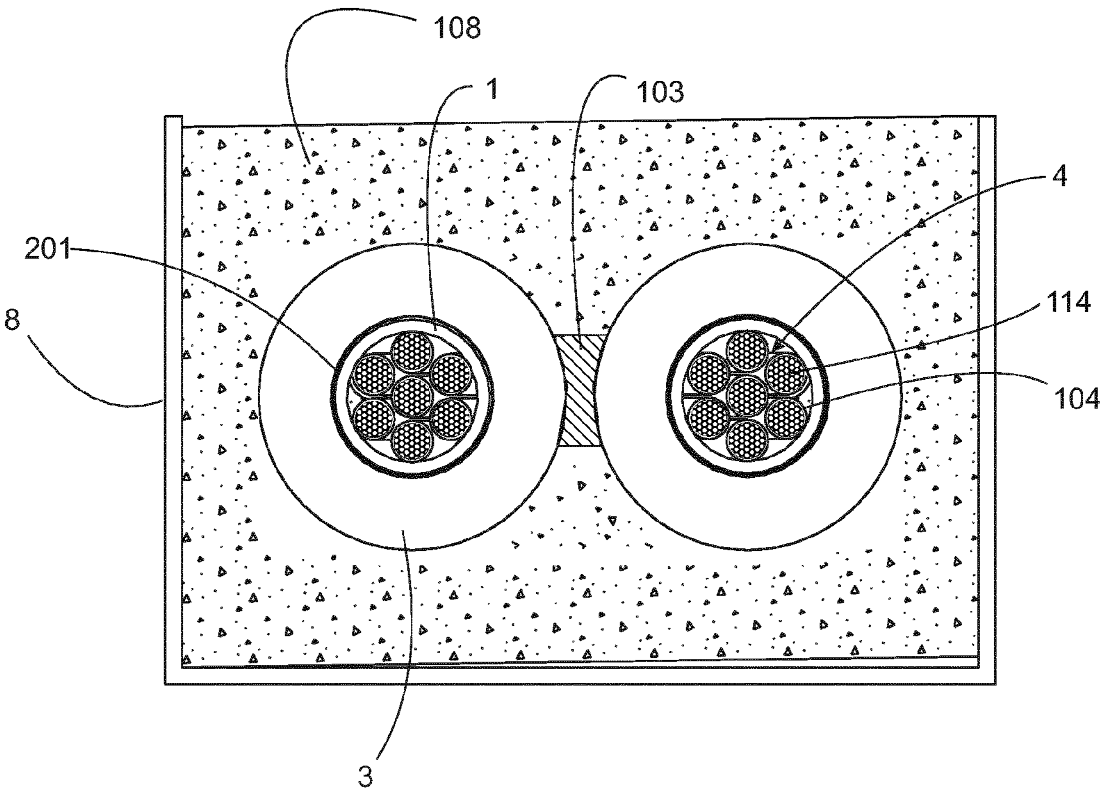
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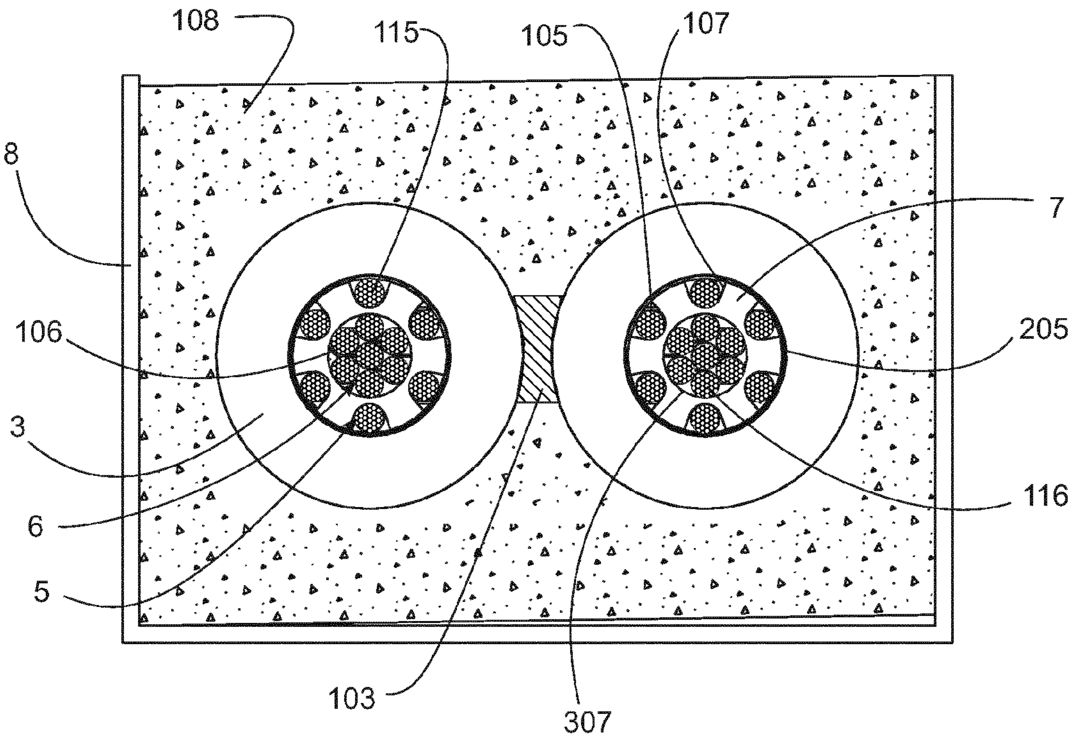
Fig. 5


108
115
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107
8
7
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205
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116
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103
307

Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 1385867 A **[0005]**
- EP 1496527 A **[0006]**
- EP 1675139 B1 **[0007]**