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(54) **Three phase choke coil with reduced emission of electromagnetic energy in the environment**

(57) The present invention refers to a fabrication system of three phase electric transformers that consists in using - instead of one traditional three phase transformer - two three phase transformers with halved power and voltage conveniently coupled electrically and mechanically.

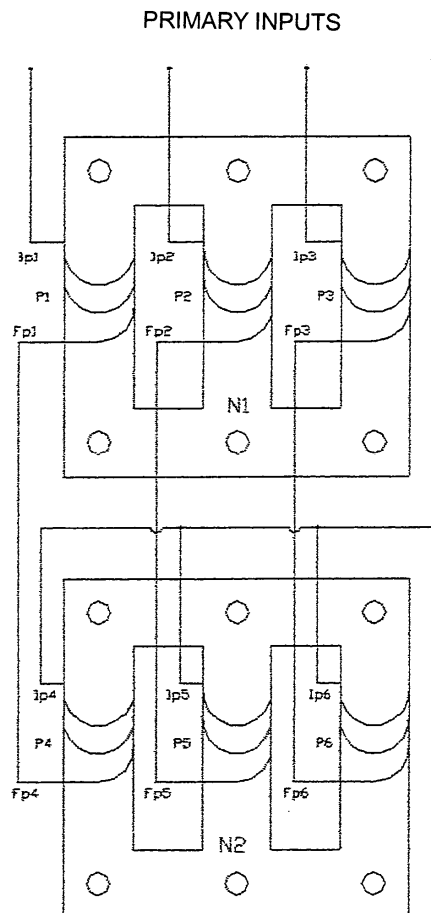


FIG. 1

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Description

[0001] The present patent application refers to a fabrication system of three phase electric transformers with reduced emission of electromagnetic energy in the environment.

[0002] This patent application also refers to the three phase electric transformer obtained with such a fabrication system.

[0003] The problem of undesired emission of electromagnetic energy into the environment is related to the intrinsic nature of electrical transformers, where the electromagnetic flux needed to operate the transformer implies undesired emission of energy proportional to the power supply current of the transformer.

[0004] From the beginning of the last century, conscientious investigators recommended to keep individuals far away from electric devices and transformers. Because of the enormous diffusion of electric and electronic devices, which have become an integral part of our daily life, it is impossible to comply with this recommendation.

[0005] More and more frequently, transformation cabins and three phase transformers that are necessary for energy distribution on the territory are located near or in civil buildings or working places.

[0006] This causes increasing worries in public opinion, while scientific investigations have started to demonstrate the harmful effects for human cells exposed to very low frequency electromagnetic fields for frequencies lower than 100 Hz (ELF).

[0007] Currently, the only measure taken to protect individuals from undesired emissions is represented by electromagnetic screening.

[0008] The creation of effective electromagnetic screen, however, is a complicated, expensive and often ineffective process.

[0009] Low frequency magnetic fields can be screened in two different ways: it is possible to maximise losses by absorption; lines can be deviated with the introduction of low reluctance materials.

[0010] High permeability materials must be used in both cases, because they have the best μ s value (μ =permeability; s =conductivity) and therefore allow for good losses by absorption and because they have very low reluctance.

[0011] Permeability also depends on the thickness of metal plates: generally speaking, these two parameters are mutually dependant, and for this reason the two effects are not easy to separate. Generally, relative permeability tends to decrease when plate thickness increases. This means that very thick screens sometimes do not give the expected results.

[0012] As regards the second screening method, that is to say the possibility of deviating magnetic field lines by using low reluctance materials, it must be noted that the introduction of a highly-permeable screen alters the magnetic field, because a certain number of lines is attracted towards the screen, it being easier for the line to flow in the ferrous material than in the air.

[0013] The practical difficulties encountered in the fabrication of screens for magnetic fields with low frequency (50 Hz) can be summarised as follows:

- as mentioned above, need to overlap different screens, alternating electromagnetic plates to copper plates, separating them with air and insulating them;
- difficult machining of magnetic plates, which are especially delicate and subject to rapid degradation of permeability properties in case of shocks and mechanical machining operations;
- need to drill holes for electrical wires, which cause discontinuity on the screen, thus considerably reducing the effectiveness of screening.

[0014] In any case, these types of screening are only a passive defence from electromagnetic fields, and do not contribute to reduce the emission of electric transformers.

[0015] The purpose of the present invention is to reduce the emission of electromagnetic fields of three phase electric transformers in order to protect our health.

[0016] This primary objective has been pursued by adopting different solutions that are not characterised by:

- worse efficiency parameters with respect to traditional three phase transformers;
- excessive complication in winding technique;
- high fabrication costs;
- use of special materials that are difficult to find on traditional markets.

[0017] The aforementioned purpose has been achieved with the system according to the present invention, which consists in using - instead of one traditional three phase transformer - two three phase transformers with halved power and voltage conveniently coupled electrically and mechanically.

[0018] Each of the three primary windings and each of the three secondary windings of a traditional three phase

transformer are divided into two semi-windings wound on two three phase ferromagnetic cores.

[0019] The semi-windings are connected in series by connecting their respective final ends; in this way, the initial ends of primary semi-windings are the power supply connections of the transformer and the initial ends of secondary semi-windings are the output connections of the transformer (inverted connection is possible without impairing the achievement of the desired purpose, by connecting the initial ends of the semi-wirings and using the final ends as power and output terminals).

[0020] The two three phase ferromagnetic cores are electrically and mechanically connected by means of six iron bars/screws located above and below the six semi-windings connected in series; the bars/screws are provided with suitable mechanical spacers and ensure electrical connection between the "external" surfaces of the two cores, while being suitably insulated to avoid "magnetic short circuit" phenomena in the cores.

[0021] Without impairing the electrical operation of the transformer, the system of the invention creates two dispersed magnetic fluxes, in mutual phase opposition, which tend to neutralise each other.

[0022] A comparison between a transformer obtained according to the fabrication system of the invention and a traditional three phase transformer with same power, primary/secondary transformation ratio, core magnetisation and, consequently, number of coils, has given the following results:

	New transformer	Traditional transformer
Iron area	9+9 cm ²	16 cm ²
Magnetisation	1.2W/m	1.2W/m
Primary Volt	380	380
Secondary Volt	380	380
Current intensity	1.5 A	1.5 A
Maximum field value at 10 cm	3.4uT	35uT

[0023] The results show that the main purpose of the invention has been achieved, since the transformer obtained with the fabrication system of the invention produces an electromagnetic emission about 10 times lower (-20dB) than the emission of a traditional transformer with similar electrical characteristics.

[0024] Also the secondary purposes of the invention have been achieved, since:

- efficiency parameters are the same or higher than traditional three phase transformers, also due to a different, more advantageous copper/iron ratio;
- windings can be obtained easily with ordinary winding machines;
- in spite of using a double number of windings and two electromagnetic cores (although with smaller size and weight), fabrication costs are lower than the expenses needed to obtain the same result with a traditional transformer with electromagnetic screening;
- the system of the invention can be used with ordinary electromagnetic cores for three phase transformers found on the market.

[0025] For major clarity the description of the system according to the present invention continues with reference to the enclosed drawing, whereby:

- Fig. 1 is a diagrammatic view of a three phase electric transformer obtained according to the fabrication system of the invention.
- Fig. 2 is a diagrammatic view of an alternative embodiment of the three phase electrical transformer obtained according to the fabrication system of the invention.
- Fig. 3 shows the mechanical and electrical assembly diagram of the two three phase magnetic cores.

[0026] Figure 1 only shows the electrical connections of primary windings. As a matter of fact, being similar to primary windings, the electrical connections of secondary windings have been omitted for easier reference. It can be noted that each of the three primary windings of the transformers has been divided into two semi-windings obtained on two three phase ferromagnetic cores N1, N2).

[0027] According to the fabrication system of the invention, the connection in series between the primary windings (and the connection between the secondary windings) has been made by connecting the final end of each semi-winding with the final end of the corresponding semi-winding (Fp1 with Fp4, Fp2 with Fp5 and Fp3 with Fp6); the initial ends of the semi-windings (Ip1-lp4, Ip2-lp5 and Ip3-lp6) are the power supply connections of the primary circuit (output

connection of the secondary circuit).

[0028] Figure 2 shows an alternative embodiment of the three phase transformer of the invention with inverted connection of semi-windings compared to Fig. 1.

[0029] More precisely, in this embodiment:

- the initial ends of primary semi-windings (for example Ip1-Ip4, Ip2-Ip5 and Ip3-Ip6 of Fig.3), and the initial ends of secondary semi-windings are connected;
- the final ends of corresponding primary semi-windings (for example Fp1-Fp4, Fp2-Fp5 and Fp3-Fp6 of Fig.3) are the power supply connections of the primary circuit, and the final ends of secondary semi-windings are the output connection of the secondary circuit.

[0030] With reference to Fig. 3, it must be noted that, according to the fabrication system of the invention, the two three phase cores (N1 and N2) are mechanically and electrically connected by means of six iron bars/screws (B1, B2, B3, B4, B5 e B6) located above and below the six semi-windings connected in series; the bars/screws are provided with suitable mechanical spacers and ensure the electrical connection between the "external" surfaces of the two cores, while being suitably insulated to avoid "magnetic short circuit" phenomena in the cores.

Claims

1. Fabrication system of three phase electric transformers with reduced emission of electromagnetic energy in the environment, **characterised in that:**

- each primary and secondary winding of the transformer has been divided into two semi-windings wound on two three phase magnetic cores;
- the final ends of corresponding primary windings (for example Fp1-Fp4, Fp2-Fp5 and Fp3-Fp6 of Fig. 1) and the final ends of secondary windings are connected;
- the initial ends of primary semi-windings (for example Ip1-Ip4, Ip2-Ip5 and Ip3-Ip6 of Fig.1) are the power supply connections of the primary circuit and the initial ends of secondary semi-windings are the output connections of the secondary circuit.

2. Fabrication system of three phase electric transformers with reduced emission of electromagnetic energy in the environment, **characterised in that:**

- each primary and secondary winding of the transformer is divided into two semi-windings wound on two three phase magnetic cores;
- the initial ends of primary semi-windings (for example Ip1-Ip4, Ip2-Ip5 and Ip3-Ip6 of Fig.3), and the initial ends of secondary semi-windings are connected;
- the final ends of corresponding primary semi-windings (for example Fp1-Fp4, Fp2-Fp5 and Fp3-Fp6 of Fig.3) are the power supply connections of the primary circuit, and the final ends of secondary semi-windings are the output connections of the secondary circuit.

3. Fabrication system of three phase electric transformers with reduced emission of electromagnetic energy in the environment, as defined in the preceding claims, **characterised in that:**

- the two three phase cores (N1 and N2 of Fig. 2) are mechanically and electrically connected by means of six iron bars/screws (B1, B2, B3, B4, B5 and B6 of Fig. 2) located above and below the six semi-windings connected in series;
- the bars/screws are provided with suitable mechanical spacers and ensure electrical connection between the "external" surfaces of the two cores and are conveniently insulated to avoid "magnetic short circuit" phenomena in the cores.

4. Three phase electric transformer obtained according to the fabrication system as defined in claim 1 or 2.

5. Three phase electric transformer obtained according to the fabrication system as defined in the first three claims.

PRIMARY INPUTS

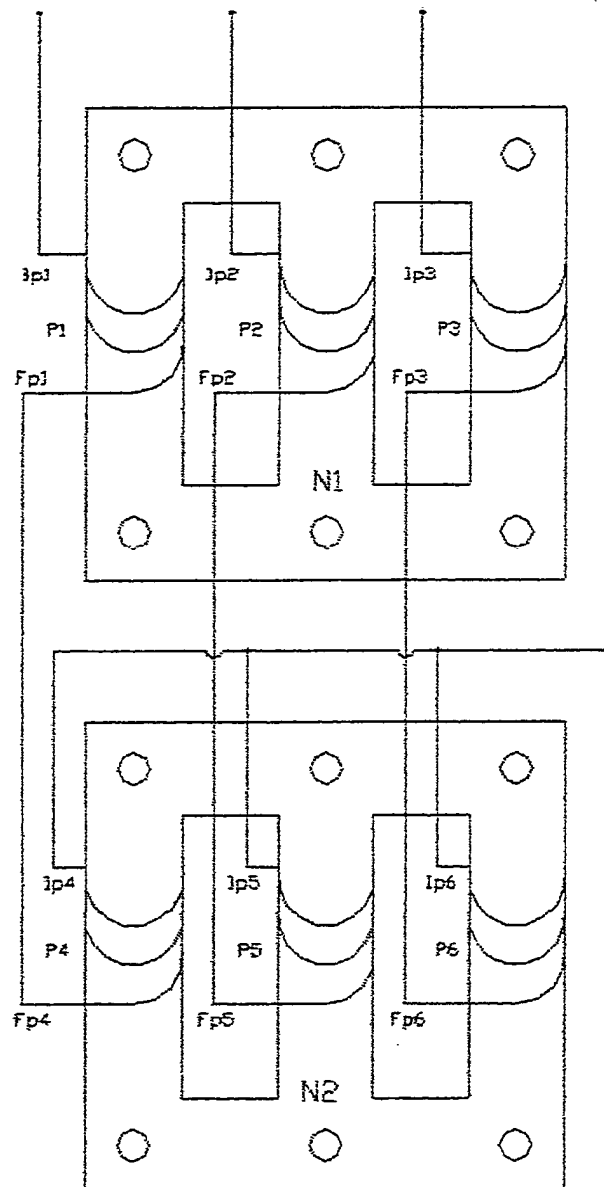


FIG. 1

PRIMARY INPUTS

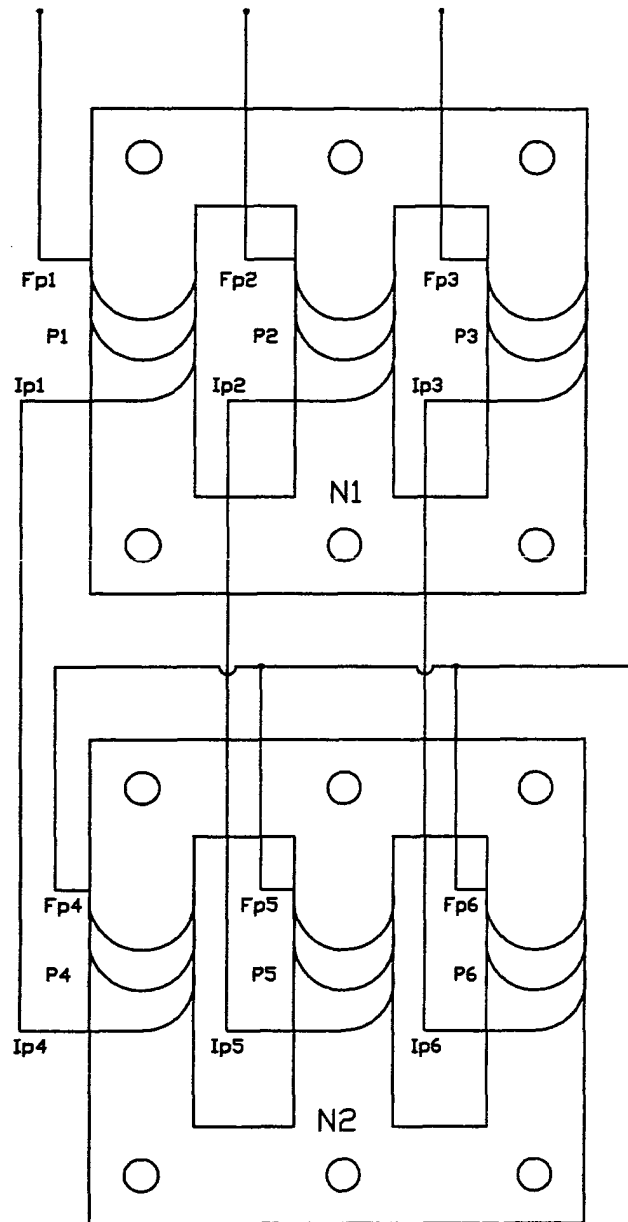


FIG. 2

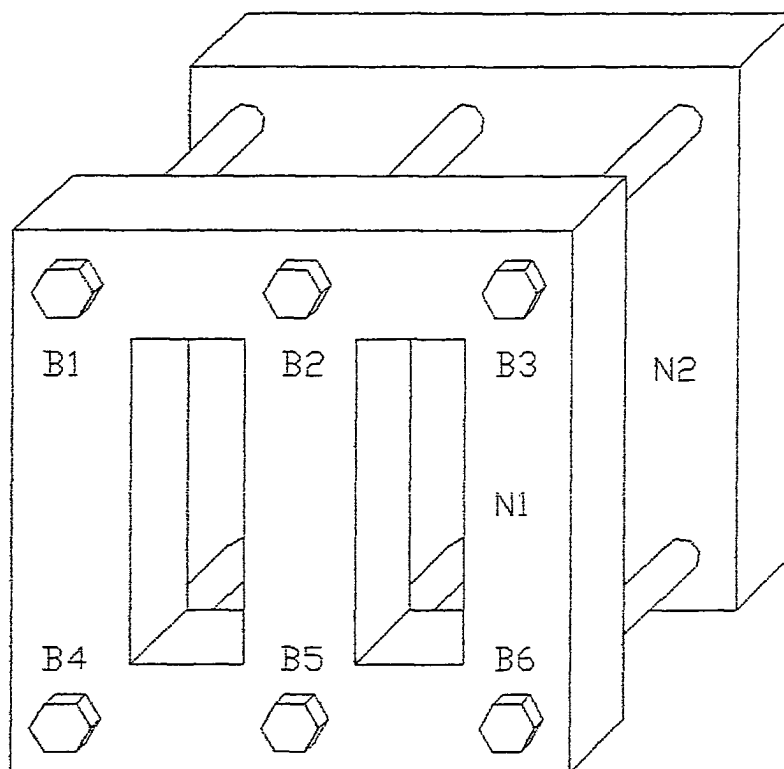


FIG. 3



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EUROPEAN SEARCH REPORT

Application Number
EP 04 42 5347

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 1 071 101 A (PHILIPS CORP INTELLECTUAL PTY ; KONINKL PHILIPS ELECTRONICS NV (NL)) 24 January 2001 (2001-01-24) * paragraph '0013! - paragraph '0014!; figure 1 *	1,2,4,5	H01F37/00 H01F27/34
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			H01F
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		1 September 2004	Marti Almeda, R
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 42 5347

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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01-09-2004

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