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(54) **COIL ASSEMBLIES FOR POWER CONVERSION CIRCUITS**

(57) A coil assembly (2), such as a choke coil, comprises a plurality of coils (10) and a metal core (12). The core (12) is divided into a first core portion (14) and a second core portion (16) spaced apart from each other. The first core portion (14) and the second portion (16)

each comprises a plurality of arms, the arms of the first core portion being aligned with the arms of the second core portion, each coil surrounding an arm of the first core portion and an arm of the second core portion.

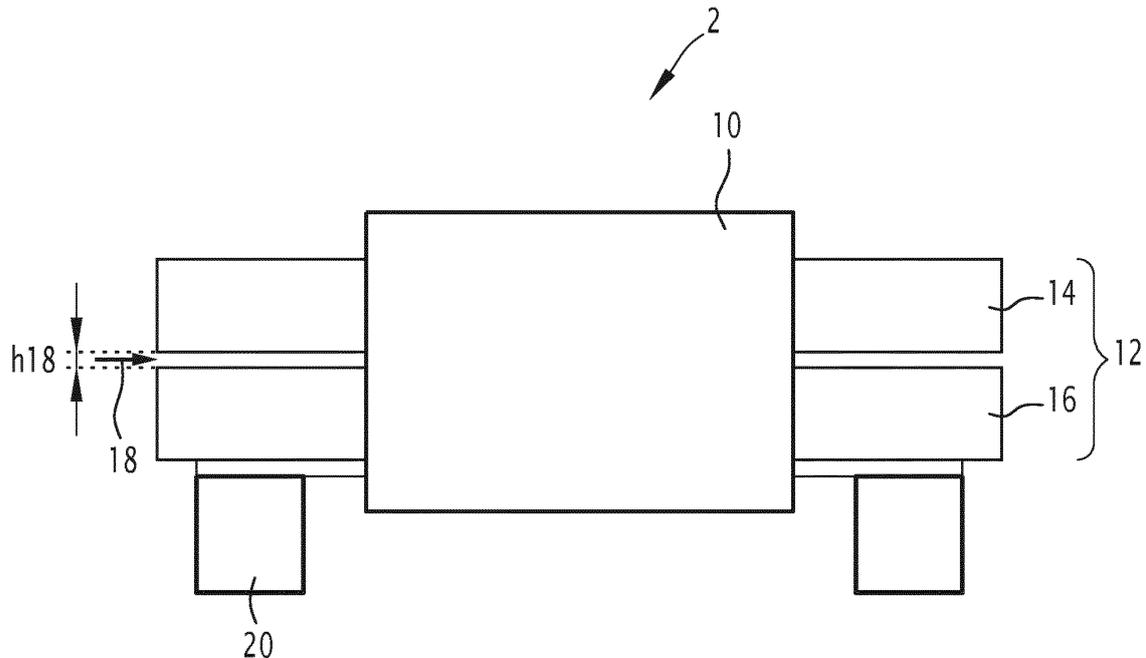


FIG. 2

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Description

TECHNICAL FIELD

[0001] Aspects of the invention more generally relate to new coil assembly designs for power conversion circuits.

BACKGROUND

[0002] Power conversion circuits, such as power factor converters (PFC) used in alternating current (AC) power systems, usually comprise an inductor element, such as a coil assembly (e.g., a choke coil), designed to filter out unwanted frequency components from electrical currents (e.g., to block higher frequencies and eliminate high-order harmonics).

[0003] Such coil assemblies typically comprise one or more windings, or coils, placed around a core made from a metallic material, such as silicon steel. Cores of coil assemblies made from silicon steel are relatively inexpensive to manufacture, but cannot be reliably used for high frequency applications (e.g., with switching frequencies higher than 10kHz) due to high core losses and excessive overheating.

[0004] It is therefore desirable to provide low-cost coil assemblies capable of being used in high frequency applications while being less prone to overheating.

SUMMARY

[0005] According to an aspect, a coil assembly comprises a plurality of coils and a metal core. The core is divided into a first core portion and a second core portion spaced apart from each other, the first core portion and the second portion each comprising a plurality of arms, the arms of the first core portion being aligned with the arms of the second core portion, each coil surrounding an arm of the first core portion and an arm of the second core portion.

[0006] According to some further aspects, the invention may comprise one or more of the following features, considered alone or according to all possible combinations:

The first and second core portions have a planar shape and are offset from each other along a direction perpendicular to the first and second core portions.

[0007] The distance separating the first and second core portions is comprised between 1mm and 35mm.

[0008] The core is configured to allow the passage of an air flow in the space between the first and second core portions.

[0009] The first and second core portions are superimposed vertically on top of each other.

[0010] The first and second core portions have an identical shape.

[0011] The first and second core portions are held together by spacer elements, said spacer elements being

preferably made from aluminum.

[0012] The first and second core portions are made from laminated iron sheets.

[0013] Each arm of the first and second core portions is divided into at least two subparts separated from each other by an air gap.

[0014] According to another aspect, a power conversion circuit comprises a coil assembly as defined above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The invention will be better understood upon reading the following description, provided solely as an example, and made in reference to the appended drawings, in which:

Fig. 1 is a simplified diagram of a power conversion circuit according to one or more embodiments of the invention;

[0016] Fig. 2 is a simplified side view of a coil assembly according to one or more embodiment of the invention;

[0017] Fig. 3 is another simplified side view of a coil assembly according to one or more embodiment of the invention;

[0018] Fig. 4 is a simplified elevated view of a core portion of the coil assembly of Figs. 2 and 3;

[0019] Fig. 5 is a simplified perspective view of the coil assembly of Figs. 2 and 3.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

[0020] Fig. 1 illustrates a coil assembly 2 part of an exemplary power conversion circuit 4 connected to an electrical device 6, such as a load or a power source.

[0021] According to some embodiments, the power conversion circuit 4 is a power factor converter, or a power inverter, or any suitable AC power conversion system.

[0022] The coil assembly 2 is configured to filter out unwanted frequency components from AC electrical currents, for example to block higher frequencies and eliminate high-order harmonics. In other words, the coil assembly 2 acts as a low pass filter upon AC electrical currents.

[0023] For example, the coil assembly 2 is a choke coil, such as a boost choke or a line choke.

[0024] As illustrated on Fig. 2, Fig. 3 and Fig. 5, the coil assembly 2 comprises a plurality of coils 10, or windings, and a metal core 12, preferably made from a magnetic material.

[0025] For example, the coils 10 are made of copper wire.

[0026] The coils 10 are placed around the metal core 12 and surround at least a portion of said metal core 12.

[0027] The coils 10 are configured to be electrically connected to one or more elements of the power conversion circuit 4, for example through connectors or leads.

[0028] According to some embodiments, each coil 10

is associated to a phase of the AC current.

[0025] In the illustrated example, the coil assembly 2 comprises three coils 10 and is configured to operate in a three-phase electrical system.

[0026] This example is not limiting and, in alternative embodiments, the number of coils 10 could be different.

[0027] The metal core 12 is divided into a first core portion 14 and a second core portion 16 spaced apart from each other. Reference "18" denotes the space between the first and second coil portions 14, 16.

[0028] According to some embodiments, the first and second core portions 14, 16 are made from laminated iron sheets, such as silicon steel, although other suitable materials could be used instead.

[0029] Preferably, the distance h18 separating the first and second core portions 14, 16 is comprised between 1mm and 35mm, or preferably between 10mm and 30mm.

[0030] In some embodiments, the first and second core portions 14, 16 are superimposed vertically on top of each other, for example along a vertical direction.

[0031] For example, the first core portion 14 and the second core portion 16 both have a planar shape and lay parallel with each other along some geometrical plane, e.g. along an horizontal geometrical plane. Core portions 14, 16 are offset from each other along a direction perpendicular to said geometrical plane.

[0032] According to some embodiments, the first and second core portions 14, 16 have a similar shape, and preferably have an identical shape.

[0033] In practice, the core 12 is configured to allow the passage of an airflow in the space 18 between the first and second core portions 14, 16, as illustrated on Fig. 3 by the arrows "F". For example, the space 18 is open along the edges of the core 12.

[0034] This airflow F is advantageously used to naturally cool the core 12 during operation, which improves the evacuation of heat generated by coils 10 and reduces the risk of overheating.

[0035] In many embodiments, the core 12 is mounted atop a support structure 20.

[0036] For example, the support structure 20 include legs preferably arranged in a lower region of the core assembly 2 and configured to be attached to a suitable reception surface, such as a printed circuit board, e.g., for integrating the coil assembly 2 in the power conversion circuit 4.

[0037] The first and second core portions 14, 16 are held together by spacer elements 21.

[0038] Preferably, said spacer elements 21 are made from aluminum, although this example is not limiting and other suitable nonmagnetic materials could be used instead.

[0039] For example, the spacer elements 21 are vertically arranged bars or plates fastened to the first and second core portions 14, 16 by fastening elements such as screws, or by welding, or by any appropriate means. The spacer elements 21 may also be fastened to the

support structure 20.

[0040] As illustrated on Fig. 4, each of the first core portion 14 and the second portion 16 comprise a plurality of arms 22, 24, 26. Said arms 22, 24, 26 may be separated by hollow portions 28 and 30.

[0041] Preferably, the arms 22, 24, 26 of the first core portion 14 are aligned with the arms 22, 24, 26 of the second core portion 16.

[0042] On Fig. 4, only the first core portion 14 is illustrated. However, it is understood that, in many embodiments, the second core portion 16 has a similar or identical shape.

[0043] According to examples, each core portion 14, 16 has a square or rectangular shape and includes rectilinear parallel arms 22, 24 and 26.

[0044] In the illustrated example, each core portion 14, 16 includes a first arm 22, a second arm 24 and a third arm 26. The first arms 22 of both first and second core portions 14 are aligned with each other. Similarly, the second arms 24 of both first and second core portions 14 are aligned with each other, and the third arms 26 of both first and second core portions 14 are aligned with each other.

[0045] Each coil 10 is placed so as to surround an arm of the first core portion 14 and an arm of the second core portion 16.

[0046] For example, a first coil 10 is mounted on the first arms 22 of both first and second core portions 14, 16. A second coil 10 is mounted on the second arms 24 and a third coil 10 is mounted on the third arms 26.

[0047] According to some embodiments 10, the coils may be wound directly onto the core 12, or may be wound onto prefabricated coil holders mounted on said arms.

[0048] According to some embodiments, each arm 22, 24, 26 of the first and second core portions 14, 16 is divided into at least two subparts separated from each other by an air gap 32, 34, 36.

[0049] For example, the two subparts have each a longitudinal rod-like shape and are both aligned essentially along a same longitudinal axis. The respective distal ends of the two subparts face each other and are separated by said air gap.

[0050] For example, each arm 22, 24, 26 includes three air gaps 32, 34 and 36, preferably having the same dimensions. However, this example is not limiting and, in alternative embodiments, the number of air gaps and/or their dimensions could be chosen differently.

[0051] For example, the number and the dimensions of air gaps can be adjusted to manage the magnetic flux coupling between the first and second core portions 14 and 16.

[0052] In the embodiments of the invention described herein, dividing the metal core 12 into two core portions 14 and 16 and allowing an airflow in the space 18 between said core portions 14 and 16 provide a natural and efficient way of cooling the core assembly 2 and preventing overheating during operation.

[0053] As a result, the core assembly 2 can be suitably

used in high frequency operations (e.g., with frequencies higher than 10 kHz) without being prone to excessive overheating, even though the core 12 is made of a low cost material such as silicon steel.

[0054] If needed, air gaps 32, 34 and 36 can be suitably shaped and arranged in the arms of the core portions 14, 16 to mitigate or eliminate possible unwanted magnetic losses and/or coupling that might occur between the core portions 14 and 16.

[0055] In accordance with some embodiments, the width of each air gap 32, 34 and 36 is higher than or equal to 1mm, to avoid any unwanted magnetic saturation of the metal core 12 due to the proximity effect. Preferentially, the width of each air gap 32, 34 and 36 is higher than or equal to 2mm, to ensure a sufficient airflow and provide adequate cooling.

[0056] However, the width of each air gap 32, 34 and 36 is preferentially lower than or equal to 10mm, in order to limit the size of the metal core 12.

[0057] The embodiments and alternatives described above may be combined with each other in order to generate new embodiments of the invention.

Claims

1. A coil assembly (2) comprising a plurality of coils (10) and a metal core (12), wherein the core (12) is divided into a first core portion (14) and a second core portion (16) spaced apart from each other, the first core portion (14) and the second portion (16) each comprising a plurality of arms (22, 24, 26), the arms of the first core portion being aligned with the arms of the second core portion, each coil surrounding an arm of the first core portion and an arm of the second core portion.
2. The coil assembly of claim 1, wherein the first and second core portions (14, 16) have a planar shape and are offset from each other along a direction perpendicular to the first and second core portions.
3. The coil assembly of claim 1 or claim 2, wherein the distance (h18) separating the first and second core portions is comprised between 1mm and 35mm.
4. The coil assembly according to any of the previous claims, wherein the core (12) is configured to allow the passage of an air flow in the space (18) between the first and second core portions (14, 16).
5. The coil assembly according to any of the previous claims, wherein the first and second core portions (14, 16) are superimposed vertically on top of each other.
6. The coil assembly according to any of the previous claims, wherein the first and second core portions

(14, 16) have an identical shape.

7. The coil assembly according to any of the previous claims, wherein the first and second core portions (14, 16) are held together by spacer elements (21), said spacer elements (21) being preferably made from aluminum.
8. The coil assembly according to any of the previous claims, wherein the first and second core portions (14, 16) are made from laminated iron sheets.
9. The coil assembly according to any of the previous claims, wherein each arm (22, 24, 26) of the first and second core portions (14, 16) is divided into at least two subparts separated from each other by an air gap (32, 34, 36).
10. A power conversion circuit (4) comprising a coil assembly (2), wherein said coil assembly (2) is according to any of the previous claims.

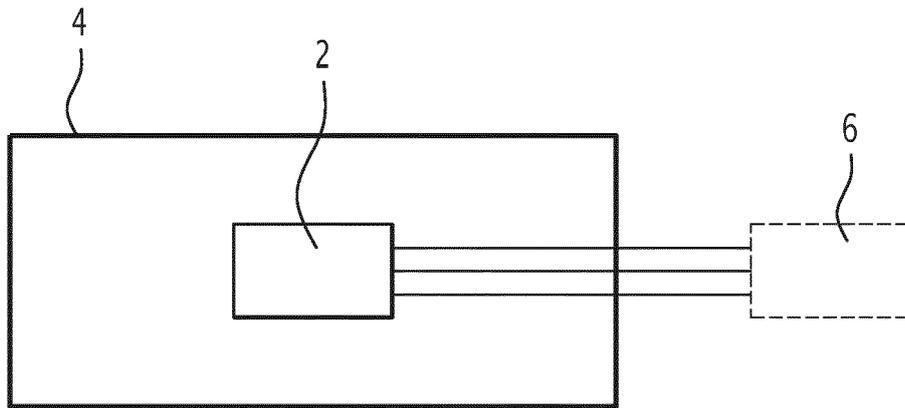


FIG. 1

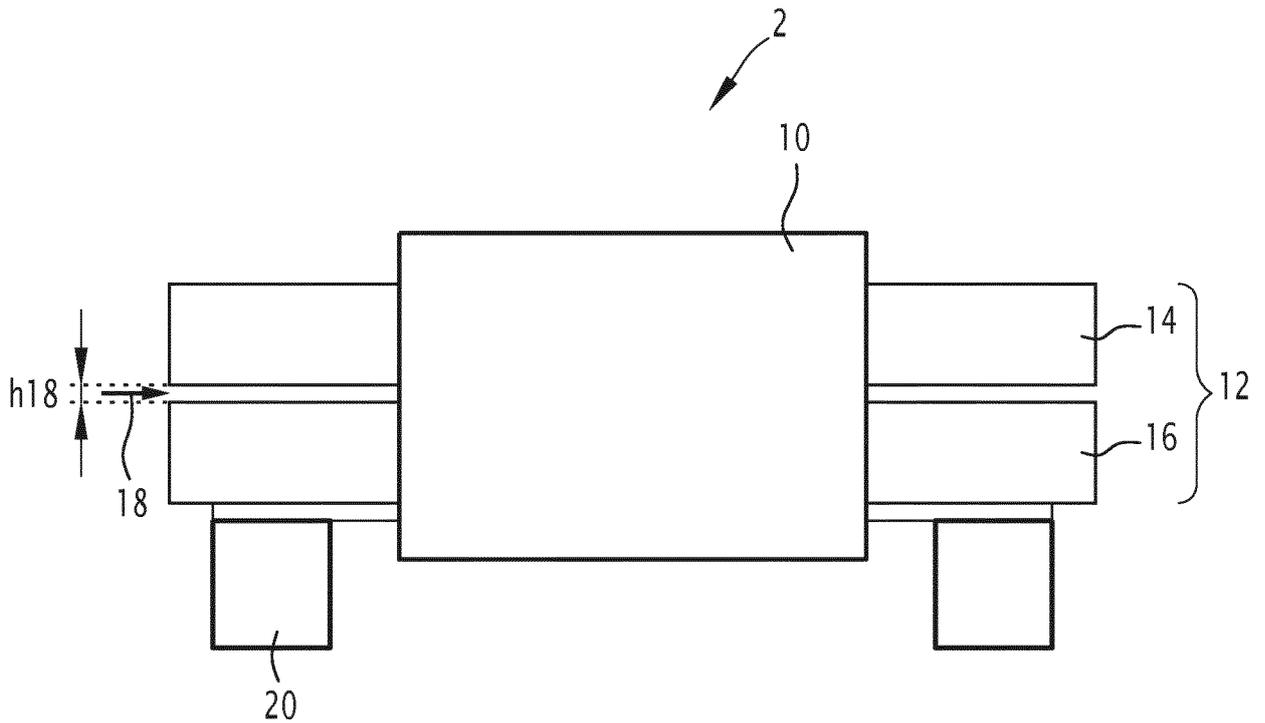


FIG. 2

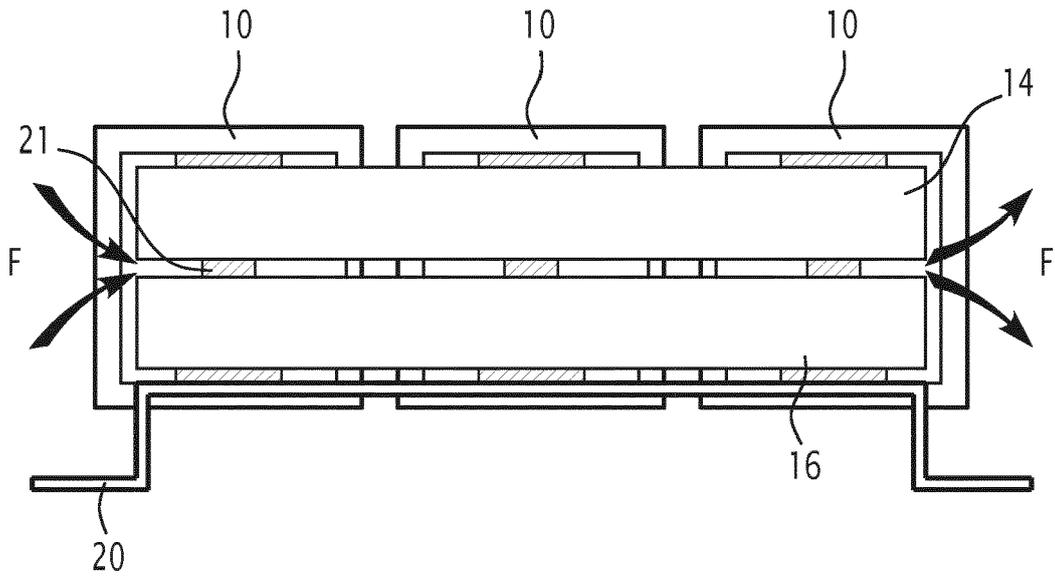


FIG. 3

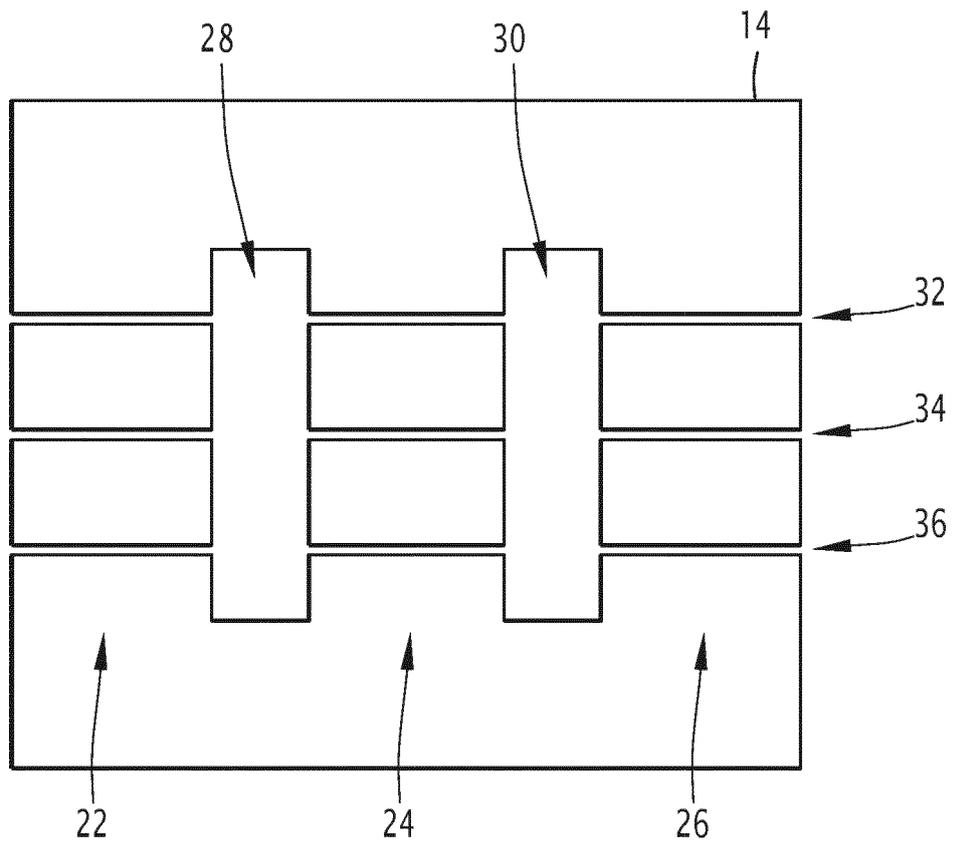


FIG. 4

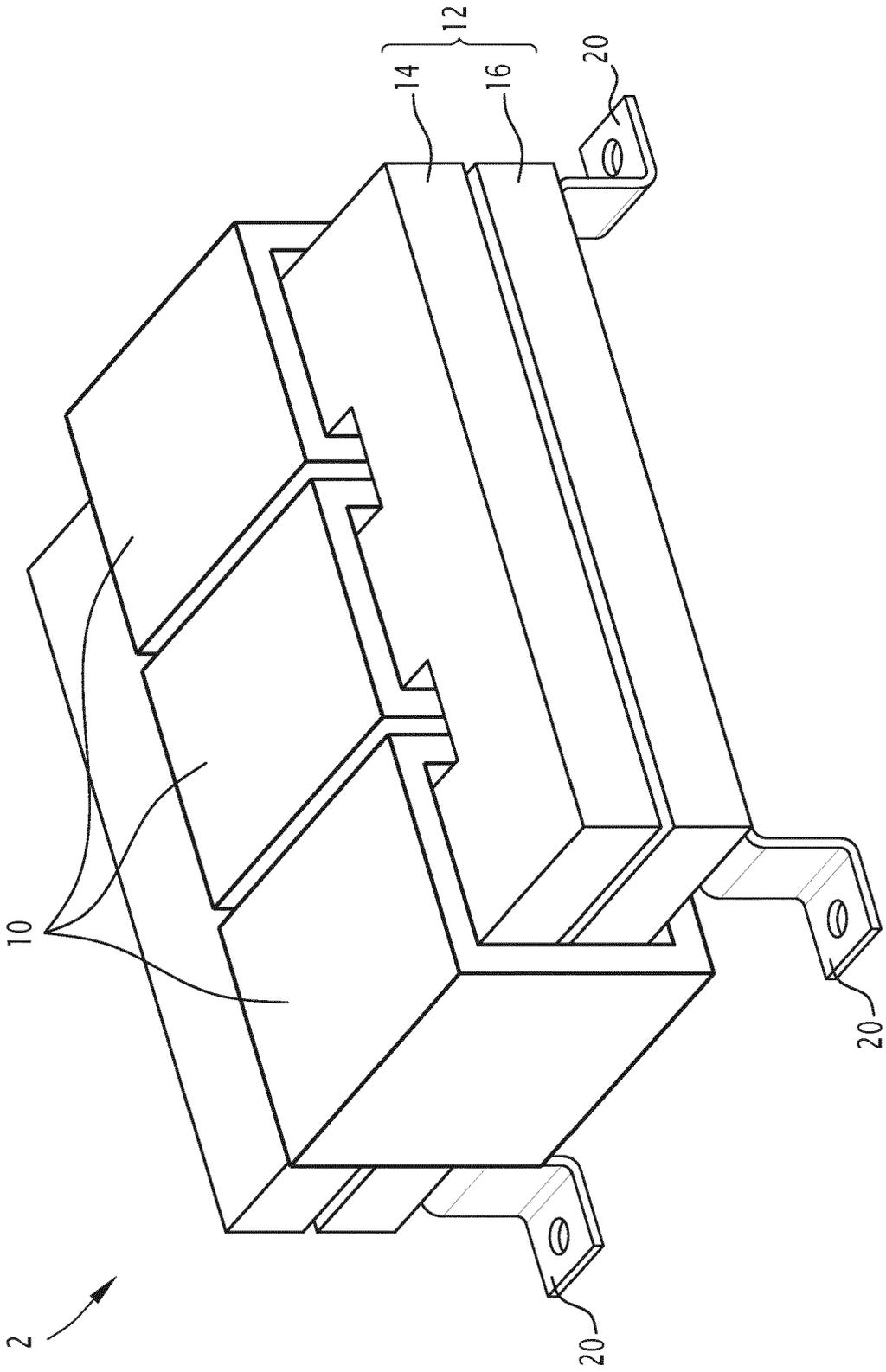


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2014/167571 A1 (U T T UNIQUE TRANSFORMER TECHNOLOGIES LTD [IL]) 16 October 2014 (2014-10-16) * page 1, lines 2 - 14 * * page 2, lines 20 - 31 * * page 6, lines 27 - 29 * * page 11, line 17 - page 12, line 2 * * page 13, line 29 - page 14, line 19 * * page 15, lines 24 - 28 * * figures 1A, 1B * -----	1-10	INV. H01F27/25
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 30 June 2020	Examiner Van den Berg, G
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.

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