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(54) A portable heat exchange panel for corrugated transformer tank

(57) The subject of the invention is portable heat exchange panel (1) for corrugated transformer tank with liquid medium. The heat exchange panel or panels are applicable for cooling corrugated transformer fins in distribution transformers. A portable heat exchange panel (1) for corrugated transformer tank characterised in that it has a form of a plate which is equipped with fastening means (3) for fixing the plate to the fins of a transformer tank and is equipped with at least two elastic distance elements (2) where one of the distance element is placed on one side of the plate and the other one is placed on the other side of the plate and each of the distance element (2) has an equal height (H).

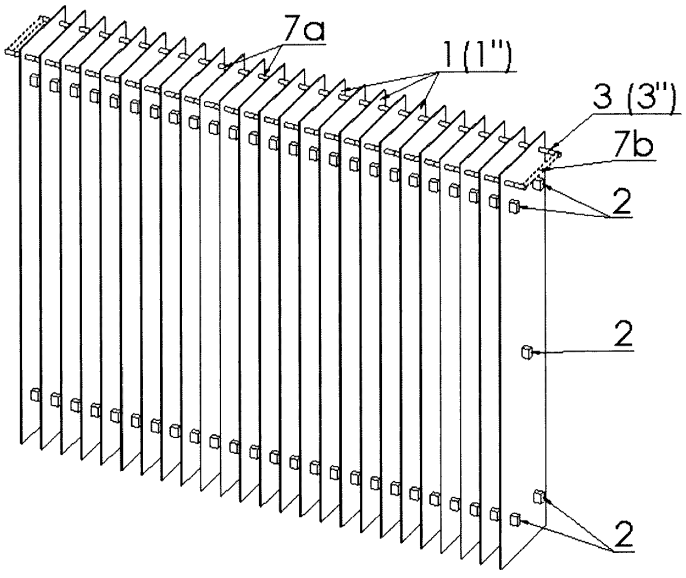

Fig. 7

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Description

[0001] The subject of the invention is a portable heat exchange panel for corrugated transformer tank with liquid medium. The heat exchange panel or panels are applicable for cooling corrugated transformer fins especially in distribution transformers.

State of the art

[0002] The cooling is one of the main problems for many electrical products. The electric losses are responsible for the heat generation and increase of the product temperature. The improvement in cooling efficiency and decreasing of internal temperature has direct influence on the product's reliability and lifetime. The cooling issue is particularly important due to increasing demands for power, energy efficiency and reduction of the product's dimensions. Natural convection is common cooling mechanism in many electric products, e.g. in distribution transformers. It is a passive cooling method and that is its main advantage, but at the same time it is considered as one of the least effective. It is estimated that the heat transfer coefficient for the pure convection of air is about 5-7 W/mK. However, it is increased to about 11-13 W/mK if the radiation effects are included. The simplest and most common way to improve efficiency of the natural convection is increasing the surface for heat exchange. It is done by applications of the ribs and/or fins. However, these elements have mainly influence on the convective heat transfer and the high potential of the radiation is not utilized.

[0003] From patent description GB884007 there is known a heat exchange apparatus comprising a container having external tubes which are directly connected to the container wall and through which liquid within the container can circulate. The tubes and the container walls providing primary heat transfer surfaces. The heat exchange apparatus further comprises radiation barriers between the container walls and the tubes, which are spaced away from the primary heat transfer surfaces to allow free circulation of fluid between the barriers and the surfaces. The container is a container for liquid-cooled electrical apparatus such as a transformer tank. The transformer tank could have banks of the external tubes and radiation barriers which are interposed between adjacent banks. In such solution the radiation barriers are placed perpendicular to the container walls. The radiator barriers are mounted in position fixtures attached to the tubes. Such solution is a good solution for transformer having the external tubes filled with the liquid from the container. The tubes allow for placing between them the radiation barriers because between tubes there is enough free space for the heat convection phenomena. Such solution is not useful for a transformer corrugated tank, where series of the fins in form of corrugated metal sheet is situated on at least one of the wall of the transformer tank. The space existing between the corrugated fins is enough for placing the radiation barriers or panels, but the distance between the fins is rather small and may be different at each fin (due to production tolerances) as well as it may differ along the fin height or depth. Some changes in the space between the fins may also be observed during transformer operation, when temperature of the device is going up or down. Due to relatively high thermal expansion coefficient the oil changes its volume and that causes deformations of the fins.

[0004] The distance between the surface of the corrugated fins and radiation panels is critical regarding efficiency of the heat exchange system. If that distance is small it must be well controlled in order to assure undisturbed air flow between the corrugated fins and radiation panels.

[0005] There is a need for increasing of the cooling efficiency of the electrical apparatus like transformer. It may be achieved by increasing of the radiative heat transfer from the corrugated fins in a simple and efficient manner. It is possible by application of a portable heat exchange panels according to the present invention.

The essence of the invention

[0006] The main idea of the invention is increasing of the radiative heat transfer from the fin based structure. It is done by placing of the additional elements - panels - between the fins and parallel to them. The essential radiative heat transfer between surfaces of the fins and panels is present, because the panels have lower temperature. In the proposed solution a thermal contact by means of conduction between the panels and the fins must be minimized. Primary, the proposed invention was considered for the fin based cooling systems, in which further increase of the surface for the convective heat transfer is not possible. However, the modifications in the design of the panels may extend the area of application.

[0007] The essence of the invention is that the portable heat exchange panel has a form of a plate which is equipped with fastening means for fixing the plate to the corrugated fins of a transformer tank and is equipped with at least two elastic distance elements. One of the distance element is placed on one side of the plate and the other one is placed on the other side of the plate and each of the distance element has an equal height.

[0008] In one embodiment of the invention the fastening means have a form of at least two catches connected to the plate.

[0009] In the other embodiment of the invention the fastening means have a form of at least two openings carried out in the top part of the plate and a supporting modular element in the form of a pair of rods or bars provided with longitudinal pipes connected together by slipping one part into another, where said rods or bars are inserted to the openings of the plate. In this embodiment a modification is possible where the rods or bars are connected together by two cross-bars forming a

frame.

[0010] In still another embodiment of the invention the fastening means have a form of one opening carried out in the top corner of the plate and one longitudinal pipes inserted to the opening and at least one catch which is connected to the plate.

[0011] The heat exchange panel is made of metal or thermoplastic or it has a composite structure consisting of metal, thermoplastic or organic materials.

[0012] The both surfaces of the heat exchange panel are covered by a coating for increasing the infrared radiation emissivity of the panel's surfaces to the value higher than 0.7.

[0013] The heat exchange panel has a flat surfaces or the both surfaces of the panel are shaped as sinusoidal, zig-zag or meander waves.

[0014] The distance elements of the heat exchange panel are made of elastic foam or elastomer rubber or thermoplastic or metal.

[0015] The distance elements have a shape of a regular solid like a disc or cylinder, an openwork solid, a flat or a spiral spring.

[0016] The distance elements are placed symmetrical to each other on the both sides of the plate.

[0017] The subject of the invention is also a set of heat exchange portable panels which is formed from panels according to claim 1 which are connected together by the fastening means according to claims 3-4 or by the fastening means according to claim 5.

[0018] The essence of the method for cooling the fins of a corrugated transformer tank is that said method consists in placing at least one heat exchange portable panel or a set of heat exchange portable panels according to the invention between the corrugated fins of a transformer tank perpendicular to the transformer wall, using a fastening means in such a way that the cooling plate is inserted between two adjacent transformer fins in an equal distance from the adjacent fins.

[0019] The advantages of the invention is a simple construction allowing for increasing a cooling efficiency, what has direct influence on the product's characteristics. The potential benefits may be related to improved performance, e.g. higher power level without changes in dimensions of the transformer tank and longer lifetime of the product and tolerance to the environment with extremely high ambient temperature.

An embodiment of the invention

[0020] The subject of the invention is depicted in exemplary embodiment on the drawings where:

fig.1 presents schematically the single panel from a front view,

fig.2 presents the panel in the first embodiment in side view,

fig.3 presents the panel in the second embodiment in the axonometric view with a part of the frame cut away,

fig.4 presents the panel in the third embodiment in side view,

fig.5 presents the different embodiments of the distance elements of the heat exchange panel from fig.2, fig.3 and in fig.4 in a front view,

fig.6 presents the different shapes of the panels from fig.2, fig.3 and fig.4 in a top view,

fig.7 presents the set of panels according the embodiment from fig.3 in an axonometric view,

fig.8 presents the set of panels according the embodiment from fig.4 in an axonometric view,

fig.9 presents the transformer with the set of heat exchange panels according to the first embodiment of the invention in an axonometric view,

fig.10 presents the transformer with the set of heat exchange panels according to the second embodiment of the invention in an axonometric view,

fig.11 presents the transformer with the set of heat exchange panels according to the third embodiment of the invention in an axonometric view.

[0021] A portable heat exchange panel for transformer has a form of plate 1, which has a rectangular like shape. The plate 1 is made of metal or thermoplastic or it has a composite structure consisting of metal, thermoplastic or organic materials. To the both surfaces of the plate 1 at least one elastic distance element 2 is fixed. The distance element 2 is designed in such a way that allows for placing the panel 1 between the fins of the transformer in an equal distance. The distance element 2 is made of elastic foam or elastomer rubber. The distance element 2 can also be made as metal or thermoplastic spring. Each of the distance element 2 has a height H which is the same for both elements 2 located on each side of the panel 1. The panel 1 is equipped with fastening means 3 for affixing the panel to the corrugated transformer tank between its fins and perpendicular to the transformer walls. The fixing means 3 are indicated schematically as a slanting crosses in the fig.1 in dashed lines. The both surfaces of the panel 1 could be covered by a coating 4 for increasing the infrared radiation emissivity of the panel's surfaces to the value higher than 0.7. The coating 4 is indicated on fig.1 with rectangle in dashed line and in fig.2-4 as a fragment of a mesh covering the surface of the panel 1. The exemplary coating 4 is a carbon black paint.

[0022] In the first embodiment of the invention the pan-

el 1 has a form of a rectangular plate 1' containing fastening means 3 in the form of catches 3' located at two corners of the plate 1' on the longer side of the plate. Such catches 3' could be formed by cutting out a material straps from the longer edge 5 of the plate 1' near its two corners. The catch 3' could also be made as a simple hook fixed to the two corners of the plate on the longer side of the plate, what is not presented in the drawings. Such catches could also be made as simple clips attached to the two corners of the plate 1'. All catches 3' are adapted to fixing the panel 1 to the transformer rod which is connecting the transformer fins at their external top and bottom corners.

[0023] In the second embodiment of the invention the panel 1 has a form of a rectangular plate 1" having two openings 6 which are located near the top corners of the plate. Fastening means 3 have a form of a supporting modular element 3" in the form of two rods or bars provided with longitudinal pipes 7a connected together by slipping one pipe into another or in the form a frame formed by modular longitudinal pipes 7a connected with two lateral pipes 7b. Each of the longitudinal pipe 7a is placed in the opening 6.

[0024] The modular construction of the two pipes 7a placed in the openings 6 of the plate 1" with the lateral pipes 7b used, what is indicated in dashed line, forms a portable set of heat exchange panels where the set is placed on the corrugated transformer fins.

[0025] In the third embodiment of the invention the panel has a form of a rectangular plate 1"' having one opening 6 located near the top corner of the plate and one catch 3' in the form of rectangular relief cut out near the second other top corner. Fastening means 3 are carried out as a combination of means from the first and second embodiments. Through the opening 6 the one supporting modular element 3" is inserted having the form of one rod or bar provided with longitudinal pipes 7a connected together by slipping one pipe into another. The modular construction of the pipe 7a placed in the openings 6 of the plate 1"' and catch 3' affixed to the other top corner of the plate 1"', forms a portable set of heat exchange panels where the set is placed on the corrugated transformer fins.

[0026] In all embodiments of the invention each of the distance elements 2 could be formed in different shapes. For example it could be a shape of a regular solid like a disc or cylinder 2a, or an openwork solid 2b, or a flat spring 2c, or a spiral spring 2d. The distance elements are preferably placed symmetrically to each other on the both sides of the panel 1, what is indicated in fig.5.

[0027] In all embodiments of the invention the heat exchange panel 1 may be carried out in different way. The panels could have their surfaces as a simple flat plate 1a, or a sinusoidal plate 1b, or a zig-zag plate 1c or a meander plate 1d, what is presented in fig.6. The different shape of the surfaces of panel 1 allows for increasing the surface of the plate and increase an efficiency of the heat exchange between the plate and the corrugated fins of the transformer tank.

[0028] The method for cooling corrugated fins of the transformer 10 consists in placing at least one heat exchange portable panel 1 according to invention perpendicular to the transformer wall 11 between the corrugated fins 12 of a transformer 10 (10a, 10b) using a fastening means 3 (3', 3") in such a way that the cooling panel 1 is inserted between two adjacent transformer fins 12 in an equal distance from the adjacent fins.

[0029] For the transformer 10a equipped with the rods 13 connecting the external fins 12 on the top and on the bottom of transformer fins, the fastening means in the form of a catch 3' is used for fastening a panel 1 between two adjacent transformer fins 12 in an equal distance from the adjacent fins.

[0030] For the transformer 10a a set of panels 1 connected together by fixing means in the form of combination of catches 3' and one supporting modular element 3" inserted to the opening 6 are also used. In this way the caches 3' are fixed to the rod 13. For the transformer 10b, without any rods connecting the fins, at least one panel 1 in the form of plate 1" is fixed using the fastening means 3" that is placed on the top of corrugated transformer fins 12.

Claims

1. A portable heat exchange panel (1) for corrugated transformer tank **characterised in that** it has a form of a plate which is equipped with fastening means (3) for fixing the plate to the fins of a transformer tank and with at least two elastic distance elements (2) where one of the distance element is placed on one side of the plate and the other one is placed on the other side of the plate and each of the distance element (2) has an equal height (H).

2. A heat exchange panel according to claim 1, **characterised in that** the fastening means have a form of at least two catches (3') connected to the plate (1').

3. A heat exchange panel according to claim 1, **characterised in that** the fastening means have a form of at least two openings (6) carried out in the top part of the plate (1") and a supporting modular element (3") in the form of a pair of rods or bars provided with longitudinal pipes (7a) connected together by slipping one part into another, where said rods or bars are inserted to the openings (6).

4. A heat exchange panel according to claim 3, **characterised in that** longitudinal pipes (7a) are connecting together by two cross-bars (7b).

5. A heat exchange panel according to claim 1, **characterised in that** the fastening means have a form of one opening (6) carried out in the top part of the

plate (1"') and a supporting modular element in the form of a rod or bar provided with longitudinal pipes (7a) connected together by slipping one part into another, where said rod or bar are inserted to the openings (6) and at least one catch (3') which is connected to the plate (1"').

6. A heat exchange panel according to claims 1-5, **characterised in that** is the panel (1) is made of metal or thermoplastic or it has a composite structure consisting of metal, thermoplastic or organic materials.

7. A heat exchange panel according to any previous claims, **characterised in that** the both surfaces of the panel (1) are covered by a coating (4) for increasing the infrared radiation emissivity of the panel's surfaces to the value higher than 0.7.

8. A heat exchange panel according to claim 1-7 **characterised in that** the panel (1) has a flat surfaces.

9. A heat exchange panel according to claim 1-7 **characterised in that** the both surfaces of the panel (1) are shaped as sinusoidal waves (1b) or zig-zag waves (1c) or meander waves (1d).

10. A heat exchange panel according to any previous claims, **characterised in that** the distance elements (2) are made of elastic foam or elastomer rubber or thermoplastic or metal.

11. A heat exchange panel according to claim 11, **characterised in that** distance elements have a shape of a regular solid like a disk or cylinder (2a), or an openwork solid (2b), or a flat spring (2c), or a spiral spring (2d).

12. A heat exchange panel according to any previous claims, **characterised in that** the distance elements (2) are placed symmetrical to each other on the both sides of the plate (1', 1", 1"').

13. A set of heat exchange portable panels **characterized in that** it is formed from many panels (1) according to claim 1 which are connected together by the fastening means according to claims 3-4 or by the fastening means according to claim 5.

14. A method for cooling the fins of a corrugated transformer tank (10), **characterized in that** consists in placing at least one heat exchange portable panel according to claims 1-12 or a set of heat exchange portable panels according to claim 13, between the corrugated fins (12) of a transformer tank 10 (10a, 10b) perpendicular to the transformer wall (11), using a fastening means (3) in such a way that the cooling plate (1') or (1") or (1") is inserted between two adjacent transformer fins (12) in an equal distance from the adjacent fins.

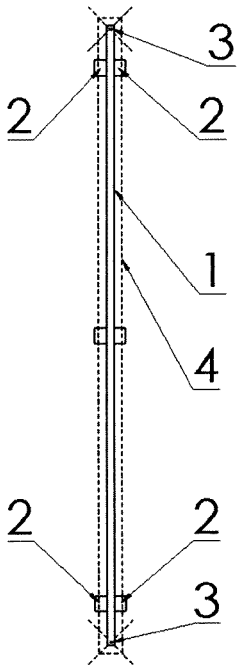

Fig. 1

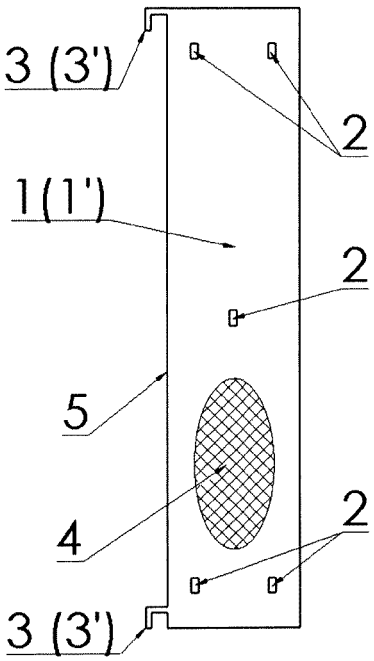

Fig. 2

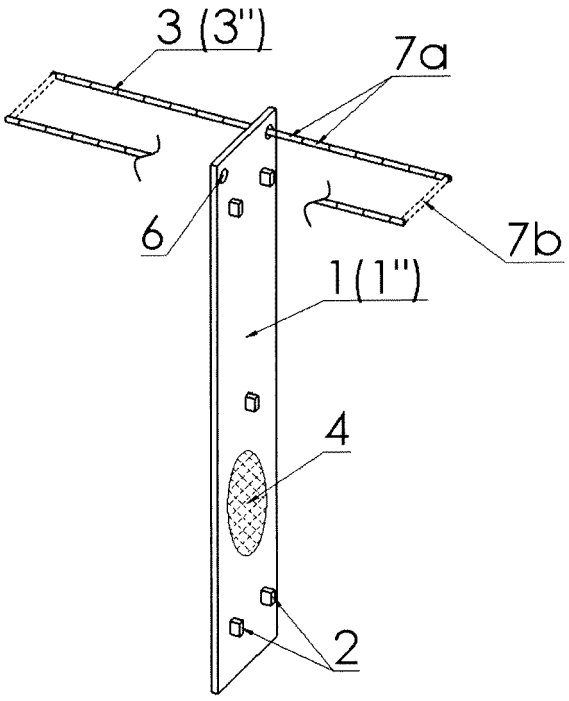

Fig. 3

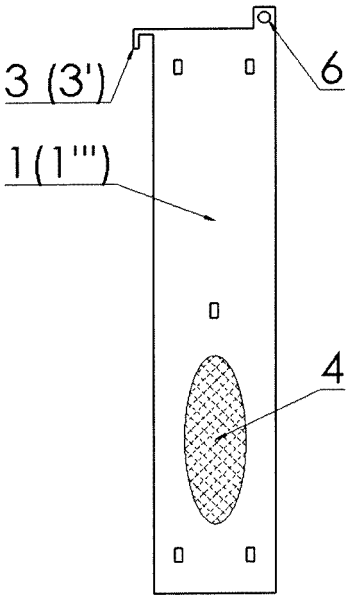

Fig. 4

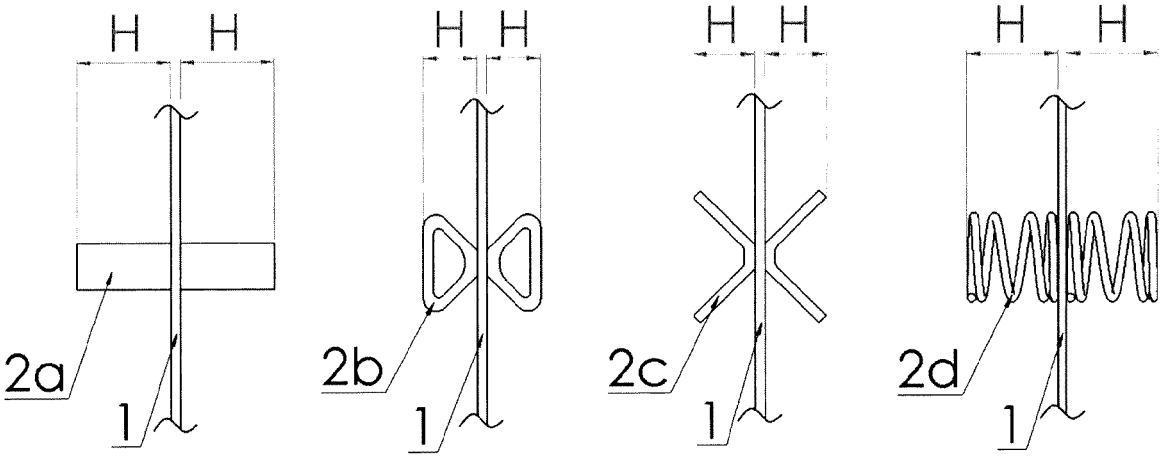

Fig. 5

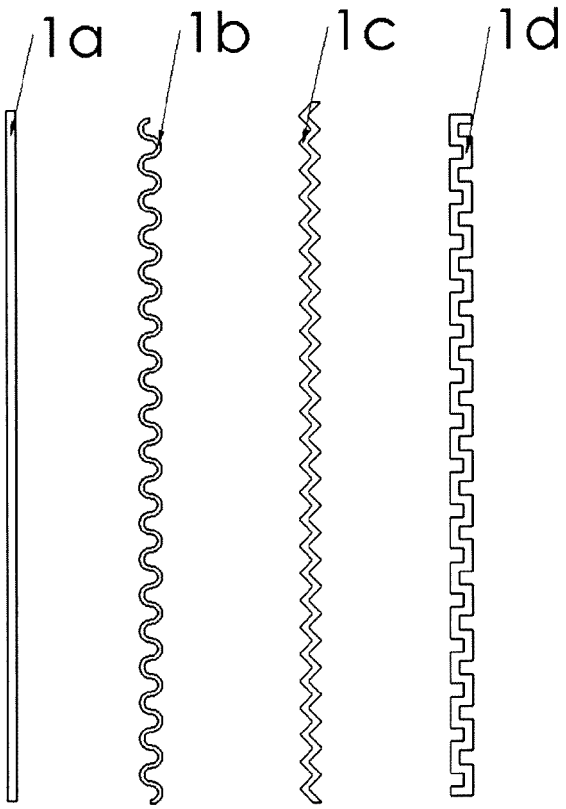

Fig. 6

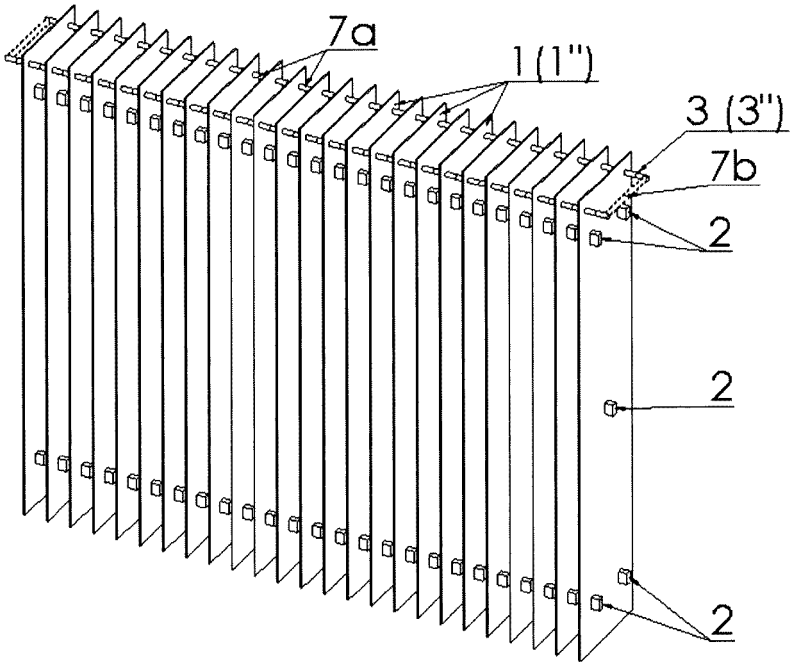

Fig. 7

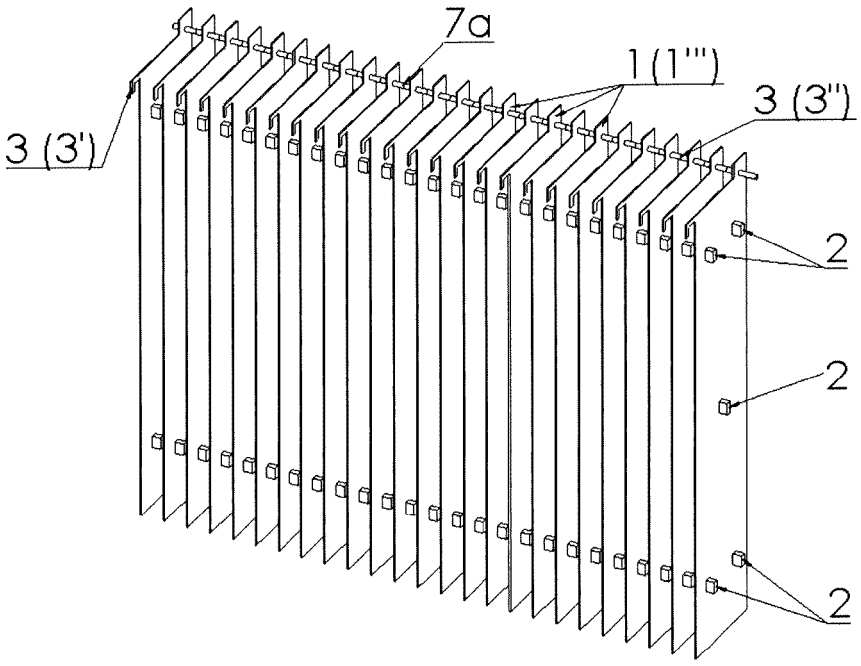

Fig. 8

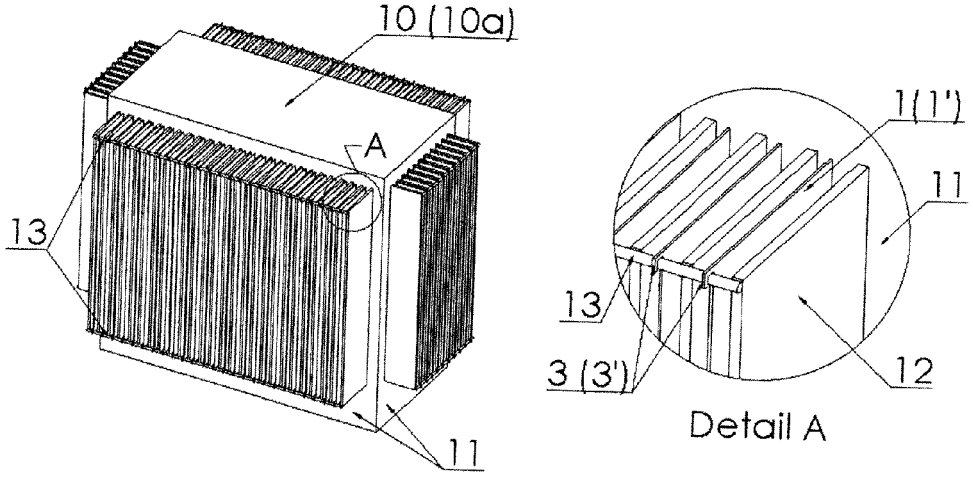
10 (10a)
A
13
11
1(1')
11
13
3 (3')
12
Detail A

Fig. 9

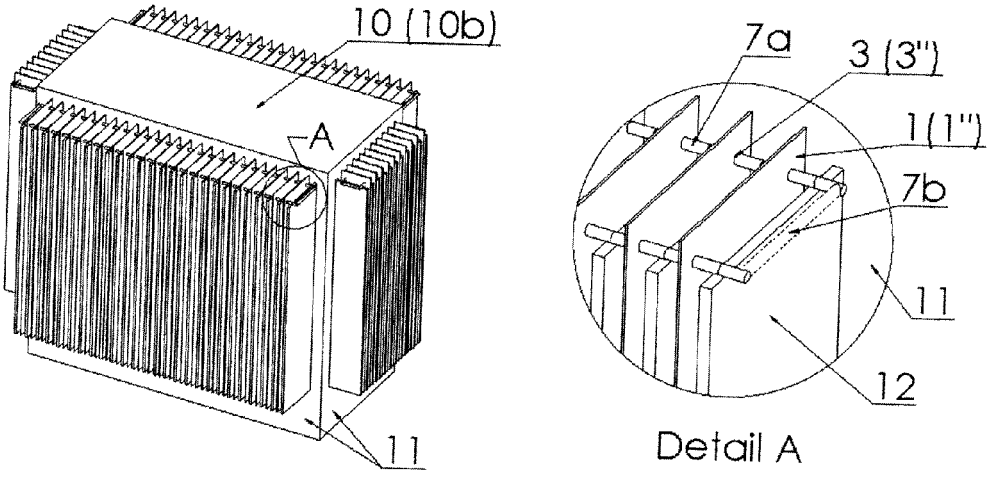
10 (10b)
A
11
7a
3 (3")
1(1")
7b
11
12
Detail A

Fig. 10

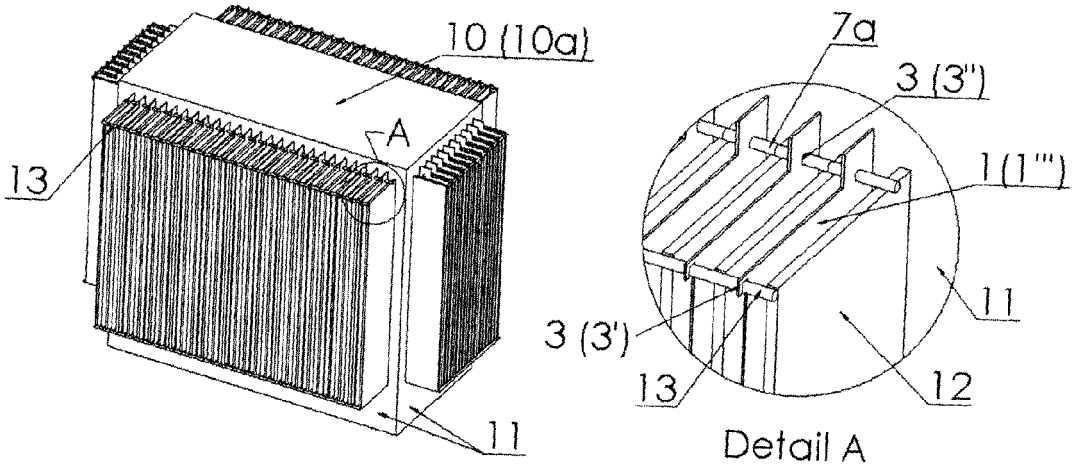

Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 13 46 0057

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 1 500 793 A (BINGAY ROBERT V) 8 July 1924 (1924-07-08) * page 1, lines 9 - 17, 50 - 79 * * page 2, lines 10 - 23, 32 - 39 * -----	1-14	INV. H01F27/02
A	DE 20 2011 103495 U1 (LOOS & CO KG [DE]) 7 November 2011 (2011-11-07) * paragraphs [0001] - [0003], [0006] * -----	1-14	
A	US 4 745 966 A (AVERY RANDALL N [US]) 24 May 1988 (1988-05-24) * column 1, lines 6 -12, 25-35 * * page 3, line 56 - column 4, line 5 * * column 4, line 64 - column 5, line 11 * * column 6, lines 44-50 * -----	1-14	

TECHNICAL FIELDS SEARCHED (IPC)
H01F
F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 December 2013	Van den Berg, G

CATEGORY OF CITED DOCUMENTS

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18-12-2013

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