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(54) Heat exchanger provided with improved side plates

(57) The invention proposes a heat exchanger, in particular for an automotive vehicle, comprising a bundle of tubes (2) with fins (7) interposed between the tubes for heat exchange, the bundle being delimited by two end fins (70, 72), the heat exchanger further comprising two headers (541, 543) receiving the ends of the bundle and at least one side plate (50, 52) disposed on one of said end fins, characterized in that the side plate comprises two side plate portions (501,503), each side plate portion being connected to one of the header.

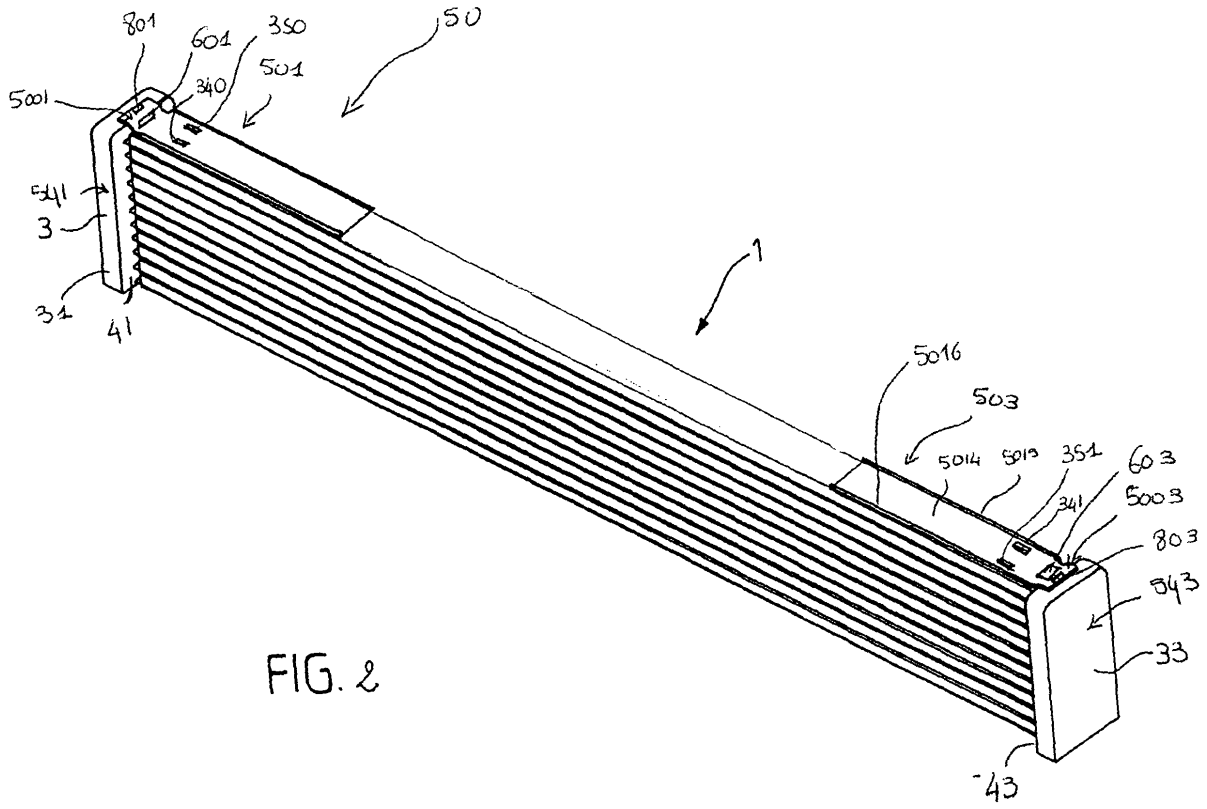

FIG. 2

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Description

[0001] The invention relates to heat exchangers, in particular to air-conditioning heat exchangers for automotive vehicles.

[0002] A conventional heat exchanger comprises a tube bundle delimited by two end tubes. Fins are further provided between the tubes of the bundle in order to improve heat exchange, included on the external face of each end tube.

[0003] In the heat exchanger, heat exchange occurs between a refrigerant flowing in the tubes and another refrigerant running through the heat exchanger. Such exchanger is used in automotive vehicles in order to ensure the engine cooling or the vehicle interior air-conditioning.

[0004] The heat exchanger further has two headers crossed by the bundle ends and a side plate provided on the fins disposed on the external face of the end tubes (end fins).

[0005] Side plates act as spacers between the headers, as they maintain a constant distance therebetween, which makes the heat exchanger manufacturing easier. They also provide rigidity to the heat exchanger and protect the end fins. Such side plates may further be used to support heat exchanger related equipments, such as a fan unit.

[0006] A conventional side plate comprises a base flanked with two longitudinal side walls provided to strengthen and rigidify the side plate.

[0007] When the heat exchanger is in use, refrigerant flow variations inside the tubes might result in temperature differences which in turn may cause thermal expansion at the heat exchanger centre. This generates mechanical stress in the tubes which might cause the tubes to buckle or to disengage from the headers.

[0008] Conventional heat exchangers tend to have a thin thickness in order to limit manufacturing costs. This makes the tubes less and less resistant to thermal shocks and the risks that tubes may buckle or break accordingly increase.

[0009] To limit these risks, it is known to mechanically dissociate the ends of each side plate from the central part thereof. Such dissociation prevents the transfer of stress linked to thermal expansion towards the tubes. To achieve this dissociation, it is known to provide openings at the side plate central part. This solution improves the resistance of the tube to thermal shocks but has the drawback to generate shavings prejudicial to the cleanliness of the heat exchanger and of the manufacturing machines. This solution also has the drawback to reduce the resistance of the heat exchanger to vibrations and/or alternate pressures.

[0010] Another known solution is to perform regions of weakening in the side plate in order to allow the side plate to locally expand, thus relieving the thermal stresses in the tubes and the headers.

[0011] FR 2 183 375 provides for instance a transversal fold on the lugs that connect the side plate to the header or directly on the side plate.

[0012] A heat exchanger is also known from EP 1 195 573 in which openings are provided between the edges of the side plate that delimit a periphery. A part of this periphery is in close proximity of one of the edge of the side plate. EP 1 195 573 also provides a line of weakening that extends from this part of the periphery to the edge. Thermally induced stress causes the side plate to sever at the location of the openings and of the lines of weakening.

[0013] Another heat exchanger is known from US 6 328 098 with regions of weakening comprising sharp folds or a score in the side plate base and/or in the longitudinal side walls of the side plate. These regions are adapted to break under low tension to alleviate the problem caused by expansion.

[0014] The above mentioned solutions improve the resistance of the tube to thermal shocks for side plates having side walls of a substantially important height, typically around 8 mm. However, they are not adapted when the side walls of the side plate are smaller. Furthermore, these solutions involve complex structures which add additional operations to the manufacturing process and accordingly increase the costs of the heat exchanger.

[0015] The invention relieves these problems by providing a heat exchanger, in particular for an automotive vehicle, comprising a tube bundle and fins interposed between the tubes of the bundle for heat exchange, the bundle being delimited by two end fins, the heat exchanger further comprising two headers receiving the bundle ends, and at least one side plate disposed on one of said end fins. The invention provides that the side plate comprises two side plate portions, each side plate portion being connected to one of the header.

[0016] Other complementary or substitute features of the heat exchanger of the invention are enumerated below:

- each side plate portion has a U-shaped cross-section.
- each side plate has a substantially plane base, flanked with two longitudinal side walls.
- each side plate portion has one of its end portions provided with two longitudinal lugs.
- Each longitudinal lug edges a slot.
- Each side plate portion comprises a tab at one of its end for connection to one of the header, the bent tab being bent to the shape of one of the header transversal edges so that the tab overlaps the header edge when connected thereto.
- The tab has a slot perpendicular to the side plate axis.

- Each side plate further comprises an additional side plate member made of plastic, the side plate member being arranged at the middle part of the side plate for end fin protection.

[0017] Further objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawings on which:

- Figure 1 shows a schematic view of the heat exchanger according to the invention;
- Figure 2 is a perspective view of the heat exchanger according to the invention;
- Figure 3 is a detailed view of a part of the heat exchanger according to the invention;
- Figure 4 shows a perspective view of one of the side plate portion; and
- Figure 5 is a cross sectional diagram showing the connection between a header and an associated side plate portion.

[0018] Figure 1 depicts a heat exchanger 1, in particular an air-conditioning heat exchanger for an automotive vehicle. In such applications, the heat exchanger 1 may be used for example as a condenser or an evaporator.

[0019] The heat exchanger 1 comprises a tube bundle disposed between two headers 541 and 543. The bundle comprises a plurality of parallel tubes 2. In the drawings, the tubes are flat tubes. However, the invention is not limited to such tubes.

[0020] The ends of the tubes 2 are received in the corresponding header 541 and 543. Each header 541 and 543 may comprise a header plate 41 and 43 covered by a respective header tank 31 and 33, the ends of the tubes then being secured to slots provided in the header plates, for instance by brazing.

[0021] Heat dissipation is provided by fins 7 which are inserted between the tubes 2. Heat exchange occurs between a refrigerant flowing inside the tubes and another refrigerant, air for instance, running through the fins 7. The fins may be formed of a variety of material, for instance aluminium or copper.

[0022] The tube bundle is delimited by two end tubes 20 and 22, respectively corresponding to the upper end tube and the lower end tube of the bundle. Here, the expressions "upper tube" and "lower tube" are used with reference to the heat exchanger representation of figure 1. As shown in figure 1, the tubes 2, 20 and 22 are substantially horizontal. Alternatively, the heat exchanger could be disposed with the tubes 2, 20 and 22 in vertical position.

[0023] The following description will be made with reference to the disposition of the heat exchanger in the drawings where the two headers 541 and 453 are disposed laterally, by way of example. Therefore, the end tubes 20 and 22 will be hereinafter referred to as "upper tube" and "lower tube" respectively.

[0024] An end fin 70 is disposed on the external face of the upper tube 20 and an end fin 72 is disposed on the external face of the lower tube 22. These end fins 70 and 72 will be similarly referred to as "upper fin" and "lower fin" respectively in the following description.

[0025] The heat exchanger 1 further has at least one member 50 or 52 disposed on one of the end fins 70 and 72 respectively. In the alternative disposition of the heat exchanger, where the headers are disposed one above the other for vertical flow of the refrigerant, those members 50 or 52 are known as "side plates". However, for the purpose of the description, the expression "side plate" will be used herein without restriction as to the disposition of the heat exchanger in the drawings.

[0026] Side plates are generally provided to rigidify the heat exchanger and to protect the end fins. However, temperature variations generally cause thermal shocks, due to the stress on the ends of the tubes that are close to the header. Such stress results from the time difference required for heating and for cooling, and from the elongation difference between the end tubes, the end fins and the side plates. Conventional side plates provide complex and costly expansion joints at the connections between the headers and the side plates, and/or complex cuttings and folds on the side plate end parts to prevent those thermal shocks from causing deteriorations in the heat exchanger.

[0027] The Applicant has also observed that when a side plate is designed to break in two places, the middle portion that appears after the breaking, that is the portion between those connected to the headers remains brazed to the fins during all the vehicle life.

[0028] Further, it is more and more required in current heat exchangers that the side plate breaks as quickly as possible at the beginning of the vehicle life, which is not always easy to obtain, except with very complex structures.

[0029] The Applicant has worked on a solution that would improve all the aspects mentioned above and in particular the resistance to thermal shocks, while simplifying the structure of the side plates. Surprisingly, the Applicant has found out that a side plate consisting of two separate portions provides satisfying results to vibration and pressure pulsation tests.

[0030] The Applicant has also found that the suppression of the middle part portion that appeared after the breaking in two places of the side plate in the prior art improves the resistance to those thermal shocks.

[0031] More specifically, the invention proposes a side plate 50 (respectively 52) consisting of two side plate portions 501 and 503 (respectively 521 and 523) totally separated from each other, before the heat exchanger assembling. The side plate 50 is thus not designed to break after brazing since it already has a two-portion structure. The two side plate portions are conformed to

delimit a gap between each other when mounted on the associated end fin. Each side plate 50 or 52 has therefore a two-portion structure, and a length that is lower than the spacing between the headers, when the heat exchanger is assembled, for instance 150 mm. As will be described in more details thereinafter, the invention makes it possible to provide simple side plate structure with satisfying performances.

[0032] The description will be made only with reference to the upper side plate portion 50, for more clarity. However, the man skilled in the art will understand that this description similarly applies to the lower side plate 52.

[0033] Figure 2 is a perspective view of the heat exchanger showing in more details the side plate portions. In this figure, the tube bundle is schematically represented.

[0034] The side plate portions 501 and 503 of the upper side plate 50 are connected to the headers 541 and 543 respectively.

[0035] The upper tube 20, the upper fin 70, the headers 541 and 543 and the side plate portions 501 and 503 are brazed together.

[0036] In use, a refrigerant enters into one of the header 541 and 543 and flows through the tubes 2. The refrigerant high temperature causes a heat transfer towards the tube walls and the fins. The air flowing through the fins cools the refrigerant that flows inside the tubes.

[0037] The tubes then tend to expand in the longitudinal direction, due to the refrigerant high temperature, which causes stress at the connection between the tubes and the headers. This stress appears because the side plate 50 does not directly contact the refrigerant and has therefore a temperature that increases in a manner different to the temperature of the associated end tube 20. Indeed, the side plate 50 actually contacts the upper fin 70 so that the pressure inside the upper tube 20 is transmitted to the side plate portion by the upper fin 70. This result in a differential expansion at the ends of the side plate 50. The invention makes it possible to compensate for that differential expansion since the end parts of the side plate 50 are mechanically dissociated by virtue of its two-portion structure.

[0038] Accordingly, it is no more required to provide the conventional expansion areas, expansion lyres and/or expansion joints which are complex to manufacture and costly. Further, less material is required for the side plate since it has no central portion.

[0039] Figures 3 and 4 are partial view of the heat exchanger showing the side plate portion 501. In figure 3, the fins are not shown for more clarity.

[0040] The side plate portion 501 will be described in more details hereinafter. The man skilled in the art will understand that this description applies as well to the other side plate portion 503 of side plate 50, and to the side plate portions 521 and 523 of side plate 52.

[0041] The side plate portion 501 has generally a U-shaped cross section. More specifically, it comprises a base 5004, substantially flat, flanked with two longitudinal side walls 5005 and 5006. The side walls are generally perpendicular to the base plane and are arranged at the edges of the side plate portion 501, whereby each longitudinal side wall 5005 and 5006 protrudes from the plane defined by the base 5004. These side walls aim at reinforcing and rigidifying the side plate portion 501.

[0042] The side plate portions may be made of aluminium, or any suitable metal.

[0043] The separation between the side plate portions 501 and 503 constitutes somehow an expansion area that compensates for a longitudinal thermal expansion, while allowing a bending strength or resistance to bending sufficient to ensure a satisfying resistance to vibration and to maintain a high degree of structural integrity to the heat exchanger.

[0044] Although not limited to this embodiment, the invention is particularly advantageous for side plate portions having side walls of a small high, for instance 1 to 7 mm above the base.

[0045] The side plate portions of the invention may be obtained by profiling techniques or alternatively by shaping techniques.

[0046] The side plate portion 501 comprises two small lugs 340 and 350 extending outwardly from the web plane 5004 for the heat exchanger brazing. Each lug edges a corresponding longitudinal slot 440 and 450 respectively made on the base 5004. On those lugs 340 and 350 special tooling may be mounted to maintain the core assembly before brazing.

[0047] Referring again to figure 2, the side plate 50 may further comprise an additional side plate member made of plastic for fin protection. Such side plate member is arranged at the middle part of the heat exchanger to cover the gap between the two side plate portions 501, 503. The ends of such plastic side plate portion could be maintained by the lugs 340, 350 of the side plate portion 504and by the lugs 341, 351 of the side plate portion 503.

[0048] Figures 3 through 5 show the connection between the side plate portion 501 and the corresponding header 541.

[0049] The side plate portion 501 is provided with a tab 5001 at its left end for connection with the header 541. The tab 5001 is bent to the shape of the adjacent end of the header 541, here the upper end. Thus, the bent tab 5001 closely overlaps this header upper end when connected thereto. A pressure lug 801 may be also provided on the header to maintain the bent tab 5001 against the header upper end 541. A notch 601 may further be provided in the bent tab 5001. The notch 601 extends perpendicularly to the side plate axis.

[0050] The side plate portion 503 (not shown in figure 4) is provided with a similar tab 5003 at its right end for connection with the header 543.

[0051] The connection between the side plates and the headers is thus sufficiently strong to withstand the thermal stress on the side plate portions and on the headers, while ensuring that the thermal stress is not exerted on the tubes, the fins or the connections between the

tubes 2 and the headers which constitute the more brittle parts of the heat exchanger.

[0052] The notch 601 is used to limit the breaking due to thermal shocks. However, the invention is not limited to such element for limiting thermal shocks. For instance, a goose neck or a heating loop as described in FR 2 873 434 could be used either.

[0053] The invention also proposes a method for assembling and brazing the heat exchanger 1 described above.

[0054] The bundle components are first assembled: the tubes 2 are assembled with the fins 7 and then the end fins 70 and 72 are disposed on the upper and lower tubes 20 and 22 respectively. The ends of the tube bundle are afterwards engaged in the headers 541 and 543. The side plate portions 501, 503 and 521, 523 are lastly secured to the header, so that their respective bent tabs (5001, 5003 for side plate 50) overlap the upper or lower ends of the corresponding headers 541 or 543 and be maintained under the associated pressure lug (801, 803 for side plate 50). This provides mechanical connection between the headers and the side plate portions. The heat exchanger thus assembled is then submitted to a brazing process, comprising the step of heating the assembled heat exchanger to the temperature which melts a brazing alloy covering at least parts of the heat exchanger.

[0055] During brazing, the tubes may expand in a manner different to that of the side plates, but the fact that each side plate is provided in two separate portions, before brazing, allows to compensate for the differential expansion while preventing stress to be exerted between the ends of the tubes 2 and the headers 541, 543, and therefore there occurs no tube buckling.

[0056] The heat exchanger is then cooled, which causes the heat exchanger to become solid with all its parts connected. During cooling, each bent tab 5001, 5003 is also brazed with the part of the header on which it rests and with the cooperating pressure lug 801, 803, 821, 823, which provides a rigid connection

[0057] When the headers 541 or 543 consist of a header plate 41 or 43 and a header tank 31 or 33, the header tank may be mounted after brazing.

[0058] The invention allows the standardization of the tooling, since it makes it possible for to use a same side plate tooling for several heat exchangers independently from the length of the core.

[0059] Further, since the side plate according to the invention consists of two portions whose length is lower than the spacing between the headers, less material is required for the side plate and therefore, it is possible to reduce the weight of the heat exchanger, as well as its cost. The exchanger of the invention thus constitutes an economical solution.

[0060] The invention provides a side plate structure which is more simple than the structures disclosed in the prior art, which were designed to break as quickly as possible at the beginning of the vehicle life. Further, the side plate of the invention is not subject to any breaking phenomenon during brazing. It remains in two portions fixed to the headers for all the vehicle life.

[0061] The solution of the invention has also a satisfying mechanical strength, a good resistance to vibration and to thermal shocks.

[0062] Although the invention has been described with respect to the above described embodiments, the man skilled in the art will understand that other embodiments can be produced without departing from the spirit and the scope of the invention. In particular, the invention is not limited to a connection with bent tab between the side plate portions and the headers. Other types of connection may be possible between the side plate portions and the headers, like tabs provided in the end of the side plate portion for insertion in the headers.

Claims

1. A heat exchanger, in particular for an automotive vehicle, comprising a bundle of tubes (2) with fins (7) interposed between the tubes for heat exchange, the bundle being delimited by two end fins (70, 72), the heat exchanger further comprising two headers (541, 543) receiving the ends of the bundle and at least one side plate (50, 52) disposed on one of said end fins, **characterized in that** the side plate comprises two side plate portions (501,503, 521, 523), each side plate portion being connected to one of the header.

2. A heat exchanger as claimed in any of claims 1 and 2, **characterized in that** each side plate portion has a U-shaped cross-section (501,503, 521, 523).

3. A heat exchanger as claimed in claim 2, **characterized in that** each side plate has a substantially plane base (5004), flanked with two longitudinal side walls (5005, 5006).

4. A heat exchanger as claimed in any of claims 1 through 3, **characterized in that** each side plate portion has one of its end portions provided with two longitudinal lugs (340,350, 361, 371).

5. A heat exchanger as claimed in claim 4, **characterized in that** each longitudinal lug (340,350) edges a slot (440, 450).

6. A heat exchanger as claimed in any of claims 1 through 5, **characterized in that** each side plate portion (50) comprises a tab (5001) at one of its end for connection to a header (541), the tab being bent to the shape of the adjacent end of the header (541) so that the tab overlaps this header end when connected thereto.

7. A heat exchanger as claimed in claim 6, **characterized in that** the bent tab (5001) has a slot perpendicular to the side plate axis.

8. A heat exchanger as claimed in any of claims 1 through 7, **characterized in that** each side plate comprises an additional side plate member (50, 52), the side plate member being arranged at the middle part of the side plate for end fin protection.

9. Method of making the heat exchanger according to one of the preceding claims, wherein it comprises the steps of:

a) assembling the bundle components;
b) assembling the headers (541, 543) to the tube bundle;
c) connecting the side plate portions (501, 503) of each side plate to one of the end fins (70), and to the headers (541, 543); and
d) brazing the heat exchanger thus assembled.

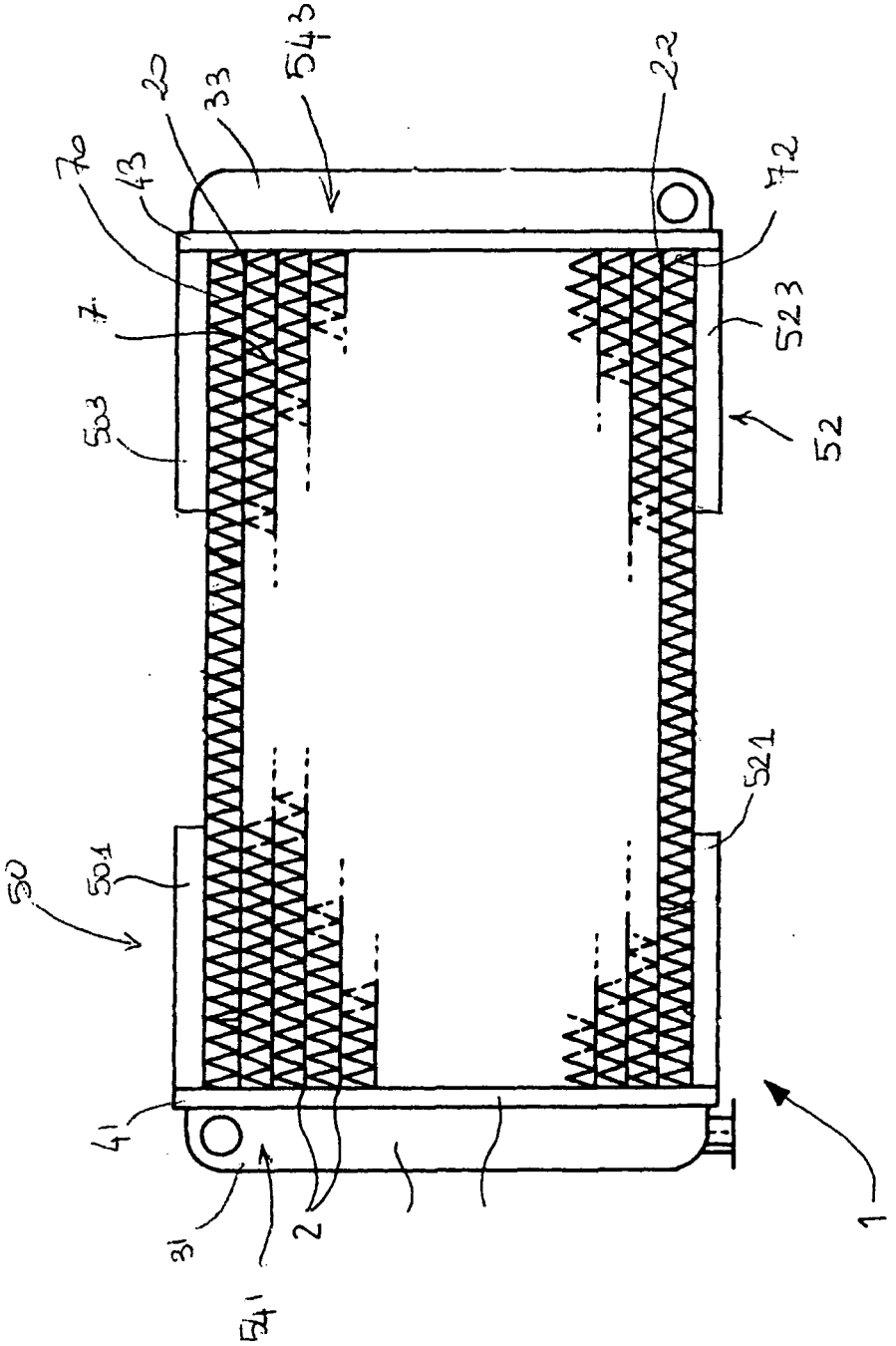

FIG.1

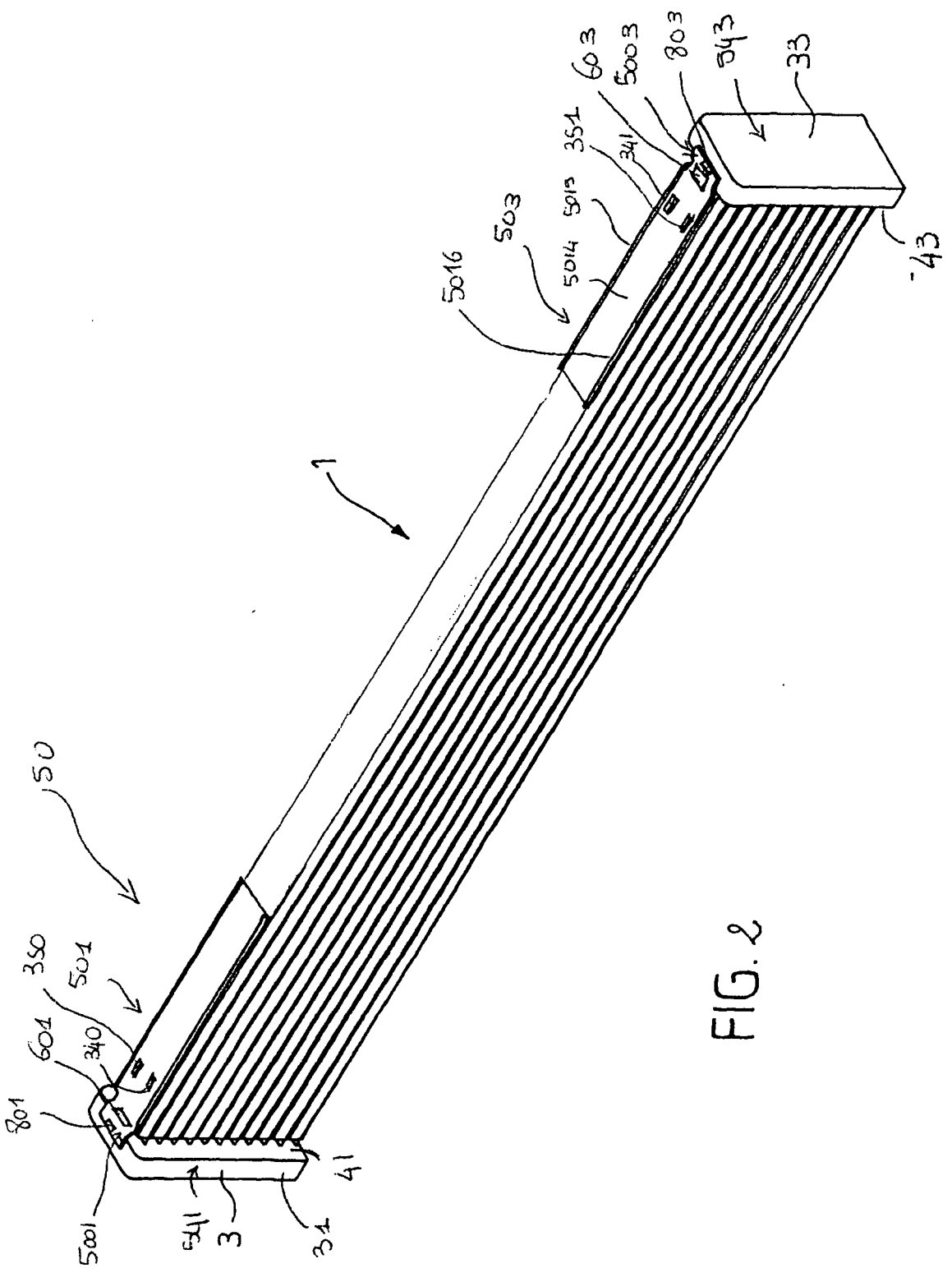
50
350
501
604
340
801
5001
541
3
31
41
1
5016
503
5014
5013
351
341
603
5003
803
343
33
43

FIG. 2

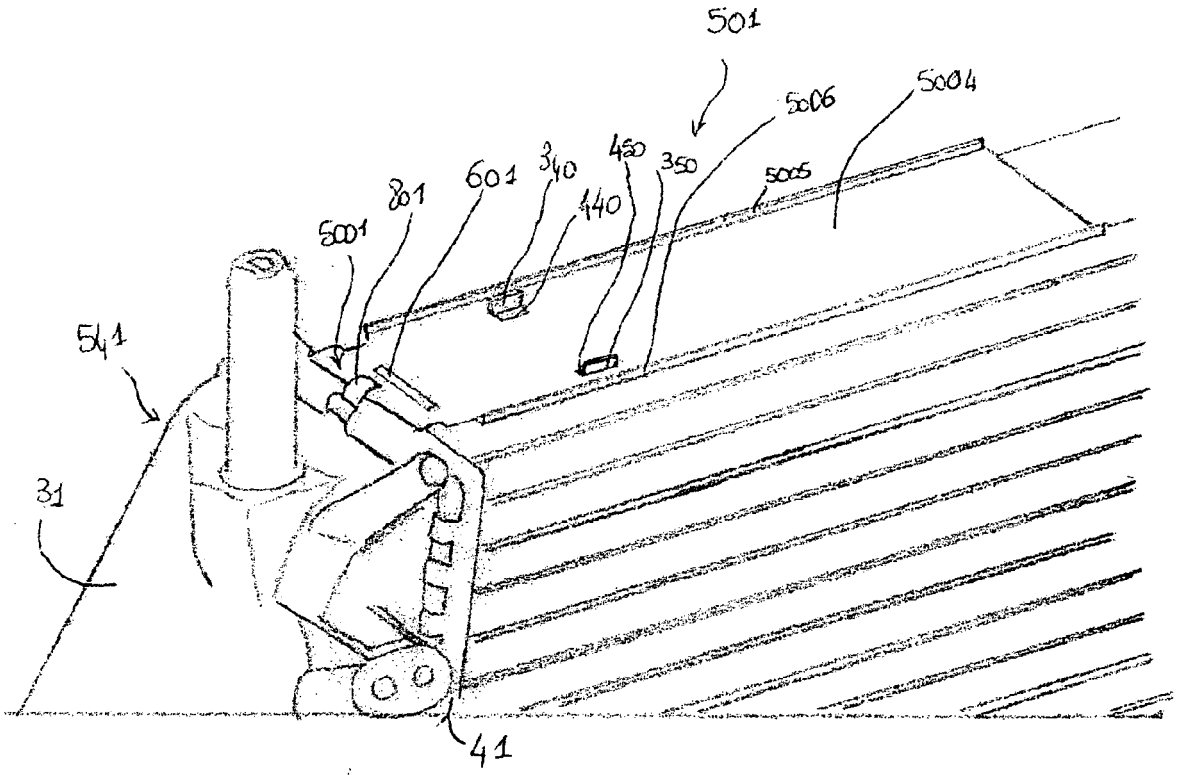

FIGURE 3

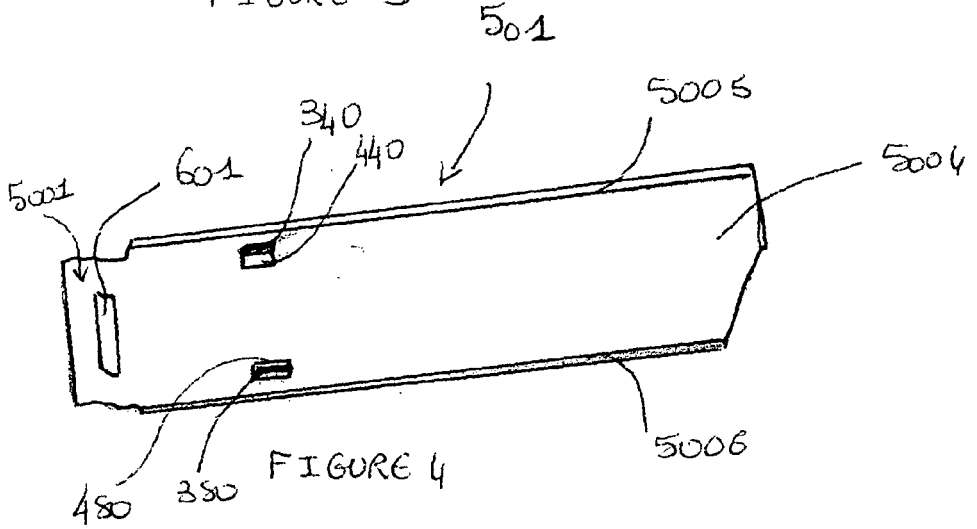

FIGURE 4

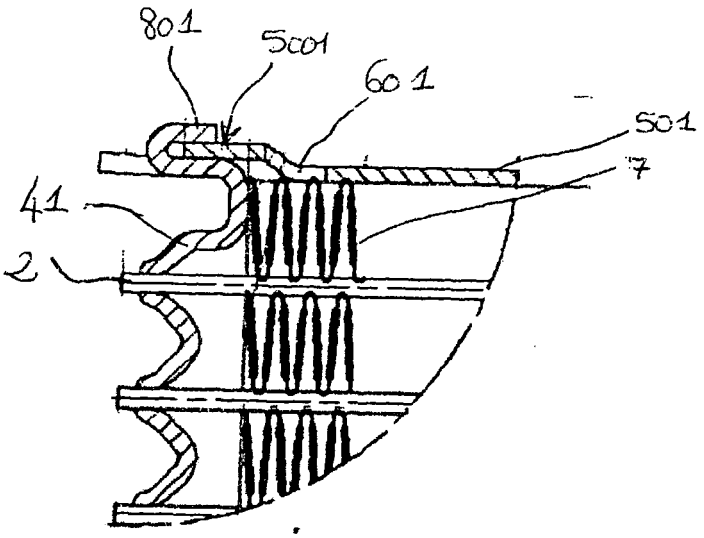

FIGURE 5

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EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS

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