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(71) Applicant: **MODINE MANUFACTURING COMPANY** [US/US]; 1500 Dekoven Avenue, Racine, WI 53403-2552 (US).

(72) Inventors: **PESKOS, T.**; 1500 DeKoven Avenue, Racine, WI 53403-2552 (US). **GLÜCK, R.**; 1500 DeKoven Avenue, Racine, WI 53403-2552 (US).

(74) Agents: **FORSTER, Natalie, K.** et al.; Michael Best & Friedrich LLP, 100 East Wisconsin Avenue, Suite 3300, Milwaukee, WI 53202-4108 (US).

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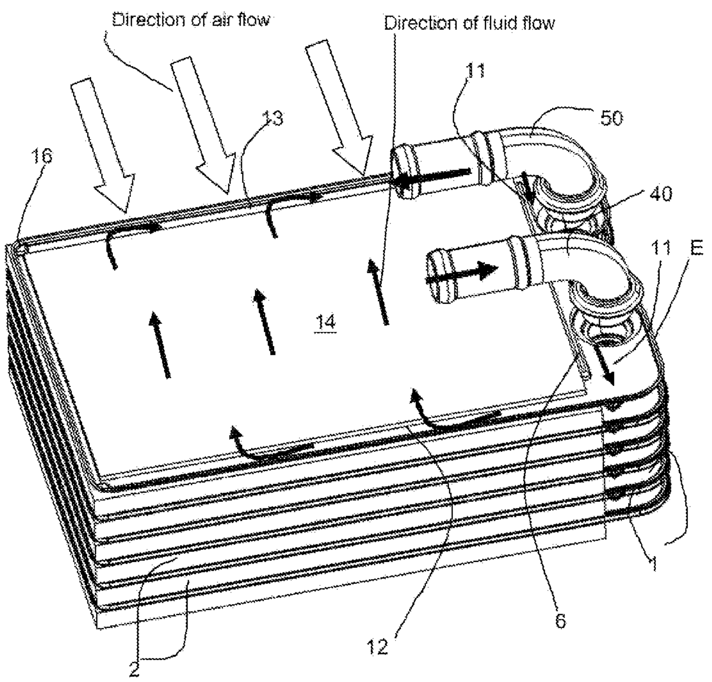
(54) **Title**: HEAT EXCHANGER



(57) Abstract: The invention relates to a heat exchanger, for example an indirect air cooler, in which the air, for example compressed charge air for an internal combustion engine, is cooled, for example by means of a fluid, wherein the heat exchanger is constructed from stacked pairs, having two longitudinal edges and two lateral edges, of plates having fins arranged therebetween, and the stack is arranged in a housing into which, for example, air flows, flows around the fins and leaves the housing again, wherein said air is cooled by the fluid flowing in the plate pairs, which fluid flows into the plate pairs via at least one inlet and is conducted away via at least one outlet.

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HEAT EXCHANGER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to German Patent Application No. DE102012006346.6, filed March 28, 2012, the entire contents of which are hereby incorporated by reference.

BACKGROUND

[0002] The present invention relates to a heat exchanger.

SUMMARY

[0003] The invention relates to a heat exchanger, for example an indirect air cooler, in which the air, for example compressed charge air for an internal combustion engine, is cooled, for example, by means of a fluid, wherein the heat exchanger is constructed from stacked pairs of plates with fins arranged therebetween, and the stack is arranged in a housing to which the air flows, flows through the fins and flows out, wherein said air is cooled by the fluid flowing in the plate pairs, which fluid is conducted into the plate pairs via at least one inlet and conducted away via at least one outlet, wherein the inlet and the outlet are located at a common edge of the plates and the air flows through the fins approximately in the direction of this edge.

[0004] Charge air coolers which are installed in motor vehicles and serve to cool the charge air by means of a cooling fluid are often referred to as indirect air coolers, in contrast to direct air coolers, a term used when the exemplary charge air is cooled with ambient air which is conveyed through the cooler by means of a fan.

[0005] The cooling fluid used is cooled directly by means of cooling air and is then used for cooling the engine as well as for other cooling purposes, and recently also to a greater extent for (indirect) charge air cooling.

[0006] The efficiency of the transmission of heat is known to be highest if the media are conducted through the heat exchanger in countercurrent (DE 29 809 080 U1). However, a throughflow in countercurrent is not always possible depending on the locality in which the air cooler (heat exchanger) is located and on other restrictions. The positions of the inlets and outlets can actually rarely be defined in such a way that the preferred throughflow can also occur or the actualization thereof often requires excessively high complexity in terms of design and construction.

[0007] For this reason, sometimes what is referred to as countercurrent or often cross countercurrent is selected in which, for example, at least one of the media describes a meandering path. An example of cross-countercurrent can be found in DE 10 2006 048 667 A1. This document serves to form the preamble of Patent Claim 1 specified at the beginning.

[0008] The object of the invention is to construct the described heat exchanger with simple structural features, that is to say features which are also manufacture-friendly, in such a way that said heat exchanger provides a relatively high level of efficiency.

[0009] The solution to this problem is obtained with a heat exchanger which has the features of Patent Claim 1.

[0010] According to one essential aspect of the invention there is provision that the fluid can be conducted in an inlet region and/or outlet region of the plate pairs in at least one flow path approximately parallel to the air flow direction and/or of the common edge, flows further through at least a first duct approximately in cross current with respect to the air, and passes through the plate pairs over the largest heat exchange area of the plate pairs, substantially approximately in countercurrent with respect to the air, in order to flow through at least one second duct, approximately in cross current, back to the outlet.

[0011] There is preferably at least one inlet-side flow path and the inlet-side first duct as well as the at least one outlet-side second duct and also outlet-side flow path. In both flow paths, the preferred fluid flows approximately in the direction of the air. The lengths of the flow paths can be minimized by arrangement of the inlets and outlets at the corners of the plates. According to the present invention the entire mass flow of the fluid does not pass over the entire length of the ducts but instead a considerable portion thereof does. Shortly after the entry of the fluid into the at least one first duct, a partial flow already flows through the plate pairs in countercurrent with respect to the air via corrugated internal fins. The same applies to the at least one second duct which leads to the outlet-side flow path. The ducts have a relatively low flow resistance so that the regions of the plates which are remote from the outlet are also sufficiently involved in the exchange of heat. The cross-sectional geometry of the ducts can be of corresponding design so that sufficient involvement is achieved.

[0012] The largest heat-exchanging region of the plates is equipped with the corrugated internal fins. The corrugated internal fins can be embodied as lanced and offset fins, such as are used, for example, in the field of oil cooling and elsewhere. In such fins, parts of the corrugation edges are arranged offset alternately to the right and to the left. Breakthroughs or cutouts are present between the offset parts. They permit a throughflow in the longitudinal direction. If this direction is blocked, a throughflow in the lateral direction is also possible. The longitudinal direction is parallel to the direction of the corrugation edges here. The internal fins in the plate pairs have a significantly smaller pressure loss than in the lateral direction when throughflow occurs in the longitudinal direction.

[0013] The direction in which the corrugations of the corrugated internal fins run is preferably provided transversely with respect to the longitudinal direction of the plates so that the fluid can flow in the longitudinal direction with relatively little resistance along the offset corrugation edges. A significantly larger flow resistance is present in the direction in which the corrugations run, a direction which, as mentioned above, is located transversely with respect to the direction of the corrugation edges because the fluid must flow through the numerous breakthroughs or cutouts in the corrugation edges and in the process also experiences numerous changes in the direction of flow. Approximately the entire mass flow flows through one flow path which is formed near to the inlet and the outlet by means of a flow barrier. In the flow path, the fluid flows in countercurrent with exemplary air since the flow barrier is arranged approximately parallel to the lateral edges. This can be accepted because the proportion of the entire heat-exchanging area taken up by the portion of the inlet and outlet region including the flow paths in terms of area is very small. It is generally not significantly more than approximately 15%, with 3 to 12% being preferred. The flow barrier is also located relatively close to the one lateral edge of the plate pairs, which is referred to above as the common edge. At the ends of the flow barrier located opposite there is a hydraulic connection to the ducts. At the other lateral edge of the plate pairs there is preferably no such flow path or duct so that the fluid cannot escape or is forced to take the path through the internal fin which has greater pressure loss and is located in countercurrent with respect to the airflow.

[0014] Simulation calculations carried out by the Applicant have resulted in a significant increase in the heat exchange rate for the proposed heat exchanger compared to the prior art.

[0015] The invention will be described in exemplary embodiments with reference to the appended drawings. Further features of the invention can be found in the following description, said features being either contained in the dependent claims or may prove to be significant later.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] Fig. 1 shows a perspective view of the heat exchanger (illustrated without a housing).

[0017] Fig. 2 shows a similarly perspective view with a cover plate on the stack of plate pairs and fins.

[0018] Fig. 3 shows a stack made of plates and fins in which the one plate of the upper plate pair has been removed in order to make the interior of this plate pair visible.

[0019] Figs. 4 and 5 show two plates which form a plate pair.

[0020] Fig. 6 shows a perspective view of a plate part with an internal fin.

[0021] Fig. 7 shows a view of the heat exchanger in a suitable housing.

[0022] Figs. 8 and 9 show modified plate configurations.

DETAILED DESCRIPTION

[0023] In the perspective illustration (figure 1) of the heat exchanger, which is an indirect air cooler in the exemplary embodiment, the inlet 4 and the outlet 5 are located at the right-hand edges of metallic plates 1, which therefore represent the "common" edges E here. The inlet 4 is arranged at the end remote from the air inflow side AAir of the heat exchanger. The outlet 5 is, on the other hand, located closer to the inflow side of the charge air which is indicated by three block arrows. The inlet and outlet connectors have the reference symbols 40 and 50. The inlet and outlet cross sections have a circular shape in these embodiments. Instead of charge air, a mixture of charge air and exhaust gas or pure exhaust of an internal combustion engine (not shown) can also be present.

[0024] An advantage of the invention worth mentioning is that the inlet 4 and the outlet 5 can be located on opposite edges which would then constitute the "common" edges E, without changing the throughflow, as a result of which structural restrictions can be coped with better than hitherto. In the exemplary embodiment shown, these edges E are the lateral edges of the plates 1. Two parallel longitudinal edges of the plates 1 are located approximately perpendicularly on the lateral edges, wherein the terms are used merely to differentiate between the edges, but do not in any case mean that the longitudinal edges, as shown in the exemplary embodiment, are longer than the lateral edges. The edges can all have the same length. The lateral edges can also be longer than the longitudinal edges. The fact that the edges in the exemplary embodiment shown are straight and therefore approximately rectangular plates 1 are present is also not an important precondition for solving the stated problem. The edges can also be arcuate or embodied in some other way which deviates from a straight line.

[0025] In the exemplary embodiment shown, the plates 1 have a cutout 8 at the common edge E which is the right-hand lateral edge in fig. 1. The depth of the cutout 8 is somewhat smaller than the depth of the inlet and outlet region 10. The position of the inlets and outlets 4, 5 is situated approximately in the center between the central longitudinal axis 15 of the plates 1 and their longitudinal edges. The inlet-side flow paths 11 extend from the inlets to the first ducts 12, which are arranged in the inner edge region of the one longitudinal edge in the plate pairs 1a, 1b. In the inner edge region of the other longitudinal edge there is the at least one second duct 13 which leads to the outlet-side flow path 11 and further to the outlet 5.

[0026] In the exemplary embodiment shown, the ducts 12, 13 have the same cross section throughout. The ducts 12, 13 have a low flow resistance, that is to say at least a partial cross section of the ducts 12, 13 does not have flow impediments or the like. Since, as mentioned, approximately rectangular plates are present in the exemplary embodiment shown, the flow paths 11 and the ducts 12, 13 are also located approximately perpendicularly with respect to one another.

[0027] In embodiments (not shown), the inlets and outlets 4, 5 are also arranged at a common edge E but in the vicinity of the corners of the plates 1 here, with the result that the lengths of the flow paths 11 becomes virtually zero. In other words, fluid can enter virtually directly into the first ducts 12 and virtually directly enter the outlets 5 from the second ducts

13. Such embodiments are to be considered to be covered by Patent Claim 1 even if they only have an extremely short flow path 11. There would also be no reason, for example, not to arrange the inlets 4 in the corners and merely to position the outlets 5 approximately as shown, or vice versa. As a result, only significantly pronounced outlet-side flow paths 11 would be present while the length of the inlet-side flow paths 11 would approach zero, that is to say would be virtually invisible. The designer therefore has multiple options available for adapting the heat exchanger to restrictions forced on him by the installation location, without having to accept a loss of power. Such embodiments are also to be considered as covered by Patent Claim 1.

[0028] The flow paths 11 are preferably implemented by construction of beads in the plates 1 forming the pairs, as is apparent from the illustrations according to figs. 4 and 5. Instead of beads, rods which are inserted and soldered (or braised or welded) in the plate pairs can also be provided. In the exemplary embodiment shown, the beads or the rods form the flow barriers 6 mentioned above. These figures show plan views of the two plates 1 which form a plate pair 1a, 1b, with an internal fin 14 which is inserted therein, but is not illustrated in detail here.

[0029] The plate 1b shown in figure 5 is rotated through 180 about its longitudinal axis 15 and is positioned on the plate 1a in fig. 4. The two beads come to bear one against the other in the plate pair 1a, 1b and are connected later. They accordingly have a height which is approximately half as large as the distance between the two plates 1 which form the plate pair 1a, 1b. The height of the internal fin 14 must correspond to this distance. In addition, the plates 1a and 1b come to bear one against the other with their edges and are connected to one another in a sealed fashion. In the exemplary embodiment they are bent-over edges.

[0030] Various other edge configurations are known from the prior art. These can alternatively be provided.

[0031] The inlet and outlet openings 4, 5 of the plate pair 1a, 1b are provided with collars 41, 51 which protrude upward at the upper plate 1a and downward at the lower plate 1b. The connection to the adjacent plate pairs 1a, 1b takes place at these collars. Sealing rings which are located between the plate pairs and connect the latter are also an alternative to such collars 41, 51. In embodiments which are not shown just one of the plates 1 has a bead whose height has to be correspondingly larger, that is to say which should correspond to the height of the internal fin 14. Of course, the entire stack, that is to say the plate pairs and the fins 2 located therebetween are connected to one another, preferably connected metallically, for example soldered (or braised or welded) in a soldering (or braising or welding) oven. The soldered-in (or braised-in or welded-in) internal fin 14 through which the fluid flows is located within each plate pair 1a, 1b.

[0032] Since the aforementioned internal fin 14 can have a smaller dimension than the plate 1 in which it is inserted owing to construction of the ducts 12, 13, the position of the internal fin 14 is indeterminate, which is disadvantageous. A correct position of the internal fin 14 the plate 1 can be implemented by virtue of the fact that inwardly protruding knobs or similar shaped elements 16 are formed in the corners of the plates 1 and serve as a stop for the internal fin 14. As a result, the preassembly of the heat exchanger improves. With this measure it is also possible to prevent an undesired bypass for the fluid, or at least largely suppress it.

[0033] In figures 3, 4 and 5, the inlet and outlet region which has already been mentioned is provided with the reference symbol 10. It makes up approximately 12% of the entire heat exchanging area here. Since this region for exchanging heat cannot contribute very much, the aim is to make it as small as possible. In fig. 3, two arrows indicate that the corrugated internal fin 14 is preferably inserted into the plate pair 1a, 1b in such a way that when there is a flow through them in the longitudinal direction a significantly lower pressure loss dp occurs than when there is a throughflow in the lateral direction. The fluid is forced by the special design to take the path in the lateral direction and accordingly to flow though the plate pairs 1a, 1b in countercurrent with respect to the AAir.

[0034] Fig. 6 shows, in a section, a perspective view of the corrugated internal fin 14 which is located in the plate 1. Some details of the corrugated internal fin 14 can be seen. The direction in which the corrugation runs in the heat exchanger is the lateral direction thereof, that is to say the direction of the significantly higher pressure loss dp. In the corrugation edges 17 there are breakthroughs or cutouts 18 offset alternately to the left and to the right when viewed in the direction of said corrugation edge 17. The width of the ducts 12, 13 is determined by the distal end of the flow barrier 6 and the longitudinal edge of the plate. As is also shown by fig. 6, a narrow strip of the duct 12 is completely free.

[0035] In embodiments according to the invention (not shown) the entire duct 12, 13 is of free design. In other embodiments (not shown) the longitudinal edge of the internal fin 14 extends directly to the longitudinal edge of the plates 1, with the result that the entire duct cross section is occupied by a section of the internal fin 14. The function of the ducts 12, 13 is retained because the aforementioned section points in the direction of the low pressure loss dp which corresponds to the direction of the duct. There is also the possibility of covering the cross section of the one duct completely with part of the internal fin 14 and leaving the other duct completely free.

[0036] As is also the case in known heat exchangers, the compressed charge air AAir to be cooled flows through an opening into a housing 3 in which the aforementioned stack made of plate pairs 1a, 1b and fins 2 (not illustrated in more detail) are located (fig. 7). The housing 3 can be the intake manifold of an internal combustion engine. According to the proposal, the charge air then flows through the corrugated fins 2 in countercurrent with respect to the fluid flowing in the plate pairs, and in the process it is cooled extremely efficiently. The direction of flow of the charge air is, also according to the proposal, provided in the direction of the common edge E at which the inlet 4 and the outlet 5 for the fluid are located, or in the exemplary embodiment in the direction of the lateral edges of the plates 1. As a result, the cooled charge air leaves the heat exchanger through another opening in the housing 3 in order to be available for charging the internal combustion engine (not shown). The protruding edge 9.1, of the cover plate 9 which can be seen in fig. 2 and which terminates the stack and is connected metallically thereto, for example, can be used in a known fashion to attach the plate stack in the housing 3 and therefore serves as a closure of an assembly opening in the housing 3.

[0037] Fig. 8 shows a plate 1 with elongate holes as inlets and outlets 4, 5. The flow paths 11 have been virtually integrated into the elongate holes since there to a certain extent a flow guide is formed in the direction of the common edge E, as is also the case with the flow paths of the other exemplary embodiments. In embodiments which are not shown, the inlets and outlet 4, 5 have other different hole shapes. These may also include hole shapes which are configured asymmetrically. Fig. 9 in turn shows round plate holes 4, 5 but modified flow barriers 6.

CLAIMS

What is claimed is:

1. Heat exchanger, for example indirect air cooler, in which the air, for example compressed charge air for an internal combustion engine, is cooled, for example by means of a fluid,

wherein the heat exchanger is constructed from stacked pairs (1a, 1b) of plates (1) having fins (2) arranged therebetween, and the stack is arranged in a housing (3) into which, for example, air flows, flows around the fins (2) and leaves the housing (3) again,

wherein said air is cooled by the fluid flowing in the plate pairs (1a, 1b), which fluid flows into the plate pairs via at least one inlet (4) and is conducted away via at least one outlet (5),

wherein the inlet (4) and the outlet (5) are located at a common edge (E) of the plates (1) and the exemplary air flows approximately in the direction of the common edge (E),

wherein the exemplary fluid can be conducted from the inlet (4) into an inlet region and/or outlet region (10) of the plate pairs (1a, 1b) in at least one flow path (11) and at least to a certain extent approximately in the direction of the common edge (E), and further through at least a first duct (12) approximately in cross current with respect to the exemplary air, and passes further through the plate pairs over the largest heat exchange area of the plate pairs (1a, 1b) approximately in countercurrent with respect to the air, in order to flow through at least one second duct (13), approximately in cross current with respect to the exemplary air, and to the outlet (5).

2. Heat exchanger according to Claim 1, wherein the first and second ducts (12, 13) are arranged approximately perpendicularly with respect to the flow path (11) and/or the common edge (E).

3. Heat exchanger according to Claims 1 and 2, wherein the common edge (E) preferably constitutes one of two lateral edges of the plates.

4. Heat exchanger according to Claims 1 to 3, wherein the direction which is perpendicular to the common edge (E) is the longitudinal direction.

5. Heat exchanger according to one of the preceding claims, wherein the first and second ducts (12, 13) are formed in inner edge regions of the plate pairs (1a, 1b), have a low flow resistance and preferably run approximately parallel to one another.

6. Heat exchanger according to the preceding claims, wherein the inlet and outlet region (10) takes up, with the at least one flow path, not more than 15% of the effective heat exchange area, preferably in the range from 3% to 12%.

7. Heat exchanger according to Claim 1, wherein the fluid passing approximately in countercurrent with respect to the air over the largest heat exchange area of the plate pairs flows through internal fins (14) which are arranged in the plate pairs.

8. Heat exchanger according to Claim 7, wherein the internal fins are of corrugated design and have offset cutouts (18) in their corrugation edges (17) (lanced and offset fins) with the result that they permit both a throughflow in the direction of the corrugation edges and a through flow laterally with respect thereto.

9. Heat exchanger according to Claims 7 and 8, wherein the internal fins are preferably arranged in the plate pairs in such a way that the direction in which the corrugations run extends parallel to the lateral edges of the plates, wherein a relatively low flow resistance (dp low) for the fluid is present in the direction of two longitudinal edges, and a relatively high flow resistance (dp high) for the fluid is present in the direction of the lateral edges.

10. Heat exchanger according to Claim 1, wherein at least one flow barrier (6), which makes available the flow path from the inlet to the first duct and from the second duct to the outlet, extends approximately in the direction of the common edge (E) in the plate pairs, near to the inlet and the outlet.

11. Heat exchanger according to Claim 10, wherein the flow barrier (6) is made available by a bead in at least one plate of the plate pairs or by means of an inserted rod.

12. Heat exchanger according to Claim 1, wherein the plates (1) have a cutout (8) between the inlet (4) and the outlet (5).

13. Heat exchanger according to one of the preceding claims, wherein the flow path or paths (11) either adjoin the inlets and/or outlets (4,5) or are integrated therein by virtue of the shaping. A

FIG. 1

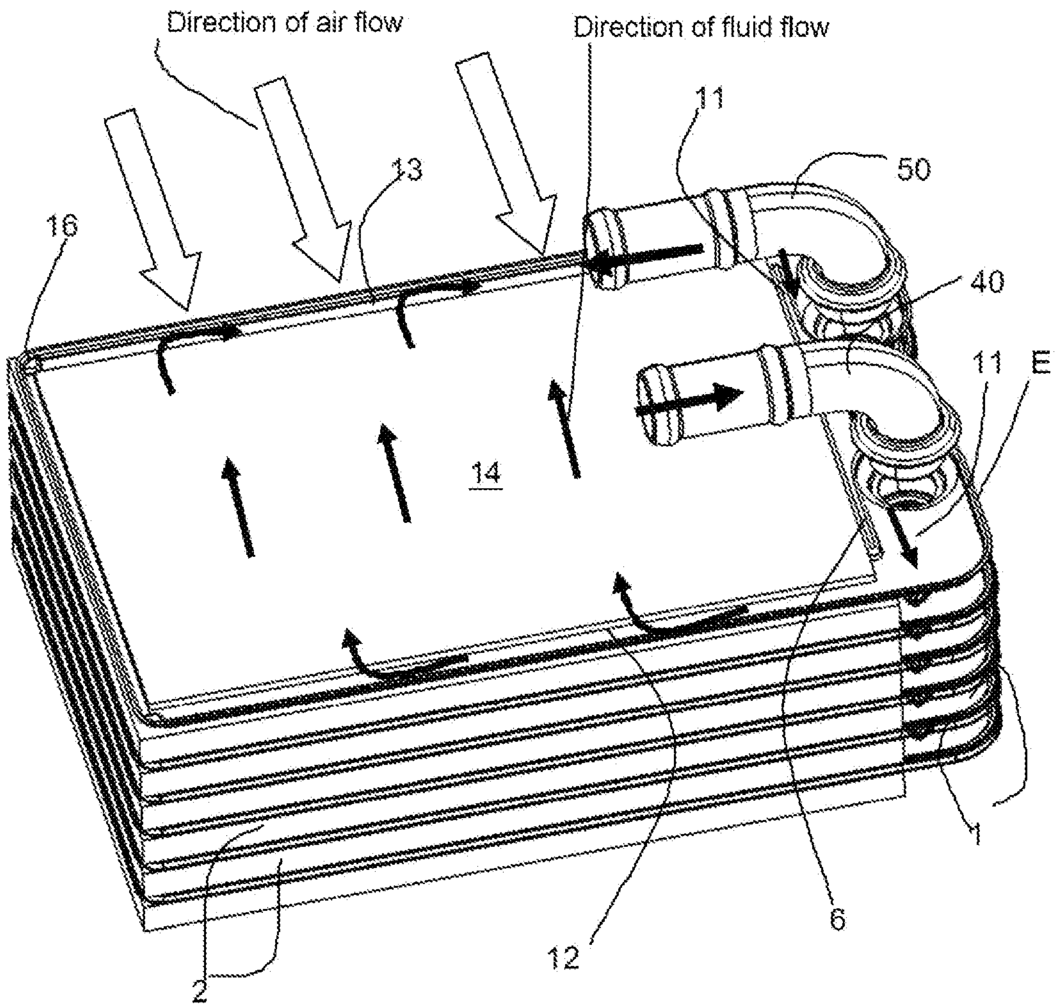

Direction of air flow
Direction of fluid flow
11
50
13
16
40
11
E
14
1
6
12
2

FIG. 2

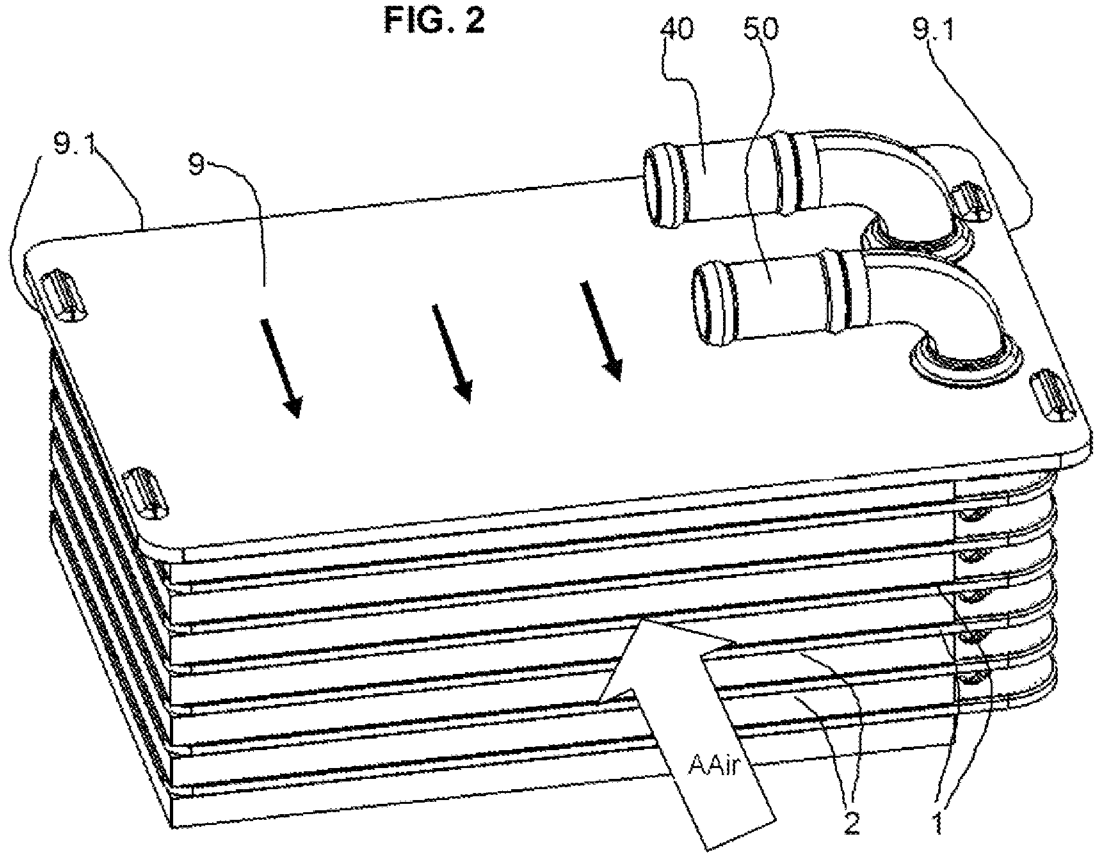


FIG. 3

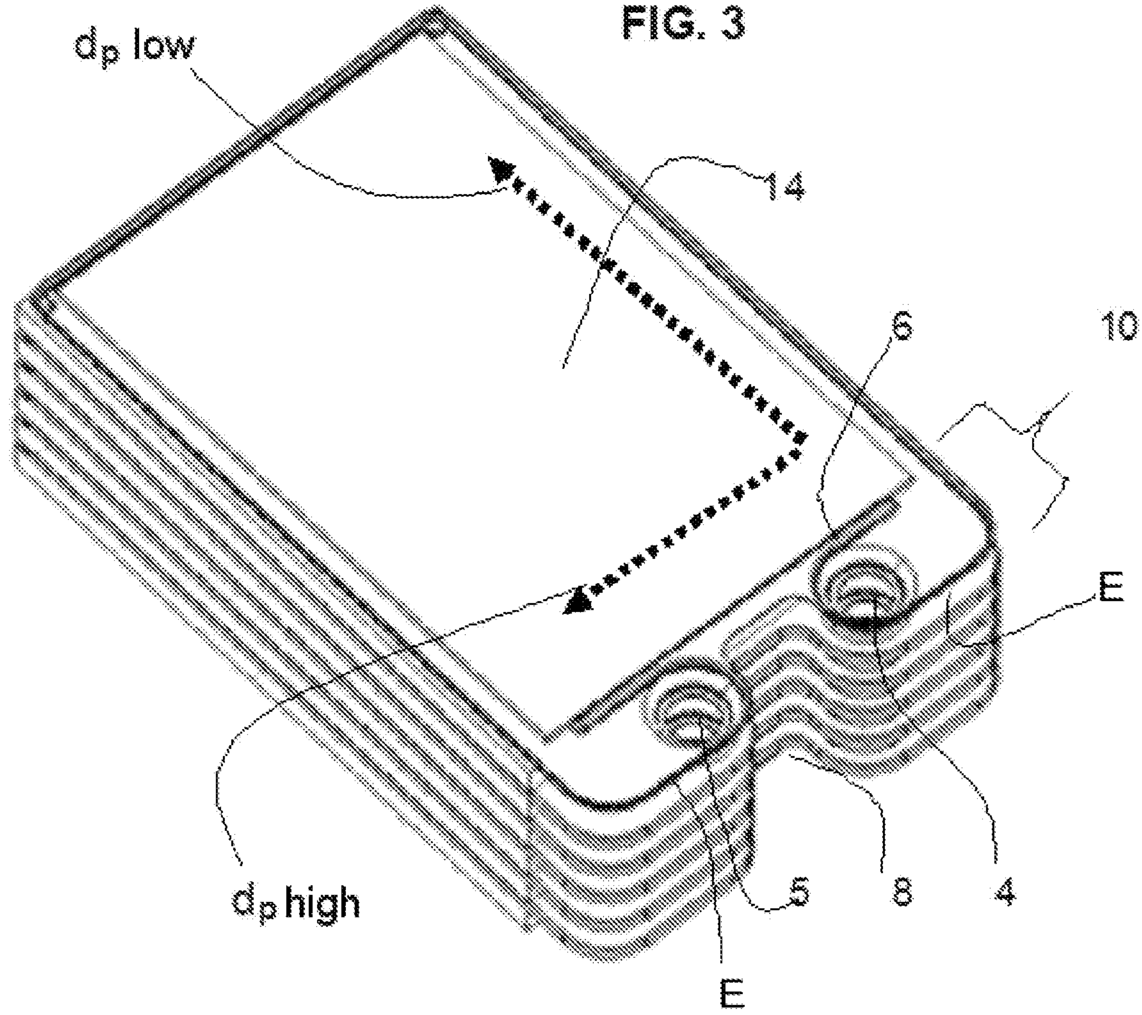


FIG. 4

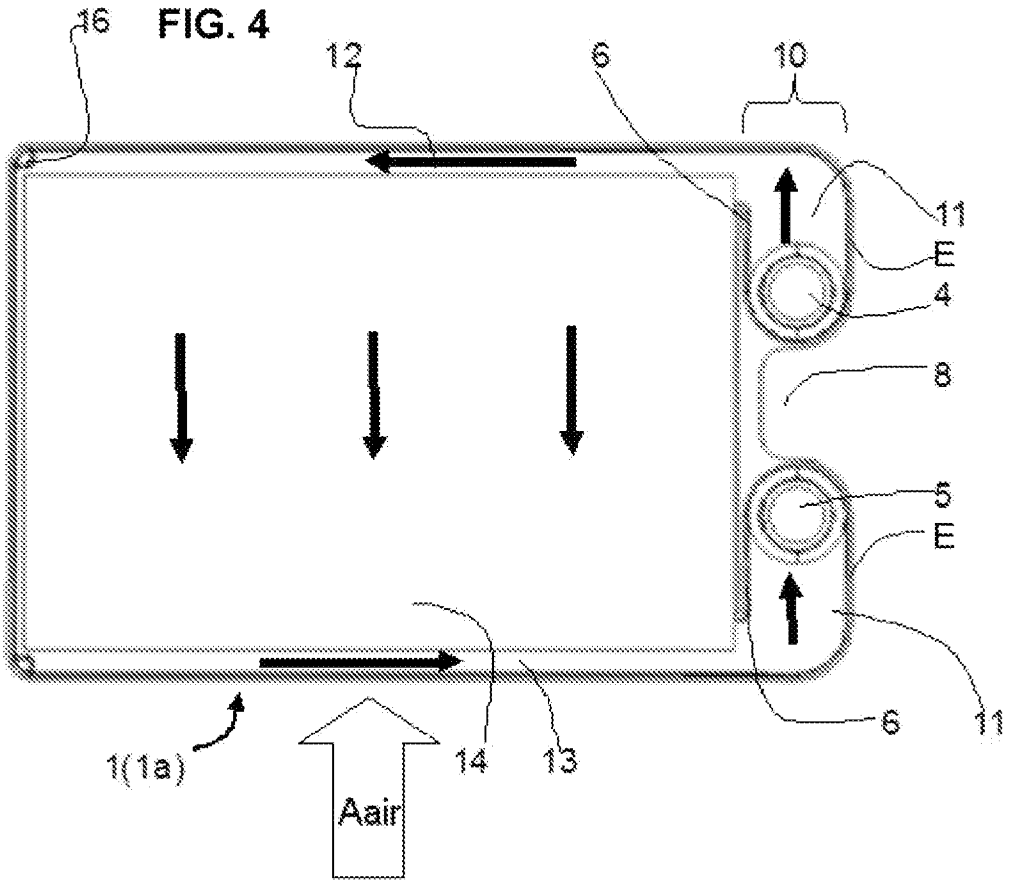


FIG. 5

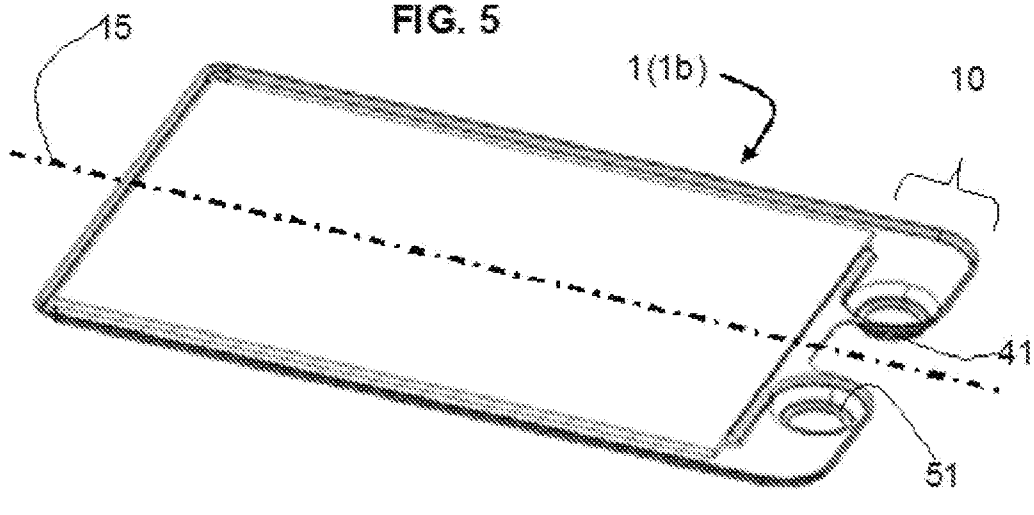


FIG. 6

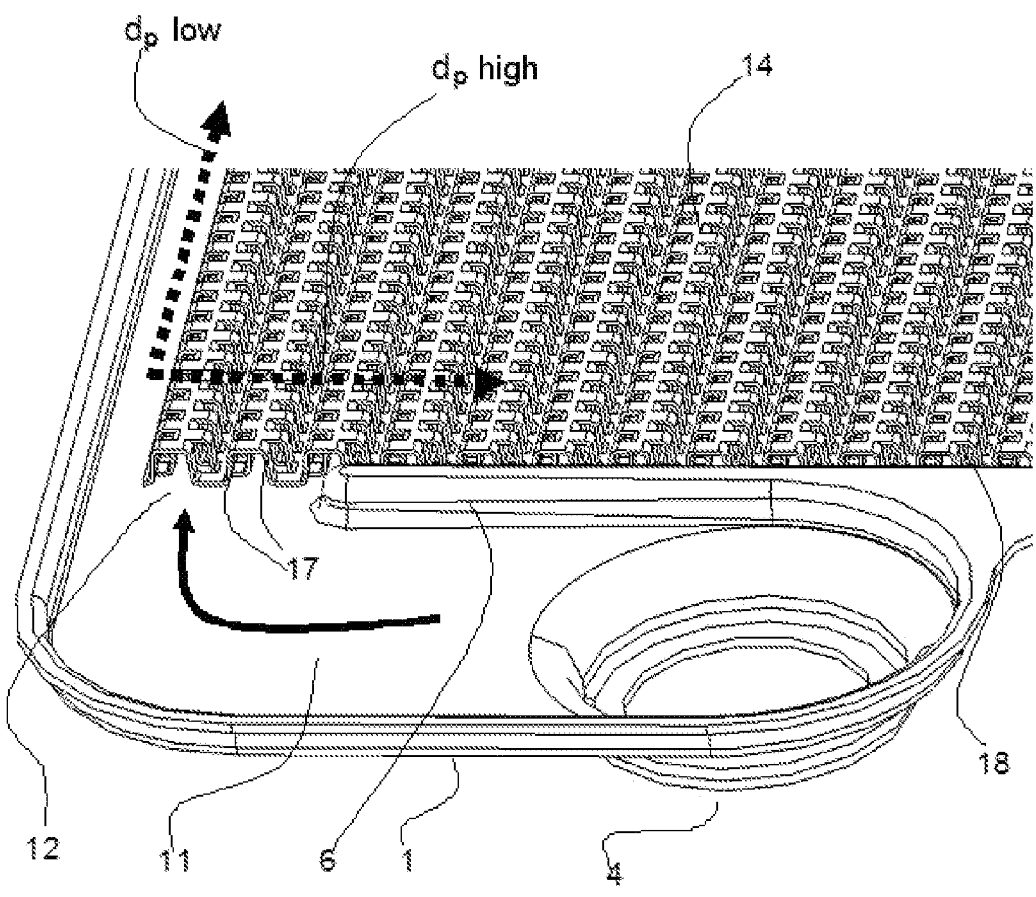


FIG. 7

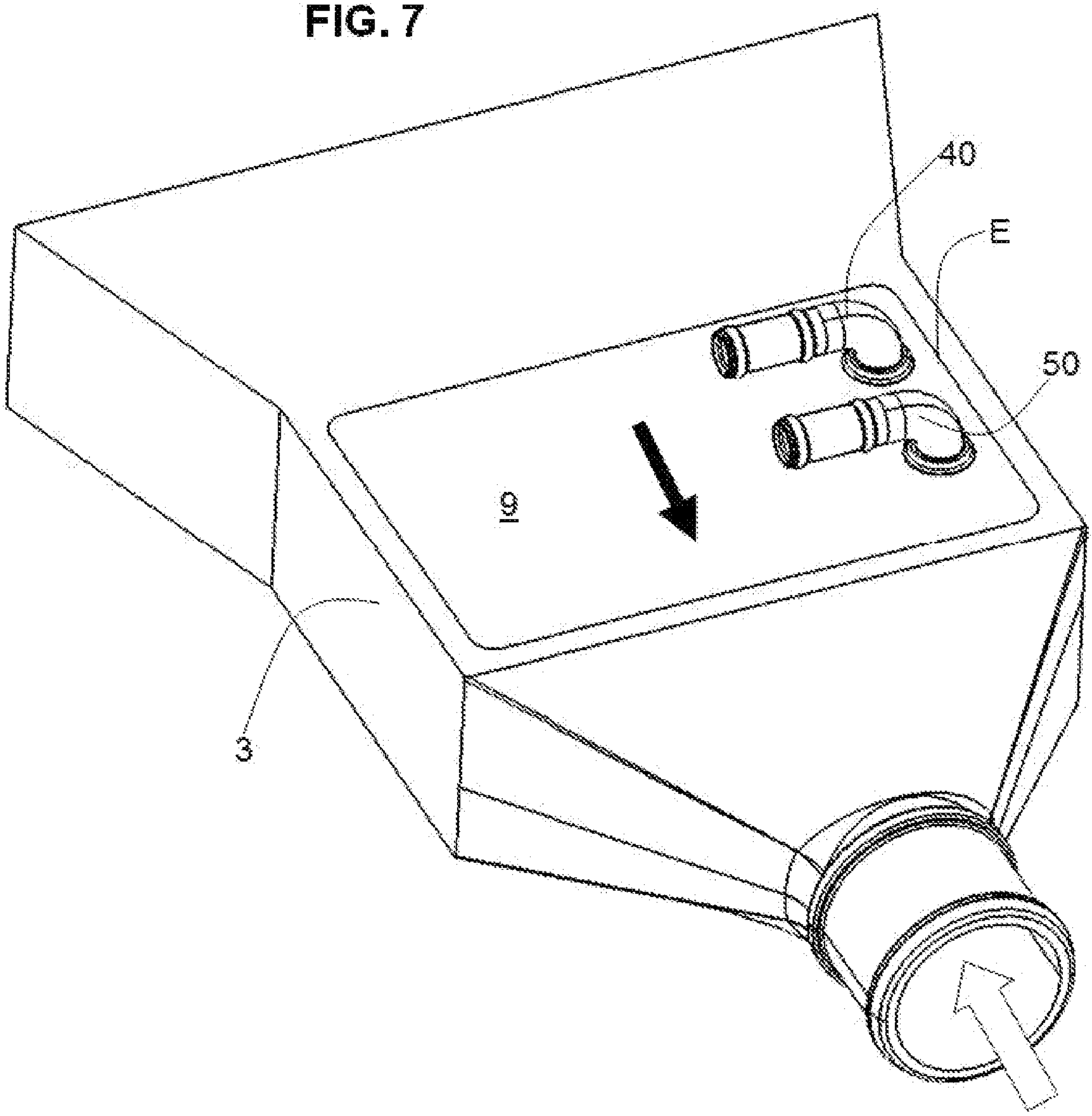


FIG. 8

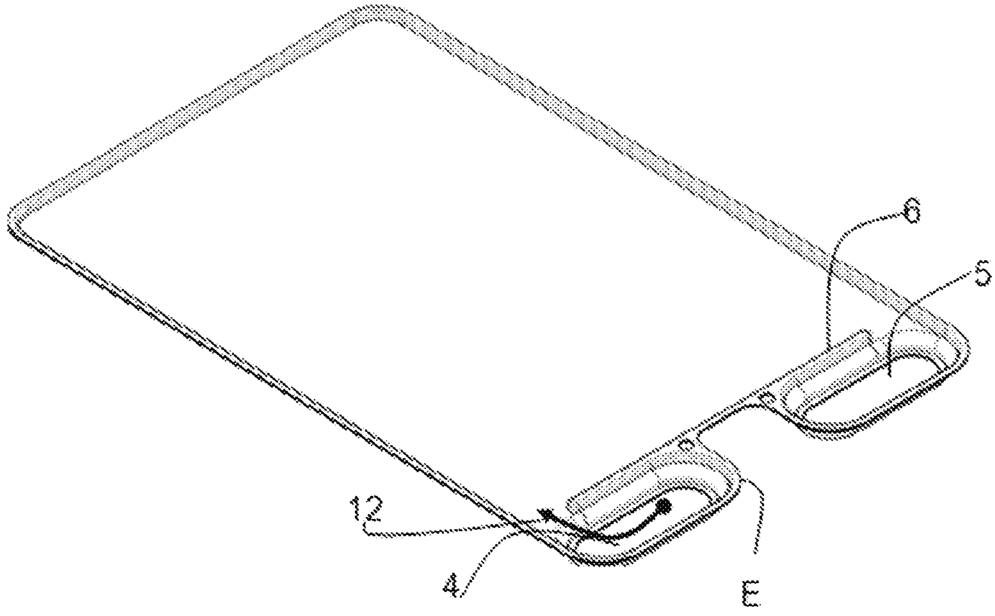
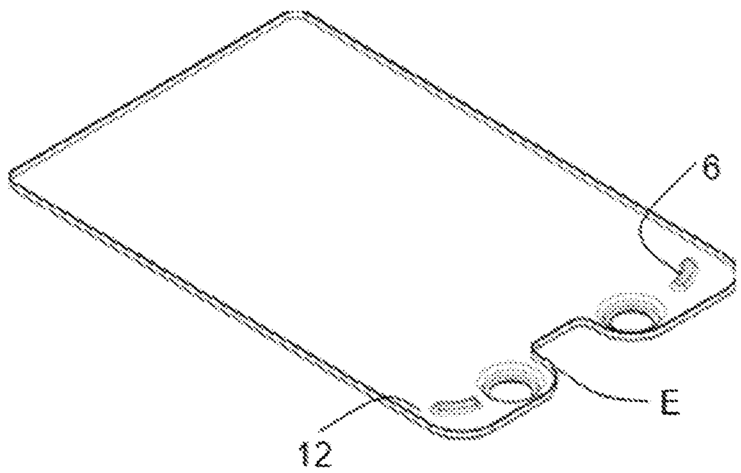


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/034494

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - F28F 3/02 (2013.01)
USPC - 165/166
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - F02B 29/04; F28D 1/00, 1/03, 7/16, 9/00; F28F 1/00, 3/02, 3/08 (2013.01)
USPC - 165/152, 153, 165, 166, 167, 173, 181

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC - F02B 29/04; F28D 1/03, 7/16, 9/00; F28F 1/00, 3/02, 3/08 (2013.01)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase, Google Patents, Google

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 8,016,025 B2 (BROST et al) 13 September 2011 (13.09.2011) entire document	1, 2, 7, 8, 10 --- 11, 12
Y	US 2008/0087410 A1 (MULLER-LUFFT et al) 17 April 2008 (17.04.2008) entire document	11, 12
A	US 2009/0014153 A1 (PIMENTEL et al) 15 January 2009 (15.01.2009) entire document	1, 2, 7, 8, 10-12
A	US 2010/0300647 A1 (STEURER et al) 02 December 2010 (02.12.2010) entire document	1, 2, 7, 8, 10-12

☐ Further documents are listed in the continuation of Box C. ☐

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Date of the actual completion of the international search
12 June 2013

Date of mailing of the international search report
27 JUN 2013

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PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 3-6, 9, 13
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.