(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 198 435 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.06.2023 Bulletin 2023/25

(21) Application number: **22212503.1**

(22) Date of filing: **09.12.2022**

(51) International Patent Classification (IPC):
F28D 9/00 *(2006.01)* ***F28F 3/12*** *(2006.01)*
F28F 7/02 *(2006.01)* ***F28F 3/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F28D 9/0062; F28D 9/0031; F28D 9/0081; F28F 3/025; F28F 3/12; F28F 7/02

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **17.12.2021 US 202117553929**

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(54) HEAT EXCHANGER WITH PARTIAL-HEIGHT FOLDED FINS

(57) A heat exchanger (20) has a plurality of plates (24) having opposed surfaces (30, 32) and side walls (36) extending beyond the opposed surfaces (30, 32) to a height; and a fin pack (26) extending from one opposed surface (30) toward an opposed surface (32) of an adjacent plate (24), and having a fin height, wherein the fin height is equal to or less than the height. The plates (24) can be stacked to form a heat exchanger assembly with a gap between adjacent fin packs (26, 28).

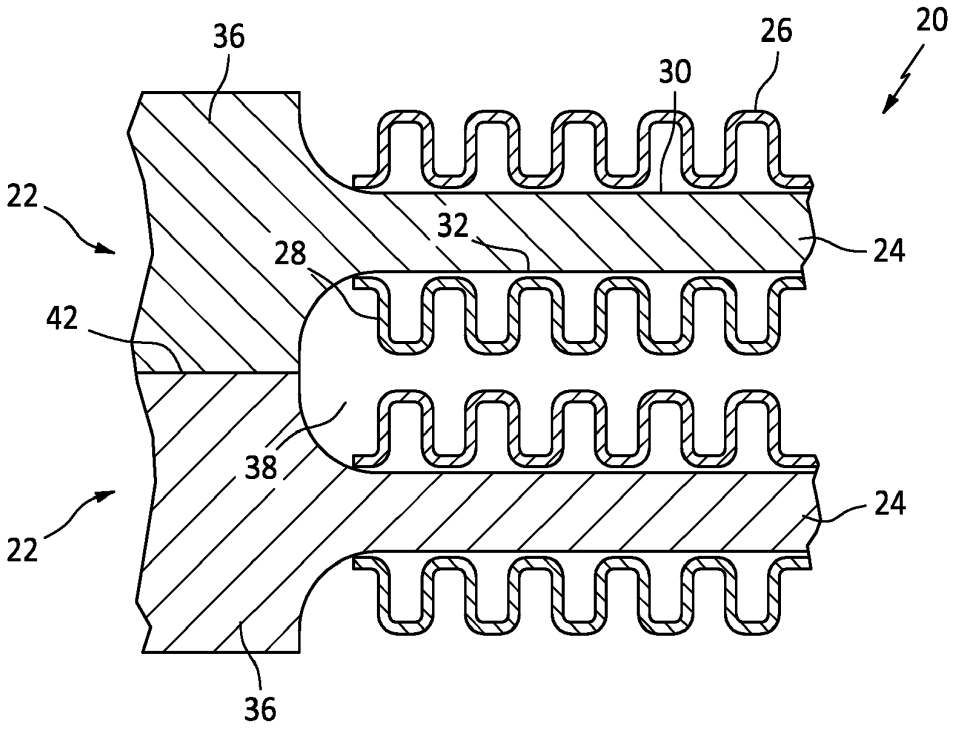


FIG. 4

EP 4 198 435 A1

Description

BACKGROUND OF THE DISCLOSURE

[0001] The disclosure relates to heat exchangers and more particularly to a heat exchanger having fin pack structures to facilitate stacking.

[0002] Conventional plate fin heat exchangers use folded fins on one or both sides of a parting plate, with side bars to seal flows from one another. This structure involves numerous parts that are brazed together to form a cube structure.

[0003] Heat exchangers may also be cast. In this configuration, the cast plates define internal flow passages and external flow passages, and the plates are stacked with a fin pack positioned in the external flow passage defined between two cast plates.

[0004] Tolerance stackups when stacking such structures make it difficult to bond the fin pack to upper and lower sides of the two cast plates, where the fin pack either does not fit within the space, or does not reach both of the upper and lower sides to allow bonding to each surface.

SUMMARY OF THE INVENTION

[0005] In one aspect, there is provided a heat exchanger that comprises a plurality of plates having opposed surfaces and side walls extending beyond the opposed surfaces to a height (h); and a fin pack extending from one opposed surface toward an opposed surface of an adjacent plate, and having a fin height (f), wherein the fin height (f) is equal to or less than the height (h) .

[0006] In some examples, the heat exchanger further comprises a second fin pack having a height (h) and extending from the opposed surface of the adjacent plate toward the one opposed surface and having a fin height (f) that is less than or equal to the height (h).

[0007] In some examples, a gap is defined between the fin pack and the second fin pack.

[0008] In some examples, the fin packs are a folded structure, and the gap is defined between crests of the folded structure.

[0009] In some examples, the gap is less than or equal to 0.020 inches (0.508 mm).

[0010] In some examples, the plurality of plates are stacked with side walls of adjacent plates bonded to each other.

[0011] In some examples, the plurality of plates define an internal flow passage.

[0012] In some examples, the opposed surfaces of adjacent plates of the plurality of plates define an external flow passage, and the fin pack comprises two fin packs in the external flow passage, with one of the two fin packs extending from each of the opposed surfaces toward the other of the two fin packs.

[0013] In some examples, the fin pack is diffusion bonded or brazed to one of the opposed surfaces.

[0014] There is also provided a heat exchanger subassembly that comprises a plate having first and second opposed surfaces, and side walls extending transverse to the opposed surfaces to define a side wall height (h) relative to the opposed surfaces; at least one internal flow passage defined in the plate; and a first folded fin pack on the first opposed surface and a second folded fin pack on the second opposed surface, each folded fin pack having a fin height (f) that is less than or equal to the side wall height (h).

[0015] In some examples, the internal flow passage extends substantially transverse to flow passages defined along walls of the first folded fin pack and the second folded fin pack.

[0016] In some examples, the first folded fin pack and the second folded fin pack are bonded to the first and second opposed surfaces.

[0017] There is also provided a method for making a heat exchanger comprises bonding a first folded fin pack and a second folded fin pack to opposed surfaces of a plate having side walls and an internal flow passage to form a heat exchanger subassembly; stacking the heat exchanger subassembly with a further heat exchanger subassembly with a gap defined between adjacent folded fin packs; and bonding the heat exchanger subassembly to the further heat exchanger subassembly at contacting surfaces of the side wall of each heat exchanger subassembly.

[0018] In some examples, the bonding step comprises diffusion bonding.

[0019] In some examples, the bonding step comprises brazing.

[0020] In some examples, the side walls extend beyond the opposed surfaces to a height (h), and wherein the fin pack has a fin height (f), wherein the fin height (f) is equal to or less than the height (h).

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] A detailed description of preferred embodiments of the invention follows, with referenced to the attached drawings, wherein:

FIG. 1 schematically illustrates components of a known heat exchanger;
FIG. 2 illustrates a cross sectional view of a different configuration of a known cast heat exchanger;
FIG. 3 schematically illustrates one non-limiting configuration of a heat exchanger sub-assembly;
FIG. 4 is a cross section through a stacked heat exchanger having sub-assemblies such as are illustrated in FIG. 3; and
FIG. 5 is an enlarged view of a portion of FIG. 4.

[0022] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0023] The present disclosure relates to heat exchangers and, more particularly, to cast heat exchangers defining external cooling passages when stacked, and having partial-height fin packs in the external cooling passages.

[0024] FIG. 1 illustrates a known heat exchanger assembly 1 wherein brazing sheets 2 and folded fins 3 are alternatingly stacked. Side bars 4 are positioned along the non-flow edges of the fins to seal flows from one another, and the entire structure is brazed together.

[0025] FIG. 2 is a cross section through a known cast heat exchanger 5 that can be an alternative to the heat exchanger of FIG. 1. In FIG. 2, cast plates 6 have internal flow passages (not shown in FIG. 2) and have cast side portions 7 that extend vertically above the central surfaces 8 of plates 6. When stacked, this defines an external passage 9 bounded by surfaces 8 and side portions 7. A fin pack 10 is positioned in external passage 9. In this configuration, tolerance stackups may lead to mismatch of the fin pack, particularly the height of the fin pack, and the height of the external passage defined between the plate surfaces. This leads to either difficulty in bonding the fin pack to both surfaces, or the fin pack being too large for the height of the external passage, leading to difficulties in manufacturing.

[0026] Turning to FIGS. 3-5, a heat exchanger 20 can include heat exchanger subassemblies 22 having a cast plate 24 and partial-height fin packs 26, 28 on opposed surfaces 30, 32 as shown. Cast plate 24 defines internal passages 34 for an internal flow, and has side walls 36 that extend upwardly and downwardly beyond a central surfaces 30, 32 (or beyond a central part of each plate 24 defining the opposed surfaces 30, 32).

[0027] Subassemblies 22 as shown in FIG. 3 can be stacked, see cross section of FIG. 4, and this defines heat exchanger 20 having external flow passages 38 defined between surfaces 30, 32 and internal portions 40 of side walls 36. In the configuration shown, internal passages 34 are substantially transverse to external flow passages 38, defining a cross flow heat exchanger. It should be appreciated that the partial height fins as disclosed herein would also be well suited to a counter flow heat exchanger wherein flows are counter to each other and substantially parallel, and to other configurations as well.

[0028] Each side wall 36 extends beyond a surface 30, 32 by a height h, and when stacked, the height h of two adjacent plates 24 defines an external flow passage height H between surfaces 30, 32 of adjacent plates 24.

[0029] Fin packs 26, 28 are referred to herein as "partial-height" fin packs because they are configured to have a fin height (f) that can correspond to the height (h) defined by side wall 36. In this configuration, fin height (f) can be approximately the same or less than height (h) such that, when subassemblies 22 are stacked, fin packs 26, 28 of adjacent plates extend toward each other in external flow passage 38 with a small gap defined between them. This allows each fin pack 26, 28 to be bonded to a surface 30, 32 without issues caused by tolerance stackups. As shown in FIGS. 4 and 5, stacking defines external flow passage 38 between surfaces 30, 32 and having two fin packs 26, 28 positioned for interacting with flow as desired.

[0030] The disclosed configuration is well suited to fabrication through casting but it should be appreciated that other methods of manufacturing could also be utilized to produce heat exchanger 20 and subassemblies 22 as disclosed.

[0031] Suitable materials for plate 24 include, but are not limited to: stainless steel, austenitic nickel-chromium-based superalloy such as that marketed under the trademark Inconel, nickel chromium superalloy such as that marketed under the trademark Rene 41, nickel based super-alloy such as that marketed under the trademark Mar-M, and other nickel based super-alloys.

[0032] Plate 24 can be flat, or can be shaped to suit specific uses. In one non-limiting example the plate can be curved.

[0033] Fin packs can be made using known techniques, and suitable materials for fin packs 26, 28 include, but are not limited to: stainless steel, nickel-chromium-based superalloy such as that marketed under the trademark Inconel and other nickel based super-alloys.

[0034] Fin packs 26, 28 can be bonded, for example diffusion bonded, or brazed, to plate 24, for example to both surfaces 30, 32 of plate 24, to produce subassembly 22 such as that illustrated in FIG. 3.

[0035] Subassemblies 22 can then be stacked and joined at contacting sidewall surfaces 42, again for example by bonding or brazing, diffusion bonding, or other techniques that are known to persons skilled in the art.

[0036] Height (h) of sidewalls can be the same or different on opposite sides of plate 24. Having height (h) be the same is suitable from a uniformity standpoint, but in specialized configurations it may be desirable to have different heights (h) on different surfaces 30, 32.

[0037] Fin height of the fin packs 26, 28 can also be the same, and this matches up with the configuration wherein height (h) is the same on both surfaces 30, 32. It should be appreciated that in some configurations, it may be desirable to have fin heights be different on different surfaces 30, 32, and this can still be accomplished as long as the combined fin height is configured to match height H defined between surfaces 30, 32.

[0038] When height (h) is the same on both sides, then the same fin packs can be bonded to each surface 30, 32.

[0039] With the configuration as disclosed herein, gap 44 between fold ends 46 (FIG. 5) can be kept to a very small dimension, for example less than about 0.020 inches (0.508 mm). Gap 44 is not shown to scale.

[0040] Fin packs having fin height (f) equal to or less than height (h) allow fabrication of a stacked heat exchanger where fin packs are brazed to both opposed surfaces that define the external flow passage, and there-

fore have the desired heat exchange properties with these surfaces, and at the same time the disclosed fin height allows stacking of the heat exchanger subassemblies without issues caused with a single fin pack in known heat exchangers such as that illustrated in FIGS. 1 and 2.

[0041] Partial height fin packs allow manufacture of heat exchanger subassemblies having the heat exchanger plate as disclosed, with a fin pack on each opposed surface, and brazed or diffusion bonded to the opposed surface. Heat exchanger subassemblies can then be stacked, and the height of the fins as compared to the side wall of the plate allows stacking with a small gap between the fin packs, thereby avoiding issues with respect to stack up tolerance mismatch and the like wherein a single fin pack would either be too large to fit in the space between plates, or would be too small and therefore difficult to bond to both surfaces.

[0042] Once the subassemblies are stacked as desired, they can then be brazed or diffusion bonded together at the contacting side wall surfaces to complete the heat exchanger.

[0043] One or more embodiments of the present disclosure have been described. Nevertheless, it will be understood that various modifications may be made without departing from the scope of the invention.

[0044] Accordingly, other embodiments are within the scope of the following claims.

Claims

1. A heat exchanger (20), comprising:

a plurality of plates (24) having opposed surfaces (30, 32) and side walls (36) extending beyond the opposed surfaces (30, 32) to a height (h);
a fin pack (26) extending from one opposed surface (30) toward an opposed surface (32) of an adjacent plate (24), and having a fin height (f), wherein the fin height (f) is equal to or less than the height (h).

2. The heat exchanger (20) of claim 1, further comprising a second fin pack (28) having a height (h) and extending from the opposed surface (32) of the adjacent plate (24) toward the one opposed surface (30) and having a fin height (f) that is less than or equal to the height (h).

3. The heat exchanger (20) of claim 2, wherein a gap (44) is defined between the fin pack (26) and the second fin pack (28).

4. The heat exchanger (20) of claim 3, wherein the fin packs (26, 28) are a folded structure, and wherein the gap (44) is defined between crests (46) of the folded structure.

5. The heat exchanger (20) of claim 3 or 4, wherein the gap (44) is less than or equal to 0.020 inches (0.508 mm).

6. The heat exchanger (20) of any preceding claim, wherein the plurality of plates (24) are stacked with side walls (36) of adjacent plates (24) bonded to each other.

7. The heat exchanger (20) of any preceding claim, wherein the plurality of plates (24) define an internal flow passage (34).

8. The heat exchanger (20) of any preceding claim, wherein the opposed surfaces (30, 32) of adjacent plates (24) of the plurality of plates (24) define an external flow passage (38), and wherein the fin pack (26, 28) comprises two fin packs (26, 28) in the external flow passage (38), with one of the two fin packs (26, 28) extending from each of the opposed surfaces (30, 32) toward the other of the two fin packs (28, 26).

9. The heat exchanger (20) of any preceding claim, wherein the fin pack (26; 28) is diffusion bonded or brazed to one of the opposed surfaces (30, 32).

10. A heat exchanger subassembly (22), comprising:

a plate (24) having first and second opposed surface (30, 32), and side walls (36) extending transverse to the opposed surfaces (30, 32) to define a side wall height (h) relative to the opposed surfaces (30, 32);
at least one internal flow passage (34) defined in the plate (24); and
a first folded fin pack (26) on the first opposed surface (30) and a second folded fin pack (28) on the second opposed surface (32), each folded fin pack (26, 28) having a fin height (f) that is less than or equal to the side wall height (h).

11. The heat exchanger subassembly (22) of claim 10, wherein the internal flow passage (34) extends substantially transverse to flow passages (38) defined along walls of the first folded fin pack (26) and the second folded fin pack (28); and/or wherein the first folded fin pack (26) and the second folded fin pack (28) are bonded to the first and second opposed surfaces (30, 32).

12. A method for making a heat exchanger (20), comprising:

bonding a first folded fin pack (26) and a second folded fin pack (28) to opposed surfaces (30, 32) of a plate (24) having side walls (36) and an internal flow passage (34) to form a heat exchang-

er subassembly (22);
stacking the heat exchanger subassembly (22) with a further heat exchanger subassembly (22) with a gap (44) defined between adjacent folded fin packs (26, 28); and
bonding the heat exchanger subassembly (22) to the further heat exchanger subassembly (22) at contacting surfaces (42) of the side wall (36) of each heat exchanger subassembly (22).

13. The method of claim 12, wherein the bonding step comprises diffusion bonding.

14. The method of claim 12, wherein the bonding step comprises brazing.

15. The method of any of claims 12 to 14, wherein the side walls (36) extend beyond the opposed surfaces (30, 32) to a height (h), and wherein the fin pack (26, 28) has a fin height (f), wherein the fin height (f) is equal to or less than the height (h).

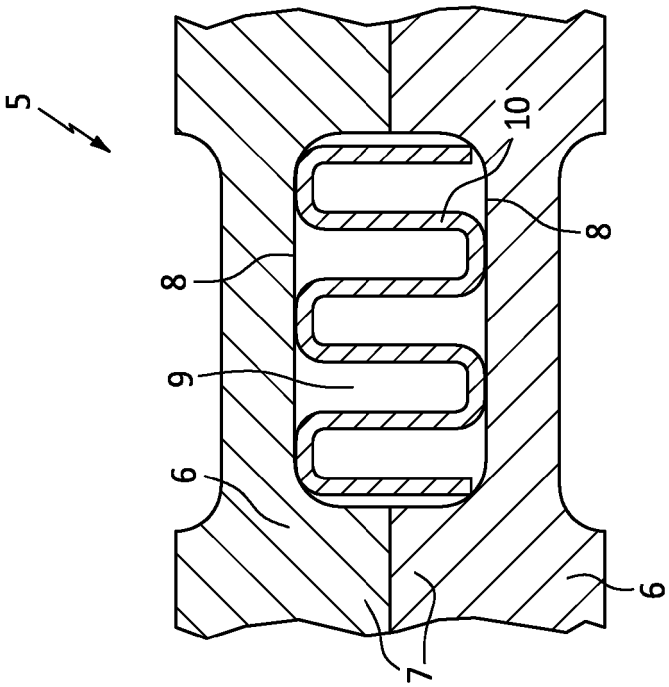


FIG. 2

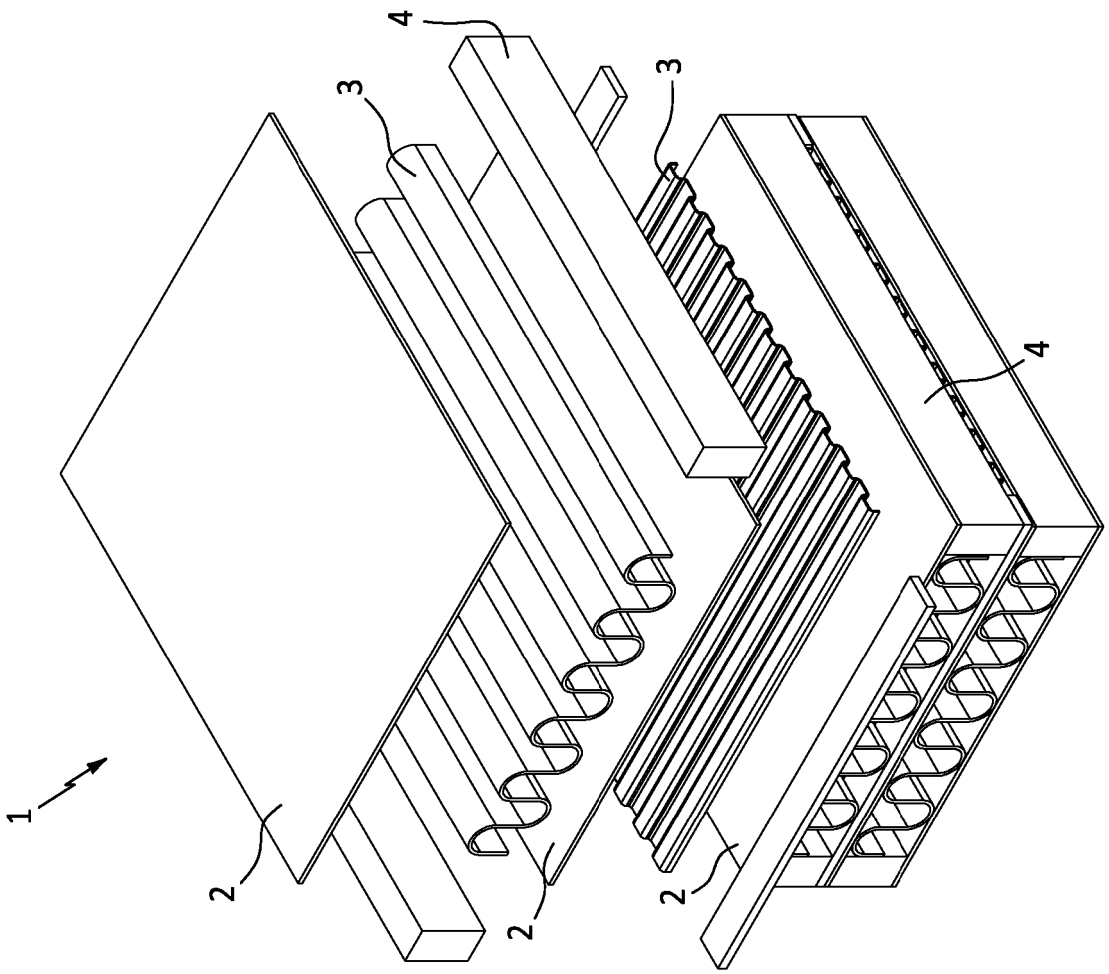


FIG. 1

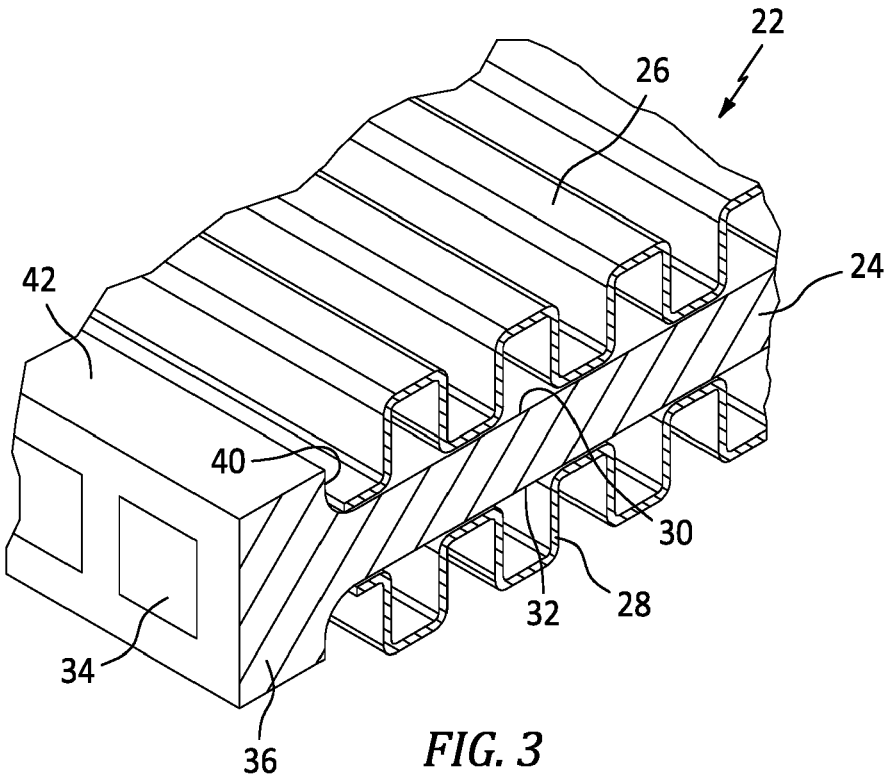


FIG. 3

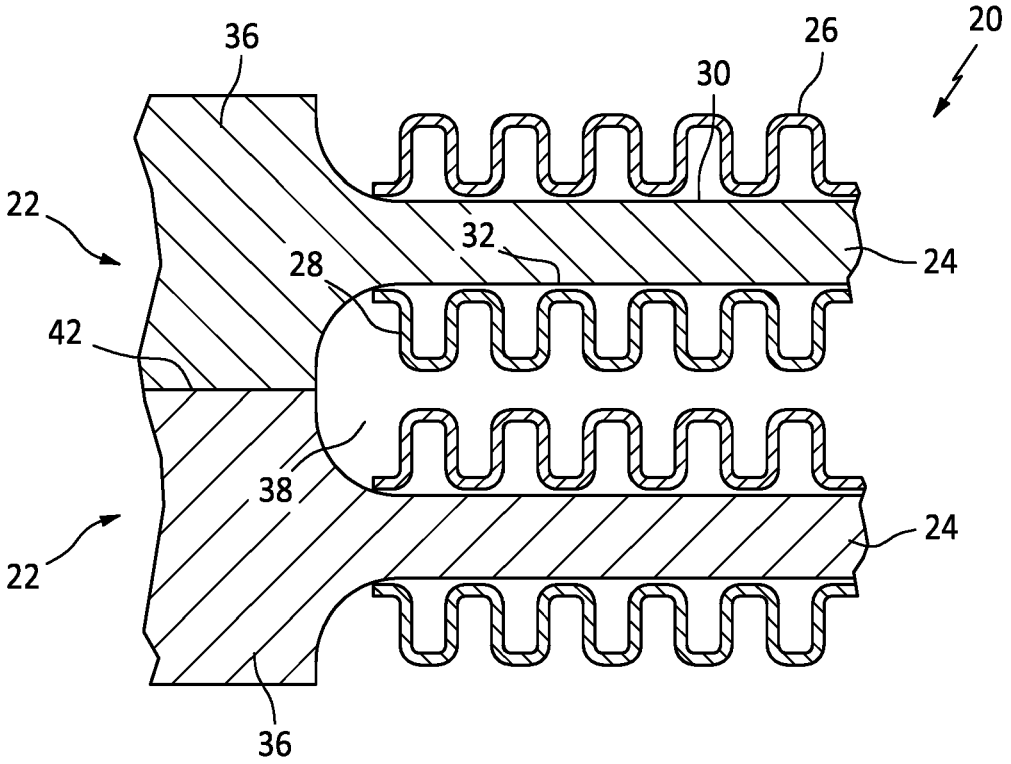


FIG. 4

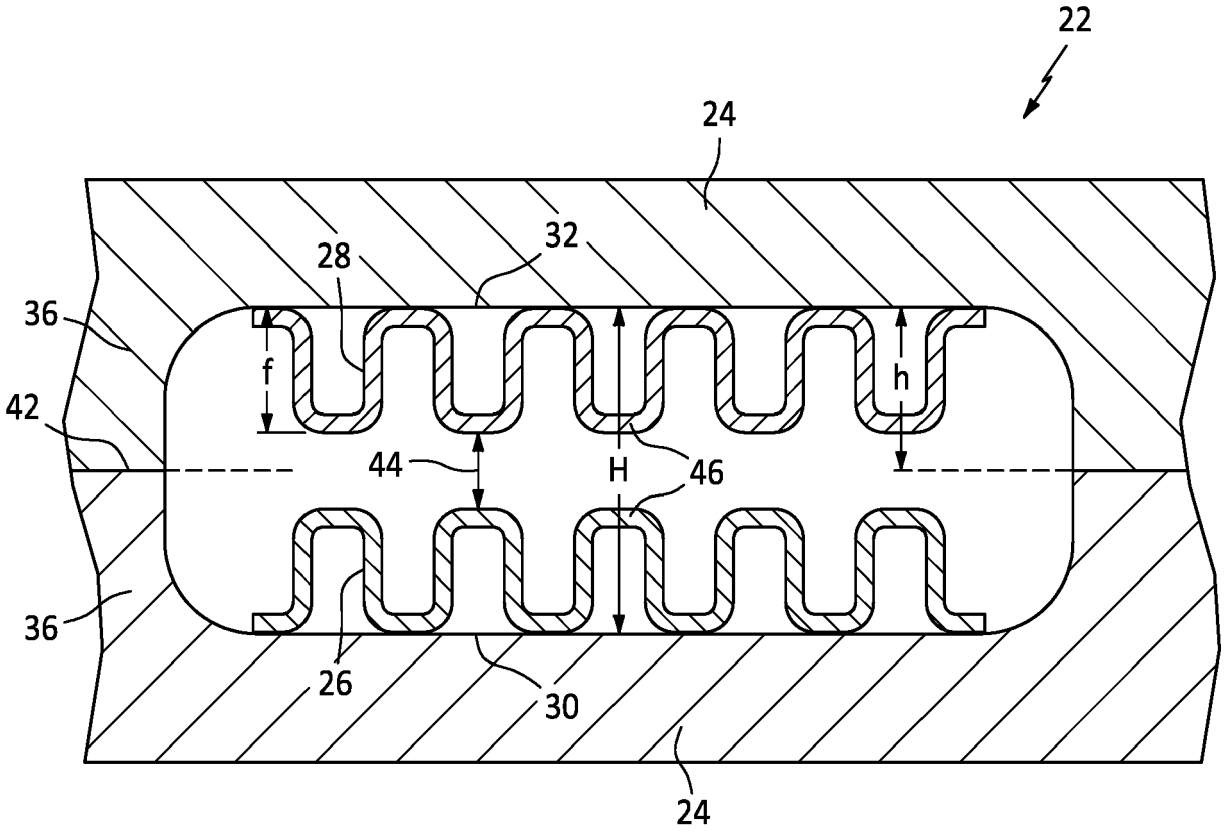


FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 22 21 2503

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	* figures 4A-4F *	7,10-15	F28F7/02 F28F3/02
A	US 2013/020061 A1 (BERGH CHARLES J [US]) 24 January 2013 (2013-01-24) * figures 1, 6-8 *	1-15	
A	DE 10 2019 119257 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 21 January 2021 (2021-01-21) * figure 2 *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

F28D
F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 March 2023	Delaitre, Maxime

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 21 2503

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