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(54) HEAT EXCHANGER WITH ENHANCED HEAT TRANSFER

WÄRMETAUSCHER MIT VERBESSERTER WÄRMEÜBERTRAGUNG

ÉCHANGEUR DE CHALEUR AVEC TRANSFERT DE CHALEUR AMÉLIORÉ

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present disclosure relates to heat exchangers.

2. Description of Related Art

[0002] Heat exchangers such as, for example, tube-shell heat exchangers, are typically used in aerospace turbine engines and other high temperature applications. These heat exchangers are used to transfer thermal energy between two fluids without direct contact between the two fluids. In particular, a primary fluid is typically directed through a fluid passageway of the heat exchanger, while a cooling or heating fluid is brought into external contact with the fluid passageway. In this manner, heat may be conducted through walls of the fluid passageway to thereby transfer energy between the two fluids. One typical application of a heat exchanger is related to an engine and involves the cooling of air drawn into the engine and/or exhausted from the engine.

[0003] However, typical tube shell design heat exchangers have structural issues when their canti levered tube bundles are exposed to typical aerospace vibration environments. In addition, there can be bypass of flow around the tubes on the low pressure side of the heat exchanger, resulting in reduced thermal effectiveness as well as other adverse system impacts such as excessive low pressure flow. A heat exchanger is known from DE 23 62 885.

[0004] Traditional plate-stack heat exchangers are also used in high temperature applications and address some of the aforementioned structural and flow bypass issues. In prior art applications, plate stack heat exchangers have been designed to have a large product of heat transfer coefficient and heat transfer surface area to achieve a large amount of heat transfer in a small volume. However, as this product of heat transfer coefficient and heat transfer surface area increases on the hot side of a plate stack heat exchanger, the metal temperature increases.

[0005] As peak operating temperatures of both tube shell and plate stack heat exchangers is increased in high temperature applications, these prior art heat exchangers operate at conditions such that metal temperatures in the hottest regions of the device, specifically where the hot inlet flow and cold outlet flow are in closest proximity are close enough to the metal melting point that creep of the material occurs, significantly shortening the life of the prior art device. Creep is a phenomenon whereby the material at high temperatures deforms plastically at stresses below the yield strength of the material. Furthermore, rapid changes in temperatures of one or both of the heat transfer fluids flowing through the heat exchanger result in large thermal gradients and large resultant stresses and strains into the plastic region of the heat exchanger material, resulting in reduced life of the heat exchanger. These thermal gradients are typically largest near the hottest portion of the heat exchanger.

[0006] Such conventional methods and systems have generally been considered satisfactory for their intended purpose. However, there is still a need in the art for improved heat exchangers with reduced peak metal temperatures and reduced thermal gradients in the metal of these devices during thermal transients. The present disclosure provides a solution for this need.

SUMMARY OF THE INVENTION

[0007] A heat exchange device according to claim 1 is provided.

[0008] The features of the systems of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description of the preferred embodiments taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, preferred embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

Fig. 1 is a perspective view of a prior art heat exchanger, showing fins within flow passages forming flow channels between the fins;

Fig. 1A is a cross-sectional view of prior art fins of Fig. 1, showing only shaped fins;

Fig. 2 is an example of fins showing the transition between straight fins to shaped fins within the flow passage; and

Fig. 3 is a perspective view of a heat exchange device, showing first and second sections and a center manifold.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure. For purposes of explanation and illustration, and not limitation, a partial view of an example of a heat exchange device in accordance with the disclosure is shown in Fig. 2 and is designated generally by reference character 100. Other examples of the heat exchange device in accordance with the disclosure, or aspects thereof, are provided in Figs. 1-3, as will be described. The systems and methods described herein can be used in turbine engines exposed

to high pressure and high temperatures, for example in aerospace application. The present disclosure provides for a device that reduces the product of heat transfer coefficient and heat transfer surface area in regions of the device where metal temperatures must be limited to meet life requirements, while still maintaining a large product of heat transfer coefficient and heat transfer surface area where large amounts of heat transfer per unit heat exchanger volume and weight can be achieved with reasonably low metal temperatures from a structural perspective between the hot and cold fluids.

[0011] With reference to Figs. 1 and 1A a typical heat exchanger known in the prior art is shown. Hot fluid enters through an inlet 20 at one end and passes through fin channels in flow passages to an outlet 22 at an opposing end. Cold fluid is passed surrounding the flow passages to transfer heat between the hot fluid within the flow passages and the cold fluid. Typical heat exchangers include secondary heat transfer elements, such as fins 10, within each flow passage. As shown in Fig. 1 and in more detail in Fig. 1A, generally these fins extend from the inlet 20 to the outlet 22 and are equal in dimensions throughout the length of the flow passage 10. As shown in Fig. 1A, fins 10 are herringbone fins that extend from the inlet 20 to the outlet 22.

[0012] In contrast, with reference to Fig. 2, fins 132 in accordance with the present disclosure are shown. Fins 132 are included within each of the flow passages 110 and fins 134 extend from the flow passages 110. The fins 132, 134 form a solid matrix to provide thermal and structural connection. Fins 132 provide increased heat transfer in a direction from the inlet 120 to the outlet 122. Straight fins 132a are positioned proximate the inlet 120 where creep and transient thermal stresses are greatest. The straight fins 132a transition to shaped fins 132b at the outlet 122 where enhanced thermal performance is desired. Positioning straight fins 132a at the hottest regions reduces peak temperatures and associated creep, and peak temperature gradients and associated thermal stresses, which in turn will provide a longer life span for the heat exchange device. The shaped fins 132b allow for increased extended secondary heat transfer surface area or increased heat transfer coefficient, which is more desirable at the outlet 122. With the variation in fins 132a, 132b, the device allows for peak metal temperatures and thermal transient stresses that are limited such that the device meets specified life requirements for a specified set of operating conditions or duty cycle. Fins 132 can be within each flow passage 110 and/or adjacent each flow passage 110. This allows the metal temperature in any given region of the device to be affected by the heat transfer characteristics of the heat transfer elements on both the hot and cold fins. While varying heat transfer characteristics on just the inlet side alone can solve the temperature and stress problems, varying heat transfer characteristics on both inlet and outlet sides or even just the outlet side is also suitable. The optimal configuration will depend on the specific design. For example, cost or manufacturing constraints could result in various design configurations.

[0013] According to the invention a first predetermined number of straight fins 132a can be positioned proximate the inlet 120. An intermediate section of the flow passage 110 between the inlet 120 and outlet 122 includes a second predetermined number of straight fins 132a and a third predetermined number of shaped fins 132b, where the second predetermined number of straight fins 132a is greater than the first predetermined number 132a. Proximate the outlet 122 a fourth predetermined number of shaped fins 132b is included that is less than the third predetermined number of shaped fins 132b.

[0014] With reference to Fig. 3, one embodiment of a heat exchange device 100 is shown. The device includes a first section 102 and a second section 104. The first and second sections 102, 104 are two identical heat exchange plate core sections each made up of flow passages 110 configured for heat exchange between heat exchange fluid within the flow passages 110 and fluid external of the fluid passages 110. Each of the flow passages 110 includes an inlet 120 and an outlet 122 (as shown in Fig. 2) with a bend or loop 130 at the outer edges of the device 100 to return the fluid to a center manifold 106. The bulk of the heat transfer occurs within the flow passages 110 of the first and second sections 102, 104.

[0015] The center manifold 106 separates the first and second sections 102, 104 and is configured to allow high pressure fluid to enter the manifold 106 at one end 112, pass into the flow passages 110 on either side of the manifold 106, and return to the manifold 106 to exit the manifold 106 at the opposite end 114. More specifically, the center manifold 106 includes a first plenum 112a at one end and a second plenum 114a on an opposing end. Fluid flows into the first plenum 112a of the center manifold 106, passes through a respective fluid inlet 120 of a flow passage 110, follows a bend/loop 130 of the flow passage 106, enters the center manifold 106 again through the fluid outlet 122 and then exits the center manifold 106 through the second plenum 114a. The design for the first and second sections 102, 104 and the center manifold 106 facilitates installation of the proposed heat exchange device 100 in place of an existing tube-shell unit.

[0016] The systems of the present disclosure, as described above and shown in the drawings, provide for a heat exchange device with superior properties including heat transfer enhancements.

Claims

1. A heat exchange device, comprising:

a plurality of flow passages (110), each flow passage having an inlet (120) and an outlet (122) configured for hot fluid flow in a direction from

the inlet to the outlet; and
secondary heat transfer elements (132, 134) within and adjacent each flow passage having heat transfer characteristics varying in the direction of the hot fluid flow such that peak metal temperatures, associated creep, and transient thermal stresses are limited to values producing acceptable life of the device; and
wherein the heat transfer elements are positioned proximate the inlet and the outlet and gradually transition from straight heat transfer elements at the inlet to shaped heat transfer elements proximate the outlet;

wherein proximate the inlet of each flow passage includes a first predetermined number of straight heat transfer elements (132a);
characterised in that an intermediate section between the inlet and outlet of the flow passage includes a second predetermined number of straight heat transfer elements and a third predetermined number of shaped heat transfer elements (132b), wherein the second predetermined number is greater than the first predetermined number; and

wherein proximate the outlet of the flow passage includes a fourth predetermined number of shaped heat transfer elements greater than the third predetermined number of shaped heat transfer elements;
a first section (102) and a second section (104), each of the first and second sections including flow passages of said plurality of flow passages, and

a center manifold (106) disposed between the first and second sections, wherein hot fluid enters the manifold at a first plenum (112a), passes through the first and second sections and exits the center manifold at a second plenum (114a).

2. The heat exchange device of claim 1, wherein the shaped heat transfer elements include wavy fins.

3. The heat exchange device of claim 1 or 2, wherein the shaped heat transfer elements allow for increased extended secondary heat transfer surface area.

4. The heat exchange device of claim 1,
wherein each flow passage includes the heat transfer elements positioned therein to provide increased heat transfer in a direction from the inlet to the outlet.

5. The heat exchange device of claim 4, wherein the first and second sections include plate sections in a stacked arrangement with each of the flow passages having a bend at an outer edge of the heat exchange device configured to return high pressure fluid to a center manifold (106).

6. The heat exchange device of claim 1, wherein fluid flows through the first plenum into an inlet of a respective flow passage within the first and second sections, enters the center manifold through an outlet of the respective flow passage, and exits the center manifold through the second plenum.

7. The heat exchange device of claim 1, wherein the heat transfer fins include herringbone fins.

Patentansprüche

1. Wärmetauschvorrichtung, die Folgendes umfasst:

eine Vielzahl von Strömungsdurchlässen (110), wobei jeder Strömungsdurchlass einen Einlass (120) und einen Auslass (122) aufweist, die für warmen Fluidstrom in eine Richtung von dem Einlass zu dem Auslass konfiguriert sind; und
sekundäre Wärmeübertragungselemente (132, 134) innerhalb von und benachbart zu jedem Strömungsdurchlass, die Wärmeübertragungsmerkmale aufweisen, die in der Richtung des warmen Fluidstroms variieren, sodass die Metallhöchsttemperaturen, zugehöriges Kriechen und transiente Wärmebelastungen auf Werte beschränkt sind, die eine annehmbare Lebensdauer der Vorrichtung erzeugen; und
wobei die Wärmeübertragungselemente nahe dem Einlass und dem Auslass positioniert sind und allmählich aus geraden Wärmeübertragungselementen an dem Einlass zu geformten Wärmeübertragungselementen nahe dem Auslass übergehen;
wobei nahe dem Einlass von jedem Strömungsdurchlass eine erste vorbestimmte Anzahl von geraden Wärmeübertragungselementen (132a) beinhaltet;
dadurch gekennzeichnet, dass ein Zwischenbereich zwischen dem Einlass und dem Auslass des Strömungsdurchlasses eine zweite vorbestimmte Anzahl von geraden Wärmeübertragungselementen und eine dritte vorbestimmte Anzahl von geformten Wärmeübertragungselementen (132b) beinhaltet, wobei die zweite vorbestimmte Anzahl größer ist als die erste vorbestimmte Anzahl; und
wobei nahe dem Auslass des Strömungsdurchlasses eine vierte vorbestimmte Anzahl von geformten Wärmeübertragungselementen beinhaltet, die größer ist als die dritte vorbestimmte

Anzahl von geformten Wärmeübertragungselementen;
einen ersten Bereich (102) und einen zweiten Bereich (104), wobei jeder des ersten und des zweiten Bereichs Strömungsdurchlässe der Vielzahl von Strömungsdurchlässen beinhaltet, und
einen mittleren Krümmer (106), der zwischen dem ersten und dem zweiten Bereich angeordnet ist, wobei warmes Fluid in den Krümmer an einem ersten Plenum (112a) eintritt, durch den ersten und zweiten Bereich läuft und an einem zweiten Plenum (114a) aus dem mittleren Krümmer austritt.

2. Wärmetauschvorrichtung nach Anspruch 1, wobei die geformten Wärmeübertragungselemente gewellte Rippen beinhalten.

3. Wärmetauschvorrichtung nach Anspruch 1 oder 2, wobei die geformten Wärmeübertragungselemente eine größere ausgedehnte sekundäre Wärmeübertragungsfläche ermöglichen.

4. Wärmetauschvorrichtung nach Anspruch 1, wobei jeder Strömungsdurchlass die Wärmeübertragungselemente aufweist, die darin positioniert sind, um erhöhte Wärmeübertragung in eine Richtung von dem Einlass zu dem Auslass bereitzustellen.

5. Wärmetauschvorrichtung nach Anspruch 4, wobei der erste und der zweite Bereich Plattenbereiche in einer gestapelten Anordnung mit jedem der Strömungsdurchlässe aufweisen, die eine Krümmung an einer äußeren Kante der Wärmetauschvorrichtung aufweisen, die dazu konfiguriert sind, Hochdruckfluid zu einem mittleren Krümmer (106) zurückzuleiten.

6. Wärmetauschvorrichtung nach Anspruch 1, wobei Fluid durch das erste Plenum in einen Einlass eines entsprechenden Strömungsdurchlasses innerhalb des ersten und zweiten Bereichs strömt, durch einen Auslass des entsprechenden Strömungsdurchlasses in den mittleren Krümmer eintritt und durch das zweite Plenum aus dem mittleren Krümmer austritt.

7. Wärmetauschvorrichtung nach Anspruch 1, wobei die Wärmeübertragungsrippen fischgrätenförmige Rippen beinhalten.

Revendications

1. Dispositif d'échange de chaleur, comprenant :

une pluralité de passages d'écoulement (110), chaque passage d'écoulement ayant une entrée (120) et une sortie (122) configurées pour un écoulement de fluide chaud dans une direction allant de l'entrée à la sortie ; et
des éléments de transfert de chaleur secondaires (132, 134) à l'intérieur de chaque passage d'écoulement et adjacents à ceux-ci, ayant des caractéristiques de transfert de chaleur variant dans la direction de l'écoulement de fluide chaud, de sorte que les températures maximales du métal, le fluage associé et les contraintes thermiques transitoires sont limités à des valeurs produisant une durée de vie acceptable du dispositif ; et
dans lequel les éléments de transfert de chaleur sont positionnés à proximité de l'entrée et de la sortie et passent progressivement d'éléments de transfert de chaleur droits au niveau de l'entrée à des éléments de transfert de chaleur façonnés à proximité de la sortie ;
dans lequel à proximité de l'entrée de chaque passage d'écoulement, un premier nombre prédéterminé d'éléments de transfert de chaleur droits (132a) est prévu ;
caractérisé en ce qu'une section intermédiaire entre l'entrée et la sortie du passage d'écoulement comporte un deuxième nombre prédéterminé d'éléments de transfert de chaleur droits et un troisième nombre prédéterminé d'éléments de transfert de chaleur façonnés (132b),
dans lequel le deuxième nombre prédéterminé est supérieur au premier nombre prédéterminé ; et
dans lequel à proximité de la sortie du passage d'écoulement un quatrième nombre prédéterminé d'éléments de transfert de chaleur façonnés supérieur au troisième nombre prédéterminé d'éléments de transfert de chaleur façonnés est prévu ;
une première section (102) et une seconde section (104), chacune des première et seconde sections comportant des passages d'écoulement de ladite pluralité de passages d'écoulement, et
un collecteur central (106) disposé entre les première et seconde sections, dans lequel du fluide chaud entre dans le collecteur au niveau d'un premier plénum (112a), traverse les première et seconde sections et sort du collecteur central au niveau d'un second plénum (114a).

2. Dispositif d'échange de chaleur selon la revendication 1, dans lequel les éléments de transfert de chaleur façonnés comportent des ailettes ondulées.

3. Dispositif d'échange de chaleur selon la revendication 1 ou 2, dans lequel les éléments de transfert de chaleur façonnés permettent d'augmenter la superficie de transfert de chaleur secondaire étendue.

4. Dispositif d'échange de chaleur selon la revendication 1, dans lequel chaque passage d'écoulement comporte les éléments de transfert de chaleur positionnés à l'intérieur de celui-ci pour fournir un transfert de chaleur accru dans une direction allant de l'entrée à la sortie.

5. Dispositif d'échange de chaleur selon la revendication 4, dans lequel les première et seconde sections comportent des sections de plaque dans un agencement empilé, chacun des passages d'écoulement ayant une courbure au niveau d'un bord extérieur du dispositif d'échange de chaleur configuré pour renvoyer un fluide haute pression à un collecteur central (106) .

6. Dispositif d'échange de chaleur selon la revendication 1, dans lequel le fluide s'écoule à travers le premier plénum dans une entrée d'un passage d'écoulement respectif à l'intérieur des première et seconde sections, entre dans le collecteur central à travers une sortie du passage d'écoulement respectif, et sort du collecteur central à travers le second plénum.

7. Dispositif d'échange de chaleur selon la revendication 1, dans lequel les ailettes de transfert de chaleur comportent des ailettes en chevrons.

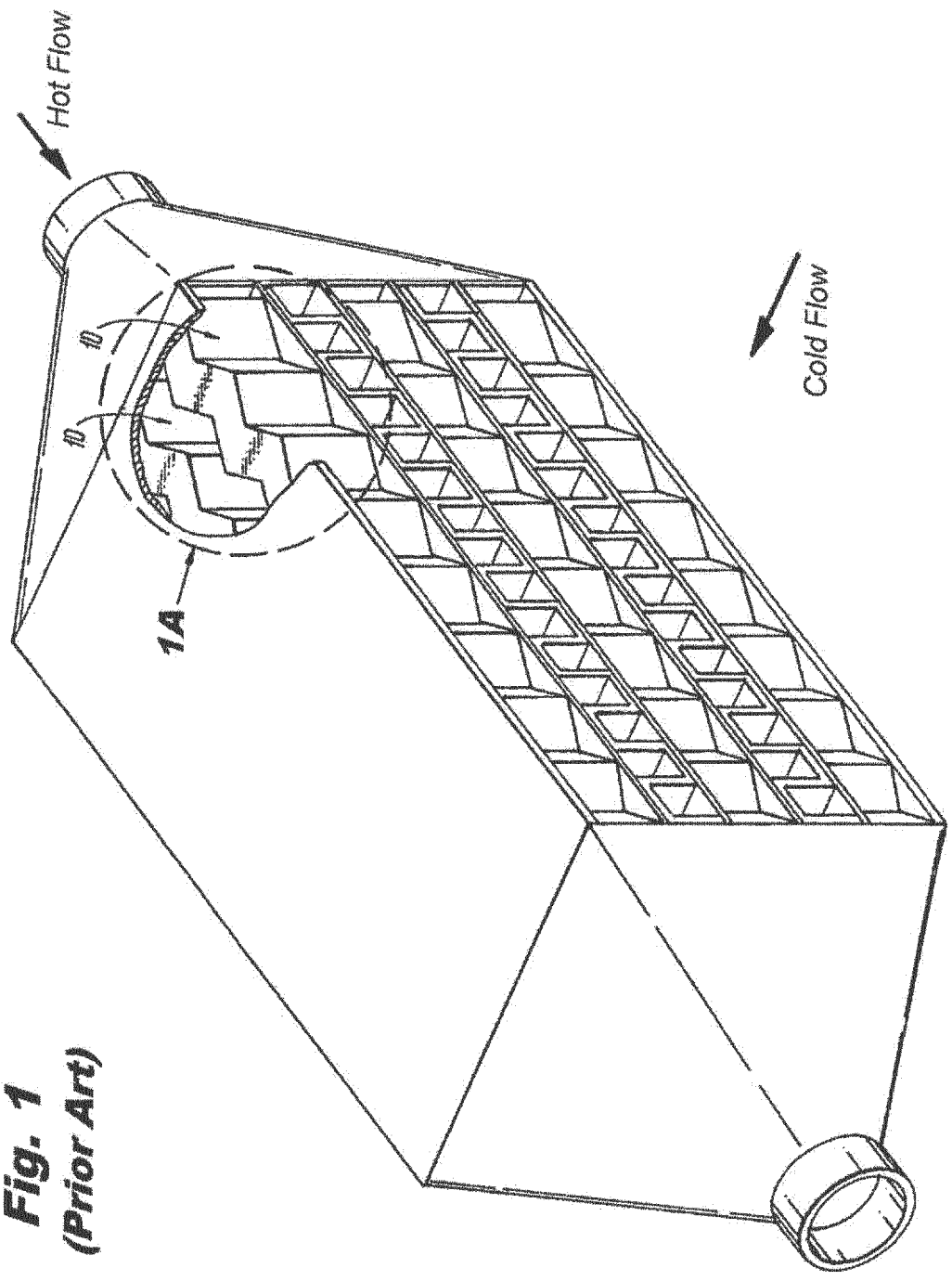


Fig. 1
(Prior Art)

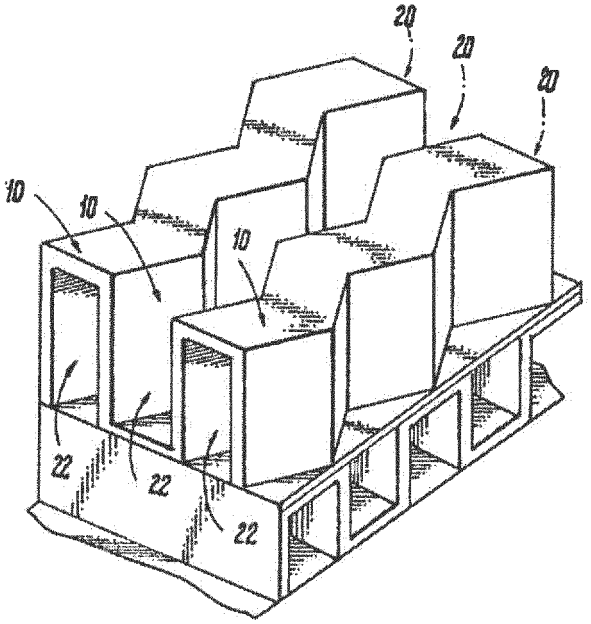


Fig. 1A
(Prior Art)

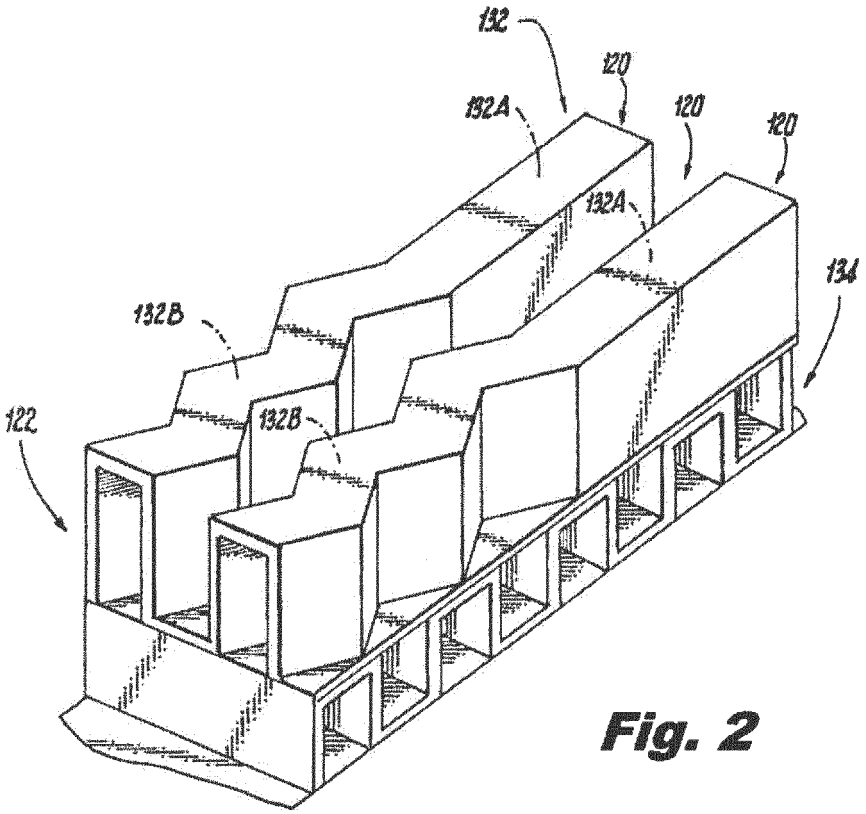


Fig. 2

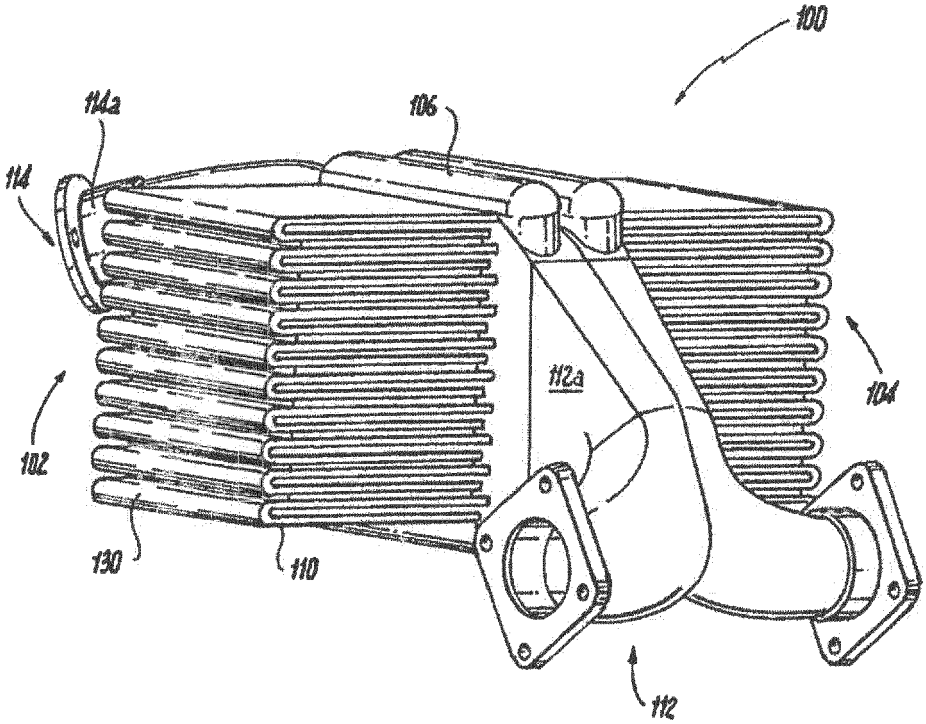


Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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