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(54) **HEAT EXCHANGER WITH CENTER MANIFOLD AND THERMAL SEPARATOR**

(57) A heat exchange device (100) includes a first section (102) and a second section (104). Each of the first and second sections include flow passages (110) configured for heat exchange between hot fluid within the flow passages (110) and cold fluid external of the flow passages. Each of the flow passages (110) having cold fluid flow therebetween. A separator (144) is positioned dividing the cold fluid flow between flow passages (110). The separator (144) includes two separator sheets (140) spaced apart with a pillar matrix (142) structurally connecting the separator sheets (140) configured to prevent cold fluid mixing.

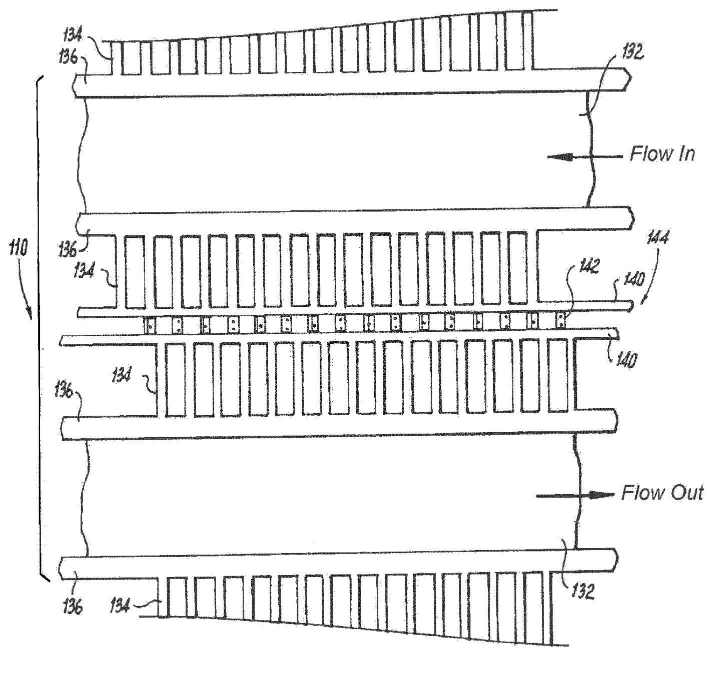

Fig. 3

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present disclosure relates to heat exchangers, and more particularly to plate-stack 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. 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 cantilevered tube bundles are exposed to typical aerospace vibration environments. In addition, there can be significant 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. Subsequently, the heat exchangers either fail, or are heavy, expensive, and difficult to manufacture.

[0004] 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. The present disclosure provides a solution for this need.

SUMMARY OF THE INVENTION

[0005] A heat exchange device includes a first section and a second section. Each of the first and second sections include flow passages configured for heat exchange between hot fluid within the flow passages and cold fluid external of the flow passages. Each of the flow passages having cold fluid flow therebetween. A separator is positioned dividing the cold fluid flow between flow passages. The separator includes two separator sheets spaced apart with a pillar matrix structurally connecting the separator sheets configured to prevent cold fluid mixing.

[0006] Each of the flow passages can have a hot fluid inlet and a hot fluid outlet wherein the temperature of the fluid entering at the hot fluid inlet is greater than the temperature of the fluid exiting the hot fluid outlet. The separator sheets can be positioned between each hot fluid inlet and hot fluid outlet of each adjacent flow passage configured to provide insulation between the different temperatures of the hot fluid inlet and the hot fluid outlet. The cold fluid flow channel includes secondary heat transfer element such as fins, pins or vanes extending from the flow passages. The pillar matrix can be between the two separator sheets and include the same material as that of the cold fins. The pillar matrix can include material with reduced thermal conductivity relative to other material of the device in order to reduce thermal conduction.

[0007] A center manifold is disposed between the first and second sections. Hot fluid can enter the manifold at one end, pass through the first and second sections and hot fluid exits the manifold at the opposing end. The hot fluid entering the flow passage can be greater in temperature than the hot fluid entering the manifold upon exiting the flow passage. Each of the first and second sections include heat exchanger plates with secondary heat transfer elements in a stacked arrangement. The secondary heat transfer elements and flow passages can form a solid matrix configured to prevent wear of the device and prevent relative motion with the device. The components of the heat exchange device can be created through the use of additive manufacturing.

[0008] These and other features of the systems and methods 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 by way of example only in detail herein below with reference to certain figures, wherein:

Fig. 1 is a perspective view of a heat exchange device with first and second core sections connected by a center manifold;

Fig. 2 is a perspective view of a single hot flow passage of the heat exchange device shown in Fig. 1, showing the direction of fluid flow from the center manifold into the hot flow passage, returning to the center manifold to exit the device after heat exchange between hot and cold fluids has occurred; and

Fig. 3 is a detailed view of an exemplary embodiment of a single flow passage of Fig. 2 constructed in accordance with the present disclosure, showing a separator positioned between adjacent flow passages.

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 exemplary embodiment of a heat exchange device in accordance with the disclosure is shown in Fig. 1 and is designated generally by reference character 100. Other embodiments of the heat exchange device in accordance with the disclosure, or aspects thereof, are provided in Figs. 2-4, 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.

[0011] With reference to Fig. 1, a heat exchange device 100 in accordance with the present disclosure is shown. The device includes a first section 102 and a second section 104 separated by a center manifold 106. The first and second sections 102, 104 are two identical plate-fin core sections each made up of flow passages 110 configured for heat exchange between hot heat exchange fluid within the flow passages 110 and cold fluid external of the fluid passages 110. It will be understood by one skilled in the art that the cold and hot fluids can be interchanged. Each of the flow passages 110 includes a bend or loop 130 at the outer edges of the device 100 to return the fluid to the center manifold 106. The bulk of the heat transfer occurs within the flow passages 110 of the first and second sections 102, 104.

[0012] With reference to Fig. 2, each of the flow passages includes a fluid inlet 120 and a fluid outlet 122 connecting the flow passages to the center manifold 106. Fluid temperature entering from the fluid inlets 120 is greater than fluid temperature exiting from the fluid outlets 122. Fins 132 are included within each of the flow passages 110 and cold fins 134 extend from the flow passages 110. The fins 132, 134 act as heat transfer elements and form a solid matrix to provide thermal and structural connection. Parting sheets 136 are positioned above and below fins 132 to prevent fluid mixing.

[0013] Because of the flow passage loop configuration of the heat exchange device (see Figure 1), the cold side flow cooling the hot inlet and hot outlet at different temperatures can mix within each flow passage and as a result, the center manifold design will behave like typical single-pass cross-flow heat exchanger with the low pressure fluid mixed, resulting in reduced efficiency relative to a typical plate-fin cross-flow heat exchanger where both hot and cold fluids remain unmixed throughout the heat exchanger. This results in an increase in size and weight of roughly 20% in some cases to achieve the same heat transfer performance as a true single-pass cross-flow heat exchanger.

[0014] To increase the efficiency, the present disclosure includes a physical barrier between the cold flow fins 134. With reference to Fig. 3, a separator 144 is positioned to divide cold fluid flow between adjacent flow passages. The separator 144 is a mostly hollow structure comprised of two thin, solid separator sheets 140 supported with intermittently spaced pillar-like or vane-like structures, defining a pillar matrix 142. The separator 144 is positioned between cold fins 134 of each flow passage 110 and configured to provide insulation between the fluid inlets 120 and fluid outlets 122 of the each flow passage to allow for reduced conductance normal to the plane of the sheets which is minimized by incorporating only as much material (i.e. the pillar matrix 142) between the upper and lower separator sheets 140 as is required to meet structural requirements or to facilitate production with additive or other manufacturing methods. Because the high pressure loading forces on the high pressure sides are reacted by fins in the high pressure layer in tension, the fins in the lower pressure layers are not supporting high pressure loads and therefore neither the cold side fins nor the pillars between the separator sheets require the same high strength material properties of the parting sheets and fins in the high pressure layers. Therefore, the fins in the lower pressure layers and pillars between the separator sheets add only enough structural rigidity to move core resonant modes out of the region of concern.

[0015] With reference to Fig. 1, the center manifold 106 is configured to allow high pressure fluid to enter the manifold 106 at one end 112, pass into the flow passages 102, 104 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 112 of the center manifold 106, passes through a respective air 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 air 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 facilitate installation of the proposed heat exchange device 100 in place of an existing tube-shell unit.

[0016] The methods and systems of the present disclosure, as described above and shown in the drawings, provide for heat exchange device with superior properties including a thermal separator to prevent cold flow mixing and reduce heat conduction between flow passage inlets and outlets. While the apparatus and methods of the subject disclosure have been shown and described with reference to preferred embodiments, those skilled in the art will readily appreciate that changes and/or modifications may be made thereto without departing from the scope of the subject disclosure.

Claims

1. A heat exchange device (100), comprising:

a first section (102) and a second section (104), each of the first and second sections including flow passages (110) configured for heat exchange between hot fluid within the flow passages and cold fluid external of the flow passages, each of the flow passages (110) having cold fluid flow therebetween; and
a separator (144) dividing the cold fluid flow between flow passages (110), wherein the separator (144) includes two separator sheets (140) spaced apart with a pillar matrix (142) structurally connecting the separator sheets (140) configured to prevent cold fluid mixing.

2. The heat exchange device of claim 1, wherein each of the flow passages has a hot fluid inlet and a hot fluid outlet wherein the temperature of fluid entering at the hot fluid inlet is greater than the temperature of fluid exiting the hot fluid outlet.

3. The heat exchange device of claim 2, wherein the separator sheets are positioned between each hot fluid inlet and hot fluid outlet of each adjacent flow passage configured to prevent mixing of the fluids providing heat transfer to and from the flow passage inlet and flow passage outlet.

4. The heat exchange device of claim 1, wherein the cold fluid flow channel includes secondary heat transfer element extending from the flow passages.

5. The heat exchange device of claim 4, wherein the pillar matrix between the two separator sheets includes the same material as that of the secondary heat transfer elements.

6. The heat exchange device of claim 4, wherein the pillar matrix includes material with reduced conductivity relative to other material of the device in order to reduce thermal conductivity.

7. The heat exchange device of claim 6, wherein the two separator sheets are reduced to a single sheet to prevent mixing of the fluids providing heat transfer to and from the flow passage inlet and flow passage outlet.

8. The heat exchange device of claim 1, further comprising a center manifold disposed between the first and second sections, wherein hot fluid enters the manifold at one end, passes through the first and second sections and cooled fluid exits the manifold at the opposing end.

9. The heat exchange device of claim 1, wherein each of the first and second sections include heat exchange plates with secondary heat transfer elements in a stacked arrangement.

10. The heat exchange device of claim 9, wherein the secondary heat transfer elements and flow passages form a solid matrix configured to limit relative motion of parts within the device.

11. The heat exchange device of claim 1, wherein the first and second sections and the separator are created through the use of additive manufacturing.

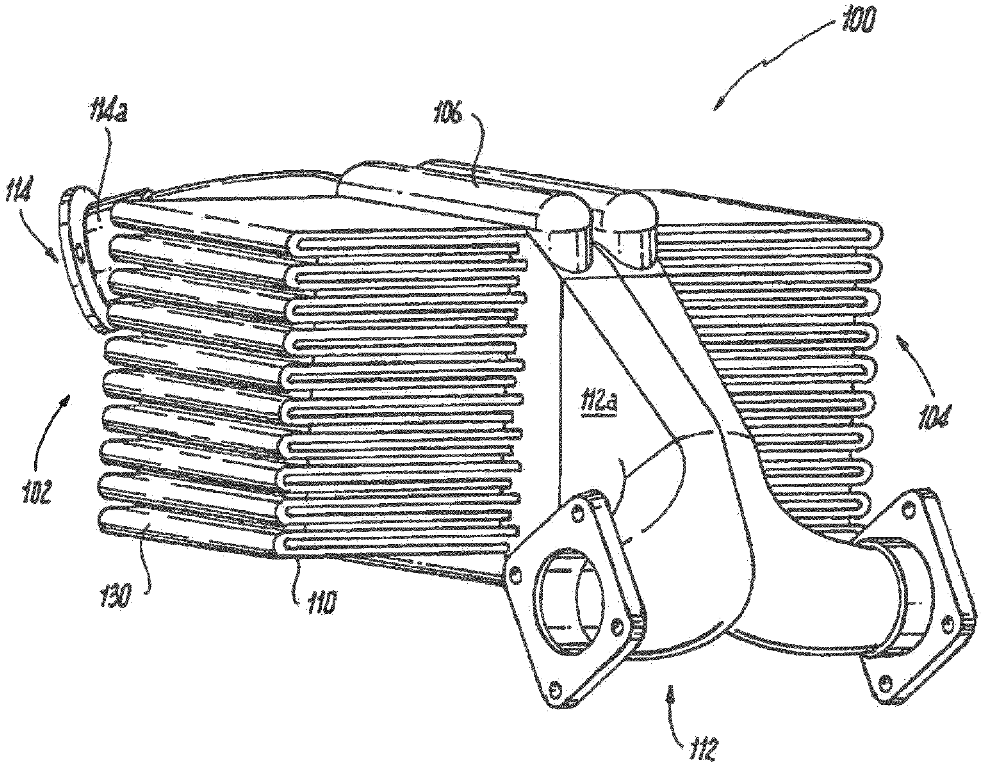

Fig. 1

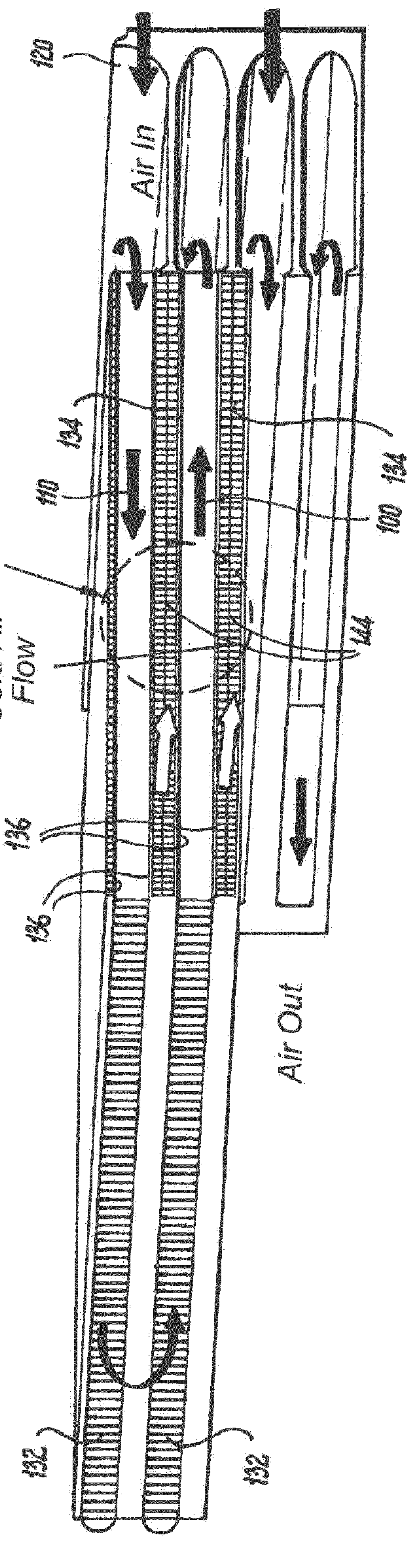
120
Air In
134
110
134
100
3
Cold Air Flow
144
136
136
Air Out
132
132

Fig. 2

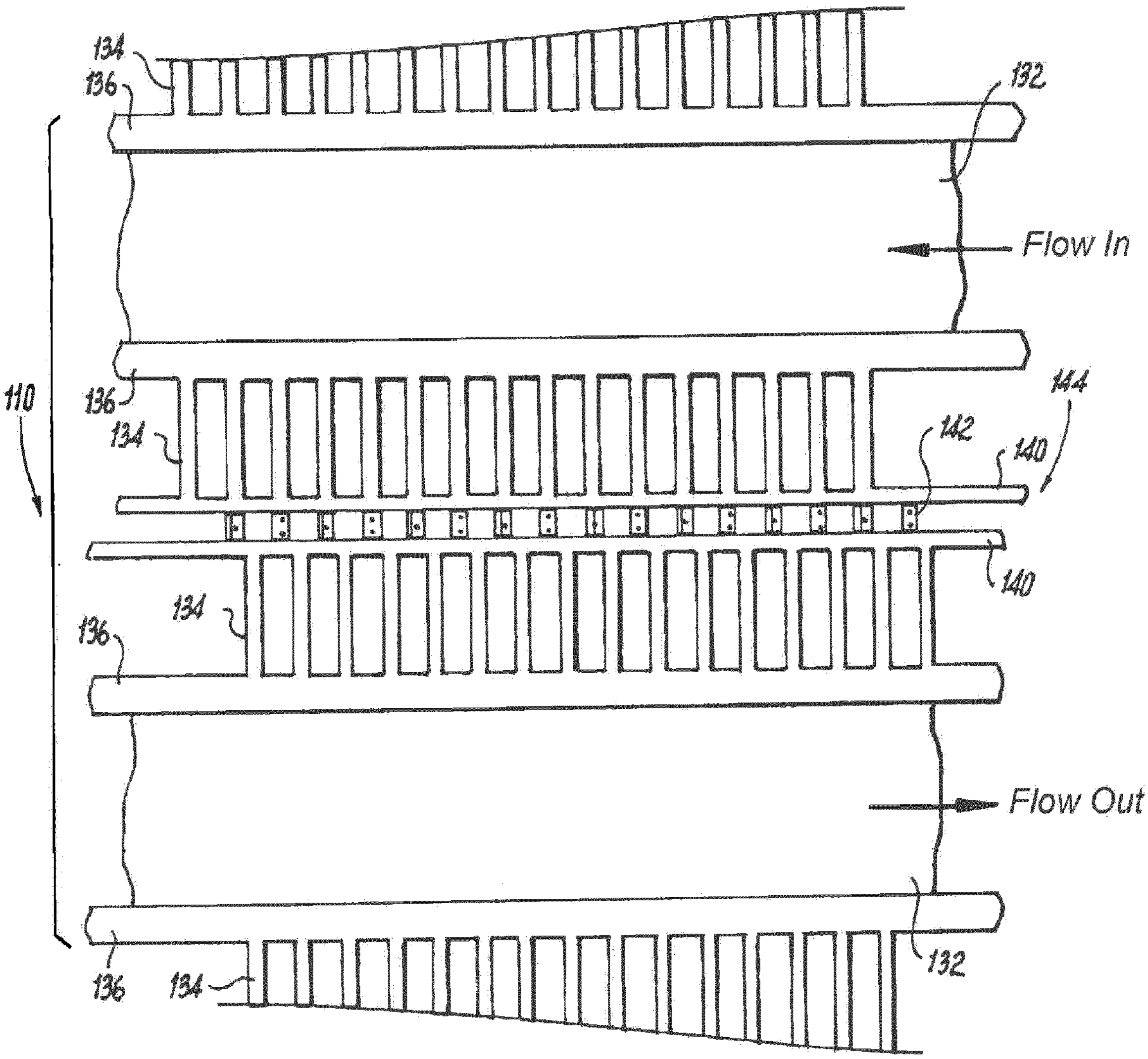
134
136
132
Flow In
110
136
134
144
142
140
140
134
136
Flow Out
136
134
132

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 17 15 0276

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	US 2013/201628 A1 (AOKI MICHIMASA [JP] ET AL) 8 August 2013 (2013-08-08) * figure 7 * -----	8	INV. F28F1/42 F28F9/02 F28D1/04 F28D1/047
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TECHNICAL FIELDS SEARCHED (IPC)

F28F
F28D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	24 May 2017	Martínez Rico, Celia

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 17 15 0276

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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24-05-2017

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82