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(54) **HEAT EXCHANGER CLOSURE BAR**

(57) A heat exchanger includes first and second parting sheets, a cold fin extending between the first and second parting sheets, and a closure bar extending between the first and second parting sheets (34, 36). The closure bar (10) includes first, second, third, and fourth surfaces, a body (112), first and second ends, an inlet, and an outlet. The body forms an opening that extends from the first end to the second end of the body. The first

surface faces the cold fin. The second surface is an opposite side of the body from the first surface. The third surface is in contact with the first parting sheet. The fourth surface is in contact with the second parting sheet. The inlet is disposed at the first end of the closure bar and is fluidly connected to the outlet via the opening. The outlet is disposed at the second end of the closure bar.

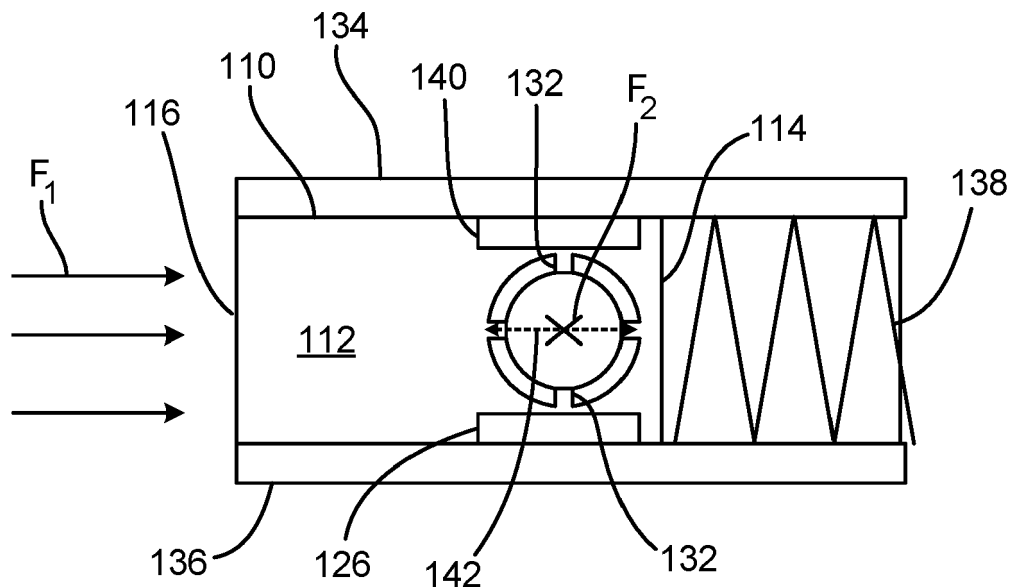


Fig. 3

Description

STATEMENT OF GOVERNMENT INTEREST

[0001] This invention was made with government support under Contract #FA8626-16-C-2139 awarded by the Air Force. The government has certain rights in the invention.

BACKGROUND

[0002] The present disclosure relates generally to heat exchangers and more particularly to closure bars incorporated into a heat exchanger.

[0003] For heat exchangers exposed to large temperature differentials, closure bars at the heat exchanger inlet are subjected to higher temperatures than at other locations. Thermal growth of the closure bar(s) can result in significant stress and potential damage to other heat exchanger parts.

SUMMARY

[0004] A heat exchanger includes first and second parting sheets, a cold fin extending between the first and second parting sheets, and a closure bar extending between the first and second parting sheets. The closure bar includes first, second, third, and fourth surfaces, a body, first and second ends, an inlet, and an outlet. The body forms an opening that extends from the first end to the second end of the body. The first surface faces the cold fin. The second surface is an opposite side of the body from the first surface. The third surface is in contact with the first parting sheet. The fourth surface is in contact with the second parting sheet. The inlet is disposed at the first end of the closure bar and is fluidly connected to the outlet via the opening. The outlet is disposed at the second end of the closure bar.

[0005] A method of managing thermal energy in a heat exchanger includes impinging a flow of hot air onto a closure bar of the heat exchanger. Thermal energy is transferred from the flow of hot air to the body of the closure bar. A flow of cold air is inserted into and through the opening. Thermal energy is transferred from the body of the closure bar to the flow of cold air. The flow of cold air is then ejected out of the opening.

[0006] The present summary is provided only by way of example, and not limitation. Other aspects of the present disclosure will be appreciated in view of the entirety of the present disclosure, including the entire text, claims, and accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1A is a perspective view of a closure bar of a heat exchanger and shows a cooling hole with fins.

FIG. 1B is a perspective view of the closure bar shown in phantom to illustrate the fins of the cooling hole.

FIG. 2 is a side view of the closure bar, parting sheets, and a cold fin.

FIG. 3 is a side view of another closure bar with flow openings, parting sheets, and a cold fin.

[0008] While the above-identified figures set forth one or more embodiments of the present disclosure, other embodiments are also contemplated, as noted in the discussion. In all cases, this disclosure presents embodiments by way of representation and not limitation. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art, which fall within the scope and spirit of the principles of the disclosure. The figures may not be drawn to scale, and applications and embodiments of the present disclosure may include features and components not specifically shown in the drawings.

DETAILED DESCRIPTION

[0009] The present disclosure presents a heat exchanger closure bar that incorporates a flow path/hole with swirl vanes through the depth of the bar (along the cold flow length) to enhance heat transfer and induce mixing to preclude the development of a hot fluid layer along the surface of the cold side of the closure bar.

[0010] FIG. 1A is a perspective view of closure bar 10 of a heat exchanger and shows body 12, first surface 14, second surface 16, third surface 18, fourth surface 20, first end 22, second end 24, opening 26 (with inlet 28, outlet 30, features 32), first flow F_1 of air, and second flow F_2 of air. FIG. 1B is a perspective view of closure bar 10 with body 12 shown in phantom to more clearly show features 32. FIGS. 1A and 1B will be discussed in tandem.

[0011] Closure bar 10 is a flat piece of solid material. In this example, a material of closure bar 10 includes a metal. Body 12 is a bulk of solid material of closure bar 10. First surface 14, second surface 16, third surface 18, and fourth surface 20 are exterior faces or sidewalls of body 12. First end 22 and second end 24 are opposite ends of body 12. Opening 26 is a channel or passage. In this example, a shape of opening 26 includes a cylinder or tube. Inlet 28 and outlet 30 are fluidic ports or openings. Features 32 are protrusions of solid material. In this example, features 32 include four swirl vanes that each include a helical shape. Other shapes of features 32 can include a spiral, a helicoid, or a corkscrew shape. In other non-limiting embodiments, features 32 can include more or less than four features, and can include turbulence imparting/inducing features such as airfoils, blades, vanes, or splitters. First flow F_1 and second flow F_2 are streams of airflow. In this example, first flow F_1 is a flow of hot air and second flow F_2 is a flow of cold air (i.e., second flow F_2 of air has a lesser amount of thermal

energy than first flow F_1 of air).

[0012] Closure bar 10 is positioned between parting sheets as part of a heat exchanger. (See e.g., FIGS. 2-3). First surface 14 of body 12 is positioned on a side of body 12 that is nearest opening 26. Second surface 16 is positioned on an opposite side of body 12 as first surface 14 and is exposed to first flow F_1 of air. In FIGS. 1A and 1B, third surface 18 is shown as an end surface of body 12 and fourth surface 20 is shown as an end surface of body 12. First end 22 is positioned on an opposite end of body 12 from second end 24. Opening 26 is disposed in and extends along a length of body 12. Opening 26 is exposed to second flow F_2 of air. Inlet 28 is disposed in body 12 at first end 22 of body 12. Inlet 28 is fluidly connected to outlet 30 via opening 26. In one example, inlet 28 is also fluidly connected to a source of second flow F_2 of air. Outlet 30 is disposed in body 12 at second end 24 of body 12. In an example, outlet 30 can be fluidly connected to a destination for second flow F_2 of air. Features 32 are connected to and extend from body 12 into opening 26. In this example, features 32 extend radially inward relative to the cylindrical shape of opening 26.

[0013] During operation of the heat exchanger, closure bar 10 functions as a barrier to prevent mixing of first flow F_1 of air, second flow F_2 of air, and other flows of air flowing through the heat exchanger. Body 12 absorbs thermal energy from first flow F_1 of air and transfers the thermal energy from first flow F_1 of air to a portion of second flow F_2 of air that is passing through opening 26. Second surface 16 is in contact with first flow F_1 of air and transfers thermal energy from first flow F_1 of air to body 12. Opening 26 provides a fluidic through-hole through which second flow F_2 of air passes through body 12. Inlet 28 provides an intake through which second flow F_2 of air enters opening 26. Outlet 30 provides an output through which second flow F_2 of air exits opening 26. Features 32 impart turbulence into second flow F_2 of air by swirling (e.g., inducing a rotation or spin into) second flow F_2 of air due to the helical shape of features 32.

[0014] Closure bar 10 with features 32 prevents the development of a hot fluid layer along first surface 14 (e.g., the cold side) of closure bar 10. Such a hot fluid layer would prevent thermal energy transfer due to a reduced temperature differential between first surface 14 and a fluid passing across first surface 14. As a result, a temperature of closure bar 10 is reduced, which reduces stresses to surrounding components due to thermal growth of closure bar 10.

[0015] FIG. 2 is a side view of closure bar 10 assembled together with first parting sheet 34, second parting sheet 36, and cold fin 38. FIG. 2 also shows body 12, first surface 14, second surface 16, third surface 18, fourth surface 20, opening 26 (with features 32), first flow F_1 of air, and second flow F_2 of air.

[0016] First parting sheet 34 and second parting sheet 36 are planar sheets of solid material. In this example, first parting sheet 34 and second parting sheet 36 include a metallic material. Cold fin 38 is a thin sheet with a cor-

rugated or zig-zag shape. In this example, features 32 are shown as extending radially inward relative to the generally circular shape of opening 26. Here, a height (or depth) of features is shown as extending partially towards a centerpoint of opening 26. In other non-limiting embodiments, features 32 can radially extend to or past the centerpoint of opening 26.

[0017] In this example, second flow F_2 of air flows into and through opening 26 in a direction that is into the page (as shown in FIG. 2). First parting sheet 34 and second parting sheet 36 are positioned on opposite sides of and in contact with closure bar 10. Cold fin 38 is positioned between first parting sheet 34 and second parting sheet 36 on an opposite side of closure bar 10 from first flow F_1 of air. First parting sheet 34 and second parting sheet 36 hold closure bar 10 in place relative to first parting sheet 34 and second parting sheet 36. First parting sheet 34 and second parting sheet 36 also provide structural support throughout the heat exchanger. Cold fin 38 functions as a heat exchanging element through which thermal energy is transferred to/from a flow of air across cold fin 38.

[0018] During operation, a temperature of first flow F_1 of air can be so high as to impart damaging temperature differentials between closure bar 10 and first and second parting sheets 34 and 36. Here, closure bar 10 with opening 26 acts to reduce the temperature differentials between closure bar 10 and first and second parting sheets 34 and 36 by increasing a rate of cooling of closure bar 10 with second flow F_2 of air through opening 26. Features 32 impart swirl into second flow F_2 of air thereby increasing the transfer of thermal energy between closure bar 10 and second flow F_2 of air, which also prevents a hot layer of air forming at first surface 14 of closure bar 10. It can also be understood that other components that closure bar 10 is in contact with or in the vicinity of may also see a reduction of damaging temperature differentials via the improved transfer of thermal energy between closure bar 10 and second flow F_2 of air.

[0019] FIG. 3 is a side view of closure bar 110 and shows body 112, first surface 114, second surface 116, opening 126, features 132, first parting sheet 134, second parting sheet 136, cold fin 138, first channel 140, second channel 142, first flow F_1 of air, and second flow F_2 of air. In this example, the elements of FIG. 3 are shown as including character reference numerals correlating to similar/respective features shown in FIGS. 1A, 1B, and 2, with the addition of 100 (e.g., closure bar 110 relates to closure bar 10, etc.)

[0020] In FIG. 3, closure bar 110 includes first channel 140 and second channel 142. First channel 140 and second channel 142 are openings or passages. First channel 140 is cut into a portion of closure bar 110 and is positioned between opening 126 and first parting sheet 134. Second channel 142 is cut into another portion of closure bar 110 and is positioned on an opposite side of opening 26 as from first parting sheet 134, at a location between opening 126 and second parting sheet 136. First channel

140 and second channel 142 are parallel to opening 126 (e.g., 26 in FIGS. 1A and 1B) and extend from the first end of closure bar 110 to the second end of closure bar 110.

[0021] First channel 140 and second channel 142 provide additional through-channels through which second flow F_2 of air can flow through closure bar 10 thereby increasing the rate of transfer of thermal energy from first flow F_1 of air, to closure bar 10, and to second flow F_2 of air.

Discussion of Possible Embodiments

[0022] A heat exchanger includes first and second parting sheets, a cold fin extending between the first and second parting sheets, and a closure bar extending between the first and second parting sheets. The closure bar includes first, second, third, and fourth surfaces, a body, first and second ends, an inlet, and an outlet. The body forms an opening that extends from the first end to the second end of the body. The first surface faces the cold fin. The second surface is an opposite side of the body from the first surface. The third surface is in contact with the first parting sheet. The fourth surface is in contact with the second parting sheet. The inlet is disposed at the first end of the closure bar and is fluidly connected to the outlet via the opening. The outlet is disposed at the second end of the closure bar.

[0023] The heat exchanger of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components.

[0024] A feature can extend from the body into the opening, wherein the feature can be configured to impart turbulence into a flow of air that passes through the opening.

[0025] The feature can comprise a swirl vane.

[0026] The swirl vane can include a helical shape.

[0027] The feature can comprise a plurality of swirl vanes.

[0028] The second surface of the body can be exposed to the hot air flow, and wherein the opening can be exposed to the cold air flow.

[0029] A first channel can be formed between the body and the first parting sheet, wherein the first channel can be parallel to the opening and/or can extend from the first end to the second end of the body.

[0030] A second channel can be formed between the body and the second parting sheet, wherein the second channel can be positioned on an opposite side of the opening as from the first channel, wherein the second channel can be parallel to the opening and/or can extend from the first end to the second end of the body.

[0031] A method of managing thermal energy in a heat exchanger includes impinging a flow of hot air onto a closure bar of the heat exchanger. Thermal energy is transferred from the flow of hot air to the body of the closure bar. A flow of cold air is inserted into and through

the opening. Thermal energy is transferred from the body of the closure bar to the flow of cold air. The flow of cold air is then ejected out of the opening.

[0032] The method of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following steps, features, configurations and/or additional components.

[0033] The flow of air can be swirled with a feature that extends from the body into the opening.

[0034] The flow of air can be swirled with a plurality of swirl vanes that extend from the body into the opening.

[0035] While the invention has been described with reference to an exemplary embodiment(s), it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

Claims

1. A heat exchanger for managing thermal energy between a hot air flow and a cold air flow, the heat exchanger comprising:

first and second parting sheets (34, 36);
a cold fin (38) positioned and extending between the first and second parting sheets; and
a closure bar (10) extending between the first and second parting sheets, the closure bar comprising:

a body (112);
a first surface (114) that faces the cold fin (138);
a second surface on an opposite side of the body from the first surface;
a third surface in contact with the first parting sheet;
a fourth surface in contact with the second parting sheet;
a first end; and
a second end opposite the first end, wherein the body forms an opening disposed in the body (112), wherein the opening extends from an inlet disposed at the first end to an outlet disposed at the second end of the body (112),
wherein the inlet is fluidly connected to the outlet via the opening.

2. The heat exchanger of claim 1, wherein the closure

bar further comprises:

a feature extending from the body into the opening, wherein the feature is configured to impart turbulence into a flow of air that passes through the opening.

3. The heat exchanger of claim 2, wherein the feature comprises a swirl vane.

4. The heat exchanger of claim 3, wherein the swirl vane includes a helical shape.

5. The heat exchanger of claim 2, wherein the feature comprises a plurality of swirl vanes.

6. The heat exchanger of claim 1, wherein the second surface of the body is exposed to the hot air flow, and wherein the opening is exposed to the cold air flow.

7. The heat exchanger of claim 1, further comprising: a first channel formed between the body and the first parting sheet, wherein the first channel is parallel to the opening and extends from the first end to the second end of the body.

8. The heat exchanger of claim 7, further comprising: a second channel formed between the body and the second parting sheet, wherein the second channel is positioned on an opposite side of the opening as from the first channel, wherein the second channel is parallel to the opening and extends from the first end to the second end of the body.

9. A method of managing thermal energy in a heat exchanger, the method comprising:

impinging a flow of hot air onto a closure bar of the heat exchanger, wherein the closure bar comprises:

a body (112);
a first surface (114);
a second surface on an opposite side of the body from the first surface, wherein the second surface is exposed to the flow of hot air;
a first end;
a second end opposite the first end; and
an opening disposed in the body, wherein the opening extends from the first end to the second end of the body;

transferring thermal energy from the flow of hot air to the body of the closure bar;
inserting a flow of cold air into and through the opening;
imparting turbulence into the flow of cold air through the opening;

transferring thermal energy from the body of the closure bar to the flow of cold air; and
ejecting the flow of cold air out of the opening.

10. The method of claim 9, wherein imparting turbulence into the flow of cold air through the opening comprises swirling the flow of air with a feature that extends from the body into the opening.

11. The method of claim 9, wherein imparting turbulence into the flow of cold air through the opening comprises swirling the flow of air with a plurality of swirl vanes that extend from the body into the opening.

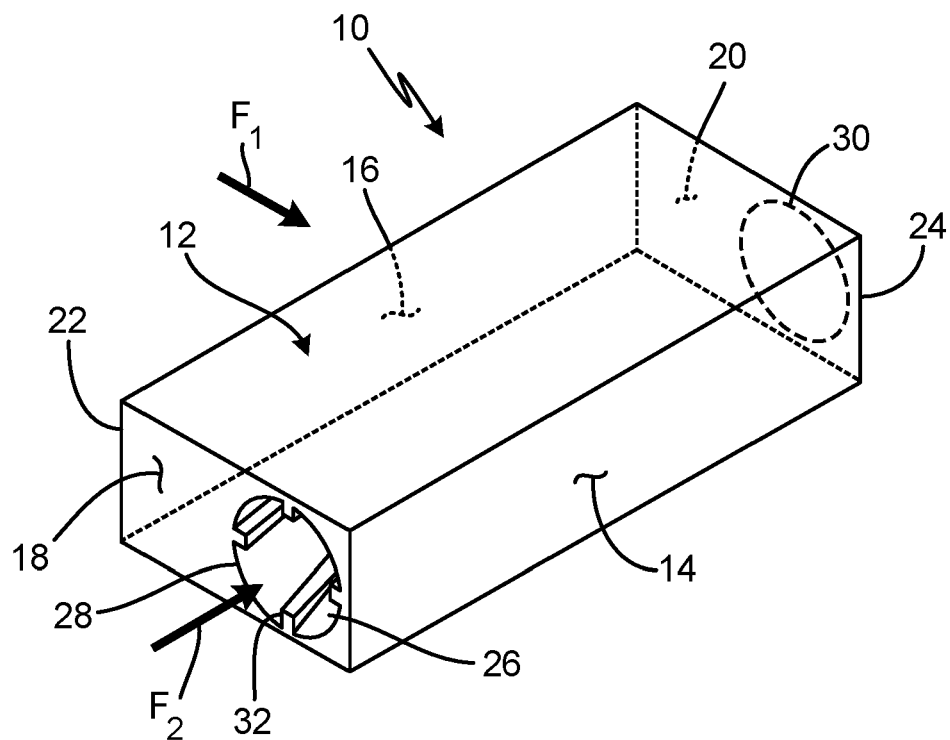


Fig. 1A

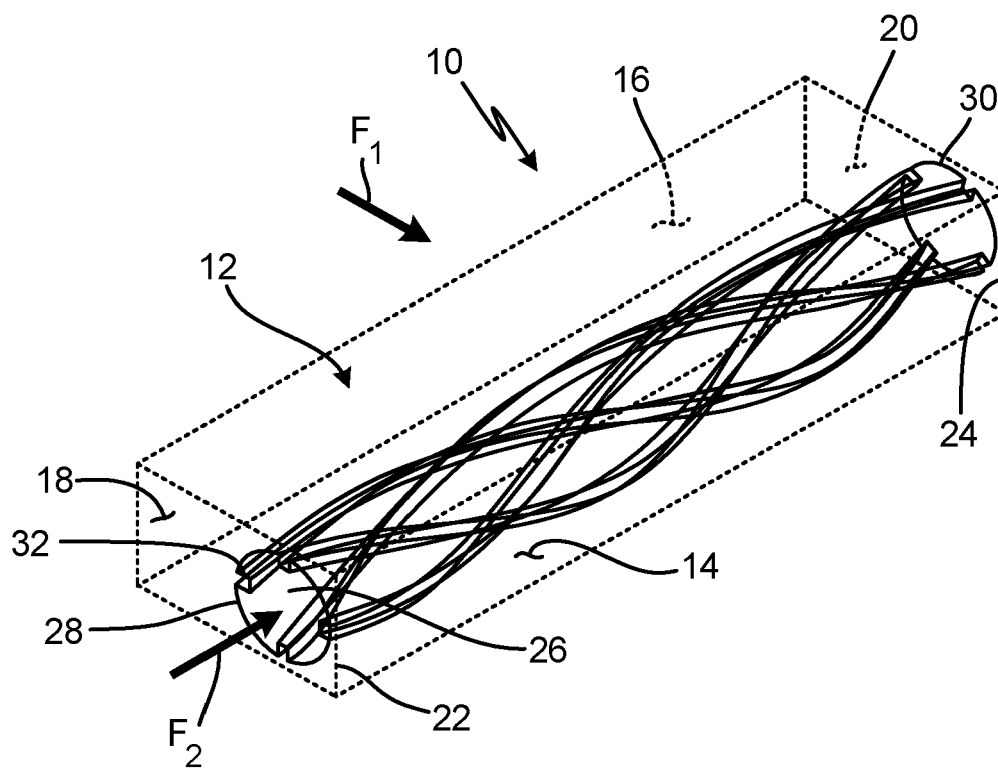


Fig. 1B

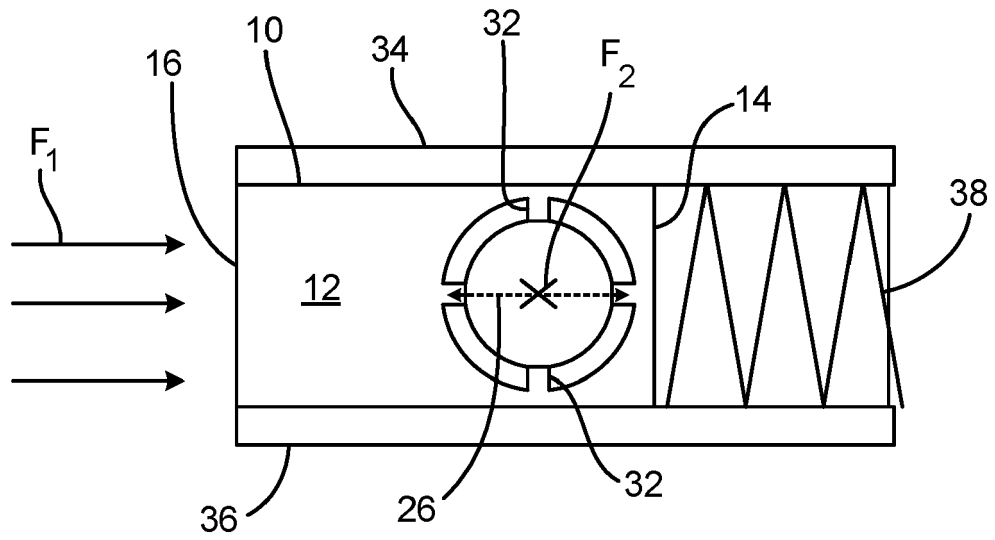


Fig. 2

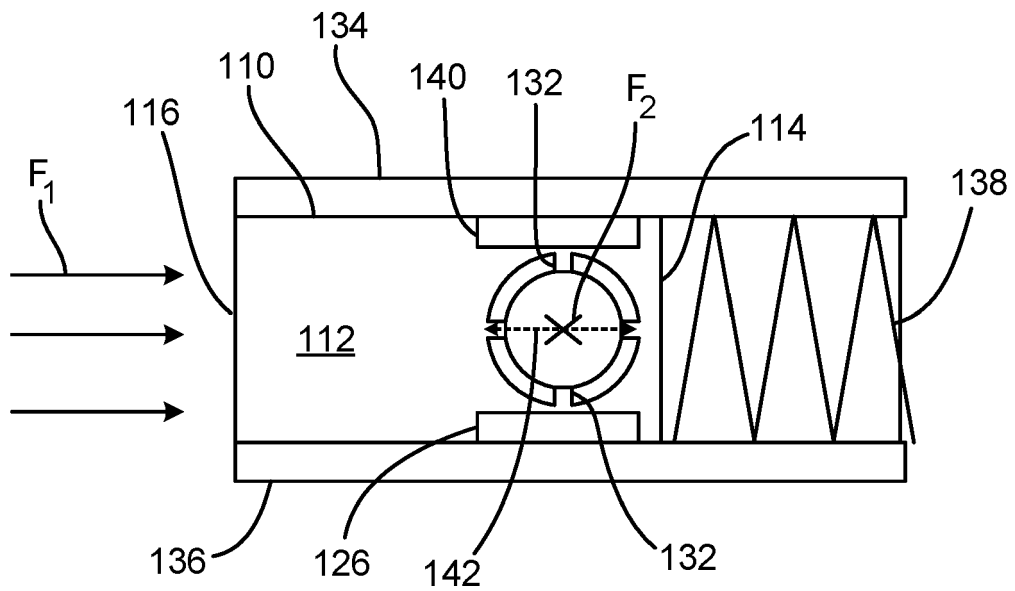


Fig. 3



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Application Number
EP 20 16 3928

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Place of search Munich		Date of completion of the search 2 September 2020	Examiner Axters, Michael
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
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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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