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A HEAT EXCHANGER

(57)

A heat exchanger (100) comprises at least one header-tank assembly (10) and tubular elements (20). Each header-tank assembly (10) comprises a tank (12) and a header (14). The header (14) is formed with apertures (14a). The tubular elements (20) are received in the corresponding apertures (14a) and secured to the

header (20). The tubular elements (20) are in fluid communication with the at least one header-tank assembly (10). At least one of the tubular elements (10) is bent proximal to at least one of the extreme ends thereof to configure a main portion (20a) and at least one end portion (20b) extending along different planes A and B.

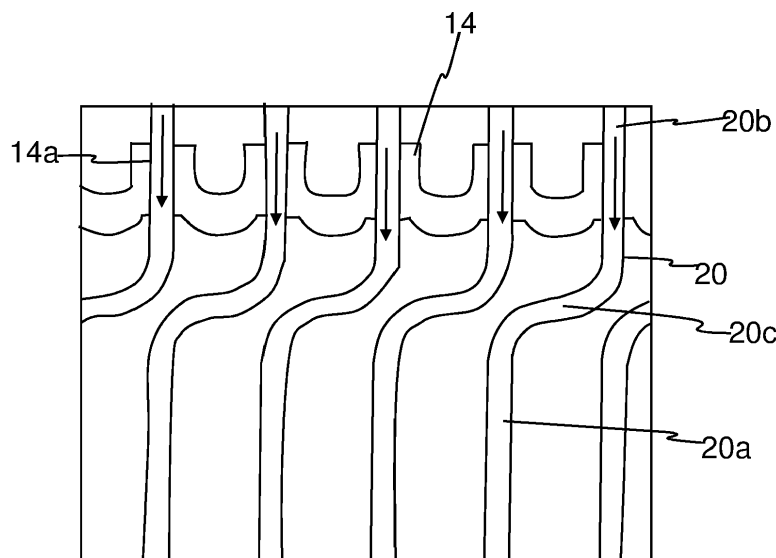


FIG. 4

Description

FIELD OF INVENTION

[0001] The present invention relates to a heat exchanger. More particularly, the present invention relates to a vehicle heat exchanger.

BACKGROUND

[0002] A conventional heat exchanger, for example a radiator for use in automotive industry, comprises at least a header-tank assembly and a plurality of tubular elements in fluid communication with the at least one header-tank assembly. Each header-tank assembly comprises a tank, a header and a gasket disposed between the tank and the header to configure leak-proof connection between the tank and the header. The tank is generally in the form of an enclosure defined by walls, wherein the walls are connected at one end to form a closed end, whereas other end of the walls forms an open end of the tank opposite to the closed end. The tank comprises foot portions formed along a periphery of the open end of the tank, particularly along longitudinal and lateral sides of the tank. The header is complementary to the tank and closes the open end of the tank. The header comprises tabs disposed along longitudinal and lateral sides thereof. Generally, the tabs are crimped to the foot portion of the tank to arrest any relative movement between the tank and the header. Further, the header comprise apertures formed thereon to receive corresponding tubular elements that are secured to the header by using a joining process.

[0003] The tank receives a first heat exchange fluid, often, pressurized and heated heat exchanging fluid, particularly coolant that gets heated after undergoing heat exchange to extract heat from a drive, for example, an engine in an internal combustion engine driven vehicle. The tanks in conjunction with the corresponding headers facilitate distribution of the first heat exchange fluid to and collection of the first heat exchange fluid from tubular elements that are generally, heat exchange tubes. Generally, the heat exchange tubes are secured to the header by brazing. Particularly, the first heat exchange fluid ingresses with respect to the tank via an inlet, passes through the heat exchange tubes, and in the process, undergoes heat exchange with a second heat exchange fluid, particularly, air flowing around the heat exchange tubes. In order to achieve better heat exchange between the first heat exchange fluid, for example, coolant flowing through the heat exchange tubes and the second heat exchange fluid, for example, air flowing around the heat exchange tubes, a plurality of fins are disposed adjacent the heat exchange tubes to retard air flow across the heat exchange tubes.

[0004] The heat exchanger is generally subjected to thermal shock test and to thermal stresses at critical areas such as at the joint between the tube and the header,

during operation thereof. The thermal stresses may cause the length of the tubes to change, thereby resulting in deformation of the headers and the tubes secured to the headers. The thermal stresses and deformation of the tubes and headers resulting from the thermal stresses may cause mechanical failure of the tubes, the fins, the headers and the joint between the tubes and the headers leading to reliability issues, frequent breakdowns and replacements, high maintenance, inefficient operation and reduced service life. Also uncontrolled deformation, particularly, difference in elongation of the adjacent tubular elements may further aggravate the problems caused by the thermal stresses.

[0005] Accordingly, there is a need for a heat exchanger that addresses the problems such as deformation and mechanical failure of the headers, the fins and the tubes secured to the headers due to high thermal stresses at critical areas. There is a need for a heat exchanger that is reliable, require less maintenance and exhibits longer service life compared to conventional heat exchanger. Further, there is a need for a heat exchanger that exhibits controlled elongation of the adjacent tubular elements to control and limit difference in elongation between adjacent tubular elements.

SUMMARY

[0006] A heat exchanger is disclosed in accordance with an embodiment of the present invention. The heat exchanger comprises at least one header-tank assembly and tubular elements. Each header-tank assembly comprises a tank and a header. The header is formed with apertures. The tubular elements are received in the corresponding apertures and secured to the header. The tubular elements are in fluid communication with the at least one header-tank assembly. At least one of the tubular elements is bent proximal to at least one of the extreme ends thereof to configure a main portion and at least one end portion extending along different planes A and B.

[0007] Particularly, the end portion is at least partially received in the corresponding aperture of the header.

[0008] Generally, the main portion and the end portion are connected by an intermediate portion.

[0009] Generally, the main portion and the end portion and offset with respect to each other.

[0010] Further, the main portion and the intermediate portion are disposed outside the apertures and between the headers.

[0011] Particularly, the intermediate portion forms first and second angles α_1 and α_2 with the main portion and end portions respectively.

[0012] Generally, the bent tubular element is bent at both extreme ends thereof.

[0013] Further, the heat exchanger comprise a pair of side plates, wherein at least one side plate is bulging outwards away from the tubular elements to conform to the shape of corresponding end tubular element that is

bent and bulging outwards towards the side plate.

[0014] Furthermore, the at least one side plate is depressed inwards towards the tubular elements to conform to shape of corresponding end tubular element that is bent and depressed inwards away from the side plate.

[0015] Generally, the heat exchanger comprise fins disposed between adjacent tubular elements.

[0016] Preferably, the apertures are uniformly spaced with respect to each other.

[0017] In accordance with an embodiment of the present invention, few of the tubular elements are bent and remaining tubular elements are straight.

[0018] Generally, at least one of the tubular element is dummy tubular element with at least one end thereof blocked.

[0019] In accordance with one embodiment, the first apertures formed on first header of first header tank assembly are offset with respect to second apertures formed on second header of the second header tank assembly.

[0020] Generally, at least one extreme end of all the tubular elements are bent.

[0021] Preferably, the first angle and the second angle are equal.

BRIEF DESCRIPTION

[0022] Other characteristics, details and advantages of the invention can be inferred from the description of the invention hereunder. A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying figures, wherein:

FIG. 1 illustrates a schematic representation of a header of a conventional heat exchanger with apertures and receiving straight tubular elements received in the apertures;

FIG. 2 illustrates an isometric view of a heat exchanger in accordance with an embodiment of the present invention depicted with few tubular elements along opposite sides thereof;

FIG. 3 illustrates an enlarged isometric view depicting a bundle of tubular elements of the heat exchanger of FIG. 2, wherein all the tubular elements are bent at one of the extreme ends thereof;

FIG. 4 illustrates a schematic representation of a header of the heat exchanger of FIG. 2 with apertures and receiving tubular elements that are bent at extreme ends thereof;

FIG. 5 illustrates a sectional view of a portion of a heat exchanger in accordance with another embod-

iment configured with a few bent tubes and remaining straight tubes;

FIG. 6 illustrates a sectional view of a portion of the heat exchanger of FIG. 2 depicting a first side wall bulging outwardly to conform to a first end tubular element that is bent and bulging outwards;

FIG. 7 illustrates a sectional view of a portion of the heat exchanger of FIG. 2 depicting a second side wall opposite to the first side wall and depressed inwardly to conform to a second end tubular element that is bent and bulging inwards; and

FIG. 8 illustrates a schematic representation of one of the tubular elements of the heat exchanger of FIG. 2 with main portion and extreme end portion thereof along different planes.

DETAILED DESCRIPTION

[0023] The present invention envisages a heat exchanger such as for example, radiator. The heat exchanger comprise at least one header-tank assembly and tubular elements. Each header-tank assembly comprise a tank and a header. The header is formed with apertures. The heat exchange tubes are received in the corresponding apertures and secured to the header. The heat exchange tubes are in fluid communication with the at least one header-tank assembly. At least one of the tubular elements is bent proximal to at least one of the extreme ends thereof to configure a main portion and at least one end portion. The main portion and the end portion are extending along different planes and are connected by an intermediate portion. The end portion is at least partially received in the corresponding aperture of the header, whereas the intermediate portion and the main portion are disposed outside the aperture and between the headers, in case the headers are disposed opposite to each other. The intermediate portion forms first and second angles α_1 and α_2 with the main portion and end portions respectively. With such configuration, the main portion and the end portion are offset with respect to each other. The intermediate portion acts as stress relief feature and permits expansion of the tubular elements and reduces the bending angle of the tubular element at the critical region, thereby preventing stress built up at critical region, for example the joint between the tubular element and the header. By reducing the bending angle, damage to the tubular element, the header and the fins is prevented. The heat exchanger of the present invention with at least one bent tube bent near at least one extreme end thereof, prevents deformation and mechanical failure of the tubular elements and headers due to stress built up at critical region by distributing the stresses to intermediate portion, thereby rendering the heat exchanger reliable. Although, the present invention is explained with example of a heat exchanger for

use in vehicle, such as for example, a radiator, however, the present invention is also applicable for use in any other heat exchanger used in vehicular or non-vehicular applications, where it is required to reduce bending angle formed by the tubular element with header and reduce the thermal stresses at the joint between the tubular element and the header to avoid deformation and mechanical failure of the headers, the fins and the tubes secured to the headers.

[0024] FIG. 1 illustrates a section of a conventional heat exchanger 1 configured with straight tubular elements, particularly, tubes 2. Generally, the conventional heat exchanger comprises a tank (not illustrated), a header 4 and the straight tubes 2. The tanks in conjunction with the corresponding headers 4 facilitate distribution of the first heat exchange fluid, particularly, heated coolant to and collection of the first heat exchange fluid from tubular elements 2. The heat exchange tubes 2 are secured to the header 4 by a joining process such as for example, brazing. The first heat exchange fluid ingresses into the tank via an inlet, passes through the heat exchange tubes 2, and in the process, undergoes heat exchange with a second heat exchange fluid, particularly, air flowing across the heat exchange tubes 2. The hot coolant flowing through the tubes 2 may cause increase in length of the tubes, due to thermal expansion, that in turn may cause thermal stresses, particularly, at the critical regions, such as at the joint between the tubes 2 and the header 4. Such thermal stresses may result in deformation of the tubes 2, particularly, bending of the tubes. Also, the thermal stresses may result in deformation of the fins and the headers 4 and can also lead to mechanical failures.

[0025] FIG. 2 illustrates a heat exchanger 100 in accordance with an embodiment of the present invention. The heat exchanger 100 of the present invention addresses the problems such as deformation and mechanical failure of headers 14, tubular elements 20 secured to the headers 14 due to high thermal stresses at critical areas, such as for example, the joint between the header 14 and the tubular elements 20. The deformation of the tubes may in turn cause damage to the fins 40 disposed between adjacent tubular elements 20 as illustrated in FIG. 5, thereby rendering the fins unusable and inefficient. The heat exchanger 100 of the present invention comprises at least one header-tank assembly 10 and the tubular elements 20 that are bent at the ends. FIG. 3 illustrates a bundle of tubular elements of the present invention bent at the extreme ends thereof.

[0026] Each header-tank assembly 10 comprises a tank 12 and the header 14. The header 14 is formed with apertures 14a. The tubular elements 20 are received in the corresponding apertures 14a and secured to the header 14 by any joining process such as for example brazing. However, the present invention is not limited to any joining process used for joining the tubular elements 20 to the header 14 as long as the joining process is capable of forming a secure joint between the header 14

and the tubular elements 20. The tubular elements 20 are in fluid communication with the at least one header-tank assembly 10. The tubular elements 20 can be of circular cross section or any other cross section. The present invention is not limited to any particular configuration of the tubular elements 20 as long as the tubular elements comprise bends proximal to at least one extreme end thereof and are capable of configuring fluid flow there through.

[0027] FIG. 4 illustrates a schematic representation of a header of the heat exchanger 100 formed with apertures and receiving tubular elements 20 that are bent at extreme ends thereof. Generally, at least one of the tubular elements 20 is bent proximal to at least one of the extreme ends thereof to configure a main portion 20a and at least one end portion 20b. Particularly, all the tubular elements 20 are bent at the extreme ends thereof to configure the main portion 20a and the at least one end portion 20b of the tubular element 20 extending along different planes A and B. A substantial length of the tubular element 20 between the end portions 20b of the tubular element 20 forms the main portion 20a of the tubular element 20, whereas portions of the tubular element 20 proximal to the extreme ends of the tubular element 20 define the end portions 20b. In accordance with a preferred embodiment all of the tubular elements 20 are bent proximal to both the extreme ends thereof. Generally, at least one extreme end of all the tubular elements 20 is bent. More specifically, each of the tubular elements 20 is bent near both the extreme ends thereof. Referring to the FIG. 4 to FIG. 7, the end portion 20b is at least partially received in the corresponding aperture 14a of the header 14. The main portion 20a and the end portion 20b are connected by an intermediate portion 20c. Further, the main portion 20a and the intermediate portion 20c are disposed outside the apertures 14a and between the headers 14. The intermediate portion 20c forms first and second angles α_1 and α_2 with the main portion 20a and end portions 20b respectively as illustrated in FIG. 8. Preferably, the first angle α_1 and the second angle α_2 are equal. With such configuration of the bent tubular element 20, the main portion 20a and the end portion 20b are offset with respect to each other.

[0028] With such configuration of the bent tubular elements 20, the thermal stresses at the critical regions, such as joint between the header 14 and the tubular elements 20 is reduced, particularly, the bend shifts the thermal stresses from the critical region at the joint between the tubular elements 20 and the header 14 to the intermediate portion 20c of the tubular elements 20. The intermediate portion 20c undergoes deformation to dissipate the thermal stresses at the joint between the header 14 and the tubular elements to reduce the bending angle of the tubular element 20 with respect to the header 14. The configuration of the intermediate portion 20c is based on the distance of the tubular element 20 with respect to the inlet, particularly, the fluid flow through the tubular element 20 based on distance thereof from the

inlet. Such configuration of the bent tubular elements 20 ensures uniform elongation of the tubular elements 20 and reduces difference in elongation of adjacent tubular elements, thereby reducing deformation of the header 14. For example, the tubular elements distal from the inlet is likely to receive less heat exchange fluid therein, thereby likely to undergo comparatively less elongation than tubular elements proximal to the inlet. However, with different configuration of the intermediate portions of tubular elements, the elongation of the tubular elements that are distal and proximal to the inlet can be controlled to prevent large differences in elongation of tubular elements. More specifically, the intermediate portion of the tubular element proximal to the inlet is capable of withstanding more thermal stresses compared to the tubular element distal from the inlet. The intermediate portion 20c of the tubular elements 20 undergoes deformation to dissipate the thermal stresses, thereby reducing deformation of the tubular elements 20 and the headers 14 and preventing mechanical failure of the tubular elements 20 and the header 14. The bent configuration of the tubular elements limit and controls the elongation of the tubular elements, thereby addressing the problems of uncontrolled elongation of the tubular elements. The intermediate portion 20c is unrestrained to allow deformation thereof and reduce the bending angle of the tubular element at the critical region, particularly, at the joint between the tubular elements 20 and the header 14. More specifically, such configuration of the bent tubular elements 20 reduces the bending angle of the tubular element 20 at the critical region, particularly, at the joint between the tubular element 20 and the header 14. More specifically, such configuration of the bent tubular elements 20 reduces the bending angle of the tubular element 20 with respect to the header 14 and the axis of the tubular element 20.

[0029] Further, the other elements of the heat exchanger 100 of the present invention are also modified to adjust according to the configuration of the bent tubular elements 20. More specifically, the heat exchanger 100 comprises a pair of side plates 30, wherein at least one side plate 30a is bulging outwards away from the tubular elements to conform to shape of corresponding end tubular element 20 that is bent and bulging outwards towards the side plate 30a. Further at least one side plate 30b is depressed inwards towards the tubular elements 20 to conform to shape of the end tubular element 20 that is bent and depressed inwards away from the side plate 30b. Particularly, referring FIG. 6 illustrates a first side plate 30a bulging outwardly to conform to a first end tubular element 20 that is bent and bulging outwards towards the side plate 30a. FIG. 7 illustrates a second side plate 30b opposite to the first side plate 30a and depressed inwardly towards the tubular elements 20 to conform to the second end tubular element that is bent and bulging inwards away from the second side plate 30b.

[0030] Furthermore the heat exchanger 100 comprises fins 40 disposed between adjacent tubular elements 20.

[0031] The heat exchanger 100 of the present invention can have different configurations based on different combinations of the bent tubular elements 20 and straight tubular elements 22 and whether the tubular elements used in the heat exchanger 100 are bent proximal to one extreme end or both extreme ends of the tubular elements. In accordance with an embodiment of the present invention, few of the tubular elements 20 are bent whereas remaining tubular elements are straight tubular elements 22 as illustrated in FIG. 5.

[0032] Generally, the apertures 14a formed on the header 14 are uniformly spaced with respect to each other. Specifically, the spacing between the apertures is based on the combination of the bent tubular elements and straight tubular elements 22 used in the heat exchanger 100. In case the heat exchanger 100 comprises few bent tubular elements 20 and remaining straight tubular elements 22, the headers 14 and the apertures formed on the headers 14 are modified to permit such combination of bent tubular elements 20 and straight tubular elements 22 disposed between the headers. The adjacent apertures for receiving adjacent bent tubular element 22 and straight tubular element 20 are more widely spaced than the adjacent apertures for receiving adjacent bent tubular elements 20 and adjacent apertures for receiving the adjacent straight tubular elements 22. More specifically, the spacing between the adjacent apertures 14a for receiving the adjacent bent tubular elements 20a and straight tubular elements 22a is more at the transition region between the bent tubular elements 20 and straight tubular elements 22 to enable use of standard size of fins 40 between the adjacent tubular elements even when the tubular elements are combination of bent and straight tubular elements 20 and 22.

[0033] Generally, at least one of the tubular element is dummy tubular element with at least one end thereof blocked. Particularly, the inlet side of the tubular element 20 proximal to the inlet header tank assembly 10 is blocked. In accordance with one embodiment, the first apertures formed on first header of first header tank assembly are offset with respect to second apertures formed on second header of the second header tank assembly.

[0034] In any case, the invention cannot and should not be limited to the embodiments specifically described in this document, as other embodiments might exist. The invention shall spread to any equivalent means and any technically operating combination of means.

Claims

1. A heat exchanger (100) comprising:

- at least one header-tank assembly (10), each header-tank assembly comprising:

- a tank (12); and

- a header (14) formed with apertures (14a),
 - tubular elements (20) received in the corresponding apertures (14a) and secured to the header (14) and adapted to be in fluid communication with the at least one header-tank assembly (10),
- characterized in that** at least one of the tubular elements (20) is bent proximal to at least one of the extreme ends thereof to configure a main portion (20a) and at least one end portion (20b) extending along different planes A and B.
2. The heat exchanger (100) as claimed in previous claim, wherein the end portion (20b) is at least partially received in the corresponding aperture (14a) of the header (14).
 3. The heat exchanger (100) as claimed in any of the preceding claims, wherein the main portion (20a) and the end portion (20b) are connected by an intermediate portion (20c).
 4. The heat exchanger (100) as claimed in any of the preceding claims, wherein the main portion (20a) and the end portion (20b) are offset with respect to each other.
 5. The heat exchanger (100) as claimed in the claim 3, wherein the main portion (20a) and the intermediate portion (20c) are disposed outside the apertures (14a) and between the headers (14).
 6. The heat exchanger (100) as claimed in the claim 3, wherein the intermediate portion (20c) forms first and second angles α_1 and α_2 with the main portion (20a) and end portions (20b) respectively.
 7. The heat exchanger (100) as claimed in any of the preceding claims, wherein the bent tubular element (20) is bent at both extreme ends thereof.
 8. The heat exchanger (100) as claimed in any of the preceding claims further comprises a pair of side plates (30a) and (30b), wherein at least one side plate (30a) is bulging outwards away from the tubular elements (20) to conform to the shape of corresponding end tubular element that is bent and bulging outwards towards the side plate (30a).
 9. The heat exchanger (100) as claimed in the previous claim, wherein at least one side plate (30b) is depressed inwards towards the tubular elements (20) to conform to shape of corresponding end tubular element (20) that is bent and depressed inwards away from the side plate (30b).
 10. The heat exchanger (100) as claimed in any of the preceding claims further comprises fins (40) disposed between adjacent tubular elements (20).
 11. The heat exchanger (100) as claimed in any of the preceding claims, wherein the apertures (14a) are uniformly spaced with respect to each other.
 12. The heat exchanger (100) as claimed in any of the preceding claims, wherein few of the tubular elements (20) are bent and remaining tubular elements (22) are straight.
 13. The heat exchanger (100) as claimed in any of the preceding claims, wherein at least one of the tubular element (20) is dummy tubular element with at least one end thereof blocked.
 14. The heat exchanger (100) as claimed in any of the preceding claims, wherein the first apertures (14a) formed on first header (14) of first header tank assembly (10) are offset with respect to second apertures (14b) formed on second header (14) of the second header tank assembly (10).
 15. The heat exchanger (100) as claimed in any of the preceding claims, wherein at least one extreme end of all the tubular elements (20) is bent.

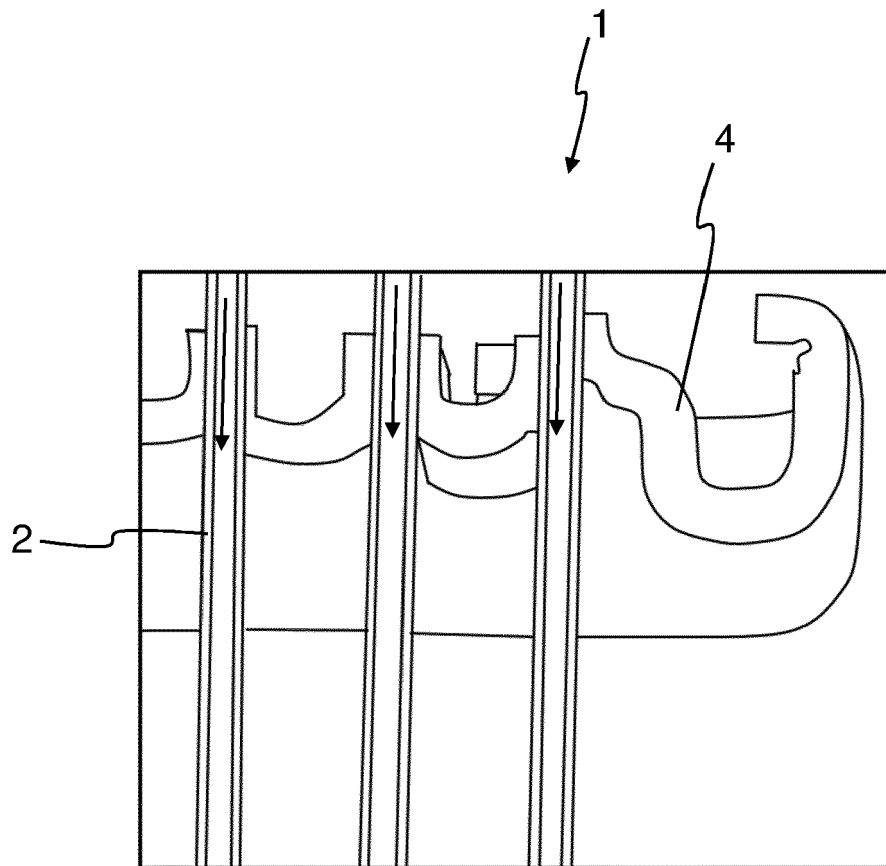


FIG. 1

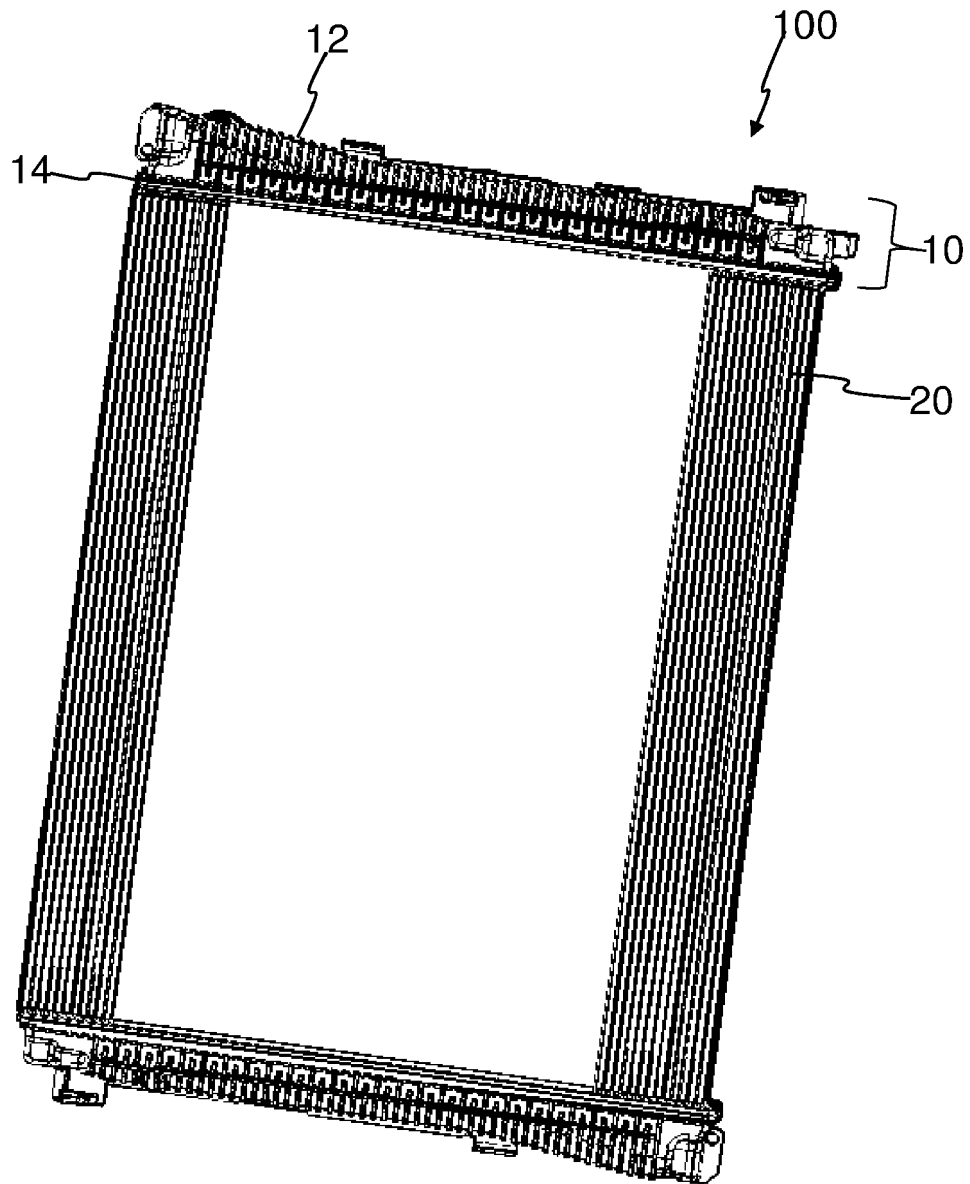


FIG. 2

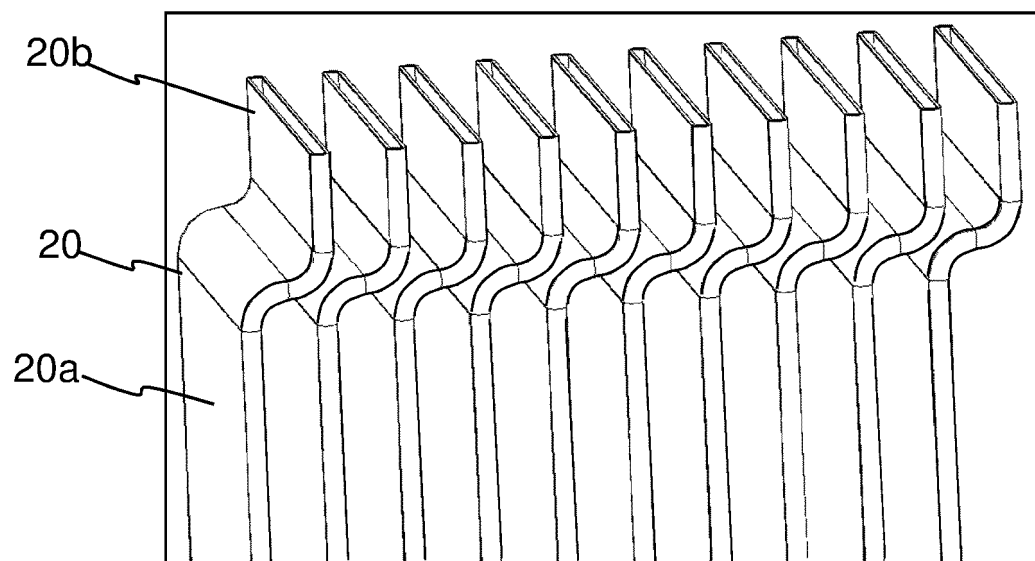


FIG. 3

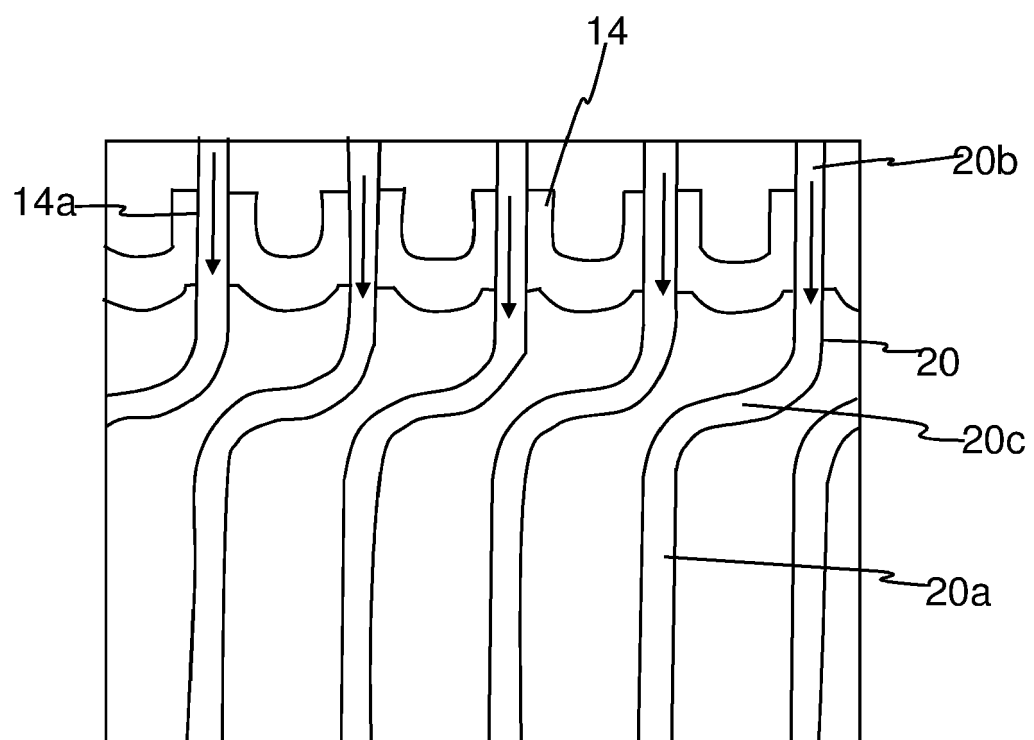


FIG. 4

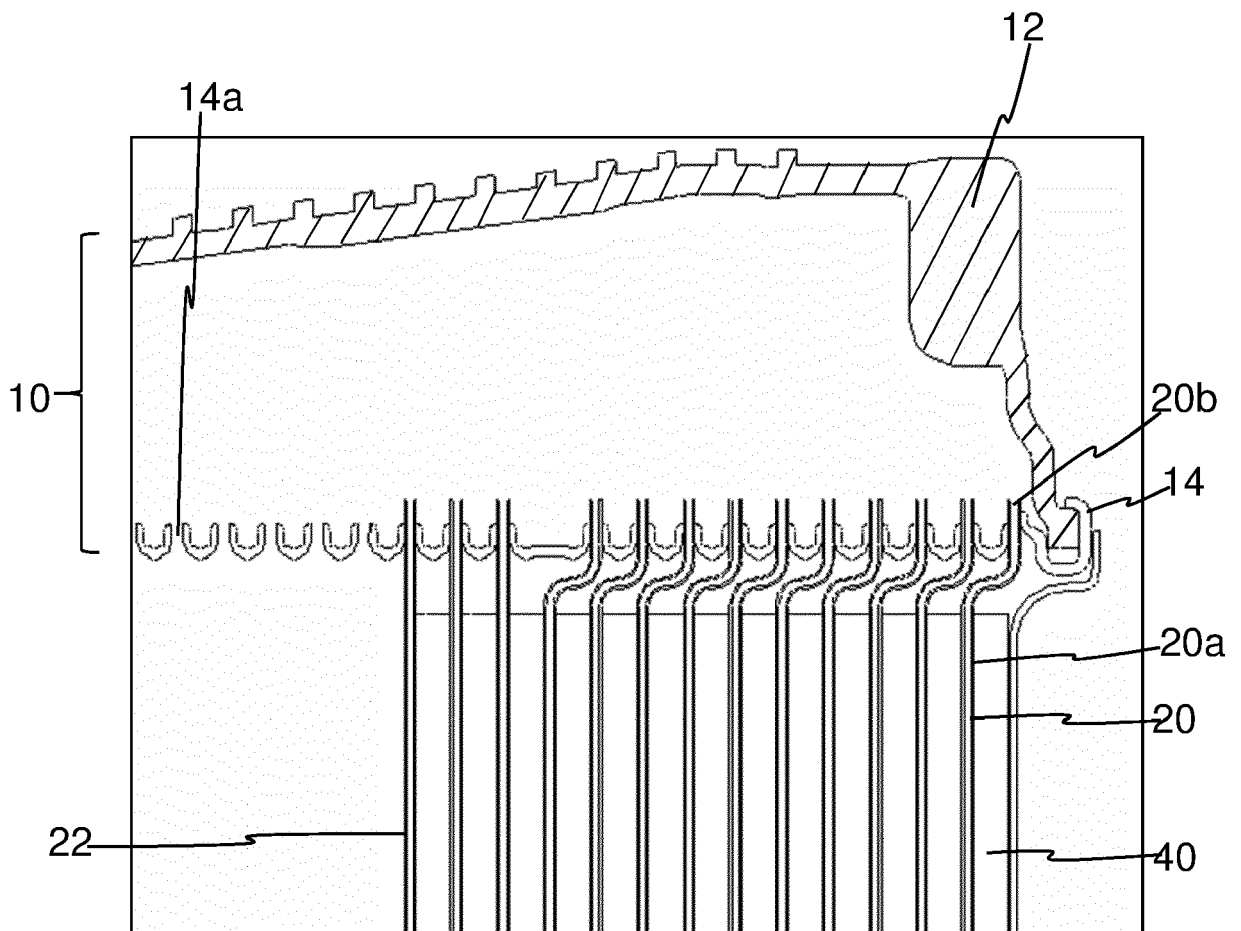


FIG. 5

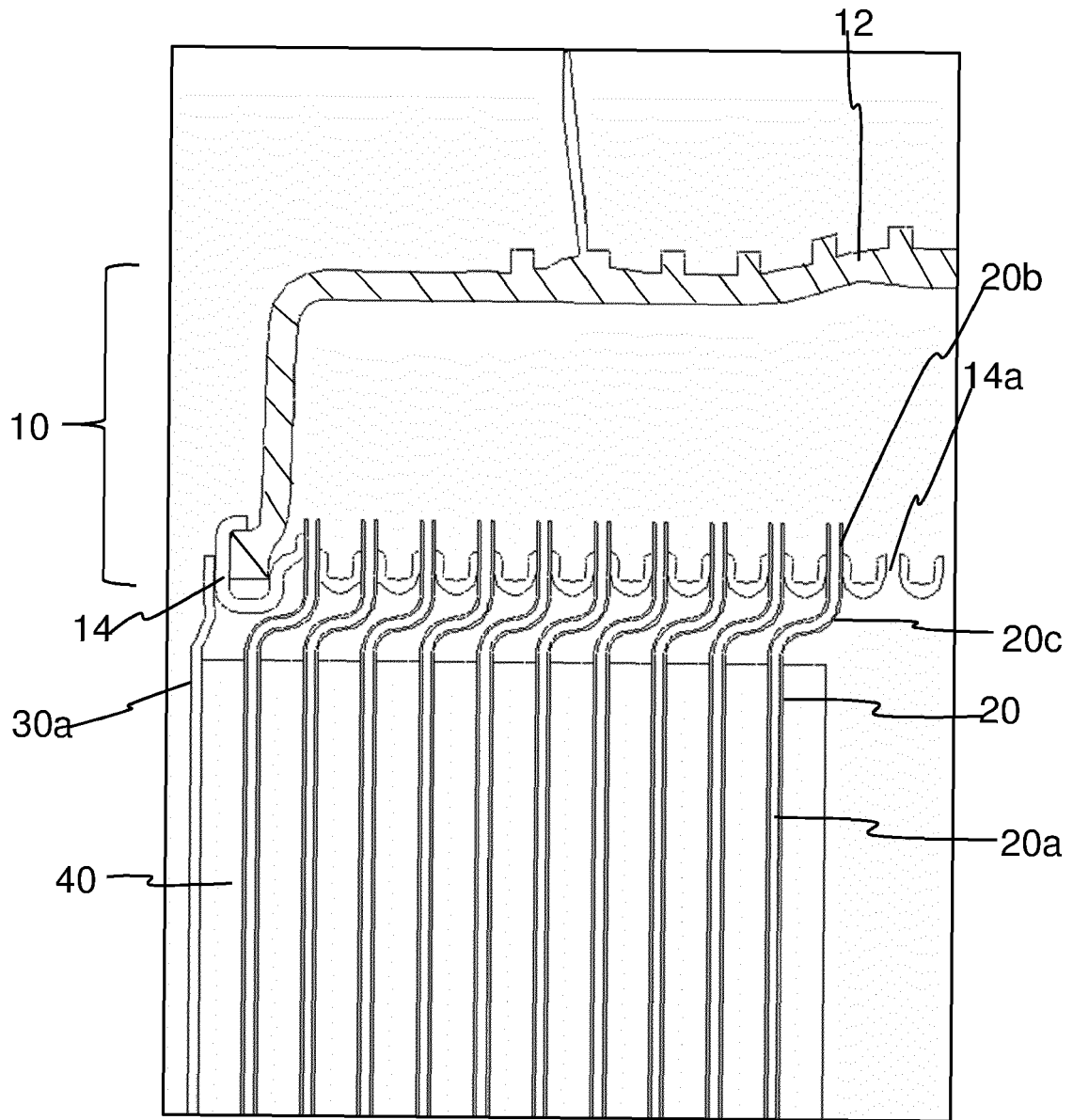


FIG. 6

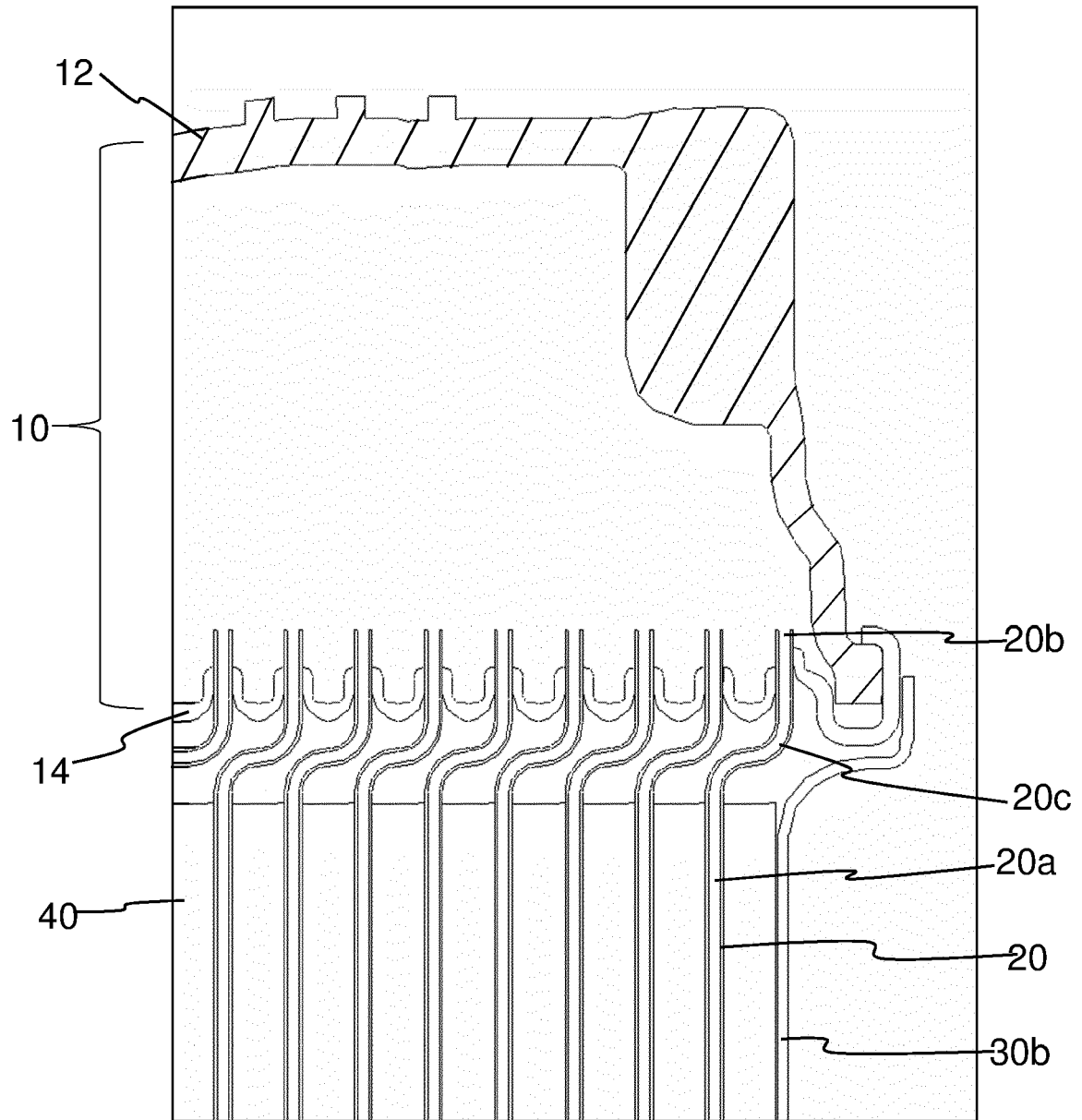


FIG. 7

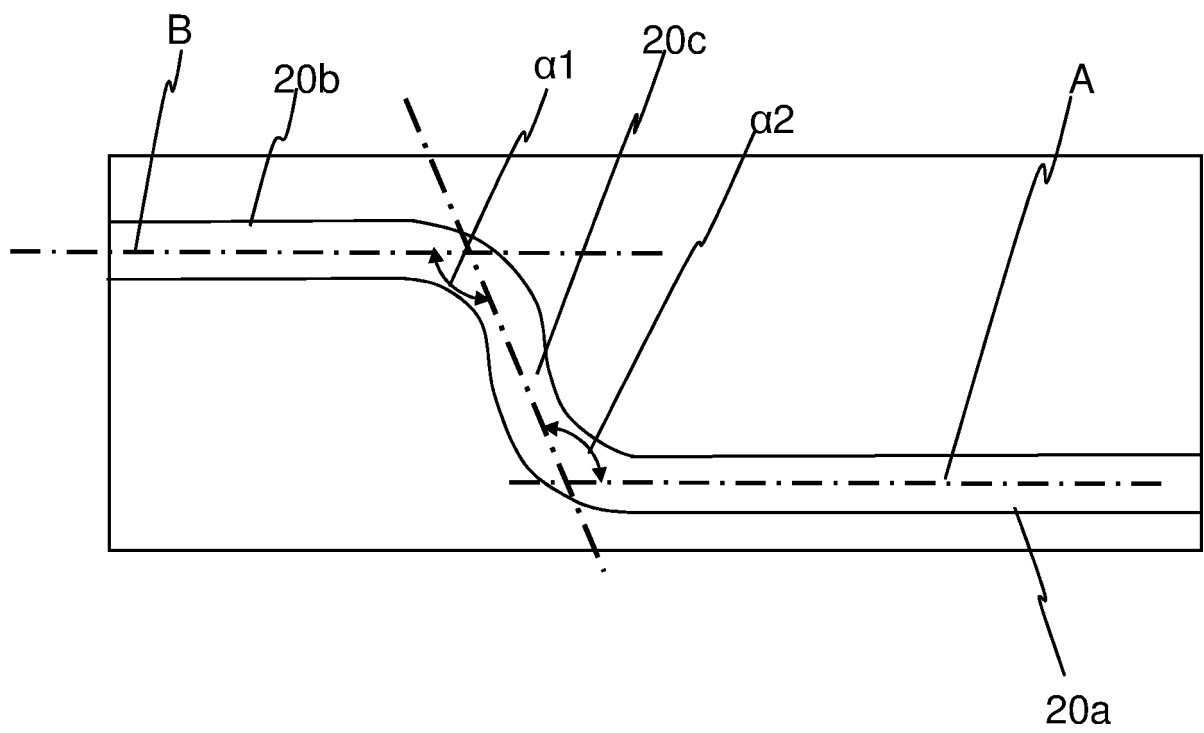


FIG. 8



EUROPEAN SEARCH REPORT

Application Number

EP 23 16 4165

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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X	EP 3 907 459 A1 (VALEO AUTOSYSTEMY SP ZOO [PL]) 10 November 2021 (2021-11-10) * figure 5 *	1, 15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F28F
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		28 August 2023	Bain, David
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			

1
EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 23 16 4165

5 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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28-08-2023

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