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Parker

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[54] **MULTI-MATERIAL HEAT EXCHANGER CONSTRUCTION**

[75] Inventor: **Kenneth O. Parker**, Rolling Hills Estates, Calif.

[73] Assignee: **The Garrett Corporation**, Los Angeles, Calif.

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[52] **U.S. Cl.** ..... **165/166**; 165/180; 29/196.6; 148/127; 29/157.3 D

[51] **Int. Cl.** **F28b 21/08**

[58] **Field of Search** 29/196.6; 165/166, 180; 148/127

[56] **References Cited**

UNITED STATES PATENTS

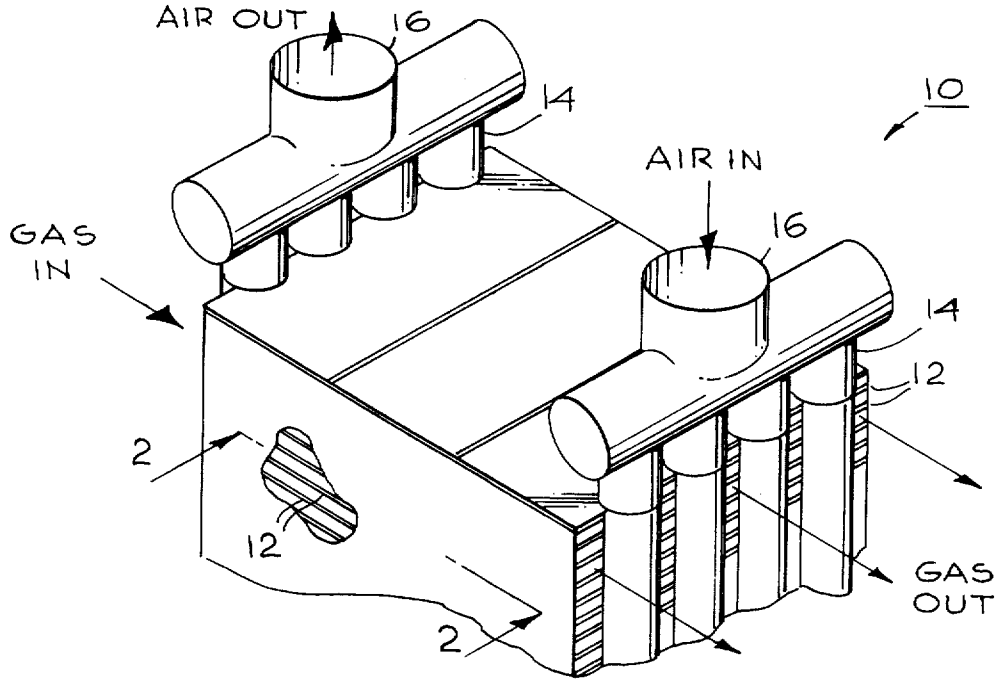
2,464,735	3/1949	Vanderweil	165/180
2,769,227	11/1956	Sykes et al.	29/196.6
2,952,445	9/1960	Ladd	165/166
3,731,738	5/1973	Cooper	29/196.6 X

Primary Examiner—Manuel A. Antonakas
Assistant Examiner—Theophil W. Streule, Jr.
Attorney, Agent, or Firm—Henry M. Bissell

[57] **ABSTRACT**

A recuperative heat exchanger in which the material composition of the fins and plates varies in the flow direction of the higher temperature fluid according to the designed temperature and stress conditions. A first plate of high stress- and heat-resistance quality material is welded edgewise to a second plate of lower stress- and heat-resistance quality material which in turn may be edge-welded to another plate of still lesser quality material. The resulting multi-material plate is then rolled to a desired thickness and formed to provide the particular heat exchanger element. A plurality of such elements, formed as plates and fins for example, are then fabricated into a unitary heat exchanger core and arranged in a position whereby the portions of the elements having the high stress- and heat-resistance qualities are at the higher temperature end of the heat exchanger.

4 Claims, 4 Drawing Figures



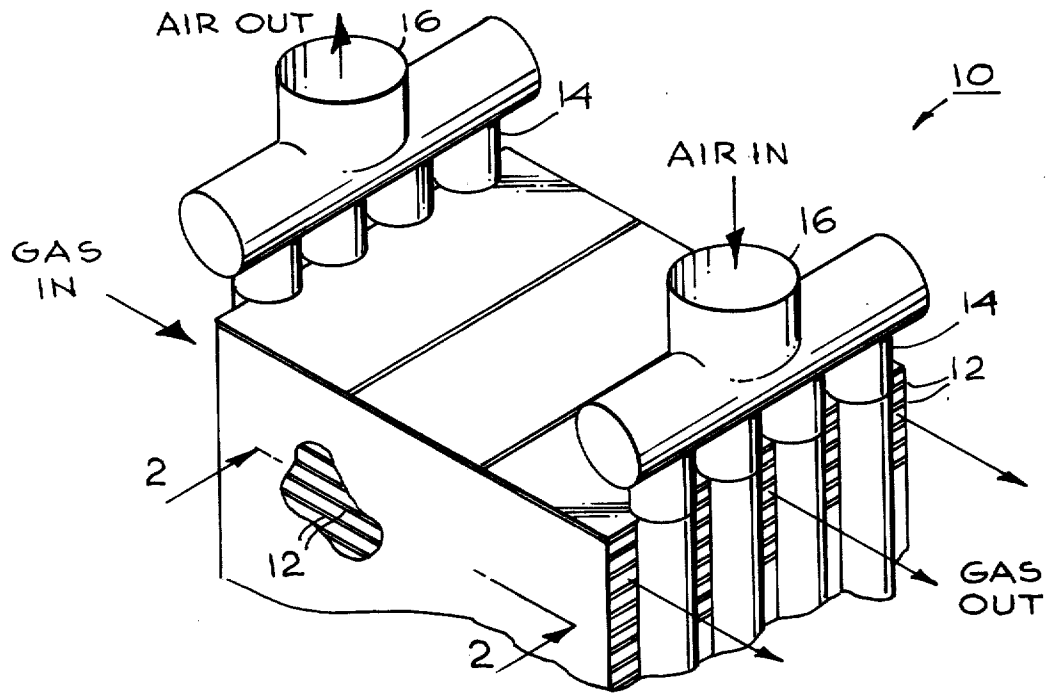


Fig. 1

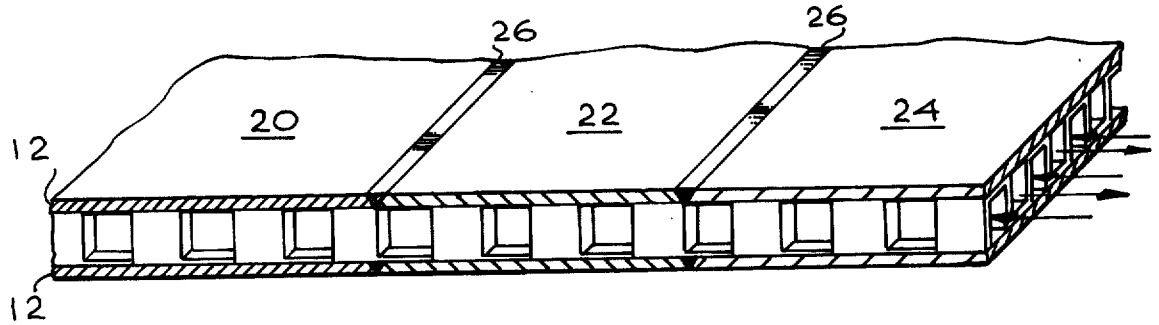


Fig. 2

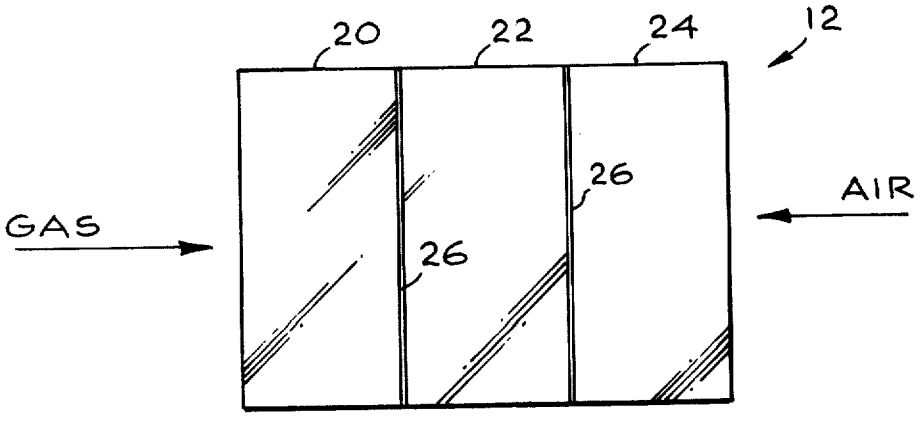


Fig. 3

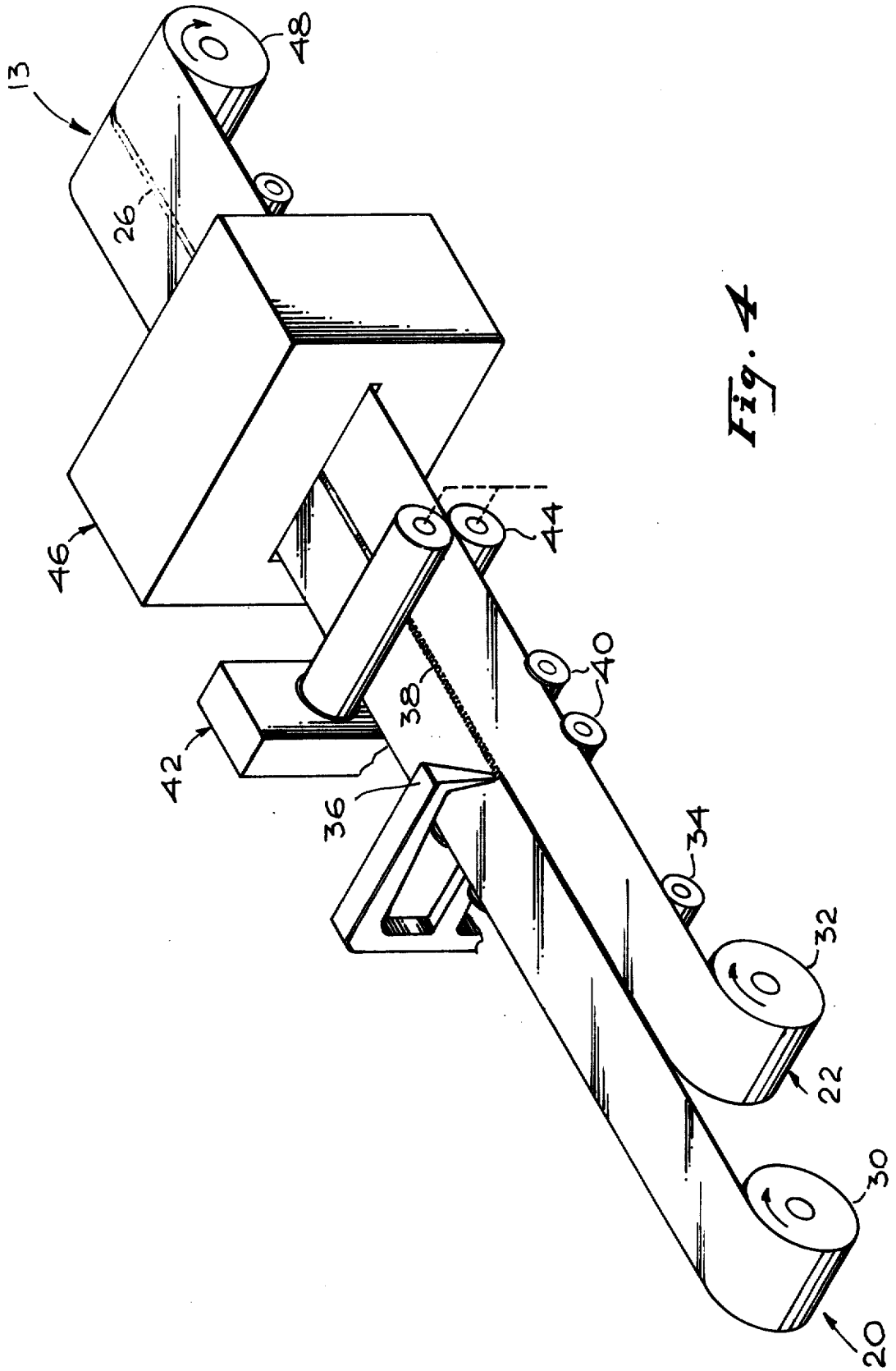


Fig. 4

MULTI-MATERIAL HEAT EXCHANGER CONSTRUCTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to recuperative heat exchangers and in particular to the construction of such devices with plates of dissimilar materials.

2. Description of the Prior Art

Heat exchangers of the plate type have plates of relatively thin material formed and stacked to provide heat transfer through the plates between adjacent series of flow passages, containing fins, formed between adjacent plates. In a typical counter-flow heat exchanger, flow of the high temperature fluid proceeds from the input end which may receive, for example, hot exhaust gases from a gas turbine engine, through the heat exchanger core with the temperature of the gases continuously falling as the heat is transferred to the low temperature fluid. Accordingly, the temperature of the plates and fins of the heat exchanger core varies in the flow direction from the high temperature input end to the low temperature output end. The resulting thermal gradient causes the stress levels on the plate and fins to vary throughout the core matrix with the highest stresses occurring at the high temperature input end and the lowest stresses occurring at the low temperature output end. The high stresses at the input end tend to decrease the life of the core elements whereas low stresses at the output end have less effect on the materials. In addition to the thermal stresses the high temperatures at the input end tend to oxidize and otherwise corrode the core parts.

In the present day design of heat exchangers, the core materials may be selected to conform to the higher stresses at the high temperature input end thereby providing a recuperator of longer life but at considerable material cost. In a sense this is somewhat wasteful because the costly, high quality material at the input end is not required at the low temperature output end. Therefore the expensive material is essentially wasted at the low temperature end. On the other hand, if the heat exchanger is designed of material having low thermal stress quality at the high temperature ends, the stress will exceed the yield strength of the low temperature material and thereby reduce the life of the heat exchanger.

Various attempts in the prior art have been made to overcome the aforementioned design requirement of a higher quality material at the high temperature input end and a lower quality material at the low temperature output end. One common approach utilizes a plurality of heat exchangers in series with the first heat exchanger receiving the exhaust gas at its highest temperature, and accordingly being designed to have high quality material. The next heat exchanger in the line is constructed of lower quality material and so on. While this type of design may provide a partial solution to the problem, such combined units are still costly and occupy more space because several different heat exchangers are required, each duplicating the components of the other exchangers. Moreover, such an approach is particularly inappropriate to the special manifolding configurations of integral manifold, counter-flow heat exchangers now being designed.

Accordingly, it is a primary object of the present invention to provide a heat exchanger core and specific components thereof fabricated of materials which vary in heat-and stress-resistance qualities according to the different temperature and thermal stress conditions encountered in the core.

SUMMARY OF THE INVENTION

Briefly, according to a preferred embodiment of the invention a counter-flow heat exchanger core is formed of plates having dissimilar material compositions resulting in different thermal stress- and heat-resistance qualities. Associated fin elements may also be so formed, if desired. The dissimilar material portions are first welded together and then rolled to provide a desired thickness prior to fabrication in conventional manner. The resulting multi-material elements may be positioned in a heat exchanger with the portion having high heat- and stress-resistance properties being at the high temperature end of the heat exchanger and the portion of the low heat- and stress-resistance properties being at the low temperature end of the heat exchanger.

In this manner the desired objective of heat- and stress-resistance qualities and low overall cost of the heat exchanger can be achieved with the quality of the material corresponding to the stresses it is subjected to.

The primary object of this invention is therefore to provide a single unitary plate structure formed from plate sections of dissimilar materials with a plurality of such plates fabricated in a counter-flow heat exchanger such that the portions of highest quality are placed near the high temperature and thermal stress end of the heat exchanger.

BRIEF DESCRIPTION OF THE DRAWING

A better understanding of the present invention may be had from a consideration of the following detailed description, taken in conjunction with the accompanying drawing, in which:

FIG. 1 is a fragmentary view of a particular counter-flow heat exchanger core fabricated in accordance with the paresent invention;

FIG. 2 is a sectional view of a portion of the heat exchanger of FIG. 1, taken along the lines 2—2 thereof and looking in the direction of the arrows;

FIG. 3 is a plan view of a particular heat exchanger plate fashioned in accordance with the present invention; and

FIG. 4 is a view showing a particular method of fabrication of the plate of FIG. 3 in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1 and 2 illustrate details of construction of a particular type of counter-flow heat exchanger core 10 fabricated in accordance with the present invention. As shown in these figures, the heat exchanger core 10 is made up of a plurality of individual plates separated by fins in known fashion. Each individual plate 12 serves as a divider sheet between adjacent streams of hot exhaust gas, as from a turbine, and cooler air driven by a compressor. In the counter-flow arrangement of FIG. 1, the exhaust gas is shown flowing straight through the gas passages whereas the air is transported to and from the various interspersed air layers by means of integral manifolds 14 and headers 16. Thus, the heat exchanger 10 of FIG. 1 comprises a sandwich structure of alternate layers of fluid channels, half of the channels pro-

viding straight-through passages for the exhaust gas and the remainder providing passages between the manifold portions **14** with the flow in adjacent gas and air passages being arranged in opposed directions.

In counter-flow heat exchangers, the side at which the exhaust gas enters and the heated air leaves is the hot side, whereas the opposite side where the air to be heated enters and the exhaust gas leaves is the cool side. As a result of the present invention, it therefore becomes possible to fabricate the respective divider sheets of plates of sections of different materials which are welded together to form a single plate. FIG. **3** illustrates a metal sheet **13** having three sections **20, 22,** and **24** joined together by weld lines **26.** The sections **20, 22** and **24** extend across the sheet **13** in a direction generally orthogonal to the flow direction of the counter-flow fluids. Thus, the section **20** comprises a material which is particularly selected for qualities of high stress resistance and heat resistance. A particular material which is suited for this section **20** is Inconel **625.** The section **24** at the cool side of the sheet **13** may be fabricated of a lower cost steel such as SAE **1020** steel which has lower stress- and heat-resistance qualities and accordingly is much cheaper than the material of the section **20.** Intermediate sections such as **22** are operated at some temperature between the hot and cold temperatures at opposite ends of the heat exchanger core and may be fabricated of material having intermediate stress- and heat-resistance qualities, such as CRES 347.

Sheets such as that shown in FIG. **3** are trimmed and shaped to form the divider plates **12** of FIG. **2** and fabricated into the heat exchanger core of FIG. **1.** If desired, sheets **13** of FIG. **3** may also be fabricated into the separator fins of FIG. **2** which are fitted between adjacent divider plates **12.** Alternatively, the finned sections may be separated at the juncture line between adjacent plate sections **20,22** and **24** and selected from respective materials matched to meet the design requirements of the temperatures encountered in these sections.

As shown in FIG. **1,** such a construction in accordance with the present invention of the heat exchanger core **10** results in a single heat exchanger core having materials selected for the various sections thereof to meet the temperature and stress requirements to be encountered in the particular sections. Heretofore, those efforts directed toward realizing economy of manufacture for heat exchangers have resulted in a plurality of heat exchangers intereonnected in series. These have comprised cross-flow heat exchangers strung out in line with manifolds tortuously directing the flow of one of the fluids to and from adjacent sections in a serpentine manifold arrangement. The present invention avoids such manifolding problems by fabrication of the various sections comprising different materials in a single integrated unit.

FIG. **4** illustrates in schematic form a method of fabrication of sheets such as are employed in the practice of the present invention. As shown in FIG. **4,** a pair of sheets **20** and **22** of dissimilar materials are being fabricated to form a single sheet comprising two sections of different materials. The separate sheets **20** and **22** begin from rolls **30** and **32** respectively and are drawn through guide rollers **34** to a position underneath a welding head where the adjacent edges are butt welded together. If desired, the butt weld edges prior to the welding step may be prepared by suitable bevelling, smoothing and cleaning operations. After being edge-welded by the welding head **36,** the combined sheets, joined by the butt weld **38,** are passed along guided by additional guide rollers **40** to a planisher **42** having rollers **44** above and below the joined sheets **20, 22** where the butt weld **38** is pressed and shaped to the dimension of the sheets **20, 22.** From the planisher **42,** the sheet is transported to an annealing oven **46.** Additional rolling or planishing and annealing steps may be incorporated if desired. Finally, the sheet **26** is rolled up into a roll **48** for storage until needed for cutting and trimming to form the sheets such as **13** of FIGS. **2** and **3.** Although FIG. **4** shows only two sheets being welded together, additional strip stock of a third material may be joined by incorporating one more coil and one more welding head.

Although there have been described above specific arrangements of a multi-material heat exchanger structure and methods of fabrication thereof in accordance with the invention for the purpose of illustrating the manner in which the invention may be used to advantage, it will be appreciated that the invention is not limited thereto. Accordingly, any and all modifications, variations or equivalent arrangements which may occur to those skilled in the art should be considered to be within the scope of the invention.

What is claimed is:

1. A heat exchanger core of the counterflow fluid type wherein one of the fluids is introduced to and removed from the core in a direction orthogonal to the direction of fluid flow through the core, comprising:

a plurality of stacked plates formed to define layered passages for fluid streams flowing between opposite ends of the core, adjacent pairs of said streams being arranged to flow in opposed directions, one of said pair of streams comprising a hot gas and the other being a fluid entering the core at a cooler temperature;

each of said plates comprising sections of different materials having different stress- and heat-resistance qualities, said sections being edge-welded together along juncture lines between adjacent sections, the sections and welded edges extending transversely to the direction of fluid flow through the core;

said plates being disposed within the heat exchanger such that the sections of highest stress- and heat-resistance qualities are located adjacent the hot gas inlet end of the heat exchanger core and the sections of lowest stress- and heat-resistance qualities are located adjacent the inlet end of the cooler temperature fluid.

2. A heat exchanger core in accordance with claim **1** further comprising a plurality of finned elements individually arrayed between adjacent pairs of plates defining said passages.

3. A heat exchanger core in accordance with claim **2** wherein said finned elements comprise sections of different materials respectively corresponding in stress- and heat-resistance qualities to adjacent plate sections, the different finned element sections extending transversely to the direction of fluid flow through the core and generally coextensively with the adjacent plate sections of corresponding stress- and heat-resistance qualities.

4. A heat exchanger core in accordance with claim **3** wherein said finned elements adjacent sections are edge-welded together to form integral units.

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