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[54] **HEAT EXCHANGER**
1 Claim, 1 Drawing Fig.

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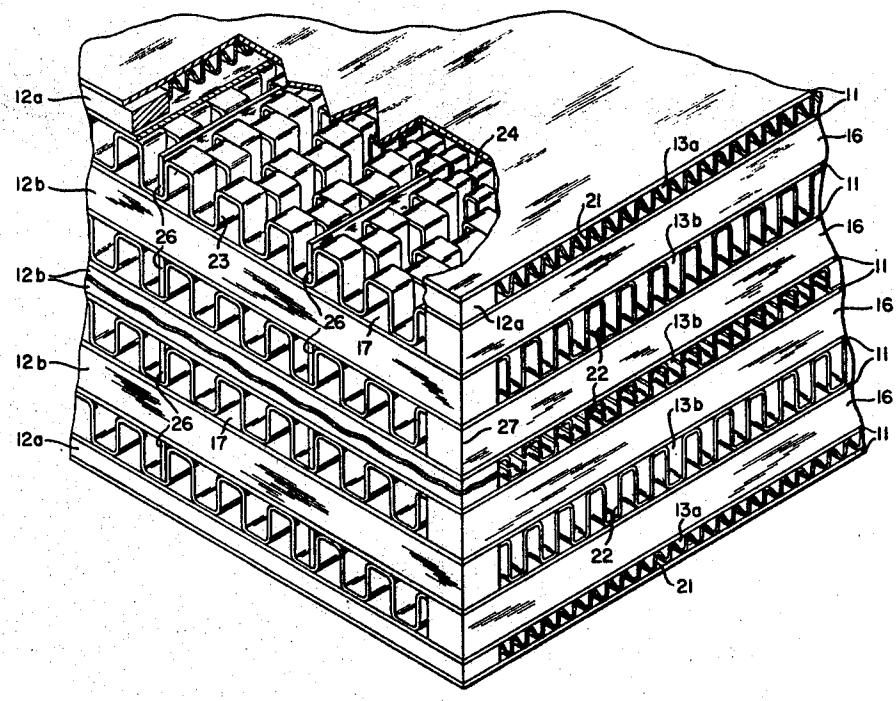
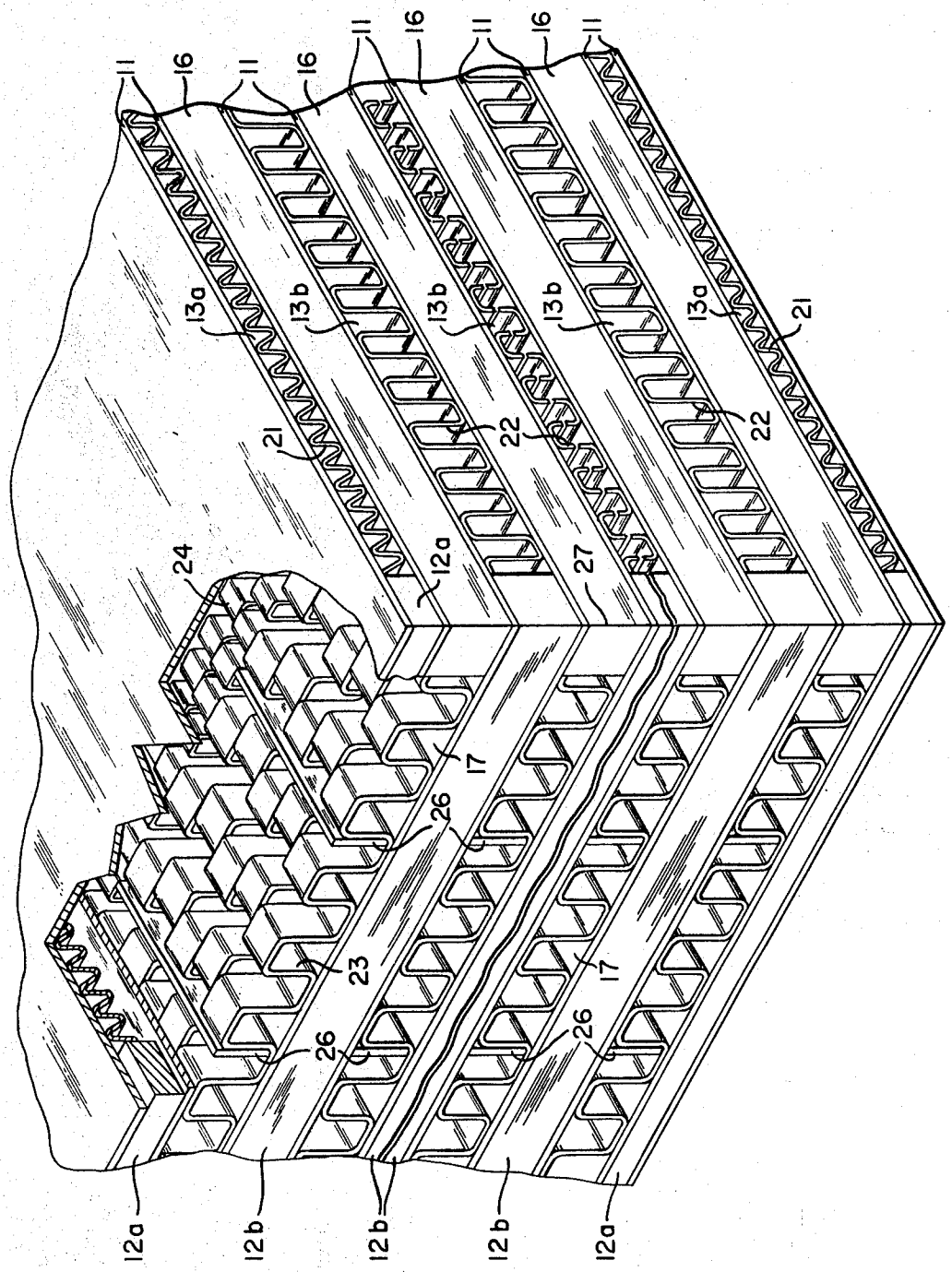
ABSTRACT: In a heat exchanger having passageways formed between spaced parallel plates bounded in a stack with fins connecting adjacent plates, means are provided for relieving columnar stresses within the fins.





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HEAT EXCHANGER

This invention relates to a heat exchanger constructed, in particular, of a plurality of plates disposed in a stack and spaced from each other with fins bonded to two adjacent plates.

Within heat exchangers of the type above described, one fluid flows between two adjacent plates to give up heat to another fluid that flows on the opposite side of the respective plates. Fins are provided between the plates to more readily extract the heat from one fluid and transfer it to the other. To minimize friction, the fins are disposed parallel to the fluid flow, providing a path for heat flow without adding appreciable flow resistance. In addition, the thickness of the fins is such as to provide maximum flow area, maximum wetted surface, and maximum area for heat flow. A relatively thin fin normally satisfies this requirement. However, a thin fin buckles or bends under relatively light compression loads such as may be encountered at the inlet end for the hot fluid. The fins are subjected to repeated buckling whenever the system is started and stopped due to the thermal cycle formed by the heating and then cooling of the heat exchanger. Then, after a few thermal cycles, the fins become stress fatigued and break. When this happens to the fins within the high pressure passageways, the plates are subjected to repeated bending by the higher pressure fluid whereby the plates become fatigued and break, causing an intermixing of the coolant and fluid to be cooled.

Therefore, an object of this invention is to provide added columnar support to the fins without decreasing the area of fluid flow.

Another object of this invention is to provide an improved lightweight heat exchanger.

These and other objects, features and advantages will become more apparent from the following description of the invention and shown in the accompanying drawing wherein the sole figure schematically shows an enlarged pictorial view of the heat exchanger incorporating the invention.

Referring to the drawing, the heat exchanger has a plurality of spaced parallel plates 11 having preferably a rectangular shape. Between alternate spaces formed by the plates 11 and along opposite edges thereof are bonded edge closure elements 12*a* and 12*b*. The edge closure elements 12*a* and 12*b* along one of the respective edges are shown, the opposite plate edges, not shown, have similar edge closure elements bonded thereto to form a plurality of passageways 13*a* and 13*b* which are parallel to each other. Passageways 13*a* are located outside of passageways 13*b* and edge closure elements 12*a* are, for example, one-half as wide as edge closure elements 12*b*, making passageways 13*a* narrower than passageway 13*b*. This arrangement is preferred since, as it will become apparent, the fluid in the outer passageways 13*a* can only absorb or give up heat on one side thereof instead of two sides like the fluid within passageways 13*b*. The remaining spaces between the plates have edge closure elements 16 bonded to the two other opposing edges of the plates 11. Only the edge closure elements 16 along one of the other edges are shown, but similar edge closure elements are understood to be bonded to the opposite edges to form parallel passageways 17. One end of each of the passageways 13*a* and 13*b* communicates with an inlet manifold (not shown) and the other end communicates with an outlet manifold (not shown). In addition, opposite ends of passageways 17 communicate respectively with inlet and outlet manifolds (not shown), in a manner well known in the art.

The plates 11 should be of minimum weight and are made as then as possible. However, the fluid passing within one group of parallel passageways may be at a higher pressure than the fluid passing within the other group of parallel passageways. This pressure differential tends to bend the thin plates. As mentioned above, suitable fins are normally bonded to adjacent plates 11 and these fins are capable of safely withstanding tensile stresses due to any pressure differential. Therefore, the fins help to maintain the plates 11 flat. However, the two fluids, in addition to having unequal pressures, have inherently unequal temperatures. Therefore, if the hot fluid enters the

passageways 17 through the ends thereof shown in the drawing, the inlet ends of passageways 17 will be hotter than both ends of passageways 13 and 13*b*. Both edges of the heat exchanger, such as a corner edge 27, that are common to both passageways 13*b* and 17, will also be colder than any portion therebetween at the inlet ends of the hot fluid passageways 17. Therefore, the corner edges, such as corner edge 27, being colder, expand less than the portion therebetween. In other words, all the plates and fins experience thermal expansion but are restrained by the corner edges. This restraint imposes compression loading on the fins. When the temperature gradient is too large, the fins in some of the passageways have been observed to bend and buckle. The fins 23 fatigue when the fins are repeatedly buckled under this compression loading due to the cycle of thermal expansion and contraction. When the fins in a high pressure passageway crack or break, the plates 11 bend due to the pressure differential thereacross. Then, after more cycling of the heat exchanger, plates 11 fatigue and break causing the hot and cold fluids to intermix.

One method of preventing the fins from breaking is to increase the number of fins per inch; but obviously, the flow area for the fluid decreases in about the same relationship as the increase in the number of fins and, in turn, the flow area decreases almost directly with increases in buckling strength. Another method is to make the fins thicker. Since the compression strength increases as the cube of the thickness and since the flow area decreases as fin thickness increases, the flow area decreases approximately as the cube root of the buckling strength increases. In other words, an increase by a factor of two in the fin buckling strength decreases the flow area by approximately one-quarter. This invention teaches another method which is unique and novel, *i.e.*, the use of relatively thick bars in combination with the fins so that the flow area remains substantially constant as the buckling strength is increased. Then where the temperature gradient is less severe, the bars are discontinued and fins only are provided for efficient heat conduction between the fluids.

The fins in this embodiment have different configuration within the various passageways. Passageways 13*a* have fins 21, which are shorter than fins 22 in passageways 13*b*, to accommodate the width of the respective passageways. The passageways 17 have fins 23 at the inlet side thereof and extend a predetermined distance into the passageway. Fins 23 are followed by fins 24 which preferably give more corrugations per unit length than fins 23. The fins 23 are disposed at the inlet end of the higher pressure fluid, where the temperature gradient is greater so that means, in the form of the aforementioned bars 26, are placed longitudinally within passageways 17 to withstand any compressive force that may be encountered. For clarity in the drawing, the relative thickness of the various plate elements are not shown to scale. The bar thickness is chosen to provide maximum strength and minimum loss to flow area within the passageways. The bars 26 do not extend the full length of the passageway since the temperature gradient is less severe as the fluid passes through the heat exchanger. The fins 23 preferably extend along the passageway the same distance as the bars 26. With this arrangement the flow area through the passageways 17 can be made substantially optimum and uniform. Means, such as bars 26, are placed within passageways 13*a* and 13*b* but normally, since the pressure therein is lower than the other passageways, the heat exchanger will not fail if the fins 22 happen to break. Various other modifications may be contemplated by those skilled in the art without departing from the spirit and scope of the invention as hereinafter defined by the following claim.

We claim:

1. A heat exchanger comprising:

a plurality of spaced parallel plates;

a plurality of first edge closure elements arranged between alternately spaced parallel plates to define a plurality of first passageways for receiving a first fluid;

a plurality of second edge closure elements arranged between the alternately spaced parallel plates not includ-

ing said first edge closure elements to define a plurality of second passageways for receiving a second fluid at a temperature different from the temperature of said first fluid;

a plurality of bars positioned between adjacent parallel plates at the inlet ends of the first and second passageways to provide support between said plates, said bars being of a substantially rectangular cross section with the short sides adjacent the plates and the long sides extending therebetween;

a plurality of first corrugated fins disposed between adjacent parallel plates at the inlet ends of the first and

second passageways, said first corrugated fins offset to provide lateral support alternately to the long sides of said bars; and

a plurality of second corrugated fins disposed throughout the remainder of said first and second passageways, said second offset corrugated fins having more corrugations per unit length than said first offset corrugated fins to provide substantially the same flow area as the flow area at the inlet ends of the first and second passageways having said first corrugated fins and said bars.