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Bongaards et al.

[11] **3,896,874**

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[54] **SUPPORT SYSTEM FOR SERPENTINE TUBES OF A HEAT EXCHANGER**

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[52] **U.S. Cl.** **165/82;** 165/162; 165/163; 122/510

[51] **Int. Cl.** **F28d 7/00;** F28f 9/00

[58] **Field of Search** 122/510; 165/162, 67, 163, 165/82

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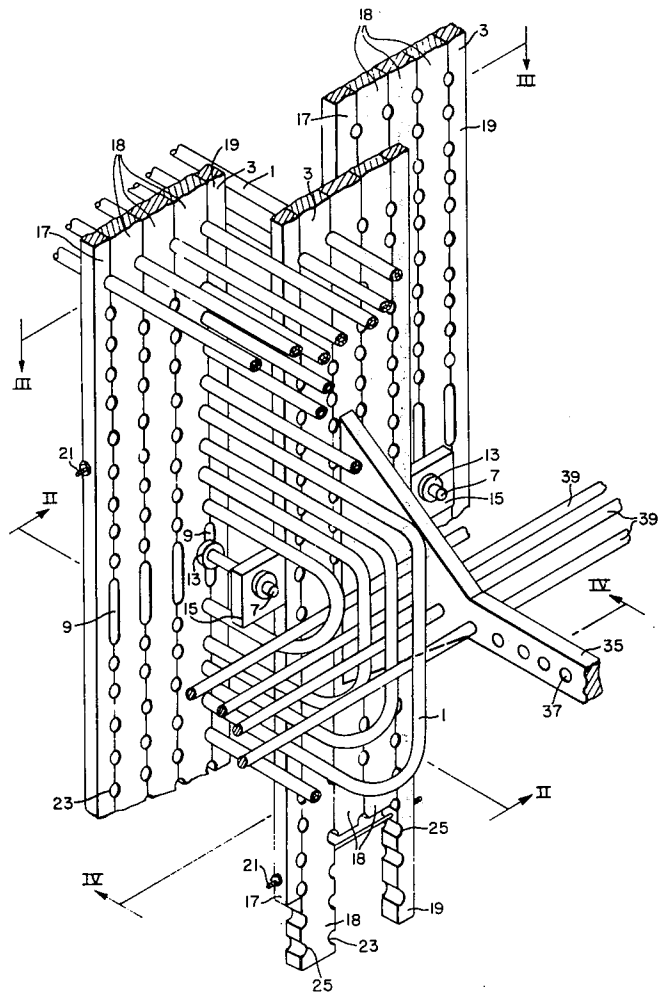
[57] **ABSTRACT**

Tightly packed serpentine tubes forming a tube bundle are repeatedly supported by a plurality of flat bars having regularly spaced notches along the longitudinal margins; the notches register to form an opening for receiving the tubes, and the bars are fastened together to form strips which depend from a tube sheet. A plurality of the strips are fastened together in such a manner that they are free to move lengthwise with respect to each other to allow for differential thermal expansion and to reduce vibration of the strips.

4 Claims, 5 Drawing Figures



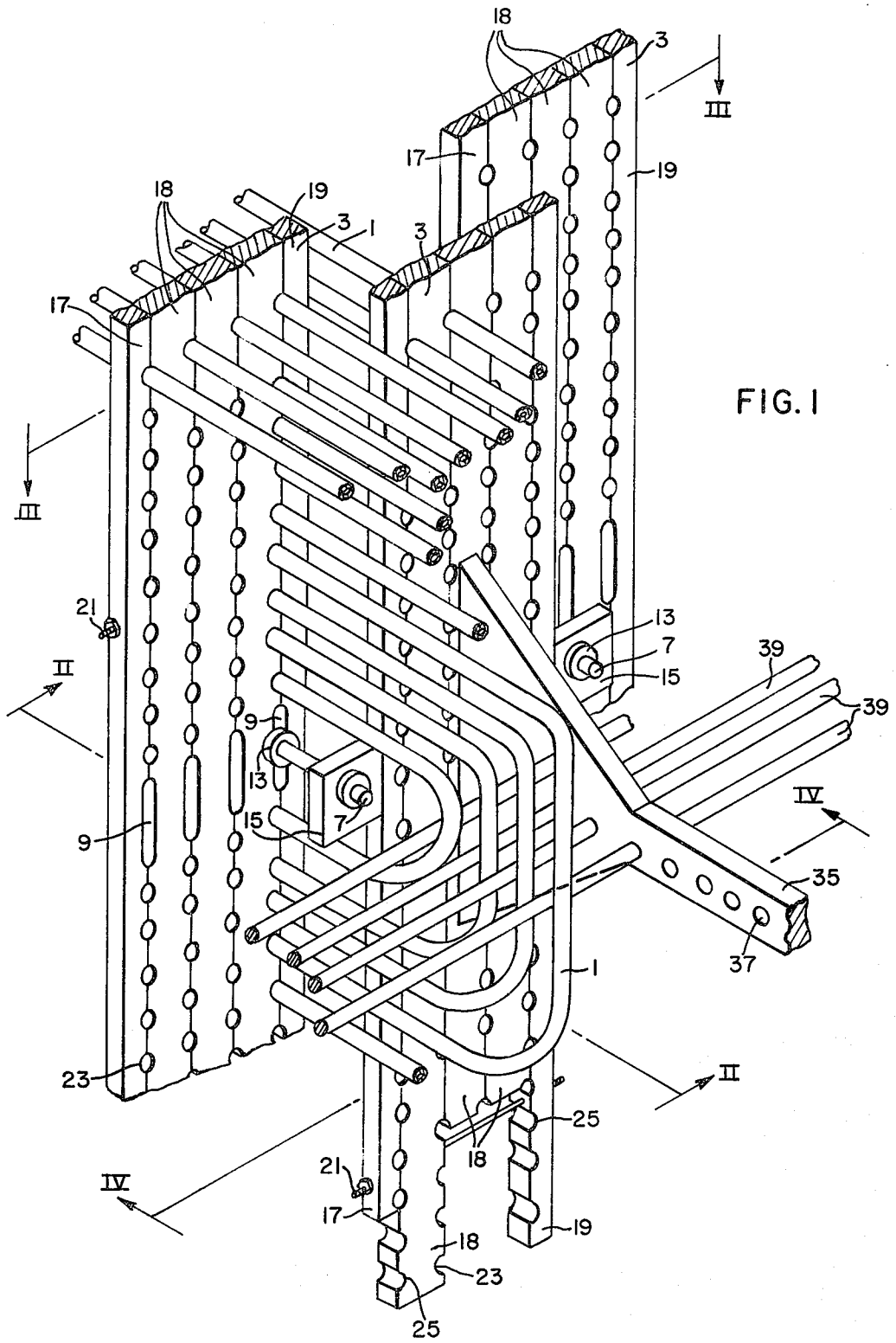

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FIG. 1

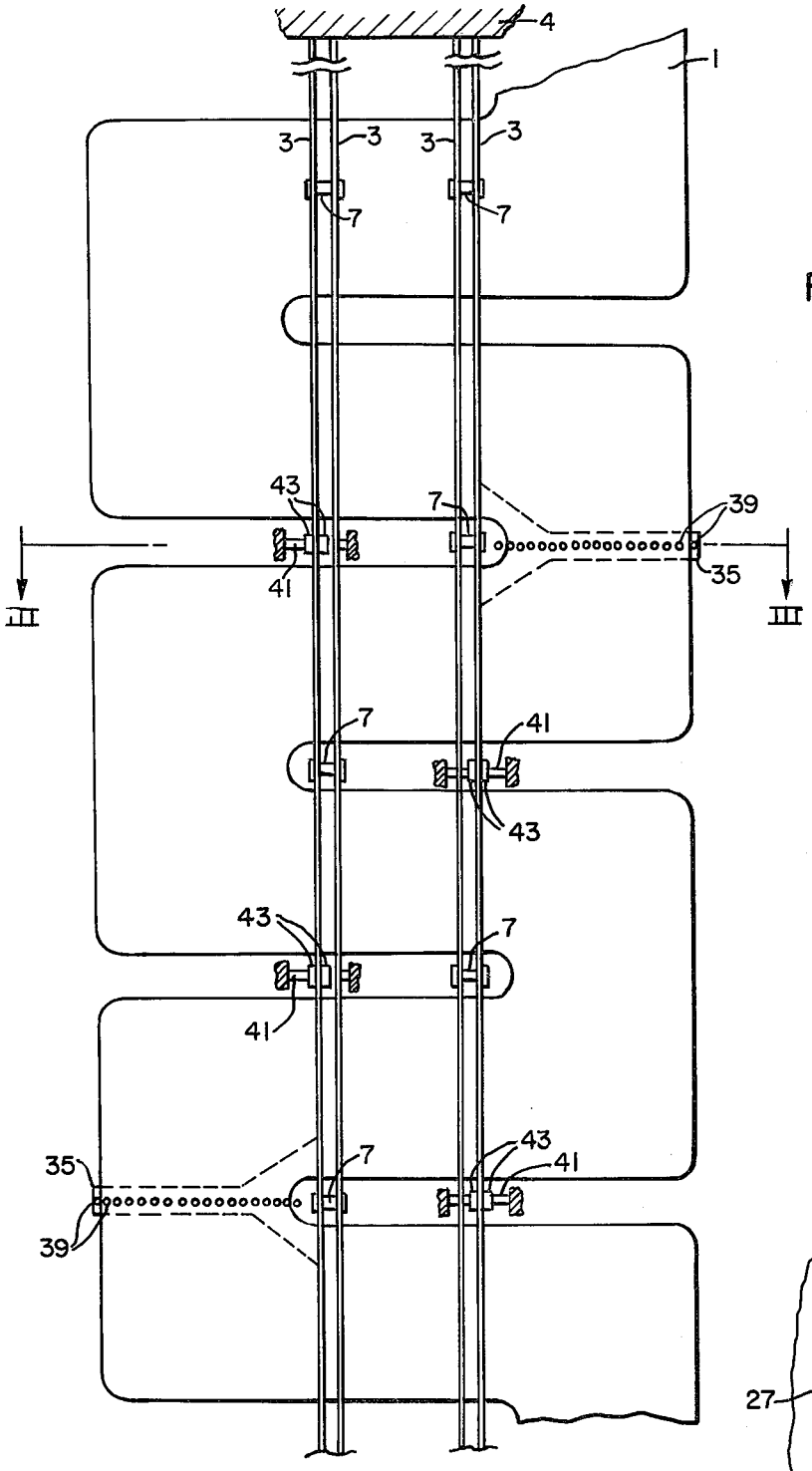
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FIG. 2

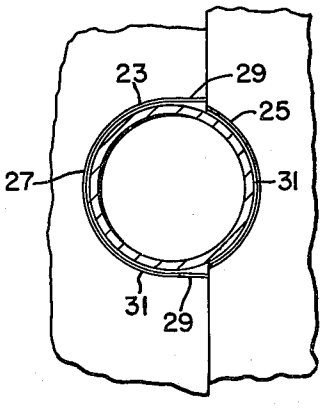
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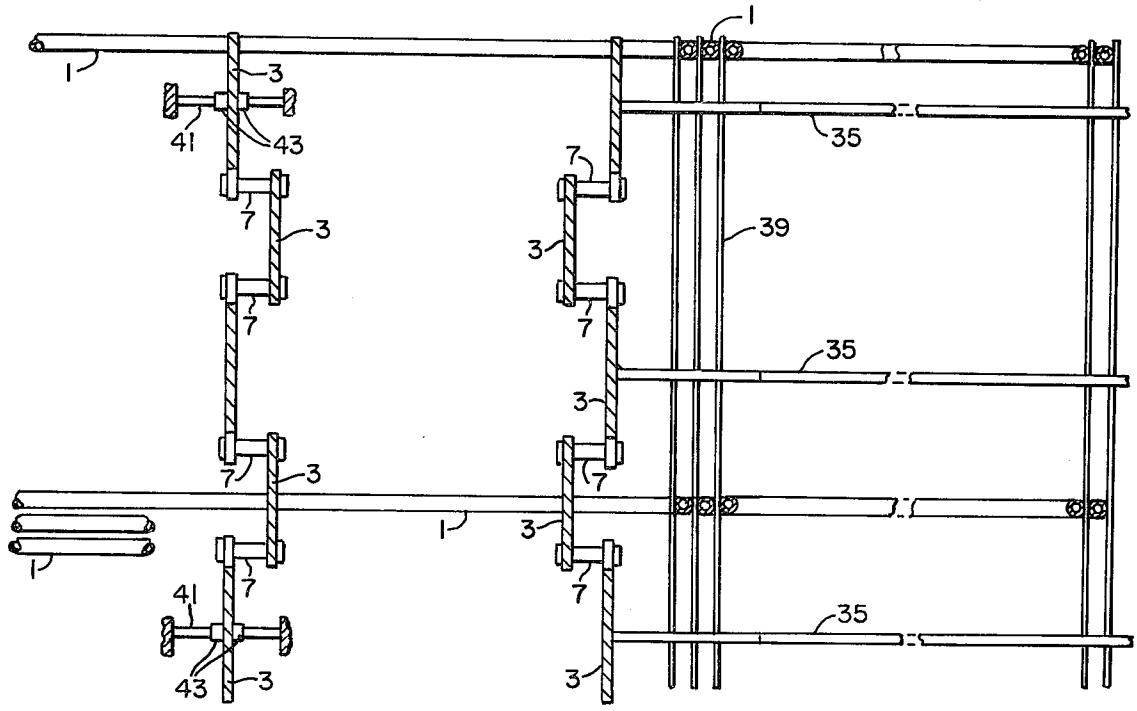
FIG. 5

FIG. 3



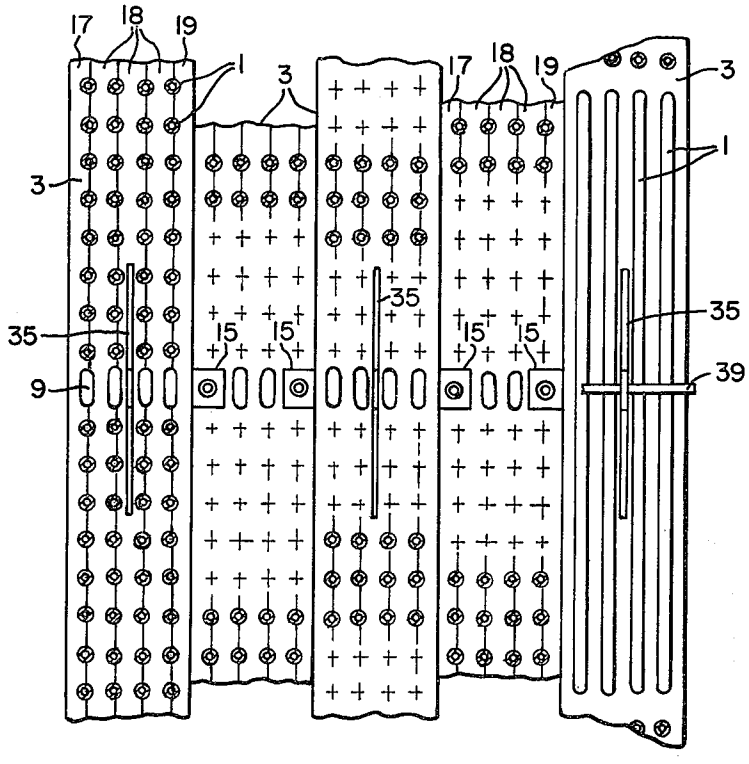


FIG. 4

SUPPORT SYSTEM FOR SERPENTINE TUBES OF A HEAT EXCHANGER

BACKGROUND OF THE INVENTION

This invention relates to heat exchangers and more particularly to tube supports for serpentine tubes utilized in a nuclear steam generator.

The demand for electrical power in the United States doubles approximately every ten years. Presently fossil fuels provide the majority of the heat energy necessary for producing electrical power. However, in the next 30 years it is estimated that over 50 percent of our electrical power will be produced by nuclear energy. The supply of fissionable material is limited so that the future of nuclear power generation depends on developing a fast breeder reactor, which produces more fissionable material than it consumes. Such a system presently anticipates the use of liquid sodium as a primary heat transfer medium utilized to cool the reactor. In the present design the shell side of the steam generator is supplied with liquid sodium and steam is produced in a once through, forced circulation, single wall serpentine tube bundle, which must provide an impervious barrier between the sodium and water or steam to prevent the explosive chemical reaction, which occurs when sodium comes into contact with water or steam.

The tubes forming the serpentine tube bundle may have walls as thin as 65,000 of an inch, therefore it is imperative that they be protected from damage.

The serpentine arrangement necessarily subjects portions of the tubes to transverse flow and results in resonant vibration. The large temperature differential occurring across the steam generator results in thermal differential expansion, which must be accommodated. Thus, the system utilized to support the tubes for such a liquid metal to water heat exchanger warrants judicious analysis to prevent tube damage. To provide an economical heat exchanger its size must be minimized requiring closely spaced tubes, which leaves little room for the tube support system.

SUMMARY OF THE INVENTION

A support system for supporting closely packed serpentine tubes for a heat exchanger, when made in accordance with this invention, comprises a plurality of support strips which are disposed to repeatedly support each serpentine tube, and each support strip is fastened to an adjacent support strip in such a manner that the strips can only move lengthwise with respect to each other.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and advantages of this invention will become more apparent from reading the following detailed description in connection with the accompanying drawings, in which:

FIG. 1 is a partial enlarged isometric view of a support system for serpentine tubes made in accordance with this invention;

FIG. 2 is a partial sectional view taken on line II—II of FIG. 1;

FIG. 3 is a partial sectional view taken on line III—III of FIG. 1;

FIG. 4 is a partial sectional view taken on line IV—IV of FIG. 1; and

FIG. 5 is an enlarged partial sectional view showing the detail of the notches in the bars forming the support system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings in detail, FIG. 1 shows a portion of a tube support system for a nuclear steam generator, in which closely packed serpentine tubes 1 are utilized to transfer heat from a liquid metal, such as sodium, which is introduced into the shell side of the heat exchanger to water, which is evaporated to produce steam in the tubes.

A serpentine tube bundle is formed by bending a plurality of tubes so that they may be closely packed in a group generally resembling a multiple return bend or serpentine shape. When disposed vertically in the heat exchanger, the individual tube must be repeatedly supported by the tube support system in order to prevent resonant vibration induced by the transverse flow of liquid metal around the outside of the tubes.

The support system as shown in the drawings comprises a plurality of strips or panels 3 depending vertically from a tube sheet 4 of the heat exchanger; each panel 3 is supported at its upper end and depends therefrom.

Adjacent panels are fastened together by a pin 7, which slidably fits into a vertical slot 9 in one panel and a hole 11 in the other panel. Collars 13 are fastened to the pin on opposite sides of each panel 3 allowing the panels to move vertically or lengthwise with respect to each other. The pins 7 also provide spaces between adjacent panels to allow liquid metal to flow therebetween. The holes 11 which receive the pins 7 are disposed in ears 15, which extend outwardly from the margins of every other panel 3.

The panels 3 are formed by a plurality of flat bars 17, 18 and 19 clamped or fastened together by through bolts 21 or bars plug welded at the ends. Bars 17 and 19 are the outer bars and have a plurality of notches 23 and 25, respectively, spaced longitudinally or lengthwise along one margin thereof, while bars 18 are intermediate bars having a plurality of notches 23 spaced longitudinally along one margin and a plurality of notches 25 spaced lengthwise along the other margin.

As shown in FIG. 5 the notch 23 is U-shaped formed by a semicircular opening 27 with parallel tangential extensions 29, while the notch 25 is a chordal shaped opening 31 smaller than a semicircular opening. The U-shaped and chordal shaped notches 23 and 25 cooperate to form an opening which will receive a tube, but will not contact the tube with a sharp corner or edge if the notches do not register exactly. To further prevent the tube from being contacted by a sharp edge the bars are chamfered or a radius 31 is formed on both sides of the bar adjacent the notches.

The notches 23 register with the notches 25 of an adjacent bar to provide a plurality of openings to repeatedly support a serpentine shaped tube. Thus, to assemble a serpentine tube bundle one row of serpentine tubes is laid in the notches 23 of one of the end bars 17. An intermediate bar 18 is slipped over the through bolts 21 and the notches 25 engage the tube to lock it in position. Another row of tubes is laid in the notches 23 disposed along the opposite margin of the bar 18 and another intermediate bar 18 is put in place; this continues until the bar 19 is in place and the through

bolts are tightened or bars plug welded in place to secure the tubes and form a portion of the tube bundle. The next portion of the tube bundle is formed in a similar manner, however, the bars **17** and **19** of the next panel have ears **15** which receive the pins **7**. The two portions are then assembled by inserting the pins **7** in the slots **9** and holes **11** and fastening the collars **13** to the pins **7**.

As noted in FIGS. **1** and **4** the slots **9** are disposed lengthwise at regular intervals and are formed by elongated notches in the margins of the bars **17, 18** and **19**. Besides allowing for relative longitudinal movement of the panels the slots **9** also allow liquid metal to flow from one side of the panel to the other to help distribute the flow evenly across all portions of the tube surfaces.

Lateral support is provided by a plurality of lateral support plates **35** which are fastened to an intermediate bar **18** and extend outwardly normal thereto. The lateral support plates **35** are disposed at the axis of the tube bends and have a plurality of lenthwise spaced openings **37**, which receive spacer rods or bars **39** which are disposed normal to the lateral support plates and are spaced and sized to provide generally equal spacing between the return bends of the tubes and to limit lateral movement of the tubes with respect to the support panels **3**.

As shown in FIGS. **2** and **3**, guide pins **41**, which are fastened to the heat exchanger by horizontal bars or other means, may be slidably disposed in several of the slots to prevent the long support panels **3** from vibrating in a transverse direction. The guide pins **41** have collars **43** which fasten to the guide pins **41** on each side of the panels **3** to allow the panels to move only lengthwise with respect to the heat exchanger, and to prevent the long support panels **3** from vibrating in a direction perpendicular to the panels **3**.

As shown in FIGS. **2** and **3** the tube support system may utilize multiple panels **3** in parallel relation to support the tube and have lateral support plates **35** which extend outwardly in opposite directions to maintain equal spacing between the reverse bends and to maintain the serpentine tubes in predetermined positions. The pins **7** and **41** may be chrome plated to prevent galling and to allow free lengthwise movement of the panels.

The hereinbefore described support system advantageously provides a low cost reliable system which permits adequate thermal expansion, minimizes the effect of transverse fluid flow, which causes tube vibrations, and prevents lateral tube movement. It also advantageously provides the following:

1. Off center tube holes which reduce the possibility of damaging the tubes on the sharp edges, which would be formed if the joints were made at the center of the openings, and the tube holes are chamfered to prevent the tube from contacting any sharp edge;

2. Flow holes and staggered tubes support panels, which allow sodium to flow evenly across all portions of the tube bundle;

3. Lateral tube supports which avoid the possibility of tubes bunching together or "walking" in the support holes;

4. Guide pins, which allow the supports to grow longitudinally or lengthwise due to the differential thermal expansion and minimize tube, vibration plus prevent vibration of the support in transverse direction and the guide pins are located at the outermost support panels to prevent twisting of the support assembly;

5. Utilization of stock materials for construction of the support system;

6. A streamlined shape which prevents high shell side pressure drops;

7. Panels, which can be made in half, third or less lengths to reduce stress caused by differential thermal expansion;

8. A simply constructed system, which requires a minimum amount of assembly time.

What is claimed is:

1. A heat exchanger having a tube bundle of closely packed serpentine tubes and a support system for the tubes, said support system comprising a plurality of support strips, which are disposed to repeatedly support each serpentine tube, means for fastening each support strip to an adjacent support strip in such a manner that the strips can only move lengthwise with respect to each other, and a plurality of lateral support sheets disposed normal to the strips, said support sheets having a plurality of openings spaced lengthwise along the sheet, the openings in adjacent support sheets registering and being adapted to receive a spacer which fits between adjacent rows of tubes.

2. A heat exchanger as set forth in claim **1**, wherein the strips are vertical and are fastened to the heat exchanger at the upper end thereof.

3. A heat exchanger as set forth in claim **2**, wherein the strips are also fastened to the heat exchanger at intermediate locations, said intermediate fastening being such that the strips are free to move lengthwise with respect to each other and with respect to the heat exchanger.

4. A heat exchanger as set forth in claim **1**, wherein each support strip comprises a bar having a plurality of U-shaped notches spaced along a longitudinal margin thereof and a bar having a chordal shaped notch spaced along a longitudinal margin thereof, and a plurality of bars having a series of U-shaped notches along one margin and a series of chordal notches along the opposite margin, the bars being so disposed that the U-shaped notches register with the chordal shaped notches providing an opening which will accept a tube.

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