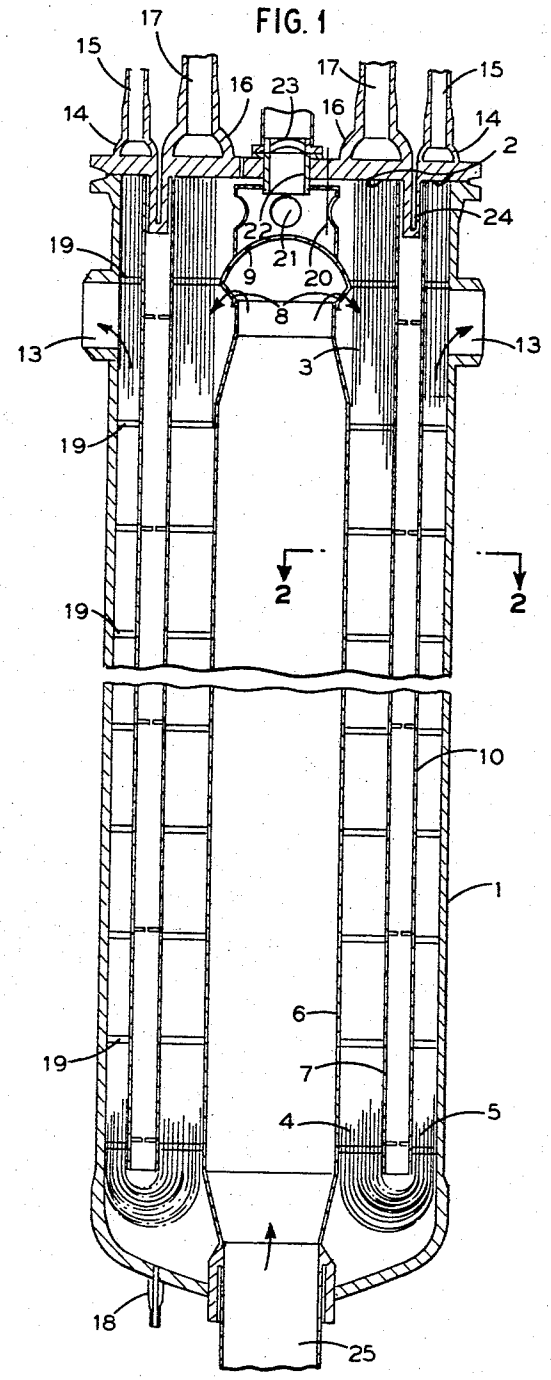
Aug. 1, 1967 A. N. CHARCHAROS 3,333,630

UNIFORMLY SPACED TUBE BANKS

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FIG. 1



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UNIFORMLY SPACED TUBE BANKS

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FIG. 2

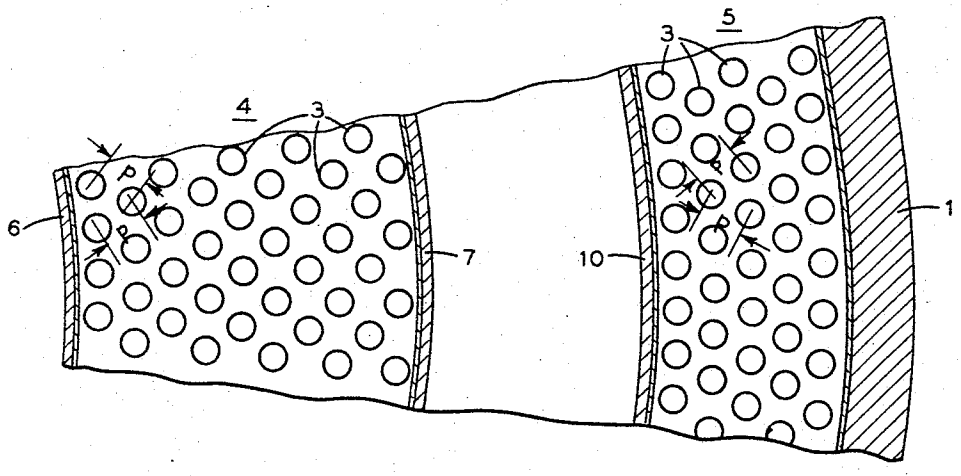
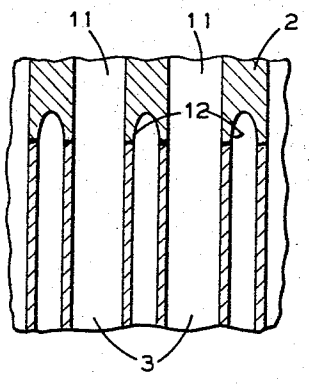


FIG. 3



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UNIFORMLY SPACED TUBE BANKS

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4 Claims. (Cl. 165—158)

This invention is concerned with heat exchangers and more particularly is directed to the disposition of an annular bank of tubes in a heat exchanger, and the arrangement of the openings in a tube plate to which the tubes may be connected.

In a heat exchanger containing parallel tube lengths, there is usually a minimum tube spacing that must be observed if the heat exchanger is to operate at its maximum efficiency. It is also usually preferable to contain the maximum heat exchanging surface in the minimum overall volume so that it is desirable to exceed this spacing to the minimum possible extent.

Satisfying these two desiderata simultaneously becomes difficult when the tubes of the heat exchanger are to be arranged in an annular array and it has been suggested that the axes of the tubes, and the axes of the openings in tube plates to which the tubes are connected, should be arranged in an involute pattern. Marking out and setting up to comply accurately with such a pattern is not, however, easy.

According to the present invention there is provided a heat exchanger having straight parallel tube lengths arranged in an annular bank with their axes lying in a group of concentric circular, or circularly arcuate, rows, the separations between the axes in any row being uniform and an axis in each row being equidistant from two axes that are adjacent to each other in the bordering circular row or rows. The distances between an axis in any row and each of the two adjacent axes in the bordering row or rows are equal.

Also, according to the present invention, there is provided a tube plate having openings arranged so that the axes of the openings lie in a group of concentric circular rows, the separation between the axes in any row being uniform and an axis in each row being equidistant from each of the two adjacent axes in the bordering row or rows.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

Of the drawings

FIGURE 1 is a sectional side view through the centerline of a superheater,

FIGURE 2 is an enlarged sectional plan view along 2—2, FIGURE 1, of a portion of a superheater showing the disposition of the tubes therein, and

FIGURE 3 is an enlarged sectional side view showing end portions of the tubes welded to a portion of the tube plate.

In FIGURE 1 a superheater is illustrated comprising a vessel **1** closed at one end by a tube plate **2** and containing a plurality of U-tubes **3**. The vessel **1** has an inlet **25** and two outlets **13** for a heating fluid such as liquid sodium.

Each U-tube **3** has one limb as a tube length in an annular space **4** and the other limb as a tube length in an annular space **5**. The annular space **4** lies between cylindrical baffles or partitions **6** and **7**. The cylindrical partition **6** is sealed at its lower end to the inlet **25** and at its upper end has outlets **8** beneath a domed cover **9**. The cylindrical partition **7** is sealed at its upper end to the tube plate **2**. The annular space **5** lies between the wall of the vessel **1** and a cylindrical baffle or partition **10**, which is sealed to the tube plate **2**.

In FIGURE 2 the axes of the limbs of the U-tubes **3** are shown arranged in concentric circular rows in the annular spaces **4** and **5**. The separations between the axes in any row are uniform, with the separations of the innermost row in the annular space **4** being P inches and the uniform separation in the other rows increasing outwardly therefrom progressively. The separations of each axis in each row from the axes adjacent to it in the bordering row or rows are equal to one another and are made P inches by placing the circular rows closer to one another as their radii increase. As each tube length in the annular space **4** is one limb of a U-tube having the other limb as a tube length in the annular space **5** it is necessary to provide an equal number of tube lengths in each of the annular spaces **4** and **5**. An equal number of tube lengths in the annular spaces **4** and **5** is facilitated by spacing the tube lengths in radially extending rows with the tube lengths in adjacent radially extending rows staggered relatively to one another and with the angle between adjacent radial rows in the annular space **5** equal to half the angle between adjacent rows in the annular space **4**. An equal number of tube lengths in the annular spaces **4** and **5** is then achieved by making the number of tube lengths in a radially extending row in the annular space **4** equal to the number of tube lengths in two adjacent radially extending rows in the annular space **5**. In this embodiment the angle between radially extending rows of five tube lengths in the annular space **4** is B° whilst the angle between alternate, radially extending rows of two and three tube lengths in the annular space **5** is $B°/2$. The tube length nearest to the partition **10** of two adjacent radially extending rows in the annular space **5** is joined by a U-bend to the tube length nearest to the partition **7** in a radially extending row in the annular space **4**. The next tube length disposed outwardly from the partition **10** of the two adjacent rows is joined by a U-bend to the tube next length disposed inwardly from the partition **7** and so on until each of the tube lengths in the two adjacent rows in the annular space **5** are joined to a tube length in the annular space **4**.

In FIGURE 3 the open ends of tube lengths of three U-tubes **3** are shown welded to the tube plate **2** with the bores of the tube lengths communicating with openings **11** which extend through annular extensions **12** to the top side of the tube plate **2**. Each of the tube lengths of the U-tubes **3** is welded to an opening in the tube plate **2** in this manner. The openings **11** in the tube plate **2** which communicate with the tube lengths in space **4** are connected by a header in the form of an annular semi-toroidal cover **14** to pipes **15** and the openings **11** in the tube plate **2** which communicate with the tube lengths in the space **5** are connected by a header in the form of an annular semi-toroidal cover **16** to pipes **17**.

In FIG. 1 the vessel **1** is provided with a drain **18** and tube support grids **19**. The upper end of the partition **6** at line **9** is attached to a cap **20** containing ports **21**. The cap **20** is connected through a sliding joint with the sleeve **22** which passes through and is welded to the tube plate **2**. The sleeve **22** is sealed by two bursting discs **23**. The tube plate **2** has an annular expansion joint **24** serving to allow movement of the concentric parts of the plate **2** relatively to each other in the direction of the axis of the vessel **1**.

In operation a heating fluid such as liquid sodium is passed into the opening **25**, flows up within the partition **6** then down the annular space **4** and up the annular space

5 and emerges from the vessel at the outlets 13. Steam is passed through the pipes 15 into the tube lengths in the annular space 5, round the U-bends and up the tube lengths in the annular space 4 to the pipes 17. During passage along the U-tubes 3 the steam is superheated by the liquid sodium which is circulating through the vessel 1 over the tubes.

If desired the tube lengths may occupy portions of the annular spaces 4 and 5 only, which are circularly arcuate and may be circularly arcuate portions which are equally spaced round the annular spaces 4 and 5 with each circularly arcuate portion containing an equal number of tube lengths.

The innermost circular row of tube lengths in the annular space 4 need not be spaced at a distance equal to the spacings between a tube length in a row and the nearest tube lengths in an adjacent row and if desired a different circular row of tube lengths may be so spaced.

The tube lengths need not be joined to form U-tubes 3 but may convey the steam from one tube plate at the bottom of the pressure vessel to another tube plate at the top thereof. In this instance the tube lengths in the annular space 5 may be omitted and the vessel 1 made correspondingly smaller in diameter to house the tube lengths in the annular space 4 only. The lower tube plate may be a sliding fit in the lower end of the vessel 1 and be fitted with a domed header on its lower side. The domed header may connect the tube bores to a pipe passing through the lower end of the vessel 1 by means of a flexible bellows.

In the embodiment shown in the accompanying drawings the inner most circular row is one wherein the axes of the tubes are spaced apart P inches and similarly the outermost row, if such a number of tubes is required, is preferably one in which the distance between its tubes and the adjacent tubes in the next inner row is equal to P inches. If further circular rows of tubes are required they are preferably arranged so that the distances between adjacent tubes in radially spaced rows remains at P inches and the radical distance between the circular rows and the tube spacing for each circular row is varied.

By providing the two partitions 7 and 10 in the embodiment shown in the accompanying drawings a still layer of liquid sodium is contained between them which acts as a heat insulating layer between the liquid sodium in the space 4 and the liquid sodium in the space 5.

While in accordance with the provisions of the statutes there is illustrated and described herein a specific embodiment of the invention, those skilled in the art will understand that changes may be made in the form of the invention covered by the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of the other features.

What is claimed is:

1. A heat exchanger comprising:

(A) a vertically elongated pressure vessel,

(B) vertically extending baffle means dividing said pressure vessel into an inner annular space and an outer annular space,

(C) tube sheet means having a plurality of tube openings therethrough disposed within said vessel,

(D) heat exchanger means comprising an annular shaped bank of U-tubes, each tube of said bank comprising a first leg located in said inner annular space and a second leg located in said outer annular space joined by a U-bend at the ends of said legs opposite said tube sheet means, with the other ends of said legs disposed within the tube openings in said tube sheet means,

(E) said vessel having an inlet, an outlet, and means for passing a heat transfer fluid therethrough over said U-tubes,

(F) the legs of each of said tubes in said bank being substantially straight and parallel to one another, and arranged in concentric circular rows,

(G) the axes of the legs of the tubes in each circular row being uniformly spaced from one another, and each tube leg axis in each of said rows being equidistantly spaced from the nearest two mutually adjacent axes in the, or either, bordering circular row; whereby the distance between any axis in a row and each of the nearest two mutually adjacent axes in any bordering circular row is the same as the distance between any other axis in any other row and each of the nearest two mutually adjacent axes in any circular row bordering said other row.

2. A heat exchanger as set forth in claim 1 wherein a cylindrical partition is disposed in said vessel within the annular bank of tubes.

3. A heat exchanger as set forth in claim 1 wherein the annular bank of tubes is comprised of a number of concentric rows in said inner annular space and said outer annular space, the tubes within said inner annular space arranged in a plurality of radial rows, the tubes within said outer annular space disposed within a plurality of radial rows, the angle between adjacent radial rows within said inner annular space being twice that of the angle between adjacent radial rows within said outer annular space.

4. A heat exchanger as set forth in claim 1 wherein said inner annular space and in said outer annular space, the spacing between tubes in a concentric circular row increases as the rows progress outwardly from the radially inner boundary to the radially outer boundary of the space and at the same time the spacing between bordering concentric circular rows decreases as the rows progress outwardly whereby the distance between a tube in one circular row and the adjacent tubes in bordering circular rows are equidistant.

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