Sept. 3, 1957 W. A. KATHOLI 2,805,049

HEAT EXCHANGER TUBE SPACERS

Filed Jan. 27, 1954 2 Sheets-Sheet 1

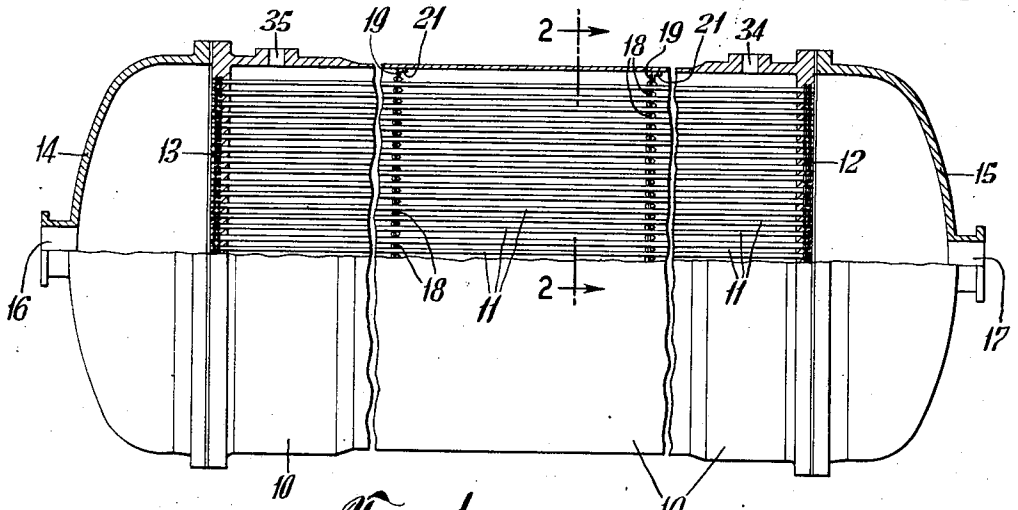


Fig. 1.

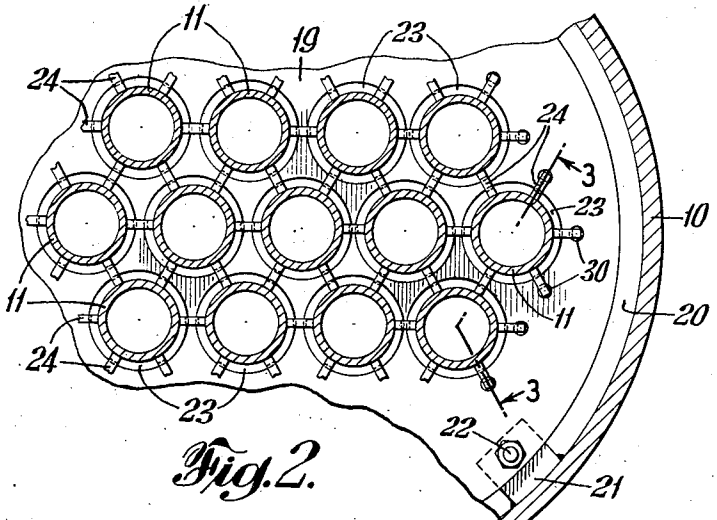


Fig. 2.

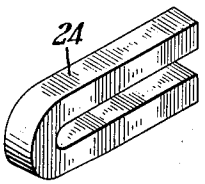


Fig. 4.

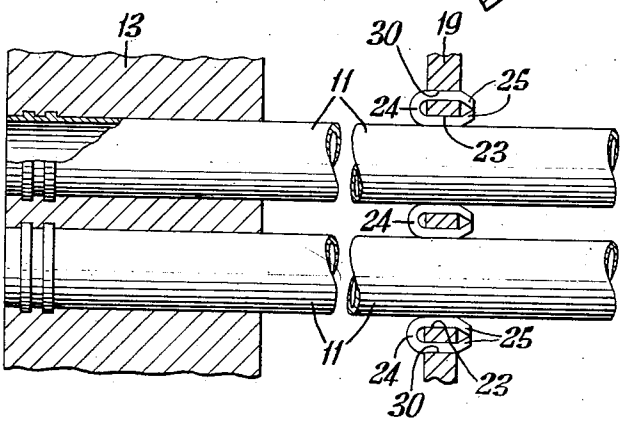


Fig. 3.

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Sept. 3, 1957 W. A. KATHOLI 2,805,049

HEAT EXCHANGER TUBE SPACERS

Filed Jan. 27, 1954 2 Sheets-Sheet 2

Fig. 5.

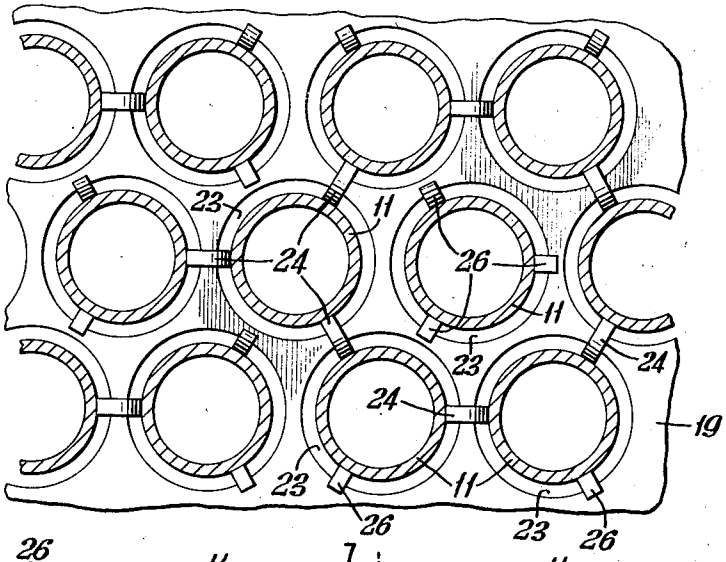
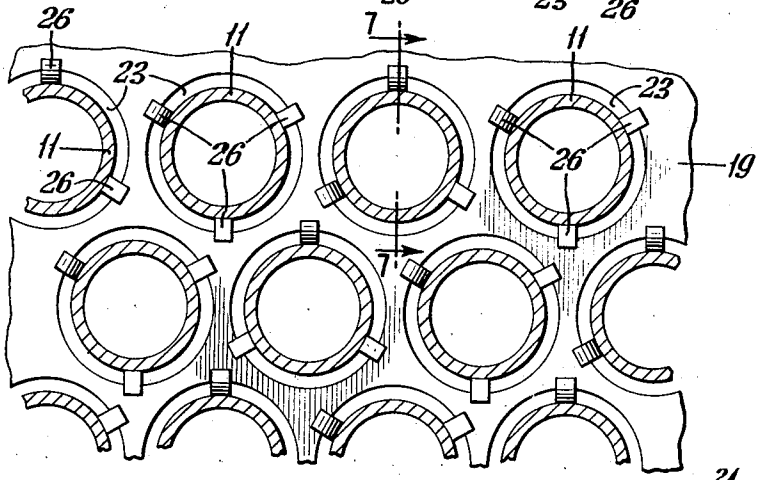


Fig. 6.



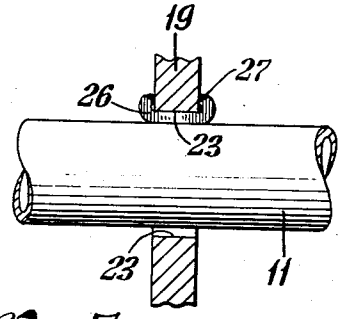


Fig. 7.

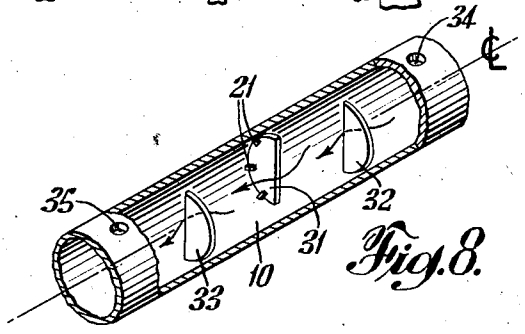


Fig. 8.

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HEAT EXCHANGER TUBE SPACERS

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Application January 27, 1954, Serial No. 406,405

15 Claims. (Cl. 257—236)

This invention relates to tube spacers for heat exchangers such as converters and has for an object to provide an improved device of this class which is capable of supporting and spacing heat exchanger tubes so that less flexure may occur in them due to vibrations from causes within them or without, which is capable of providing ample space for the longitudinal flow of tempering fluid within a shell and outside the tubes, which is capable of having the tube sheets of substantially less thickness especially when in use the tubes are under a compressive stress tending to aggravate any flexural tendency in the tubes, and which is capable of eliminating the disadvantages which prior efforts at supporting and spacing such heat exchanger tubes have possessed.

Heretofore the tube supports that have been used and suggested have not been satisfactory. Such a support must provide as its name implies adequate support for not only one tube but all of them, tend to oppose vibration or flexure in them, yet permit adequate flow of shell fluid along the tubes for efficient heat transfer between the fluids within the shell and tubes. One prior suggestion was a spoked wheel type washer around a tube to space it from adjacent tubes, but such was found to be unsatisfactory when the heat exchanger tubes were horizontal. A more satisfactory type of support for the tubes was known as the cloverleaf design in which spaced fingers to contact each tube were cut in a plate. This provided more space around a tube by having the supporting plate perforated in a manner to provide several finger projections which touch each tube surface, but such construction was of prohibitive cost in manufacture. In brief the simple and inexpensive suggestions were either inefficient by obstructing the desired flow of shell fluid or were not mechanically strong enough to support the cumulative flexure in all the tubes. These disadvantages are now believed to have been eliminated for the first time in a simple construction that is both rugged and efficient for its intended purpose.

Specifically, according to this invention supporting plates are arranged within the shell at a distance apart of not more than sixty times a tube diameter. Around each tube is a perforation larger than the tube by a convenient amount such as about 25% of the tube radius. Instead of having integral fingers spacing the tube from the edge of the perforation as was done in the cloverleaf design, separate flat faced or round pins are placed transversely of a sheet before the tubes are inserted and held in place against angular and longitudinal displacement. Such pins provide adequate bearing surface against the outer surface of a tube without danger of any edge cutting into a tube. As tight a fit as is desired can be obtained by selection of appropriate thickness for the pins radially of a tube. In a preferred form the pin is of U shape with the leg portions located in adjacent perforations. Such has the advantage of keeping the pin or U clip held against displacement angularly without the necessity for welding it to the supporting plate. To retain this same clip against longitudinal displacement the unconnected end portions are bent toward one another.

The preferred embodiment contemplates the use of a support plate covering most of the cross section of the shell. The relatively large open spaces around the plate periphery and within the perforations around each tube obstructed only by the spacing pins, allow ample space for the longitudinal flow of tempering fluid. These full circular plates may be spaced at sixty times the tube diameter. Thus in a heat exchanger having a length of one hundred twenty times a tube diameter, one plate between tube sheets would be sufficient. A modification of this arrangement may be made by using semicircular support plates covering alternate halves of the tube bundle. Thus, in an exchanger having a length of one hundred twenty times the tube diameter, one support plate covering half of the shell cross section would be placed in the center, and midway between this center half-plate and each end are complementary half-plates covering the opposite half of the shell cross sectional area. These half-plates would not be serving a baffle function of channeling the tempering fluid transverse to the tubes since the main flow would still be longitudinal to the tubes as in the case of the full diameter support plate. This modification would, however, allow support plates of non-weldable material to be made from sheets of half the size required for a full diameter plate.

Referring to the drawings Fig. 1 is an elevation partly in section of a heat exchanger embodying this invention. Fig. 2 is an enlarged view at the section line 2—2 of Fig. 1. Fig. 3 is a section on the line 3—3 of Fig. 2. Fig. 4 shows a detail of one of the spacing clips before being inserted between a tube and the spacing plate. Fig. 5 is a view corresponding to Fig. 2 but of an embodiment of this invention in which both the double pins of Fig. 4 and the single pins of Fig. 7 are used. Fig. 6 is a view corresponding to Fig. 2 and Fig. 5 but showing still another embodiment of this invention in which all the spacing pins are of the single type shown in Fig. 7. Fig. 7 is a section on the line 7—7 of Fig. 6. Fig. 8 shows a schematic arrangement of the semi-circular supporting plates without the tubes being shown.

As shown in Fig. 1 this heat exchanger comprises a shell **10**, with tubes **11** expanded into tube sheets **12** and **13** at their ends. Heads **14** and **15** are for the ingress and egress of fluid passing through the tubes **11**. Some convenient type passageways **16** and **17** connect with each of the heads **14** and **15**. One or more tube supporting and spacing means **18** are provided for at least every length of the tubes **11** equal to 60 tube diameters.

In this invention the tube supporting and spacing means **18** comprises a plate **19** radially supported from the shell **10** by a space **20** to permit longitudinal flow of shell fluid. Preferably each plate **19** is secured to the shell by an L-shaped bracket **21** welded to the shell for having the plate **19** attached thereto by a bolt **22** as shown in Fig. 2. Each plate **19** is provided with a plurality of perforations **23** larger than the outside diameter of each tube to allow shell fluid to pass longitudinally as well as transversely of the tubes. Each tube **11** is spaced from the supporting plate **19** by a number of U-shaped clips **24**, or pins. As shown in Fig. 2 each clip spans a plate portion between a pair of plate perforations **23** at a location where the spacing between these perforations is a minimum. In this way each spacing clip **24** is retained against angular displacement.

As shown in Fig. 3 the tubes **11** are expanded into a tube sheet **13** in some accustomed manner. The open or unconnected ends of each spacing clip **24** are bent until substantially touching one another as shown at **25**. This bending preferably takes place before the tubes are inserted. To prevent the sides of the spacing clip bowing radially inward toward a center of a perforation **23** during the bending of the end portions **25**, a mandrel of

appropriate size may be inserted between the pins to hold them longitudinally contiguous to the sides of the perforations **23**. As many as six spacing clips are used around each tube. Where no perforations **23** are located adjacent the periphery of the supporting plate **19** small perforations **30** are made for one side of a clip **24**.

In the embodiment illustrated in Fig. 5 three instead of six spacing pins are used. Some of the tubes **11** have all pins of the U or double type **24** shown in Fig. 4. Other tubes have all pins of the single type **26** shown in Fig. 7. Either or both types may be used wherever convenient. However, where the single pins **26** are used then to prevent their becoming angularly displaced from their intended position it will be found desirable to weld at least one end of a pin **26** to the plate **19** as shown at **27** in Fig. 7.

The embodiment illustrated in Fig. 6 is like that in the preceding Fig. 5 except that all the pins are of the single type **26** and each is welded at one end. Any number of either single or double pins may be used. Either three or four such pins have been found convenient. Preferably no more than six spacing pins per perforation **23** are used because a larger number tends to obstruct the flow of shell fluid longitudinally along each tube.

In Fig. 8 is shown an arrangement for the tube supporting plates in the shell **10** without the tubes, tube sheets, and heads being shown. In this embodiment it is assumed the tubes have a length between tube sheets of 120 times the tube diameter. A semi-circular supporting plate **31** is placed at a mid-position between the tube sheets and is of a size to support the tubes in a left side cross section of the shell. Semi-circular tube supporting plates **32** and **33** are each located midway between the center plate **31** and a tube sheet. As illustrated these plates **32** and **33** support the tubes in the right or complementary half of the shell cross section. In this way each tube is supported so that not over sixty diameters of its length is unsupported. The supporting brackets **21** are shown diagrammatically in Fig. 8. The arrows in Fig. 8 indicate how a major portion of the shell fluid entering the shell through an opening **34** adjacent one head may pass out an opening **35** adjacent the other head. These openings for shell fluid ingress and egress may be located at either the top, bottom or sides or one disposed 180° from the other, as is well known in the heat exchanger art.

Heat exchangers embodying this invention have been built in two sizes. In one size the tubes are 25 ft. long between tube sheets and the shell 10 ft. in diameter inside the shell. In the other size the same length is used but the inside diameter of the shell is 11 ft. 6 in. As stated previously the pins or clips **24** and **26** are preferably secured in place before the tubes are passed through the supporting plates. One tube sheet is secured to the shell, the support plates with accompanying pins or clips are installed, the other tube sheet is secured to the other end, and the tubes are threaded from one end to the other and their ends are expanded within both tube sheets as is well known in this art.

Among the advantages of this invention may be mentioned that an efficient heat exchanger of the converter type is provided having the tubes adequately supported to suppress flexure of a degree tending to loosen the tubes in the tube sheets and enabling tube sheets to be reduced in thickness roughly 40% by allowing the tubes to act as columns. Also adequate space is provided for the longitudinal movement of shell fluid along the tubes, next to the shell, and, when, semi-circular plates are used, also somewhat transversely of the tubes as shown by the curved arrows in Fig. 8, all of which makes for efficient heat transfer. By the term "converter" is meant a heat exchanger in which a chemical reaction takes place within the tubes so that the tubes are at a higher temperature than the shell, causing the tubes to be under a compressive stress. Heretofore tubular converters have usually had the tubes bent to take up their change in length due to their being at a higher temperature than the shell, but under this invention straight converter tubes have been provided. When a heat exchanger tube is under compressive stress and there is a tendency to vibrate due to a sudden change of fluid pressure within the tube, or to other causes, such vibration is likely to cause a permanent set or bend in the tube or else the vibration may loosen the fit of the tube within a tube sheet. Smaller clearances between the supporting pins and tubes are possible with this invention inasmuch as tubes not only have a snug running fit within each supporting plate but well over 50% of the cross sectional area of the shell is available for the flow of shell fluid with this invention whereby dead spots may be eliminated and sufficient heat transfer obtained with a minimum pressure drop with each of the tube and shell fluids. In one use contemplated for this converter the tubes contain a catalytic material which reacts with the tube fluid causing an exothermic reaction and resulting in the tubes being approximately 25° F. hotter than is the shell fluid, the tubes being under around 50 lb. per sq. in. of internal pressure. As soon as the tubes become heated in use and expand a tight enough fit within the supporting plates takes place so that some of the compressive stress in the tubes may be transmitted to the shell to sectionalize the stresses and reduce the total stress in both the shell and tubes. Without the large space around the supporting plates and without the large space around each tube, this invention may also be applied to a heat exchanger having segmental baffles, in which event the pins **24** or **26** may be set in recesses in each tube perforation. Its chief use however is believed to be with constructions which do not use segmental baffles but allow longitudinal flow of shell fluid along the tubes.

What is claimed is:

1. In a heat exchanger having a shell, tube sheets adjacent the ends of said shell, a plurality of tubes extending between said sheets and having their end portions secured to the sheet at each end of said shell for transmission of stress longitudinally thereof, and a head adjacent each tube sheet through which tube fluid may pass, said shell being provided with a perforation adjacent each tube sheet and through which shell fluid may pass around and along said tubes, the combination therewith of the improvement enabling less thick tube sheets to be used, especially when said tubes are under a longitudinal compressive stress, said improvement including a supporting plate for at least substantially suppressing the combined flexure of at least some of said tubes, intermediate the tube sheets, connected to but spaced from said shell, said supporting plate having a perforation around each tube passing through it with some of the edge portions of such perforation spaced from the tube, spacing and supporting pins between each tube and said plate and extending transversely of said plate, and means for retaining each pin against longitudinal and angular displacement with respect to the tube with which it contacts.

2. A heat exchanger according to claim 1 in which said pins have their end portions bent to preclude their removal longitudinally of said tubes in either direction.

3. A heat exchanger according to claim 2 in which said pins are of general U shape with their unconnected ends bent toward one another.

4. A heat exchanger according to claim 3 in which a number of said U-shaped pins have their side portions passing through adjacent perforations in said supporting plate.

5. A heat exchanger according to claim 1 in which at least two tube supporting plates are located intermediate the tube sheets and each such supporting plate is substantially semi-circular in shape.

6. A heat exchanger according to claim 1, in which a major portion of each plate perforation is open for the flow of shell fluid therethrough longitudinally of its tube, and in which the number of pins between each tube and

its supporting plate is from 3 to 6, and each plate perforation is spaced from its tube by about the thickness of said pins.

7. A heat exchanger according to claim 1 in which at least a portion of certain of said pins extends through respective smaller perforations offset from a plate perforation.

8. In a heat exchanger of the type having a plurality of elongated tubes, a sheet at each end of said tubes to which they are anchored for transmission of stress longitudinally of said tubes, means whereby fluid may be supplied to and withdrawn from said tubes, a shell around said tubes, means whereby a fluid may be supplied to and withdrawn from the space within said shell and around the outside of said tubes, and at least one plate between the tube sheets through which at least some of said tubes are passed for supporting and spacing said tubes passing through it, the combination therewith of the improvement for supporting and spacing such tubes in a simplified manner while offering less of an obstacle to the flow of a tempering fluid longitudinally of said tubes and outside of them, said improvement including said tube supporting and spacing plate being provided with a plurality of perforations through which tubes are passed with the walls of each such perforation, spaced from, and substantially coaxial wtih the tube passing therethrough, and bifurcated spacing and supporting clips respectively passing through two adjacent perforations with side portions of said clip in different perforations and each side portion of a clip extending longitudinally of the tubes between a tube and an edge of a plate perforation, each clip having its side portions connected at one end by a bridging portion extending across a narrow portion of said spacing and supporting plate between adjacent perforations, and the opposite ends of said clip from said bridging portion being bent toward one another to retain said clip against being withdrawn, whereby ample space is provided for the longitudinal fluid flow around each tube.

9. A heat exchanger according to claim 8 in which at least six clips are spaced substantially equidistantly from one another, and the opposite side portions of each clip are flattened for cooperation with a tube and a wall of said perforations.

10. In a heat exchanger of the type having a plurality of tubes extending between tube sheets and along which a tempering fluid is passed, and a supporting and spacing plate through which at least some of said tubes pass, the combination therewith of the improvement enhancing the support of such tubes from said spacing plate while providing little obstruction to movement of tempering fluid along the tubes on the outside thereof, said improvement including said spacing plate being provided with a substantially concentric perforation around each tube, and a plurality of U-shaped clips each having one side inserted longitudinally between a tube and an edge of its spacing sheet perforation and its opposite side inserted between an adjacent tube and an adjacent edge of its spacing sheet perforation.

11. In a heat exchanger having a plurality of tubes extending between tube sheets, and a supporting and spacing plate having perforations through which at least some of said tubes pass intermediate their ends, the combination therewith of the improvement for reducing the cost of such construction while at the same time allowing ample space for the longitudinal flow of tempering fluid around and along such tubes and through said plate, said improvement including at least three longitudinal spacing members around each tube between it and an edge of said plate perforation, each such spacing member having substantially flattened opposite faces, a head at one end and an opposite end portion thereof being deformable to retain them in position longitudinally.

12. The combination with a spacing and supporting plate having a number of perforations therein arranged in rows, of a plurality of heat exchange pipes, at least some of such pipes coaxially passing through said perforations and spaced from the edges thereof, and removable spacers between each pipe and an edge of its perforation, each such spacer being held against being angularly displaced by being held in two adjacent plate perforations and being spaced angularly a substantially uniform amount from each adjacent spacer.

13. A combination according to claim 12 in which each spacer is of general U shape with its side portions spacing pipes in adjacent holes and the connecting portion between the sides of the spacer spanning the portion of said plate of minimum width between adjacent perforations whereby said spacer side portions are retained in position against angular displacement by the connected side portion in an adjacent perforation.

14. A heat exchanger comprising in combination a shell, tubes, tube sheets to which the tubes are connected at each end, a head outside of each tube sheet through which tube fluid may pass, a passageway adjacent each tube sheet by means of which shell fluid may pass, at least one supporting plate for said tubes between the tube sheets, said plate being connected to but spaced from said shell, said supporting plate having a perforation around each tube that passes through it with the edges of such perforations spaced from the tube, spacing and supporting pins extending transversely through said plate and secured thereto for positioning each tube within its plate perforation, and means for retaining each pin against longitudinal and angular displacement with respect to its tube, said means comprising each end of a pin being bent away from said tube to retain it against longitudinal displacement and at least one bent end portion of said pin cooperating with said plate to retain said pin against angular displacement.

15. In a heat exchanger of the converter type comprising longitudinal tubes adapted to be placed under compressive stress longitudinally, a shell around the tubes adapted to be placed under tension longitudinally thereof, tube sheets in which the tube end portions are anchored, a head on said shell beyond each tube sheet, the interior of each tube being connected to a space at each end of the shell between the head and tube sheet, a supply passageway for the fluid leading into one such space, a discharge passageway leading from the other such space between a head and tube sheet, a passageway leading into the shell around said tubes adjacent one tube sheet, another passageway leading from said shell from around said tubes adjacent the other tube sheet, and at least one tube supporting plate intermediate the tube sheets, the combination therewith of the improvement providing a substantially rigid support for a plurality of said tubes intermediate their ends whereby flexure of said tubes is reduced, less thick tube sheets may be provided, and longitudinal stresses in the shell and in at least some of the tubes sectionalized, said improvement including a plurality of spacing and supporting members between each tube and the edge of its supporting plate, each such spacing and supporting member extending longitudinally of its tube and transversely of its supporting plate, having its ends bent away from its tube, and held against angular displacement with respect to its tube and another spacing member for its tube, all of such spacing and supporting members contacting one tube occupying but a minor portion of the area of the plate perforation around the tube.

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