June 16, 1931. J. H. SMITH 1,809,915

CONDENSER

Filed Aug. 13, 1930

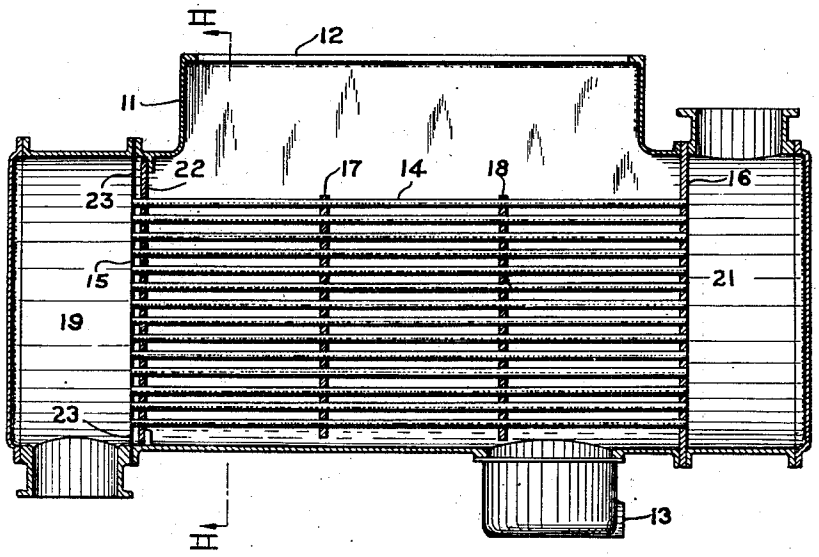


FIG. 1.

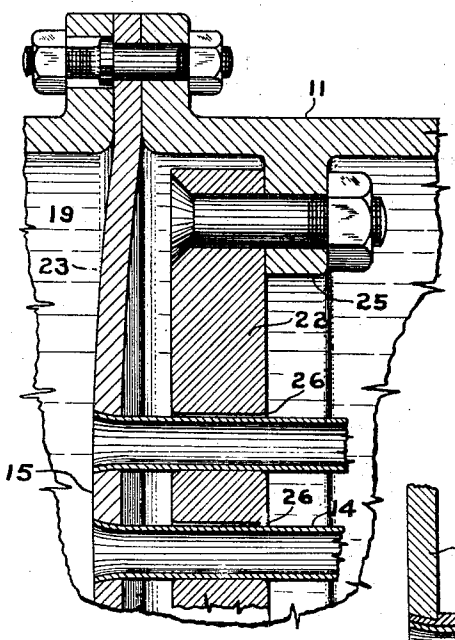


FIG. 3.

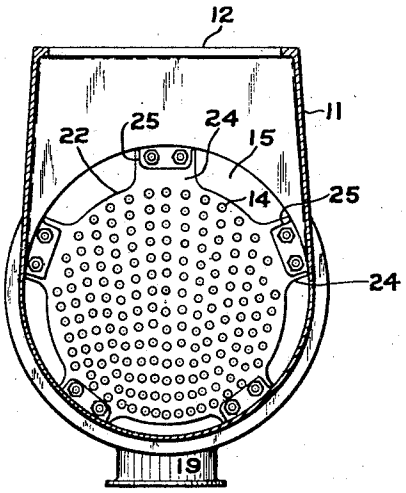


FIG. 2.

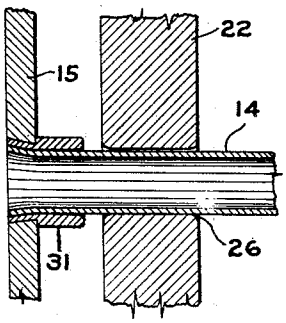


FIG. 4.

WITNESS
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Patented June 16, 1931 1,809,915

UNITED STATES PATENT OFFICE

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CONDENSER

Application filed August 13, 1930. Serial No. 475,050.

This invention relates to heat exchangers, more particularly to surface condensers, and it has for an object to provide improved means for compensating for expansion and contraction of the tubes due to temperature variations within the condenser.

In large surface condensers, it is desirable to secure the ends of the tubes in the end tube sheets by rolling, or by some other means of fixed attachment, to eliminate packed joints between the ends of the tubes and the tube sheets. It is common practice, when the tubes are rigidly secured in this manner in the end tube sheets, to provide for relative expansion and contraction between the tubes and the shell by so arranging one of the end tube sheets as to permit it to have a limited movement back and forth longitudinally of the shell. It is old to provide a relatively rigid tube sheet with a flexible diaphragm element interposed between the periphery of the tube sheet and the shell, which diaphragm element is arranged to flex to allow longitudinal movement of the tube sheet with respect to the shell. This arrangement is objectionable on account of joints, the difficulty of arranging the diaphragm with respect to condenser structure for ready inspection and repair, and severe localized loading of slidable supports on the nest.

A more simple method has been proposed which comprises utilizing a relatively thin tube sheet at one end of the condenser which will flex at its marginal portions to allow the diaphragm action. This arrangement avoids the complications of the added elements to constitute the flexible portions, but has been generally avoided in practice because a tube sheet sufficiently thin to provide the required flexibility cannot be safely relied upon to carry the weight imposed thereon by the tube nest.

I have conceived of the idea of providing a condenser which utilizes a thin tube sheet at one or both ends of the shell having the necessary flexibility, and of providing an improved arrangement in connection therewith for supporting the tubes in such a manner as to carry most of the weight which, otherwise, would be imposed on the relatively thin end tube sheet or sheets. More specifically, my arrangement comprises a relatively thin tube sheet disposed at one end of the shell and a relatively rigid tube sheet secured near to the thin tube sheet and arranged to slidably embrace each of the tubes so as to provide a support for the tube nest which will permit the latter to freely expand and contract.

With my improved arrangement, I can safely utilize a tube sheet which is sufficiently thin to permit the required diaphragm or flexing action. Heretofore, in the modern type of large surface condensers, it has been the practice to utilize end tube sheets of the order of 1¼ inches to 1¾ inches in thickness. Tube sheets of such thickness have been required because of the stresses imposed thereupon by the weight of the tubes. My arrangement relieves the end tube sheet of the necessity for carrying most of the weight and, consequently, the end tube sheet may be so proportioned as to give it the required flexibility to compensate for any relative expansion between the tube nest and shell, and in addition, compensate for any relative expansion between the different portions of the tube nest. In accordance with my invention, I may utilize tube sheets of the order of ¼ to ¾ inches in thickness.

A further object of my invention, therefore, is to provide a surface condenser having an end tube sheet which shall be so formed as to be flexed in response to expansion and contraction of the tubes and having auxiliary supporting means for the tubes comprising a relatively rigid tube sheet in engagement with each of the tubes near the flexible end tube sheet.

My improved arrangement is particularly adaptable to the radial-flow type of condenser in which the shell is radially spaced away from the tube nest about the whole circumference thereof. In this, as well as other types of condensers, the marginal portion of the sheet lying between the tube nest and the shell may constitute the flexible portion of the sheets.

A still further object of my invention, therefore, is to provide, in a type of condenser having a shell radially spaced from

the tube nest, a tube sheet adapted to flex at the marginal portions which intervene between the tube nest and the shell, and auxiliary supporting means in engagement with each of the tubes to cooperate with the flexible tube sheet to support the tubes.

These and other objects are effected by my invention, as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a view, in sectional elevation, of one form of condenser arranged in accordance with my invention;

Fig. 2 is a cross-sectional elevation taken along the line II—II of Fig. 1 and showing the method of securing the auxiliary tube sheet in the shell;

Fig. 3 is an enlarged, fragmentary view showing the intermediate tube-supporting sheet as well as the end tube sheet, with the latter in flexed position; and,

Fig. 4 is a fragmentary view of another form of condenser in which a thimble is secured in the flexible tube sheet for fixedly retaining the ends of the tubes in the latter.

Referring now to the drawings, I show a condenser of the radial-flow type comprising a shell 11 having an inlet 12 for gaseous media to be condensed and an outlet 13 for condensate. A nest of tubes 14 is disposed longitudinally within the shell 11 and fixedly secured, as by rolling, at one end in tube sheet 15 and at the other end in tube sheet 16. Intermediate their ends, the tubes are supported by intermediate tube sheets 17 and 18. An inlet water box 19 and an outlet water box 21 are associated with the end tube sheets 15 and 16, respectively, to provide for circulating cooling water through the tubes.

As heretofore set forth, when the tubes are rolled or otherwise fixedly secured at both ends in the end tube sheets, it is necessary to provide means for allowing the tubes to expand or contract with respect to the shell. In this embodiment of my invention, provision for such expansion and contraction is made by making the end tube sheet 15 relatively thin so as to permit it to flex back and forth longitudinally of the shell in response to expansion and contraction of the tubes. Most of the diaphragm action of the thin tube sheet 15 takes place in the substantially circular portion 23 lying between the interior portion of the tube sheet, in which the tubes are secured, and the marginal portion of the tube sheet or that portion which is attached to the shell.

To carry most of the weight of the tube nest which would otherwise be imposed on the thin tube sheet 15, I provide an auxiliary and relatively thick tube sheet 22 supported in the shell and located close to the end tube sheet 15. The auxiliary tube sheet 22 may be rigidly supported by radial extensions 24 which are secured to brackets 25 on the interior of the shell.

As best illustrated in Fig. 3, the auxiliary tube sheet 22 is provided with openings or holes 26 which slidably embrace each of the tubes 14 at points near the ends thereof and closely adjacent to the tube sheet 15. In this manner, the auxiliary tube sheet supports each of the tubes, prevents vibration thereof and, at the same time, permits the tube nest to freely expand and contract.

In Fig. 3, the tubes are shown as being expanded directly into holes provided in the flexible tube sheet. In cases where it is desired to have a larger bearing surface between the relatively thin tube sheet 15 and the ends of the tubes, an arrangement such as illustrated in Fig. 4 may be utilized. The additional surface is provided by rolling or welding thimble-like members 31 into suitable openings in the flexible tube sheet, which members are of greater length than the thickness of the tube sheet. The tubes 14 are rolled or otherwise fixedly secured in the bores of the thimble members and, in this way, provide increased bearing surface for the ends of the tubes.

Referring to the drawings, it will be seen that I have illustrated, in Fig. 2 the tube nest as being eccentrically disposed in the shell as in the ordinary radial-flow arrangement. Also, I have shown conventional radial spacing of the tubes, wherein the tubes are concentrated in the lower part of the tube bundle. Therefore, it will be seen that with a conventional type of radial-flow condenser the spacing of the tube nest in the shell leaves a diaphragm portion of less width at the bottom than at the top, and this would increase the stress per tube at the lower part of the nest compared to the upper part except for the increased number of stress-sustaining tubes in the lower part.

While, in the embodiment set forth and described, I have shown a flexible tube sheet at one end of the condenser and a rigid tube sheet at the other end, the contemplated scope of my invention is such as to not restrict its application to condensers having the flexible tube sheet at one end only. Also, while I have shown and described my flexible tube sheet as having uniform thickness throughout; the contemplated scope of my invention is not limited to the utilization of a flexible sheet of uniform thickness.

While I have shown my invention in but two forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What I claim is:

1. In a surface condenser, in combination, a shell, a flexible tube sheet, a plurality of tubes each fixedly secured at one end in the flexible tube sheet, and tube-supporting means in slidable engagement with each of the tubes adjacent to the flexible tube sheet.

2. In a heat exchanger, the combination of a shell, a flexible tube sheet disposed at one end of the shell, a plurality of tubes each fixedly secured at one end thereof in the flexible tube sheet, and a relatively rigid tube sheet secured in close proximity to the flexible tube sheet and providing a slidable support for the tubes.

3. In a heat exchanger, the combination of a shell, a tube sheet disposed at one end of the shell and arranged to flex at its marginal portions, a plurality of tubes each fixedly secured at one end thereof in the flexible tube sheet, a relatively rigid tube sheet secured in close proximity to the flexible tube sheet and arranged to slidably engage each of said tubes so as to support the latter.

4. The combination with a surface condenser including a shell, a flexible tube sheet having an interior portion thereof arranged to shift longitudinally of the shell and a plurality of tubes disposed longitudinally within the shell and fixedly secured at one end in said flexible tube sheet, of means independent of the flexible tube sheet and located adjacent thereto for slidably supporting each of the tubes of the nest.

5. In a surface condenser, the combination of a shell, a relatively thin tube sheet secured at one end of the shell and arranged to deflect longitudinally of the shell, a nest of tubes disposed within the shell and secured at one end in the thin tube sheet, and a relatively rigid tube sheet disposed in closely spaced relation with respect to the flexible tube sheet, said rigid tube sheet embracing each of the tubes and providing for movements of expansion and contraction thereof.

6. In a heat exchanger, the combination of a shell having an inlet and an outlet for a fluid to be circulated through the shell, tube sheets secured to the shell at its ends and intermediate of its ends, a series of tubes extending longitudinally within the shell through the intermediate tube sheets and fixedly secured at their ends in the end tube sheets, and fluid chambers associated with said end tube sheets for circulating a fluid through the tubes, one of said end tube sheets being so formed as to flex in response to movements of expansion and contraction of the tubes and one of said intermediate tube sheets being spaced a slight amount from the flexible end tube sheet and slidably engaging each of the tubes for supporting one end portion thereof.

7. In a condenser, in combination, a shell, a relatively thin tube sheet secured to an end of the shell and having an opening extending therethrough, a thimble having a length greater than the thickness of the tube sheet and fixedly secured directly in said opening, and a tube extending longitudinally of the shell and fixedly secured at one end directly in the bore of said thimble.

8. In a heat exchanger, in combination, a shell, a relatively thin tube sheet secured to an end of the shell and having an opening extending therethrough, a thimble having a length greater than the thickness of the tube sheet and having a portion thereof rolled in said opening, and a tube extending longitudinally of the shell and rolled in the bore of the thimble.

In testimony whereof, I have hereunto subscribed my name this 1st day of August, 1930.

JOHN H. SMITH.