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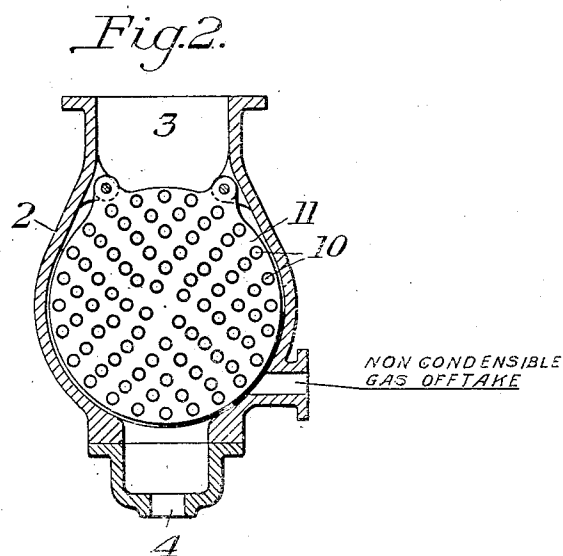
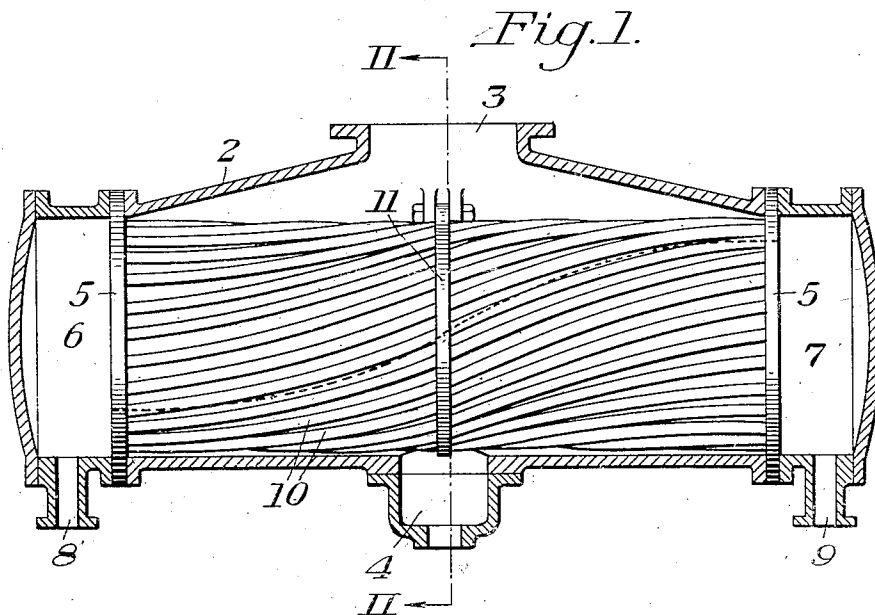
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HEAT EXCHANGER

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2 Sheets-Sheet 1



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HEAT EXCHANGER.

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The present invention relates broadly to the art of heat exchangers, and more particularly to tubular heaters, condensers, coolers or the like of such improved construction as to effectively take care of the dimensional changes of the tubes, without the consequent disadvantages of certain of the structures which have heretofore been provided for this purpose.

One type of heat exchanger constructed to take care of tube expansion as herein contemplated has embodied the so called ferrule or ferrule packing. It has been found in actual practice that ferrules screwed into or otherwise secured in a tube plate, while permitting the desired elongation of the tubes, are generally unsuitable where either high pressures or high temperatures are to be dealt with. In practice, the ferrules usually fit into receptacles in the tube plate and surround the tubes. A soft packing is generally used under the ferrules to prevent leakage, but obviously such packing is only effective for moderate pressures and temperatures. Where high temperature is encountered, it is difficult to provide a packing that will permanently maintain its sealing characteristics, although the construction is such as to effectively permit the tubes to be freely elongated due to expansion when heated. Where the pressure is high, there is likewise considerable difficulty in preventing leakage from the liquid side to the steam side of the heat exchanger. It will thus be apparent that such a construction has a limited range of use both with respect to temperature and pressure.

So called floating heads have also been used with considerable success in an attempt to solve this problem, but such constructions are not only expensive, but they are not immune from trouble where very high temperatures are encountered. Where but a single floating head is used, there is often a severe distortion thereof, due to the fact that tubes in different parts of the nest or nests are at different temperatures, and consequently, expand differently, thus unevenly straining either the tubes or the other parts of the structure. Floating head heat exchangers also have limitations with respect to the number of passes for fluid circulation. Where one head is fixed and the other floating, there is considerable difficulty in having anything but an even number of passes which in some cases prohibits the use of

such a construction. Also, since the shells must either be made considerably larger than the tube nest or else belled out at the floating head end to accommodate such head with its flanged ends, there is necessarily an increase both in the cost and the size of the resulting apparatus.

In still other cases, so called "hair pin" tubes have been used. Such a construction effectively takes care of tube expansion, but has the distinct disadvantage in that there is no convenient and effective manner of cleaning the inside of the tubes in the event they become scaled up. They do not compare in this respect with straight tube installations, in which a rod or brush can easily be run therethrough in a manner not possible with the hair pin type tubes. Such a heat exchanger also has one of the disadvantages inherent in the use of a floating head type construction in that an even number of passes is necessary.

Recourse has also been had to coiled tube heaters, but such heaters have so many limitations, both with respect to operation and construction, that the use thereof is confined to a very limited type of service. The impossibility of effectively cleaning the coiled tubes also rules them out of many places where straight tube heaters would be eminently satisfactory.

It is one of the objects of the present invention to provide a type of heat exchanger which obviates the disadvantages referred to, but in which the various advantageous features of construction and operation are retained. In the apparatus constructed in accordance with the present invention, both of the tube heads are fixed, whereby the expense of the floating head type is eliminated to a considerable extent. I am also able to do away with the packed type of tube and its consequent disadvantages, while retaining a tube shape which can readily be cleaned as compared with hair pin and coiled tube types in which complete cleaning is only possible with considerable difficulty, if at all.

In the accompanying drawings, there are shown for purposes of illustration only certain preferred embodiments of the present invention, it being understood that the drawings are largely diagrammatic and that they do not define the limits of my invention, as changes in the construction and operation disclosed therein may be made

without departing from the spirit of the invention or the scope of the broader claims.

In the drawings:

Figure 1 is a longitudinal sectional view through a heat exchanger constructed in accordance with the present invention; the tubes and heads, however, being shown in elevation;

Figure 2 is a transverse sectional view on the line II—II of Figure 1, looking in the direction of the arrows;

Figure 3 is a view similar to Figure 1;

Figure 4 is a transverse sectional view on the line IV—IV of Figure 3, looking in the direction of the arrows;

Figure 5 is a diagrammatic view illustrating the circumferential and angular progression of the tubes.

In accordance with the present invention, there may be provided a shell 2 of any desired construction and material, provided with an inlet 3 for the heating fluid and an outlet 4 for the condensate. Adjacent each end of the shell, there may be provided a rigidly mounted tube plate or head 5, there being an inlet chamber 6 adjacent one of the tube plates and an outlet chamber 7 cooperating with the other tube plate, these chambers having an inlet 8 and an outlet 9, respectively.

Arranged within the shell and extending from one of the tube plates to the other is a plurality of tubes 10, these tubes, as indicated in Figure 2, preferably being arranged in a plurality of concentric circles. In Figure 1, for the sake of clearness, only the outside circle of tubes is indicated. Instead of constructing the heat exchanger in such a manner that the tubes extend in substantially a straight line from one end of the heat exchanger to the other, the tubes are preferably of such construction that they follow substantially the path of a helix, all of the tubes in any one circle following substantially similar helical paths. This disposition of tubes necessarily involves a circumferential progression of the tubes in any of the tube circles, but this circumferential progression is such that internal cleaning may be accomplished with comparative ease. In other words, the departure of the tubes from true straightness is not so great in any instance, but that a brush or other cleaning means may easily be passed through the tubes by means of an elastic rod, or such that the well known rubber cleaning slugs or the like may be easily forced through the tubes by pneumatic or hydraulic pressure.

If desired, there may be provided a supporting means 11, conveniently in the form of a plate, cooperating with the tubes for limiting deflection thereof or limiting vibration. Such a construction is particularly advantageous where comparatively long tubes are being used. This supporting

means is preferably so located that the opening therein which embraces any particular tube will lie substantially midway in the path of circumferential progression of such tube. This is clearly shown in Figure 1 of the drawings, from which it will appear that the point where the tubes pass through the supporting plate is substantially midway between the junctures of the tubes with the tube plates, measured on the circumference of the circle in which such tubes lie. When the tubes expand, their natural deformation will be substantially as indicated by the dotted lines in Figure 1, it being apparent that, with the construction shown, there is no tendency toward the suppression of the deforming tendency caused by elongation of the tubes under temperature. In other words, a construction as herein illustrated enables the building of a heat exchange apparatus in which the supporting means while limiting deflection and restraining vibration, does not in any manner restrain the natural expansion of the tube, this expansion being in a clockwise direction adjacent one end of the apparatus and in a counter-clockwise direction adjacent the opposite end thereof.

While Figures 1 and 2 of the drawings indicate a heat exchanger having only a single pass, it will be understood that any desired number of passes is possible. It will likewise be understood that the tubes may be arranged otherwise than in concentric circles and that different tubes may have a circumferential progression either in the same or in opposite directions. In all cases, however, I preferably mount the tubes adjacent the inner portion of the heat exchanger in such manner that they make a greater angular progression than the tubes in the outer portion of the apparatus. Where the tubes are arranged in circles, it will be apparent that if the same angular progression were used in the inner circles as in the outer ones, the tubes in the inner circles would be comparatively rigid, and their resistance to expansional elongation would be too high, if the angular progression of the tubes in the outer circles were right to give the desired flexibility thereof to permit deformation under expansion without undue strains on such tubes or on the rest of the structure. This applies with equal force whether the tubes are arranged in concentric circles or are grouped in any other desired manner.

In order to clearly set forth exactly what is meant by the expression "circumferential progression" and "angular progression", it may be stated that if when facing one of the tube plates, one of the tubes be selected and its path followed to the next tube plate on the opposite end of the heat exchanger, it will be found that on the particular circle

from which the tube is selected, the tube has traveled a certain distance in its helical path. This travel is herein termed "circumferential progression". The angular progression, on the other hand, is the angular amount that any tube progresses in its helical path from end to end of its length.

In Figures 3 and 4, there is illustrated a modified embodiment of the invention for the purpose of showing the adaptability thereof to a multiple-pass heat exchanger. Where a plurality of passes is provided for, I find that it is necessary to make the two heads dissimilar with respect to the void space or spaces necessitated between the tubes by reason of the use of division walls between the different fluid passes incident to the circulation within the tubes.

In the construction illustrated in Figures 3 and 4, the header 12 has an inlet 13 and an outlet 14, the header 15 at the opposite end of the heat exchanger being merely for the purpose of directing the fluid, as indicated by the arrows. Within the header 12 is a division wall 16 of such nature as to make a two-pass heater. This division wall necessarily takes up a certain amount of space on the tube plate 5' with which it co-operates, which space would, in a single-pass heater, be utilized for the installation of tubes, as indicated for example in Figures 1 and 2. This space and the corresponding space existing between the tubes is referred to herein as the "void space", and is indicated by the reference letter S. If the division wall 16 is substantially horizontal, it will be apparent that a transverse sectional view through the tubes adjacent this tube plate, as indicated in Figure 4, will show the void space as being substantially horizontal. If all the tubes had the same angular progression, the void space on the opposite end of the condenser would have substantially the position indicated by the dotted lines S in Figure 4, thus providing tube plates which are dissimilar with respect to symmetry about the transverse axis of a heat exchanger. On the other hand, if the tubes had a constant circumferential progression, the lines S' would necessarily be curved or of irregular contour, inasmuch as a constant circumferential progression would necessarily require a greater angular progression of the tubes adjacent the center of the heat exchanger than of the tubes adjacent the outside thereof.

In Figure 5 of the drawings, there is indicated diagrammatically the condition which would obtain if a constant circumferential progression, as just referred to, were employed. In this figure, there is indicated by solid circles the row of tubes 10', starting below the void space S' on one of the tube plates. In dotted circles there is indicated the corresponding position of these tubes

on the opposite tube plate. The dotted lines S' indicate the general location of the void space on such opposite tube plate. Referring to this figure, the arrows A indicate the circumferential progression, while the angles $a b c$, etc., indicate the different angular progression of succeeding tubes by reason of the constant circumferential progression shown.

Certain advantages of the present invention arise from the provision of a heat exchanger utilizing tubes which may be easily cleaned and in which expansional elongation is permitted, while preventing leakage or other objectionable tendencies at either high temperatures or pressures.

Other advantages of the invention arise from the provision of a heat exchanger in which the tubes follow substantially a helical path from end to end.

Still other advantages of the invention arise from the provision of a heat exchanger in which the tubes have a circumferential or angular progression from end to end, and preferably, in which the angular progression of tubes adjacent the center of the heat exchanger is greater than the angular projection of tubes adjacent the outside thereof.

Still further advantages arise from the provision of an apparatus in which tubes of any desired length may be utilized and supported against deflection and vibration at a desired point, without restraining the natural tendency of the tubes to expansional elongation.

I claim:

1. In a heat exchanger, a shell, and inner and outer tubes therein, said tubes having an angular progression from end to end with certain of said tubes having a greater angular progression than other of said tubes, substantially as described.

2. In a heat exchanger, a shell, and inner and outer tubes therein, said tubes having an angular progression from end to end with certain of said tubes having a greater angular progression than other of said tubes, the tubes having the greater angular progression being located adjacent the center of the heat exchanger, substantially as described.

3. In a heat exchanger, a shell, a plurality of tubes extending substantially longitudinally of said shell and disposed in substantially concentric circles, each of said tubes having a circumferential progression in their respective circles from end to end thereof, substantially as described.

4. In a heat exchanger, a shell, a plurality of tubes extending substantially longitudinally of said shell and disposed in substantially concentric circles, each of said tubes having an angular progression in their respective circles from end to end thereof with the angular progression of the tubes in

the inner circles greater than the angular progression of the tubes in the outer circles, substantially as described.

5 In a heat exchanger, a shell, a plurality of tubes extending substantially longitudinally of said shell and disposed in substantially concentric circles, each of said tubes having an angular progression in their respective circles from end to end thereof, the
10 angular progression of the tubes gradually increasing from the outer to the inner circles, substantially as described.

6. In a heat exchanger, a shell, tube plates therein, tubes carried by said plates, and
15 supporting means for said tubes located substantially midway between said plates, said tubes being of such helical contour that when expanded in length by heat they show substantially no tendency to displace that portion of the tubes cooperating with said sup-
20 porting means, substantially as described.

7. In a heat exchanger, a shell, tube plates therein, tubes carried by said plates, and supporting means for said tubes located sub-
25 stantially midway between said plates, said tubes being of such helical contour that when expanded in length by heat they show substantially no tendency to displace that portion of the tubes cooperating with said
30 supporting means, said tube plates being rigidly fastened in position and said tubes being rigidly connected to the tube plates, substantially as described.

8. In a heat exchanger, a shell, tube plates
35 rigidly fastened thereto, and tubes rigidly secured to said tube plates, said tubes having an angular progression from end to end with the tubes adjacent the center of the nest having a greater angular progression than the
40 tubes more remote therefrom, substantially as described.

9. In a heat exchanger, tube plates, tubes carried by said plates and so positioned as to provide void spaces thereon, the void
45 spaces being located dissimilarly in relation to a plane including the longitudinal axis of the heat exchanger, substantially as described.

10. In a heat exchanger, tube plates, and
50 tubes carried by said plates, said tubes cooperating with said plates to provide void spaces so located that no similar void spaces on respective plates are in line one with the other, substantially as described.

11. In a heat exchanger, tube plates, tubes
55 carried by said plates, said tubes cooperating with said plates to provide void spaces so located that no similar void spaces on respective plates are in line one with the other, and supporting means intermediate said tube
60 plates for said tubes, substantially as described.

12. In a heat exchanger, tube plates, and tubes carried by said plates and providing a void space therebetween, said void space hav-
65 ing an angular progression throughout the length of the heater, substantially as described.

13. In a heat exchanger, tube plates, and tubes carried by said plates and providing a
70 void space therebetween, said void space having a circumferential progression throughout the length of the heater, substantially as described.

14. In a heat exchanger having spaced
75 apart heads, tubes extending longitudinally of the heat exchanger, the tubes being helical and having substantially the same curvature from head to head.

15. In a heat exchanger having spaced
80 apart heads, tubes extending longitudinally of the heat exchanger, the tubes being helical and having substantially the same curvature from head to head, and a tube support intermediate the heads.
85

16. In a heat exchanger having spaced
85 apart heads, tubes extending longitudinally of the heat exchanger, the tubes being helical and having substantially the same curvature from head to head, and a tube support in-
90 termediate the heads, the intermediate support having openings therethrough to accommodate the tubes.

17. In a heat exchanger having a head at each end, tubes extending from head to head,
95 the tubes being helical and having substantially the same curvature from head to head, but making less than a full turn from head to head.

18. In a heat exchanger having a pair of
100 spaced apart heads, tubes extending from head to head, the tubes being helical for at least a portion of their length, but making less than a full turn from head to head.

In testimony whereof I have hereunto set
105 my hand.

ROBERT L. BLANDING.