Aug. 4, 1936.

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2,049,748

HEAT EXCHANGER

Filed July 7, 1934

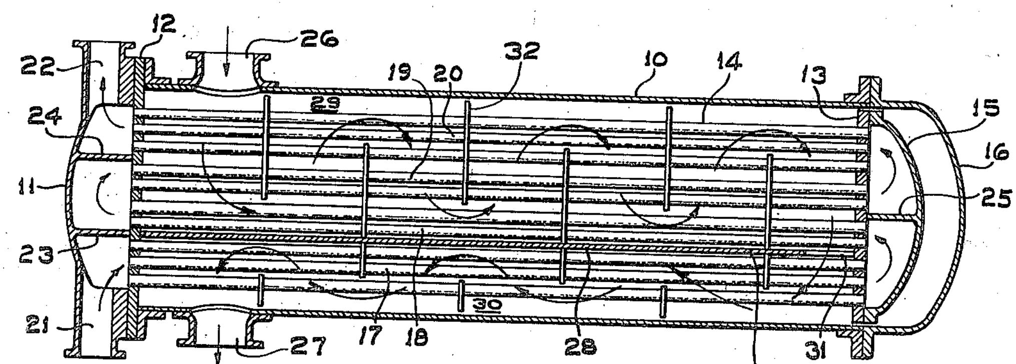

FIG. 1.

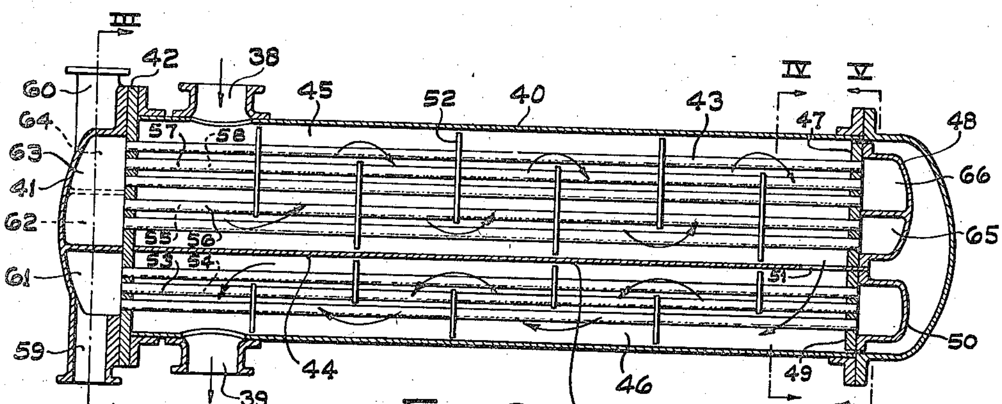

FIG. 2.

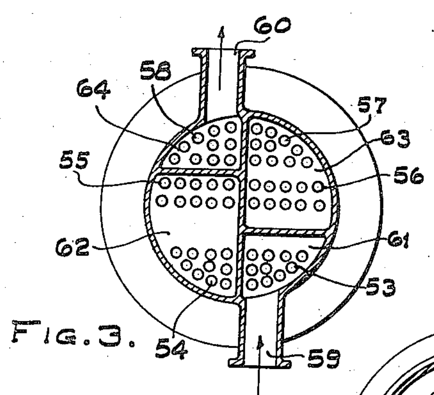

FIG. 3.

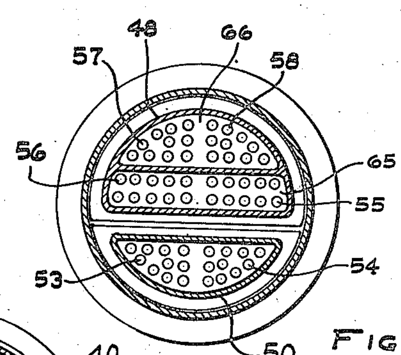

FIG. 5.

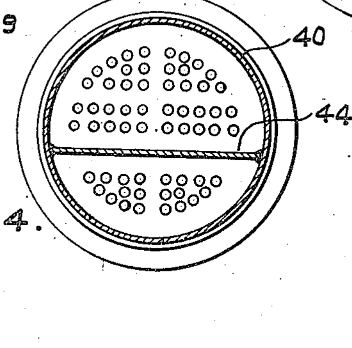

FIG. 4.

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Patented Aug. 4, 1936

2,049,748

UNITED STATES PATENT OFFICE

2,049,748

HEAT EXCHANGER

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Application July 7, 1934, Serial No. 734,095

3 Claims. (Cl. 257—239)

My invention relates to heat exchanger apparatus, more particularly to a heat exchanger in which a smaller terminal temperature difference between the two fluids is desired at one end of the flow path than at the other, and it also relates particularly to such apparatus having a floating head and a single baffle dividing the shell into two passes.

An object of my invention is to provide improved apparatus of the character set forth.

A further object is to provide smaller terminal temperature difference at one end of the flow path than at the other.

In accordance with my invention, I provide a shell, a tube bundle having a floating head, and a baffle dividing the shell into two passes. The baffle is disposed off center, toward the terminal at which minimum temperature difference is desired, providing a shell pass of greater cross section and a shell pass of lesser cross section. The tubes are divided into a plurality of tube passes, there being a greater number of tube passes extending through the shell pass of greater cross section.

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

Fig. 1 is a vertical longitudinal sectional view of one embodiment of my invention;

Fig. 2 is a similar view of a second embodiment; and

Figs. 3, 4 and 5 are cross-sectional views taken on the section lines of Fig. 2 designated by the corresponding roman numerals.

Referring to the drawing in detail, I show in Fig. 1 a heat exchanger comprising a shell 10, a stationary head 11, a tube sheet 12 adjacent the head 11, a floating tube sheet 13 at the opposite end of the heat exchanger, tubes 14 extending between the tube sheets 12 and 13, a floating head 15 secured to the tube sheet 13, and a closure member 16 for the end of the shell 10 adjacent the head 15. The tubes 14 are divided into a plurality of tube passes designated 17, 18, 19 and 20 respectively. The head 11 is formed with an inlet 21, an outlet 22, and horizontal partitions 23 and 24. The head 15 is formed with a horizontal partition 25.

The shell 11 is formed with an inlet 26 and an outlet 27 adjacent the stationary head 11. A longitudinally extending baffle 28, disposed between the inlet 26 and the outlet 27, is provided to divide the shell into two shell passes 29 and 30, extending longitudinally or parallel to the tubes 14 and communicating with said inlet and said outlet, respectively. Preferably, and as shown, the baffle 28 is in the form of a flat horizontal plate. The baffle 28 is disposed off center, in this case toward the outlet 27, thereby providing a first shell pass 29 with greater cross sectional area than the second shell pass 30. The shell pass 29 may have, for example, a cross-sectional area three times that of the shell pass 30. The baffle is formed with a slot 31, adjacent the floating head 15, to connect the shell passes 29 and 30. Baffles 32, extending transversely of the tubes, may be provided in each shell pass, to cause the fluid admitted through the inlet 26 to pass back and forth across the tubes as indicated by the arrows on the drawing. In the embodiment of Fig. 1, the baffle 28 is removable with the tube bundle, being preferably secured to the tube sheet 12.

In order to illustrate the utility of the present invention, I shall give an example of one application to which it is particularly suitable. The heat exchanger may be used to cool and partially condense hydrocarbon vapor which is admitted through the inlet 26 at a temperature of 200° F., for example, and cooled to a temperature of 90° F. Cooling water enters the inlet 21 at a temperature of 80° F. and leaves the outlet 22 at a temperature of 120° F. In this case, it is not necessary to obtain a close temperature difference between the cooling water discharged through the outlet 22 and the vapor entering through the inlet 26. However, it is desired to obtain as low an outlet temperature of the hydrocarbon fluid as is possible, in order to condense the greatest possible amount of that portion of the hydrocarbon fluid known as the lighter ends, which means that as low a temperature difference as possible should be obtained between the inlet 21 and the outlet 27.

The operation of the above described apparatus is as follows: the fluid to be cooled, such as hydrocarbon vapor, enters through the inlet 26 and flows to the right through the shell pass 29. It then flows through the slot 31 in the baffle 28 to the second shell pass 30, through which it flows to the left to the outlet 27. Cooling water enters the inlet 21 and flows to the right through the tube pass 17, opposite to the direction of flow of the hydrocarbon vapor through the shell pass 30, wherefore the tube pass 17 is designated a counterflow pass, and then through the shell passes 18, 19 and 20 successively, to the outlet 22. The flow through the tube passes 18 and 20 is counterflow or opposite to the flow of the vapor through the shell pass 29, while the flow through the tube pass 19 is parallel flow or in the same direction of flow.

In the present case, ample cooling water is provided to effect the desired cooling without a great increase in temperature of the cooling water, hence, in the shell pass 29 there is ample temperature difference to effect cooling and partial condensation of the hydrocarbon vapor.

Inasmuch as approximately three-fourths of the tubes are in the shell pass 29, and the mean temperature difference therein is greater, by far the greater percentage of the total heat load is transferred there. With the assumed conditions, approximately 90% of the heat, a portion of which is heat of vaporization of the hydrocarbon vapor, will have been transferred when the hydrocarbon fluid passes from the shell pass 29 to the shell pass 30 with a resulting temperature of 115° F. at this point. The difference between this temperature and that of the cooling water is now materially decreased. In accordance with my invention, I convey this hydrocarbon fluid through the shell pass 30 in which there is a single tube pass 17 through which the cooling water flows in the direction opposite to the hydrocarbon fluid. As the hydrocarbon fluid flows to the left through the shell pass 30 it is in contact with successively cooler water, until, adjacent the outlet 27, it is in heat exchange relation with the coolest water being admitted to the heat exchanger. Hence, the coldest possible temperature of the hydrocarbon fluid is obtained. The major portion of the hydrocarbon fluid is condensed when it passes through the outlet 27.

An analysis, taking the assumed conditions of the above example, shows that the construction shown in Fig. 1, with the baffle located off center, produces an average of the effective mean temperature differences in the two shell passes which is 30% greater than that obtained when the baffle is centrally located as in previous constructions.

In Figs. 2 to 5, I show an embodiment of my invention which is applicable, for example, when a baffle is welded to the shell and 6 or more tube passes are desired. The heat exchanger includes a shell 40, a stationary head 41 and a stationary tube sheet 42 at one end of the shell, and tubes 43 secured at one end to the tube sheet 42. The shell 40 is formed with an inlet 38 and an outlet 39 adjacent the stationary head. A baffle 44 is welded to the shell 40, dividing the shell into two passes 45 and 46, communicating with the inlet 38 and the outlet 39, respectively. The baffle 44 is disposed off-center toward the outlet 39, so as to provide a shell pass 45 of greater cross-sectional area than the shell pass 46, for example, the shell pass 45 may be twice the cross-sectional area of the shell pass 46.

Due to the fact that the baffle 44 is welded in, it is necessary to provide a split floating head and floating tube sheet. Accordingly, I show a floating tube sheet portion 47 and a floating head portion 48 which are formed to pass through the upper shell pass 45, and a floating tube sheet portion 49 and a floating head portion 50 formed to be passed through the lower shell pass 46.

The baffle 44 is formed with a slot 51 to provide communication between the shell passes 45 and 46 adjacent the floating head. Baffles 52 may be provided in each shell to cause the fluid passing through the shell passes to pass back and forth across the tube surfaces, as indicated by the arrows on the drawing.

Due to the floating head construction, it is necessary to have an even number of tube passes in each shell pass. Accordingly, I provide two tube passes 53 and 54 which extend through the shell pass 46, and tube passes 55, 56, 57 and 58, which extend through the shell pass 45. The stationary head 41 is formed with an inlet 59, an outlet 60, and partitions forming a chamber 61 for admitting cooling water from the inlet 59 to the tube pass 53, a chamber 62 for admitting cooling water from the tube pass 54 to the tube pass 55, a chamber 63 providing communication between the tube passes 56 and 57, and a chamber 64 for conveying the cooling water from the tubes 58 to the outlet 60. The floating head portion 50 comprises a single chamber for directing the flow of cooling water from the tube pass 53 to the tube pass 54. The floating head portion 48 is divided by a horizontal partition into a chamber 65 which directs the flow of cooling water from the tube pass 55 to the tube pass 56 and a chamber 66 which directs the cooling water from the tube pass 57 to the tube pass 58.

The operation of this embodiment is generally similar to that of the first embodiment. Hydrocarbon vapor or other fluid to be cooled, or cooled and condensed, is admitted through the inlet 38 at a relatively high temperature, passes to the right through the shell pass 45 and through the slot 51 to the shell pass 46, then to the left through the latter to the outlet 39. Cooling water enters through the inlet 59, passes to the right through the tube pass 53 and then to the left through the tube pass 54. The cooling water then passes through the tube passes 55, 56, 57 and 58, successively, in the shell pass 45.

Due to the fact that the volume of the shell pass 45 is twice as great as the volume of the shell pass 46, and due to the fact that there is a greater temperature difference in the shell pass 45, more than ⅔ of the temperature reduction of the fluid to be cooled will have been effected when the fluid enters the shell pass 46. The cooling water flowing through the tubes in the shell pass 46, on the other hand, having passed through but ⅓ of the tube passes when it leaves the tube pass 54, and having passed through that portion of its path in which there is the smaller temperature difference between the two fluids, has acquired not more than ⅓ of its temperature rise and, when it leaves the tube pass 54, is still at a lower temperature than the hydrocarbon fluid. Consequently, it is able to effect a relatively low temperature of the fluid discharged through the outlet 39.

From the above description, it will be seen that I have provided a heat exchanger which is particularly suitable for certain applications, namely, where it is desired to obtain the lowest possible terminal temperature difference at one end of the fluid flow while the temperature difference at the other end of the fluid flow need not be as small. It will be noted that I have provided a larger number of tube passes, some of which are counterflow and other parallel flow, in the larger shell pass in which a higher temperature difference may exist, and that I have provided a smaller number of tube passes adjacent the terminals where a lower temperature difference is desired.

While I have shown and described my invention in connection with a heat exchanger in which minimum terminal temperature difference is obtained at the cold end, it is also applicable to a heat exchanger in which minimum terminal temperature difference is obtained at the hot end. In the latter case, the baffle is disposed nearer said hot end, to provide a smaller shell pass and a smaller number of tube passes adjacent said end. It is also to be understood that my invention is applicable both to heat exchangers in which there is transfer only of sensible heat and to heat exchangers in which there is transfer also of latent heat.

While I have shown my invention in several 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. A heat exchanger comprising a shell, a stationary head at one end thereof and a floating head at the other end thereof, tubes extending between said heads, said shell having an inlet and an outlet adjacent said stationary head, a baffle disposed in said shell between said inlet and outlet and dividing said shell into a larger shell pass on the inlet side and a smaller shell pass on the outlet side, and means for circulating fluid through the tubes, first in a single counterflow pass through the tubes in the smaller shell pass from the stationary head to the floating head, and then through the tubes in the larger shell pass, the latter tubes being divided into a plurality of tube passes of which the number of counterflow passes is one greater than the number of parallel flow passes.

2. A heat exchanger comprising a shell, a stationary head at one end thereof and a floating head at the other end thereof, tubes extending between said heads, said shell having an inlet and an outlet adjacent said stationary head, a baffle disposed in the shell between said inlet and said outlet and dividing said shell into two longitudinally extending passes through which a first fluid flows successively externally of tubes therein, and means for circulating a second fluid first through tubes of one shell pass and then through tubes of the other shell pass, said tubes being arranged in the shell passes so that one shell pass contains a larger number of tube passes than the other shell pass and each shell pass has at least one counterflow tube pass and at least one of the shell passes has at least one parallel flow tube pass and one more counterflow than parallel flow tube passes.

3. A heat exchanger comprising a shell, a stationary head at one end thereof and a floating head at the other end thereof, tubes extending between said heads, said shell having an inlet and an outlet adjacent said stationary head, a baffle disposed in the shell between said inlet and said outlet and dividing said shell into two longitudinally extending passes through which a first fluid flows successively, one of said shell passes being larger than the other, and means for circulating a second fluid first through tubes in one shell pass and then through tubes in the other shell pass, said tubes being arranged in passes with the number of tube passes in the larger shell pass greater than said tubes being arranged in passes with the number of tube passes in the smaller shell pass, and each shell pass having at least one counterflow tube pass and one of the shell passes having at least one parallel flow tube pass and one more counterflow tube pass than parallel flow tube passes.

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