April 12, 1932. D. W. R. MORGAN 1,853,628

OIL STILL CONDENSER

Filed March 23, 1927 2 Sheets-Sheet 1

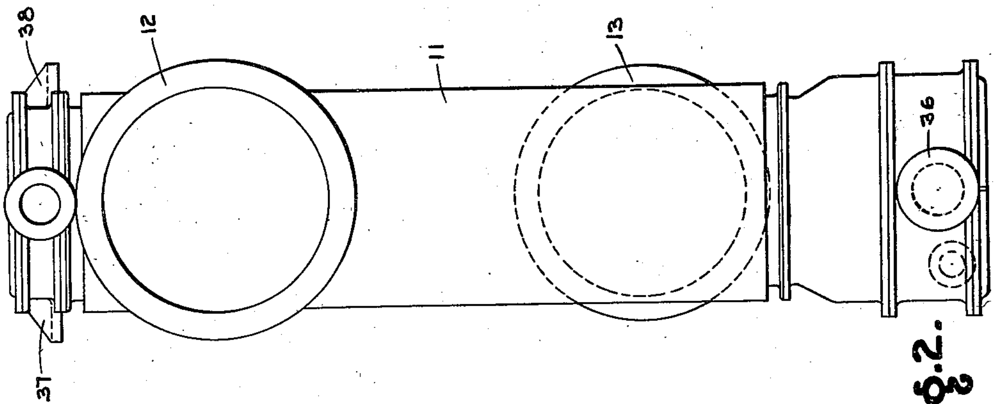

Fig. 2.

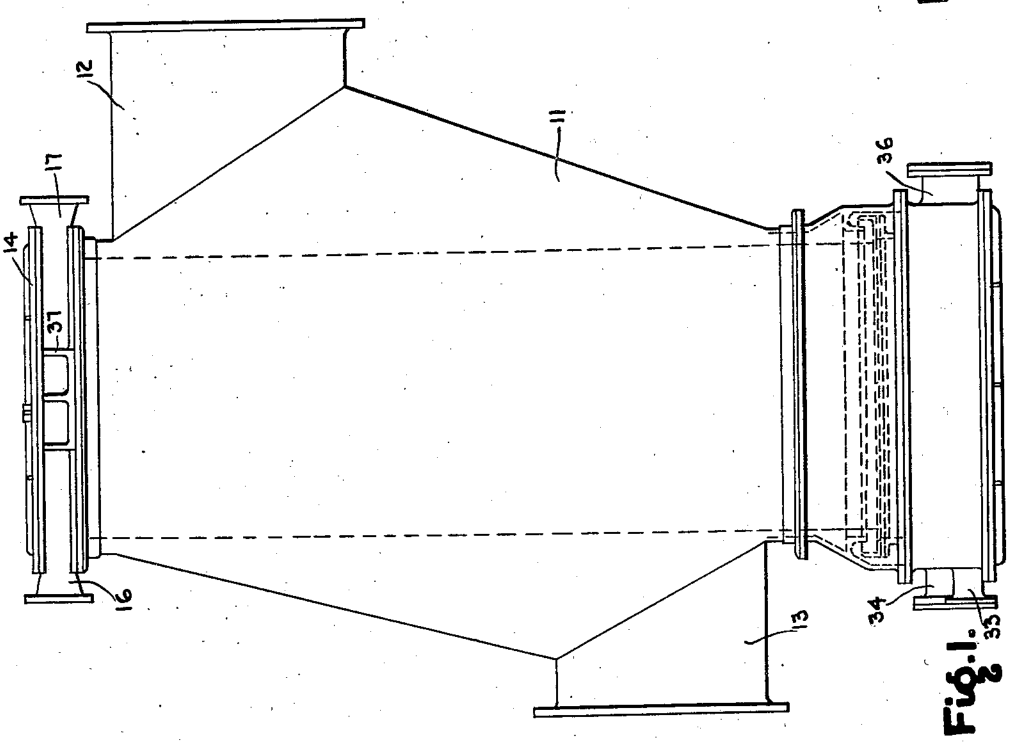

Fig. 1.

WITNESS

E. Lutz.

INVENTOR

D.W.R.Morgan

BY A. B. Reavis

ATTORNEY

April 12, 1932. D. W. R. MORGAN 1,853,628

OIL STILL CONDENSER

Filed March 23, 1927 2 Sheets-Sheet 2

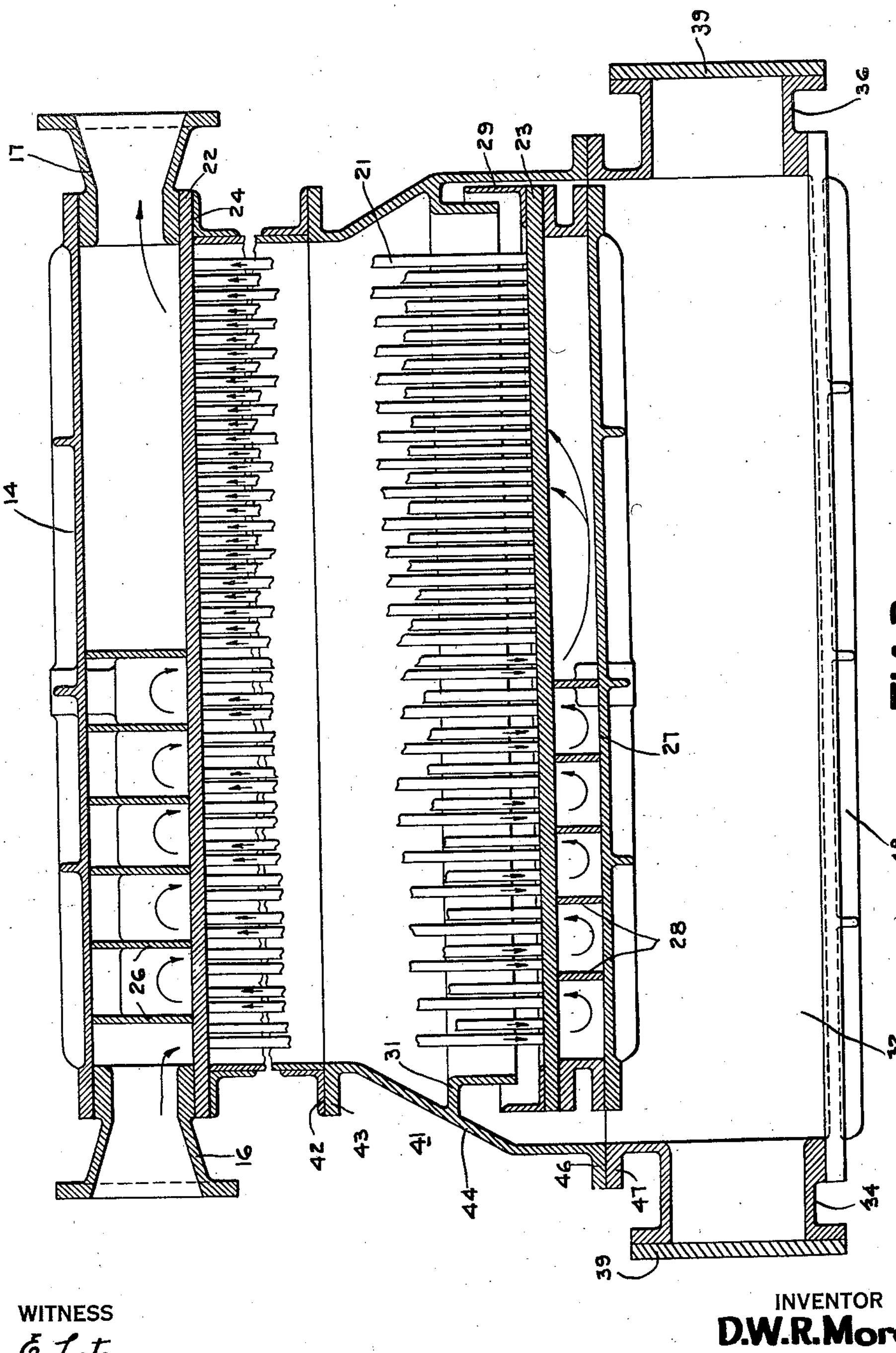

Fig. 3.

WITNESS
E. Lutz.

INVENTOR
D.W.R. Morgan
BY
A. B. Reavis
ATTORNEY

Patented Apr. 12, 1932 1,853,628

UNITED STATES PATENT OFFICE

DAVID W. R. MORGAN, OF SWARTHMORE, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

OIL STILL CONDENSER

Application filed March 23, 1927. Serial No. 177,715.

My invention relates to heat exchange devices, particularly to heat exchange devices which are especially adapted for use in the process of refining crude petroleum oil and it has for an object to provide apparatus of the character designated which shall be capable of initially heating and subsequently vaporizing the oil in a very effective and efficient manner.

It has for a further object to provide a heat exchange device which shall be adapted to use, as a heating medium, oil which has been vaporized, and it has for a still further object to provide a heat exchange device in which the heating agent passing therethrough encounters a minimum amount of resistance to flow and consequently incurs very little pressure drop.

These and other objects, which will be made apparent throughout the further description of my invention, may be obtained by the employment of the apparatus hereinafter described and illustrated in the accompanying drawings, in which:

Fig. 1 is a side elevation of a tubular heat exchanger;

Fig. 2 is an end elevation of the exchanger shown in Fig. 1; and,

Fig. 3 is a longitudinal section through the exchanger, the central portion thereof being broken away.

Briefly speaking, my heat exchange device comprises essentially a shell portion provided with a suitable inlet and a suitable outlet for the heating medium, generally oil vapor. The shell is so formed that the heating agent passes completely therethrough with a minimum amount of resistance to flow and with a minimum amount of pressure drop. Provided within the shell portion is a tube nest which is divided essentially into a heater section and a boiler or vaporizing section. The heater section preferably consists of a number of passes arranged in series, each pass consisting of a relatively small number of tubes while the boiler section is composed of only a single pass consisting of a relatively large number of tubes. Suitable means are provided for removing any oil or condensate accumulating in the shell, liquid sealing means being provided for preventing the egress of any oil vapor along with the condensate.

Referring now to the drawings, the exchanger comprises a shell 11 having an inlet connection 12 adjacent one end thereof, and an outlet connection 13 on the opposite side of the shell, and adjacent to the other end thereof. Preferably, the connection 12 is somewhat larger than the discharge connection 13, and the shell is arranged to converge from the respective connections to the opposite ends of the shell in the manner shown. Disposed within the shell, and longitudinally thereof, is a nest of tubes 21, and suitable tube sheets 22, and 23, are provided for the nest. The upper tube sheet 22 is secured to the shell in any suitable manner, such as by means of angles 24, and, secured to this tube sheet 22, is a header 14, which is provided with an inlet connection 16, and a discharge connection 17, for circulating media. The header is provided with a number of partitions 26, for directing the circulating media through the tubes in a number of passes. The partitions 26, preferably, are arranged so as to include substantially the same number of tubes in each of the first several passes through the nest, and to provide a final pass which includes a relatively large number of all of the tubes in the nest.

The lower tube sheet 23 is not secured to the shell, but is arranged to be movable, with respect to the shell, to allow for expansion and contraction of the tubes. Secured to this tube sheet 23, is a return header 27, which is provided with a number of partitions 28 so disposed as to cooperate with the partitions 26, in the upper header, in causing circulating media to pass through the tubes in a number of passes in series.

Disposed about the periphery of the lower tube sheet 23, is an upstanding wall 29, which, it will be noted, projects farther above the tube sheet on the right side in Fig. 3, or adjacent the tubes in the final pass, than is the case on the left, where this wall is adjacent to the tubes in the first pass. Extending downwardly between the wall 29 and the nest of tubes, is a wall 31, likewise surrounding the nest of tubes, and so arranged with respect to the wall 29 as to form a liquid seal, between the interior of the shell and a chamber 32 for collecting condensate.

The means which provide this chamber 32, preferably, take the form of a box-like member 41, which is adapted to be secured to the lower end of the shell in any suitable manner, as by fitting the upper flange 43, of the member 41, against the angles 42, which are secured about the periphery of the adjacent end of the shell 11.

While the member 41 may be made integral, it is, preferably, composed of an annular member 44 which diverges, or tapers, outwardly from the shell and is secured, by means of its lower flange 46, to the upper flange 47, of a box-like member 48. In this form, the annular member 44 carries the downwardly extending wall 31, and also the upper flange 43, which latter may be secured to the shell in the manner just described.

A discharge connection 33 shown in Figs. 1 and 2, for removing condensed vapors, and the like, from chamber 32, is provided in the lower portion of the box-like member 48.

The member 41 is also provided with connections 34 and 36 which may be disposed on opposite walls of this member and are, preferably, arranged in the lower portion thereof, as on the walls of the box-like portion 48. The connections 34 and 36 are of such a size as would be suitable for passing circulating media through the chamber 32, should it be desired to provide a nest of cooling tubes, or other cooling device, therein. In the form shown, however, these cooling tubes are not shown, as this provision is made for the purpose of taking care of unusual conditions and, therefore, the connections 34 and 36 are closed by securing plates 39 across these connections.

Any suitable means may be provided for supporting this exchanger, but, preferably, these means take the form of feet 37 and 38 which are provided on the opposite sides of the header 14, as shown in Figs. 1 and 2. By this arrangement, the exchanger is allowed to expand and contract as a unit, and, it will readily be seen, that the construction, which permits this, is of a simple and inexpensive character.

In the operation of the apparatus just described, circulating media to be vaporized, as for example petroleum crude oil, is passed through the inlet connection 16, of header 14, and through the several passes of the nest, which are provided by the partitions 26, and 28, in the headers 14 and 27, respectively, and finally out through the final pass, which, as shown, includes a relatively large proportion of the total heating surface of the unit. Vapor which has previously been heated is introduced, preferably through the inlet connection 12, and, due to the irregular shape of the shell, is passed through the nest of tubes and out through the outlet connection 13. The arrangement of the various elements of my device is such that, as the circulating media, such as crude oil, reaches the final pass, it is just beginning to vaporize, the velocity of flow through the first several passes not having changed to any appreciable extent. However, when vaporization begins, the velocity of flow through the tubes in this final pass is greatly and progressively accelerated due to the tremendous increase in volume of the circulating media as it changes to the vapor state. The transformation from liquid to vapor is progressive rather than instantaneous, bubbles of vapor being formed as the liquid enters the final pass increase the volume requirements and, as more and more vapor is generated with the continued application of heat, the increase in volume of the circulating media becomes so great as to considerably increase the velocity of flow through this final pass, even though it contains many more tubes than any of the previous passes.

As a result of this gradual and progressive transformation, the vaporization of the circulating media is completed in the final pass, so that the circulating media leaves the exchanger with its volume greatly increased and at a relatively high velocity. As the circulating media in the upper portions of the tubes of the final pass consists almost entirely of vapor at a somewhat higher temperature than the circulating media entering the final pass where the process of vaporization is at its initial stage, it will be clear that the lower portion of the tubes in this final pass will be capable of absorbing relatively greater quantities of heat.

In heat exchangers of the type described, the natural tendency of gaseous media, such as the heating vapor, is to flow directly across a nest of tubes and not to flow longitudinally of the nest. For this reason, it has heretofore been considered necessary to provide baffles, or other directing means in order to secure proper longitudinal distribution so that all of the tube surface will be fully effective. These baffles, and the like, necessarily, produce a pressure drop and retard the vapor flow and are objectionable for that reason.

In order to overcome these objectionable features, I have provided a shell of a special construction so that there will be a greater heat head available at the end thereof remote from the vapor inlet. This difference in heat head is sufficient to effect proper longitudinal distribution without the aid of baffles, or the like, and consequently, all of the tube surface is fully effective.

It will be clear from Figs. 1 and 2 how this difference in heat head is obtained, for it will be observed that the wall on the entrant side of the shell 11 is inclined outwardly from the tube nest in a direction toward the vapor inlet 12. This inclination of the shell wall serves to facilitate the longitudinal distribution of gaseous media to the entire length of the tube nest due to the fact that there is a greater temperature difference between the heating vapor and the circulating media in the tubes at the lower end of the tubes of the final pass than between the heating vapor and the circulating media in the upper region of the final pass. This difference in heat head is sufficient to draw the heating vapor directly from the vapor inlet 12 to the lower portion of the shell and in general to effect proper longitudinal distribution of the heating vapors before they enter the nest. Once longitudinal distribution is established, the heating vapors pass directly across the nest, thus rendering all of the tube surface fully effective.

By arranging the outlet connection 13 in a similar manner, so that the wall on the outlet side of the shell 11 is inclined outwardly with respect to the tube nest in a direction toward the outlet 13, ample provision is made for readily removing gaseous media which has passed through the nest and thus, for avoiding the formation of gas pockets or other areas of poor circulation.

In tubular heat exchangers of the type described, it is advantageous to have the circulating media, such as crude petroleum oil for example, pass through the heating section of the nest in several passes, and this is particularly true where heating media is available at a relatively high temperature, for in this way it is possible to bring about an exchange of heat more nearly in accordance with the contra flow principle, whereas, if the heating tubes are all arranged in a single pass, the heating of the circulating media is not progressive and, of course, such a heater would not involve an application of the contra flow principle and would be, comparatively inefficient. Considering my heat exchange apparatus from this view point, it will be observed that not only is ample provision made for proper vapor distribution and for proper vapor flow, but that, by arranging a relatively small number of tubes in each of the several passes of the heating section, it is possible to abstract a considerable portion of the heat remaining in the heating vapor after it passes the final pass, or boiler section. As this heat transfer is effected in accordance with the contra flow principle, it will readily be seen that a very efficient means is also provided for heating the circulating media up to its boiling point.

By the arrangement of the walls 29 and 31, about the nest of tubes, and adjacent the movable tube sheet, a convenient arrangement is provided for removing condensed vapors from the tube nest, for, while this arrangement does not in any way interfere with the expansion and contraction of the tubes, it will also be noted, that, due to the fact that that portion of the wall 29 which is adjacent the tubes in the first pass, is the lowest, any condensed media, which collects adjacent the lower tube plate 23, will flow over this lower portion of the wall first, while, of course, if the condensed vapors rapidly accumulate, provision is made for overflow about the entire periphery of the wall 29.

In normal operation, however, these condensed vapors pass only over the lower portion of the wall 29 and, consequently, set up a current in the condensate from the general direction of the tubes in the final pass to those tubes in the first pass, and, thus, it will be observed that the condensate is caused to flow in a direction counter to that in which the circulating media is passed through the tubes. In this way, a very efficient means is provided for transferring heat, from the condensed vapors, to media circulating through the tubes.

Condensed vapors, so discharged from the liquid seal, pass to the chamber 32, in which they are collected, and, if desired, may be cooled by any suitable means, as, for example, by a nest of cooling tubes (not shown). In the event that it is desired to cool the condensed vapors which collect in the chamber 32, this might be accomplished by passing raw, crude oil through the connections 34 and 36, and through the cooling tubes, as cooling media for these condensed vapors, and thus effect a preliminary heating of crude oil before it is introduced into the inlet 16.

While I have shown my invention in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various 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 tubular heat exchanger comprising a shell enclosing a vapor space and having an inlet and an outlet, a nest of tubes traversing said space, connections for passing circulating media through the tubes in a number of passes in series, a relatively large number of tubes of the nest being arranged in the final pass, a condensate removal connection, and means for providing a liquid seal between said space and said condensate removal connection.

2. A tubular heat exchanger comprising a shell enclosing a vapor space and having an inlet and an outlet, a nest of tubes traversing said space, connections for passing circulating media through the tubes in a number of passes in series, a relatively large number of the tubes of the nest being arranged in the final pass, a condensate collecting chamber, and means for providing a liquid seal

around and between said space and said condensate collecting chamber.

3. A tubular heat exchanger comprising a shell enclosing a vapor space and having an inlet and an outlet, a nest of tubes traversing said space, connections for passing circulating media through the tubes in a number of passes in series, a relatively large number of the tubes of the nest being arranged in the final pass, a condensate collecting chamber, and means for providing a liquid seal around and between said space and said condensate collecting chamber, the seal being arranged to overflow first in the portion thereof which is adjacent the tubes in the first pass.

4. A substantially vertical tubular heat exchanger comprising a shell enclosing a vapor space and having an inlet and an outlet, a nest of substantially vertically disposed tubes within the vapor space in said shell, tube sheets for the nest of tubes, one of the tube sheets being secured to the shell, the other of said tube sheets being movable with respect to the shell, connections for passing circulating media through the nest of tubes, and means for providing a liquid seal between the movable tube sheet and the shell.

5. A substantially vertical tubular heat exchanger comprising a shell enclosing a vapor space connections on the shell for passing gaseous media through the vapor space, a nest of substantially vertically disposed tubes within the vapor space, tube sheets for the tubes, one of said tube sheets being secured to the shell, the other of said tube sheets being movable with respect to the shell, connections for passing circulating media through the tubes in a number of passes in series, and means for providing a liquid seal between the movable tube sheet and the shell, the seal being arranged to overflow first from the portion thereof which is adjacent tubes in the first pass.

6. A tubular heat exchanger of the type described comprising a chamber having an inlet adjacent one end thereof, heat transfer tubes traversing said chamber, and means for directing circulating media through said tubes in several passes in series, each of said passes except the final pass consisting of a relatively small number of tubes and said final pass consisting of a relatively large number of tubes, said means being so constructed and arranged as to direct circulating media through said final pass in a direction toward said inlet, whereby an increasing heat head along the tubes in the final pass in a direction away from the inlet is obtained.

7. In heat-exchange apparatus, the combination of a shell structure having an inlet and an outlet for the circulation of media therethrough, a tube nest disposed within the shell structure and including a stationary tube sheet supporting one end of the tube nest and secured to the shell structure and a floating tube sheet supporting the other end of the tube nest and freely movable with respect to the shell structure, means for circulating heat-absorbing media through the tube nest, and means cooperating between the shell structure and the floating end portion of the tube nest for forming a liquid seal.

8. In heat-exchange apparatus, the combination of a shell structure having an inlet for media to be condensed and an outlet for the condensate derived therefrom, a nest of tubes disposed within the shell structure, an inlet connecting with one end of the tube nest for admitting heat-absorbing media thereto and an outlet connecting with the other end of the tube nest for discharging the heated media therefrom, whereby the entrant portion of the tube nest has a relatively lower temperature than the discharge portion, and means provided within the shell structure for damming up condensate about a portion of the tube nest so as to transfer heat thereto, said damming means being so arranged as to spill the condensate to the condensate outlet in the vicinity of a relatively low temperature portion of the tube nest.

9. A tubular heat exchanger comprising a shell, an inlet connection and an outlet connection on the shell for gaseous media, a nest of tubes disposed within the shell, and means for passing circulating media through the tubes in a number of passes in series, a relatively large number of the tubes of the nest being arranged in the final pass, the shell and the tubes being arranged to define a vapor passage of substantially uniform sectional area extending through the tube nest.

10. A tubular heat exchanger comprising a shell, an inlet connection and an outlet connection on the shell for gaseous media, a nest of tubes disposed within the shell, and means for passing circulating media through the tubes in a number of passes in series, some of the passes consisting of like numbers of tubes and the final pass consisting of a relatively large number of the tubes in the nest, the shell and the tubes being arranged to define a substantially straight vapor passage of substantially uniform sectional flow-area extending through the tube nest.

11. A tubular heat exchanger comprising a shell, an inlet connection and an outlet connection on the shell for gaseous media, a nest of tubes disposed within the shell, and means for passing circulating media through the tubes in a number of passes in series, a relatively large number of the tubes of the nest being arranged in the final pass, the remaining tubes of the nest being equally apportioned to the remaining passes, the shell and the tubes being arranged to direct gaseous media through the tube nest in a single pass of substantially uniform flow-area through the tube nest.

12. In heat exchange apparatus, the combination of a shell structure, a tube nest extending longitudinally through the shell structure and an inlet for gaseous media provided in a side wall of the shell structure adjacent one end thereof, said side wall being spaced away from the tube nest near the gaseous media inlet and being inclined toward the tube nest as it approaches the end of the tube nest remote from the gaseous media inlet.

13. In heat exchange apparatus, the combination of a shell structure, a tube nest extending longitudinally through the shell structure, an inlet connection for gaseous media provided in one of the side walls of the shell structure and adjacent to one end of the tube nest, and an outlet connection for gaseous media provided in an opposite side wall of the shell structure and adjacent to the other end of the tube nest, said side walls being spaced from the tube nest near their associated connections and being inclined toward the tube nest as they approach the opposite ends of the shell structure.

14. In heat exchange apparatus, the combination of a casing, a tube nest, means for supporting the tube nest in the casing and providing for movement of one end of the tube nest relative to the casing, and means including a liquid seal for effecting a fluid-tight joint between the casing and the movable end of the tube nest.

15. In a device for transferring heat from one gas to another, tubes, a casing, and means to permit relative movement between said tubes and casing, said means comprising flanges extending into liquid.

16. In an air heater, a casing, tube sheets, tubes connected to one of said tube sheets, and a slidable connection between said tube sheet and casing with a yielding closure for said connection.

In testimony whereof, I have hereunto subscribed my name this eleventh day of March, 1927.

DAVID W. R. MORGAN.