

June 28, 1938.

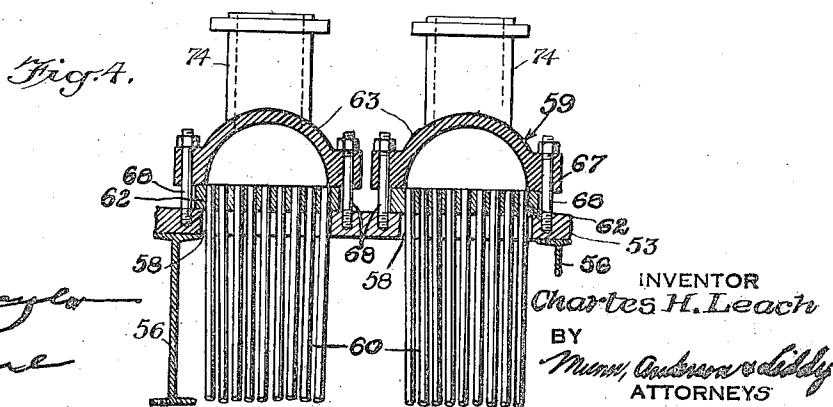
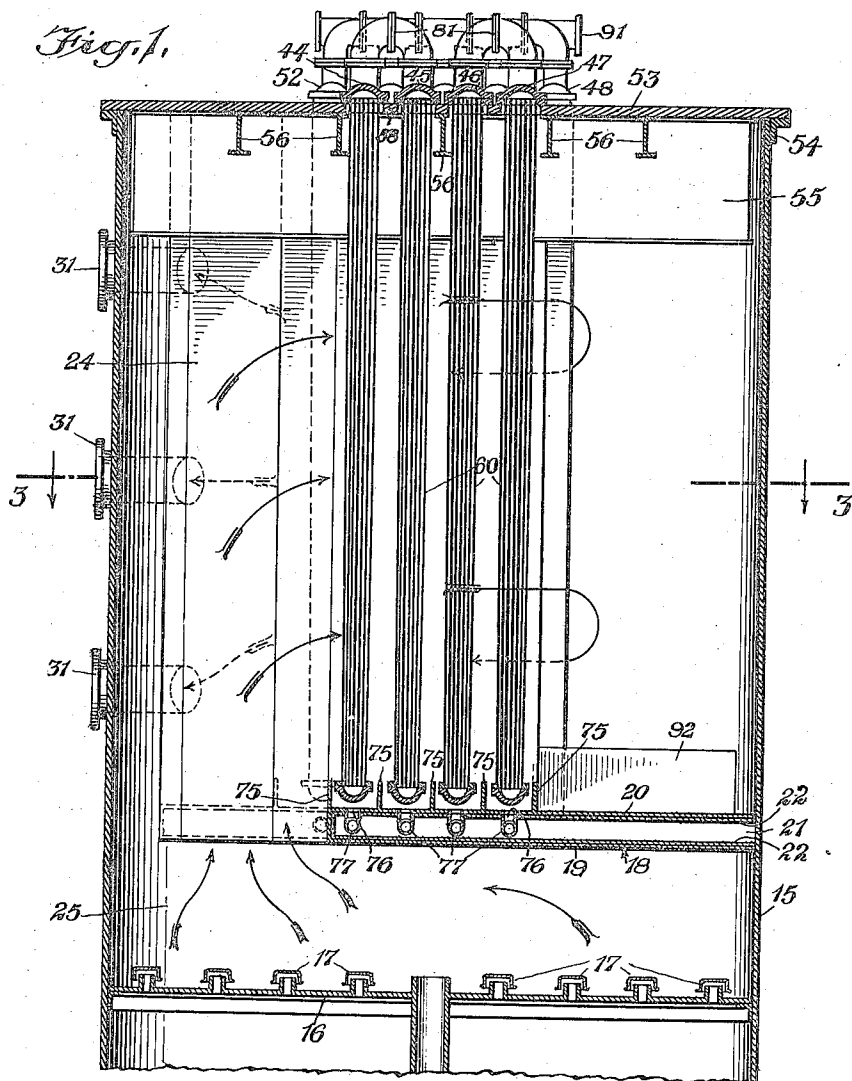
C. H. LEACH

2,122,256

HEAT EXCHANGE APPARATUS

Filed March 2, 1936

4 Sheets-Sheet 1



WITNESSES

George
D. H. Kane

INVENTOR

Charles H. Leach

BY

Munn, Anderson & Liddy
ATTORNEYS

ATTORNEYS

June 28, 1938.

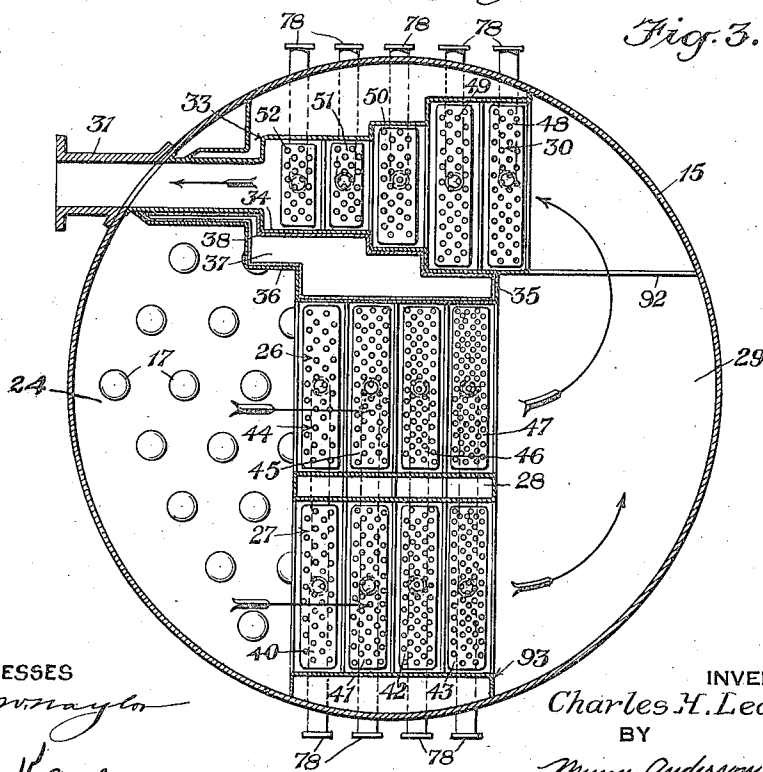
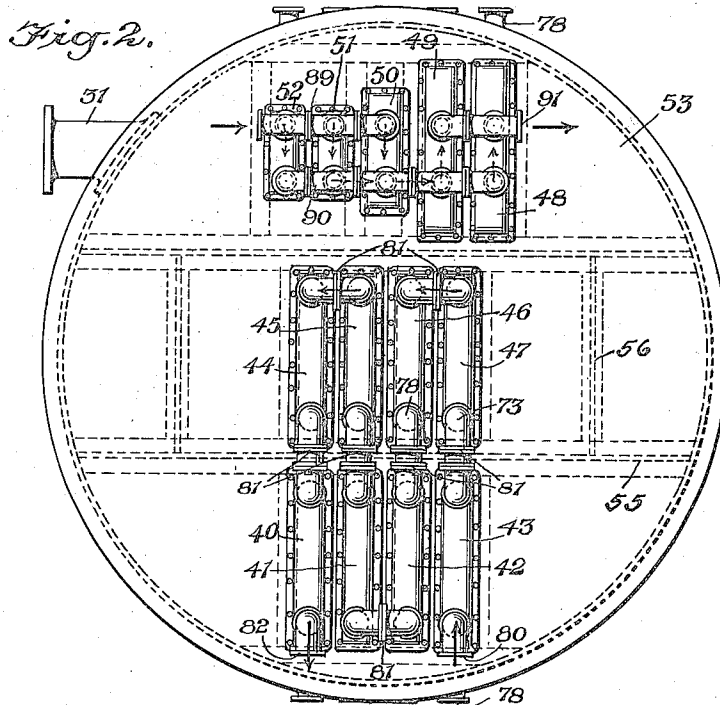
C. H. LEACH

2,122,256

HEAT EXCHANGE APPARATUS

Filed March 2, 1936

4 Sheets-Sheet 2



WITNESSES

George Mayhew

D. H. Kane

INVENTOR

Charles H. Leach

BY

Mumford Anderson & Liddy
ATTORNEYS

June 28, 1938.

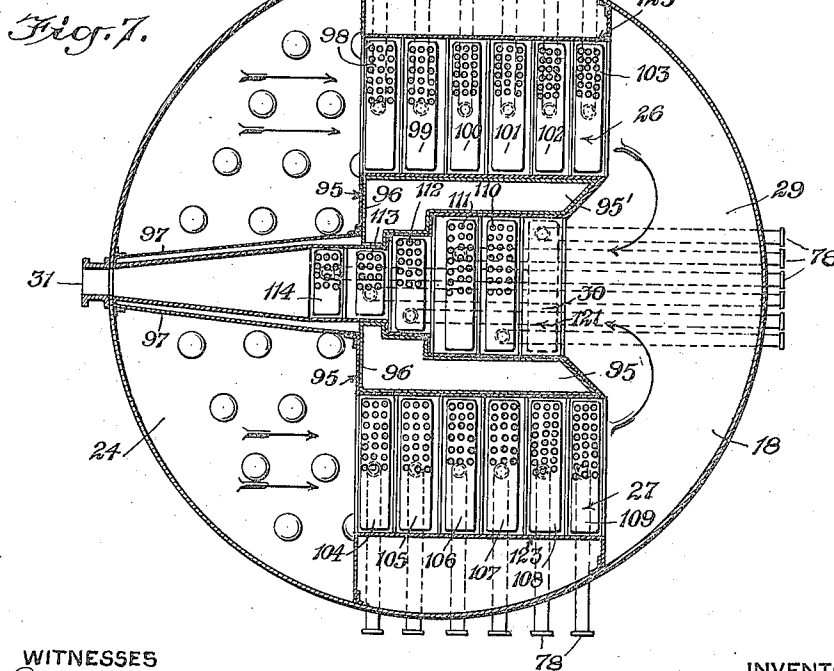
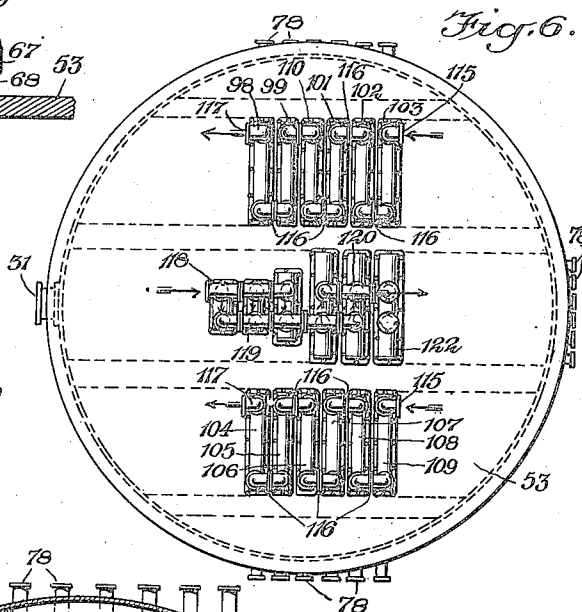
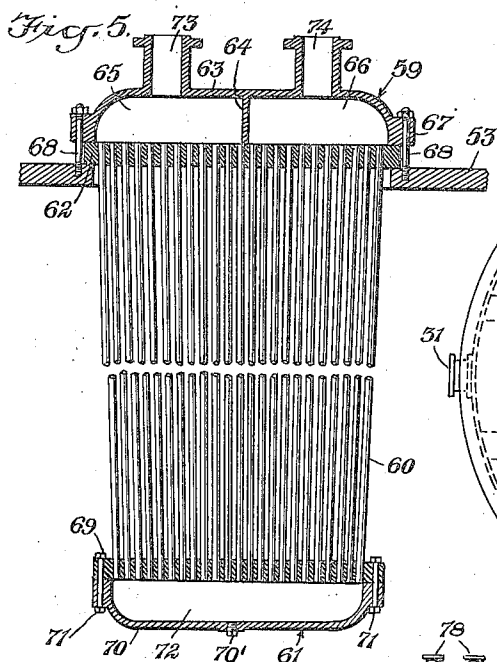
C. H. LEACH

2,122,256

HEAT EXCHANGE APPARATUS

Filed March 2, 1936

4 Sheets-Sheet 3



WITNESSES

George Taylor
J. H. Kane

INVENTOR

Charles H. Leach

BY

Mumford & Liddy
ATTORNEYS

June 28, 1938.

C. H. LEACH

2,122,256

HEAT EXCHANGE APPARATUS

Filed March 2, 1936

4 Sheets-Sheet 4

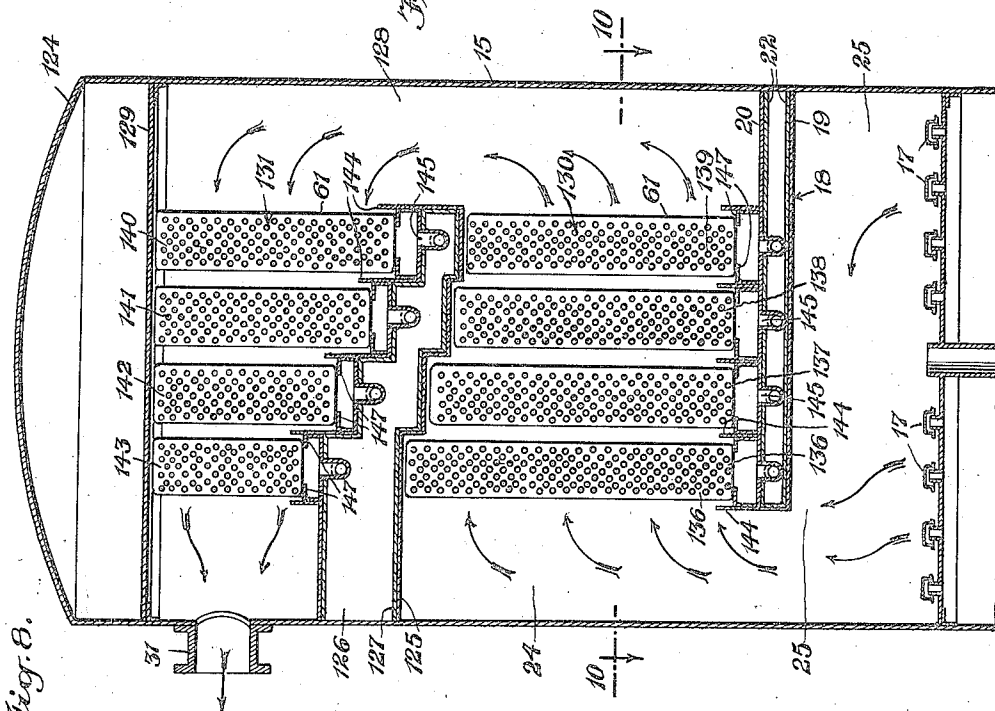
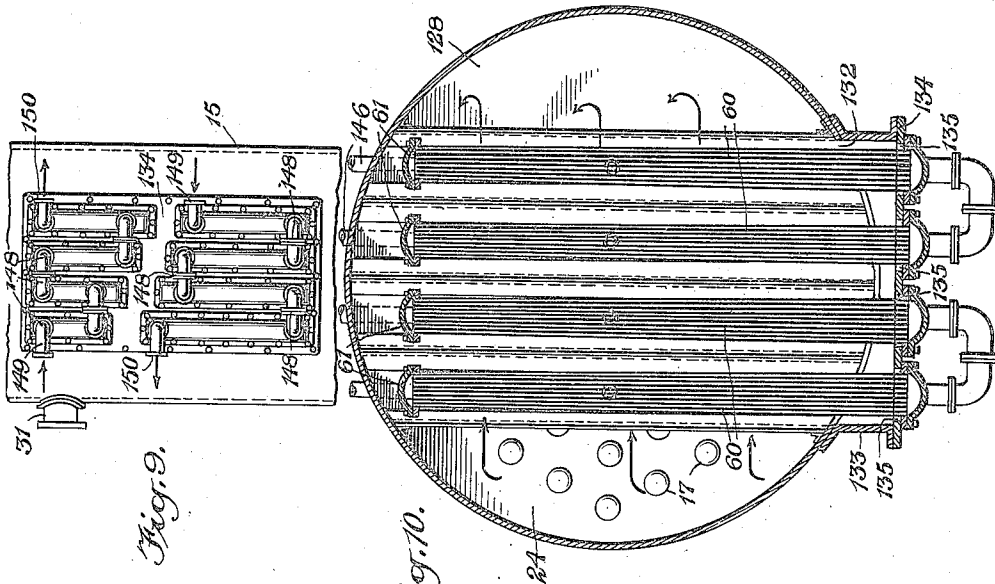


Fig. 8.

WITNESSES

James H. Kane
D. H. Kane

INVENTOR

Charles H. Leach

BY

Murray, Anderson & Liddy
ATTORNEYS

UNITED STATES PATENT OFFICE

2,122,256

HEAT EXCHANGE APPARATUS

Charles H. Leach, Roselle, N. J.

Application March 2, 1936, Serial No. 66,520

22 Claims. (Cl. 257-223)

This invention relates to heat exchange apparatus, and has particular relation to heat exchange apparatus used in the refining of petroleum oil.

5 It is an object of the invention to provide improved heat exchange apparatus of the above character which will operate in a more efficient manner having an improved insulated construction, and which is formed so as to prevent any
10 substantial loss in the velocity of movement of the hot gases or vapors which pass through the apparatus so as to maintain a high heat exchange ratio.

A further object is the provision of improved
15 apparatus of the above character which is flexible in design so that it can be adapted to varying operating conditions and which is provided with a plurality of condenser or cooling elements which may be independently removed and replaced by
20 units of different sizes, or which may be omitted entirely depending upon the operating conditions and the results desired.

Another object is to provide improved heat exchange apparatus especially adapted for use
25 in association with a fractionating tower in the refining of oil which is provided with a sturdy mounting which will not warp, thereby resisting wear and preventing leakage; which is of flexible construction and can be readily adapted to vary-
30 ing operating conditions; which is efficient in operation having an improved insulated construction and arranged so as to prevent any substantial loss in velocity in the movement of the gases or hot vapors passing through the apparatus, thereby maintaining a high heat transfer
35 ratio; and which is constructed so that water may be used as a cooling element without any danger of it coming into contact with the oil in the lower part of the fractionating tower if a
40 leak should develop.

For a fuller understanding of the invention reference should be had to the accompanying drawings, in which:

45 Fig. 1 is an elevation in section of the upper part of a bubble tower showing heat exchange apparatus applied thereto and which embodies features of the present invention;

Fig. 2 is a top plan view of the bubble tower shown in Fig. 1;

50 Fig. 3 is a plan view in section in the direction of the arrows on the line 3-3 of Fig. 1;

Fig. 4 is a side elevation in section of the upper part of two of the banks of tubes used as cooling elements, showing the manner in which
55 they are applied to the top of the bubble tower;

Fig. 5 is a front elevation in section with the central portion omitted of one of the banks of tubes used as cooling elements;

Fig. 6 is a top plan view similar to Fig. 2 of a bubble tower embodying a modified form of the
5 invention;

Fig. 7 is a sectional plan view similar to Fig. 3 of the form of my apparatus shown in Fig. 6;

Fig. 8 is an elevation in section of the upper portion of a bubble tower showing another modi-
10 fication of my invention;

Fig. 9 is a side elevation showing in detail the fixed heads and the mounting for the banks of tubes in the form of the invention shown in Fig.
15 8; and

Fig. 10 is a sectional plan view in the direction of the arrows on the line 10-10 of Fig. 8.

In the accompanying drawings the heat exchange apparatus is illustrated as applied to a
20 fractionating tower used in the refining of petroleum oil to which my invention has particular application. However, it is to be understood that my invention may be used in many other associations, such as making the heat exchangers in
25 separate units and utilizing them as such in the usual manner in the refining of petroleum oil. The particular type of fractionating tower shown is known as a bubble tower, but it is to be understood that my invention is equally applicable to
30 other types of fractionating towers.

In the accompanying drawings the numeral 15 indicates the casing or shell for the upper end of a fractionating or bubble tower of a well known type having the usual horizontal partition 16 formed therein on which the bubble caps 17 of
35 conventional construction are mounted. The hot gases and vapors from the lower portion of the tower thus pass upwardly through the bubble caps 17 to the upper portion of the tower. A short distance above the partition 16, I provide a second partition 18 which is of insulated construction, such as having two spaced walls 19 and 20
40 closed at their edges, leaving the insulating chamber 21 therebetween which may be lined, if desired, with asbestos sheets indicated at 22 in the drawings. The partition 18 conforms in size and shape with the inside of the tower and is suitably
45 secured along its edge to the internal surface thereof but does not extend completely across the inside of the tower, leaving a space indicated at 24 which is above the horizontal plane of the partition 18 but communicates directly at its lower end with the space 25 provided between the partitions 16 and 18.

Above the partition 18, I provide a vapor pas-
55

sage communicating at one end with the space 24 and preferably gradually decreasing in capacity towards the end thereof, which communicates with an outlet having connection with suitable suction apparatus such as a pump. In the form of my invention shown in the first three figures of the drawings, the vapor passage consists of an inlet portion formed in two parallel sections 26 and 27 positioned adjacent each other and separated by a partition 28 which may be of hollow construction as shown. The sections 26 and 27 communicate at one end with the space 24 and at the other end with a space or chamber 29, which in turn communicates with the outlet portion 30 of the vapor passage extending in the opposite direction to the sections 26 and 27, and which communicates with a plurality of outlet nozzles 31 extending through the shell or casing 15 of the bubble tower to the outside thereof. Both inlet and outlet portions of the vapor passage are formed so as to decrease in capacity in a direction from the inlet towards the outlet for the purpose of preventing any substantial decrease in the velocity of the movement of the gases passing through the passage.

The decrease in the capacity of the passage may be accomplished in several ways. Thus in the outlet portion 30 of the form shown in the first three figures of my drawings, the side walls 33 and 34 are made in stepped or staggered form so as to gradually converge towards the outlet nozzle 31. In the two sections 26 and 27 of the inlet portion, however, the decrease in capacity is brought about by increasing the number of tubes in each bank of heat exchange tubes in a direction away from the inlet, as will be later more fully explained.

To prevent the gases from the sections 26 and 27 of the inlet portion of the passage from heating the gases in the outlet portion 30, the partition indicated generally at 35 between the inlet and outlet sections is preferably of insulated construction, such as being formed of two spaced walls 34 and 36 extending upwardly from the partition 18 to the top of the tower and closed at their edges so as to provide a space or chamber 37 therebetween which may be lined, if desired, with a sheet of asbestos or similar material 38. Since the outlet passage 30 extends completely across the bubble tower through the vapor space 24, the side partition 35, side wall 33 and the portion of the horizontal partition 18 which underlies the passage 30 likewise extend completely across the bubble tower, as is more clearly shown in Figs. 1 and 3.

The outlet nozzles 31 have connection by means of suitable pipes to suction apparatus such as a vacuum pump, with the result that petroleum vapors and gases pass upwardly through the bubble caps 17, into the chamber 25, and from thence proceed into the space 24 above the horizontal plane of the partition 18 and thence proceed in a generally horizontal direction first through the inlet sections 26 and 27 of the vapor passage into the chamber 29, and thence through the outlet section 30 of the passage, and the highly volatile gases which are not condensed in the passage are extracted through the outlets 31.

To cause the successive cooling of the hot petroleum vapors and their fractional condensation, I provide a plurality of elongated cooling elements or condenser units extending transversely of both inlet and outlet portions of the vapor passage, preferably consisting of banks of

heat exchange tubes such as those indicated at 40, 41, 42, 43, 44, 45, 46 and 47 in the sections 26 and 27 of the inlet portion and the banks of tubes 48, 49, 50, 51 and 52 in the outlet portion of the vapor passage. The banks of tubes are supported from a deck 53 fitted over the top of the bubble tower and which is preferably of slightly larger diameter than the tower so that it not only rests upon the top of the shell 15 but also upon the top of a flange formed upon the ring 54 secured around the bubble tower at the top thereof.

The deck 53 should be suitably secured to the ring 54 as by being welded, bolted or riveted thereto. The weight of the banks of condenser tubes supported by the deck 53 is considerable, with the result that there is a tendency for the deck to buckle or warp, especially under the influence of the hot petroleum vapors. To prevent this buckling or warping action I preferably reinforce the deck by securing a plurality of parallel beams or steel girders 55 on the under surface of the deck extending substantially across the inside of the bubble tower and a plurality of intermediate transverse girders 56 of smaller size extending between the larger girders. This structure prevents any warping of the deck 53.

In the top of the deck are provided a plurality of openings indicated at 58 in the same vertical plane as the sections 26 and 27 of the inlet portion of the passage and of the outlet portion 30 of the passage, and through these openings the banks of heat exchange tubes are projected.

Each of the banks of tubes is of substantially the same construction extending downwardly from the deck to a point slightly above the horizontal partition 18, the only difference being that in the sections 26 and 27 the number of heat exchange tubes in each bank is increased in the direction of movement of the vapors, i. e., in the direction of the arrows in Fig. 3, and the size of the heads and accordingly the number of tubes in each bank decreases in the direction of vapor movement in the outlet portion 30 of the passage. Because of the fact that the banks decrease in size in the outlet portion 30 of the passage, the openings 58 formed in the deck above the portion 30 will correspondingly decrease in size.

The construction of the banks of tubes is shown most clearly in Figs. 4 and 5 of the drawings, and consists of a fixed head 59 connected by means of a plurality of tubes 60 to a floating head 61. The fixed heads consist of a tube sheet 62 of a size slightly larger than the opening 58 over which it is applied, in which a plurality of small holes are formed which receive the tubes 60, the latter being expanded in the holes so as to tightly fit in the tube sheet. When the bank of tubes is positioned in the bubble tower as shown in the drawings, the tube sheet 62 rests directly over the opening 58. Cooperating with the tube sheet 62 is a hollowed-out cover member 63 having a central partition 64 cast integral therewith so as to provide in association with the cover and tube sheet a pair of chambers 65 and 66 each communicating with the interior of substantially one-half of the tubes in the bank. The lateral edges of the cover 63 are formed with a projecting lateral edge 67 which overlaps the edges of the tube sheet 62 and through which are secured the bolts 68 for fastening the bank of tubes in place on the top of the deck. The tubes 60 project downwardly inside the bubble tower to a short distance above the partition 18 where they

are secured to the floating head 61. The floating head consists of a tube sheet 69 somewhat similar to the tube sheet 62 which is likewise provided with a plurality of holes into which the tubes 60 project, the latter being expanded therein so as to fit tightly.

Cooperating with the tube sheet 69 is the hollowed-out cover member 70 which is fastened thereto as by the bolts 71 forming the chamber 72 communicating with the interior of the tubes 60 at the lower end thereof. If desired, an opening may be formed in the cover 70 into which a plug 70' may be fitted, the opening providing a flushing outlet for cleaning the interior of the tubes and heads. The floating head 61 is smaller than the fixed head 59 and is of a size to pass through the opening 58 to which the bank of tubes is applied and the tubes converge from the fixed head to the floating head. In the cover 63 are formed inlet and outlet nozzles 73 and 74 communicating with the chambers 65 and 66 respectively.

If a fluid is introduced into either of the nozzles 73 or 74, it passes through the chamber 65 or 66, as the case may be, through the tubes communicating with the chamber in question, to the chamber 72 formed in the floating head, and thence back through the other set of tubes to the opposite chamber formed in the fixed head, 65 or 66, as the case may be, and thence out through the outlet 73 or 74.

Beneath each of the banks of tubes in the vapor passage may be formed a separate condensate basin by providing a series of upright walls 75 secured to or formed integral with the wall 20 of the partition 18 and extending completely across the passage, and suitable means may also be provided to separately drain the condensate from each of the basins. This means consists of a drain hole 76 formed in the bottom of each chamber and communicating with a pipe 77 extending through the insulated partition 18 and having connection with a nozzle 78 formed outside the shell of the bubble tower. In this way the condensate from each basin can be separately withdrawn. Instead of providing separate condensate basins under each bundle, however, a single collection basin for the entire passage or separate condensate basins for the inlet and outlet portions may be provided.

Suitable cooling fluids are introduced into the banks of tubes and caused to circulate there-through so as to cool the hot gases coming from the bubble tower and passing through the vapor passage, and for this purpose I have found it desirable to link the banks of tubes together as shown in Fig. 2 so that one cooling medium may be circulated through the banks of tubes in the inlet portion of the vapor passage and another cooling medium circulated through the banks of tubes in the outlet portion of the vapor passage. Banks of tubes 40 through 47 are preferably connected in series by the connectors 81 as shown in Fig. 2. Thus the cooling fluid is introduced at 80 in the inlet nozzle of the bank of tubes 43 and circulates through the tubes thereof out through the other nozzle and through connecting link 81 into the inlet of the banks of tubes 47, and from the outlet thereof through connector 81 to the inlet of tube bank 46, and through the outlet thereof, through the connector 81, through the bank of tubes 42, and thence through connector 81, through the banks of tubes 41, through connector 81 to the bank of tubes 45, through the bank of tubes 45 and connector 81, and thence

through the bank of tubes 44, connector 81, bank of tubes 41, connector 81, bank of tubes 40, and through the outlet at 82 as indicated by the arrows in Fig. 2.

The movement of the cooling fluid through the banks of tubes in the sections 26 and 27 in the inlet portion of the passage is thus longitudinally of the tubes in a direction transversely of the vapor passage and progressively from bank to bank in a direction generally opposite to the movement of the vapor through the passage. I have found that satisfactory results are obtained by using as a cooling medium for this series of banks of tubes petroleum oil, such as a charge oil.

The banks of tubes 48, 49, 50, 51 and 52 in the outlet portion of the passage are preferably not linked in series as in the case of the banks of tubes in the inlet portion because of the great discrepancy in size between some of the banks. For this reason a connector 83 is provided between the inlets of the three banks of tubes 52, 51 and 50, so that the three banks of tubes are hooked in parallel. The outlets of the same banks of tubes are likewise hooked together by means of a connector 90 which is connected directly to the inlets of the two banks 49 and 48, which are likewise thus hooked in parallel having a single connector 91 running to both outlets thereof. The cooling fluid in this series of tubes will thus travel through the inlet connector 83 and simultaneously through the three banks of tubes 52, 51 and 50, and thence through the connector 90 and simultaneously through the two banks of tubes 49 and 48 and out through the outlet connector 91. I have found that highly satisfactory results are obtained by using water as a cooling medium in the banks of tubes which are disposed in the outlet portion of the vapor passage. In this connection it should be observed that should any leak develop in the heat exchange tubes in the outlet portion of the vapor passage, the water can not seep back into the hot oils in the bubble tower due to the provision of horizontal partition 18, vertical partition 35, and an upright 92 extending up from the partition 18 and formed continuous with the vertical partition 35 and extending to the shell 15 of the bubble tower. In this manner any leakage from the tubes will be confined inside the outlet portion of the vapor passage, preventing any danger of conflagration from the intermingling of water and steam with the extremely hot oil or hot oil vapors.

It is to be understood, of course, that the path of flow of the cooling medium through the banks of tubes may be varied by changing the arrangement of the connectors between the banks and that the cooling mediums employed may be changed. It is also to be understood that instead of utilizing two separate cooling mediums, three or more may be employed and also, if desired, under certain operating conditions, but a single cooling medium may be used for all of the banks.

In operation, the hot oil vapor passing through the bubble caps 17 enters the chamber 25 and then passes upwardly into the vapor space 24. From that point the vapor enters the sections 26 and 27 of the inlet portion of the vapor passage, traveling in a generally horizontal direction and passing between and around the tubes in the successive banks of tubes disposed in the inlet portion of the vapor passage. The vapor thus passes in a direction generally perpendicular to the heat

exchange tubes and is confined to the area around the tubes by the vertical partitions 28 and 35 and by the wall 92 secured to the side of the shell and extending upwardly from partition 18 adjacent section 27 of the vapor passage. As the vapor comes in contact with the successive banks of tubes it is cooled and the vapor is fractionally condensed, that portion having the highest specific gravity and highest boiling point being condensed when it comes into contact with the first bank of tubes and draining downwardly along the tubes into the condensate basin formed below that bank of tubes, and the vapor having the next highest boiling point or specific gravity being condensed by contact with the next bank of tubes and so forth. Thus petroleum oils of differing specific gravities are separately condensed and collected in the successive condensate basins formed beneath the banks of tubes. Due to the fact that each condensate basin has a separate drain, the condensates may be separately withdrawn and may be blended together or separately used.

After passing through the sections 26 and 27 the vapors enter chamber 29 and from that point enter the outlet portion 30 of the vapor passage where they again come in contact with successive banks of heat exchange tubes having a cooling fluid therein, with the result that the vapor will be further cooled and further fractional condensation will take place. The remaining highly volatile gases which are not condensed by contact with the successive banks of tubes are withdrawn through the vapor outlets 31.

The quantity of vapor passing through the vapor passage progressively diminishes due to the condensation of a portion thereof and also due to the contraction of the vapor as it is cooled. Any material decrease in the velocity of movement of the vapor while passing through the sections 26 and 27 of the inlet portion or the outlet portion 30 of the vapor passage is prevented because the capacity of both portions of the vapor passage decreases in a direction from the inlet towards the outlet of the passage.

Due to the construction previously described, the individual banks of tubes can be readily removed and may be entirely omitted or may be replaced by banks of tubes of different sizes. In this way the apparatus can be adapted to varying operating conditions and can be adjusted to produce any desired results.

In the form of my invention shown in Figs. 6 and 7 of the drawings, substantially the same arrangement as that shown in the first three figures is employed, with the exception that the sections 26 and 27 of the inlet portion of the vapor passage, instead of being disposed adjacent each other, are placed one on either side of the outlet portion 30 of the vapor passage, as more clearly shown in Fig. 7, and a greater number of banks of tubes is shown in the sections 26 and 27 of this form than in the first form of my invention; although it is to be understood that the number of banks of tubes may be modified at will. In Fig. 7, for clarity, the tubes on one side of each tube bundle or bank are omitted.

In this form of my invention the sections 26 and 27 are each separated from the outlet portion 30 by means of partitions 95 extending between the partition 18 and the top of the tower and which are suitably insulated, such as being made of a pair of spaced walls closed along their edges providing an insulating air chamber or space 95' therebetween which may be lined, if

desired, with some insulating material such as the asbestos sheets 96. The insulating partitions 95 are formed with extensions 97 likewise of insulated construction, which extend to the casing or shell of the bubble tower and communicate with the vapor outlets 31 similar to those provided in the first form of my invention. The horizontal partition 18 is extended beneath and is suitably sealed to the lower ends of the insulating walls 97 so as to provide a completely closed passage.

In each of the inlet sections 26 and 27 of the vapor passage are disposed six banks of heat exchange tubes indicated respectively by the numbers 98, 99, 100, 101, 102 and 103 in the section 26, and by the numbers 104, 105, 106, 107, 108 and 109 in the section 27. The number of tubes in each bank progressively increases in the banks of tubes disposed in the inlet sections 26 and 27 so as to progressively decrease the capacity of the passage, the tubes increasing from bank 98 to bank 103 and from bank 104 to bank 109. In the outlet portion 30 of the vapor passage are disposed five banks of tubes indicated by the numbers 110, 111, 112, 113 and 114, which are similar in form and arrangement to the banks of tubes 48, 49, 50, 51 and 52 in the first form of my invention. The banks of tubes are similar in construction to those previously described and particularly shown in Figs. 4 and 5 of the drawings, and are supported in a similar manner from the deck 53 disposed at the top of the bubble tower so as to project downwardly in their respective portions of the vapor passage.

The deck is provided with the reinforcing girders 55 and 56, all as has been previously described. The banks of tubes in sections 26 and 27 are each connected in series by connectors 116, the bank 103 having an inlet nozzle 115 thereon through which the cooling medium is introduced entering into the fixed head traveling through one-half of the series of tubes into the floating head and back through the remaining tubes to the fixed head, and thence through connector 116 to the fixed head of bank 102 through the tubes of this bank and connector 116 to the bank of tubes 101, which in turn is connected to bank 100, the cooling fluid thus progressing successively through each bank of tubes, each being connected by means of a connector 116 to the next bank, until it is withdrawn through nozzle 117 formed on the bank of tubes 98.

The banks of tubes disposed in the section 27 are likewise connected in series by means of connectors 116, the cooling fluid being introduced through the nozzle 115 formed on the bank of tubes 109 and traveling successively through banks of tubes 108, 107, 106, 105 and 104, until it is withdrawn through nozzle 117. The banks of tubes disposed in the outlet portion 30 of the vapor passage are preferably connected together in the same manner as in the first form of my invention, the first three banks being connected in parallel by means of an inlet pipe 118 and having an outlet pipe 119 leading from the first three banks to the inlet nozzles of the two remaining banks, an outlet pipe 120 being connected to the two banks 111 and 110 to withdraw the cooling fluid therefrom.

As has been previously stated, satisfactory results are attained by using petroleum oil, preferably charge oil, as the cooling medium for the banks of tubes disposed in the inlet portion of the vapor passage and water as the cooling me-

dium in the banks of tubes disposed in the outlet portion. It will be seen that the cooling fluids are caused to travel transversely of the vapor passage and successively from tube bank to tube bank in a direction opposite to the direction of movement of the hot oil vapors.

Beneath each bank of tubes is formed a condensate basin, as in the first form of my invention, each having separate connection by means of drain pipes to the nozzles 73 disposed outside the bubble tower. The hot oil vapors enter the space 24 from the bubble tower and will then proceed in a generally horizontal direction through the inlet portions 26 and 27 into the space 29 and thence through the outlet portion 30, the highly volatile gases being withdrawn through the outlet nozzles 31 by means of suitable suction apparatus. The vapors are progressively cooled and fractionally condensed by contact with the successive banks of tubes, and in order to maintain a substantially uniform velocity of movement of the gases through the inlet and outlet portions, the capacity of both portions of the vapor passage is decreased in the direction towards the outlet. This is accomplished in the sections 26 and 27 by increasing the number of tubes in each successive bank and in the section 30 by making the walls of the partitions 95 in stepped formation so as to converge toward the outlet. The vapor is directed into contact with the heat exchange tubes by means of the partitions 95 and the walls 123 secured to the sides of the bubble tower.

As an illustration of the flexibility of apparatus employing my invention, Figs. 6 and 7 are shown with one of the banks of tubes in the outlet portion 30 of the vapor passage omitted, leaving a blank space 121 inside the vapor passage, while over the opening on the top of the deck is provided a cap or closure 122 suitably secured thereto as by means of bolts.

In the form of my invention shown in Figs. 8, 9 and 10 of the drawings, the inlet and outlet portions, instead of being disposed in the same horizontal plane, are arranged so that the outlet portion is above the inlet portion and the banks of tubes, instead of being supported on a deck on top of the bubble tower, are inserted through the side of the bubble tower, but they nevertheless are arranged so as to extend transversely of the vapor passage. It is unnecessary, accordingly, to provide a reinforced deck at the top of the bubble tower as in the first two forms of my invention, and any type of closure such as shown at 124 in Fig. 8 may be employed.

The horizontal partition 18, generally similar to that employed in the first two forms of my invention, is provided a short distance above the bubble caps 17, and is arranged so as to extend only partly across the bubble tower leaving a vapor space 24 above the plane of the partition 18 communicating at its lower end with the space 25 above the bubble caps. Another partition 125 likewise of insulated construction, such as being formed of two spaced walls providing an air chamber 126 therebetween which may be lined with insulating material such as asbestos shown at 127, is provided above the partition 18 and extends from the opposite side of the bubble tower almost completely across the inside thereof, leaving a space 128 at the other side extending from the partition 18 upwardly to a horizontal wall 129 provided a short distance below the top of the tower.

The partition 125 is of staggered formation

extending progressively downwardly from the point where it is connected to the side of the bubble tower, thereby providing a vapor passage having inlet and outlet portions 130 and 131 respectively, each decreasing in capacity in a direction away from the inlet towards the outlet. In this way vapor entering space 25 from the bubble caps 17 travels upwardly through the space 24 and thence horizontally through the inlet portion 130 of the vapor passage into the space 128 from which it travels again in a generally horizontal direction through the outlet portion 131 of the vapor passage, and the highly volatile gases which are not condensed are drawn out through the outlet nozzles 31 which are connected to suitable suction apparatus.

As has been previously stated, in this form of my invention the banks of tubes are inserted horizontally through the side of the bubble tower so as to extend transversely across both portions of the vapor passage. To support the banks of tubes so that they may be readily removed and so as to minimize the danger of warping or leakage, one side of the bubble tower in the horizontal plane of both the inlet and outlet portions 130 and 131 respectively of the vapor passage is broken away as shown at 132 in Fig. 10 of the drawings. An extension 133 having sealing connection with the vapor tower at its sides, top and bottom is provided over this portion of the tower and is formed so as to have a flat outer face 134 in which a series of openings 135 is provided. These openings correspond to the openings 58 in the deck 53 in the first two forms of my invention and receive the banks of tubes which are projected inside the vapor passage.

In Figs. 8 through 10, four banks of tubes are illustrated as being disposed in each of the inlet and outlet portions of the vapor passage, and these are indicated by the numerals 136, 137, 138 and 139 in the inlet portion 130, and by the numerals 140, 141, 142 and 143 in the outlet portion 131. The banks of tubes are preferably of such size and formation as to extend over the major portion of the vapor passage so that vapor passing therethrough will necessarily come into contact with the tubes. The banks of tubes are accordingly of progressively smaller size, the bank 139 being smaller than the bank 136 and the bank 143 being smaller than the bank 140. However, each bank of tubes, aside from this variation in size, is preferably of the same construction as shown in Figs. 4 and 5 of the drawings.

The floating heads are projected inwardly through the openings 135 so that the tubes extend substantially across the vapor passage and the fixed heads are then bolted over the openings 135, and in that manner providing a sealed closure for the openings. A series of vertical partitions 144, corresponding to the members 75 in the first two forms of my invention and parallel to the tubes and disposed in a plane between the banks and along the outside of the tubes of the end banks, are secured to the upper surfaces of the insulating partitions 18 and 125, thereby providing separate condensate basins beneath each bank of tubes, each having connection by means of drain 145 to pipes 146 extending through the partitions 18 and 125 to the outside of the bubble tower. In that manner the condensate forming around each bank of tubes can be separately collected and withdrawn.

To aid in supporting the banks of tubes and to serve as guides in inserting and removing the banks of tubes, I provide the angle bars 147 in

association with the uprights 144 positioned so as to provide a bed for the floating heads 61 to rest on. In inserting and removing the banks of tubes the floating heads slide along the angle bars 147, and when the banks are in operative position as shown in Figs. 8 through 10 the angle bars serve to support the floating heads so that the tubes are in generally horizontal positions.

The banks of tubes in both the inlet and outlet portions are connected in series by the connectors 148 as shown most clearly in Fig. 9 of the drawings, the first bank in each series being provided with an inlet nozzle 149 and the last bank being provided with an outlet nozzle 150. In the banks disposed in the inlet portion 130 petroleum oil, such as charge oil, may be used as the cooling medium, and it is introduced in the inlet nozzle 149 and travels successively through the banks of tubes 130, 131, 137 and 136, and in a direction opposite to the movement of the vapor through the vapor passage and is discharge through outlet 150.

On the other hand, water is preferably used as the cooling medium in the banks of tubes disposed in the outlet portion 131 of the vapor passage, the water being introduced in the inlet nozzle 149 and passing through the banks of tubes 143, 142, 141 and 140, likewise in a direction opposite to the direction of movement of the vapor through the vapor passage, and is discharged through outlet 150. The hot oil vapor passing through the vapor passage is cooled and fractionally condensed as it passes through the vapor passage, but the velocity of its movement will not substantially decrease due to the progressive diminution of the capacity of the passage in the two portions thereof 130 and 131. The oil which is fractionally condensed by the successive banks of tubes drips downwardly into the condensate basins formed beneath the banks and may be withdrawn through drain 145 and pipes 146. Highly volatile vapors which are not condensed are withdrawn through outlet 31.

It will be seen by means of the invention herein illustrated and described that a highly efficient heat exchange apparatus particularly suitable for use in the refining of petroleum oils has been provided. In spite of the fact that the vapors are to a considerable extent condensed and are caused to contract due to cooling, there is substantially no decrease in the velocity of movement of the vapors through the inlet and outlet portions of the vapor passage. The cooled vapors passing through the vapor passage are insulated from the hotter vapors and from the lower portion of the bubble tower, thereby further increasing the efficiency of the apparatus. The apparatus is also highly flexible and can be modified to suit varying conditions or to produce any desired results. The construction also is such as to permit ready access to the interior of the apparatus for cleaning or inspection. Furthermore it will be seen that the condensates may be separately cooled and withdrawn, permitting highly critical fractional condensation of the vapor. The heat exchange tubes are also so arranged as to permit the use of several cooling mediums and the circuit between the several banks of tubes is such as to permit of the circulation of the cooling medium successively from bank to bank in a direction opposite to the path of movement of the hot vapor. It is preferable to provide tube bundles which are rectangular in cross section, although circular and other design tube bundles may also be used, for the reason

that rectangular tube bundles aid in maintaining a substantially uniform velocity of movement of the vapors throughout the entire width of the vapor passage.

It is to be understood, of course, that many changes may be made in the illustrated and described embodiments of my invention without departing from the invention as defined in the accompanying claims. Thus, as previously stated, it is not necessary to provide a separate condensate basin under each tube bundle but instead separate condensate basins for the entire outlet portion and the entire inlet portion of the vapor passage may be provided or, at times, but a single basin for the entire vapor passage is needed. Also the path of flow of the cooling medium through the tube bundles may be varied by modifying the arrangement of the connectors and the type of cooling medium employed may also be changed. Furthermore, the progressive reduction in capacity of the vapor passage may be accomplished in a number of ways, such as forming the walls of the passage so that they converge towards the vapor outlet and by increasing the number and concentration of the tubes as shown, and also by increasing the size of the individual tubes in each bundle. The tube bundles may also be modified as by changing the spacing size and gauge of the tubes.

I claim:

1. Heat exchange apparatus for exchanging heat from hot vapors or gases to a cooling medium, comprising means providing a vapor passage having an inlet and an outlet adjacent the beginning and end thereof, and a plurality of heat exchange tubes disposed transversely of said passage and having means associated therewith cooperable to direct a cooling medium through the inside thereof and progressively from tube to tube towards the inlet, said tubes increasing in number towards the outlet so as to decrease the capacity of the passage and substantially maintain a uniform velocity of movement of the vapor passing through the passage.

2. Heat exchange apparatus for exchanging heat from hot vapors or gases to a cooling medium, comprising means including a plurality of walls providing a vapor passage, means providing an inlet and an outlet adjacent the beginning and end respectively of said passage, and a plurality of heat exchange tubes disposed transversely of the passage, said walls converging in one portion of the passage and the number of tubes increasing in another portion of the passage from the inlet towards the outlet so as to progressively decrease the capacity of the passage.

3. Heat exchange apparatus for exchanging heat from hot vapors or gases to a cooling medium, comprising means including a plurality of walls providing a vapor passage, means providing an inlet and an outlet adjacent the beginning and end respectively of said passage, a plurality of heat exchange tubes disposed transversely of the passage, said walls converging in one portion of the passage and the number of tubes increasing in another portion of the passage from the inlet towards the outlet so as progressively to decrease the capacity of the passage, and means associated with the tubes cooperable to direct a cooling fluid therethrough so as to travel longitudinally of the tubes and progressively from tube to tube in the direction of the inlet.

4. Heat exchange apparatus comprising means providing a vapor passage having an inlet at one

end and an outlet at the other end, a portion of said passage extending in one direction and a second portion disposed adjacent thereto and extending in an opposite direction, an insulated partition disposed between the two portions of the passage to prevent the exchange of heat therebetween, a plurality of heat exchange tubes in each portion of the passage and extending transversely thereof, means associated with the tubes in the first-mentioned portion of the passage for directing a cooling fluid therethrough longitudinally of the tubes and progressively from tube to tube in a direction opposite to the vapor movement, and means associated with the tubes in the second-mentioned portion of the passage for directing another cooling fluid therethrough longitudinally of the tubes and progressively from tube to tube in a direction opposite to the vapor movement.

5. Heat exchange apparatus comprising means providing a vapor passage having an inlet at one end and an outlet at the other end, a portion of said passage extending in one direction and a second portion disposed adjacent thereto and extending in an opposite direction, an insulated partition disposed between the two portions of the passage to prevent the exchange of heat therebetween, a plurality of heat exchange tubes in each portion of the passage and extending transversely thereof, means associated with the tubes in the first-mentioned portion of the passage for directing a cooling fluid therethrough longitudinally of the tubes and progressively from tube to tube in a direction opposite to the vapor movement, and means associated with the tubes in the second-mentioned portion of the passage for directing another cooling fluid therethrough longitudinally of the tubes and progressively from tube to tube in a direction opposite to the vapor movement, both portions of said vapor passage decreasing in capacity in a direction from the inlet towards the outlet so as to maintain a substantially uniform velocity of movement of the vapor therethrough.

6. Heat exchange apparatus comprising means providing a vapor passage having an inlet at one end and an outlet at the other end, a portion of said passage extending in one direction and a second portion extending in an opposite direction, said portions being disposed adjacent each other, and heat exchange tubing disposed in both of said portions, the number of tubes in one of said portions progressively increasing and the walls of the other portion converging in the direction of the outlet so as progressively to decrease the capacity of both portions of the passage.

7. Heat exchange apparatus for use with a fractionating tower, comprising a plurality of condenser units mounted adjacent the top of the tower, an insulated partition disposed beneath and adjacent said units, and means providing with said partition a vapor passage extending between and around said condenser units and having an inlet communicating with the interior of the tower at one end and an outlet at the other end.

8. Heat exchange apparatus for use with a fractionating tower, comprising a plurality of condenser units mounted adjacent the top of the tower and depending downwardly in said tower, an insulated partition disposed beneath the lower end of the units, means providing with said insulated partition a vapor passage extending between and around said condenser units, said passage having a portion extending in one direc-

tion and another portion adjacent thereto extending in an opposite direction, and an insulated partition disposed between the two portions of the passage so as to prevent any substantial exchange of heat therebetween.

9. Heat exchange apparatus for use with a fractionating tower, comprising an insulated substantially horizontal partition secured adjacent the top of the fractionating tower, said partition extending only partly across the tower and leaving a vapor space above the plane of the partition communicating directly with the lower part of the tower, means providing a vapor passage above the partition having an inlet at one end communicating with the aforementioned vapor space and an outlet at the other end, and condenser units disposed in said passage.

10. Heat exchange apparatus for use with a fractionating tower, comprising an insulated substantially horizontal partition secured adjacent the top of the fractionating tower, said partition extending only partly across the tower and leaving a vapor space above the plane of the partition communicating directly with the lower part of the tower, means providing a vapor passage above the partition having an inlet at one end communicating with the aforementioned vapor space and an outlet at the other end, said passage having one portion extending in one direction and a second portion disposed adjacent thereto extending in an opposite direction, and said means including an insulated partition between the aforesaid two portions of the passage to prevent the exchange of heat therebetween, and a plurality of heat exchange elements disposed in said passage.

11. Heat exchange apparatus for use with a fractionating tower, comprising an insulated substantially horizontal partition secured adjacent the top of the fractionating tower, said partition extending only partly across the tower and leaving a vapor space above the plane of the partition communicating directly with the lower part of the tower, means providing a vapor passage above the partition having an inlet at one end communicating with the aforementioned vapor space and an outlet at the other end, a plurality of heat exchange tubes disposed transversely of the passage having means associated therewith cooperable to direct a cooling medium through the interior of the tubes, said passage decreasing in capacity from the inlet towards the outlet.

12. Heat exchange apparatus for use with a fractionating tower, comprising a supporting deck across the top of the tower, reinforcing means for said deck comprising a plurality of substantially parallel girders extending substantially across said deck in one direction, and a plurality of intermediate girders extending between the first-mentioned girders and banks of heat exchange tubes supported from said deck.

13. In heat exchange apparatus, a casing, means providing a vapor passage inside said casing, a removable bank of heat exchange tubes disposed in said passage in horizontal position, and means providing a condensate basin beneath the bank of tubes, said condensate basin having longitudinal side walls with means forming a bed for supporting said bank of tubes and cooperable to serve as a guide when the bank of tubes is inserted in or removed from said passage.

14. For use with heat exchange apparatus, a deck for the top of a fractionating tower or the

like for supporting tube bundles, comprising a flat member having a plurality of openings for receiving tube bundles, said openings being arranged in rows and some of said openings being smaller than others.

15. For use with heat exchange apparatus having a vapor passage formed therein disposed adjacent the top of a fractionating tower, a deck for the top of the fractionating tower comprising a relatively flat disk having a plurality of openings formed therein and disposed above the vapor passage, said openings being of smaller size at one end of said passage than at the other end.

16. Heat exchange apparatus for exchanging heat from hot vapors or gases to a cooling medium comprising means providing a vapor passage having an inlet at one end and an outlet at the other end, said passage having a portion which is of substantially uniform cross sectional area throughout its entire length, and a plurality of heat exchange tubes extending transversely of said passage so that the vapor passing through the passage travels between and around said tubes substantially at right angles thereto, said tubes increasing in number from the inlet towards the outlet in the aforesaid portion of the passage which is of uniform cross sectional area so as progressively to decrease the capacity thereof and thereby maintain the velocity of the vapor particles passing through the passage.

17. Heat exchange apparatus for exchanging heat from hot vapors or gases to a cooling medium comprising means providing a vapor passage having an inlet at one end and an outlet at the other end, said passage having a portion which is of substantially uniform cross sectional area throughout its entire length, and a plurality of heat exchange tubes extending transversely of said passage so that the vapor passing through the passage travels between and around said tubes substantially at right angles thereto, said tubes increasing in number from the inlet towards the outlet in the aforesaid portion of the passage which is of uniform cross sectional area so as progressively to decrease the capacity thereof and thereby maintain the velocity of the vapor particles passing through the passage, and said tubes having means associated therewith for directing a cooling medium through the tubes and progressively from tube to tube in the direction of the vapor passage inlet.

18. Heat exchange apparatus for use with a fractionating tower comprising a plurality of condenser units mounted adjacent the top of the tower, and means providing a vapor passage extending between and around said condenser units, said passage having two adjacent portions, one extending in one direction and the other in the opposite direction and said means including an insulated partition between the two portions of the passage to prevent the exchange of heat therebetween.

19. Heat exchange apparatus for use with a fractionating tower comprising a plurality of condenser units mounted adjacent the top of the tower, a partition disposed beneath and adjacent said units, and means providing with said partition a vapor passage extending between and around said condenser units and having an inlet communicating with the interior of the tower at one end and an outlet at the other end, said passage having two adjacent portions, one extending in one direction, and the other in the opposite direction and said means including an insulated partition between the two portions to prevent the exchange of heat therebetween.

20. Heat exchange apparatus for use with a fractionating tower comprising a plurality of condenser units mounted adjacent the top of the tower, and means providing a vapor passage extending between and around said condenser units and having an inlet communicating with the interior of the tower at one end of the passage and an outlet at the other end, said passage having two adjacent portions, one extending in one direction and the other in the opposite direction, and said means including an insulated partition between the two portions to prevent the exchange of heat therebetween, the number of tubes in one of said portions of the passage progressively increasing and the walls of the other portion converging in the direction of outlet so as progressively to decrease the capacity of both portions of the passage.

21. In heat exchange apparatus, a casing, means providing a vapor passage inside said casing, a plurality of removable banks of heat exchange tubes disposed in said casing in horizontal position, and means providing a separate condensate basin beneath each of the banks of tubes, said means including a plurality of longitudinal partitions forming the sides of the basins, each partition having a laterally projecting flange associated therewith serving as a bed for supporting the adjacent bank of tubes and cooperable to serve as a guide when the bank of tubes is inserted in or removed from said passage.

22. The combination with a fractionating tower having means forming a vapor passage with an inlet and an outlet adjacent the top of the tower and bundles of heat exchange tubes disposed in the passage, of a deck for the top of the tower for supporting the tube bundles, said deck comprising a relatively flat member having openings for receiving the tube bundles arranged above the vapor passage so that tube bundles projecting downwardly through the openings extend into the vapor passage, some of the openings progressively decreasing in size towards the outlet of the passage.

CHARLES H. LEACH.