

Aug. 26, 1941.

G. T. JACOCKS

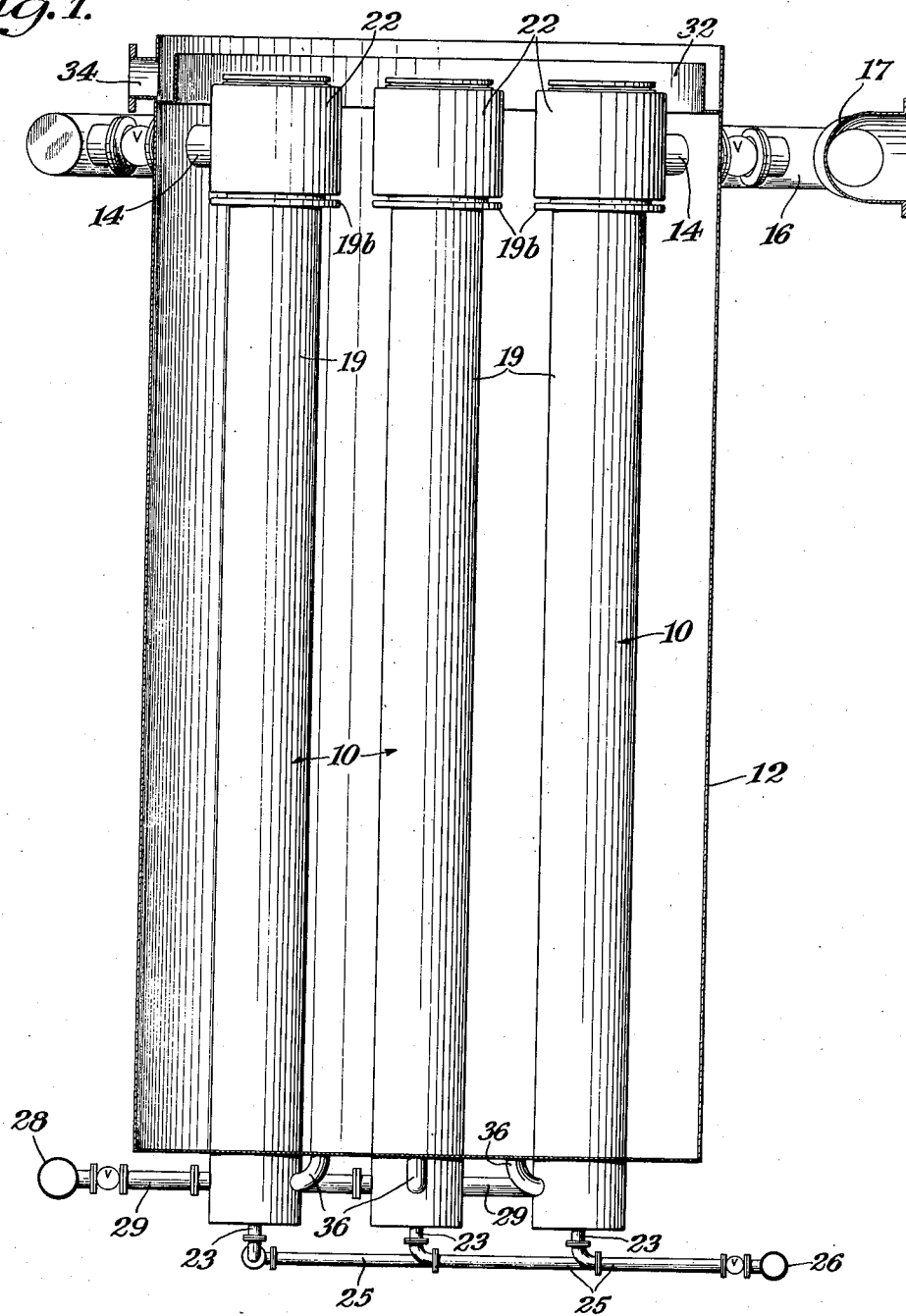
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HEAT EXCHANGER

Filed July 22, 1938

5 Sheets-Sheet 1

Fig. 1.



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5 Sheets-Sheet 2

Fig. 2.

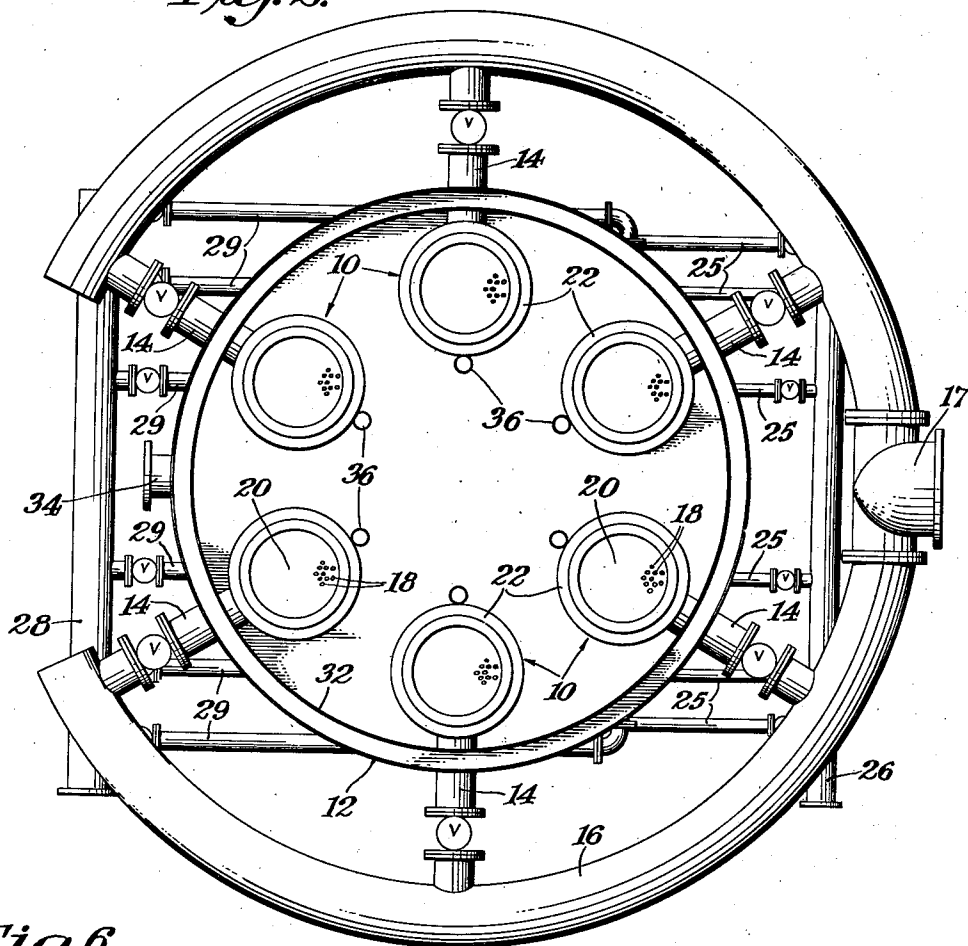
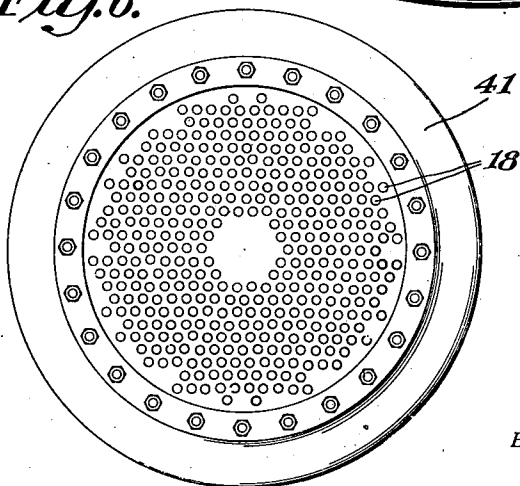


Fig. 6.



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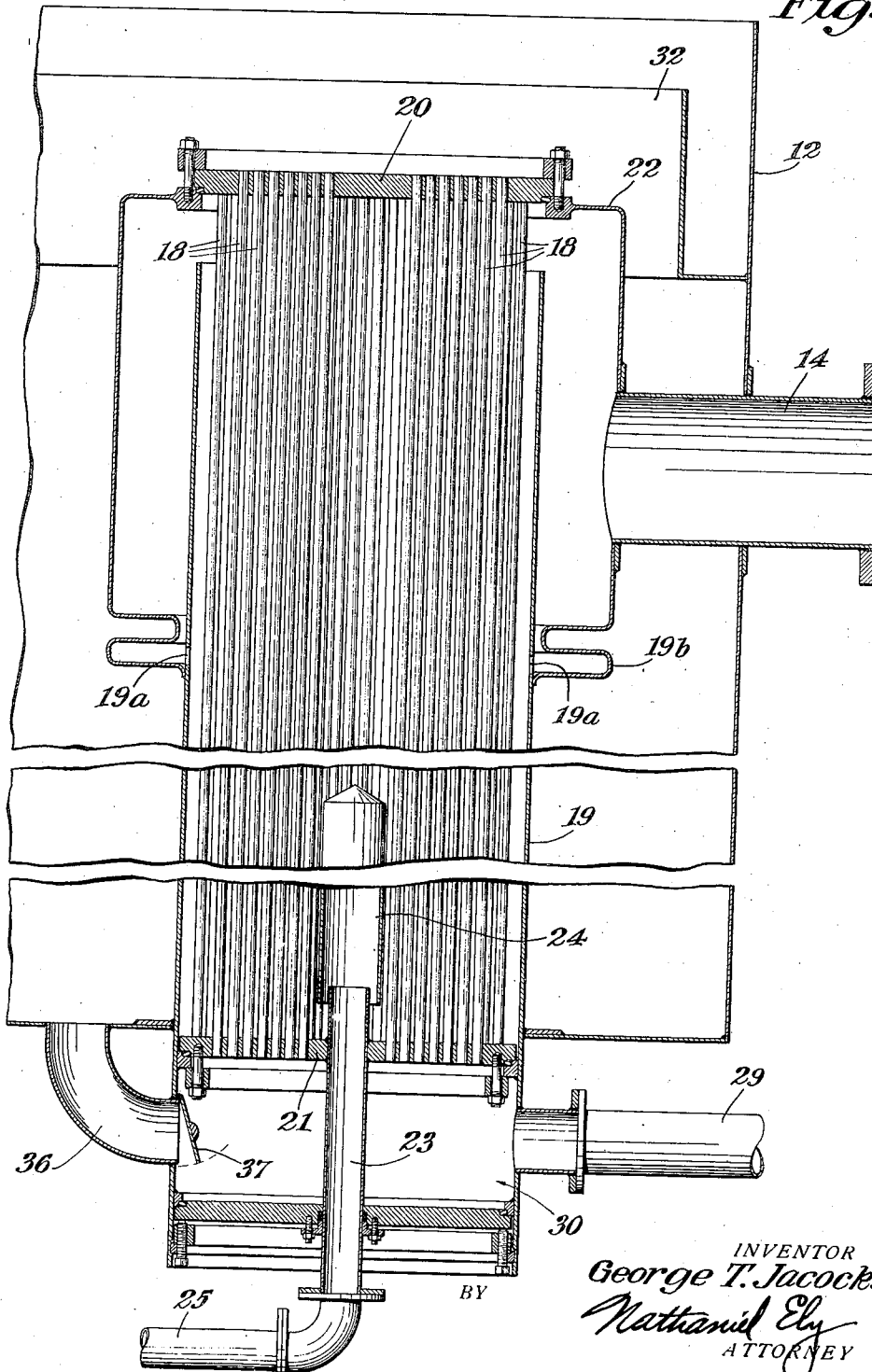
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5 Sheets-Sheet 3

Fig. 3.



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Fig. 4.

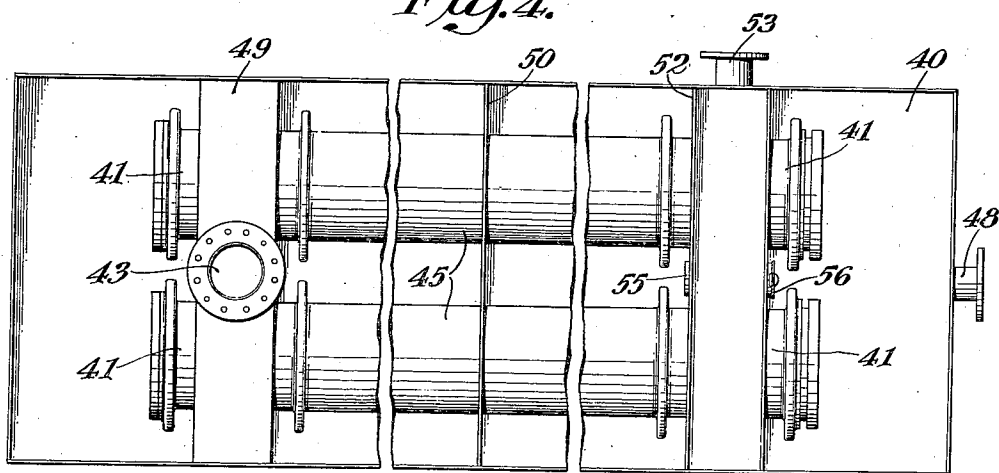
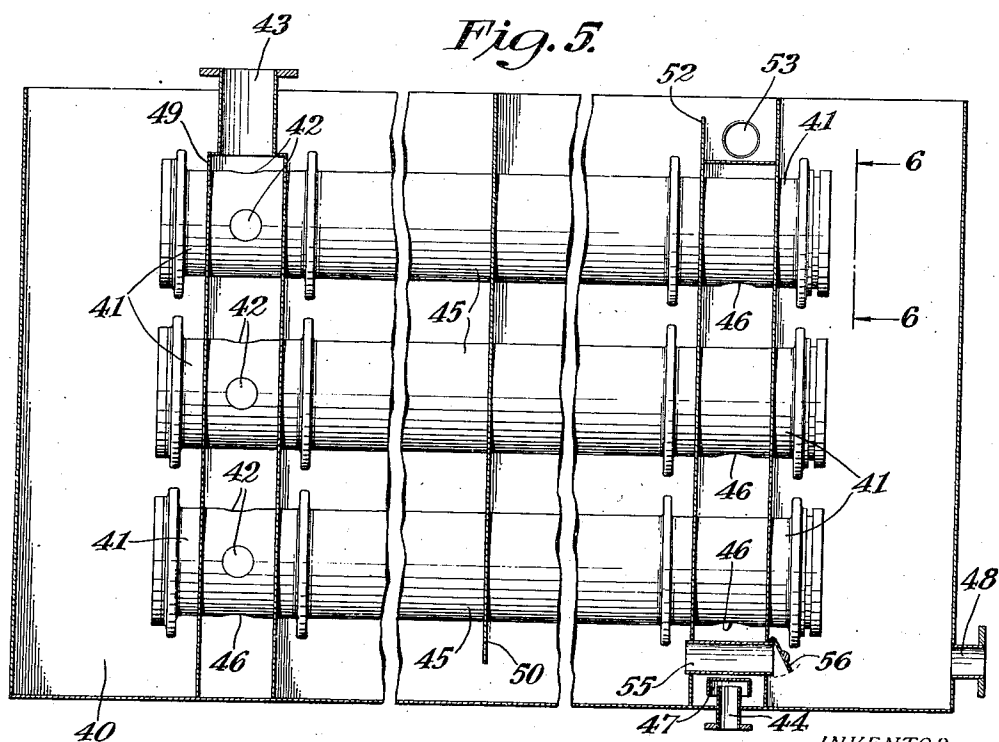


Fig. 5.



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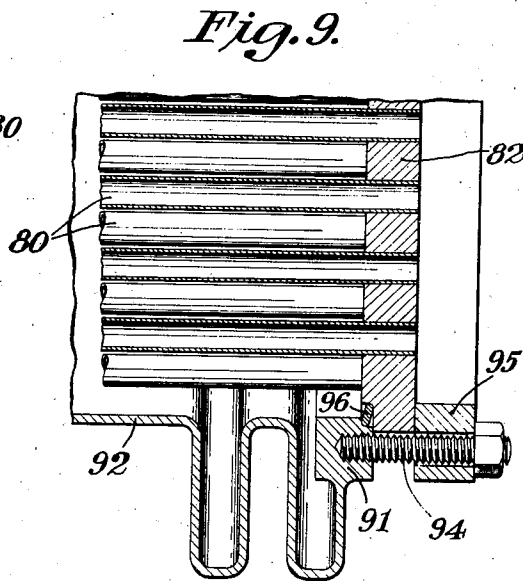
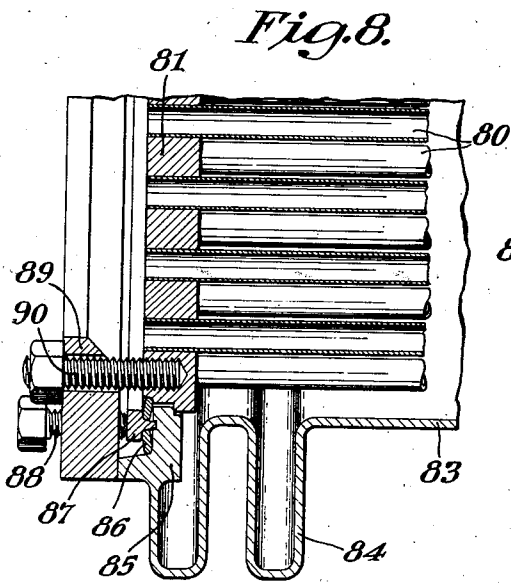
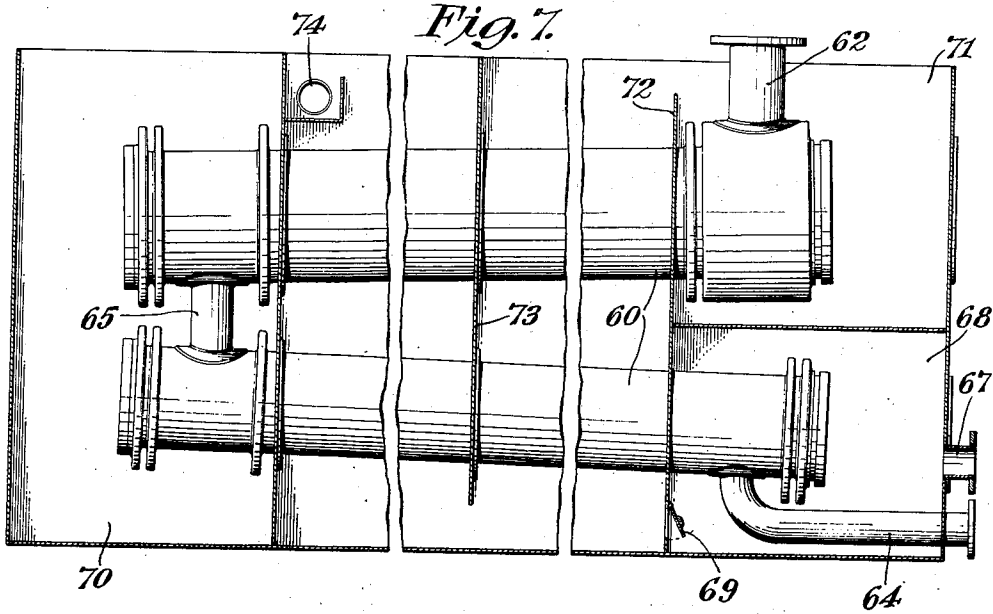
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HEAT EXCHANGER

Filed July 22, 1938

5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,254,070

HEAT EXCHANGER

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Application July 22, 1938, Serial No. 220,620

3 Claims. (Cl. 257—28)

This invention relates to improvements in heat exchangers and more particularly to an improved form of vapor condenser such as the submerged water cooled type as used to condense the hot hydrocarbon vapors in oil refining practice.

One of the principal objects of the invention is to provide an improved type of submerged condenser which is more efficient in heat exchange by having a continuous circulation of water, and which is also safer and more reliable in that the circulation is maintained even though the water supply is temporarily discontinued.

Another object of the present invention is to provide an improved form of vapor condenser having a plurality of heat exchange elements of the shell and tube type in a common tank of water or other cooling medium and so arranged as to permit independent control of the respective units for more flexible application to the vapor load.

Another object of the invention is to provide an improved form of submerged condenser unit, as for vapor condensation, in which a highly efficient transfer of heat is accomplished by an open ended shell and tube type of element which may be easily disassembled and may be easily cleaned.

Another object of the invention is to provide an improved multiple unit vapor condenser consisting of a plurality of similar heat exchange elements confined in a common tank and having automatic valve control means to initiate thermo-syphon flow so that the heat exchange elements are continuously cooled to protect the apparatus during temporary failure of the cooling medium supply.

A still further object is to construct the heat exchanger units in such a manner that they function as heat pumps and thus stimulate the velocity of the cooling medium through the units.

Another object is to arrange the components of heat exchanger units to insure a positive continuous fluid flow therethrough under all normal and abnormal working conditions.

Further objects and advantages of this invention will appear from the following description of the preferred form of embodiment thereof, taken in connection with the attached drawings in which:

Figure 1 is a vertical section with parts in elevation of a preferred form of vapor condenser;

Figure 2 is a top plan view of the apparatus shown in Figure 1, illustrating the manifold arrangement;

Figure 3 is an enlarged vertical section partially broken away, showing a single unit of the vapor condenser shown in Figure 1;

Figure 4 is a top plan view of a modified form of vapor condenser;

Figure 5 is a vertical section through the modified form of vapor condenser shown in Figure 4;

Figure 6 is an end view of a heat exchanger unit, as shown on lines 6—6 of Figure 5;

Figure 7 is a vertical section through a vapor condenser in accordance with further modified form of the invention; and

Figures 8 and 9 are enlarged vertical sections showing the attachment of the tube bundle to the condenser shells.

In accordance with a preferred form of embodiment of my invention, the vapor condenser preferably has a plurality of individual heat exchange units 10 mounted in a common reservoir or tank 12, which, under normal circumstances, receives a continuous supply of a cooling medium such as water. As shown in Figures 2 and 3, the separate heat exchange units 10 are each connected on the shell side by a vapor inlet 14 to a common manifold 16 into which the condensable vapors are introduced by the inlet nozzle 17. Inasmuch as the flow of vapors into each of the heat exchange bundles is substantially the same, the description of the vapor flow will only be described in connection with a single unit, such as shown in Figure 3.

Although the individual heat exchange units 10 may be of any desired construction, I prefer the specific form shown in Figure 3 in which each unit has a tube bundle 18 within the individual shell 19. The shell 19 does not extend to the top of the tube bundle 18, but it is connected to the floating tube sheet 20 by an enlarged vapor chamber shell 22, into which the vapor inlet nozzle 14 is connected. Preferably, the shell 19 extends above the nozzle opening so that the vapors which circulate around the shell 19 and into contact with the tubes in the tube bundle 18 for intermediate heat exchange therewith, must first pass to the top of the tube bundle so that the full area of the tubes is available. If there is any condensation between the vapor chamber shell 22 and the heat exchanger shell 19, the liquid can be discharged through perforations 19a therein. A bellows portion 19b provides for expansion between the parts.

The condensate normally collects in the bottom of the shell 19, on top of the fixed tube sheet 21, being maintained at a suitable liquid level by the discharge pipe 23, which is trapped by an

inverted bell 24 to prevent the vapors from blowing through. The condensate is withdrawn through the pipes 25 from the respective heat exchange units into the condensate outlet 26.

The cooling medium, which is usually water, is normally introduced to the respective heat exchange units from the water main 28 through the respective connecting pipes 29 into the channel 30 of the respective heat exchange unit. From this channel, the water flows through the tubes 18 and overflows over the top of the floating tube sheet 20 and surrounds the heat exchange units on the outside of their shells 19 and the shell chamber 22. The water is confined by the external shell 12 which serves as a reservoir for all of the cooling medium. The level of the cooling medium is determined by the weir 32, and the water which overflows the weir is drawn off at the water outlet 34 as shown in Figure 1.

Under normal operating conditions, the condensation of vapors is most efficiently accomplished in this apparatus and the size may be materially decreased over the usual form of submerged condenser. This is due to the high heat exchange transfer rate which results from the substantial velocity of the cooling medium through the tubes. The great vertical travel and the high temperature drop between the condensate at the bottom of the condenser and the vapors at the top of the condenser greatly improve the heat transfer to the cooling medium. The number of tubes can thus be reduced and yet the total volume of cooling medium need not be changed. If desired, longer tubes may be used as intermediate supports are unnecessary and with vertical tubes, the tube cleaning can be facilitated without stopping operations. The floating tube sheet, although normally covered with water, is exposed.

Under abnormal circumstances which would stop the entrance of cooling medium, the flow of cooling medium is still sufficiently active to complete condensation of the hot vapors entering at 14. This is accomplished by the provision of return flow conduits 36 at the bottom of the reservoir 12 which are separately connected into the respective heat exchanger channels 30. These are provided with normally closed valve 37 to assure a normal water flow through the tubes 18. If, however, the water flow stops at 29, the circulation of the water within the reservoir 12 will continue automatically through the tubes 18.

This is due to a thermo-syphon circulation of the water due to the heating of the water in the tubes by the vapors entering at 14. The water tends to rise in the tubes 18 and condense these vapors. The water then falls over the top of the floating tube sheet 20 and enters the chamber outside of the shell 19 and gradually passes downward and through the return flow conduit 36 and valve 37. This movement is continuous and brings about higher heat transfer to the cooling medium as well as bringing about a higher heat transfer to the shell 12 thereby cooling the water a substantial amount.

The vapors are fully condensed before being discharged out of the condensate manifold 25 as long as there is any water left, for the heat transfer is so rapid and the heat transfer surface is so extensive that the water can remove the vapor heat as long as there is water. Usually, a substantial factor of time safety is allowed to prevent any possible damage. In this construction

the same amount of water will last longer than heretofore due to the availability of all of it.

If it is desired to use horizontal, rather than vertical, condensers for reasons of economy or to use existing equipment, it is possible to provide for the thermo-syphon circulation in such an arrangement of condensers. As shown in Figures 4, 5 and 6, the vapor condensers which are of a horizontal type, are submerged in a tank generally indicated at 40. Each condenser 41 is adapted to receive vapors at 42 from the vapor inlet 43 and the condensate is removed at 44. The condensate passes through the shell 45 of each condenser 41 and discharges out of the openings 46 therein. The condensate level will be maintained by the condensate outlet nozzle 44 which is trapped by the inverted cap 47 to prevent blow-through of the vapors.

The water or other cooling medium normally enters the tank 40 at 48 and circulates through the tubes of the respective heat exchangers, the ends of which are open for this purpose as shown in Figure 6. Under normal circumstances, the flow of cooling liquid will be from right to left through the respective heat exchangers, and the accumulation of cooling medium will then circulate above the header 49, around the vapor inlet nozzle 43 and thence down under the intermediate baffle 50 and thence upward over the weir 52 and out the outlet 53. This will afford a circuitous path for the cooling medium to facilitate the cooling of the inside of the tubes and the outside of the shell somewhat in the fashion heretofore described.

In emergencies with the water shut off, the flow will be by thermo-syphon principle through the return flow conduit 55, which is normally closed by the gravity valve 56. The hotter vapors entering at 43 will tend to expand the cooling medium which will then tend to pass out of the left ends of the heat exchangers 41 because of the relatively cold cooling medium to the right of the ends of heat exchangers 41. The expanded cooling medium will then flow over the header 49, under the baffle 50 and thence through the return flow conduit 55, past the valve 56, and thence back through the heat exchangers.

As in the prior case, the entire volume of cooling medium will be under constant circulation with a continuous condensation of the vapors until the flow of cooling medium can be restored. The velocity of flow may not be so great as in the vertical type, but the decreased costs may offset this.

A further form of embodiment of the invention is shown in Figure 7. In this case, the condensers 60 are inclined with respect to the horizontal to such an extent that extra pressure head can be obtained for a faster circulation of liquid. In this construction, the vapor inlet is shown at 62 with the condensate outlet at 64. The condenser elements 60 are connected on the shell side by the connection 65. Cooling medium enters at 67 into a chamber 68 which is normally closed by the valve 69 so that the cooling medium must pass through the lower condenser 60 to the chamber 70 from which it passes through the upper condenser to the chamber 71. This latter chamber is kept filled by the weir 72. The cooling medium then flows over the weir 72, under the baffle 73 and thence out of the outlet 74 with the liquid level being established by the weir 75.

As in the prior form of construction, the emergency circulation is caused by a differential density of the cooling medium because the hot

vapors entering the upper condenser 60 heat the cooling medium in the upper heat exchanger 60. This sets up a circulation of water from the chamber 68 through the condensers 60 and the cooler fluid runs back into the chamber 68 across the valve 69. The flow is continuous through both heat exchangers, even though the inflow of cooling medium at 61 is entirely stopped.

It will be readily understood by those skilled in the art that the heat exchanger units function in the manner of heat pumps and due to the pressure differential, there is a continuous flow of cooling fluid therethrough under all conditions.

Details of construction shown in Figures 8 and 9 represent preferred means of attaching the tube bundles to the shells. In these figures, the tube bundles have a plurality of tubes 80 which are suitably secured to tube sheets 81 and 82 and such tube sheets are secured to the shell 83 which is provided with bellows rims 84 to permit expansion. In the preferred construction shown in Figure 8, the tube sheet 81 abuts the enlarged end 85 of the shell and is sealed thereto by a plurality of gaskets 86 which are forced into position by a ring 87, actuated in turn by the bolts 88. The cover 89 is bolted to the tube sheet 81 by bolts 90.

The gaskets 86 are preferably of a frusto-conical shape, having curved edges which cooperate with recesses or channels formed in the periphery of the tube sheet 81 and in the enlarged portion 85 of the shell. The ring 87 is provided with cooperating recesses to engage the inner ends of the respective gaskets with the spacing such that upon application of pressure, a fluid tight seal is provided between the tube sheet, gasket and ring on one side, and between the ring, gasket and the heat exchanger shell on the other. The reactions are taken through the bolts 90 into the tube sheet. This seal makes removal of the tube bundle from the shell readily possible.

A slightly modified form of construction which may be used on the other end of the tube bundle, is shown in Figure 9 in which the tube sheet 82 is sealed with respect to the enlarged portion 91 of the shell 92 as by a single gasket 96 which is also of a frusto-conical shape with curved edges. Appropriate abutment recesses are formed in the tube sheet 82 and in the enlarged portion 91 of the shell, and by forcing the tube into contact with the shell as by bolt 94 and ring 95, the gasket is rotated about a normal to the plane of its cross section and forced into fluid tight relation. It will of course be obvious that other forms of gasket joints can be provided, but these are preferred, especially where the tube bundle is removable from the shell 92. It will also be noted that the seal of the respective parts is obtained by a slight axial movement of the tube bundle but as the shell is arranged for slight variations in length, the seal is not disturbed.

While I have described preferred forms of embodiment of my invention, I am aware that other modifications may be made thereto, and I therefore desire a broad interpretation of my invention within the scope and spirit of the description herein and the claims appended hereinafter.

I claim:

1. A heat exchange unit of the submerged type including a reservoir, shell and tube heat exchange means mounted within the reservoir, means to introduce condensible hydrocarbon va-

pors into one end of the shell side of the heat exchange means, means to remove the condensate therefrom, means to introduce cooling water into one end of the tube side of the heat exchange means in indirect contact with and countercurrent to the flow of the hydrocarbon vapors under a velocity to obtain a relatively high heat transfer rate, said heat exchange means being such that the water, upon discharge therefrom, will fill the reservoir, means to maintain the normal level of water in the reservoir above the upper end of the heat exchange means, a return-flow conduit between the reservoir and the water inlet end of the heat exchange means, and a self-actuating, normally closed valve in the return-flow conduit, said valve opening under thermosyphon action of the flow of water upwardly through the heat exchange tubes from the reservoir when the supply of water is cut off.

2. A submerged condenser for hydrocarbon vapors which comprises a reservoir, a plurality of individual vertical shell and tube heat exchange units mounted in said reservoir, means to introduce cooling water under pressure to the lower end of the tubes of said units, the upper end of said tubes being open whereby the water, after passing through said tubes, will fill said reservoir, weir means attached to the reservoir to maintain the normal level of water in said reservoir above the top of said tubes, a common vapor manifold interconnected to the upper portion of the shell side of said units for introduction of the hydrocarbon vapors in countercurrent, indirect heat exchange relation with the cooling water, means to remove the condensate from the shells, return flow conduits between said reservoir and the lower ends of said tubes, and normally closed valves in said return flow conduits, said valves automatically opening under thermo-syphon action of the water flowing upwardly through said tubes from said reservoir when the supply of pressure water to the tubes is cut off, said condenser having a heat transfer rate, that of a shell and tube unit with the water in the tubes, and a safety factor of an available water supply, that of a typical submerged condenser with the vapors in the tubes.

3. A submerged condenser for vapors, which comprises an open tank, a shell and tube heat exchange unit mounted within the tank, means to introduce the vapors into one end of the heat exchange unit on the shell side thereof, means to remove the condensate therefrom, means to introduce cooling water into the lower end of the tubes of the heat exchange unit in indirect contact with and countercurrent to the flow of the hydrocarbon vapors, said tubes being arranged in single pass with the upper end of said tubes being open whereby the water flowing there-through will discharge into the tank, means to maintain the normal level of water in the tank above the upper end of the heat exchange unit, a return-flow conduit between the bottom of the tank and the water inlet end of the heat exchange tubes, and a self-actuating, normally closed valve in the return-flow conduit, said valve opening under the action of the flow of water from the bottom of the tank into the tubes when the head of water in the tank overbalances the head of water in the tubes.

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