

July 6, 1943.

W. W. KRAFT

2,323,474

HEAT EXCHANGER

Filed July 31, 1941

Fig. 1.

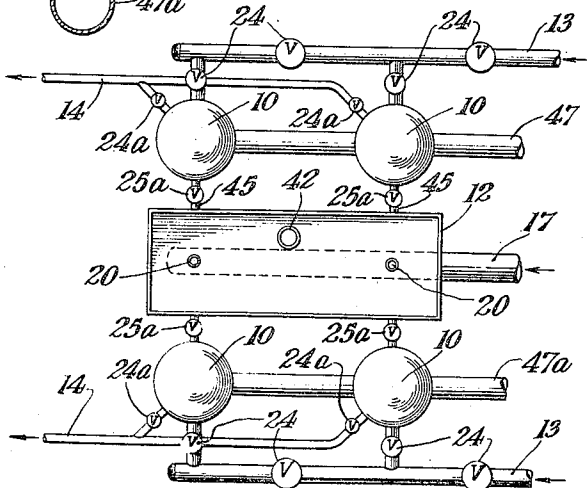
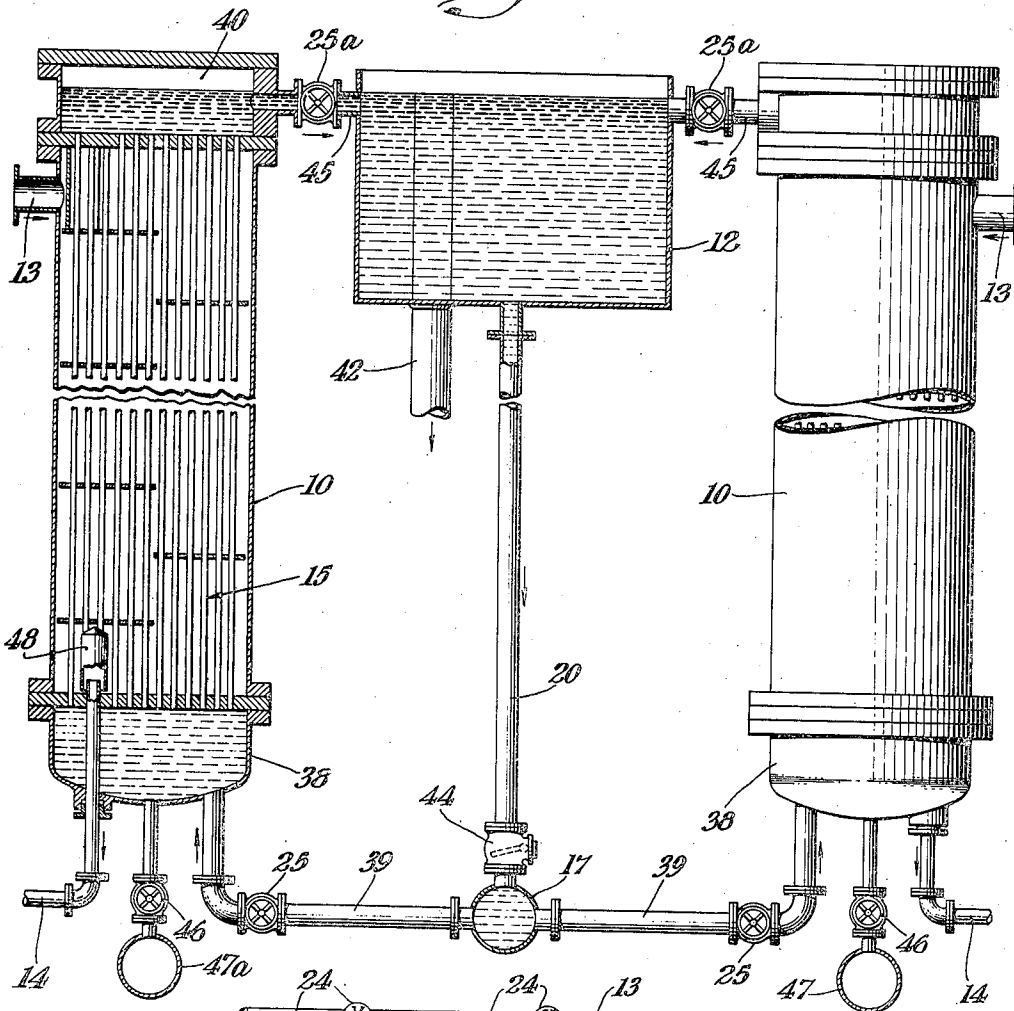


Fig. 2.

INVENTOR
Wheaton W. Kraft
BY *Nathaniel E. Kraft*
ATTORNEY

UNITED STATES PATENT OFFICE

2,323,474

HEAT EXCHANGER

Wheaton W. Kraft, Scarsdale, N. Y., assignor to
The Lummus Company, New York, N. Y., a cor-
poration of Delaware

Application July 31, 1941, Serial No. 404,861

6 Claims. (Cl. 196—138)

This invention relates to improvements in heat exchange apparatus and more particularly to apparatus for the condensation of hydrocarbon vapors from a distillation process or the like.

As is well known, distillation, particularly fractional distillation, is accomplished by introducing a hot liquid into a suitable fractionating column that may be provided with bubble decks, in which column the vaporous or low boiling portion of the heated liquid rises countercurrently to descending reflux liquid and the higher boiling liquid portion of the charge passes to the lower part of the column. At various points in such a column, portions of the material may be removed as side streams, and such streams are customarily cooled before further treatment or storage.

The overhead stream in most distillation processes is a vapor, a large proportion of which is condensible. To provide for simple handling of such a stream, it is customary to condense it. Some of the resulting condensate is customarily returned to the column as reflux, and the remainder may be withdrawn as a product.

Particularly in connection with the refining of petroleum, condensation is provided for the overhead streams, and cooling is provided for the side streams whether they come from the topping unit, the bubble tower, or the stabilizer. Ordinarily, the equipment for condensing the vapors is designed to discharge a liquid; and, if the cooling medium is not sufficiently available, the large volumes of uncondensed vapors are extremely difficult to handle and usually blow through relief valves to the atmosphere. In such case, not only are valuable products lost, but the vapors which escape because of lack of condensation are usually dangerous from the fire hazard standpoint.

Heretofore, it has been usually found necessary for absolute safety to have a reservoir of cooling medium such as is provided in a submerged condenser, which consists of a coil of tubing placed in a large water box through which cooling water is slowly circulated. In such apparatus, the vapors pass through the coil, and the operation is entirely safe because of the reservoir of water; but the heat exchange efficiency is low because of the extremely low velocity of movement of the cooling water.

In the alternative, the condensing of vapors may, in some cases, be carried out in shell and tube type heat exchangers with the water in the tubes and with a resulting high efficiency of heat transfer. In such case, however, the operation is completely dependent on a continuance of the water supply, an interruption of which may result in disaster because of the almost instantaneous failure of the condensing action with a resulting blow-through of the vapors.

In accordance with the disclosure of Jacocks in

his co-pending application for U. S. Patent, S. N. 220,620, filed July 22, 1938, now U. S. Patent 2,254,070, patented August 26, 1941, a heat exchange construction is provided that includes a tank acting as a reservoir for water which is available during emergencies such as are caused by the failure of the normal cooling water supply. In such construction, the normal operation is that of a shell and tube unit having a high heat transfer efficiency with the water in the tubes; and the residual water supply may be, for example, approximately equivalent to a thirty minute requirement in case of a failure of the cooling water. In such a period, it is usually possible to accomplish a complete shut-down of the refinery unit from which the vapors must be condensed.

The principal object of my present invention is to provide an improved condenser for the vapors of a distillation process, in which condenser the high efficiency of heat exchange afforded by the shell and tube construction is available during normal operations and a high time factor of safety is afforded in case of accidental failure of the cooling water supply.

More specifically, I provide a condenser apparatus which is adapted to condense independent vapor streams so that various conditions of vapor load can be met with a single unit consisting of individual heat exchangers interconnected to a common cooling water source and a common water reservoir.

A further advantage of my invention is that I provide a simplified apparatus consisting of multiple heat exchange units of substantially identical construction so that one or more can be temporarily removed from the system without seriously interfering with normal condensing and cooling operations.

A still further object of my invention is to provide a simplified multiple unit condenser which has a high heat transfer efficiency yet which is relatively simple to construct and service and in which the operating conditions are readily controlled.

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

Fig. 1 is an elevation view with parts in section of a heat exchange device for vapor condensation.

Fig. 2 is a plan view of the unit shown in Fig. 1.

In accordance with the preferred form of embodiment of my invention, the improved heat exchange apparatus includes a plurality of individual heat exchange units 10, the upper channels 40 of which are interconnected to a common tank or drum 12 by lines 45. These heat exchange units are primarily adapted to condense

a vapor stream, which enters the heat exchangers as by manifold 13 with the resulting condensate removed therefrom as by manifold 14. Primarily, the heat exchange units as disclosed are customary shell and tube type units which include a tube bundle 15, into the tubes of which a cooling medium is introduced as by header or manifold 17; in the space surrounding these tubes is the material (vapors) to be condensed.

The hot stream which is to be cooled is customarily a vapor although it will be appreciated that it may be either a liquid such as a petroleum or a salt as used in the cooling of catalytic reaction chambers such as employed in hydrocarbon cracking and the like or any other fluid. It is to be particularly noted, however, that the invention relates to the cooling of a hot stream as from a petroleum refinery, which stream is passed through one or more of the heat exchange units 10 and which must be cooled in an efficient manner and which, if allowed to pass out of the heat exchange units without being cooled, will cause operating difficulties. The cooling medium is generally water, and it will pass in indirect heat exchange relation with the hot stream in the heat exchange units.

I find that the individual heat exchange units are preferably interconnected in pairs to the common tank or drum 12, and multiple hot streams may be interconnected with the heat exchange units 10. It is desirable to provide duplicate units from the standpoint of continuous operation since cleaning can be accomplished by simply shutting off one unit at a time and since no general shutdown is then required. Furthermore, in order to obtain flexibility of operation, I preferably provide valves 24 in vapor manifolds 13 and valves 24a in condensate manifolds 14. In this manner, it is possible to conveniently vary the number of units 10 which may be required to take care of any particular hot stream. Similarly, I may also provide valves 25 and 25a to vary and control the circulation of the cooling water through units 10.

One of the principal features of my invention, however, is the provision of a reserve cooling water supply, which object is accomplished by maintaining a volume of water in the drum 12, the latent heat value of which is such that, if the inflow of cooling water ceases, it will require at least thirty minutes, for example, to bring about its evaporation with the normal heating capacity of the hot streams. In the interim, the flow of water through the tubes continues so that effective heat transfer takes place. This object may be accomplished by providing the drum 12 in an elevated position and connecting it by downcomers 20 with the bottom head 38 of heat of the heat exchange units 10 as through the header 17, which serves to interconnect the bottom heads of the shell portions of the several heat exchange units.

The cooling water which enters the common header 17 preferably under pressure passes through the branch pipes 39 to the respective heat exchange units 10 and passes through the tubes of the tube bundles 15 of the heat exchange units and discharges into the open reservoir 12. This reservoir has a drain pipe 42, through which the overflow discharges to waste or external coolers. It will thus be seen that, under ordinary service, the flow of cooling water is once through the tubes of the heat exchange units with a resulting high rate of heat transfer. Inadvertent upward flow of the incoming cooling water

through downcomers 20 is prevented by check valves 44. Each head 38 is provided with an independent blow-down connection including valve 46, which is connected to drains 47 or 47a respectively.

In accordance with my invention, under abnormal operation as during an interruption in the water inflow through header 17, check valves 44 open, and there is a continued circulation of water through the tubes of units 10 by virtue of the higher temperature of the water in the heat exchange tubes as compared with the temperature of the water in the downcomers 20 and the tank 12. As the water slowly warms up because of the heat transfer in the condensing operation, there will be some evaporation. With the evaporation of a part of the water, however, the water level will gradually fall below the level of the connection 45 between the top of the heat exchange units and the tank. Until this condition occurs, the heat exchange rate is substantially as high as it is with the once-through operation. Such initial abnormal operation, in which the temperature of the cooling water is being raised to its boiling point, may be arranged to last for approximately ten minutes under full load conditions. It is, of course, well known that the heat of evaporation of water is many times greater than the heat required to raise it to its boiling point.

If, in this time, it has not been possible to restore the water supply or sufficiently shut down the unit, the reserve operation becomes effective. In such case, the latent heat of evaporation of the entire supply of water in the tank 12 is available to bring about the desired condensation. It will be noted that the water will continue to flow from the tank 12 through downcomers or return-flow conduits 20 into the lower part of the respective tube bundles of the condensing units. At first, the water will completely fill the tubes, and at all times it will fill the lower portion of the tubes so that the vapors must be condensed, if condensable at 212° F., before they enter the condensate trap 48 at the lower part of the unit.

For any predetermined operation, the amount of water in tank 12 can be predetermined to give the desired safety factor. Ordinarily, stoppages are of a temporary nature, and only a few minutes' protection is required. My construction will adequately provide for this protection. If, however, the refinery unit must be shut down, a time period of about thirty minutes is normally sufficient; and absolute safety for such a time is provided by using the latent heat of evaporation value of the entire water supply.

The arrangement of a separate water reservoir apart from the heat exchange units makes possible such economies of size and construction as to prove of considerable benefit. The entire water supply can be at the desired elevated height to assure adequate flow, and tank sizes can be limited to those found most effective for the operating conditions.

It will be apparent that, with water, it is usually preferable to have the hot stream pass around the tubes in the shell as this mode of operation gives the highest heat transfer rate; but it will be understood that this feature also depends on the relative cleanness of the respective materials, and the reverse arrangement could be provided.

Although I have shown and described a preferred form of embodiment of my invention, I am

aware that 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 of the claims appended hereinafter.

I claim:

1. A heat exchange unit including a reservoir, shell and tube heat exchange means mounted adjacent the reservoir, means to introduce condensible hydrocarbon vapors 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, means to interconnect the other end of the tube side of the heat exchange means with the reservoir, said heat exchange means being at such an elevation 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 tubes, said reservoir being detached and at an elevation substantially equal to the top 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 thermosiphon action of the flow of water upwardly through the heat exchange tubes from the reservoir when the supply of cooling water is cut off, said reservoir maintaining a positive head of liquid on said tubes irrespective of an external supply of cooling water.

2. A condenser for hydrocarbon vapors, which comprises a reservoir, a plurality of detached individual vertical shell and tube heat exchange units, means to introduce cooling water under pressure to the lower end of the tubes of said units, means to connect the upper end of said tubes with said reservoir whereby the water, after passing through said tubes, will fill said reservoir, said reservoir being elevated with respect to the lower end of the heat exchange units, means attached to the reservoir to maintain the normal level of water in said reservoir above the top of said tubes, a 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, a return-flow conduit from said reservoir interconnected to the lower end of the tubes, a valve in said return-flow conduit, said valve being normally closed to upward flow and automatically opening under thermosiphon action of the water flowing upwardly through said tubes and downwardly from said reservoir when the supply of pressure water to the tubes is cut off, said condenser having a heat transfer rate equal to that of a shell and tube unit with the water in the tubes, and a safety factor of an available water supply equal to that of a typical submerged condenser with the vapors in the tubes.

3. A condenser for vapors, which comprises an open tank, a shell and tube heat exchange unit mounted adjacent the tank, means to introduce hydrocarbon 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 con-

tact 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, means to conduct the overflow from said tubes into the tank, means to maintain the normal level of water in the tank above the upper end of the heat exchange tubes, said tank being elevated with respect to the lower end of the tubes, a return-flow conduit between 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 tank into the tubes when the head of colder water in the tank overbalances the head of warmer water in the tubes.

4. A condensing apparatus for condensing hydrocarbon vapors from a distillation process, which comprises at least two individual vertical shell and tube heat exchange units, means to introduce cooling water under pressure to the lower end of the tubes of said units, an elevated and detached reservoir, means to interconnect the upper end of said tubes with said reservoir whereby the water after passing through said tubes will pass to said reservoir, means in said reservoir to maintain the normal level of water in said reservoir above the top of said tubes, a 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, and a return-flow conduit extending from said reservoir to the lower part of the tubes in said units whereby the water in said reservoir will pass into said tubes when the supply of water under pressure to the tubes is cut off, said condenser having a heat transfer rate equal to that of a shell and tube unit with the water in the tubes, said reservoir having an available water supply adequate to condense the vapors for a period substantially equivalent to that of a typical submerged condenser with the vapors in the tubes.

5. A condensing apparatus for independently condensing at least two independent streams of hydrocarbon vapors from a distillation process, which comprises at least four individual vertical shell and tube heat exchange units, means to introduce cooling water under pressure to the lower end of the tubes in said units, the upper end of said tubes being open, an elevated and detached reservoir, means to connect the open end of said tubes with said reservoir whereby the water after passing through said tubes will pass into said reservoir, means in said reservoir to maintain the normal level of water in said reservoir above the top of said tubes, vapor manifolds interconnected to the upper portion of the shell side of each pair of said units for introduction of the separate streams of hydrocarbon vapors in countercurrent indirect heat exchange relation with the cooling water, valves in each of said vapor manifolds whereby the independent vapor streams may be introduced into one or more of the respective units, a condensate manifold interconnected to said shells for the removal of condensate therefrom, and a return-flow conduit extending from said reservoir to the lower portion of said tubes whereby the water from said reservoir will flow into the lower end of said tubes and by thermosiphon action will flow upwardly through said tubes into said reservoir when the supply of pressure water to the tubes is cut off,

said condenser having a heat transfer rate equal to that of a shell and tube unit with the water in the tubes, and a safety factor of an available water supply equal to that of a typical submerged condenser with the vapors in the tubes.

6. An apparatus for use with conventional petroleum distillation equipment of the type wherein a plurality of independent streams of hot oil is removed therefrom and cooled, the combination therewith of a heat exchanger consisting of at least four identical interconnected units of the shell and tube type, a common elevated and detached water drum, means for introducing water into said units, means to discharge water into

5 said drum, means to provide thermosyphon circulation between the drum and the water portion of said units, and means for passing independent streams of hot oil in heat exchange relation with said units, said means including a manifold and valve arrangement whereby the independent hot oil streams from the petroleum distillation equipment may be separately introduced into one or more of the units, the valves in said manifold permitting the number of units to be varied to correspond to changed conditions of the hot oil streams.

10 WHEATON W. KRAFT.

CERTIFICATE OF CORRECTION.

Patent No. 2,323,474.

July 6, 1943.

WHEATON W. KRAFT.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 59, for "heat" first occurrence, read --each--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.
Signed and sealed this 10th day of August, A. D. 1943.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)