

June 24, 1941.

R. W. WATERFILL

2,247,107

REFRIGERANT EVAPORATOR

Filed Sept. 30, 1938

4 Sheets-Sheet 1

Fig. 2.

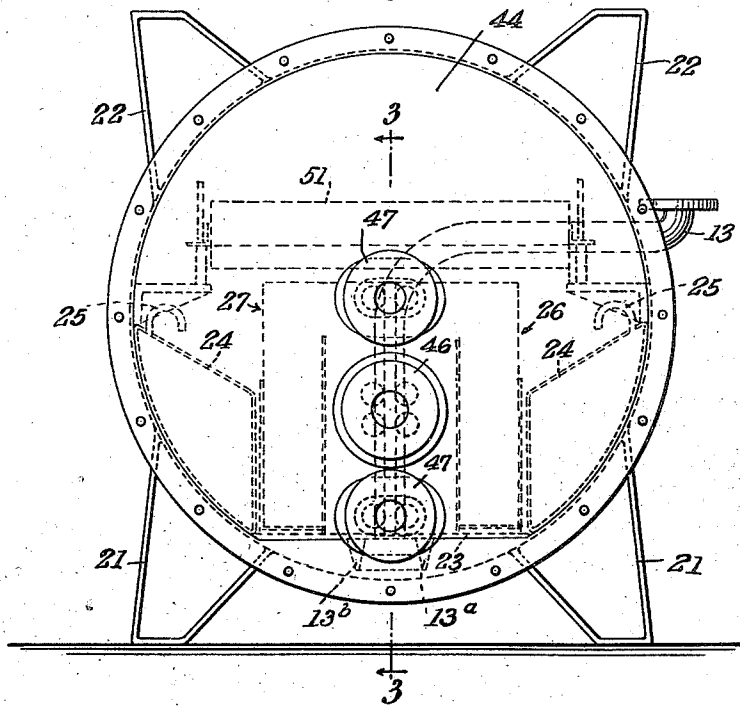
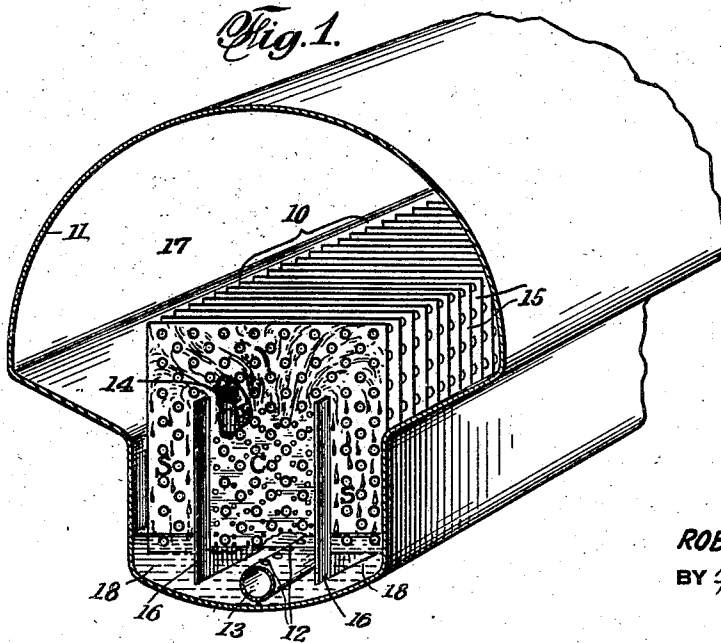


Fig. 1.



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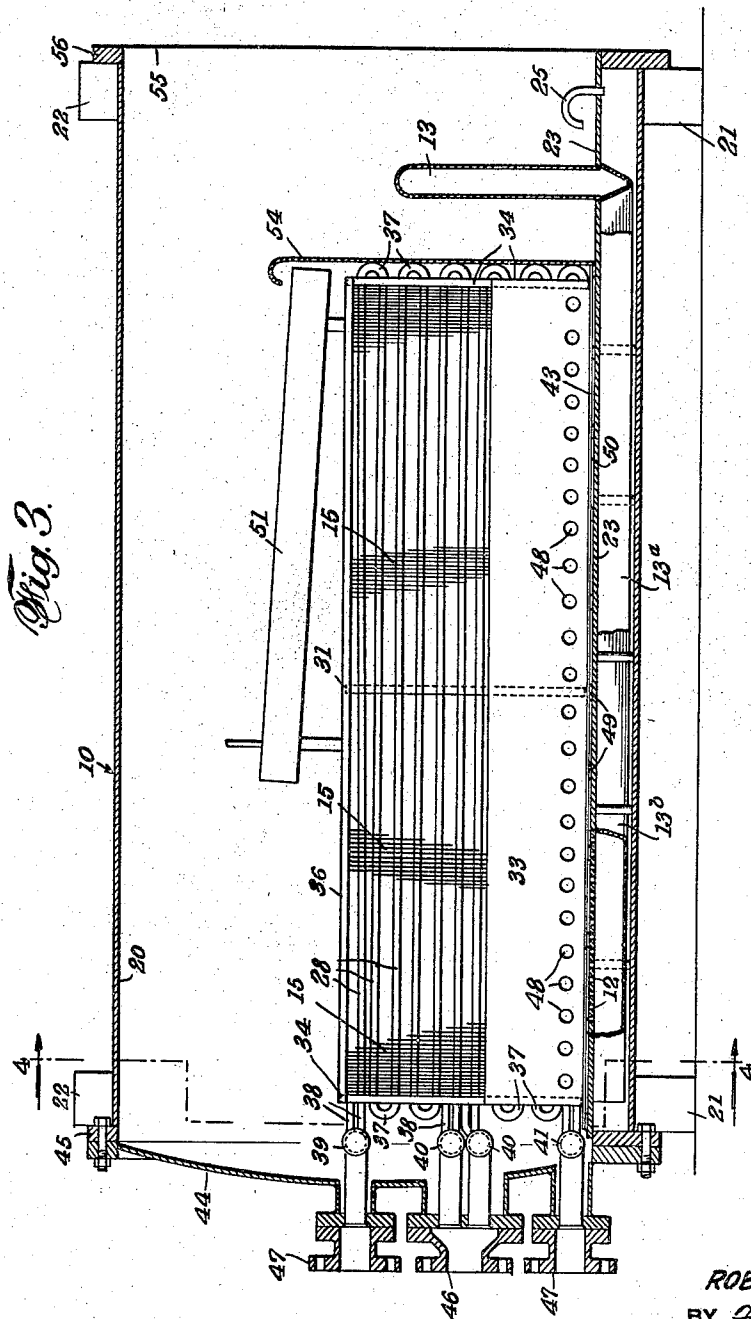
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4 Sheets-Sheet 2



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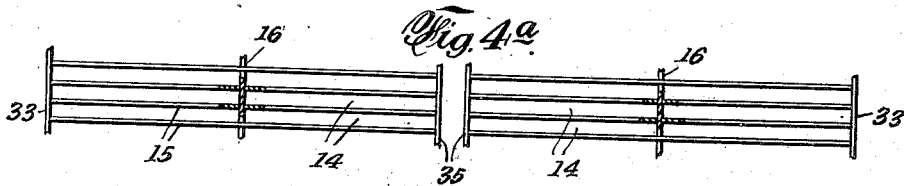
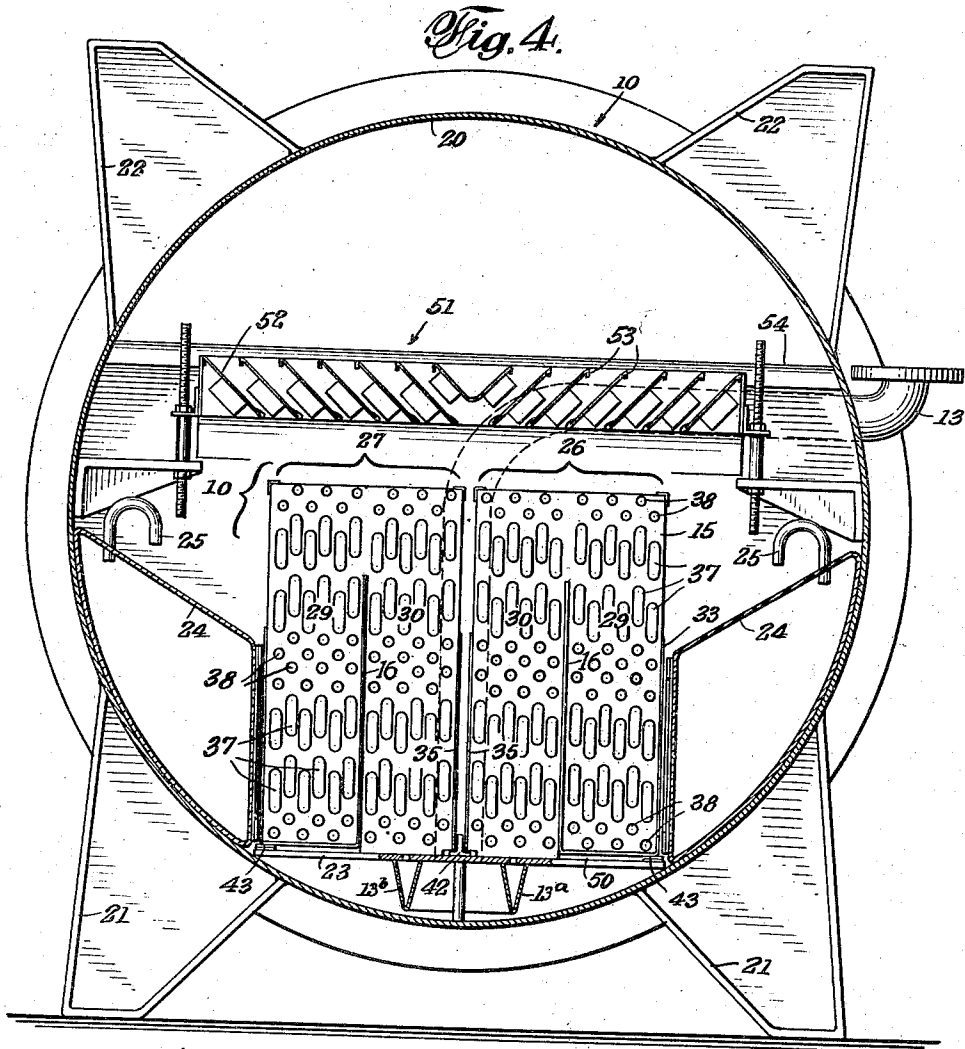
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4 Sheets-Sheet 3



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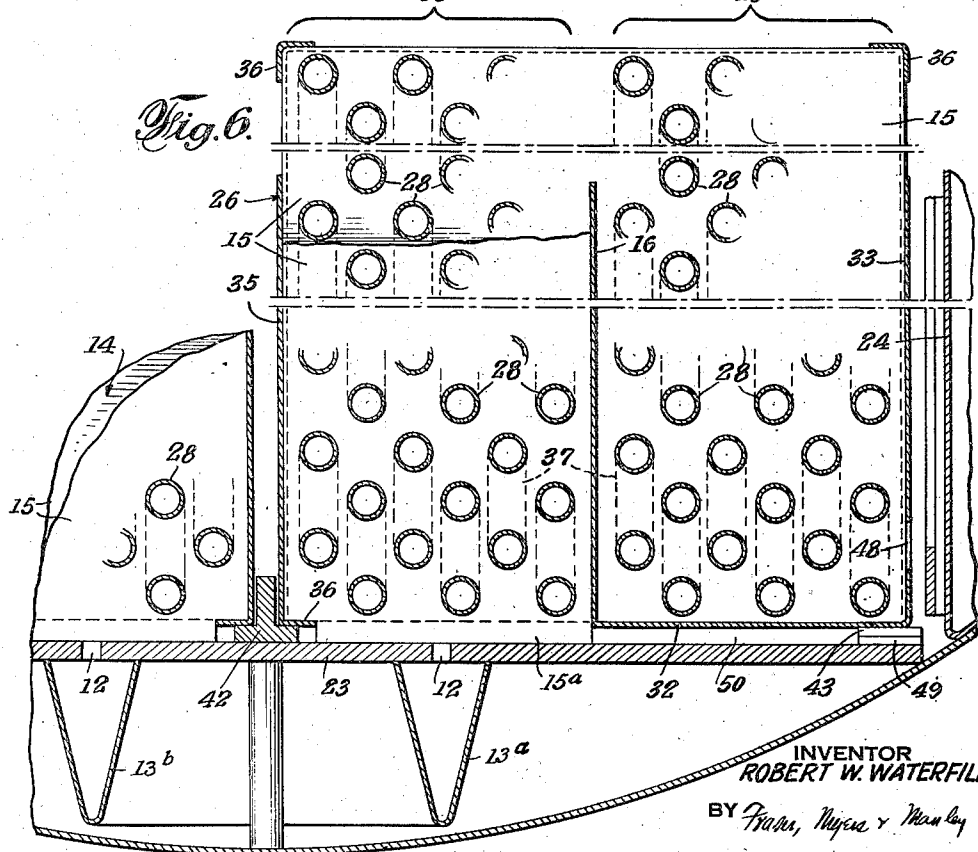
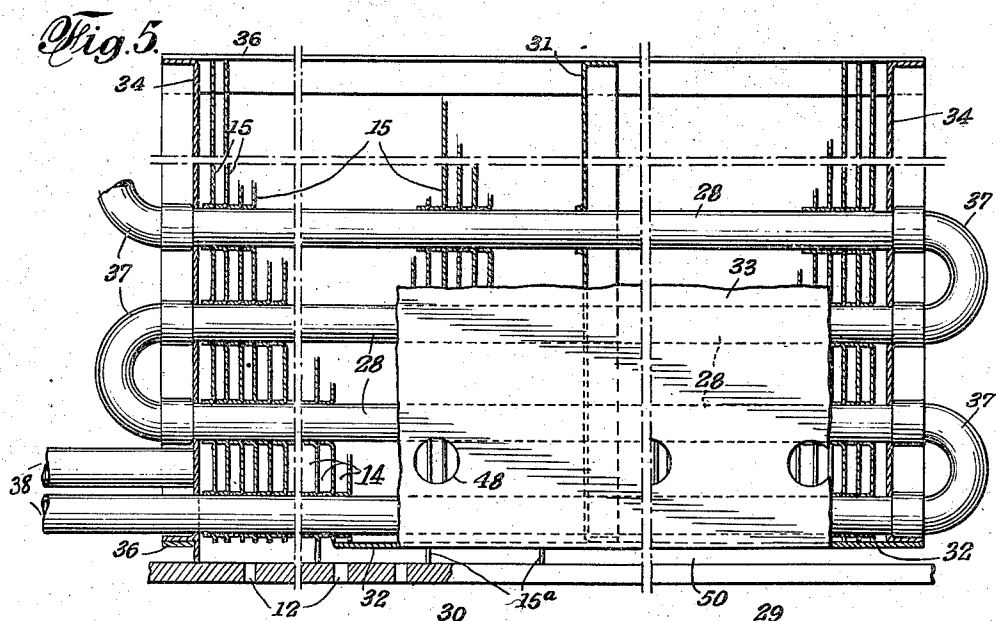
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2,247,107

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,247,107

REFRIGERANT EVAPORATOR

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Application September 30, 1938, Serial No. 232,581

18 Claims. (Cl. 62—126)

This invention relates to improvements in refrigerant evaporators, and more particularly to a method and means for distributing refrigerant liquid over the heat-exchanging surfaces of a shell-and-tube evaporator.

The principal object of the invention is to provide an evaporator or cooler into which liquid refrigerant may be introduced directly from the condenser, and its own energy utilized to raise the liquid from the base of the evaporator and circulate it over the heat-exchanging surfaces therein.

It is another object of the invention to provide a shell-and-tube cooler with a plurality of narrow channels extending vertically from the base of the shell upwardly between the tubes of the bank which serve to confine flash gas resulting from the evaporation of liquid refrigerant introduced into the base of the shell to cause it to lift unevaporated refrigerant through the channels and over the heat-exchanging surfaces of the tubes.

It is yet another object of the invention to provide a shell-and-tube refrigerant evaporator characterized in that the tube bank is divided longitudinally into a plurality of sections having their open upper ends in free communication and their open lower ends sealed one from another by the presence of liquid refrigerant in the base of the shell, and in that one section is further divided into a plurality of vertical channels through which refrigerant liquid may percolate upwardly from the base of the shell over the surfaces of the tubes in that section and be discharged into an adjacent section from whence it may flow downwardly over the tubes therein and return through the liquid seal to that portion of the base of the shell immediately beneath the vertical channels in the first-mentioned section.

It is a further object of the invention to discharge a plurality of streams of liquid refrigerant from the condenser of the refrigerating system into the shell of the evaporator immediately beneath the vertical channels mentioned in the foregoing objects for the purpose of inducing a flow of liquid into such channels, and to provide an initial volume of flash gas which is needed, or at least is highly desirable, in starting the circulating cycle.

It is a more specific object of the invention to provide a shell-and-tube evaporator with a plurality of plate fins extending crosswise of the tubes with their lower edges disposed adjacent the base of the shell and defining a large num-

ber of thin vertical channels through which liquid refrigerant introduced into the base of the shell may percolate upwardly over the heat-exchanging surfaces of the tube bank in accordance with the foregoing objects.

It is yet another specific object of the invention to provide an evaporator of the character described having a pair of vertically disposed plates dividing the tube bank longitudinally into three sections with their lower edges spaced slightly above the base of the shell to provide passageways between adjacent sections which may be sealed by the presence of refrigerant liquid in the base of the shell, and a conduit for discharging jets of liquid refrigerant from the condenser side of the system into the base of the shell immediately beneath the center section of the tube bank so that flash gas resulting from the evaporation of some of the introduced liquid will be confined within vertical channels formed between the just-mentioned vertical plates and a plurality of plate fins extending crosswise of the tubes of the center section to cause it to lift remaining liquid therethrough and to discharge it over the tubes in the two outer sections of the bank.

The foregoing and other objects of the invention, along with various features thereof making for economy in manufacture and efficiency in operation, will be more apparent from the following description when read in connection with the accompanying drawings, in which

Figure 1 is a perspective view, partly in section, of a fragment of a shell-and-tube evaporator embodying the principles of the present invention and illustrating in a more or less diagrammatic fashion the manner in which it operates;

Fig. 2 is an end elevational view of an evaporator embodying the invention in practical form;

Fig. 3 is a longitudinal section taken on the line 3—3 of Fig. 2;

Fig. 4 is a vertical section taken on the line 4—4 of Fig. 3;

Fig. 4a is a plan view of a fragment of the tube bank of Fig. 4;

Fig. 5 is an elevational view of a fragment of the tube bank of the evaporator illustrated in Figs. 2, 3 and 4, with certain parts thereof broken away better to show the underlying ones; and

Fig. 6 is an end elevational view, in section and on an enlarged scale, of a fragment of the evaporator of Figs. 2, 3 and 4 and illustrating

certain features of the invention not readily apparent in Fig. 4.

The essential elements of a shell-and-tube heat interchanger adapted to be used as an evaporator or cooler on the low pressure side of a refrigerating system are illustrated in Fig. 1. There it may be seen to comprise a bank of inter-connected tubes 10 through which water, brine, or any other suitable media, may be circulated so as to be cooled by the evaporation of liquid refrigerant within the shell 11. For best results, maximum heat transfer, the surfaces of the tube bank should be maintained in a wetted state. In conventional present-day systems this is done either by providing a circulating pump which draws a constant volume of liquid from the base of the shell and showers it over the bank of tubes, or by the submergence of the bank in a large volume of refrigerant, all in a well understood manner. The evaporator of the present invention, however, needs no such pump. It is arranged to utilize the energy of refrigerant introduced into the shell from the condenser, as represented by the pressure differential between the condenser and evaporator, as well as the energy released by the change of state of some of the refrigerant from a liquid to a gas, to lift remaining liquid from the base of the shell and to distribute it over the heat exchanging surfaces of the tube bank. Briefly stated, this is done by discharging jets of refrigerant from the condenser of the system within the base of the shell immediately beneath the tube bank, and by confining flash gas resulting from the evaporation of some of the refrigerant to cause it to froth the remaining liquid, and to lift the froth through a plurality of vertical channels over the heat exchanging surfaces of the tube bank. Once the action starts, and the lower rows of tubes are wetted, a further portion of refrigerant is evaporated by heat interchange with the media in the tubes. The resulting vapor is added to the initial volume of flash gas and provides additional energy to assist in conveying the froth to the top of the bank. It is evident that the action accumulates as it proceeds, i. e., more and more energy is made available to lift less and less liquid as the froth rises through the bank.

The foregoing may better be understood by considering the operation of a practical embodiment of the invention. For this purpose reference will be had to the more or less diagrammatic representation of the invention in Fig. 1. There liquid refrigerant is introduced into the shell 11 of the evaporator from a condenser (not shown) through the orifices 12 in conduit 13 located in the base of the shell immediately beneath the center section C of the tube bank. This introduced liquid, being under greater pressure than that existing in the evaporator, is discharged upwardly in the form of jets and entrains some of the liquid from the base of the shell and carries it into the lower ends of the vertical channels 14. In the preferred arrangement, these channels are defined between the opposing surfaces of the plate fins 15 which extend crosswise of the tube, and the vertically disposed plates 16 which divide the bank longitudinally into the center section C and the two adjacent outer sections S. Some of the liquid immediately vaporizes upon its introduction into the shell. The resulting flash gas, however, is confined within the center section C, and can escape

only through the open upper ends of the channels 14. In so doing it bubbles through the liquid in the lower ends of the channels, and creates a light froth of liquid and gas, which necessarily is lifted through the channels under the influence of the escaping gas as well as by the action of the jets of introduced liquid. This column of froth, obviously, serves to maintain the surfaces of the fins and tubes of the center section thoroughly wetted.

The volume of confined flash gas is augmented as the action proceeds by the evaporation of liquid from the surfaces of the tubes through heat interchange with the medium therein. This additional gas, of course, provides additional energy to lift the froth and discharge it from the upper ends of the channels. At that point, i. e., the top of the channels are defined by the upper edges of the dividing plates 16, the flash gas rapidly expands, breaks up the froth, and throws the remaining liquid in all directions. Some of it passes upwardly to wet the tubes of the center section lying above the upper ends of the channels, and some of it is blown sidewise into the adjacent side sections S. The latter drips downwardly over the fins and tubes in those sections to keep their surfaces thoroughly wetted. Some of it is necessarily evaporated by heat interchange with the medium to be cooled. The resulting vapor, however, is not confined, but may readily escape into the upper portion 17 of the shell without interfering with the downward flow of liquid over the heat exchanging surfaces. There it joins other vapor to be withdrawn from the shell by a compressor or absorber (not shown) in a well understood manner.

Any excess liquid drains from the fins and tubes and collects in the base of the shell beneath the side sections S of the tube bank from whence it must be returned to the center section in order that the circulation may continue. In the preferred embodiment the return is provided for in a very simple way, namely, through liquid sealed passageways connecting the bases of adjacent sections of the tube bank. Thus, and again referring to Fig. 1, it will be noted that the dividing plates 16 extend down into the reservoir of liquid in the base of the shell, but have their lower edges spaced from the surface of the shell to define small passageways between the center and the two side sections. The operation is simple and wholly automatic. As soon as the refrigerating system is started, the pools of liquid 18 in the side sections promptly build up to points at which their static heads just balance the columns of froth in the channels 14 of the center section. Thereafter, any excess liquid draining into these pools merely displaces liquid therein causing it to pass under the lower edges of the dividing plates 16 and into the center section C.

The constructional details of a preferred practical embodiment of the invention are illustrated in Figs. 2 to 6 inclusive. In that embodiment the main body of the shell 11 is formed from a section of cylindrical steel tubing 20, which is supported on legs 21 welded to its outer surfaces at its opposite ends. Additional legs 22 may be provided to serve as a support for the condenser or any other part of the complete refrigerating system. The effective base of the shell is defined by a deck plate 23 extending the full length of the body 20 and welded thereto; and its effective lower side portions are defined by filler plates

24. The purpose of these last-mentioned parts, which may hereinafter be referred to as the base and sides of the shell, is to reduce the effective volume of the base portion of the shell to that actually required, and thus to reduce the quantity of refrigerant which must be placed in the system. Appropriate breather pipes 25 (Figs. 3 and 4) connect the used and unused spaces to equalize the pressure in all parts of the actual shell.

The tube bank 10 (Fig. 4) is built up from two units 26 and 27 in order to facilitate assembly of the many tubes and fins, and for other reasons which will later appear. The construction of unit 26 will first be considered. As shown in Figs. 3, 4 and 6 it consists of twelve rows of inter-connected tubes, twelve to a row, having plate fins 15 applied thereto at regularly spaced points, and divided longitudinally into a pair of sub-units 29 and 30 by the presence of the dividing plate 16, the bottom plate 32 and the side plate 33. According to the preferred method of assembly all of the plate fins 15, the center supporting plate 31 and the two end plates 34 are mounted in an appropriate rack with their various tube openings properly aligned. Individual tubes 28 may then be threaded through the aligned openings and, by the application of hydraulic pressure, may be expanded so as to engage each plate, thus to secure the various parts in assembled relation. It will be noted in Fig. 6 that each fin has a central slit for the reception of the dividing plate 16 which may be inserted at this or a prior time as may be most convenient. At its lower edge the dividing plate joins the metal sheet 32 disposed across the bottom of the sub-unit 29 for its full length, and the bottom in turn joins the sheet 33 extending along the side of the sub-unit to a point substantially opposite the break in the filler plate 24. The unit is completed by the application at appropriate times of the inner side plate 35, the framework 36, and (Figs. 3 and 5) the return bends 37 to the opposite ends of the individual tubes 28. The open end portions 38 of the inter-connected tubes then all lie at one end of the unit for ready connection to the upper header 39, the two center headers 40, and the lower header 41.

The other main unit 27 is substantially identical with the unit 26 which has just been described, except insofar as its sub-units 29 and 30 are reversed right for left. The two units may be slid into place in the main body of the shell along the rails 42 and 43 attached to the center and side edges of the deck plate 23. When in position, the cap 44 may be bolted to the flange 45 of the shell, and the headers 39, 40 and 41 of the units connected to the inlet and outlet connections 46 and 47. In assembled relation the two outer sub-units 29 then serve as the outer sections S of the complete bank 10, while the adjacent sub-units 30 serve conjointly as the center section C, such lettered sections corresponding to those referred to in the description in Fig. 1. The two-sub-units 30, however, are still separated one from the other by the inner side plates 35. In order to supply refrigerant liquid to each, the liquid supply conduit 13 is brought in through the side of the shell and carried beneath the deck plate 23 where it is divided into two branches 13a and 13b, one extending under each of the sub-sections 30. In this particular embodiment it is to be noted that the deck serves as the actual top of each of the

branches of the conduit, and is pierced at regularly spaced intervals to provide orifices 12 corresponding to those in the conduit 13 of Fig. 1.

5 Other constructional details of the evaporator will be considered in the description of the operation of the system.

The operation of the evaporator of Figs. 2 to 6 as a part of a complete refrigerating system is functionally identical with that described in connection with Fig. 1. Thus, and referring now to Figs. 3, 4 and 6, liquid refrigerant introduced from the condenser of the system through the two branches of conduit 13, is discharged upwardly through the orifices 12 into the two sub-sections 30, and into the lower open ends of the channels 14 defined between the fins 15, the dividing plates 16, and the side plates 35. Some of that liquid immediately evaporates. The resulting flash gas is confined, however, in the channels 14, and can escape only through their upper ends. In so doing it forms froth and lifts that froth through the channels to maintain the fins and tubes of the center sections thoroughly wetted. At the top of the channels, and just as previously described, the flash gas breaks up the froth and throws any remaining liquid in all directions, some of it passing upwards over the adjacent tubes in the center sub-units 30, and the remainder being blown sidewise over the tubes in the upper portions of the sub-units 29. From that point the liquid flows downwardly over the fins and tubes in the two outer sub-units to maintain the surfaces thereof thoroughly wetted. Any excess, of course, collects in the bottoms of the troughs within which the tubes of the outer sections lie. When a sufficient pool has been built up excess liquid then drains through the openings 48 in the outer side plate 33, and passes down between the side plate 33 and the adjacent surface of the filler 24, under the rails 43 which it may be noted (Figs. 3 and 6) are supported above the deck 23 on spacers 49, and through the passageway 50 beneath the bottom 32 back into the base of the sub-section 30. There it meets the incoming streams of liquid, introduced at condenser pressure through the orifices 12, and is carried into the lower ends of the vertical channels 15 of the sub-section 30 again to percolate upwardly with the escaping flash gas to repeat the cycle just described.

In this form of the invention it will be noted that the lower tubes of each sub-unit 29 lie wholly within a trough defined by the dividing plate 16, the bottom plate 32, the side plate 33 and the two end support plates 34. The bases of these sub-units 29 are effectively separated from those of sub-units 30 by the presence of liquid in the space between the bottom 32 and the deck plate 23 and that between the side 33 and the adjacent surface of filler 24. If these passages are dry when the evaporator is first started, liquid entering through the orifices 12 escapes through them and promptly builds up a static head between the side plate 33 and the adjacent surface of the filler, spilling into the trough through the openings 48 if necessary, sufficient to balance the head in the sub-units 30 so that the percolating action may proceed. It will readily be recognized by those skilled in the art that the presence of the deck plate 23 and the filler 24 reduces the effective volume of the shell to that which is actually required and thus reduces the quantity of refrigerant necessary for proper operation to a minimum.

The large majority of the portions of the fins 15 within the sub-units 30 have their lower edges spaced slightly above the surface of the deck plate 23. An occasional one of them 15a, at regularly spaced intervals, extends below the others, and has its lower edge resting on the deck plate, as may best be seen in Fig. 5. These extended fins 15a serve to divide the space immediately beneath the sub-units 30 into a number of longitudinal compartments into each of which liquid is discharged from one or more of the orifices 12. This is done for the purpose of securing better distribution of the liquid throughout the entire sub-section 30—to prevent any tendency of the liquid to flow into any particular part of the sub-section 30 and leave the remainder more or less dry.

The refrigerant flash gas or vapor escapes from the upper part of the tube bank at fairly high velocity. As always, there is some tendency on the part of this escaping gas to entrain and carry liquid with it. An eliminator 51 is therefore positioned immediately above the tube bank, as best shown in Figs. 3 and 4 to remove liquid from the escaping vapor. The eliminator is of more or less conventional construction, comprising a series of baffles 52 extending lengthwise of the tube bank in an angular position so that each baffle overlaps an adjacent one. The escaping vapor, in passing through these baffles, throws entrained liquid against them so that the latter may be caught by the intumed edges 53 of the baffles and drained along the eliminator to the cross-baffle plate 54 from whence it may flow back to the base of the shell for recirculation. The eliminator is required only in that section of the shell wherein the velocity of escaping vapor is sufficiently high to entrain and carry liquid refrigerant with it. Such is not the case near the left-hand end of the shell and accordingly the plates extend only from a point adjacent the baffle 54 to some point beyond the center of the tube bank.

The refrigerant vapor is withdrawn from the shell through the outlet 55 by a compressor, an absorber, or any other usual device. In the embodiment of the invention illustrated in Figs. 2 to 4 inclusive, this outlet is defined by the right-hand end of the shell, a flange 56 being provided to receive a complementary flange of a compressor or a suitable connecting conduit. With this arrangement the necessity for the usual outlet opening in the top of the shell, and for a head to cover the right-hand end of the shell, is completely obviated. To do so, however, it is essential that the tube bank shall not extend the full length of the shell, and that its right-hand end shall be blocked off, so to speak, by the provision of the baffle indicated at 54.

The circulation of liquid refrigerant from the base of the evaporator shell over the heat exchanging surfaces of the tube bank is achieved principally by the percolating action which has been described. It is not, as might be assumed, a mere matter of entraining liquid from the base of the shell with the jets of liquid introduced from the condenser. The energy for lifting the liquid in the present evaporator is derived partly from the change of state of the refrigerant as a result of heat interchange. The ability of the jets to entrain liquid is also utilized but their principal function is to supply the initial volume of flash gas which is needed to start the percolating cycle.

In the preferred embodiments of the invention

the tube bank is divided into several longitudinal sections by the presence of the plates 16; and provision has been made for introducing liquid refrigerant into the evaporator shell immediately beneath one of these sections. This has been done in order to confine the initial volume of flash gas available from the liquid within a relatively small space where it may function most effectively as a priming agent to start the percolating action which thereafter gains momentum, so to speak, as it proceeds. The division is further desirable however, in that it assures proper distribution of the refrigerant throughout the entire bank to maintain all heat transfer surfaces in a wetted state. The bank may, if desired, be divided into a great many more sections than the three which have been shown. On the other hand, it need not be longitudinally sub-divided at all. The percolating action will still start in the channels defined by the fins although possibly not so promptly; and it will continue, through with less complete distribution of liquid at times.

The principles of the invention are applicable regardless of the character of the refrigerant which is being used. Thus, they may be embodied in evaporators using refrigerants of the high pressure group, such as carbon dioxide, propane, ammonia, freon, and the like, as well as in others which use low-pressure refrigerants such as dichloro-menthane, trichloro-ethylene and the like. The main difference between these classes of refrigerants, so far as the present invention is concerned, lies in the fact that with the first-mentioned ones a small volume is circulated through the system at a fairly high evaporator-condenser pressure differential, whereas with the others a large volume is circulated at a fairly low pressure differential. The essential differences between evaporators designed for these refrigerants will readily be apparent to those skilled in the art—and will involve mere changes in the size and section of the tube bank, etc.

The practical evaporator shown in Figs. 3 to 6 inclusive, is particularly designed for use with a refrigerant of the so-called low-pressure class. It is there possibly that the invention has its greatest application. Those skilled in the arts will readily appreciate the impracticability of wetting the heat exchange surfaces by submergence in a large volume of a refrigerant of this class. Surface evaporation is needed, and the present invention provides a way to secure it without requiring an independent pump, and accessories, to shower the bank with refrigerant in the manner now practiced.

Since certain changes may be made in the invention and in the practical embodiments thereof, it is intended that the foregoing shall be construed in a descriptive rather than in a limiting sense.

What I claim is:

1. A shell and tube refrigerant evaporator comprising a shell adapted to serve as a path for a volatile refrigerant, a bank of tubes extending through said shell which serve to conduct a medium to be cooled, a pool of liquid refrigerant in the base of said shell which is insufficient to submerge more than a few rows of tubes at the bottom of the bank, means for supplying additional refrigerant to said pool, at a temperature above that prevailing in said pool, and fins extending from said tubes at closely spaced points, which fins and tubes serve to confine vaporous refrigerant formed in the pool to cause it to create a

froth of liquid and vapor, and also to confine said froth so that it may rise through said bank and wet said tubes and fins thereof.

2. A shell and tube refrigerant evaporator of the type wherein the tube bank is not submerged in liquid refrigerant, such evaporator comprising a shell adapted to serve as a path for a refrigerating fluid, a bank of tubes extending through the shell and serving to conduct a fluid to be cooled, means defining a plurality of channels extending crosswise of and vertically within the bank of tubes and including the outer surfaces of the tubes, each such channel having its lower end open adjacent the base of the shell and its upper end open adjacent the top of the tube bank, and a conduit for discharging liquid refrigerant into the base of said shell whereby flash gas resulting from the evaporation of some of the refrigerant may be confined and caused to lift remaining liquid refrigerant through said channels and over the outer surfaces of the tubes of the bank.

3. A refrigerant evaporator according to claim 2 further characterized in that said channels have their open lower ends spaced above the base of the shell, and in that said conduit is disposed beneath the bank of tubes and is arranged to discharge liquid refrigerant through liquid refrigerant in the base of the shell beneath the tube bank to carry some of that liquid into the lower ends of said channels.

4. A refrigerant evaporator according to claim 2 further characterized in that said means includes a plurality of fins extending from the surfaces of the tubes at closely spaced points.

5. A refrigerant evaporator according to claim 2 further characterized in that said tubes extend lengthwise of the shell in a horizontal position, and in that said means includes a plurality of closely spaced, plate fins extending crosswise of the tubes, and a vertically disposed dividing plate extending crosswise of such fins parallel to the tubes.

6. A shell and tube refrigerant evaporator of the type wherein the tube bank is not submerged within liquid refrigerant in the shell, such evaporator comprising a shell, a bank of horizontally disposed tubes extending lengthwise of the shell and partially filling the same, a plurality of fins extending crosswise of the tubes at closely spaced points, means cooperating with the ends of such fins at the sides of the bank of tubes to define a plurality of channels extending vertically within the bank of tubes and having their lower open ends adjacent but spaced from the base of the shell and their open upper ends terminating within the bank of tubes, and a conduit for discharging liquid refrigerant into the base of the shell and for directing such liquid within said channels whereby to confine flash gas resulting from the evaporation of some of the liquid to cause it to lift liquid from the base of the shell through the channels over the fins and tubes.

7. A refrigerant evaporator according to claim 6 further characterized by the provision of a substantially vertically disposed plate extending crosswise of the fins and dividing the tube bank longitudinally into a plurality of sections; and in that said conduit is arranged to discharge liquid refrigerant into the space beneath the open ends of the vertical channels lying within one section of the bank whereby some of it may be lifted by flash gas through such channels over the fins and tubes of that section and be discharged into another section.

8. A refrigerant evaporator according to claim 6 further characterized by the provision of a substantially vertically disposed plate extending crosswise of the fins and dividing the tube bank longitudinally into a plurality of sections; in that said conduit is arranged to discharge liquid refrigerant into the space beneath the open ends of the vertical channels lying within one section of the bank whereby some of it may be lifted by flash gas through such channels over the fins and tubes of that section and be discharged into another section; and by the provision of means for returning excess liquid refrigerant from the last-mentioned section to the space beneath the vertical channel in the first-mentioned section.

9. A refrigerant evaporator according to claim 6 further characterized by the provision of a substantially vertically disposed plate extending crosswise of the fins and dividing the tube bank longitudinally into a plurality of sections; in that said conduit is arranged to discharge liquid into the base of one section immediately beneath the open lower ends of the vertical channels lying within that section whereby some of it may be lifted by confined flash gas through such channels over the surfaces of the fins and tubes of that section and be discharged into an adjacent section; and in that said vertically disposed plate has its lower edge spaced above the base of the shell to provide a passageway for the return of liquid from the said adjacent section to the first-mentioned one, such passageway being sealed to the passage of liquid by liquid refrigerant therein.

10. A shell and tube refrigerant evaporator of the type wherein the tube bank is not submerged in liquid refrigerant in the shell, such evaporator comprising a shell, a bank of horizontally disposed tubes extending lengthwise of the shell and partially filling the same, a plurality of plate fins disposed crosswise of the tubes to define a plurality of channels extending vertically within the bank of tubes, such channels having their lower ends open adjacent but spaced from the base of the shell and their upper ends open adjacent the top of the bank of tubes, said shell having a reservoir portion in its base beneath the bank of tubes for a small volume of liquid refrigerant, and a conduit having a plurality of orifices therein for discharging jets of liquid refrigerant upwardly into said reservoir portion whereby to entrain liquid from the reservoir and to direct it into the lower ends of said channels.

11. A refrigerant evaporator comprising a shell serving as a path for a refrigerant fluid; a bank of horizontally disposed tubes extending lengthwise of the shell and serving to conduct a medium to be cooled, such bank partially filling the shell with the lower tubes disposed adjacent the base of the shell; a plurality of plate fins extending from the surfaces of the tubes at closely spaced points along their lengths; a pair of substantially vertically disposed plates dividing the tube bank longitudinally into inner and outer sections, said plates cooperating with the fins on the tubes in the inner section of the bank to define a plurality of narrow vertical channels; and a conduit extending along the base of the shell beneath the inner section of the tube bank, such conduit having a plurality of openings therein for discharging liquid refrigerant into the shell and for directing it into the lower ends of said channels in the inner section.

12. A refrigerant evaporator according to claim 11 further characterized in that the dividing

plates extend less than the full height of the tube bank whereby liquid refrigerant lifted through the channels of the inner section may be discharged into the outer sections and flow by gravity over the tubes in such outer sections; and in that such plates have their lower edges spaced above the base of the shell whereby liquid refrigerant collecting in the outer sections may return beneath the edges of such plates to the inner section.

13. A refrigerant evaporator according to claim 11 further characterized by the provision of side and bottom plates for the tubes in the two outer sections of the bank, such plates cooperating with the adjacent dividing plates to form troughs for collecting liquid refrigerant draining from the tubes in the outer sections; in that the side plates have a plurality of openings therein through which liquid refrigerant may escape when it reaches predetermined levels in the troughs; and in that the bottom plates are spaced above the base of the shell to provide passageways through which liquid refrigerant escaping from the side sections may pass back into the inner section.

14. A refrigerant evaporator according to claim 11 further characterized by the provision of side and bottom plates cooperating with the adjacent dividing plates to form troughs within which the tubes of the two outer sections lie, said side plates having openings therein at points spaced above their lower edges to permit the overflow of excess refrigerant from the troughs, and said bottom plates being spaced above the base of the shell to define passageways through which overflowing liquid may return to the inner section, such liquid serving as a liquid seal between the center and outer sections.

15. A refrigerant evaporator according to claim 11 further characterized by the provision of side and bottom plates cooperating with the adjacent dividing plates to form troughs within which the tubes of the two outer sections lie, said side plates having openings therein at points spaced above their lower edges to permit the overflow of excess refrigerant from the troughs, and said bottom plates being spaced above the base of the shell to define passageways through which overflowing liquid may return to the inner section, such liquid serving as a liquid seal between the inner and outer sections; and in that some of the fins for the tubes of the inner sec-

tion have their lower edges engaging the base of the shell while the remaining ones terminate short of the base, such extended fins being provided at regularly spaced intervals along the length of the tubes.

16. A refrigerant evaporator according to claim 11 further characterized by the provision of side and bottom plates cooperating with the adjacent dividing plates to form troughs within which the tubes of the two outer sections lie, said side plates having openings therein at points spaced above their lower edges to permit the overflow of excess refrigerant from the troughs, and said bottom plates being spaced above the base of the shell to define passageways through which overflowing liquid may return to the inner section, such liquid serving as a liquid seal between the inner and outer sections; in that some of the fins for the tubes of the inner section have their lower edges engaging the base of the shell while the remaining ones terminate short of the base, such extended fins being provided at regularly spaced intervals along the length of the tubes; and in that said conduit has at least one opening discharging liquid refrigerant into the base of the shell between each adjacent pair of extended fins.

17. A refrigerant evaporator according to claim 11 further characterized by the provision of a cap at one end of the shell; fluid supply and discharge connections between such cap and the tubes; a baffle extending crosswise of the shell adjacent the end of the tube bank which is remote from said cap; and in that the other end of the shell is adapted to serve as an outlet for the discharge of refrigerant from the shell.

18. A refrigerant evaporator comprising a horizontally disposed shell serving as a path for a refrigerant fluid; a bank of tubes extending lengthwise of and partially filling said shell, such tubes being interconnected at their opposite ends and serving to conduct a fluid to be cooled; a cap on one end of the shell; fluid supply and discharge connections between such cap and said tubes; a baffle extending crosswise of the shell at that end of the tube bank which is remote from said cap; a conduit for supplying refrigerant to the base of the shell; and an opening in the shell for the discharge of refrigerant vapor therefrom, such opening comprising the other end of the shell.

ROBERT W. WATERFILL.

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CERTIFICATE OF CORRECTION.

Patent No. 2,247,107.

June 24, 1941.

ROBERT W. WATERFILL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 1, for "longitddinal" read --longitudinal--; page 5, second column, line 33, claim 9, for "paper" read --vapor--; 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 2nd day of September, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.