Sept. 4, 1945. J. R. ZWICKL 2,384,413

COOLER OR EVAPORATOR

Filed Nov. 18, 1943 3 Sheets-Sheet 1

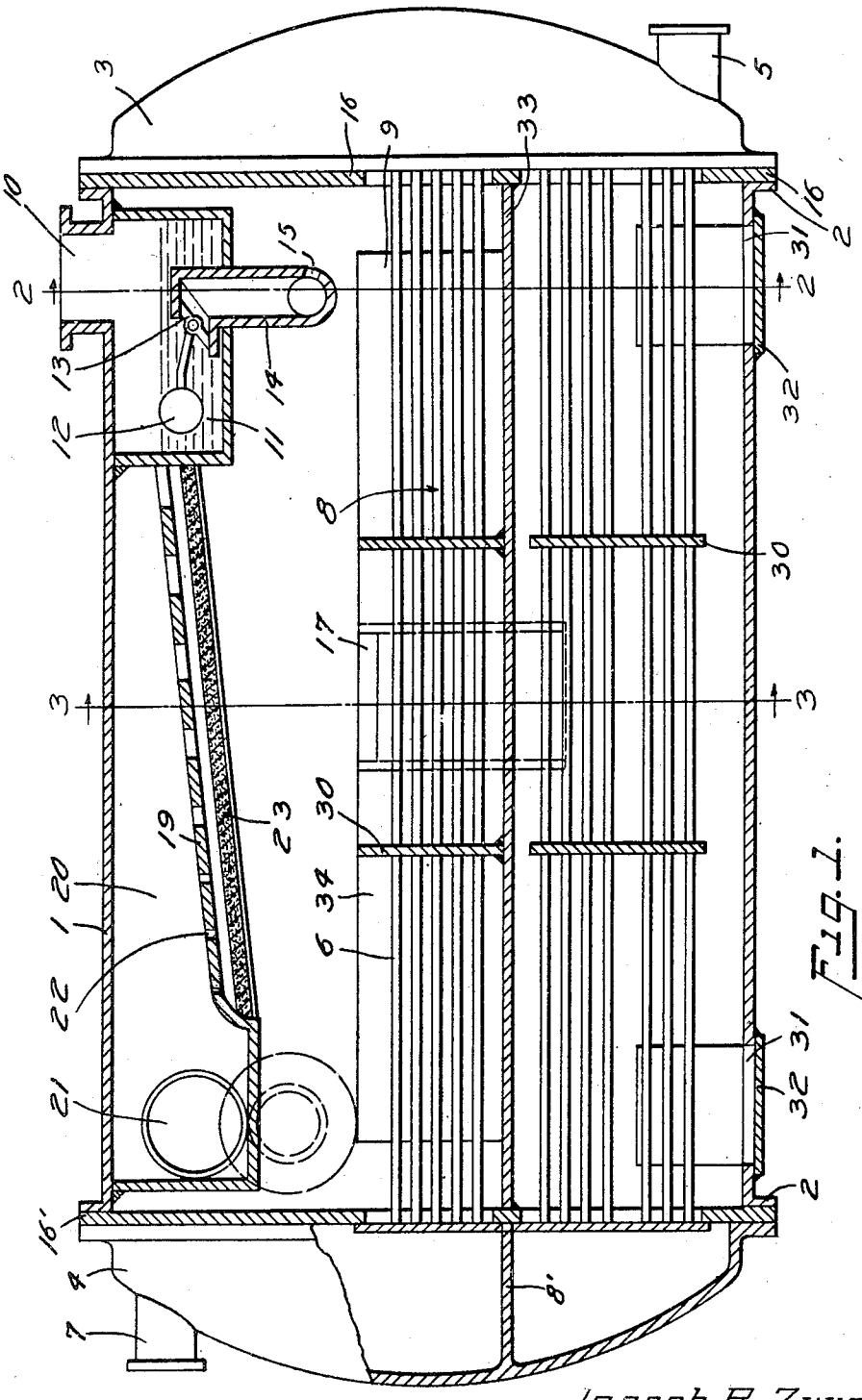

FIG. 1.

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Fig. 2.

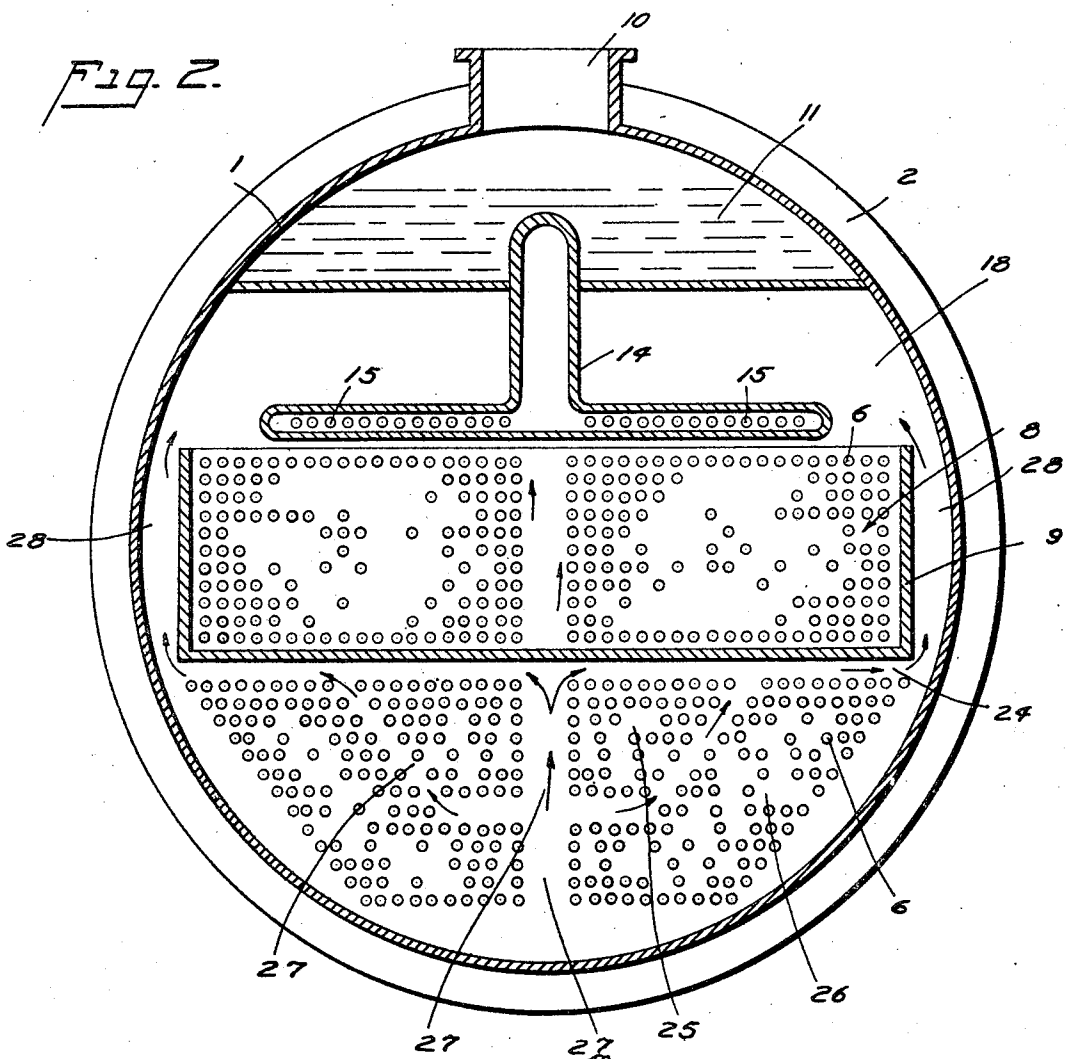

Fig. 4.

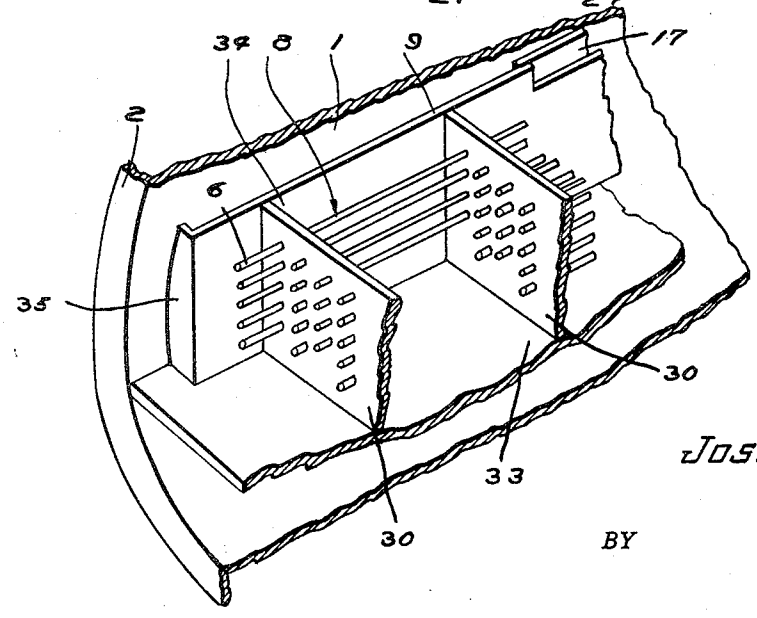

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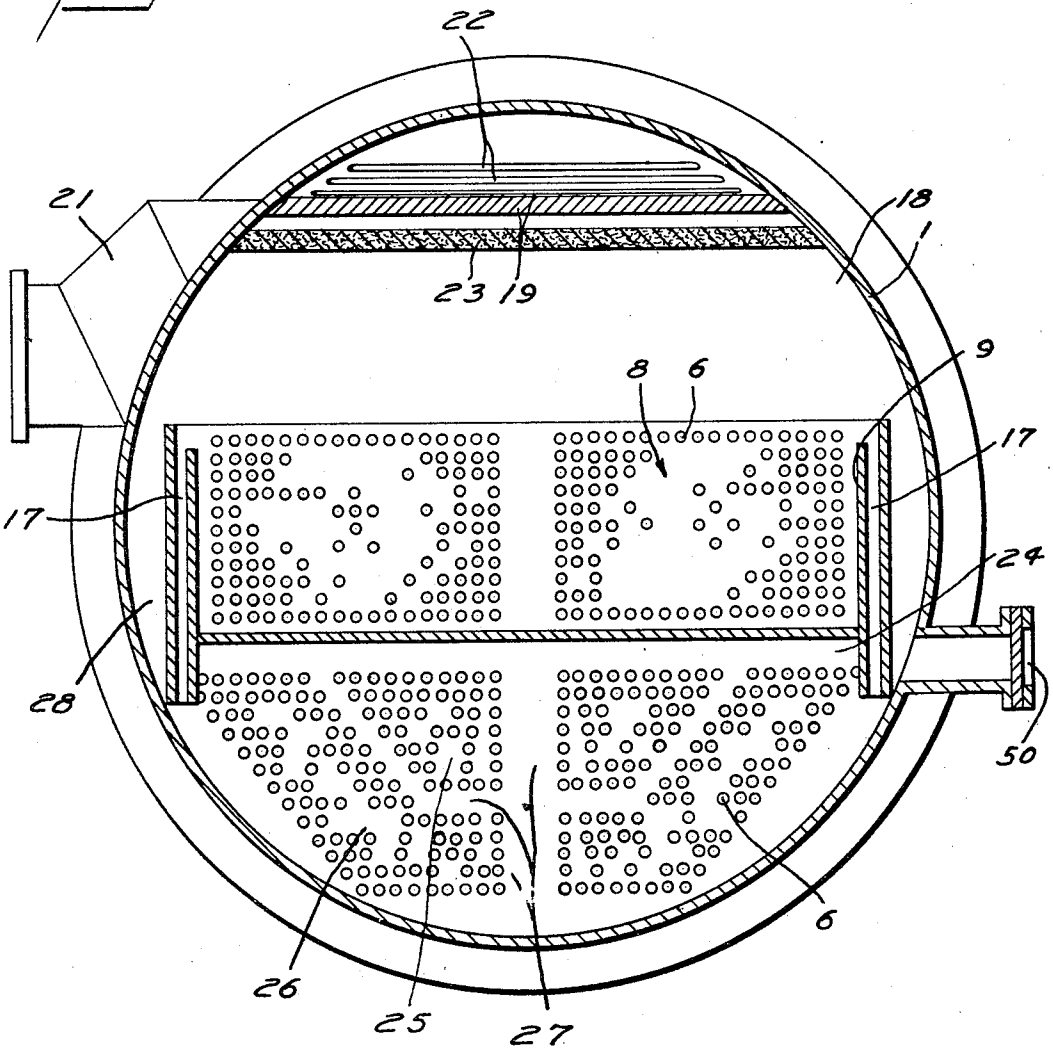
Fig. 3.



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UNITED STATES PATENT OFFICE

2,384,413

COOLER OR EVAPORATOR

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Application November 18, 1943, Serial No. 510,745

10 Claims. (Cl. 62—126)

This invention relates to heat exchange apparatus, and more particularly to coolers or evaporators of the type employed in refrigeration systems of the closed circuit compression type employing a volatil refrigerant as a coolant.

An object of the present invention is to provide a cooler or evaporator which is constructed and arranged whereby a lower static head in the liquid coolant or refrigerating medium is provided relative to the static head existing in coolers or evaporators of the same size of approved types now in use. The providing of a lower static head in the liquid refrigerant in the evaporator results in a lesser average temperature rise of the refrigerant above that which corresponds to the suction pressure of the compressor in the system, which in turn results in a lower evaporation temperature of the liquid refrigerant surrounding the tubes; or if the temperature of the liquid refrigerant surrounding the tubes is to be at a fixed degree, then the system is permitted to operate at a higher vapor pressure, resulting in less work to be performed to provide the desired cooling of the fluid to be cooled.

Another object of the present invention is to provide an evaporator of the surface type wherein the coolant surrounds a plurality of tubes through which the fluid to be cooled flows and in which the vaporizing surface; i. e., the tube surfaces which are contacted by the coolant, is divided into a plurality of banks or nests, providing at least two liquid surfaces instead of the usual one liquid surface, thus resulting in a reduction of approximately one half or more in the exit velocity of the vapor out of the liquid surface. This reduction of the exit velocity of the vapor out of the liquid surface results in reduction of the quantity of liquid refrigerant carried along, as spray, with the vaporized refrigerant, thus providing an evaporator or cooler which will tolerate a higher heat load per square foot of tube surface than those of approved construction which have only one liquid surface for vapor emission.

Another object of the present invention is to provide an evaporator or cooler as specified which is relatively simple in construction and of assembly, resulting in an evaporator which, due to the reduced labor of assembly, may be produced at a lower cost than conventional types of evaporators.

A further object of the invention is to provide simple, relatively inexpensive means for filtering out any liquid refrigerant from the vapor during the passage of the vapor to the suction inlet of the compressor of the system in which the evaporator is employed.

A still further object of the present invention is to provide an evaporator structure in which rupture of parts, leakage, etc. as the result of expansion in the unit is eliminated. The evaporator of the present application comprises a circular cylindrical shell having the internal structural elements attached to the shell only at its ends, thus allowing bulging of the shell in the middle due to expansion when under pressure without disrupting any supporting or sealing joints in the structure.

With these and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a cooler or evaporator of a preferred form embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a longitudinal vertical section through the improved evaporator.

Figure 2 is a vertical cross-section taken on the line 2—2 of Figure 1.

Figure 3 is a vertical cross-section taken on the line 3—3 of Figure 1.

Figure 4 is a fragmentary perspective view of a part of the cooler structure.

Referring more particularly to the drawings, the improved cooler or evaporator comprises a cylindrical shell 1 which, in its construction, is preferably rolled and welded from sheet metal having annular flanges 2 on its ends to which the liquid headers 3 and 4 are attached in the usual manner. The fluid to be cooled enters the liquid header 3 through the inlet 5 and passes through the tubes 6 in the coolant, finally leaving the cooler through the outlet 7. The number of passes through which the fluid to be cooled travels in the cooler may be determined or provided as desired through the medium of partitions such as indicated at 8' in the fluid header 3 and 4.

The tubes 6 are arranged in banks or nests as clearly shown in Figures 2 and 3 of the drawings, and the tubes in the uppermost bank 8 are confined in a trough 9 formed of sheet metal and extending substantially throughout the length of the shell.

The coolant or refrigerant which contacts the outer surface of the tubes 6 and serves to cool the fluid flowing through the tubes enters the cooler through the inlet 10 and is collected in the inlet collection box or chamber 11 from where its flow is controlled by the float 12 which opens

the valve 13. The liquid refrigerant then flows through the delivery header 14 through a plurality of longitudinally spaced openings 15 into the trough 9 and over the tubes 6 in the upper tube nest 8. The openings 15 are preferably arranged so that they will deliver the incoming refrigerant towards the header plate 16 at the adjacent end of the shell 1. The liquid refrigerant, not vaporized by the upper tube bank 8, overflows from the trough 9 through overflow passages 17 which are spaced at any desired position or positions along the length of the trough at its sides; the inner inlet ends of the overflow passages 17 are arranged so that all of the tubes 6 in the tube bank 8 will be submerged before any of the liquid refrigerant overflows from the trough.

The refrigerant vapor produced by the heat transfer action of the liquid refrigerant contacting the tubes 6 in the nest or bank 8 passes upwardly into the vapor collection space 18 in the shell directly above the tube nest 8, and from this collection space it passes through the distribution plate 19 into the vapor outlet chamber 20. The vaporized refrigerant passes from the vapor outlet chamber 20 through the outlet 21 to the compressor (not shown) of the refrigerating system. As clearly shown in Figures 2 and 3 of the drawings, the distribution plate 19, which extends at an angle longitudinally of the interior of the shell 1, is provided with a plurality of properly spaced slots 22 to provide a substantially even distribution of the vaporized refrigerant during its passage into the outlet chamber 20.

A filter 23 which is constructed of any suitable material such as relatively fine metal shavings is placed at a suitable distance under the distribution plate 19 and serves to filter out any liquid refrigerant which may be carried, in spray form, with the vaporized refrigerant for the purpose of providing a relatively dry vapor passing to the compressor.

The liquid refrigerant overflowing from the trough 9 into the space within the shell 1 below the trough 9 is delivered below the normal level of the liquid refrigerant in this space, as is clearly indicated in Figure 3 of the drawings. A sight window 30 is provided in the shell 1 to permit viewing of the liquid level in the space below the trough 9 so as to permit control of the liquid level. The tubes 6 which extend through the shell 1 below the trough 9 are arranged in nests and spaced so as to provide a vapor collection and escape space 24 directly beneath the trough 9 and above the tubes 6 in the lower tube nests 25 and 26. The tube nests 25 and 26 are further arranged so as to provide escape lanes 27 for the vaporized refrigerant, allowing the vaporized refrigerant to flow from the various portions of the tube nests upwardly into the escape space 24 and from thence through the passages 28, formed along each side of the trough 9 between the trough and the inner wall of the shell 1, into the vapor collection space 18 from which the vaporized refrigerant flows into the outlet chamber 20 as above described. The provision of the trough 9 and the arrangement of the tube nests 25 and 26 provide a plurality of liquid surfaces, that is, at least two, one being at the top of the liquid in the trough 9, and the other at the top of the liquid in the space below the trough 9, and by providing this plurality of liquid surfaces the exit velocity of the vapor is reduced approximately one-half which, of course, very materially reduces the quantity of liquid refrigerant carried along, as spray, with the vaporized refrigerant.

Also by the provision of the two distinct liquid compartments and liquid levels for the liquid refrigerant in the cooler, a lower static head in the coolant or refrigerating medium is provided than would be provided if only a single liquid surface or single depth of the liquid refrigerant were maintained in the cooler. The reduction of the static head results in a lesser average temperature rise of the refrigerant above that which corresponds to the suction pressure of the compressor (not shown) in the system which in turn results in an average lower temperature of the liquid refrigerant surrounding the tubes, or in the event the temperature of the liquid surrounding the tubes is to be maintained at a given degree, then the provision of the lower static head in the refrigerant permits the system to operate at a higher vapor pressure resulting in a power savings to provide the desired degree of cooling.

The cooler or evaporator of the present invention is particularly designed and constructed to the end of simplifying and consequently reducing the cost of its assembly, and the structure is so arranged that after the shell 1 has been formed, the entire internal structure comprising the trough 9, the tube support plates 38, and the various other elements may be all assembled and welded together after which the entire structure in its assembled form as one unit is moved longitudinally into the shell and then the various parts are welded at their ends to the inside of the shell. After this, the heads 16 and 16' are fastened to the shell and then the bottom plate of the trough 9 is welded to the head plates 16 and 16'. This latter welding operation is facilitated by the provision of openings 31 which are left in the shell 1 to permit access to the interior thereof for the welding operation. After the assembled internal mechanism has been welded into place, cover plates 32 are placed over the openings 31 and welded in place to seal the shell. As will be noted by particular reference to Figure 4 of the drawings, the trough structure 9 comprises the bottom plate 33 to which the side plates 34 are welded. The side plates terminate short of the ends of the bottom plate 33 and have their ends out-turned as shown at 35 to properly space the side walls 34 of the trough from the interior of the shell 1 and also to provide means for welding or securely attaching the side plates 34 to the shell. The plate 33, the side walls 34 as well as the structure which goes to make up the outlet chamber 20 are welded to the shell only at their ends; thus being free from rigid connection to the shell intermediate therein, they allow the shell to bulge at its center under expansion action without disrupting any of the joints or causing leaks.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In an evaporator, a shell, a plurality of tubes extending through said shell, means for delivering a coolant into said shell for submerging said tubes, said tubes arranged in a plurality of sets, means whereby a vaporization surface of the coolant and vapor escape space will be provided above each set of tubes, and means whereby a predetermined level of liquid coolant will be maintained in one set of said tubes before liquid coolant is allowed to flow to the other sets of tubes.

2. In an evaporator, a shell, a plurality of tubes

extending through said shell, means for delivering a coolant into said shell for submerging said tubes, said tubes arranged in a plurality of sets, means whereby a vaporization surface of the coolant and vapor escape space will be provided above each set of tubes, means whereby a predetermined level of liquid coolant will be maintained in one set of tubes before liquid coolant is allowed to flow to the other sets of tubes, said shell having a vapor outlet chamber therein to receive vaporized coolant from said vapor escape spaces, and a filter over the inlets to said chamber.

3. In an evaporator, a shell, a plurality of tubes extending through said shell, means for delivering a coolant into said shell for submerging said tubes, said tubes arranged in a plurality of sets, means whereby a vaporization surface of the coolant and vapor escape space will be provided above each set of tubes, means whereby a predetermined level of liquid coolant will be maintained in one set of tubes before liquid coolant is allowed to flow to the other sets of tubes, said shell having a vapor outlet chamber therein to receive vaporized coolant from said vapor escape spaces, a filter over the inlets to said chamber, and said filter comprising closely packed metal shavings.

4. In an evaporator, a shell, a plurality of tubes extending through said shell, said tubes arranged in superimposed sets with a vapor collection space above the uppermost set, a trough-like structure enclosing the uppermost set of tubes, means for delivering a liquid coolant into said trough-like structure, said trough-like structure having overflow openings arranged so that the uppermost tubes in the upper set will be submerged in liquid coolant before any liquid will overflow into the shell below the trough-like structure.

5. In an evaporator, a shell, a plurality of tubes extending through said shell, said tubes arranged in superimposed sets with a vapor collection space above the uppermost set, a trough-like structure enclosing the uppermost set of tubes, means for delivering a liquid coolant into said trough-like structure, said trough-like structure having overflow openings arranged so that the uppermost tubes in the upper set will be submerged in liquid coolant before any liquid will overflow into the shell below the trough-like structure, the tubes in the sets below the trough-like structure being arranged to provide a vaporization surface of the coolant and a vapor escape space above the tubes of each set.

6. In an evaporator, a shell, a plurality of tubes extending through said shell, said tubes arranged in superimposed sets with a vapor collection space above the uppermost set, a trough-like structure enclosing the uppermost set of tubes, means for delivering a liquid coolant into said trough-like structure, said trough-like structure having overflow openings arranged so that the uppermost tubes in the upper set will be submerged in liquid coolant before any liquid will overflow into the shell below the trough-like structure, the tubes in the sets below the trough-like structure being arranged to provide a vaporization surface of the coolant and a vapor escape space above the tubes of each set, the sides of said trough-like structure intermediate its ends being spaced from the inner surface of the shell to provide vapor escape lanes from said vapor escape space to said vapor collection space.

7. In an evaporator, a shell, a plurality of tubes extending through said shell, said tubes arranged in superimposed sets with a vapor collection space above the uppermost set, a trough-like structure enclosing the uppermost set of tubes, means for delivering a liquid coolant into said trough-like structure, said trough-like structure having overflow openings arranged so that the uppermost tubes in the upper set will be submerged in liquid coolant before any liquid will overflow into the shell below the trough-like structure, the tubes in the sets below the trough-like structure being arranged to provide a vaporization surface of the coolant and a vapor escape space above the tubes of each set, the sides of said trough-like structure intermediate its ends being spaced from the inner surface of the shell to provide vapor escape lanes from said vapor escape space to said vapor collection space, said shell having a vapor outlet chamber therein above said vapor collection space, and means to cause substantially an equal distribution of vapor over said outlet chamber.

8. In an evaporator, a shell, a plurality of tubes extending through said shell, said tubes arranged in superimposed sets with a vapor collection space above the uppermost set, a trough-like structure enclosing the uppermost set of tubes, means for delivering a liquid coolant into said trough-like structure, said trough-like structure having overflow openings arranged so that the uppermost tubes in the upper set will be submerged in liquid coolant before any liquid will overflow into the shell below the trough-like structure, the tubes in the sets below the trough-like structure being arranged to provide a vaporization surface of the coolant and a vapor escape space above the tubes of each set, the sides of said trough-like structure intermediate its ends being spaced from the inner surface of the shell to provide vapor escape lanes from said vapor escape space to said vapor collection space, said shell having a vapor outlet chamber therein above said vapor collection space, and a filter over the inlets to said outlet chamber.

9. In an evaporator, a cylindrical shell, end plates for the shell, heat transfer inducing means in said shell and comprising support plates and structures for controlling the flow of liquid coolant in the shell, said plates and structures being formed in a unit and welded to said end plates and to the shell near its ends but being free from connection with the shell intermediate the ends of the shell, and tubes carried by said support plates whereby the heat transfer means may be assembled and inserted as a unit longitudinally into the shell.

10. In an evaporator, a shell, a plurality of tubes extending through said shell, said tubes arranged in a plurality of sets with at least one set of tubes disposed above the other sets, means for delivering a coolant into said shell and on to the tubes in said uppermost set, and means for retaining a sufficient quantity of liquid coolant about the tubes in the upper set to maintain submergence thereof before the liquid coolant is delivered to the lower sets of tubes.

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