July 28, 1959 J. KARMAZIN 2,896,429

HEAT EXCHANGE DEVICE

Filed Oct. 20, 1955 2 Sheets-Sheet 1

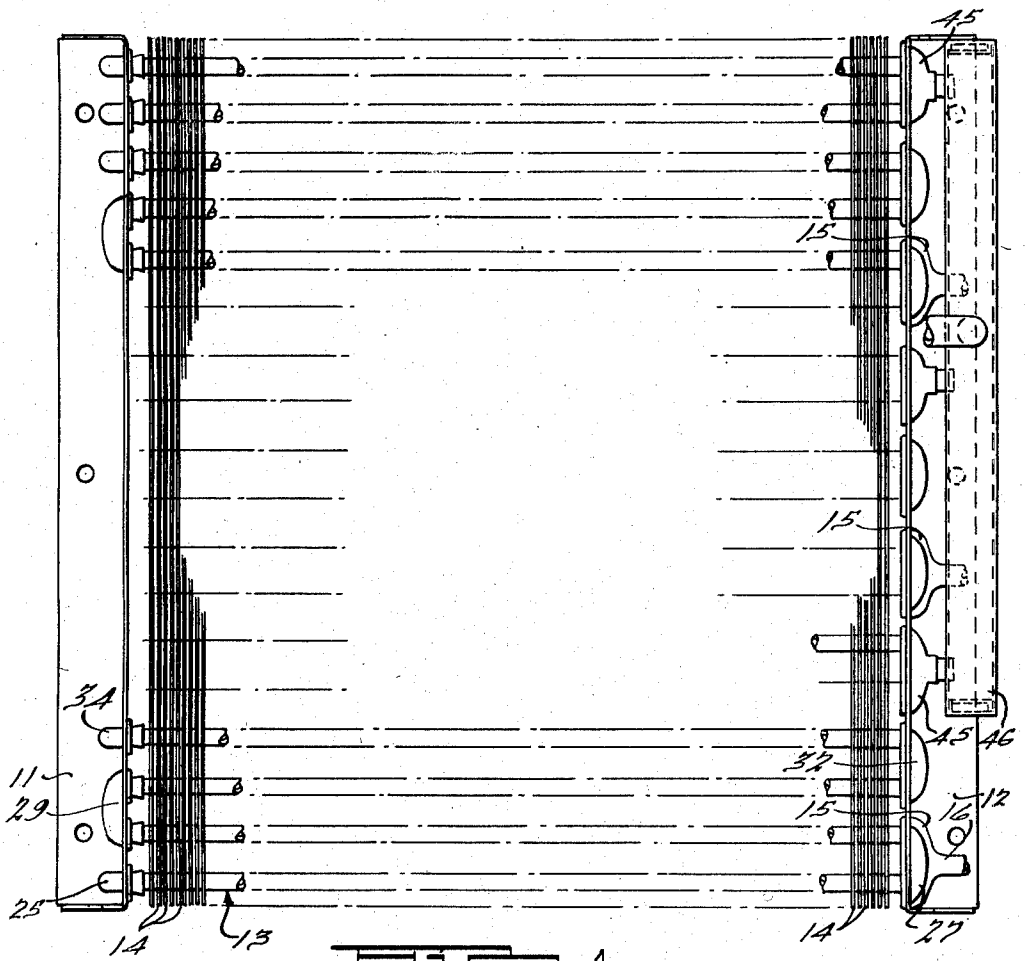


FIG. 1.

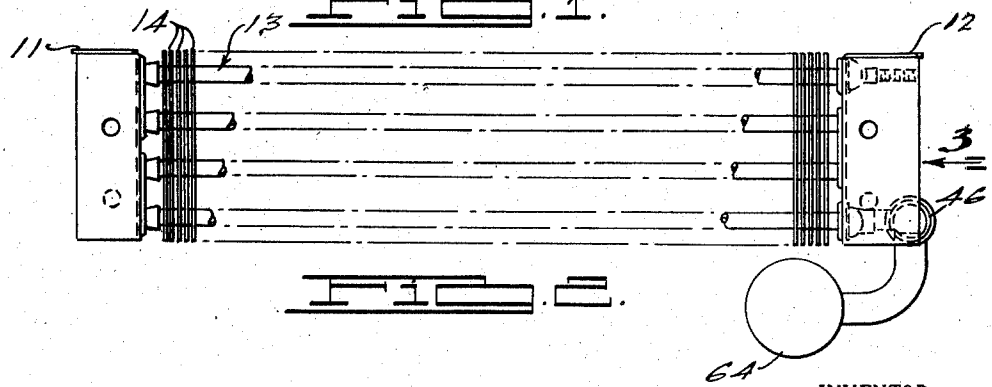


FIG. 2.

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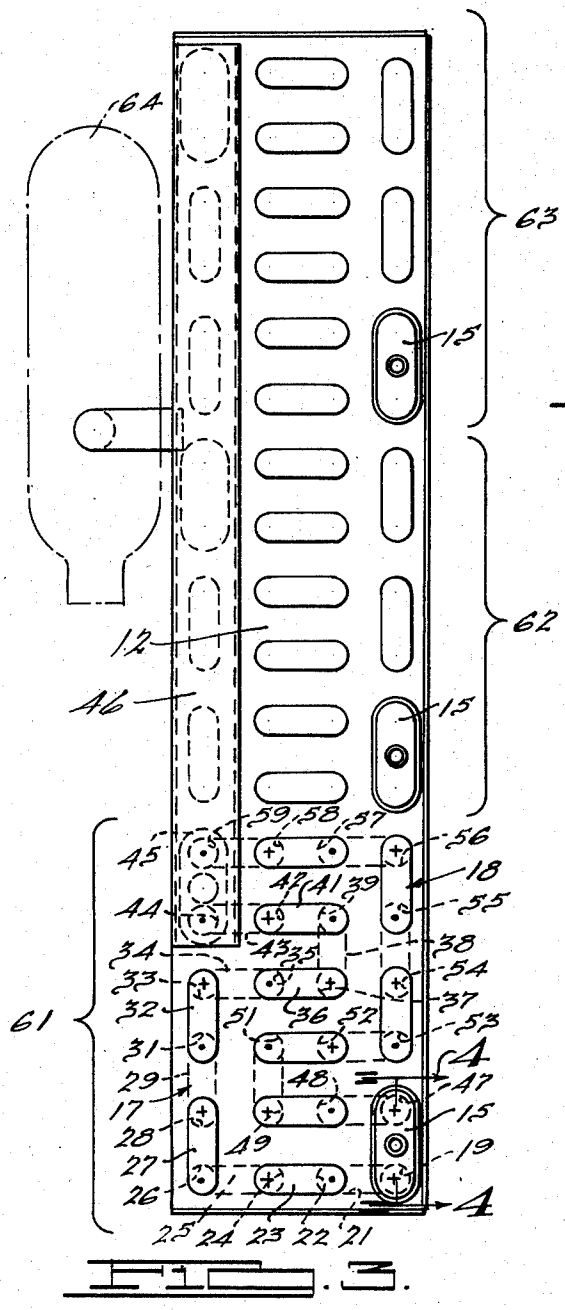


FIG. 3.

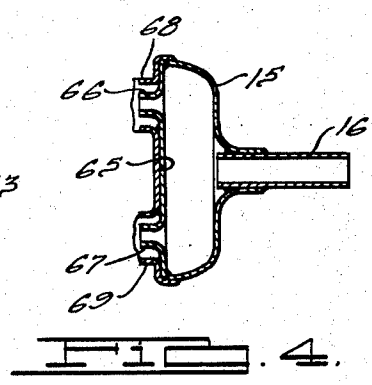


FIG. 4.

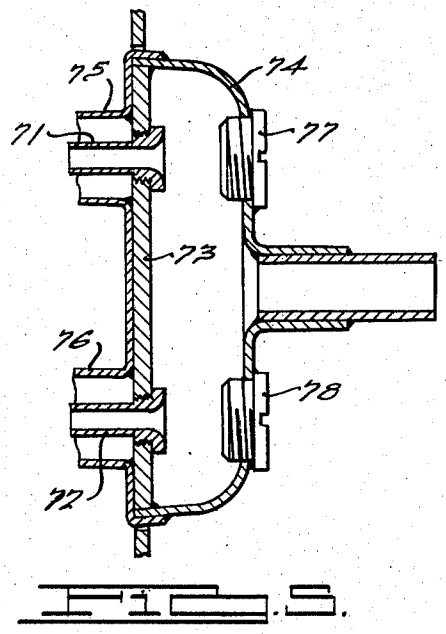


FIG. 5.

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HEAT EXCHANGE DEVICE

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Application October 20, 1955, Serial No. 541,583

7 Claims. (Cl. 62—515)

This invention relates to heat exchangers, and more particularly to evaporators of the type used in refrigerating apparatus.

It is an object of the present invention to provide an improved evaporator for refrigerating apparatus which is of extremely compact construction and utilizes a maximum of space for primary and secondary heat transfer surfaces.

It is another object to provide an improved evaporator of the above nature in which the refrigerant fluid traverses a plurality of parallel conduits which are nested in such a manner as to utilize all portions of the evaporator core.

It is a further object to provide an improved evaporator construction of this character which includes capillary passages at the inlet ends of the refrigerant conduits to increase the heat transfer efficiency, these capillaries in one form of the invention being removable for maintenance purposes.

It is also an object of the present invention to provide an improved evaporator construction of this type which is economical to fabricate and which may be made of any desired capacity while maintaining the maximum usage of space in the core for heat transfer purposes, but without increasing the core thickness.

Other objects, features, and advantages of the present invention will become apparent from the subsequent description, taken in conjunction with the accompanying drawings.

In the drawings:

Figure 1 is a side elevational view of an evaporator core constructed according to the principles of the invention and showing the general arrangement of the parts;

Figure 2 is a top plan view of the evaporator showing the relative thickness of the core;

Figure 3 is an end elevational view in the direction of the arrow 3 of Figure 2, showing the configuration of the nested sections of conduits and the position of the outlet header;

Figure 4 is a detailed cross-sectional view taken along the line 4—4 of Figure 3 and showing the construction of an intake connection as well as the capillaries; and

Figure 5 is a detailed cross-sectional view similar to Figure 4 but showing a modified form in which the capillaries are constructed in a removable manner.

The invention comprises generally an evaporator core of rectangular cross-sectional shape and having a plurality of refrigerant conduit sections which carry the refrigerant in parallel paths. Each conduit section comprises a plurality of lengths of tubing which run back and forth through the core. The axes of the lengths of tubing are arranged in a predetermined pattern such that the conduit sections may be nested in groups of two, with the inlets and outlets of each pair of conduit sections being adjacent each other. In particular, the tube axes are arranged in rows parallel to and at right angles to the core thickness, and when taken together the rows for each pair of nested conduit sections form a grid-like pattern with each intersecting point of the grid marking the position of one

length of tube. Several pairs of sections may be combined to form the completed core, each pair being arranged in the manner aforesaid. When so constructed, the completed evaporator core will have all the outlet ends of the conduit sections along one edge so that a single header may be provided therefor. The inlet connections for the sections will likewise be disposed in a line. Capillary entrances of a permanent or removable type are preferably provided at the inlet ends of the conduit sections.

Referring to the drawings, the evaporator core comprises a pair of supporting brackets **11** and **12** disposed at opposite ends thereof. Extending between these brackets are a plurality of tubes generally indicated at **13** which are connected to form the refrigerant conduit sections. A plurality of cooling fins **14** are mounted on tubes **13** in a conventional manner and serve as secondary surface areas for the evaporator. It will be understood that tubes **13** and cooling fins **14** could be constructed in various manners, and in particular may be made in accordance with the principles taught in my Patent No. 2,134,665, dated October 25, 1938.

The arrangement of conduit sections is best seen in Figure 3 which shows in detail the manner in which tubes **13** are connected to form one pair of nested conduit sections, and which further shows the positions of the inlet and outlet connections for the remaining pairs of conduit sections. It will be noted from this figure that both the inlet and outlet connections are supported by bracket **12**, bracket **11** carrying return connections between the various tube lengths. The inlet connections are indicated at **15** and are shown in detail in Figure 4. Each inlet connection comprises a cup-shaped member having a central opening to which is connected a supply tube **16** with liquid refrigerant. Each inlet **15** supplies liquid refrigerant to a pair of conduit sections. These conduit sections are indicated generally at **17** and **18** respectively for that inlet **15** which is found at the lower right hand corner of Figure 3.

In describing the arrangement of the conduit sections it is perhaps best to trace section **17** from inlet to outlet, and then trace section **18** to demonstrate the manner in which the sections are nested. The first length of tube in section **17** is indicated at **19** in Figure 3. It will be noted that this tube is in the extreme lower right hand corner of the evaporator core, and the tube will carry liquid refrigerant from inlet **15** in a direction passing into the paper. This flow direction is indicated by the conventional arrow-tail symbol in Figure 3. When the refrigerant reaches the far end of tube **19** it will be reversed in flow 180° by a return member **21** of cup-shaped configuration which, while reversing the flow of refrigerant, maintains it in a plane parallel to the core thickness. The fluid will then flow back through the core by means of tube **22** indicated in Figure 3, and when it reaches the other end will again be reversed in flow by a return connection **23** similar to connection **21**. The fluid will then flow through tube **24** until it reaches the other end of the core where it will be reversed by a return connection **25**. The fluid will next flow back through tube **26** toward the end of the core supported by bracket **12**. It will be noted that when flowing through tubes **22** and **26** the fluid will flow in a direction out of the paper in Figure 3, and this flow is represented by the conventional arrowhead. The flow direction into the paper through pipes **24** and **19** are represented by arrow-tails. It should be observed that the axes of pipes **19**, **22**, **24** and **26** are evenly spaced and are all in the same plane traversing the thickness of the evaporator core.

After leaving tube **26** the refrigerant is led through a return connection **27** to a tube **28**. Connection **27** differs from the previous return connections in that it is disposed in a plane at right angles to the core thickness, and tube **28** is at a level above that of the previous tubes.

The refrigerant will flow through tube 28 and will then be reversed in flow by a return connection 29, after which it will return through a tube 31. Connection 29 is in the same plane as connection 27 and after leaving tube 31 the fluid will be conducted through a return connection 32, also in the same plane, and will next pass through a tube 33 one level above tube 31, tubes 26, 28, 31 and 33 being evenly spaced.

After leaving tube 33 the fluid will pass through a return connection 34 which is again in a plane parallel to the core thickness and will then flow through a tube 35. A return connection 36 will cause the fluid to flow next through a tube 37 in the same plane as tubes 33 and 35. A return connection 38 at the end of tube 37 and at right angles to the core thickness will conduct the fluid to a tube 39. It should be noted at this point that tubes 37 and 39 are in the same plane as tube 22. The fluid will next flow through a return connection 41 to a tube 42, the latter being at the same level as tube 39 and immediately above tube 35.

Upon leaving the tube 42 the fluid will pass through a return conduit 43 after which it will flow through a tube 44, finally returning to that end of the core supported by bracket 12. Tube 44 is in the same plane as tubes 39 and 42 parallel to the core thickness and is in a common plane with tubes 26, 28, 31 and 33 at right angles to the core thickness. Upon leaving tube 44 the evaporated fluid will enter an outlet connection 45 which is visible in Figures 1 and 3. This outlet connection also serves to receive the evaporated fluid leaving conduit section 18, and a manifold or header 46 is provided for receiving evaporated fluid from the plurality of outlets 45 which are on the evaporator core.

In reviewing the arrangement just described for conduit section 17, it will be apparent that the section is made up of twelve tube lengths divided into five groups or legs, the legs being alternately parallel to and at right angles to the core thickness. The first leg (tubes 19, 22, 24 and 26) traverses the entire thickness of the evaporator core. The next leg (tubes 26, 28, 31 and 33) extends in the direction of the length of the core while the third leg (tubes 33, 35 and 37) is again in the direction of the core thickness. The fourth leg (tubes 37 and 39) is in the direction of the core length and the fifth leg (tubes 39, 42 and 44) is in the direction of the core thickness. It should also be observed that since the legs in the direction of core thickness are in overlapping relation, the maximum thickness of the entire conduit section is only four spaced tube lengths.

The arrangement of conduit section 18 is such that it interfits with section 17 so as to maintain a maximum thickness for the core of only four spaced tube lengths. The first tube through which the fluid flows in section 18 from inlet 15 is indicated at 47 in Figure 3, the fluid flowing into the paper as shown in this figure. By means of appropriate return connections, the fluid next flows through tubes 48 and 49 which are aligned with tube 47 in the direction of core thickness, tube 28 of conduit section 17 also being aligned with these tubes. It will be noted that these tubes are also aligned with tubes in conduit section 17 in planes at right angles to the core thickness. In particular, tube 47 is aligned with tube 19 while tubes 48 and 49 are aligned with tubes 22 and 24 respectively. The fluid next flows through a tube 51 which together with tube 49 forms a leg in the direction of the core length. The fluid will then flow through tubes 52 and 53 forming a leg in the direction of the thickness of the core. A leg in the direction of the core length is then provided, this leg being formed by tubes 54, 55 and 56 together with tube 53. A leg in the direction of the core thickness is next provided, constituted by tubes 56, 57, 58 and 59. The fluid leaving tube 59 will enter the same outlet connection 45 which receives the fluid from tube 44.

An examination of the arrangement of conduit sections 17 and 18 in Figure 3 will reveal the compact nested character of the sections. It will be noted that the legs of section 18 formed by tubes 47, 48, 49, 51 and 52 are nested within the legs of conduit section 17 formed by tubes 19, 22, 24, 26, 28, 31, 33, 35 and 37. Similarly, the upper leg sections of conduit section 17 are nested within the surrounding legs of conduit 18. The axes of the tubes are located on the intersections of evenly spaced planes which criss-cross each other in directions parallel to the thickness and length of the evaporator core, thus affording maximum exposure of all tubes for evaporating purposes. Tubes are located at every one of these intersections so that no portion of the space occupied by the evaporator core remains unutilized. Each of the conduit sections 17 and 18 affords a maximum amount of travel for the refrigerating fluid, thus facilitating evaporation. Both sections 17 and 18 are of equal length so that there will be no disparity in degree of evaporation between portions of the fluid passing through the sections. Since sections 17 and 18 run alongside each other from their inlet to their outlet ends, the temperature gradient between the sections will be kept at a minimum thus increasing the efficiency of the device.

The remainder of the evaporator core is made up of duplicates of conduit sections 17 and 18. The evaporator core of the illustrated embodiment is composed of a total of three such groups of conduit sections, these being numbered 61, 62 and 63. Since groups 62 and 63 are identical with group 61 described above it is not necessary to review them in detail. However, it will be noted that there is no gap left between the ends of adjacent groups so that all lines of intersection of the evenly spaced planes mentioned above are occupied by refrigerant carrying tubes. Since all the outlet connections are aligned as seen in Figure 3, header 46 may be used to collect the evaporated refrigerant from all conduit sections of the core, from which it may be delivered to an accumulator 64 or to some other portion of the refrigerating system.

Figures 4 and 5 illustrate two embodiments of capillary entrances provided at the inlet ends of the conduit sections. Capillaries such as those shown serve to increase the agitation and dispersion of the liquid refrigerant, thus enhancing the evaporating action. In Figure 4, inlet connection 15 is partially enclosed by a plate 65 having a pair of capillary tubes 66 and 67 punched or otherwise formed therein. Tubes 68 and 69 enclose capillary passages 66 and 67 respectively, the parts being brazed or otherwise secured. With this construction it will be seen that liquid refrigerant entering inlet 16 to connection 15 will pass through orifices 66 and 67 which have a substantially smaller diameter than the tubes with which they are associated. Figure 5 shows a modified construction in which the capillary tubes 71 and 72 are threadably mounted in a plate 73. On one side of this plate inlet connection 74 is secured while tubes 75 and 76 are attached to the other side of plate 73 surrounding capillaries 71 and 72 respectively. A pair of removable plugs 77 and 78 are disposed in inlet connection 74 opposite the positions of capillaries 71 and 72. In this manner the capillary tubes may be removed and replaced for maintenance purposes.

In operation, liquid refrigerant will be led to all the inlet connections 15 from the refrigerating system, four such connections being shown in the illustrated embodiment. The liquid refrigerant will pass through the capillary tubes and into the conduit sections 17 and 18 which constitute each of groups 61, 62 and 63. When passing through these parallel paths the evaporating liquid will traverse equal distances in both conduit sections, and the evaporated fluid will exit through outlet connections 45 to header 46. It will be understood of course that any number of all of groups 61, 62 and 63 may be utilized depending upon requirements.

While it will be apparent that the preferred embodiments of the invention disclosed are well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. In a heat exchange device, a pair of nested conduit sections each composed of a plurality of tubes connected in series for alternate flow in opposite directions, each section having the same number of tubes one of which constitutes an inlet tube for the section and another one of which constitutes an outlet tube for the section, and means for supporting said tubes in such a manner as to occupy all the lines of intersection of a plurality of planes which run parallel to and at right angles to the thickness of the device, the total lengths of both sections being equal, the inlet tubes of said sections being on one pair of adjacent lines of intersection and the outlet tubes of said sections being on another pair of adjacent lines of intersection.

2. In an evaporator core, a pair of oppositely disposed elongated supporting brackets, a plurality of tubes of substantially equal length extending in parallel relation between said brackets, the axes of said tubes being disposed at the intersections of planes parallel to and at right angles to the thickness of the evaporator core, means for connecting said tubes into a pair of nested conduit sections for carrying refrigerant fluid in two parallel paths, each of said sections consisting of a plurality of said tubes one of which is an inlet tube for the section and another one of which is an outlet tube for the section, said inlet tubes for said pair of sections being arranged adjacent each other in a parallel relation and said outlet tubes for said pair of sections being likewise arranged adjacent each other and in a parallel relation, said connecting means including a common inlet connection for adjacent inlet tubes, a plurality of reversing connections supported by said brackets and connecting adjacent tubes in each of said sections in series for reverse flow of the refrigerant fluid, said reversing connections being so positioned that both conduit sections have the same number of tubes, a common outlet connection for adjacent outlet tubes, and a plurality of cooling fins on said tubes.

3. The combination according to claim 2, the inlet tubes of said conduit sections being provided with capillary passages at their entrances for increasing the agitation of refrigerant fluid.

4. The combination according to claim 3, said common inlet comprising a cup-shaped member, said capillary passages being formed in a plate covering said cup-shaped member and extending into the entrances of said inlet tubes.

5. The combination according to claim 3, said common inlet comprising a cup-shaped member, a plate covering said member, a pair of capillary passage members threadably mounted on said plate and extending into said inlet tubes, and a pair of removable plugs in said cup-shaped member and aligned with said capillary passage members, whereby the members may be removed.

6. A heat exchange device comprising a plurality of substantially straight tubes of equal length extending longitudinally of said device and arranged in parallel rows, said rows extending both laterally and transversely of said device and adjacent parallel rows having equal numbers of tubes therein, spaced brackets supporting said tubes adjacent the ends thereof, means for connecting said tubes into a pair of nested conduit sections for carrying fluid in two parallel paths, each of said sections consisting of a plurality of said tubes one of which is an inlet tube for the section and another one of which is an outlet tube for the section, said inlet tubes for said pair of sections being arranged adjacent each other in a parallel relation and said outlet tubes for said pair of sections being likewise arranged adjacent each other and in a parallel relation, said connecting means comprising a plurality of reversing connections connecting only adjacent tubes in each section, an inlet connection for said pair of adjacent inlet tubes, and an outlet connection for said pair of adjacent outlet tubes.

7. A heat exchange device comprising a plurality of substantially straight tubes of equal length extending longitudinally of said device and arranged in parallel rows, said rows extending both laterally and transversely of said device and adjacent parallel rows having equal numbers of tubes therein, spaced brackets supporting said tubes adjacent the ends thereof, means for connecting said tubes into a pair of nested conduit sections for carrying fluid in two parallel paths, each of said sections consisting of a plurality of said tubes one of which is an inlet tube for the section and another one of which is an outlet tube for the section, said inlet tubes for said pair of sections being arranged adjacent each other in a parallel relation and said outlet tubes for said pair of sections being likewise arranged adjacent each other and in a parallel relation, said means comprising a plurality of reversing connections connecting only adjacent tubes in each section, and means providing inlet and outlet connections for said inlet and outlet tubes, respectively.

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