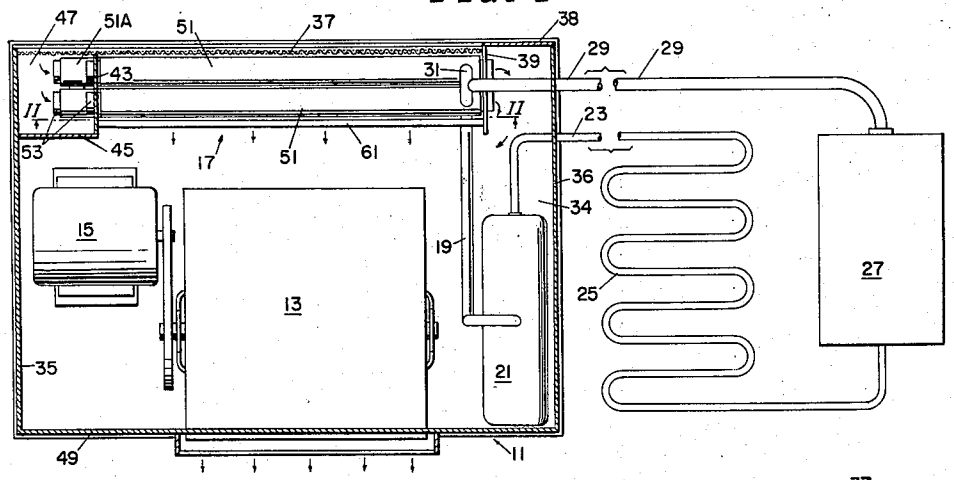
March 17, 1959 W. A. WARRINGTON, JR 2,877,991

HEAT EXCHANGERS

Filed Sept. 12, 1957 2 Sheets-Sheet 1

FIG. 1



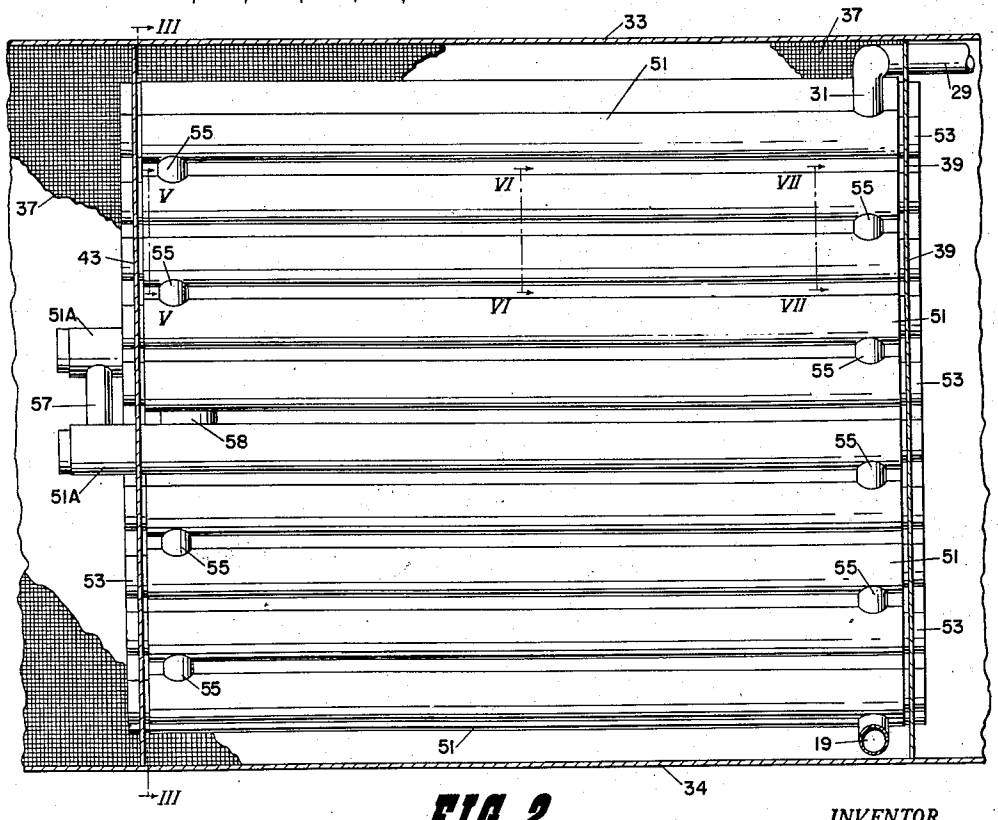


FIG. 2

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HEAT EXCHANGERS

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FIG. 3

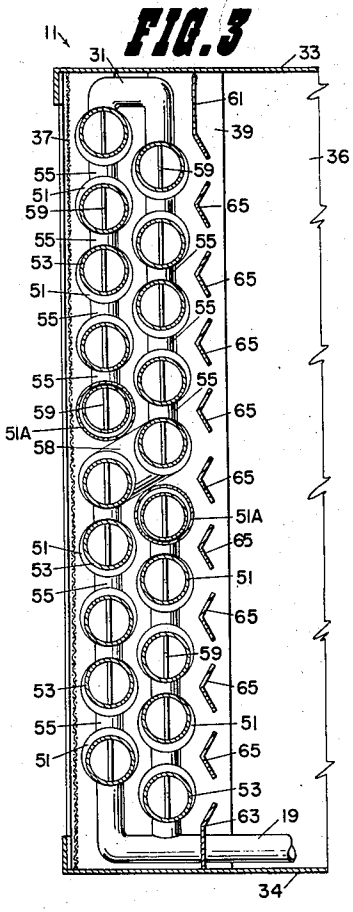


FIG. 5

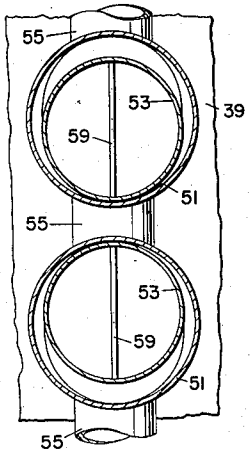
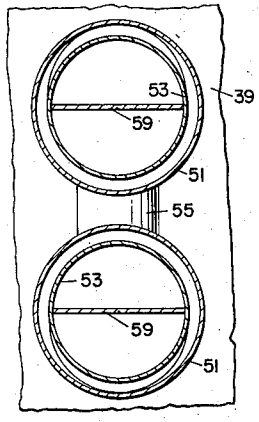


FIG. 6



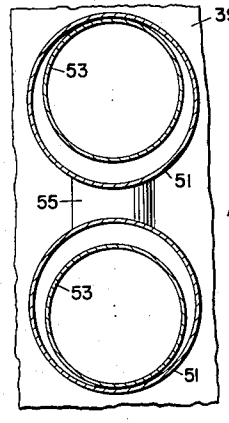
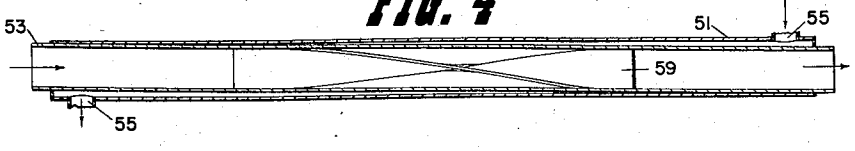


FIG. 7

FIG. 4



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United States Patent Office 2,877,991 Patented Mar. 17, 1959

2,877,991

HEAT EXCHANGERS

William A. Warrington, Jr., Cordova, Tenn.

Application September 12, 1957, Serial No. 683,531

10 Claims. (Cl. 257—39)

This invention relates to certain new and useful improvements in heat exchangers, and particularly relates to heat exchanging means which are adapted for utilization in refrigerating or cooling units, as of the type of home air conditioning units, for the purpose of cooling and condensing the refrigerant to provide for its recirculation through the system and its utilization during such recirculation for the purpose of heat absorption to effect cooling of surrounding areas. Numerous types of refrigerants are employed in systems of this sort, such as, for example, halogenated hydrocarbons and other suitable refrigerants. In such systems the refrigerant passes from an area cooling means, such as a conventional coil, into a compressor in gaseous condition, at which time it is at a relatively high temperature. It is passed thence from the compressor into a refrigerant cooling heat exchanger in which the heat carried by the refrigerant is dissipated, with the result that the gaseous refrigerant is condensed and returned to substantially liquid stage, in which condition it is ultimately passed into the cooling coil where it is brought back to a gaseous state in the coil, absorbing the surrounding heat in the process of passing from the liquified to the gaseous state.

The present device provides a new and novel improvement in the cooling heat exchangers such as are used in a system of the general type just described.

The principal object of the present invention is to provide a new and novel heat exchanging means particularly adapted for effecting cooling and condensing of gaseous refrigerants in a cooling system, such as an air conditioning device.

A further object of the invention is to provide such heat exchanging means which comprises a bank of relatively enlarged elongated conduits arranged in staggered position fore and aft, disposed for impingement by cooling air drawn thereover, with each of the conduits being provided internally with an air flow tube for the passage of cooling air longitudinally through the interior of the conduit, whereby the refrigerant is disposed in a thin substantially annular layer extending from end to end of the conduit, with large area heat-radiating surfaces comprising the exterior of the conduit, and the interior of the air tubes effecting delivery of the cooling of impinging air to the thin annular layer of refrigerant.

A further object of the invention is to provide in such a device which comprises a plurality of interconnected refrigerant conduits and internal air cooling tubes projected through such conduits, the improvement which comprises disposing the internal air cooling tubes in a position inclined from end to end relative to the refrigerant conduit whereby to vary the dispostion of the refrigerant passing through the thin layer conduit.

A further object of the invention is to provide in such a device which comprises a pair of conduit tiers with the conduits disposed in staggered relationship, and means for delivering hot refrigerant to the respective tiers simultaneously, means interconnecting the conduits of the upper portions of each of the tiers, means interconnecting

one of the intermediate conduits of one tier with an intermediate conduit of the other tier, additional means interconnecting other intermediate conduits of the respective tiers disposed in adjacency to the intermediate conduits mentioned to provide for a crossover of the flow of refrigerant whereby to equalize the cooling impingement of air and the effect thereof upon the hot refrigerant passing through the respective conduit tiers.

A further object of the invention is to provide such a device which includes refrigerant conduits and air cooling tubes projecting through the interior of such conduits, with a spirally disposed baffle incorporated within the air cooling tubes whereby to impart a turbulence to the cooling air drawn through such cooling tubes; and

A further object of the invention is generally to improve the design, construction and efficiency of heat exchanging means.

Other and further objects of the invention will become apparent from the annexed specification.

The means by which the foregoing and other objects of the present invention are accomplished and the manner of their accomplishment will be readily understood from the following specification upon reference to the accompanying drawings, in which:

Fig. 1 is a somewhat schematic sectional plan view on a reduced scale of an installation embodying the present invention.

Fig. 2 is an enlarged fragmentary sectional view taken as on the line II—II of Fig. 1 from the rear of the heat exchanging means of the present invention.

Fig. 3 is a fragmentary sectional elevational view taken as on the line III—III of Fig. 2.

Fig. 4 is a longitudinal sectional view taken as on the longitudinal midline of a typical conduit and air cooling tube contained therein.

Fig. 5 is a fragmentary cross-sectional view taken as on the line V—V of Fig. 2 on an enlarged scale.

Fig. 6 is a view similar to Fig. 5 taken as on the line VI—VI of Fig. 2; and

Fig. 7 is a view similar to Fig. 5 taken as on the line VII—VII of Fig. 2.

Referring now to the drawings in which the various parts are indicated by numerals, the present invention is adapted to be incorporated in a substantially conventional system such as is shown schematically in Fig. 1. As there shown, the invention comprises a substantially box-like housing **11** within which is mounted, in manner hereinafter to be described, the heat exchanging means of the present invention, and which includes a rearwardly discharging centrifugal fan **13**, preferably driven by a conventional motor **15**. The heat exchanging means includes specifically a conduit bank **17** comprising a double tier of conduits disposed forward of fan **13** from which refrigerant condensate is delivered as by piping **19** to a receiver **21**, from which the condensate is delivered by piping **23** to one end of a cooling coil **25**, the opposite end of the cooling coil **25** being connected to a compressor **27**, and the compressor **27** being connected as by pipe **29** to a T-connection **31** with the conduit bank **17**. It will be understood that the various components which have just been referred to may be arranged in other dispositions than that which is shown in Fig. 1, and that the showing there is primarily intended for a schematic illustration of a general system of the type in which the present invention is particularly useful.

Housing **11** includes a top **33**, a bottom **34**, and opposite side walls **35**, **36**. At its front, housing **11** is provided with a foraminous sheet **37** which may be formed of a screen wire mesh or other suitable material for permitting the passage of air therethrough. Screen **37** is fastened at one end to side wall **35** of the housing, and at its opposite end is fastened to the inner edge of a minor

front wall section 38. A supporting plate 39 comprising an upright substantially vertical plate is disposed parallel to and spaced inwardly from side wall 36. Spanning between the forward edge of plate 39, and the forward edge of side wall 36, is a minor front wall section 38. Similarly spaced inwardly from side wall 35 is an additional supporting plate 43, which is a substantially vertical disposed element and is positioned parallel to supporting plate 39 as well as parallel to side wall 35. Plates 39, 43 are of substantially the same size.

To the rearward edge of supporting plate 43, a partition 45 is connected and spans therefrom substantially parallel to screen 37 into contact and connection with side wall 35. Each of the plates 39, 43 and partition 45 are as stated, vertically disposed members and extend from housing top 33 to bottom 34. It will be seen that partition 45, plate 43 and the forward section of side wall 35 define a chamber 47, which is covered at its front by a side section of screen 37 so that air may flow into the chamber but is blocked from flowing rearwardly beyond the chamber by side wall 35, plate 43 and partition 45. It will additionally be observed that, while air may flow freely through screen 37, air is blocked from front to rear flow of housing 11 at the minor section front wall 38, but that rearwardly of front wall 38 the space between plate 39 and side wall 36 is unobstructed. Additionally, housing 11 is provided with a rear wall 49 which is apertured to provide a rearward discharge port for fan 13.

Mounted in and supported by plates 39, 43, are the elements comprising conduit bank 17. Conduit bank 17 comprises, as heretofore stated, a double tier of conduits 51, the conduits 51 being supported in substantially parallel relationship, being horizontally disposed and vertically spaced apart. Preferably the tiers are arranged, as best shown in Fig. 3, with one tier of conduits 51 disposed adjacent screen 37, being disposed horizontally and vertically spaced apart, and with the other tier of conduits 51 being similarly disposed in horizontal, parallel and vertically spaced apart relationship, but in staggered relationship relative to the forward tier and being disposed rearward thereof, with the conduits 51 of the rearward tier being respectively positioned rearward of a vertical space between two of the conduits 51 of the forward tier. The lowermost conduit 51 of the rearward tier is positioned below the lowermost conduit 51 of the forward tier and is positioned to intercept the space between the lowermost forward conduit 51 and bottom 34. Each of conduits 51 is a hollow pipe-like member and each conduit is provided an airflow tube 53 which extends from end to end through the hollow interior of its related conduit, tubes 53 being respectively of a length in excess of the length of their related conduits so that the opposite ends of tubes 53 project laterally outwardly beyond the ends of conduits 51. Each of the tubes 53 is a hollow pipe-like tube of a diameter somewhat less than the diameter of conduits 51, and the tubes 53 are open at their opposite ends.

In the preferred embodiment of the present invention each tube 53 is inclined relative to its conduit 51 so that the tube is in contact with the interior of conduit 51 at the upper portion at one end, and is in contact with the interior of the conduit at its lower portion at the opposite end thereof. At their opposite ends, conduits 51 are re-respectively sealed to their related air tubes 53 effectively closing off the ends of the interior space within conduits 51. As stated, the opposite ends of air tubes 53 respectively project beyond the opposite ends of their related conduits 51, and at one end of the conduit bank, the open ends of tubes 53 project into chamber 47, while the opposite open ends of tubes 53 project into the space between plate 39 and side wall 36. It will be seen, as best shown in Fig. 4, that the inclined disposition of the air tubes relative to the conduits is such as to provide a major portion of the interior space at the upper portion of the conduit adjacent one end thereof, and a major portion of the interior space at the lower portion thereof at its opposite end. The opposite legs of T-connector 31 communicate into the upper enlarged space at one end of the uppermost conduits 51, as shown in Figs. 2 and 3. Throughout the upper section of each of the tiers of conduits 51 the enlarged spaces are interconnected by communicators 55 which comprise short pipe-like section communicating the interiors of adjacent conduits.

It will be observed that the inclined disposition of the respective air tubes relative to the conduits is alternated, that is to say, the air tube within the uppermost conduit is downwardly inclined from left to right, that in the next adjacent conduit is downwardly inclined oppositely, that is, from right to left, and so on alternately throughout the respective tiers of conduits 51.

At the lower extremity of the upper section of conduits 51 in each tier, which upper section preferably includes one-half the conduits in the tier, it is found desirable to effect a flow cross-over so as to interchange the flow through the upper section of one conduit tier into the lower section of the other conduit tier. Preferably, this cross-over is effected by diagonally disposed communicators 57, 58, cross-over pipe 57 extending between the lowermost pipe of the upper section of forward conduit tier and the upper conduit of the lower section of the rearward conduit tier, as best shown in Fig. 2, it being observed that in the preferred embodiment these conduits are respectively extended as at 51A and so as to accommodate conveniently the reception of cross-over pipe 57. Cross-over pipe 58 connects the upper section of the rearward tier of conduits with the lower section of the forwardmost tier of conduits in similar manner, although, as shown in Fig. 2, it is convenient that this connection be effected inward of supporting plate 43 and does not require any alteration or extension of the conduits. It will be understood that, while the extension of the two intermediate conduits, as at 51A, is convenient and is preferred, the interconnection between these conduits may be made within the bank of conduits in manner similar to that accomplished by pipe 58.

It is preferred that each of the air tubes 53 be provided with a spiralled vane 59, as best shown in Fig. 4, for the purpose of imparting a turbulence and spiralling rotation to air flow through the respective airflow tubes. Rearward of conduit bank 17, a series of air directional baffles are provided. Preferably these include an upper baffle 61 depending from top 33 and terminating in a rearwardly diagonalled lower section which projects approximately to overlap the uppermost conduit of the rearward bank, a lower baffle 63 which similarly projects upwardly from bottom 34 includes a rearwardly diagonalled portion which overlaps the lowermost conduit of the rearward tier, and intermediate V-shaped baffles 65 which are respectively disposed with their spaces in alinement with the spacings between the rearward tier of conduits 51.

In the operation of the device incorporating the present invention, the hot refrigerant is fed through pipe 29 to T-connection 31 and thence to the uppermost conduits 51 of the forward and rearward tiers. The refrigerant thus flows into the maximum upper space at the ends of the uppermost conduits 51 and passes into the annular space between the interior of conduit 51 and air tube 53. As can readily be seen, this disperses the refrigerant into a thin annular layer surrounded on the outside by the conduit 51 and contained on the inside by the air tube 53. The refrigerant flows from the intake end of the conduit toward the opposite end, and due to the inclination of the air tube 53 relative to the conduit within which it is contained, a change in the contour of the layer of refrigerant is accomplished, resulting in a certain amount of turbulence and mixing in the flow of the refrigerant as it passes from end to end of the conduit and in generally improving the mixing of the refrigerant within the conduit as it flows from end to end. When it reaches the opposite end of the conduit it is discharged therefrom

through communicator 55 into the next subjacent conduit in which the air tube is oppositely inclined so that the discharging refrigerant discharges into the maximum upper space formed in the end of the conduit 51 and passes therefrom along the conduit, with the inclination of the air tube effecting similar turbulence and resulting in discharge of the refrigerant from the opposite end. The refrigerant follows this tortuous pathway from end to opposite end of the respective conduits throughout the upper section of the respective tiers.

When the refrigerant has reached the lowermost tube of the upper section of the conduits, in the preferred embodiment of the invention, as here shown, it is desirable that the refrigerant from the forwardmost tier of conduits be crossed over to pass into the conduits of the rearmost tier, and conversely that the refrigerant from the upper section of the rearmost tier of conduits be crossed over to pass into the lower section of the forwardmost conduits. Such cross-over is accomplished by the diagonal pipes 57, 58, respectively communicating the upper section of the forward tier with the lower section of the rearward tier, and the upper section of the rearward tier with the lower section of the forward tier.

While this refrigerant flow is in progress, motor 15 is activated to drive fan 13, drawing air through screen 37, and discharging same rearwardly through the port provided in rear wall 49. The air drawn through screen 37 impinges directly upon the exterior of the forwardmost tier of conduits 51, passes through the vertical spaces between the forwardmost tier of conduits, and impinges against the rearmost tier of conduits. Baffles 61, 63, 65, disposed rearwardly of the rear tier of conduits, are effective to direct the air so as to require the same to pass substantially around the rearmost conduits in flowing therefrom, and the air drawn therethrough flows between the baffles 61, 63, 65 rearwardly to discharge as indicated by the arrows in Fig. 1. The cross-over between the forward and rearward tiers of conduits, as heretofore described, is effective to more nearly equalize the cooling effect of the air which is passed over the exterior of conduits 51 upon the refrigerant contained in a thin layer therein. It will be seen that as the air passes over the conduits of the forward tier it is somewhat warmed before it impinges upon the conduits of the rearward tier. Consequently, the refrigerant is transferred from the rearward tier to the forward tier, and conversely from the forward tier to the rearward tier, in order that the refrigerant as it passes through the entire tier will be subjected to a substantially equal amount of cooling air.

During the same operation, air is also drawn in through screen 37 into chamber 47 and passes through the open ends of air tubes 53 projecting into the chamber 47, being withdrawn therefrom at the opposite open ends of the tubes in the space between plate 39 and side wall 36. As can readily be seen, the cooling air is thus passed through the internal air flow tubes 53 and provides a large surface cooling area against the interior of the thin annular layer of refrigerant passing through the respective conduits 51. The spiralled vanes 59 with which each of the air tubes 53 is provided is preferred in order to provide a rifling rotation and consequent mixing of the cooling air as the same flows through the air tube, resulting in a greater enhancement of the cooling effect on the interior of the refrigerant layer.

It will be seen that by the device of the present invention the hot refrigerant is transmitted through the conduit bank in a thin annular layer which is subjected to a relatively large radiation surface on the exterior in the form of conduits 51, and to a relatively large radiation surface on the interior in the form of the air flow tubes 53. As a result, the efficiency of the device in effectively cooling the refrigerant is greatly enhanced and eliminates the necessity of spiral baffling or other heat radiating fins which have been considered necessary in coils or other air cooled devices which are presently

in commercial usage. After the refrigerant has completed its flow through the respective tiers of conduits it passes into piping 19, from which it is delivered to receiver 21 for recirculation through the system as heretofore described.

I claim:

1. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow at one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising a conduit bank disposed in the path of said air flow, said conduit bank including an upright forward tier of conduits and an upright rearward tier of conduits, each said tier comprising a plurality of substantially horizontal cylindrical rerfigerant conduits vertically spaced apart with the conduits of the rearward tier intercepting spaces between and adjacent the conduits of the forward tier, each tier including an upper conduit section and a lower conduit section, a plurality of hollow, open ended cylindrical air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, each said air tube relative to its related conduit being inclined from contact with the upper portion of the conduit at one end to contact with the lower portion of the conduit at the opposite end, to provide said annular space with a constantly varied contour from end to end of said conduit having a maximum lower space at one end and a maximum upper space at the other end, alternate conduits and tubes in each said tier being positioned with said tubes oppositely inclined, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of each tier at the maximum upper space therein, means successively interconnecting the maximum spaces of adjacent conduits in said tier upper sections, cross-over means communicating the lowermost conduit of each upper tier section with the uppermost conduit of each lower section of the other tier to transfer flow from one tier to the other, upright plates at one end of said tiers segregating a portion of said housing open end, one of said plates engaging said tiers outwardly from the ends of the majority of said conduits and inwardly from the ends of said tubes with said tube ends projecting into said segregated portion, additional plate means adjacent the opposite end of said tiers connected with said wall means and engaging said tiers outwardly from the other end of said conduits and inwardly from the other ends of said tubes with said tube other ends projecting beyond said additional plate, said plates directing air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and internal heat radiating surfaces subjected to the cooling effect of said air flow.

2. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow through one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising a conduit bank disposed in the path of said air flow, said conduit bank including an upright forward tier of

conduits and an upright rearward tier of conduits, each said tier comprising a plurality of substantially horizontal refrigerant conduits vertically spaced apart with the conduits of the rearward tier intercepting spaces between and adjacent the conduits of the forward tier, a plurality of hollow, open ended air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, each said air tube relative to its related conduit being inclined from contact with the upper portion of the conduit at one end to contact with the lower portion of the conduit at the opposite end, to provide said annular space with a constantly varied contour from end to end of said conduit having a maximum lower space at one end and a maximum upper space at the other end, alternate conduits and tubes in each said tier being positioned with said tubes oppositely inclined, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of each tier at the maximum upper space therein, means successively interconnecting the maximum spaces of adjacent conduits, plate means located at the opposite side of said open housing end defining a chamber, the open tube ends at one end of said tiers extending into said chamber and the open tube ends at the opposite end of said tiers extending behind said wall means, for directing air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and internal heat radiating surfaces subjected to the cooling effect of said air flow.

3. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow through one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising a conduit bank disposed in the path of said air flow, said conduit bank including an upright forward tier of conduits and an upright rearward tier of conduits, each said tier comprising a plurality of substantially horizontal refrigerant conduits vertically spaced apart with the conduits of the rearward tier intercepting spaces between and adjacent the conduits of the forward tier, each tier including an upper conduit section and a lower conduit section, a plurality of hollow, open ended air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of each tier, means successively interconnecting the adjacent conduits in said tier upper sections, cross-over means communicating the lowermost conduit of each upper tier section with the uppermost conduit of each lower section of the other tier to transfer flow from one tier to the other, plate means located at the opposite side of said open housing end defining a chamber, the open tube ends at one end of said tiers extending into said chamber and the open tube ends at the opposite end of said tiers extending behind said wall means, for directing air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and internal heat radiating surfaces subjected to the cooling effect of said air flow.

4. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow through one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising a conduit bank disposed in the path of said air flow, said conduit bank including an upright forward tier of conduits and an upright rearward tier of conduits, each said tier comprising a plurality of substantially horizontal refrigerant conduits vertically spaced apart with the conduits of the rearward tier intercepting spaces between and adjacent the conduits of the forward tier, a plurality of hollow, open ended air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of each tier, means successively interconnecting adjacent conduits, plate means located at the opposite side of said open housing end defining a chamber, the open tube ends at one end of said tiers extending into said chamber and the open tube ends at the opposite end of said tiers extending behind said wall means, for directing air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and internal heat radiating surfaces subjected to the cooling effect of said air flow.

5. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow through one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising a conduit bank disposed in the path of said air flow, said conduit bank including an upright forward tier of conduits and an upright rearward tier of conduits, each said tier comprising a plurality of substantially horizontal refrigerant conduits vertically spaced apart with the conduits of the rearward tier intercepting spaces between and adjacent the conduits of the forward tier, a plurality of hollow, open ended air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of each tier, means successively interconnecting adjacent conduits, plate means located at the opposite side of said open housing end defining a chamber, the open tube ends at one end of said tiers extending into said chamber and the open tube ends at the opposite end of said tiers extending behind said wall means, for directing air flow through said tubes, and spirally twisted vanes mounted in said tubes for imparting rotation to air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and

internal heat radiating surfaces subjected to the cooling effect of said air flow.

6. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow through one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising an upright tier of conduits disposed in the path of said air flow, said tier comprising a plurality of substantially horizontal refrigerant conduits vertically spaced apart, a plurality of hollow, open ended air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, each said air tube relative to its related conduit being inclined from contact with the upper portion of the conduit at one end to contact with the lower portion of the conduit at the opposite end, to provide said annular space with a constantly varied contour from end to end of said conduit having a maximum lower space at one end and a maximum upper space at the other end, alternate conduits and tubes in said tier being positioned with said tubes oppositely inclined, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of said tier at the maximum upper space therein, means successively interconnecting the maximum spaces of adjacent conduits in said tier, plate means located at the opposite side of said open housing end defining a chamber, the open tube ends at one end of said tiers extending into said chamber and the open tube ends at the opposite end of said tiers extending behind said wall means, for directing air flow through said tubes, and spirally twisted vanes mounted in said tubes for imparting rotation to air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and internal heat radiating surfaces subjected to the cooling effect of said air flow.

7. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow through one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising an upright tier of conduits disposed in the path of said air flow, said tier comprising a plurality of substantially horizontal refrigerant conduits vertically spaced apart, a plurality of hollow, open ended air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, each said air tube relative to its related conduit being inclined from contact with the upper portion of the conduit at one end to contact with the lower portion of the conduit at the opposite end, to provide said annular space with a constantly varied contour from end to end of said conduit having a maximum lower space at one end and a maximum upper space at the other end, alternate conduits and tubes in said tier being positioned with said tubes oppositely inclined, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of said tier at the maximum upper space therein, means successively interconnecting the maximum spaces of adjacent conduits in said tier, plate means located at the opposite side of said open housing end defining a chamber, the open tube ends at one end of said tiers extending into said chamber and the open tube ends at the opposite end of said tiers extending behind said wall means, for directing air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and internal heat radiating surfaces subjected to the cooling effect of said air flow.

8. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow through one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising an upright tier of conduits disposed in the path of said air flow, said tier comprising a plurality of substantially horizontal refrigerant conduits vertically spaced apart, a plurality of hollow, open ended air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of said tier, means successively interconnecting adjacent conduits in said tier, plate means located at the opposite side of said open housing end defining a chamber, the open tube ends at one end of said tiers extending into said chamber and the open tube ends at the opposite end of said tiers extending behind said wall means, for directing air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and internal heat radiating surfaces subjected to the cooling effect of said air flow.

9. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow through one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising an upright tier of conduits disposed in the path of said air flow, said tier comprising a plurality of substantially horizontal refrigerant conduits vertically spaced apart, a plurality of hollow, open ended air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of said tier, means successively interconnecting adjacent conduits in said tier, plate means located at the opposite side of said open housing end defining a chamber, the open tube ends at one end of said tiers extending into said chamber and the open tube ends at the opposite end of said tiers extending behind said wall means, for directing air flow through said tubes, and

spirally twisted vanes mounted in said tubes for imparting rotation to air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and internal heat radiating surfaces subjected to the cooling effect of said air flow.

10. Heat exchanger means adapted for use in a cooling system which includes means for circulating a fluid refrigerant to and from said heat exchanger means, a housing open at one end for air flow into said housing and having an air flow discharge from said housing, wall means cutting off air flow through one side of said open end, and air flow impeller means disposed to establish air flow in through said open end and out through said discharge; said heat exchanger means comprising a plurality of refrigerant conduits spaced apart and disposed in the path of said air flow, a plurality of hollow, open ended air flow tubes, each said conduit having an air flow tube projecting through the interior of the conduit to define a thin, annular conduit space for the passage of refrigerant in a thin annular layer through said conduits, said air tubes being respectively of a length greater than the length of the conduits related thereto and being positioned with their opposite open ends extending outwardly beyond the ends of said conduits, each said air tube relative to its related conduit being inclined from contact with the upper portion of the conduit at one end to contact with the lower portion of the conduit at the opposite end, to provide said annular space with a constantly varied contour from end to end of said conduit having a maximum lower space at one end and a maximum upper space at the other end, alternate conduits and tubes in said tier being positioned with said tubes oppositely inclined, said conduit ends being sealed to said air tubes, means connecting said circulating means with the uppermost conduit of said tier at the maximum upper space therein, means successively interconnecting the maximum spaces of adjacent conduits in said tier, plate means located at the opposite side of said open housing and defining a chamber, the open tube ends at one end of said tiers extending into said chamber and the open tube ends at the opposite end of said tiers extending behind said wall means, for directing air flow through said tubes, whereby to provide a tortuous pathway for a thin annular layer of refrigerant between relatively large external and internal heat radiating surfaces subjected to the cooling effect of said air flow.

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