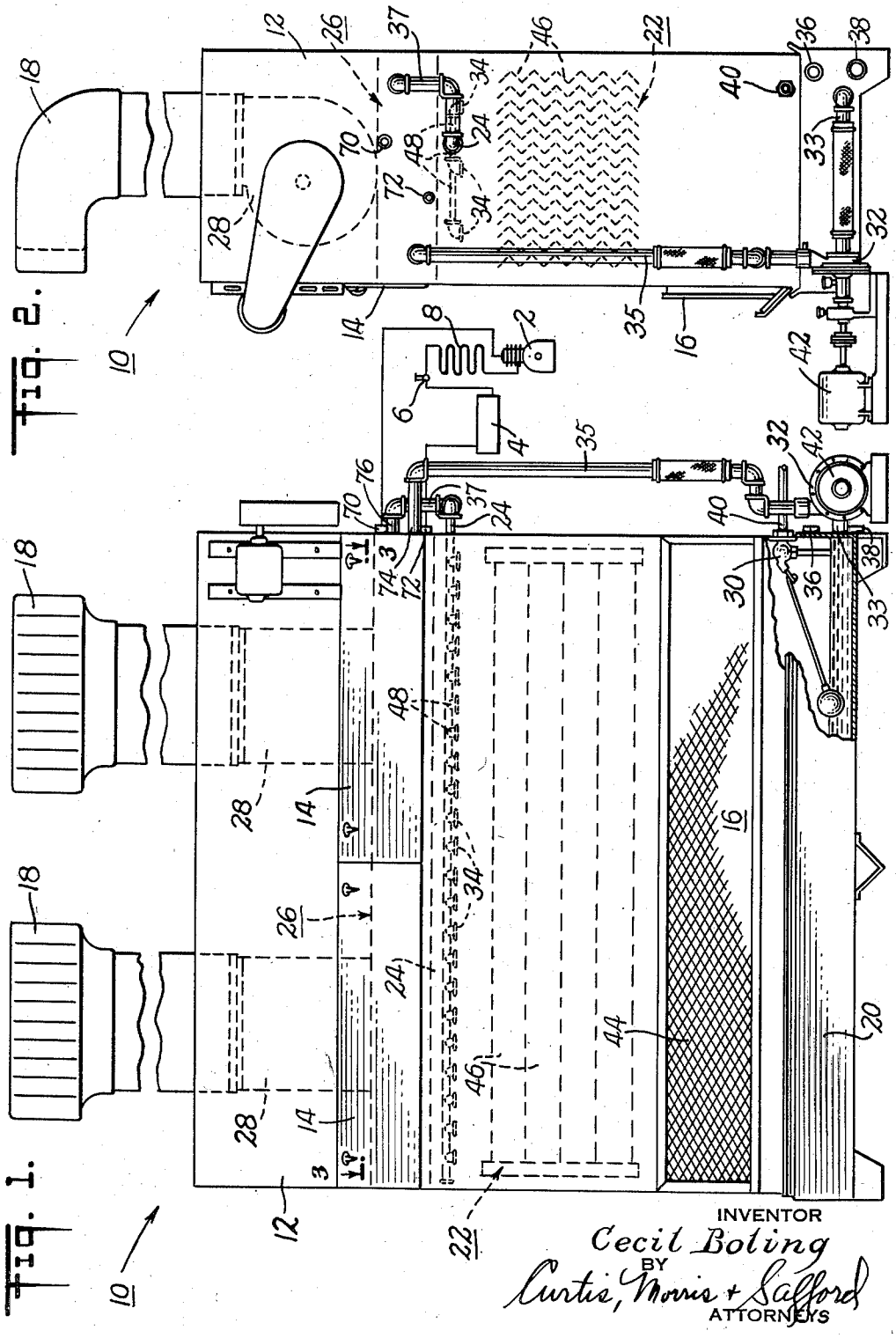
April 2, 1957 C. BOLING 2,787,134

CONDENSER FOR REFRIGERATION SYSTEM

Filed June 25, 1953 3 Sheets-Sheet 1



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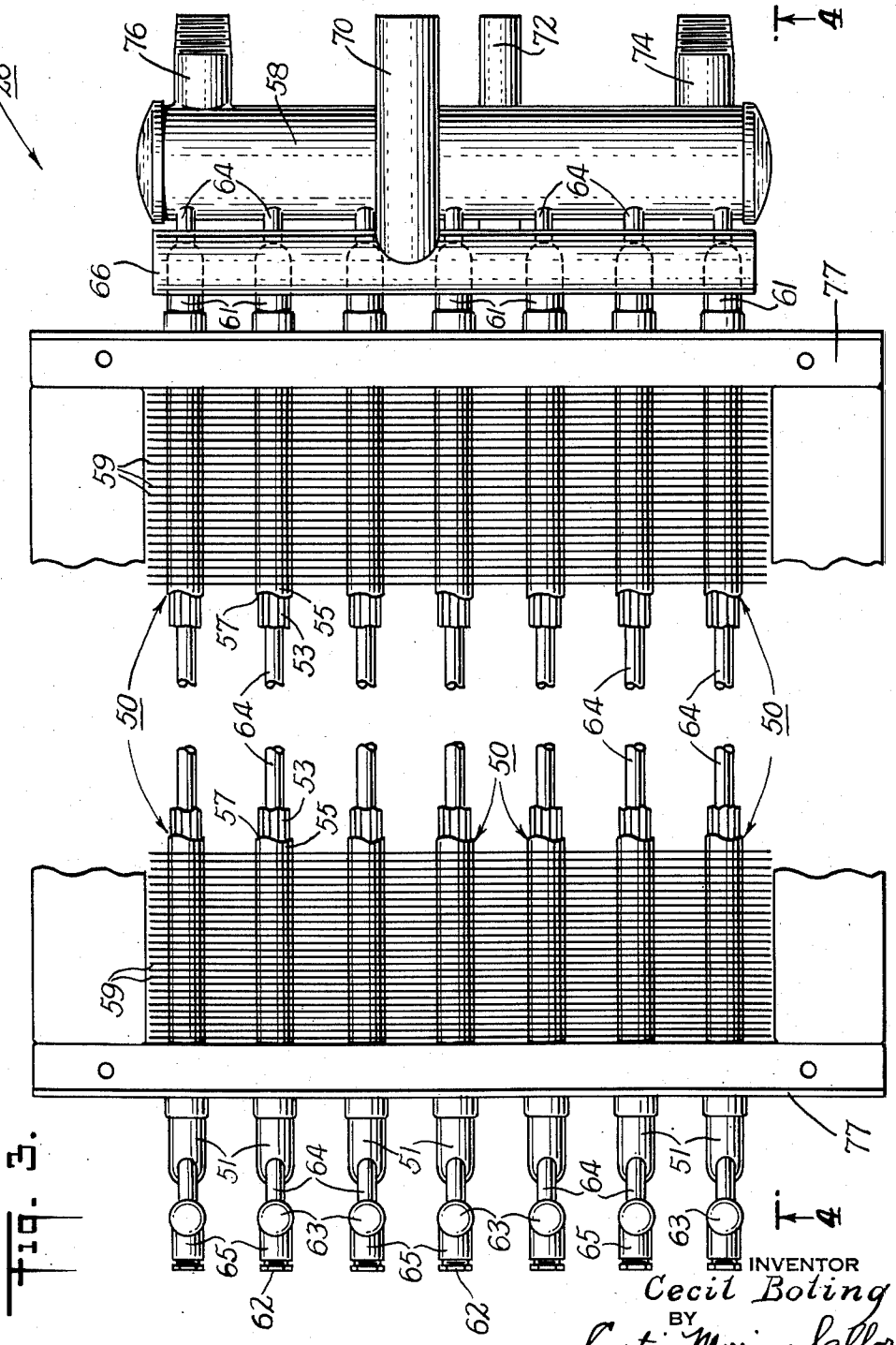


Fig. 3.

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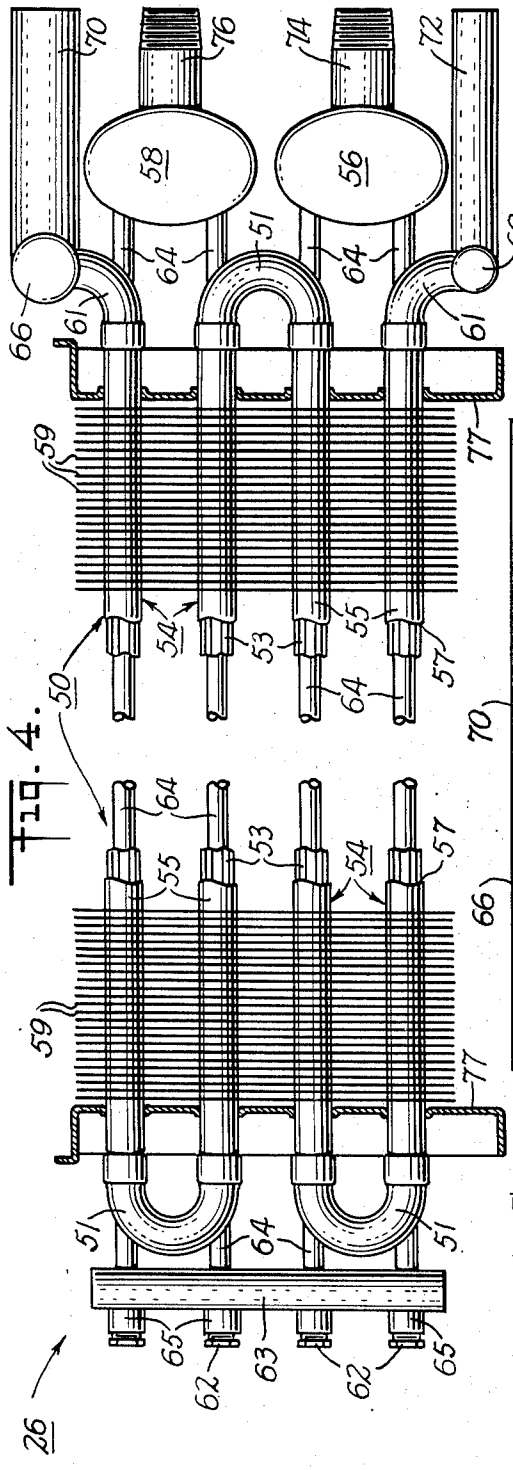


Fig. 4.

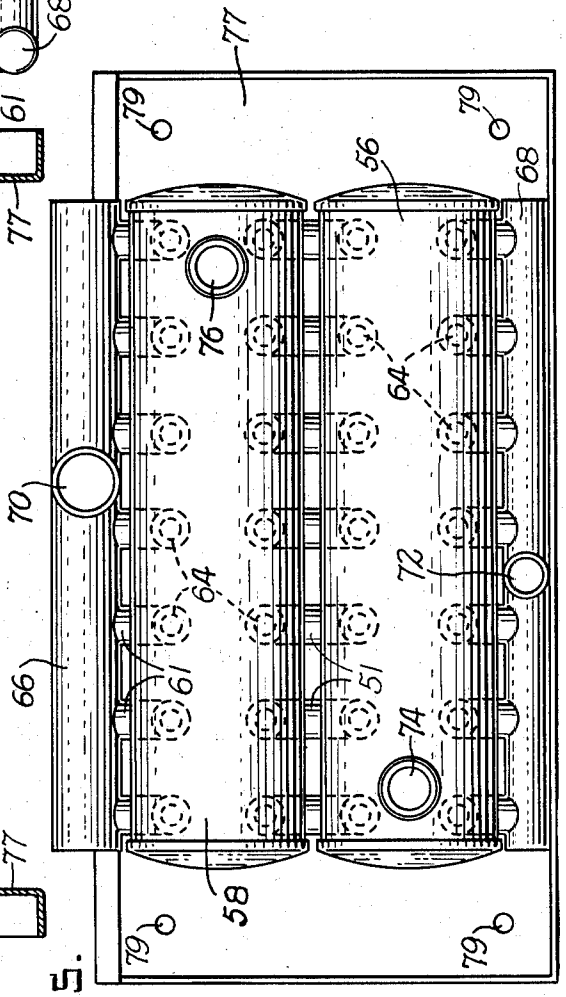


Fig. 5.

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United States Patent Office 2,787,134
Patented Apr. 2, 1957

2,787,134

CONDENSER FOR REFRIGERATION SYSTEM

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Application June 25, 1953, Serial No. 363,982

10 Claims. (Cl. 62—115)

This invention relates to refrigeration, and more particularly to an improved refrigeration system which includes novel elements for carrying out the condensing operation in the refrigerating cycle.

In refrigerating and air conditioning systems where the availability and cost of water for the condenser cooling is a problem there have been two general solutions. One is the evaporative condenser which consists of a condenser coil over which water is sprayed with the cooling being obtained by the evaporation of the water, and the other is the cooling tower in which water is sprayed over a so-called "wetted deck" surface on which the water is cooled by the evaporation of a part thereof and the cooled water is used in the condenser.

The present invention contemplates further economies than are obtainable with any of the units heretofore known by the provision of a combination air-water condenser coil together with a spray header, a wetted deck surface, and means to circulate the air.

It is an object of the present invention to provide a condenser cooling apparatus that is readily adaptable to a wide variety of operating conditions. It is another object to provide a condenser cooling apparatus that is readily convertible to emergency operation without the necessity of expensive standby apparatus. It is another object to provide a condenser cooling unit that will operate without difficulty or special attention at low temperatures such as are encountered in the winter. It is a further object to provide such condenser apparatus, which is of simplified construction, is easy and economical to manufacture and operate and maintain, and which is readily interchangeable with or convertible to use as a simple cooling tower. These and other and further objects will be in part apparent and in part pointed out below.

In the drawings:

Figure 1 is a schematic representation of a refrigeration system including in side elevation a condenser according to the present invention showing the relative positioning of the various components;

Figure 2 is an end elevation of the condenser of Figure 1;

Figure 3 is a sectional view on line 3—3 of Figure 1 showing details of the air and water condenser coil;

Figure 4 is a section on line 4—4 of Figure 3; and,

Figure 5 is an end view of the condenser coil.

A refrigeration system is shown schematically with a compressor 2, a receiver 4, an expansion valve 6, and an evaporator 8. The system also has a condenser 10 shown in side elevation in Figure 1 and described in detail below. The condenser 10 has a casing 12 with access doors 14, an air inlet opening 16 at the bottom and air outlets 18 at the top. Casing 12 is mounted upon a sump tank 20, and has therein a "wetted deck" 22 above which is positioned a spray header 24. Also mounted within casing 12 and positioned above header 24 is a combination air and water cooled condenser coil 26. Two fans 28 are mounted at the top of the casing and operate to draw air into the bottom of the casing through opening 16 and upwardly through the wetted deck surface and the condenser coil 26, and the air is discharged through outlets 18.

Sump tank 20 has positioned therein a float valve assembly 30 which automatically fills the sump tank and maintains a predetermined level of water therein. A water pump 32 has its inlet pipe 33 connected to the bottom of the sump tank, and has its outlet pipe 35 extending upwardly and connected to the water circuit of condenser coil 26 to be described in more detail below. The water flows from this water circuit through an outlet pipe 37 to the spray header 24, from which it is discharged through spray nozzles 34 onto the top of the wetted deck 22. The water flows downwardly over the deck so as to keep the deck surfaces thoroughly wetted and so as to break up the water flow, thus to expose a maximum water surface. This promotes evaporation of the water so as to cool it. The remainder of the water flows downwardly into sump tank 20 and is recirculated by pump 32 as described above.

Sump tank 20 has an overflow pipe 36 (see Figure 2), a drain pipe or port 38, and a makeup water inlet 40 through which makeup water flows into the sump tank under the control of float valve 30. Pump 32 is driven by an electric motor 42.

Air inlet 16 is positioned above sump tank 20 and below the wetted deck 22 and has positioned therein a suitable screen and air filter unit 44 to prevent the entrance of undesired dust and the like with the air. Wetted deck 22 is constructed of series of horizontal strips 46 which are of a zinc coated steel and are painted to resist corrosion and rusting. Strips 46 are Z-shaped in cross-section so as to provide a large surface for the water to flow over and promote the evaporation of the water. Spray header 24 comprises three pipes 48 (Figure 2) extending the length of the casing and having the spray nozzles 34 which produce a downwardly directed spray completely covering the wetted deck.

Referring now to Figures 3 to 5 of the drawings, the air and water condenser coil 26 is formed by a bank of seven double tube coils 50, each coil 50 (see Figure 4) comprising four lengths of double tubing or tube assemblies 54 connected in series. Each tube assembly 54 is formed by an inner tube 64 concentrically positioned within an outer tube 55, and a fin assembly 53 positioned in the annular space or passageway 57 between the two tubes. Each of the coils 50 also carries a series of external fins 59 tightly fitting the outer tube 55. The tube assemblies 54 are all parallel, and those of each coil 50 are positioned one above another in vertical alignment. The passageways 57 of the four outer tubes 54 of each coil 50 are interconnected at their ends by U-bends 51 so as to provide a series flow path.

The right hand end of the lowermost tube 54 of each coil 50 has its passageway 57 connected by an angle bend 61 to a header tube 68 (see also Figure 5), and this header tube has at its center a refrigerant outlet tube connection 72. The right-hand end of the uppermost tube 54 of each coil 50 is similarly connected by an angle bend 61 to a header tube 66 which is connected at its center to a refrigerant inlet tube or connection 70 for the refrigerant gas to be condensed. The inner tubes 64 of the tube assemblies 54 project at their two ends through their respective bends 51 and 61. At the left, the tubes 64 of each coil 50 terminate in a vertical tube header 63, and the wall of the header has in alignment with the end of each tube 64 a clean-out opening fixture 65 which is closed by a removable screw-plug 62. The right hand ends of tubes 64 terminate in two headers 56 and 58, with

the lower tubes of each coil 50 terminating in header 56 and the upper two tubes terminating in the header 58. Header 56 has at its left-hand end (Fig. 5) a water inlet connection 74, and header 76 has at the right a water outlet connection 76. A pair of plates 77 (see also Figure 4) are provided at the ends of the coils, and each of the tube assemblies 54 is snugly received at its ends in openings in these plates. This provides rigid support for the entire condenser coil assembly. These plates 77 project (Figure 5) beyond the sides of the coil and header assembly and are provided with openings 79 through which bolts extend by which the condenser assembly is secured to the casing.

As indicated above, the condenser coil 26 is the condenser of a refrigeration system, the remaining elements of which are represented schematically in Figure 1. During operation, the compressed gaseous refrigerant flows from the compressor to the top of the condenser, and it flows downwardly while it is being cooled and condensed. The cooling of the refrigerant is by the combined action of water flowing through the center tubes 64 of the coil assemblies and the air flowing upwardly in heat exchange relationship with the fins 59 (Figure 4). Accordingly, the pump 32 withdraws water from near the bottom of the sump tank 20, and directs it through pipe 35 and pipe 74 (Figure 4) into the lower water header 56. The water flows to the left through the lower two banks of the tubes 64 to the header 63, and thence to the right through the upper two banks of tubes 64 to the header 58. The water then flows from header 58 through pipe 76 to the water spray header pipes 48, from which it is discharged through nozzles 34 onto the wetted deck. The air which is drawn in at 44 flows upwardly through the wetted deck so as to evaporate a portion of the water. This cools the water and also cools the upflowing stream of air. The cool water returns to the sump tank 20, from which it is recirculated. The upflowing stream of air encounters the finned condenser coil 26, the fins of which act as eliminator baffles to intercept any entrained water spray or droplets. Thus, the lower portion of the condenser coil may be wetted so that there is further evaporation of water in this vicinity to further promote cooling. The air is also relatively cool, and it is quite effective to assist in cooling the refrigerant. The upper porton of the condenser coil tends to remain dry so as to raise the air temperature and thereby make maximum use of the air which is circulating.

The tube assemblies 54 are constructed in accordance with the disclosures of my prior Patent No. 2,611,587, and my co-pending application, Serial No. 310,820, filed September 22, 1952, now forfeited. Accordingly, the fin assemblies 53 are of corrugated sheet metal, with the corrugations extending longitudinally of the condensing passageways 57, and this insures free and efficient flow through the condensing passageways. The fin assemblies are also under radial compression so that good heat relationships are maintained between all of the elements of the tube assemblies. Thus, the refrigerant is readily cooled by the water in the inner tubes 64 and also by the air contacting the external fins. The water is constantly cooled and maintains a relatively constant cooling effect upon the refrigerant. At the same time, maximum use is made of the air in first promoting evaporation of the water, and then by assisting in cooling the refrigerant. The air is discharged in relatively warm, humid condition, free of mist or droplets of water.

The normal operation described above is extremely efficient and dependable, and involves the use of a minimum volume of air per ton of refrigeration. When the load is extremely light, the entire condensing action may be made by air passing over the external fins with the natural draft effect, in which case no water is used and the fans are not operated. Under slightly increased loads, the fans may be operated without the use of water. Under other circumstances, the entire condensing action may be effected by flowing a steady stream of cold water from the city mains or from a well through the condenser coil. Such operation might be necessary under emergency conditions where the power supply for the fans has been cut off.

In one illustrative example, a system built in accordance with the present invention produced satisfactory results with an air flow of 175 cubic feet per minute per ton of refrigeration, whereas equivalent systems used as much as 300 cubic feet of air per minute per ton of refrigeration. With this illustrative unit, assume that the air enters at 16 with a wet bulb temperature of 78° F. and a dry bulb temperature of 90° F., the air would pass upwardly from the deck surface at 89° F. wet bulb, and 90° F. dry bulb. In passing through the condenser coil, the dry bulb temperature could be increased to 110° F. and the wet bulb temperature would also increase to 92.6° F. With such operation, there would be more than a 25 percent increase in the heat dissipation because of the desuperheating effect in the upper portion of the condenser coil and the additional condensing.

It is thus seen that there is provided an improved refrigeration system and an improved condenser coil and evaporative cooling system. As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a refrigeration system wherein refrigerant is subjected to a condensing and evaporating cycle, the combination with the other elements of the system of, a condenser assembly comprising, a casing providing a vertical air passageway, a condenser unit position within said air passageway near the top thereof and having external fins and condenser tube assemblies each comprising an inner tube and an outer tube with the inner tube providing an inner passageway and with the two tubes providing an annular passageway, water distributor means in said air passageway in a zone directly below said condenser unit, and means to supply water to said water distributor means along a path extending through the inner passageways of said tube assemblies.

2. A system as described in claim 1, which includes centrifugal fan means mounted at the top of said casing and operative to draw air upwardly thereto, and sump means to collect the water at the bottom of said vertical air passageway.

3. In a refrigeration system, a condenser unit comprising, an outer casing, a water sump tank positioned at the bottom of said casing, a wetted deck mounted within said casing above said sump, an air inlet opening in said casing above said sump tank and below said wetted deck, a water spray header mounted in said casing above said wetted deck, a combination air and water cooled condenser coil mounted above said casing, fan means for circulating air through said casing, and water circulating means for circulating water from said sump through said condenser to said spray header.

4. A condenser unit for use in a refrigerating circuit comprising, a combination air and water cooled condenser coil having separate paths of flow therethrough, a water spray header, a wetted deck, means for flowing water in one of said paths through said condenser to said spray header and over said wetted deck, and means for flowing air over said wetted deck and another of said paths through said condenser coil counter-current to said water spray.

5. A condenser unit as described in claim 4 wherein said air and water cooled condenser coil comprises water inlet and outlet headers, refrigerant inlet and outlet headers and a plurality of coil assemblies, each of said coil assemblies comprising a plurality of double tube assemblies extending substantially the distance between said

headers each of said tube assemblies having an inner pasageway and an outer passageway, said outer passageways for each of said coil assemblies being connected in series between said refrigerant headers and said inner-passageways of each between said water inlet and outlet headers coil assembly being connected in a series relationship.

6. A condenser unit as described in claim 5, wherein said condenser coil includes, a plurality of external fins mounted upon said tube assemblies to provide for the dissipation of heat to the air and also to eliminate unevaporated water from the air stream.

7. A condenser unit for use in a refrigeration circuit comprising a housing, a double-tube coil assembly positioned in said housing, a plurality of fins mounted on said coil assembly, a water spray header mounted beneath said coil assembly and having a plurality of nozzles, a wetted deck positioned beneath said spray header, a water sump below said housing, pump means for circulating water from said sump through the inner tube of said coil assembly and therethrough said spray header and over said wetter deck and back to said sump and fan means to circulate air through said housing countercurrent to said water circulation and thence through said coil assembly.

8. In apparatus of the character described, a plurality of coil assemblies, each of which comprises a plurality of parallel tube assemblies, each of said tube assemblies comprising a pair of concentrically positioned tubes and being an inner tube which is of substantially greater length than the outer tube with its ends being exposed,

each of said coil assemblies having U-tube means interconnecting the outer tubes and having a single header interconnecting the ends of the inner tubes at one end of the coil assembly, and four headers at the opposite end of the coil assembly connected respectively to the inner and outer tubes of the most remote tube assemblies.

9. Apparatus as described in claim 8, wherein each of said tube assemblies includes an internal fin assembly positioned in the annular passageway between the inner and outer tubes and an external fin assembly upon the outer surface of the outer tube.

10. A condenser unit for a refrigeration system comprising, an air and water cooled condenser including means forming separate air and water paths of flow over different surfaces in heat exchange relationship with refrigerant, means for flowing water along said water path of flow, means for flowing air along said air path of flow, an evaporative cooling chamber in which water from said water path of flow is brought into contact with the air flowing to said air path of flow thereby to produce a cooling effect by evaporation of a portion of the water, and means for recirculating water from said chamber through said water path of flow and said chamber.

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