July 14, 1936. J. R. BALLARD 2,047,249

APPARATUS FOR COOLING FOOD STORAGE SPACES

Filed Oct. 23, 1931

FIG. 1.

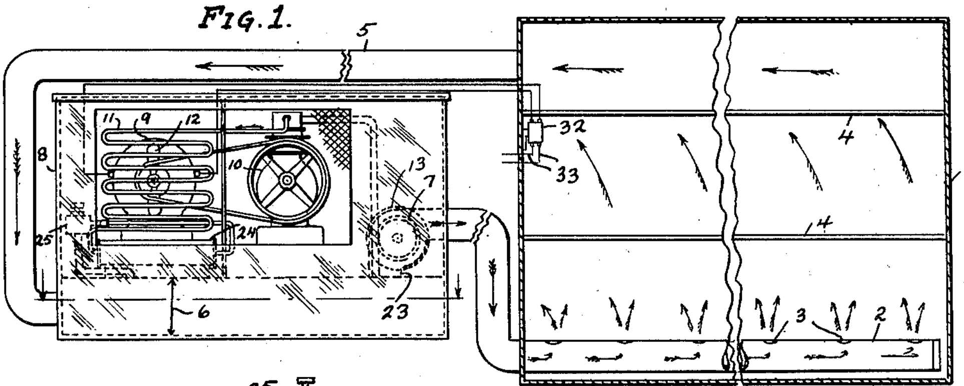


FIG. 2.

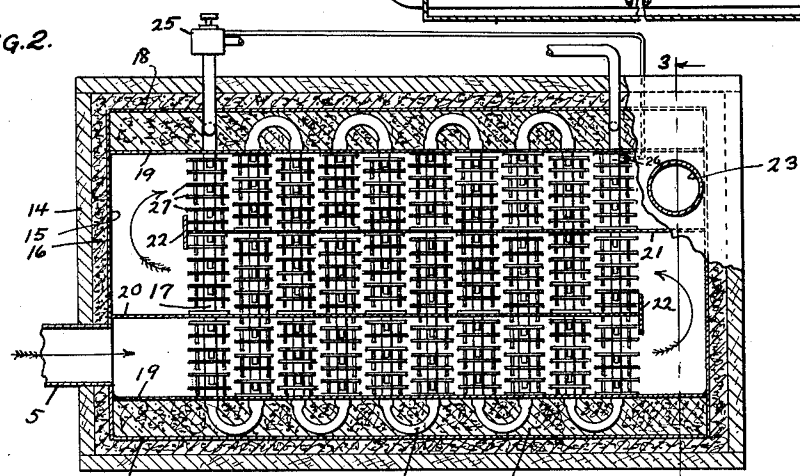


FIG. 3.

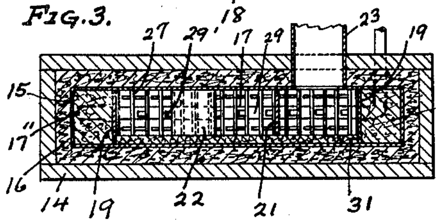


FIG. 4.

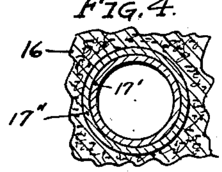


FIG. 5.

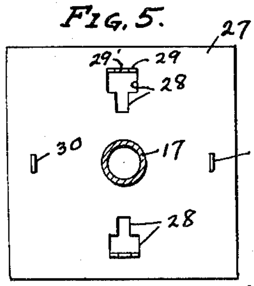
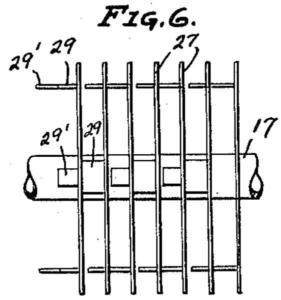


FIG. 6.



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UNITED STATES PATENT OFFICE

2,047,249

APPARATUS FOR COOLING FOOD STORAGE SPACES

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Application October 23, 1931, Serial No. 570,641

18 Claims. (Cl. 62—101)

This invention relates in general to mechanical refrigeration and has more particular reference to an improved method of and apparatus for cooling rooms, compartments, or other containers forming enclosed and unenclosed spaces, while substantially preserving the original humidity of the atmosphere within the cooled space.

Briefly stated, the invention comprises circulating air either by forced draft, or otherwise, over special cooling coils in a manner to substantially retain its moisture content.

One of the objects of the invention resides in the circulation of the air over the coil in a manner avoiding the continual condensing and freezing of the moisture onto the cooling coils, with a corresponding gradual loss of moisture content of the refrigerated atmosphere to a point where it is substantially dry.

In the present invention, the temperature of the coils is continuously raised and lowered so as to maintain any moisture, deposited on the coils, in liquid condition, thus permitting it to be reentrained in the circulating air.

Another feature is the provision of a moisture-evaporating mat having a surface of large area disposed in position to receive drippage of moisture from the coil and over which the circulating air is caused to flow in order to facilitate the reentrainment of the moisture in the air stream.

Another object is to improve the efficiency of the coil by operating it so as to prevent ice formation on the coil whereby all of the potential refrigerating energy of the refrigerant may be used in cooling the air and none sacrificed in turning moisture into frost.

Another important object of the invention is to improve the operating efficiency of a cooling coil or evaporator by insulating the coil at intervals against heat transfer to or from the circulating air stream.

Another object is to refrigerate a gaseous atmosphere without freezing the moisture therein.

Another object is to utilize heat taken from the atmosphere being cooled to prevent frosting of the moisture content of the atmosphere.

Another important object resides in insulating portions of the refrigerating coil in order to create cold zones in the cooling coil where refrigerant evaporation will be retarded and from which refrigerating energy may be drawn into the refrigerant stream.

Another important object is to control the refrigerating medium so that it passes through the cooling coil in successive surges which preferably are caused to occur rapidly so that the refrigerating medium, traveling the coil, is more or less alternately in moist, active and evaporable condition capable of heat absorption and in inactive or dry evaporated and relatively warm condition whereby frosting on the coil is substantially prevented and also whereby the efficiency of the coil is greatly increased.

Referring to the drawing:

Figure 1 is a schematic view of a refrigerating system arranged in accordance with my invention;

Figure 2 is an enlarged horizontal cross section of the air cooling coils;

Figure 3 is a cross section of Figure 2 as seen from the line 3—3 in Figure 2;

Figure 4 is an enlarged cross section of one of the return bends of the coils of Figure 2;

Figure 5 is an enlarged plan view of one of the copper heat transmitting fins fitting tightly over the copper expansion pipe of the air-cooling coils; and

Figure 6 is a side view of a plurality of the copper fins assembled in interlocked relation on a pipe.

To illustrate my invention, I have shown on the drawing, means to chill a fluid medium to be cooled without reducing its moisture content. The medium to be cooled is preferably enclosed in any suitable means forming a housing 1 or refrigerating chamber in order to separate it from the outer atmosphere. To this end, the housing may comprise walls, which are or may be of insulated construction to prevent the outer atmosphere from heating the refrigerating chamber. I do not wish to limit my invention to any particular type of refrigerating compartment since the same may be applied to any compartment, such as a room, cabinet, or even an unenclosed space. In order to illustrate the invention, however, I have shown the housing in the form of a refrigerated display case.

The case 1 is provided with a cold air injecting pipe or manifold 2 having air-emitting apertures 3. As illustrated, the manifold extends at the lower part of the case so as to cause the cold air to be blown upwardly for circulation about the shelves 4 within the case and to drive the warm air out in the general direction indicated by the arrows to the surrounding atmosphere or to a suction pipe 5 for carrying the air back to the air cooling unit 6 of the refrigerating apparatus embodying my present invention and thence through a fan 7 located at the outlet of the refrigerating apparatus to draw the air through the same instead of forcing it through, as the latter mode of installation causes a slight compression with consequent evolution of heat, which is avoided by sucking it through.

The refrigerating apparatus of the installation is or may all be mounted in a portable cabinet 8 and includes the standard refrigerating elements such as an electric motor 9 driving a compressor 10, gas radiator or condenser coils 11, air-circulating fan 12 for circulating air in and out of the cabinet, a special expansion coil or evaporator 17 forming a part of an air-cooling unit 6 through which the circulating air to be cooled is drawn by means of the fan 7, which may be directly mounted on a driving motor 13.

The air-cooling unit 6, as shown in Figures 2 and 3, preferably comprises an outer rectangular casing 14, a spaced inner casing 15 having a heavy intermediate layer of heat-insulating material 16, such as granulated cork, disposed in the space between. The construction of the air cooling coils or evaporator 17 represents an important detail of the invention as it is especially designed to carry out one of the principal objects of the invention, i. e. to refrigerate the air without stripping it of its natural moisture content.

The evaporator is provided with means to retard evaporation of the refrigerant at intervals therein and this may be accomplished by insulating the coils of the evaporator against heat transfer whereby to establish colds spots at intervals therein. These insulated portions are preferably located at points in the evaporator where, on account of its construction, heat-transferring efficiency is lowest. In the case of a serpentine coil, the points of lowest heat-transferring efficiency are at the return bends where the refrigerant channel is curved. By this arrangement, heat transfer from the air to the refrigerant medium in the evaporator is substantially prevented where heat-transferring efficiency is low and is permitted at the places where efficiency is relatively high. Additional advantages are derived by the creation of cold zones and the retardation of evaporation at intervals in the cooling coils, including the preservation of potential refrigerating capacity in the traveling medium during its travel substantially throughout the entire evaporator, so that the refrigerating effect produced at the discharge end of the coil is approximately equal to that produced at the inlet. These and other advantages will become apparent as the invention is more fully understood from the following description of a preferred embodiment of the evaporator.

The cooling coil, or evaporator, 17, which is preferably formed of copper piping closely covered with a large number of sheet copper, heat-transmitting fins 27, is or may be arranged within the inner casing 15 and I prefer to circulate the air to be cooled over and around the finned evaporator through a serpentine path.

In order to most conveniently insulate the coil at intervals against heat transfer to or from the circulating air stream, I provide sheet metal walls 19, within the inner casing 15 and providing with the side walls 18 of said casing an inner and two outer compartments, said walls 19 fitting tightly upon and extending transversely of the pipe coil with the return bends 17′ of the cooling coil lying in the two outer compartments, and the relatively straight finned portions of the coils extending in the inner compartment in heat exchanging relation with air circulating therein. The return bends of the pipe are preferably heavily coated with asphaltic compound 17″ and packed in finely ground cork 16 in order to thoroughly insulate these parts of the cooling coil against transfer of heat to or from the air circulating in the inner compartment. The walls 19 are made tight at their junction along all four edges with the inside of the casing 15 and are also sealed, as by solder, to the cooling coil 17 at the places where the same extends through said walls. The inner compartment is also provided with partitions 20 and 21, each having one end (and side edges) sealed to the casing 15 with their other ends spaced from the casing 15 and fitted with baffle plates 22 extending at their ends to the top and bottom of the casing 15.

The arrangement described provides a circuitous air passage extending back and forth transversely of the straight finned runs of the cooling coil. The return bends of the cooling coils are packed in heat-insulating material within the outer chambers, with the opposite ends of the circuitous passage connected respectively to an air inlet pipe 5 and an air outlet pipe 23, which latter conveys the air to the suction fan 7 for passage to the chamber 1.

The system may employ any suitable refrigerating medium in the cooling coil and associated refrigerating apparatus, but I prefer to use sulphur dioxide as best suited to the temperature range handled. The refrigerating medium is circulated by means of the compressor 10 through the condenser 11, and, after leaving the air-cooled condensing coils, is passed to a small tank 24, from which it is fed through a valve 25 to the evaporator 17.

The refrigerating medium is introduced into the cooling coil as a liquid, which evaporates as the medium passes through the refrigerating coil. The evaporation of the refrigerant results in heat absorption, which is utilized through the fins 27 to refrigerate the circulating air. From the cooling coil, the vaporized medium is returned to the compressor to be again used in the refrigerating cycle.

The valve 25 is a thermostatically controlled valve of any suitable or conventional design, preferably gas-operated from a thermostat 26 in contact with the cooling coil preferably at a point near its discharge end from which the gas returns to the compressor, the arrangement being such that when the temperature of the coil, at the point of contact with the thermostat, rises, the valve 25 will be opened to admit additional quantities of the refrigerating medium for evaporation in the coil, and closed to prevent or restrict the introduction of the refrigerating medium to the evaporator when the temperature at its discharge end drops sufficiently.

The heat-transferring fins 27 are preferably made of sheet copper soldered to the copper coil pipe 17 as are the partition walls 19, 20, and the whole assemblage is preferably tinned to prevent oxidation. The fins 27 preferably are square plates as shown in Figure 5 and each is preferably notched out at two places 28 in a manner to provide projecting ears 29, each stepped or shouldered to form reduced ends 29′, which will fit into small slots 30 formed in the next adjacent plate so that when the plates are forced one after another upon the pipe (before fitting to the return bends) and each is given a quarter turn with respect to the next one, the ears of one will fit into the slots 30 of the other as shown in Figure 6.

Under the coil assemblage and extending over the area between the walls 15 and 19 is a thick felt or other absorbent pad 31, which is desirable in carrying out the method of cooling the air while maintaining its original moisture content.

The refrigerant is preferably supplied to the evaporator from the condenser through the valve 25 which is adapted alternately to open fully and to partially or entirely close during the operation of the refrigerating apparatus. When the valve is open, the liquid refrigerant is admitted in relatively large quantities into the cooling coil and immediately commences to evaporate and absorb heat. The portions of the stream which become completely evaporated or dry and inactive to absorb further heat, have a relatively higher temperature than those portions which evaporate more slowly and which remain moist and in active condition capable of absorbing further heat.

The refrigerant in traveling the coil in alternately moist, evaporable condition and dry evaporated condition, causes the coil temperature to be alternately and progressively fluctuated slightly above and slightly below the freezing point so that any moisture deposited on the coil will be maintained in liquid condition by absorbing heat from the coil while the coil is slightly above freezing temperature, that is to say, while the dry or evaporated portion of the refrigerant stream is passing, and the flow of air past the coil will pick up or entrain some of the moisture thus maintained in liquid condition while the residue may drip onto the pad and be picked up by the air passing the pad.

While I prefer to cause the refrigerant to pass through the coil in a fluctuating stream to cause the alternate cold and warm anti-frosting condition, this condition may be set up in other ways, and, in any event, the insulated portions of the coil, which form cold zones in the coil where evaporation is retarded, may have an appreciable effect in aiding the creation of the fluctuating anti-frosting temperature in the portions of the coil where heat-transfer occurs.

When the refrigerant is initially introduced into the coil, the coil will become filled with the moist refrigerant before the inlet valve closes. Thereafter, the refrigerant will remain relatively moist in the cold zones and will evaporate to dry condition in the non-insulated sections. When the refrigerant at the coil outlet is gasified, the thermostat causes the inlet valve to open, thus admitting additional refrigerant in liquid condition and forcing the refrigerant already in the evaporator through the coils. The refrigerant in the pipe will be relatively dry or inactive in the uninsulated portions and relatively moist and active in the insulated portions. When the inlet valve opens, these alternate dry and moist portions will flow through the coil alternately warming and cooling the coil which prevents frosting on the coil. As a result, any moisture in the air deposited on the coil and which tends to become frozen due to the refrigerating effect of the active refrigerant is kept in liquid condition by the warming effect of the expanded refrigerant traveling through the cooling coil. The deposited moisture thus maintained in liquid condition will either drop upon and saturate the absorbent pad 31 and thus be returned to the air traveling past the pad, or will be picked up by the air in passing the cooling coil and thus become re-absorbed in the circulating air thus preserving the moisture content. At the same time, the refrigerating effect caused by the evaporation of the refrigerating medium in the cooling coil will also absorb heat from the air flowing past the cooling coil.

In addition to the thermostatic control of the valve 25, a thermostat 32 is preferably located in contact with the atmosphere being refrigerated. The thermostat 32 is arranged to make and break the main electrical circuit 33 for supplying power to the motor, which drives the compressor, whereby to stop and start the refrigerating apparatus should the temperature of the atmosphere, being refrigerated, fall or rise beyond the limits for which the thermostat is set. The apparatus is thus under double thermostat control, the temperature fluctuations at the discharge end of the evaporator coil being used to automatically produce alternate cold and relatively warmer refrigerant surges within the coil to avoid any substantial freezing out of the moisture from the circulating air, which automatically re-absorbs any moisture deposited on the fins or on the felt pad. The circulating air is guarded from extreme variations by starting and stopping the motor, said operation being repeated more often when the compartment is opened and closed at frequent intervals, and perhaps not at all during the night if the compartment is well insulated.

The high operating efficiency of the refrigerating apparatus is in part due to sealing the return bends 17′ in the well insulated spaces packed in powdered cork where they are not subject to the passing air currents drawn through the cooler, and the asphaltic coating 17″ on the bends prevents any frosting from the slight contained air in the insulating space or from such as might accidentally find entrance.

The air, in passing over the coils, travels back and forth the length of the assemblage as shown and at baffle 22 is deflected away from the partition wall carrying the baffle so as to cause a violent eddy at these points and thoroughly break up the air streams.

As the refrigerating medium reaches the discharge end of the cooling coil, it preferably will have become entirely evaporated. However, the relatively warm and cold zones will remain to effect the thermostat 26 at the discharge end of the cooling coil. This is due to the fact that the portions of the stream of the refrigerating medium, which is last to evaporate in the cooling coil, will be colder than the gases evolved at an earlier point and which have consequently absorbed more heat than the gases evolved from moist refrigerant near the discharge end of the coil. Consequently, the thermostat 26 will be automatically operated by the traveling cold and warm spots at the discharge end of the coil in order to open and close the valve 26. If, for any reason, all of the refrigerating medium is evaporated substantially before the end of the cooling coil is reached, the temperature at the discharge end of the coil will rise and cause the thermostat 26 to remain open in order to introduce the refrigerating medium to the cooling coil in sufficient quantities so that at least some portion of the refrigerant so admitted through the valve 25 will reach the discharge end of the cooling coil in cold condition so as to operate the thermostat 26 in order to close down the valve 25 and thus restrict the introduction of the refrigerating medium through the valve. It is not necessary to close the valve 25 entirely. In fact, it is desirable merely to partially close the valve and thus introduce the refrigerating medium into the coil in a pulsating stream. Even though the liquid medium is delivered to the cooling coil with only slight fluctuation, the alternate warm and cold portions will be created, since the liquid introduced to the coil when the valve is partially closed will evaporate rapidly and create a relatively warm spot between the portions of the refrigerant stream introduced when the valve is fully opened.

It is understood that in my process of cooling air in the chamber, the apparatus is set to keep the air considerably above freezing so that it will not deposit moisture in the chamber, and by reason of the temperature surges in the evaporator, with the cold surge kept at about freezing temperature, followed by a warmer surge to maintain the deposited moisture in liquid condition, the original humidity of the air is maintained.

While the above manner of fluctuating the refrigerant delivered to the evaporator is preferred to carry out the chief object of the invention, it is possible to get valuable and efficient results without fluctuating the refrigerant stream since the insulation of the less efficient portions of the evaporator in and of itself improves the overall efficiency of the device to a considerable extent.

It is thought that the invention and numerous of its attendant advantages will be understood from the foregoing description and it is obvious that numerous changes may be made in the form, construction, and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages; the form herein described being a preferred embodiment for the purpose of illustrating the invention.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is as follows:

1. In a refrigerating system, a cooling device comprising an expansion pipe coil provided with a plurality of return bends, means enclosing the coil and forming a cooling passage through which a fluid medium to be cooled may be circulated around said coil, and means thermally insulating said return bends from said cooling passage.

2. In a refrigerating system, a cooling device comprising an expansion pipe coil provided with a plurality of return bends, means enclosing the coil and forming a tortuous cooling passage passing back and forth transversely of the pipes of said coil, and means thermally insulating said return bends from said cooling passage.

3. In a refrigerating system, a cooling device comprising a pipe coil formed with a plurality of runs of pipe joined by return bends at both ends, a casing enclosing the coil provided with a partition wall extending transversely of said runs of pipe and forming a chamber, an inlet and an outlet for said casing, and means insulating the return bends from the chamber.

4. In a refrigerating system, a cooling device comprising an expansion pipe coil provided with a plurality of return bends, means enclosing the coil and forming a cooling chamber around said coil, means thermally insulating said return bends from said cooling chamber, and an absorbent pad disposed beneath the pipe coil in said chamber.

5. In a refrigerating system, a cooling expansion coil provided with a plurality of runs of pipe over which a fluid medium to be cooled is adapted to be passed, means for insulating against heat transfer the portions of the coil where heat transferring efficiency is relatively low, and means for causing the medium to flow over said coils.

6. In a refrigerating system, a cooling device comprising an expansion pipe coil provided with a plurality of runs of pipe interconnected by return bends, means enclosing the coil and forming a cooling chamber adapted to receive a fluid medium to be cooled, means thermally insulating said return bends from said cooling chamber, and means for causing the fluid medium to circulate in said chamber and about said coil.

7. In a refrigerating system, a cooling expansion coil provided with a plurality of runs of pipe over which a fluid medium to be cooled is adapted to be passed, sheet metal fins spaced on said pipe each provided with fingers projecting from one side engaging through openings in the adjacent plate.

8. In a mechanical refrigerating system, a cooling coil having variable heat transfer efficiency along its length, means to cause a circulation of air in contact with the cooling coil whereby a transfer of heat may occur between the air and the cooling coil, and means to insulate the coil against the transfer of heat at intervals in the length of the coil where heat transferring efficiency is low.

9. In a mechanical refrigerating system, a cooling coil, means to cause a circulation of air in contact with the cooling coil whereby a transfer of heat may occur between the air and the cooling coil, said coil comprising relatively straight pipe portions of relatively high heat transferring efficiency interconnected by curved end pieces of relatively low heat transferring efficiency, and means to insulate the coil against the transfer of heat at the relatively inefficient heat transferring portions of the coil.

10. In a mechanical refrigerating system a cooling coil, means to cause a circulation of air in contact with the cooling coil whereby a transfer of heat may occur between the air and the cooling coil, said coil having sections carrying projecting fins spaced apart thereon to promote the heat transferring efficiency of the coil, and means to insulate the coil against the transfer of heat at places intermediate certain fins where the heat transferring efficiency of the coil is relatively low.

11. In a mechanical refrigerating system, a cooling coil, means to insulate portions of the coil against the transfer of heat to or from the coil, means to cause a circulation of air in contact with the cooling coil whereby a transfer of heat may occur between the air and the uninsulated portions of the cooling coil, and means automatically operative to admit a refrigerating medium to the coil in variable quantities.

12. In a mechanical refrigerating system, a cooling coil having spaced portions of high heat transferring efficiency and intermediate portions having relatively low heat transferring efficiency, means to insulate the portions of the coil of low heat transfer efficiency against the transfer of heat to or from the coil, means to cause a circulation of air in contact with the cooling coil whereby a transfer of heat may occur between the air and the uninsulated portions of the cooling coil, and means to control the volume of a refrigerating medium admitted to the coil so that the medium travels the coil as an alternate succession of liquid and gaseous portions.

13. In a mechanical refrigerating system, a cooling coil, means to insulate portions of the coil against the transfer of heat to or from the coil, means to cause a circulation of air in contact with the cooling coil whereby a transfer of heat may

occur between the air and the uninsulated portions of the cooling coil, means, including a valve, at the inlet of the coil, and thermal responsive control means, for varying the opening of the valve in response to the temperature at the discharge end of the coil, for admitting the refrigerant to the coil in a variable volume stream.

14. In a refrigerating system, a cooling device comprising an expansion coil having a plurality of return bends, means enclosing the coil and forming a tortuous cooling passage passing back and forth across the portions of said coil between the return bends, said return bends being outside of said cooling passage and insulated against the transfer of heat.

15. In a refrigerating system, a cooling device comprising a coil formed with a plurality of runs of pipe joined by return bends at the ends of the runs of pipe, a casing enclosing the coil provided with a partition wall extending transversely of said runs of pipe and forming a passageway in the casing, a fluid inlet and outlet for said passageway, means to insulate the return bends against heat transfer to or from the fluid in the casing, said partition wall at one end terminating near an end of the coil and provided with a baffle extending in said passageway in order to turbulate fluid flowing therethrough adjacent the baffle.

16. In a refrigerating system, a cooling device comprising an expansion pipe having a portion of high heat-transferring efficiency and a portion of relatively low heat-transferring efficiency, means enclosing the cooling device to form a chamber adapted to receive fluid to be cooled and maintain the same in position to circulate in contact with the cooling device, and means to insulate said portion of relatively low heat-transferring efficiency against the transfer of heat to or from the fluid being cooled in said chamber.

17. In a refrigerating system, a cooling device comprising a pipe coil having at least two relatively straight runs of pipe joined by a return bend, means enclosing the coil to form a chamber for receiving and maintaining fluid to be cooled in position to flow in contact with the runs of pipe, said return bends being outside of said chamber whereby heat transfer between said return bend and fluid being cooled in the chamber is prevented.

18. A heat exchange device having a tube, a plurality of spaced apart radiating plates surrounding said tube and each having openings spaced radially from said tube, and spacing lugs carried by said plates and disposed at an angle to the planes thereof, the lugs of each plate having at their free ends tongues engaging in the opening of the next succeeding plate whereby to prevent relative rotation between the plates, said tongues further having shoulders adapted to engage the opposed face of the succeeding plate whereby to hold the plates in spaced apart relation.

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