May 11, 1943. P. A. SIDELL 2,318,891

CONDENSING RADIATOR SYSTEM FOR REFRIGERATOR INSTALLATIONS

Filed May 10, 1941 3 Sheets-Sheet 1

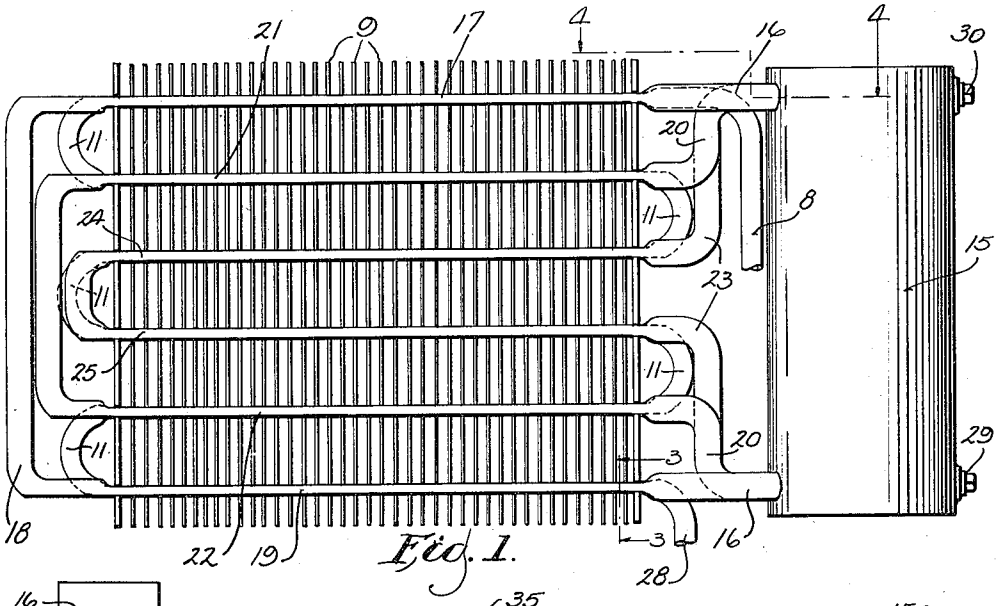


Fig. 1.

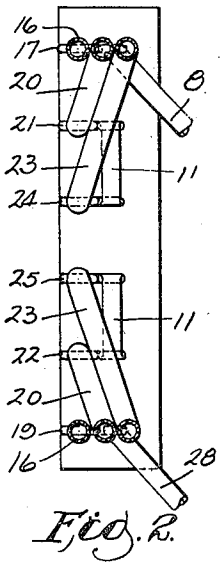


Fig. 2.

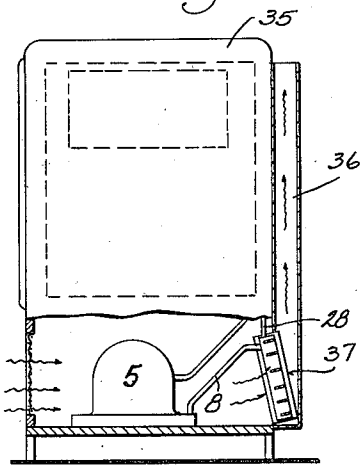


Fig. 5.

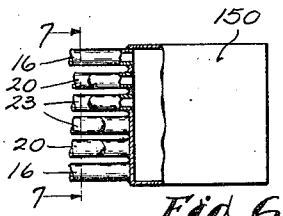


Fig. 6.

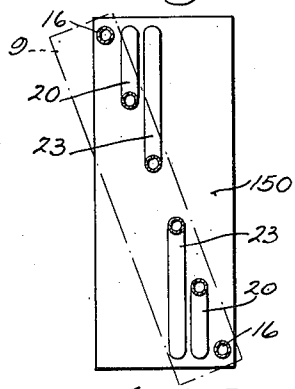


Fig. 7.

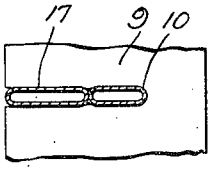


Fig. 3.

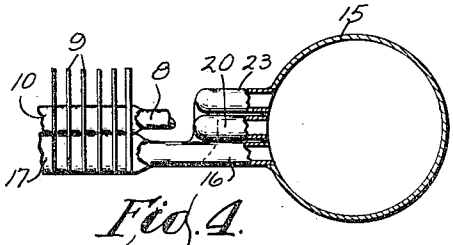


Fig. 4.

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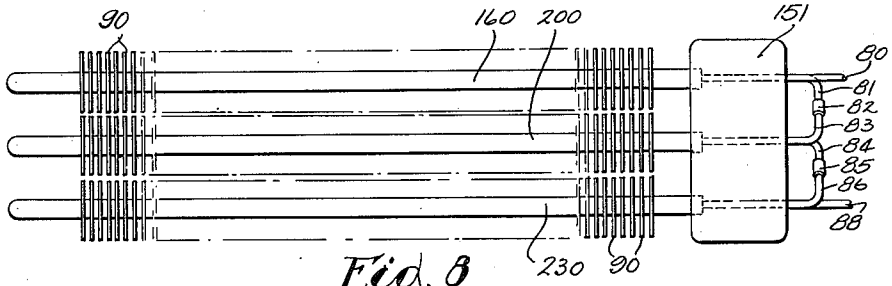


Fig. 8

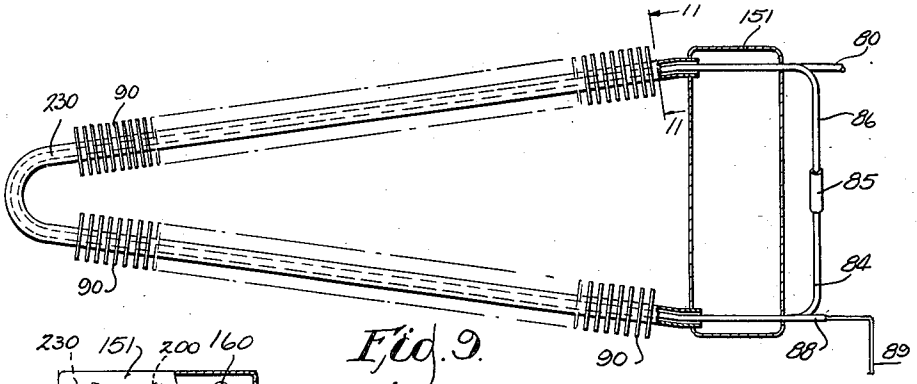


Fig. 9.

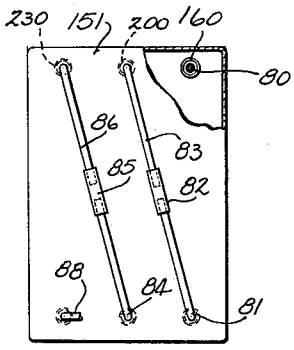


Fig. 10.

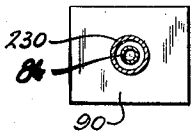


Fig. 11.

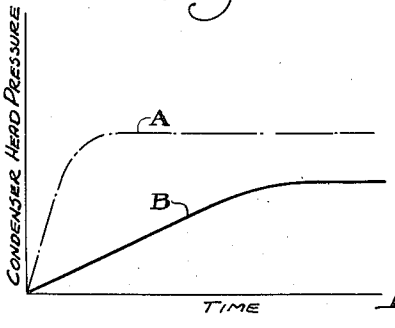


Fig. 12.

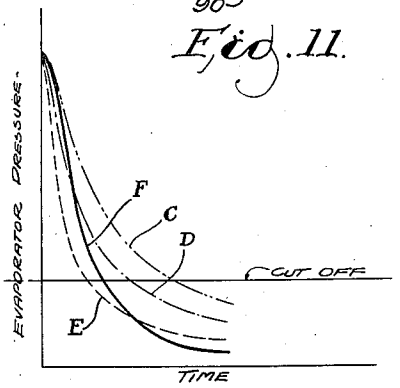


Fig. 13.

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CONDENSING RADIATOR SYSTEM FOR REFRIGERATOR INSTALLATIONS

Filed May 10, 1941 3 Sheets-Sheet 3

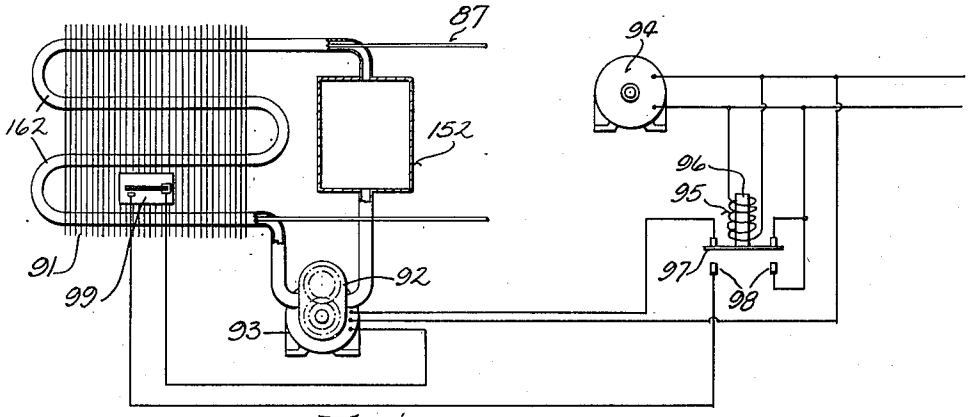


Fig. 14.

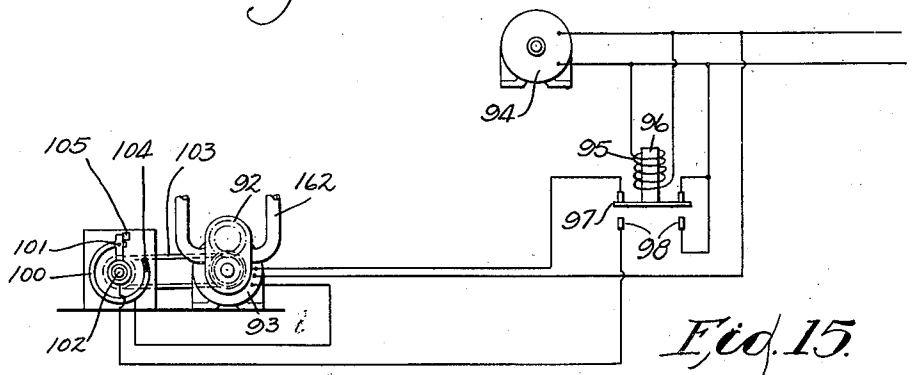


Fig. 15.

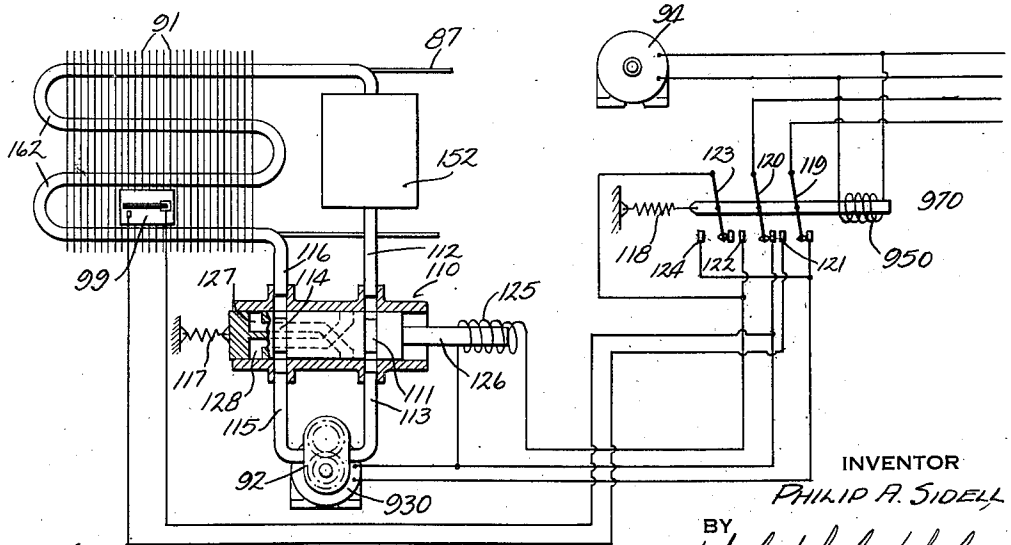


Fig. 16.

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Patented May 11, 1943 2,318,891

UNITED STATES PATENT OFFICE

2,318,891

CONDENSING RADIATOR SYSTEM FOR REFRIGERATOR INSTALLATIONS

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Application May 10, 1941, Serial No. 392,851

32 Claims. (Cl. 62—115)

This invention relates to improvements in condensing radiator system for refrigerator installation.

The invention has particular reference to household refrigeration, and it is the primary purpose of the invention to provide a novel and improved means for distributing condenser load in such a manner as to enable an air cooled system to function efficiently without using forced air circulation across the condenser. Forced air circulation is objectionable not only because of the power required to operate the fan but because of a certain amount of noise which it is desirable to eliminate in household refrigerators. Yet, in general, systems changed from forced air circulation to gravity air circulation across the condenser, without other change, have had the back pressure on the compressor so increased by the reduced efficiency of the condenser that it has been necessary to reduce the size of the compressor piston to keep the motor from being overloaded.

The present invention seeks to eliminate the air circulating fan without motor overload by storing during compressor operation such heat as cannot immediately be dissipated by convection currents and gradually dissipating such heat during that portion of the cycle when the compressor is at rest, thereby distributing the dissipation of heat from the condenser over the entire cycle instead of attempting to dissipate all the heat as fast as it is generated.

It is a further purpose of the present invention to assist in pull down in a refrigerator installation by reducing head pressure, particularly at the start of each cycle. It is also a purpose of the invention to reduce power consumption. Actual tests show a very substantial power decrease through the use of the invention. This is only partially attributable to the reduced head pressure and reduced condenser temperatures. In addition, and as a consequence of the reduced condenser temperature, it is possible greatly to reduce condenser volume whereby fewer compression strokes are required to produce condenser pressure and less hot gas is unloaded from the condenser into the evaporator when pressures are equalized. Moreover, the change in effective resistance in the capillary tube (in a system employing such a tube), attributable to the gradual rise in temperature occurring in the refrigerant of a condenser of the type herein disclosed, permits rapid refrigerant flow with consequent high suction pressure and efficient compressor operation for a greater proportion of the cycle while nevertheless resulting in shorter overall periods of compressor operation in a given cycle.

More specifically, it is proposed to give domestic refrigeration units and like apparatus the benefits of liquid cooling as well as air cooling without requiring the plumbing connections which have heretofore rendered liquid cooling prohibitive for such installations. At the same time it is proposed to take advantage of counter-flow of coolant in heat exchange with the condenser tubes by establishing thermo-syphon circulation to and from a reserve sufficient so that the supply of coolant will not become heated to the temperature of the refrigerant in any ordinary cycle and will thus maintain the original temperature differential instead of slowly heating the coolant in the manner commonly experienced where a coil is merely immersed in a reservoir.

Ordinarily at least the tubes carrying the liquid coolant will be fully exposed at all times to the air and preferably provided with fins with the object of delivering heat to the air and only absorbing the excess by the circulating water. In one embodiment of the invention both the refrigerant tube and the coolant tube are exposed to the air and, being directly bonded in side by side relation, each serves as an extended radiating surface of the other.

An important object of the invention is the arrangement whereby the convection currents of coolant reverse themselves, first flowing in counter-current relation to the refrigerant separately in each successive section of the condenser and, upon the conclusion of the compression cycle, reversing themselves to flow in the same direction in which the refrigerant was flowing.

Further objects of the invention have to do with arrangements for forced circulation of the liquid coolant, preferably reversing the direction of circulation at the conclusion of the compression cycle in the same manner in which the convection currents reverse their direction.

In the drawings:

Fig. 1 is a side elevation of an improved condenser system embodying features of the invention.

Fig. 2 is an end elevation of the condenser shown in Fig. 1, the pipes connecting to the tank being shown in section.

Fig. 3 is a detail view taken in section on the line 3—3 of Fig. 1.

Fig. 4 is a detail view taken in section on the line 4—4 of Fig. 1.

Fig. 5 is a view on a reduced scale showing a preferred installation in a domestic refrigerator.

Fig. 6 is a view similar to Fig. 4 showing the connection between the circulating coils and the storage reservoir slightly changed for the purposes of the installation of Fig. 5.

Fig. 7 is a view taken on line 7—7 of Fig. 6 through the connections to the storage reservoir and showing the storage reservoir in elevation.

Fig. 8 is a plan view of a preferred condenser embodying the invention.

Fig. 9 shows the apparatus of Fig. 8 in side elevation and partially in transverse section.

Fig. 10 is an end elevation of the apparatus shown in Fig. 8, with a portion of the wall of the storage chamber broken away.

Fig. 11 is a detail view in cross section taken on the line 11—11 of Fig. 9.

Fig. 12 is a diagram showing comparative time-pressure curves showing the advantage of my improved condenser over other convection cooled condensers.

Fig. 13 is a set of time-pressure curves showing how my improved condenser modifies the functioning of a capillary tube.

Figs. 14, 15 and 16 are diagrammatic views illustrating portions of the apparatus in side elevation and other portions in section, and diagrammatically illustrating the use of power circulation and the controls suitable therefor.

Like parts are identified by the same reference characters throughout the several views.

The general refrigerator hook-up may be that shown in my companion application Serial No. 329,140, filed April 11, 1940, and entitled Refrigeration systems. Any other type of evaporator may be used, the present invention pertaining primarily to that portion of the system in which heat is given off and condensation achieved.

From any suitable compressor, such as the motor compressor unit 5 of Fig. 5, the refrigerant arrives at the condensing radiator through a pipe 8. The radiator is preferably of the continuous tube type, the tube extending in a succession of convolutions which, in Fig. 1, are illustrated as disposed horizontally in a multiplicity of vertical heat dissipating fins 9. By way of exemplifying the invention I have illustrated a condenser in which the condenser tube 10 which carries the refrigerant has six uniformly spaced horizontal convolutions connected by elbows 11 at alternate ends of the device, there being three such elbows at the left in Fig. 1 and two at the right. This arrangement is conventional except that for the purposes of the present invention the tube 10 is flattened in the condenser proper where it passes through the radiating fins 9 in order to extend its radiating surface horizontally. As shown in Fig. 3 each flight or run of the tube 10 transversely of the condenser is of flattened oblate form in cross section.

Preferably located immediately adjacent one end of the condenser is the storage tank 15 which may be of any desired form or capacity, but preferably has sufficient capacity so that a liquid stored therein will, without undue rise of temperature, be adequate to absorb most of the heat given off by the refrigerant in the condenser tube 10 during that portion of any given cycle of refrigerator operation in which the motor compressor is functioning. The liquid stored in the reservoir 15 picks up the heat from the condenser tube 10 by means of a pipe or pipes bonded to the condenser tube and having both ends communicating with the reservoir 15 below the level of liquid therein and so arranged that liquid will circulate by convection. The liquid used in the reservoir may be sweet water or may be any convenient anti-freeze solution or other liquid, preferably of such a nature as to have high specific heat.

In order to promote gravity circulation of liquid between the reservoir 15 and the pipe in thermally conductive relation to the condenser tube 10, I preferably use not one but several such pipes each of which communicates with the reservoir 15 separately at points near the top and bottom of the reservoir, each of said pipes being therefore sufficiently short so that its internal friction will not offer any serious impediment to the gravity circulation of liquid between the pipe and the reservoir. One such pipe 16 leads from the top of reservoir 15 and has a flattened portion 17 thermally bonded to the top flight or run of the flattened condenser tube 10 as shown in Fig. 3, the pipe 17 and tube 10 being of substantially identical thickness although pipe 17 has a larger capacity due to a greater horizontal width than tube 10.

The arrangement is such that the metal surfaces of the tube 10 and the flattened portion 17 of pipe 16 act respectively as fins for the dissipation of heat, each for the other. At the same time the bonded relation between the pipe and the tube assures the transfer of heat conductively between the contents thereof.

Upon leaving the top flight of the condenser tube 10 the pipe 16 communicates with the pipe portion 18 and is extended back through the flattened portion 19 in bonded relation to the lowermost flight or run of the condenser tube 10 and thence into the bottom of the reservoir 15.

Similarly, the pipe 20 opens from the top of the reservoir 15 and has a flattened portion 21 bonded to the flight or run of condenser tube 10 which is second from the top of the condenser, and a flattened portion 22 bonded to that flight or run of condenser tube 10 which is second from the bottom of the condenser, whereupon pipe 20 returns to the bottom of the reservoir 15.

Pipe 23 likewise leads from the top of reservoir 15 and has a flattened portion 24 bonded to the third flight or run of the condenser tube 10 and thence returns with another flattened portion 25 bonded to that portion of condenser tube 10 which is third from the bottom of the condenser. Thence pipe 23 returns to the bottom of reservoir 15.

Thus each of the several pipes which carries the coolant liquid makes but a single circuit of the condenser forth and back and is bonded both in its outer traverse and its return traverse of the condenser to one flight or run of the condenser tube. As above noted, this arrangement is greatly to be preferred to the use of a single pipe coextensive with the condenser tube solely because of reduced friction in each circulating stream of coolant and a more direct passage of heated coolant to and from the storage reservoir 15.

Regardless of whether the coolant pipe is single or multiple, the condenser is in effect duplex, the condenser tube 10 and the coolant pipe bonded thereto in each flight being in mutually heat conductive relation to each other and to the several vertical fins 9.

The operation is as follows:

The refrigerant arrives at the condenser through pipe 8 and leaves it through pipe 28 after flowing through the condenser tube 10. In passing through the condenser tube 10 heat is dissipated from the refrigerant by radiation and convection from the surface of the tube and from

the extended surface represented by the flattened wall of the pipe bonded thereto and from the extended surfaces provided by the vertical fins 8. As above noted, however, the convection currents of air which may be established in this manner are not adequate to wholly relieve the compressor of head pressure in the condenser. Such head pressure is relieved by the auxiliary supply of coolant in reservoir 15 which, circulating by gravity through the coolant pipe or pipes bonded to the flights of the condenser tube 10, absorbs the excess heat beyond that which can immediately be dissipated into the air. As fast as the coolant is heated in a pipe or pipes bonded to the condenser tube, it moves by gravity back into tank 15 and is replaced by coolant of lower temperature from the bottom of the reservoir. As above noted, the capacity of the reservoir is preferably such that during the normal period of compressor operation the heat of compression will be reduced as fast as it is generated to a practicable working level by the combined continuous action of the circulating air and the circulating coolant.

After the compressor operation has ceased, the circulation of the coolant automatically reverses itself. The continued circulation of air induced by the heat given off by the condenser continues to cool the fins and the surfaces of the tube 10 and the pipe or pipes in which the coolant is carried through the condenser. As soon as the circulating air sufficiently reduces the temperature of these metal surfaces so that these surfaces are at lower temperature than that of the heated coolant in the top of the reservoir 15, such heated coolant begins to give off its heat through the metal surfaces of the condenser and the coolant flows from the top of the reservoir across the condenser and back at a reduced temperature to the bottom of the reservoir. In this operation the surfaces of the tube 10 act in effect as extended metal surfaces or fins for the coolant pipe or pipes bonded thereto, thus reversing the direction of heat transfer originally existing. The coolant will continue to give off its heat until the compressor resumes operation or until the coolant is reduced to atmospheric temperature.

This arrangement provides a convenient way of connecting an air cooled refrigeration system to a water cooling system without the use of thermostats or valves if desired. While the system as disclosed is complete and self-contained and unitary and requires no external connections whatever for its successful operation, its efficiency may be somewhat increased in a permanent installation by connecting the reservoir 15 into series with any water supply pipe through which water is intermittently drawn. For this purpose the reservoir may be provided with a normally plugged inlet at 29 and a normally plugged outlet at 30 which, whenever desired, may be connected in series with a toilet flush tank, for example. Any other household supply pipe may be connected to the reservoir 15. Every time water is drawn through the household supply pipe in which reservoir 15 is connected in series, the hot water in the reservoir will be immediately discharged therefrom and replaced by cold water from the system, thereby harmlessly and instantly dissipating the heat from the refrigeration without the necessity for dissipation of such heat through the reverse circulation above described. No valves or thermostats are necessary for the reason that the self-contained auxiliary heat dissipating system as disclosed will function in a perfectly normal manner without being connected to any circulatory water system and yet the normal use of water in the circulating system may ordinarily be sufficient to keep the condenser super-cooled below atmospheric temperatures.

In the normal vertical or erect position of the condenser shown in Figs. 1 to 4, there will ordinarily be ample air circulating by convection over the condenser surfaces to assure the proper cooling of the device. However, where the conditions are extreme and it is desired to accelerate the gravity circulation of air across the condenser surfaces, this may be done by either or both of two expedients disclosed in Fig. 5. In the first place, the refrigerator cabinet 35 may be provided at its rear with a passage 36 in the nature of a chimney to create more head or differential for promoting gravity circulation of the air heated by the condenser. In the second place the condenser may be set at a slight angle as indicated at 37 in Fig. 5. Figs. 6 and 7 simply show the connections to the reservoir 150 which may conveniently be employed if the condenser is set obliquely. The various pipes for the coolant will pass more directly to the reservoir than the construction disclosed in Figs. 1 and 2 and 4. The pipe 16 simply enters the reservoir near its front side at the top and near its rear side at the bottom, the other pipes progressively entering the reservoir nearer its center. As in the disclosure of Fig. 1, it will be understood that the number of pipes and the number of convolutions or flights of the condenser tube 10 is broadly immaterial.

A preferred and simplified form of condenser is shown in Figs. 8 to 11. In this construction the condenser coils are inside of the coils in which the cooling liquid circulates to and from the tank 151.

Three separate circulation pipes 160, 200 and 230 are disposed side by side. Each of these communicates with the storage reservoir 151 near the top of the reservoir and extends obliquely outwardly and downwardly and thence is bent upon itself and returned obliquely downwardly to the bottom of the reservoir. The relatively straight upper and lower runs of these pipes are provided with fins 90.

The refrigerant pipe from the compressor is shown at 80. It enters the reservoir 151 from the back as shown in Figs. 8 and 10, and traversing the reservoir 151 extends directly into the coolant pipe 160, through which it passes.

Issuing from the lower end of coolant pipe 160, the refrigerant conduit again emerges at 81 from the rear of the reservoir and by means of coupling 82 it is connected behind the reservoir to enter pipe 83 which passes angularly up the rear of the reservoir and re-enters the rear wall of the reservoir and is led through the coolant pipe 200 from the top of the reservoir downwardly through such pipe and back into the reservoir at its bottom.

This section of the condenser conduit emerges from the back of the reservoir at 84 and thence passes obliquely up the back of the reservoir and is coupled at 85 to another continuing section 86 of the refrigerant conduit which re-enters the back of the reservoir at the top in registry with coolant pipe 230. Running through the interior of the pipe 230 in the manner best shown in Fig. 9, this section of the condenser conduit 86 returns from the lower end of pipe 230 into the bottom of the reservoir and issues through the back of the reservoir at 88, where it connects to the capillary tube 89 leading to the evaporator in the usual manner.

While the respective flights 80, 83 and 86 of the continuous tube condenser are shown centered within the coolant pipes, it will be understood that in actual practice the pipes and condenser tubes will ordinarily be in metallic contact and may be bonded together if desired. While the refrigerant tubes are not exposed to the air directly, as in the device shown in Fig. 1, the efficiency of heat delivery is very high in this apparatus and the convection currents of coolant between the reservoir 151 and the several pipes 160, 200 and 230 are unobstructed and flow with considerable rapidity. The chief reason for preferring this construction, however, is the fact that it not only costs considerably less to make than the condenser shown in Fig. 1, but requires very materially less power for its operation.

Fig. 12 shows comparative curves of temperature (or head pressure) at the condenser. Curve A is obtained in a refrigerator system using a conventional convection tube condenser radiator with twelve passes—that is to say, twelve flights or runs of tube exposed to the air. Curve B shows the temperature and head pressure curve obtained with the same identical system except for the substitution of the condenser shown in Figs. 8 to 11 with only six passes. The power consumption per cycle is reduced in actual practice by 20% and more and the cost is reduced by one third.

In addition, the use of a shorter capillary tube is made possible at 89 because of the fact that the temperature in the condenser builds up gradually as the coolant therein becomes heated.

At the start of compressor operation it is efficient to keep the flow of refrigerant to the evaporator rapid. This keeps the evaporator pressure high and consequently furnishes refrigerant at a high back pressure to the compressor to maintain its volumetric efficiency high. Also the rapid flow fills the evaporator more completely and in less time with liquid refrigerant. Such rapid flow can be accomplished with a short capillary tube but the objection to such a short capillary tube lies in the fact that a short capillary in an ordinary organization keeps condenser pressure low by exhausting a substantial percentage of the gaseous refrigerant into the evaporator and the operating cycle is considerably lengthened, thereby increasing power requirements and reducing efficiency.

However, in the present system the capillary 89 is made very short, thus giving high initial flow to the evaporator. But as the condenser temperature increases due to the gradual heating up of the coolant in the device herein disclosed, the resistance of the capillary to the flow of the warmer refrigerant is automatically increased whereby the pressure curve at the evaporator is greatly shortened and rendered more nearly vertical, thus increasing efficiency. As the back pressure at the evaporator is reduced and the volumetric efficiency and output of the compressor are correspondingly lowered, the capillary, even though short, has a sufficient increase in resistance consequent upon its increased temperature so that this compensates for the reduced input of refrigerant to maintain condenser pressure high and approximately uniform.

In accordance with the foregoing, Fig. 13 is a chart showing at C the curve resulting from the use of a fairly short capillary in a conventional refrigerating system not embodying the present invention. The curve D shows a longer capillary and the curve E a very long capillary. The curves D and E indicate a shorter operating cycle but do not hold the evaporator pressure up as well at the start of the cycle and consequently are not as nearly vertical as is the curve F which shows the result of the use of a very short capillary with a condenser of the type herein disclosed.

As a result of this construction, the condenser volume is reduced, its cost is reduced, the compressor power requirements are reduced. Yet the efficiency of the refrigeration system as a whole is increased. The system does its work with a materially reduced operating cycle.

By way of example, the average period of operation under given circumstances with a conventional system using forced draft for cooling the condenser, was found to be 2 minutes and 45 seconds. Using a conventional convection cooled condenser, the circumstances and system being otherwise identical, the running time was 3 minutes and 10 seconds. The system embodying the condenser disclosed in Fig. 1 of this application had a running time of 2 minutes and 4 seconds. The system using a condenser and shortened capillary in accordance with the disclosure of Figs. 8 to 11 had a running time of only 1 minute and 54 seconds under otherwise identical circumstances.

It will be understood that the storage tank 151 shown in Figs. 8 and 10 may, if desired, be provided with water connections like that shown in Fig. 1. Both, however, are normally adapted to function as closed systems even when provision is made for periodically interchanging the coolant in the system through the water connections as above described.

It is also possible by increasing the vapor space above the water level in either reservoir, to use in the system a cooling liquid which is evaporable at the temperatures produced in operation, thereby employing the resulting bubbles in the pipes 16 or 160 to accelerate flow and convection cooling while also accelerating the cooling by the evaporation of the coolant during the operating portion of the cycle. The arrangement will be such that the coolant evaporated and thus containing in the form of latent heat, the heat energy of the compressed refrigerant, will be condensed in the top of the reservoir, the system remaining completely closed.

In practice I employ in the reservoir 15, 150, or 151, water which has chemicals dissolved therein to prevent freezing and corrosion. A surprisingly small amount of coolant is required due to the fact that much of the heat of the compressed refrigerant is delivered off by fins 90 from the coolant before the coolant ever enters the reservoir.

The cooling action of the coolant is very effective upon the refrigerant due partly to the fact that the circulatory paths upon which the coolant moves are very short. Upon each such path the convection currents established during the operation of the compressor are such that the flow of coolant is counter-current to the flow of refrigerant. The coolant heated in any given cycle is not recirculated through these passages in the same cycle, the capacity of the reservoir being such that it will normally retain all of the heated coolant, replacing the heated coolant in the several conduits with colder liquid supplied from the bottom of the reservoir. When the compressor shuts off and heat is no longer being given up by the refrigerant conduit, the direction of thermosyphon circulation of the coolant reverses and the hot fluid leaves the reservoir at the top and, cooled in the conduits 230, re-enters the reservoir at the bottom.

In a conventional system, in order to give up

a like amount of heat in a given amount of time to air passing over the condenser, the air will be heated to a higher temperature, which could only be obtained by a combination of an increase in condenser surface and volume and an increase in condenser temperature, with the result that the refrigerant leaving the condenser would not be as cool as in the use of the present invention and a definite increase in head pressure would be observed as compared with that existing in the use of the device here disclosed.

Moreover, since the air picks up heat relatively slowly from a conventional static condenser, not only a large surface area is required but also high internal volume, in order to allow time for the gas to dissipate its heat. The high specific heat of the liquid and its extremely high density in comparison to that of air, permits the heat from the refrigerant to be dissipated very rapidly with a greatly reduced internal condenser volume. In actual practice the condenser volume is only about one-fifth of that required in the conventional system. As a result, only one-fifth as much hot gas can, under any circumstances, be bled into the evaporator after the compressor shuts off, and only about one-fifth as much can be bled into the evaporator during the start of a new cycle, the condenser pressure being restored five times as fast as in the conventional system. This represents further substantial savings, because all heat blown into the evaporator must again be pumped out and the volume of gas bled from the condenser must be replaced at the start of a new cycle.

Where desired, the coolant may be positively circulated by power, various arrangements for this purpose being illustrated diagrammatically in Figs. 14 to 16. Even where power is used, it is preferred that the direction of circulation of the coolant should reverse at the conclusion of the compression portion of the refrigerator cycle. At this time the storage reservoir will ordinarily have heated coolant in its upper portion and some remaining relatively cold coolant in its power portion. If the circulation were to continue in the same direction during the off cycle, the cold coolant would have to pass through the coils before the hot coolant would reach the coils to be chilled thereby. By reversing the cycle it is possible to deliver the hottest portion of the coolant immediately to the radiator.

The reservoir 152 will be understood to correspond to the reservoirs indicated at 15, 150, and 151. The pipe 162 provides a closed circuit for coolant in which the reservoir is included, as is also a pump 92 driven by motor 93. The condenser tube 87 passes through portions of pipe 162 provided with fins 91.

At 94 there is illustrated an electric motor which is intended to represent the motor which drives the refrigeration compressor (not shown). In the motor circuit, either in series or parallel, is connected the coil 95 of a relay having an armature 96 which carries a switch contactor 97. Fig. 14 shows the position of the switch contactor when the compressor motor 94 is in operation and the relay coil 95 is energized. In this position the contactor 97 closes a circuit to the pump motor 93 to drive the pump in a direction such that the coolant is pumped from the bottom of the reservoir 152 into the lower end of the pipe 162, thereby displacing from the top of the pipe coolant heated by the hot refrigerant in the tube 87. For convenience of illustration, the pump is naturally shown very much larger in proportion to the size of the radiator than it would actually be in practice.

When the circuit to the refrigerator motor 94 is de-energized, the de-energization of relay coil 95 allows the contactor 97 to drop, thereby closing the circuit between contact points 98 which are in a reversing circuit for the pump motor 93, such circuit also including in series the thermostat 99. If the thermostat is cold at the time the relay is de-energized, the reversing circuit to the pump motor 93 will remain open and the pump will come to rest. However, if the thermostat has become heated due to the warming up of the entire radiator, the circuit controlled by the thermostat will be closed when the relay coil 95 is de-energized, with the result that the pump motor 93 will be reversed and will continue in operation, pumping hot coolant from the top of the reservoir 152, until the coolant is sufficiently cooled in the radiator to permit the thermostatic switch 99 to open, thereby breaking the pump motor circuit.

Fig. 15 shows a generally similar arrangement differing from that above described only in that the pump motor is time controlled instead of being controlled by a thermostatic switch for its reverse operation. In this device there is connected with reversing contacts 98 of the relay, an electrically conductive segment 100 over which operates a brush 101 frictionally mounted on a shaft 102 which is connected by belt 103 to the motor 92. At one end of segment 100 there is insulation 104 providing a non-conductive dead spot. Near the other end of the segment is a stop at 105 for arresting the movement of the brush arm 101, the frictional connection between such arm and shaft 102 permitting the continued operation of the shaft after the brush arm engages the stop.

With the armature switch 97 of the relay in its elevated position as shown both in Fig. 14 and Fig. 15, the pump will, as above explained, be operated by motor 93 in a direction to pump coolant from the bottom of reservoir 152 through the radiator pipe 162 and back into the top of the reservoir. In this direction of operation the belt 103 will drive the brush 101 from the dead spot 104 in a clockwise direction toward a position of engagement with stop 105. The brush will actually reach the stop only if the operation of the refrigerator motor 94 is long continued. Otherwise the brush will come to rest at some intermediate point, it being understood that any desired reducing gearing (not shown) will be introduced in practice between the motor 93 and the brush carrying shaft 102.

At the end of the compression cycle the refrigerator motor 94 will come to rest and the relay coil 95 will be deenergized, thereby closing the circuit between contacts 98 of the pump motor reversing line. The reversing circuit will be completed through the brush 101 and the segment 100, thereby operating the pump motor 93 in reverse to expel heated coolant from the top of the reservoir 152 and returning the relatively colder liquid from the bottom of the radiator into the bottom of the reservoir. This circulation will continue until the brush 101 reaches the dead spot 104 at the end of the segment 100, the brush being operated in a counter-clockwise direction during reverse operation of motor 93. When the brush runs onto the dead spot the operation of the pump motor will be discontinued and the parts will all remain at rest until

the refrigerator motor is re-energized, at which time the pump will again be driven forwardly and the brush 102 propelled clockwise toward the stop 105 as above described.

In the construction shown in Fig. 16, the motor 930 operates in but one direction, but the direction of flow of the coolant is changed by a reversing valve 110. While this valve might be connected for time operation as suggested in Fig. 15, I have shown it controlled for actuation to one position by a relay system and controlled for actuation to its opposite position by the thermostatic switch 99.

The valve 110 as illustrated, has an annular passage 111 aligned with ports which communicate with pipes 112 and 113, while a similar annular passage at 114 is aligned with pipes 115 and 116, this arrangement permitting circulation of hot coolant from the bottom of reservoir 152 into pipes 112, 113, 115, 116, and 162, in sequence. Valve 110 is drawn to the position shown by the tension of spring 117. The motor 930 is energized through the operation of relay coil 950 which is connected in the circuit of the refrigerator motor 94 to attract the armature 970 when the refrigerator motor is in operation. The armature 970, directed against the tension of spring 118, operates contacts 119 and 120 into engagement with stationary contacts connected in series with the motor 930.

When the refrigerator motor 94 is de-energized and comes to rest, the armature 970 is attracted by spring 118 toward the left as viewed in Fig. 16, whereby the contactors 119 and 120 energized from the line are moved into engagement with stationary terminals 121 and 122 respectively, while contactor 123, energized from terminal 122, moves into engagement with terminal 124. This arrangement maintains the circuit connections to the pump motor 930 to keep the pump 92 in operation in the same direction. At the same time a circuit is completed through the solenoid 125, the armature 126 of which is connected to the valve 110, whereby the valve is drawn to the right against the tension of spring 117 to bring the crossed conduits 127 and 128 into registry with the several pipes above described, in such a way as to reverse the direction of pump-induced circulation through such pipes, the pipe 112 being cross-connected to pipe 115 through conduit 128, and the pipe 116 being cross-connected by conduit 127 to pipe 113.

Such continued operation of the pump motor is, as in the Fig. 14 construction, contingent upon the closed status of the thermostatic switch 99, and as soon as the coolant has been cooled sufficiently to permit this thermostatic switch to open, the pump motor will be de-energized as will the solenoid 125, and the parts will all remain at rest until the operation of the refrigerator motor 94 is again commenced.

I claim:

1. In a condenser system, the combination with a storage reservoir for coolant and a coolant circulatory pipe connected to the reservoir at vertically spaced points for convection circulation of coolant therethrough, of a refrigerant condenser pipe in heat exchange relation to the first mentioned pipe and coolant therein, the system being so arranged that the convection circulation of coolant in the first mentioned pipe reverses itself when the refrigerant ceases to give off excessive heat to the coolant.

2. In a refrigeration system, the combination with a refrigerant condenser pipe adapted to handle refrigerant in a predetermined direction during the compression cycle, of a circulatory pipe for liquid coolant in heat exchange relation to the condenser pipe, and means including a reservoir for coolant connected in substantially closed circuit arrangement to said coolant pipe for the circulation of coolant in counterflow relation to the refrigerant in said first mentioned pipe during the heating cycle and for the reverse direction of coolant circulation through the coolant pipe upon the conclusion of the heating cycle.

3. In a condenser system, the combination with a refrigerant condenser pipe, of a reservoir for coolant and a coolant circulatory pipe connected to the reservoir at vertically spaced points and in heat exchange relation to a portion of the refrigerant condenser pipe, a second coolant circulatory pipe connected to the reservoir at vertically spaced points for convection circulation of coolant therethrough and in operative heat exchange relation to another portion of said refrigerant condenser pipe, at least one of said pipes being provided with radiating heat dissipating means, and the capacity of the reservoir being such that the heat rejected by refrigerant in the condenser pipe and not radiated by said means is delivered successively from said condenser pipe to coolant in the first and second circulatory pipes and thence delivered by convection to the top portion of said reservoir, the heated coolant in said circulatory pipes being replaced by cooler liquid from the bottom of said reservoir without recirculation of heated coolant during a given period of heat rejection from the refrigerant.

4. In a condenser system, the combination with a refrigerant condenser pipe having a portion extending in a direction having a vertical component, of a storage reservoir for coolant, a coolant pipe connected at vertically spaced points with the reservoir and operatively associated in heat exchange relation to the refrigerant condenser pipe portion aforesaid, the refrigerant in the condenser pipe being subject to cyclic periods of compression and heat rejection and the capacity of the reservoir being such as to provide replacement by convection circulation through the coolant pipe of heated coolant with cold coolant without recirculation in any given cycle of heat rejection of any substantial quantity of coolant previously heated during such cycle.

5. In a refrigerating circuit including a compressor and evaporator, a condenser system comprising the combination with a reservoir, of a pair of pipes one of which is inside of the other, one of said pipes communicating at vertically spaced points with the reservoir and the other comprising a refrigerant tube connected between the compressor and evaporator in said circuit, the reservoir and the pipe communicating therewith being filled with coolant for convection circulation and the external pipe being exposed to circulation of air.

6. In a refrigeration system, comprising in operative closed circuit connection a compressor, a condenser, a pressure reducing means, and an evaporator, the combination in a condenser system with a coolant reservoir and a pipe connected at vertically spaced points to the reservoir for convection circulation of coolant therethrough, of a condenser pipe in said circuit for refrigerant in thermally conductive relation to

the first mentioned pipe and the coolant therein contained, the condenser of said refrigeration system comprising the condenser pipe aforesaid at least one of said pipes being exposed to convection currents of air and provided with fins for dissipating heat.

7. In a condenser system, the combination with a reservoir and a series of coolant pipes each connected with the reservoir at vertically spaced points, of a continuous condenser pipe for refrigerant in heat exchange relation to portions of said first mentioned pipes in series, at least one of said pipes being exposed to convection currents of air.

8. The combination in a condenser with a series of refrigerant tube flights in spaced relation, of a reservoir and a coolant pipe communicating with said reservoir at vertically spaced points therein for gravity circulation of coolant between the reservoir and the pipe, said pipe including a flight extending outwardly from the reservoir in heat exchange relation to one of said tube flights, and a return flight leading back to the reservoir in heat exchange relation to another of said tube flights.

9. The combination in a condenser, of a continuous refrigerant tube extending to and fro across the condenser in a series of flights, of a reservoir, a plurality of separate pipes each connected for gravity circulation between vertically spaced points of said reservoir, each such pipe including forth and back pipe flights in bonded relation to separate convolutions of said tube.

10. The combination in a condenser with a continuous refrigerant condensing tube extending in convolutions forth and back across the condenser of a series of flights exposed to air circulation, of a reservoir, a first pipe connected at vertically spaced points to said reservoir for convection circulation of coolant between the reservoir and pipe, said pipe including flights respectively bonded to the first and last flights of said refrigerant tube, and a second pipe likewise having its ends communicating with said reservoir at vertically spaced points for gravity circulation of coolant between the reservoir and the second pipe, said second pipe having forth and back flights respectively bonded to intermediate flights of said refrigerant tube.

11. In a condenser system, the combination with an upright reservoir, of an obliquely disposed condenser comprising a continuous tube in a series of convolutions including a plurality of flights, and a coolant pipe bonded to a plurality of flights of said condenser tube and extending from an upper portion of said reservoir adjacent one side thereof obliquely to a lower portion of said reservoir adjacent the other side thereof.

12. In a condenser system, the combination with a refrigerant tube, of a coolant tube of larger cross-sectional area than the refrigerant tube and flattened to substantially the same thickness, said tubes being bonded together with their respective surfaces representing generally streamlined extensions, each of the other.

13. In a condenser, the combination with a series of spaced fins, of a condenser tube extending in convolutions forth and back across said fins and having flattened portions extending transversely between said fins and exposed to air circulation therebetween, said flattened tube portions being in thermally conductive relation to the respective fins and at least one coolant pipe having flattened portions bonded edge to edge with flattened portions of said tube to provide surfaces elongated transversely of said fins, said pipe being in thermally conductive relation to said fins and exposed to air circulation therebetween.

14. A condenser comprising the combination with a continuous condenser tube convoluted in a series of flights, of a reservoir and a coolant pipe communicating at vertically spaced points with said reservoir for gravity circulation of coolant between the reservoir and pipe, said pipe having spaced flights paralleling remote flights of said condenser tube and flattened and bonded edgewise with said parallel condenser tube flights, and a second pipe likewise communicating at vertically spaced points with said reservoir for gravity circulation of coolant between the reservoir and the second pipe, said second pipe having flattened portions bonded edgewise to flights of said condenser tube intervening in said series between the condenser tube flights to which the flattened portions of the first pipe are bonded.

15. A condenser system comprising the combination with a reservoir containing coolant, of a series of pipes communicating with the reservoir at vertically spaced points for convection circulation of coolant through said pipes, and a refrigerant tube extending through the reservoir into one of said pipes, through said pipe and back through the reservoir and into another of said pipes, and through the last mentioned pipe and through the reservoir, said pipes being finned externally of the reservoir for air cooling.

16. A condenser radiator system comprising the combination with a reservoir for coolant and at least one coolant pipe connected with said reservoir at vertically spaced points for gravity circulation, of a condenser tube for refrigerant having at least one flight in thermally conductive relation to said pipe and the coolant therein contained, the assembly of said flight and pipe being exposed for air cooling and said reservoir and pipe being adapted to function as a closed system for absorbing excess heat during a part of the refrigeration cycle and for delivering off such heat to the air during another part of said cycle, and connections at said reservoir whereby said reservoir may be connected in series into a water main for periodical exchange of its contents when water is drawn through said main.

17. A condenser system comprising the combination of a reservoir and a plurality of laterally adjacent pipes of V-shaped form each connected to the reservoir at vertically spaced points and projecting laterally with their respective apices remote from the reservoir for gravity circulation of coolant between the reservoir and said pipes, and a continuous refrigerant tube extending through said pipes in series entering each at points near the top of the reservoir and leaving each near the bottom, whereby convection currents established in said pipes by heat rejected by said tube flow counter to the path of refrigerant in said tube.

18. In a refrigeration system of the type having an evaporator, a compressor, a condenser, and a capillary tube leading from the condenser to the evaporator, the combination with a relatively short capillary, of a condenser including a condenser tube for the refrigerant leading to said capillary, a coolant pipe in thermally conductive relation to the tube and arranged for gravity circulation of coolant, and a coolant reservoir with which said pipe communicates at vertically spaced points, said reservoir and pipe containing coolant

and the portion of said condenser comprising said pipe and tube assembly being exposed to air circulation, whereby said assembly delivers heat to the air, the coolant being adapted to absorb heat from the refrigerant in said tube during the operation of the compressor but gradually to warm up if the cycle of compressor operation is prolonged, the size of the capillary being such as to discharge refrigerant freely during the initial period of compressor operation while the coolant remains cool but to retard the flow of refrigerant as the temperature of the refrigerant rises due to the heating of the coolant.

19. A condenser radiator system adapted for use in a refrigeration circuit having a compressor and evaporator operable in cycles of compressor operation and rest, said system comprising the combination with a reservoir for coolant and at least one coolant pipe connected with said reservoir at vertically spaced points for gravity circulation, of a condenser tube for refrigerant having at least one flight in thermally conductive relation to said pipe and the coolant therein contained, the assembly of said flight and pipe being exposed for air cooling and said reservoir and pipe being adapted to function as a closed system for absorbing excess heat during a part of the compressor operation cycle and for delivering off such heat to the air during another part of said cycle.

20. A cooling method comprising the establishment of a current of fluid to be cooled, the circulation of a coolant in heat exchange relation to said current from a coolant reservoir and back to said reservoir in a substantially closed circuit for a period normally insufficient to displace all of the coolant from the reservoir, and the reversal of the direction of coolant circulation at the conclusion of said period.

21. A method of cooling which comprises the establishment of a current of fluid to be cooled, the circulation in a closed circuit of coolant in heat exchange relation to said fluid from a supply of such coolant and back to such supply while rejecting heat by radiation from the coolant thus circulated, continuing such circulation of coolant in one direction until the temperature of the fluid to be cooled substantially reaches a peak, and thereafter reversing the direction of circulation of coolant whereby the hottest portion of such coolant rejects its heat.

22. A method of cooling refrigerant in a condenser radiator during the compression portion of a refrigerator cycle, such method including the delivery of the compressed and heated refrigerant through a condenser radiator, the circulation in a substantially closed path of the coolest portion of a supply of coolant through the same radiator in heat exchange relation to the refrigerant therein and returning the heated coolant to the supply and, at the conclusion of the compression cycle, reversing the flow of coolant circulation whereby to deliver heated coolant directly to said radiator from said supply while restoring coolant at a relatively lower temperature from said radiator to said supply.

23. The combination with a condenser radiator comprising a closed circuit path for coolant, a substantial storage capacity of said path being located outside of said radiator, said radiator also comprising a series-connected path for fluid intermittently requiring cooling in a predetermined cycle, said closed circuit coolant path constituting means for delivering relatively cold coolant to said radiator in heat exchange relation to said fluid and receiving heated coolant from said radiator during a portion of the cycle in which heat is being developed in said fluid and for delivering the heated coolant back to said radiator and receiving colder coolant from said radiator during the remaining portion of the cycle.

24. The combination with a tube for a fluid periodically requiring heat rejection, of a closed circuit conduit for coolant, a portion of said circuit being in heat exchange relation to said tube, said circuit portion and tube constituting a radiator, and the portion of said circuit outside of said radiator comprising coolant storage means adapted to receive and deliver coolant to and from said radiator, means for mechanically circulating coolant, and means for reversing the direction of coolant circulation.

25. The combination with a tube for fluid requiring cooling, of a substantially closed circuit conduit having a coolant storage portion and another portion in heat exchange relation to said tube, means for mechanically circulating coolant in said conduit in a direction to deliver the hottest coolant into said storage portion, and means for reversing the direction of coolant circulation in said conduit in a direction to deliver the hottest coolant in said conduit from said storage portion.

26. The device of claim 25 in which the circulating means comprises a motor driven pump and the reversing means comprises a reversing control for the motor of said pump.

27. The device of claim 25 in which the coolant circulating means comprises a motor driven pump and the reversing means comprises a reversing valve having cross-connections operatively adjustable to direct the pump output in opposite directions in said circuit.

28. The device of claim 25 in which the circulating means comprises a motor driven pump and the means for reversing the direction of circulation comprises a motor reversing connection, means for actuating said connection to reverse the direction of pump operation, and a thermostat exposed to temperatures develcped in the heat exchange portion of the conduit and connected to complete, when warm, a reversing circuit of said motor driven pump.

29. The combination with a conduit for a fluid to be cooled, of a substantially closed circuit conduit for coolant, said conduits having portions in mutual heat exchange relation, of a motor driven pump for circulating coolant in the closed circuit conduit, means for reversing the direction of circulation of fluid in said conduit, and means for limiting the continued operation of the pump to a predetermined period after the reversal of current direction.

30. In a refrigeration system, the combination with a condensing tube and fin means constituting extended heat rejecting surfaces thereof, said tube being adapted to receive and cool hot refrigerant during a predetermined compression cycle, of a conduit for coolant in heat exchange relation to the tube and the fin means, of a coolant reservoir with upper and lower portions of which said conduit communicates for the convection circulation of coolant, the storage capacity of the reservoir being sufficient to receive substantially all of the coolant heated during the aforesaid compression cycle, the coolant so received into the reservoir entering the reservoir through the upper connection of said conduit therewith and being replaced in said conduit by coolant received from the reservoir at a lower temperature, the heat rejecting ability of the radiator being sufficient at the conclusion of the cycle to reduce the

temperature of the coolant faster than such coolant loses heat in the reservoir, whereby a reverse convection current is established in the conduit in a direction such that the conduit receives the relatively high temperatured coolant from the upper connection of the conduit with the reservoir and returns coolant at a relatively lower temperature through the lower connection of the conduit with the reservoir.

31. In a refrigeration system of the type having an evaporator, a compressor, a condenser, and a capillary tube affording communication from the condenser to the evaporator, the combination with a compressor having a motor, means controlling the compressor motor for the intermittent operation thereof, and a relatively short capillary, of a condenser including a condenser tube for the refrigerant leading to the capillary, said condenser tube being provided separately with means for heat rejection by radiation and by conduction, the means for heat rejection by radiation comprising extended heat radiating surfaces inadequate to dispose of refrigerant heat as fast as such heat is developed during periods of compressor motor operation, the means for heat rejection by conduction comprising heat absorbing means in conductive relation to said condenser tube and of such heat absorbing capacity as to receive heat in substantial quantities from said tube and to become slowly heated during compressor operation, said heat absorbing means being also in heat conductive relation to the extended surfaces of the condenser tube whereby to reject heat through such surfaces by radiation during periods of compressor inactivity, the condenser and its aforesaid extended surfaces being exposed to air circulation and the size of the capillary being such as to discharge refrigerant freely during the initial period of compressor operation before said heat absorbing means is appreciably increased in temperature while retarding the amount of refrigerant passing through the tube as the temperature of the refrigerant rises due to the heating of said absorbing means.

32. A device as defined in claim 31 in which the heat absorbing means comprises a closed liquid circulatory system in heat exchange relation to the refrigerant condenser tube and said surfaces.

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