

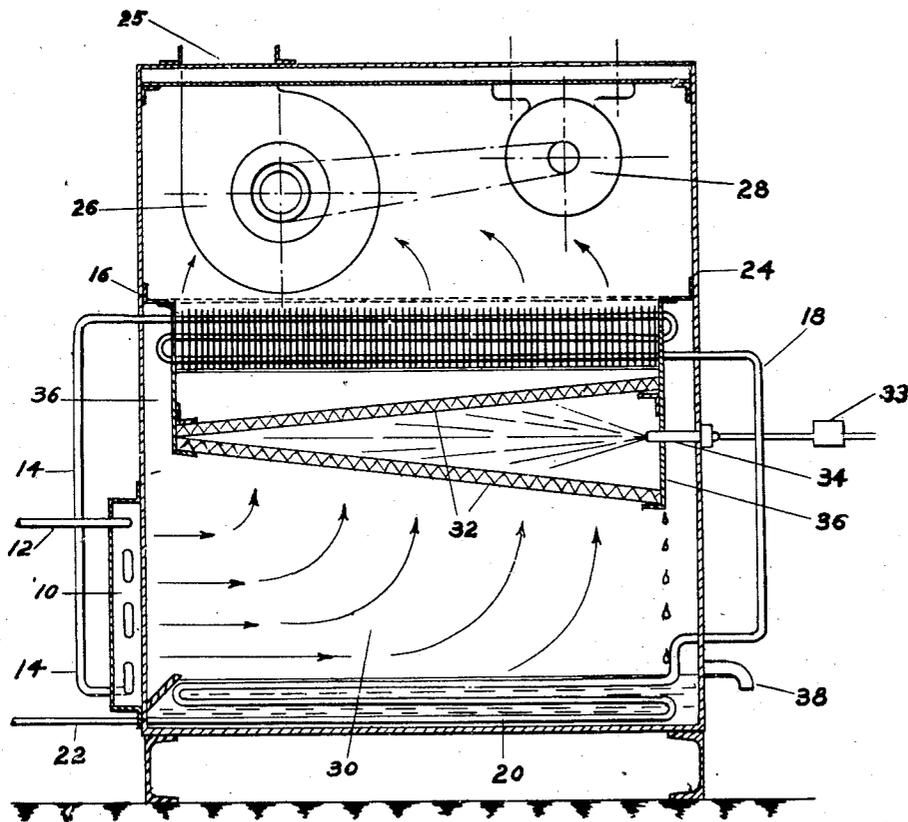
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E. GYGAX

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HEAT EXCHANGER

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INVENTOR
Ernest Gygax
BY
Roy M. Eilers
ATTORNEY

UNITED STATES PATENT OFFICE

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HEAT EXCHANGER

Ernest Gygax, St. Louis, Mo., assignor to Curtis Manufacturing Company, Wellston, Mo., a corporation of Missouri

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This invention relates to improvements in heat exchangers. More particularly, the invention relates to improvements in heat exchangers using water and air cooling.

It is an object of the present invention to provide an improved heat exchanger using water and air cooling.

Heat exchangers are used in many different thermodynamic systems. The function of the heat exchanger is to transfer heat from a warm medium to a cooler medium. Sometimes the heat exchanger is used to impart heat to a fluid as in the case of a boiler, and sometimes the heat exchanger is used to remove heat from a fluid. This fluid may be a liquid or a gas. In this latter class of heat exchangers, some method of cooling must be provided. Various methods of cooling have been used, and one of these consists of passing cool water over tubes filled with the warm fluid. The cool water is effective in removing heat from the fluid, but the use of water requires a water recirculation system that is often both expensive and difficult to install. In addition the use of water alone can be quite expensive, where the consumer must pay for the water he uses. In many municipalities, the high water rates virtually prohibit the use of water cooling alone. Air has also been used as the sole cooling agent, but the temperature of the air is often quite variable and uncertain. The changeability of the temperature of the air makes the heat-exchanging capacity of an air-cooled heat exchanger somewhat uncertain. The most ideal method of cooling consists of a combination of water and air cooling. Such a method can be made to have the economy of air cooling and the certainty of water cooling. The invention provides a novel heat exchanger for thermodynamic systems, that utilizes such a combination for cooling. It is, therefore, an object of the invention to provide a novel heat exchanger for thermodynamic systems that uses air and water to cool a warm fluid.

Some thermodynamic systems have a seasonal operation, but other systems have year-round operation. The heat exchanger that is provided by the invention may be used advantageously with both systems. Its use with systems that have year-round operation can be exceptionally advantageous since the heat exchanger can vary the amount of water it uses in accordance with the temperature of the air surrounding the heat exchanger. In the summer time, therefore, when the air surrounding the heat exchanger is warm and only a small portion of the cooling can be done with air alone, some water must be used to

supplement the cooling effect of the air. If the temperature of the air decreased, it could do more cooling and less water would be needed. In the winter time, therefore, when the air is cold, the air will do a greater share of the cooling and little water will be needed. From this it can be seen that the cooling effect of the water is supplementary to the cooling effect of the air. By utilizing the cooling effect of water to supplement the cooling effect of air, it is possible to provide adequate cooling at all times without using more water than necessary. By utilizing this type of water and air cooling, a heat exchanger may be made which has the certainty of water cooling and the economy of air cooling. It is, therefore, an object of the present invention to provide a heat exchanger that uses the cooling effect of water to supplement the cooling effect of the air.

It is often desirable to cool a warm fluid by stages. Where this is done, the temperature reduction in any particular stage may not be large, but the total reduction in the aggregate is rather large. Because of this, it is possible to cool the fluid in the first stage by air alone. The air surrounding the heat exchanger is drawn over the first stage and cools it. This air is heated by the heat it absorbs from the warm fluid, and will not have sufficient heat-absorbing capacity to cool the fluid in the next stage. The air must, therefore, be cooled before it can be used to cool the warm fluid in the next stage. This cooling is done by saturating the air with moisture. The saturating operation is essentially an evaporative process that serves to cool the air. Under certain conditions of temperature and humidity, the heated air from the first stage may be cooled by saturation until its temperature is below that of the air surrounding the heat exchanger. Such an arrangement is very satisfactory since it restores the heat-absorbing capacity of the air. This air can then be used to cool the warm fluid in the next stage. It is, therefore, an object of the present invention to provide a heat exchanger that cools the fluid by stages and cools the air between stages by saturating it with moisture.

Some heat exchangers have been made that use water and air cooling. Many of these heat exchangers have soon become relatively inefficient by reason of the deposition on their surface of lime or other substances carried in solution by the water. When the water contacts the heat exchanging surfaces, it evaporates and the substances carried in solution by it precipitate out on the surface of the heat exchanger. The de-

posit of lime or other substances must then be removed before the efficiency of the heat exchanger can be restored. The removal of this deposit is rather difficult and expensive. For these reasons heat exchangers that are subject to deposition of lime or other substances are objectionable. In addition, the possibility of having lime or other substances deposited on the heat-exchanging surfaces, prevents the use of finned coils in the heat exchanger. These finned coils materially increase the heat-transferring capacity of a heat exchanger, and their use is quite advantageous. Heat exchangers that use water and air cooling have heretofore been unable to use finned coils efficiently and most of them have used bare pipes. The pipes are usable but are not nearly as efficient as pipes that are provided with heat dissipating fins. For this additional reason, heat exchangers that are subject to deposition of lime or other substances on their heat-transferring surface, are not as desirable as heat exchangers which are not subject to such deposition. The invention avoids the deposition of lime on its heat-transferring surface by providing a heat exchanger that is arranged to have dry heat-exchanging surfaces. Since the coils are always dry, water cannot evaporate on them and deposit the lime or other substance carried in solution by the water. This is quite advantageous since it prevents the deposition of substances on the coils that would reduce the heat-transferring capacity of the heat exchanger. Furthermore, it permits the use of finned coils in the heat exchanger. By having such dry coils, the heat exchanger can have and maintain a high heat-transferring capacity. The invention does this by cooling the coils with air and by cooling the air with moisture. It is, therefore, an object of the present invention to provide a water and air cooled heat exchanger having coils that are always dry.

Where it is necessary to cool the air after it has passed through the first stage, the invention passes the air through a spray of water. The air evaporates some of the water and is cooled thereby. The excess water not absorbed by the air, is also cooled and is cooler than water in the supply line. The invention utilizes this supply of water to give an additional cooling effect to another stage of heat exchanger. It is, therefore, an object of the invention to provide a heat exchanger that uses a water spray to cool air for one stage of cooling and uses the excess water for another stage of cooling.

Other objects and advantages of the invention will appear from the drawing and accompanying description.

A preferred form of the invention is shown and described in the drawing and accompanying description, but it is to be understood that the drawing and accompanying description do not limit the invention and the invention will be defined by the appended claims.

This preferred form of the invention is shown as it may be applied to a condenser for refrigeration systems, but the invention may be used to cool the cooling water of engines. In such a case the temperature of the fluid to be cooled is higher than the temperature of the refrigerant to be condensed. Since, however, the coils are kept dry, the deposition of lime or other substances on them is prevented and the heat exchanger may be used without any deposition of lime on the surface. It can, therefore, be provided with finned coils. Because of its adaptability, the

heat exchanger may be used wherever it is desirable to cool a warm fluid. Where circumstances dictate, various changes may be made in the form of the invention without departing from the spirit of the invention.

The drawing is a side elevational view of a condenser for refrigeration systems that is made in accordance with the principles of the invention.

Referring to the drawing in detail, the numeral 10 denotes a finned coil. This coil has an inlet 12 that is connected to the high pressure line of a compressor not shown. The coil is also provided with an outlet pipe 14 that extends upwardly and is connected to finned coil 16. The finned coil 16 has an outlet pipe 18 that extends downwardly and is connected to a tube coil 20. The coil 20 has an outlet 22 that is connected to an evaporating coil not shown. The three coils 10, 16, and 20 are all secured to and supported by the condenser frame 24. This frame has a blower 26 and a motor 28. The frame is so arranged that the operation of the motor 28 and blower 26 will draw air through coils 10 and 16. This air will then be exhausted through port 25. A relatively large chamber 30 in the frame 24 separates the two coils 10 and 16. In this chamber 30, a humidifying device is positioned. This device consists of a plurality of screens, mats, filters, or other porous elements 32 and water spray 34. For convenience, the word screen will be used in the specification and claims to denote the various porous elements stated above, and all similar elements that can be substituted in their stead. In practice, the condenser has been provided with ordinary copper screening material, but any material that is porous can be used. The screens are supported and enclosed by baffle plates 36 that force the air passing through the condenser to flow through the humidifying device. The screens are disposed to form a V into which the water is sprayed. A nozzle or plurality of nozzles 34 that emits a very fine spray is preferred since small particles of water are evaporated more readily by air, then large particles are evaporated. The nozzle or plurality of nozzles 34 are dimensioned to pass more water than the air can evaporate. Such dimensioning makes certain that an excess of water will be sprayed onto the screens 32. The excess water will run down hill until it reaches the lowest point of the V where it will fall to the bottom of the chamber 30. The bottom of the chamber is substantially water tight and has an overflow drain 38. This drain determines the level of the water in the chamber 30. The drain 38 is above the top of the coil 20 and cooperates with the excess water to keep the coil submerged in water. Water is conducted to the nozzle 34 from a valve 33. This valve is supplied with water from a source of supply not shown. This valve 33 is a cut-off valve that cooperates with a thermally responsive device to meter the water flowing to the nozzle 34 in accordance with the temperature of the air surrounding the heat exchanger. As the temperature of the surrounding air decreases, the valve will automatically reduce the amount of water flowing to the nozzle 34. If the temperature of the air decreased to such a level that the air could cool the fluid without the use of water, the valve would stop the flow of water to nozzle 34. Refrigerant is introduced into the condenser through inlet pipe 12. This refrigerant passes

through the coil 10 and out of outlet pipe 14 into coil 16. While the refrigerant passes through coil 10, it is being cooled by the air that passes over the fins of the coil. In the coil 16, the refrigerant is further cooled by air and then flows into coil 20. This coil is submerged in water, and this water further cools the refrigerant. The refrigerant leaves the condenser through outlet pipe 22 and is conducted to an evaporating coil not shown. The condenser is a multi-stage coil and the refrigerant is cooled by stages. In coil 10 the refrigerant is cooled by the air that flows over the fins of the coil. In cooling the refrigerant in coil 10, this air is heated and its temperature will rise. Tests that have been made with this condenser show that although the dry bulb temperature rises appreciably, the wet bulb temperature does not. Since the dry bulb temperature rises, the relative humidity of the air in chamber 30 is less than that of the air outside of the condenser. The air in the chamber 30, therefore, has a greater water evaporating capacity than the air outside of the condenser. The air in the chamber 30 will be drawn through the wet screens 32 and will be saturated with moisture. This is essentially a process of evaporation and results in a cooling of the air and of the excess water. In many cases, the air flowing from the humidifying device will be cooler than the air surrounding the condenser, and the water will be cooler than the water in the supply line. This cooled air then flows over the coil 16 and extracts more heat from the refrigerant. The air is finally exhausted by the blower 26. In many instances, the dry bulb temperature of the air exhausted from the condenser is less than ten degrees higher than the air flowing into the condenser. This insures a low condensing pressure for the device. In some instances the air leaving the condenser was cooler than the air surrounding the condenser. One of the tests that has been made with a commercial model of this heat exchanger shows this condition. In this test, the air surrounding the heat exchanger had a dry bulb temperature of 90° F. and a wet bulb temperature of 70° F. After passing through coil 10, the air had a dry bulb temperature of 100° F. and a wet bulb temperature of 70° F. The air then passed through the humidifying device where it evaporated some water and was thereby cooled. The air then had a dry bulb temperature of 80.5° F., and a wet bulb temperature of 76° F. This gave the air a relative humidity of 90%, which means that the air cannot wet coil 16 and cause a deposition of lime on its surface, because it is carrying vapor and not water. When the air passes over the coil 16, its dry bulb temperature is raised to 87° F. but its wet bulb temperature is still 76° F. This shows that the temperature of the air exhausted from the condenser was actually less than that of the air that entered. From a study of the results of this test, it can be seen that the condensing temperature is quite low. This is advantageous since it reduces the work of the compressor and motor. The cooling effect obtained in this test is very good. In the humidifying device, the relative humidity of the air increased from 35% to 90% and the amount of water carried by the air increased from 8.1 grains per cubic foot to 10.4 grains per cubic foot. This means that every cubic foot of the air passing through the humidifying device absorbed 2.3 grains of moisture. The velocity of the air was 2000 cubic feet per minute so that

the cooling effect in the humidifying device was 40,600 B. t. u. This cooling effect reduced the sensible heat of the air and lowered the dry bulb temperature from 100° F. to 80.5° F. This cooling effect cooperates with the cooling effect in coils 10 and 20 to cool the refrigerant. From this, it can be seen that this heat exchanger is very efficient. In its passage through the screens 32, the air is saturated with moisture. Because of the relatively low velocity of the air passing through the screens, drops of water are not picked up and carried by the air. The air flowing from the humidifying device cannot, therefore, have more than one hundred per cent humidity. As this air reaches the coil 16, it becomes warm and its relative humidity will decrease. Since the relative humidity of the air issuing from the humidifying device is always less than one hundred per cent and becomes less when the air contacts the coil, there is no possibility of having evaporation of water on the surface of the coil. If water were permitted to evaporate on the surface of the coil, it would leave a deposit of lime or other substance. This is especially true where the water has a quantity of minerals dissolved in it. In such cases, large quantities of material would be deposited on the coil and would soon reduce the heat-transferring capacity of the coil. In the case of a finned coil, the deposit would soon obstruct the space between the fins and make the coil useless as a heat exchanger. By keeping the coil 16 dry at all times, the invention prevents the deposition on it of lime and other substances. Coil 10 is cooled by air alone and is always dry. This enables the invention to use finned coils in the condenser. This permits the attainment and maintenance of a heat-transferring capacity.

The coil 20 may be supplied with the condenser if desired or it may be dispensed with. This coil is preferably located in the bottom of the chamber 30. The nozzle or nozzles 34 emit more spray than the air can evaporate. This excess water issuing from the nozzle 34 is cooled by the evaporation of the rest of the water and is cooler than the water in the supply line. This water collects in the bottom of the chamber 30 and may be used to give an additional cooling effect to the refrigerant. The excess water is permitted to flow out of drain 38. Coil 20 is surrounded with water but very little, if any, lime will be deposited on its surface. This coil receives the refrigerant after it has been cooled by passage through coils 10 and 16. The refrigerant is therefore not very warm and does not evaporate the water around the coil 20. Since it does not evaporate the water, it cannot cause a deposition of lime on the coils. Lime will not be deposited on coil 20 because if the water had had any substances dissolved in them, it would have deposited them on the screens 32 when it evaporated. It is therefore practical to submerge coil 20 in the cool water.

Where the refrigeration system is operated on cool days or is operated in winter, the air flowing through the condenser will have a greater heat-absorbing capacity. On days like this, less water will be needed than is needed on warm days. On very cold days, the air may be so cold that it can cool the refrigerant without the aid of water. Some provision must be made for varying the amount of water supplied to the humidifying device to prevent a waste of water when

the air is cold. The invention provides valve 33 that cooperates with a thermally responsive device to meter the flow of water to nozzle 34 in accordance with the ambient temperature.

The preferred form of the condenser has three condensation stages. Where desired, for economic or other reasons, one or two of these stages may be dispensed with. In such a case the condenser would have the humidifying device, the coil 16, and the air-moving equipment. Such a device would draw air into the condenser, cool it by saturating it with moisture, and then pass it over the coil 16. Such a condenser would not be as compact as the condenser shown in the drawing but it would operate satisfactorily.

The screens 32 are very inexpensive and are supported in such a manner that they can be replaced quite readily. This is advisable since the evaporation of water on these screens may form a deposit on them that would reduce their efficiency.

The arrangement of coils in this condenser is advantageous since it cools the refrigerant by stages and cools the air between stages. By doing so, the condenser maintains the condensing temperature at a low level.

A preferred form of the invention has been shown and described in the drawing and accompanying description, but it is obvious to those skilled in the art, that various changes may be made in the form of the invention without affecting the scope of the invention.

What I claim is:

1. A humidifying device, arranged to bring liquid into contact with a gas stream and to eliminate entrained droplets of liquid, that comprises a liquid spray device, a pair of porous members, and a plurality of gas-directing members, each of said porous members being inclined to the horizontal, one of said members being positioned above the other of said members and having its upper end above the level of said liquid spray device, the other of said members having its lower end below the level of said liquid

spray device, said members lying substantially in planes that intersect in a substantially horizontal line and being arranged so the lower end of the upper member and the upper end of the lower member substantially abut to form the apex of a horizontally disposed V, said porous members being pervious to gas but being arranged to hold liquid sprayed thereon, said liquid spray device being positioned adjacent the open end of said V and being arranged to spray liquid, into the V formed by said porous members, in a generally horizontal direction and to spray liquid onto the under surface of the upper member and the top surface of the lower member, said gas-directing members defining a gas flow path through said lower porous member, through the space between said porous members and then through said upper porous member.

2. A humidifying device that comprises a liquid spray device, a plurality of porous members that are associated to form a V having a horizontally disposed axis, and gas-directing members, said porous members abutting each other at the substantially horizontal apex of said V to form a substantially liquid tight end for said humidifying device, said porous members having pores large enough to permit the passage of a gas stream therethrough but small enough to retain liquid sprayed onto said porous members, said liquid spray device being positioned adjacent the open end of said V and being positioned at the approximate level of the apex of said V, said spray device being arranged to spray liquid into the atmosphere in said V and onto the inner surfaces of said porous members in a generally horizontal direction, said gas-directing members defining a gas flow path through the lower porous member, through the space within said V and then through the upper porous member, said device being arranged to bring said liquid into contact with said gas stream and thereby humidify said gas stream and to eliminate entrained droplets from said gas stream.

ERNEST GYGAX.