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2,167,878

AIR CONDITIONING SYSTEM

Filed Feb. 19, 1936

2 Sheets-Sheet 1

Fig. 1

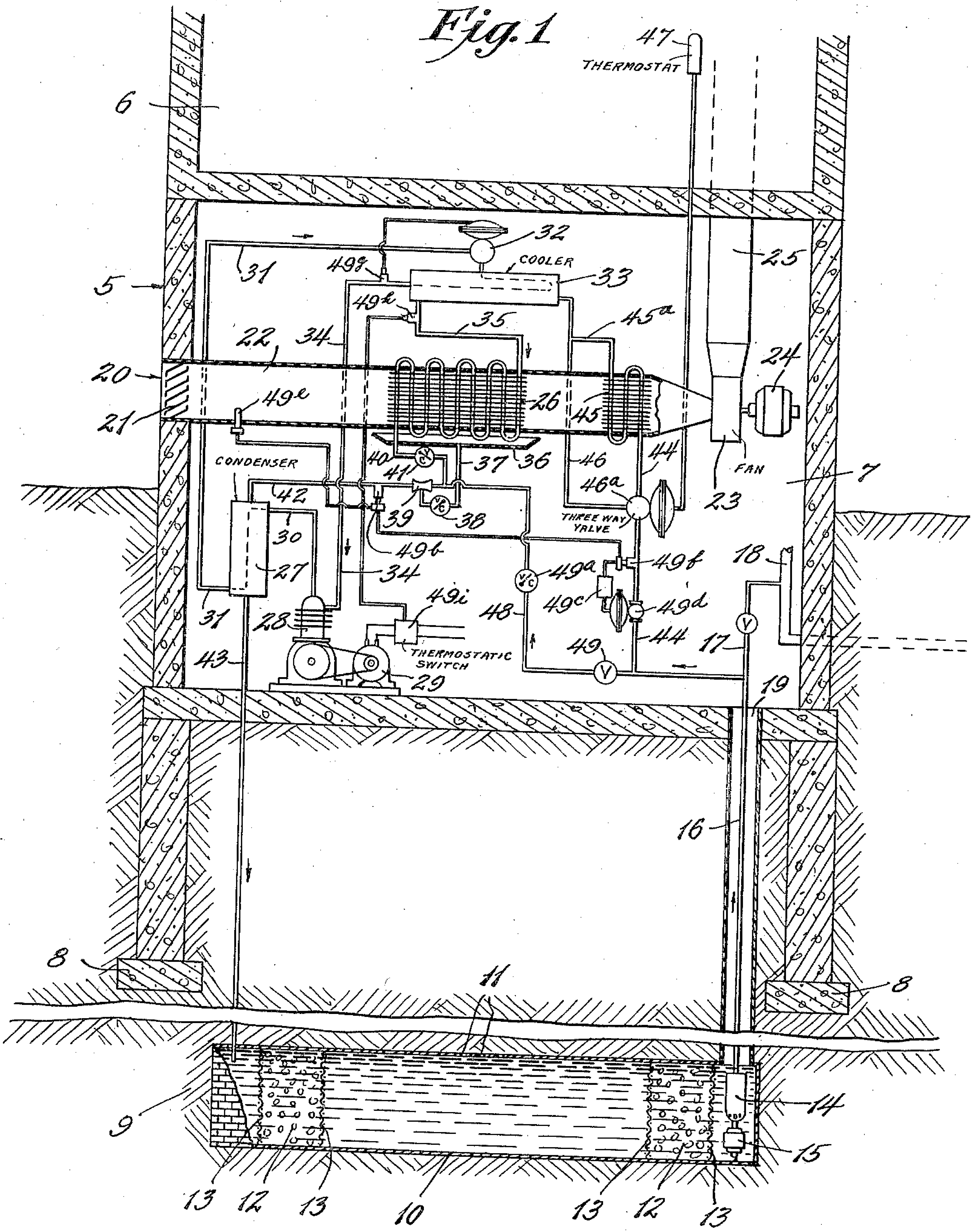

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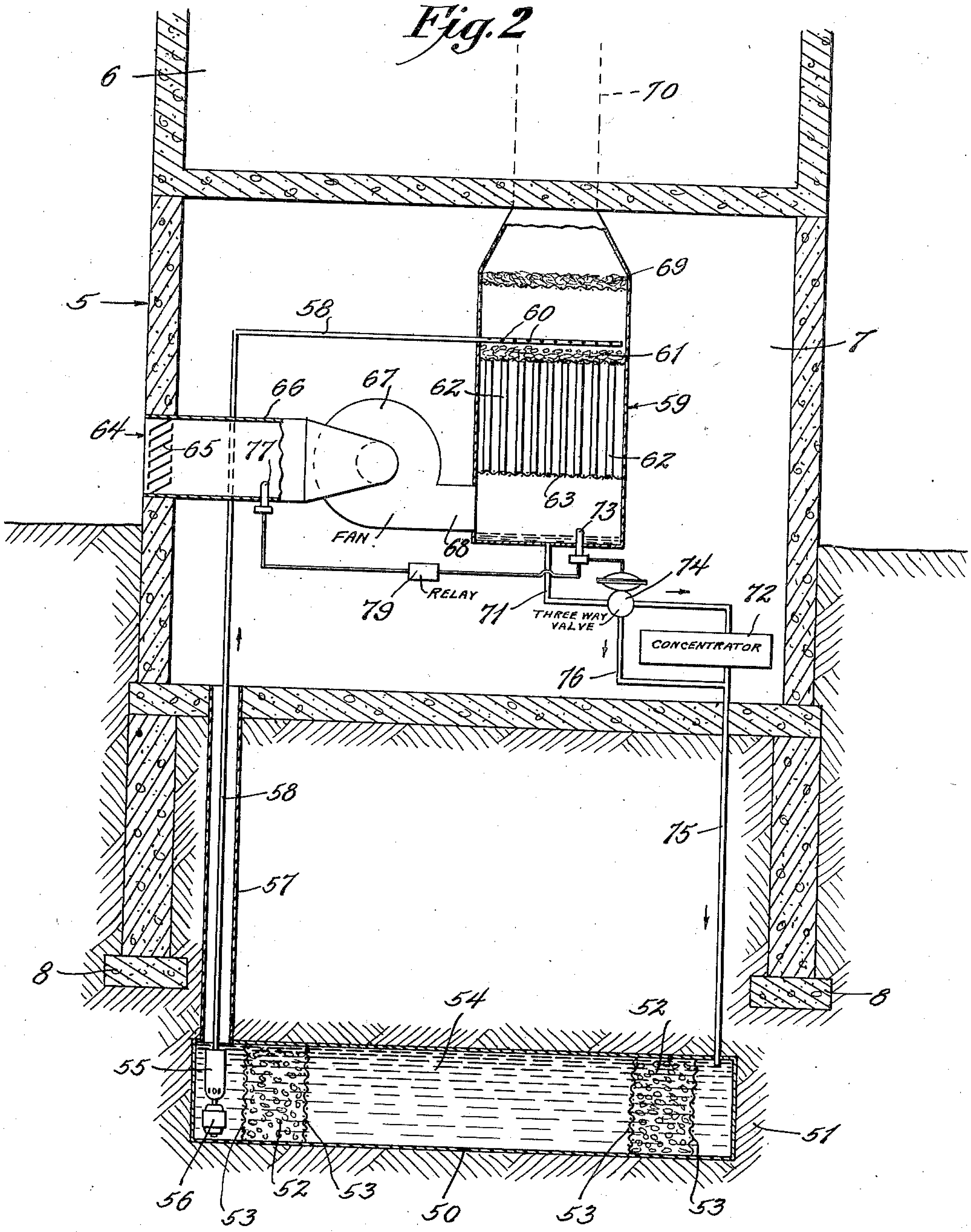
Fig. 2



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AIR CONDITIONING SYSTEM

Robert Brace Crawford, Washington, D. C.

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6 Claims. (Cl. 257—3)

This invention relates to air conditioning systems and methods, and among other objects, aims to eliminate wasting of water and to save power by employing the refrigerating or heating effect of the earth or of ground water, which is returned, after absorbing or yielding heat, to be used again. Other objects will be understood from the following description of two different installations which are within the scope of the invention and by either of which the method of the invention may be practiced.

In the accompanying drawings forming part of this specification:

Fig. 1 is a diagrammatic sectional elevation of an installation employing circulated ground water for either cooling or heating;

Fig. 2 is a similar view of an installation of a different type employing a hygroscopic chemical which is circulated in a circuit comprising the earth and air cooling apparatus.

Referring to Fig. 1, there is shown an air conditioning system which will dehumidify and cool the air to be treated. In some localities, hot ground water in almost unlimited quantities is available, and in such places, the system with some obvious modifications may be for air conditioning and heating. In most parts of the country, however, the temperature of the earth at depths of, say, 25 to 100 feet below the ground level, is nearly constant, winter and summer, and will average around 50–60° F. The earth at this temperature is a heat transfer medium of sufficient magnitude to absorb all the heat removed in the process of conditioning air in even a large building; hence a system employing a subterranean channel, as in Fig. 1, is most useful as an air conditioning means in hot weather, though useful in all seasons, if in cold weather heat is supplied to the conditioned air.

In the system of Fig. 1, air conditioning apparatus is provided having a capacity sufficient to deliver air at the desired temperature in the necessary volume, at the hour of greatest demand on the worst day of the year (from the standpoint of atmospheric conditions) with a maximum internal load arising from crowded rooms, lights, sunlight and other heat sources. In order to dehumidify the air properly, it is usually necessary to cool the air by refrigeration to a temperature which is too low for delivery directly into the area to be conditioned. To provide the reheating of the air which is necessary for less than the maximum load and for proper dehumidifying when refrigeration is used, and to gain the equivalent energy on the cooling cycle, the water circulated from the subterranean area is used to heat the air. After the water has thus been reduced in temperature (by air reheating) in the arrangement of Fig. 1, it is further cooled by refrigeration and is then used to cool the air counter-currently. Finally, before returning the water to the subterranean channel, it is heated as by absorbing heat from the condenser of the refrigerating system, thus assuring a higher temperature to the returning water than the subterranean channel has. This means that the subterranean area always does part of the cooling, which part can be the sensible part of the work.

According to this invention, a heat transfer channel in strata of the desired temperature is created for continuous circulation of a fluid preferably of high specific heat, such as water or brine. Not only is energy below the desired temperature level used but the added heat energy above this level is put back into the system and all the circulating fluid is conserved. The system to be described is particularly advantageous when all the air introduced into the system is from the outdoors, thus effecting a saving in the amount of the refrigeration equipment needed. When employing the apparatus for heating, the reverse cycle system covered in my copending application Ser. No. 18,685 filed April 27, 1935, Patent 2,135,742, issued November 8, 1938, is used.

Referring particularly to Fig. 1, there is shown a building 5 having a room 6 to be air conditioned and basement room 7 in which most of the necessary apparatus is set up. Somewhere below the level of the footings 8 there will be a stratum 9 of permanently moist earth, clay or rock which is either below the permanent water table or which may be an artificially created perched water table. In the stratum 9, in accordance with the invention, an excavation is made and a large conduit or other artificial directed channel 10 is built in the excavation, preferably by the well known shield process. Preferably the conduit or channel 10 is lined with precast concrete blocks 10a and openings 11 are left at various points in the length of the conduit so that water from the stratum 9 may gravitate into the artificial channel and maintain the same filled or saturated with water.

The conduit or channel 10 may be wholly filled with coarse gravel or broken bricks 12, though it is shown as only partly filled, with screens 13 confining the masses of gravel etc. to certain portions of the channel. The purpose of the gravel is to cleanse the water by removing clay, debris, etc., and particularly to increase the heat transfer capacity of the conduit. If desired, the gravel may be in several layers, screened and graded to size. In any event, the gravel should increase the flow of the water through the subterranean channel, so that the walls of said channel may dissipate the heat of the water at a high rate.

A submersible pump 14 driven by motor 15 takes the water from the delivery end of the channel 10 and hoists it through pipe line 16 to the machinery room 7. Here pipe line 16 (which may be termed the cool water line) is preferably connected by a valved pipe 17 to the house service pipe 18 which supplies the system initially with water. When the motor and pump assembly is to be repaired or serviced it may be lifted out of the channel 10 through a manhole 19 extending down from the floor of room 7. Motor 15 is controlled by a switch (not shown) in the machinery room, and hence the rate of circulation of the water in the system may be varied according to needs.

The air to be conditioned enters the building through inlet 20 near the ground level controlled by weatherproof vanes 21, and it passes through a conduit 22 because of the draft induced by suction fan 23 driven by motor 24. The flow of air through the system should be controllable, and the motor 24 and vanes 21 afford operator-controlled means to increase or decrease the air flow to anything desired. As the air travels through conduit 22 it is dehumidified, cooled and reheated by apparatus to be described and then goes to the suction fan 23. Then the conditioned air is blown through a conduit 25 which extends up through the walls of the building to the room or rooms 6 where the conditioned air is needed.

When the air is to be cooled as well as conditioned, the conduit 22 contains or is connected to air cooling means comprising a plurality of refrigerating coils 26 which are part of a refrigerating system which also includes a condenser 27, a compressor 28 and a motor 29. The compressor 28 delivers the compressed refrigerant through pipe 30 to the condenser 27, where the refrigerant is liquefied and then delivered to a liquid line 31 and past an expansion valve 32 to a cooler 33. From the cooler the refrigerant is returned by the pipe line 34 to the compressor 28. Expansion valve 32 may be of the thermal type actuated by a bulb 49*g* on the suction line 34. The refrigerating coils 26 are connected to the cooler 33 by pipe 35 so that a continuous supply of cold water at approximately 50° will pass through said coils. As the air is brought into contact with the cooled coils it is dehumidified and the water thus extracted is collected by a drip pan 36 which has an outlet pipe 37 controlled by a check valve 38. An eductor 39 is connected with pipe 37 and is also connected with the coils 26 by means of a pipe 40 likewise provided with a check valve 41. Water flows from the eductor 39 through the pipe 42 to the condenser 27 where it is heated, the hot water then moving down pipe 43 into the receiving end of the channel or conduit 10.

The cooled water from pipe line 16 is forced by pump 14 through the pipe 44 which conducts the water to the air reheating coils 45 located in the duct 22. Here the water is cooled a couple of degrees and then enters the water cooler 33 by means of pipe line 45*a*. If desired the water may be by-passed around the reheating coils 45 by means of a pipe line 46 leading directly to the cooler 33 and controlled by a three-way valve 46*a*. Valve 46*a* is controlled by a thermostat 47, which is preferably located in one of the rooms whose temperature is to be cooled by the conditioned air delivered by the system. Thermostat 47 will regulate the flow of water through the reheating coils 45 and if no reheating is desirable under the temperature conditions in the room the thermostat 47 will by-pass the coils 45 whereupon the entire flow of water will be directed through pipe 46 to the cooler 33. It is also desirable as shown to provide a by-pass line 48 controlled by a hand-valve 49 and a check valve 49*a* and connecting the pipe line 44 with the pipe 42.

To insure a higher fluid temperature in pipe 40 than in pipe 44, a matched thermostat 49*b*, relay 49*c* and valve 49*d* are provided. When the temperature at thermostat 49*b* is 80°, for example, valve 49*d* should be wide open. Should the temperature of the outdoor air be reduced, the temperature at thermostat 49*b* would fall, valve 49*d* would gradually close, and would be closed tight when the temperature at thermostat 49*b* fell below the temperature in pipe 44 by a small amount. This is necessary to insure getting the maximum heat removal from the air at the intake with the minimum refrigeration and power input to the motor 29. The desired temperature (50° or thereabouts) in cold water line 35 is maintained by varying the speed of said motor or by starting and stopping multiple compressor units (not shown) by motor 29. A thermostat 49*h* in cold water line 35 controls motor 29 by a thermostatic switch 49*i*. The water temperature in line 42 as sensed by thermostat 49*b* can be calibrated by matched units or setting of thermostat 49*b* can be varied by outdoor thermostat 49*e* or by fluid thermostat 49*f*.

Referring to Fig. 2, there is shown a system which, while using the refrigerating and/or heating effect of the earth as a source of energy, employs a closed fluid circuit, that is, a circuit having no inlets or outlets for ground water. Such a circuit is obviously independent of a supply of ground water, and hence the water-tight conduit 50 may be buried in stratum 51 which is perfectly dry. In this conduit, coarse gravel or the like 52 is confined by screens 53, or it may fill the interior of the conduit, which thus has a high heat transfer capacity. A quantity of a hygroscopic aqueous brine 54, for example sodium chloride or calcium chloride brine, is introduced into the circuit of which the conduit is a part and is circulated and recirculated by means of a submersible pump 55 driven by motor 56 controlled from the machinery room 7 by a switch (not shown). A manhole 57 permits hoisting of the pump and motor assembly out of the conduit and a pipe 58 conducts the brine from the conduit to the contactor 59.

The discharge end of pipe 58, which may be termed the cool brine pipe, has a series of perforations 60, or a series of perforated pipes (not shown) causing the brine to be discharged into the interior of contactor 59 in a series of fine streams. These fine streams fall upon a heterogeneous medium 61 which may be a mass of broken tile, coarse gravel or any material not reacting with the brine which will further break up the brine spray before it passes down over absorbent tubes 62 (or sheets, if preferred). The viscosity and surface tension of the brine are such as to make it adhere to the heterogeneous medium 61 until it makes contact with the tops of the tubes or sheets. The tubes or sheets are spaced apart uniformly by spacer 63.

The air to be conditioned enters the building 5 through an intake 64 controlled by vanes 65 and passes through conduit 66 because of the suction of motor-driven fan 67. The discharge side 68 of the fan forces the air into the lower end of the contactor 59 and thence the air passes up between the tubes or sheets, then through a mass of glass wool 69 and finally up to the distributing duct 70 into the room or rooms 6 to be air-conditioned. As the air passes up through the contactor, some of its heat and moisture is taken up by the brine. The heat picked up by the solution is the thermal equivalent of all the work done on the air; consequently the brine which returns to the conduit 50 (as will be described) carries all the heat and losses exactly as does the water in the system of Fig. 1.

At the bottom of contactor 59, a pipe 71, which may be termed the warm brine pipe, is provided to carry away the warm and weaker brine resulting from contact with large volumes of the atmosphere. To maintain the concentration necessary to do the work, a concentrator 72 is provided. A thermostat 73, or else a Dunlap density controller (not shown) actuates a three-way valve 74 to direct the weak brine to the concentrator, from which concentrated brine flows down to the conduit 50 through return pipe 75. The brine is concentrated to a strength greater than is desirable at the upper end of the contactor 59, and this excessively concentrated brine is mixed with more or less weak brine from pipe 76, as permitted by three-way valve 74, so that the brine returned to conduit 50 is of exactly the right strength for the atmospheric conditions and the load on the system.

The concentrator may be thermal, electro-chemical or electro-endosmatic as described in my copending applications.

If a thermostat 73 is used, rather than a density controller, it controls the concentration by a calibration of known surface and transfer conditions in the contactor with given conditions in the contactor with given conditions at the air inlet 64 as sensed by controller 77. This controller may be a dew-point thermostat, a wet bulb thermostat or a combination effective temperature controller, as required by the conditions at 64 and 70. Controller 77 resets thermostat 73, acting through a relay 79, for the known temperature for a given heat and moisture duty, so that thermostat 73 can in turn bring about the degree of brine concentration necessary for efficient operation of the system under light loads.

The walls of the conduit 50 preferably are serrated, grooved and ribbed, or otherwise shaped to insure a maximum heat transfer, but they should be substantially brine tight.

It will be clear that the systems of Figs. 1 and 2 may be used to deliver large volumes of conditioned air to the interior of a building, and that the use of expensive, noisy and ugly cooling towers is entirely obviated. Furthermore, the systems require no large supply of water, thus effecting important operating economies particularly in cities where water is metered. Both systems are notably economical, to operate and to maintain, and neither requires a huge investment.

Obviously the present invention may be practiced with systems differing in many particulars from the ones shown and described herein for illustration.

Having described the improved method and two air conditioning systems embodying my invention, what I claim as new and desire to secure by Letters Patent is:

1. An air conditioning system comprising in combination a subterranean conduit positioned below the water table and having openings providing direct contact of the fluid therein with ground water; a refrigerating system including a cooler and a condenser; a duct for conveying air to a point of distribution, a cooling coil in said air duct; and means for circulating water successively through said conduit, the cooler of the refrigerating system, the cooling coil in the air duct, the condenser of the refrigerating system and back to said conduit.

2. The invention according to claim 1, wherein there is an air-reheating coil through which the water flows on its way to the cooler, and past which the air flows on its way to the point of distribution.

3. The invention according to claim 1, wherein the conduit is at least partially filled with inert material to increase the turbulence of flow and hence the heat transfer and to remove certain impurities from the water.

4. The invention according to claim 1, wherein the water system has a coil in the air duct, for reheating the air after dehumidifying, and a by-pass around said coil, with a thermostatically-controlled valve governing the amount of flow through the by-pass and coil.

5. The invention according to claim 1, wherein the dehumidifying coil has a drip pan, and a pipe leads from the drip pan to an eductor, said eductor being in the water-circulating system, so that water extracted from the air enters the water-circulating system.

6. The invention according to claim 1, wherein the refrigerating system has an electric motor and a compressor driven by said motor, a thermostat being in the cold water line from the discharge side of the cooler, a thermostatic switch governing the motor, and means connecting the thermostat and said switch, so that the motor is governed by the temperature in the cold water line.

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