

THE NON-INTRUSIVE AND EXTENDED USE OF WATER RESERVOIRS IN BUILDINGS AS THERMAL STORAGE FOR HEATING, VENTILATION AND AIR CONDITIONING SYSTEMS

Field of the Invention

[0001] The present invention relates to methods and systems to reduce cost in a heating, ventilation and air conditioning (HVAC) system.

[0002] In particular, this invention relates to methods utilizing water reservoirs in buildings to augment the heating and cooling of a building thereby reducing energy costs.

Background of the Invention

[0003] It is a common practice for power supply companies to offer economic incentives to users who can shift their energy needs from a peak demand period to the off-peak period. The difference between peak and off-peak period tariff rates for electricity is often considerable. This makes it cost-effective for building management to implement systems that can take advantage of operating at the lower tariff rates.

[0004] An example of such a system in the art are thermal storage systems that run refrigeration equipment in the off-peak period to make ice, and then at peak period discharging the ice storage to satisfy the cooling duty, either in full or partially. The significant reduction of time-dependent energy costs such as electric demand charges and peak time-of-use energy charges is a major incentive for using of thermal storage system.

[0005] While the example of making ice is useful in cooling in the summer season or in warmer climates, the idea of using thermal storage to save costs may also be implemented using warm air in colder climates or seasons.

[0006] Thermal energy can be stored in the latent heat of fusion of water (ice) or other phase-change materials like the hydrated salts. With ice

storage, separate ice-making machines will have to be installed but these are typically less energy efficient than those used for air conditioning purpose. With phase-change materials, conventional air conditioning chillers can still be used to make for better energy efficiency.

[0007] Alternatively, water may be used as a storage medium without causing it to undergo a phase change. The amount of energy stored in a chilled water storage is directly related to the volume of water in the storage, times the temperature differential (Δt) between the water entering and leaving the system. The techniques that have been developed in chilled water storage are based on maintaining separation between cool water and warm water.

[0008] This separation may be achieved by separate containers or tanks, or by creating a thermocline to separate warm water in the upper part of a single tank with the colder water at the bottom of the tank.

[0009] The cool water (typically, 6°C) is piped into the chilled water circuit to perform the intended cooling and warmer water (typically at 12°C) is returned to the storage tank separated from the remaining stock of cool water. Alternatively, the water warmed by an electrical or solar heater, or from waste heat, may be piped into the system to warm incoming cold air. Inherently, this technique limits the temperature differential (Δt) in air conditioning systems to a conventional working range of about 10° C. The chiller cools water in storage at 5°C and coils return water to storage at 15°C.

[0010] Furthermore, chilled water systems are associated with large volumes. As a result many storage tanks are located outdoors or below ground. The location and space required by the thermal storage system are functions of the type of storage and the architecture of the building and site. Building or site constraints often shift the selection from one option to another. Architectural or structural considerations, sometimes, outweigh the performance benefits that thermal system can achieve.

[0011] Therefore, a need clearly exists for a heating, ventilation and air conditioning system that can reduce its cost of operation by shifting the

energy demands to take advantage of off-peak power rates while not requiring the installation of new storage and costly ice-making equipment or phase-change materials. In addition, use of existing water storage to achieve this shift without the need to install additional structures will also be desirable to further reduce cost.

[0012] It may be seen in the art that the working temperature differential or range of such methods is typically only 10°C and that the storage medium or water of different temperatures is usually kept separated for inventions of the prior art to work.

Summary of the Invention

[0013] The present invention seeks to provide, in one aspect, a method of using at least one thermal storage means to reduce load and electrical power costs in at least one air conditioning system, wherein the at least one thermal storage means comprising at least one existing body of water in at least one building, the method comprising:

modifying the least one existing body of water;

linking the at least one existing body of water to the air conditioning system;

changing the temperature of the water in the at least one existing body of water;

allowing the water in the at least one existing body of water to moderate the load in the at least one air conditioning system;

whereby

the volume and integrity of the water in the at least one existing body of water is preserved,

and

thereby extending the useful temperature differential of the water beyond 10°C.

[0014] In another aspect, the present invention provides a system of using thermal storage to reduce the load and electrical power costs in an air conditioning system, the system comprising:

at least one thermal storage;

at least one air conditioning system;

wherein

the at least one thermal storage is connected indirectly to the at least one air conditioning system through at least one heat exchanger,

whereby

the thermal storage contributes to the moderation of a load connected to the at least one air conditioning system, and

the volume and integrity of the at least one thermal storage is preserved;

and

the useful temperature differential of the thermal storage is extended beyond 10°C.

Brief Description of the Drawings

[0015] The preferred embodiments of the present invention will now be more fully described, by way of example, with reference to the drawings of which:

[0016] FIG. 1 illustrates a schematic diagram showing how existing water storage bodies in a building may be linked with the existing air conditioning system in accordance with the present invention;

[0017] FIG. 2 shows how the existing water storage body may be used under the present invention;

[0018] FIG. 3 shows how one method by which the water volume in multiple water storage tanks may be used in the method of the present invention without loss of total water volume;

[0019] FIG. 4 shows another method by which total water volume in one tank may be preserved by the method of the present invention;

[0020] FIG. 5 shows how the thermal storage is charged.

[0021] FIG 6 shows the first stage of the method of the present invention in discharging the thermal storage; and

[0022] FIG. 7 illustrates the second stage of the method of the present invention.

Detailed Description of the Drawings

[0023] This invention seeks to address the inadequacies in known technologies to provide a cost-effective solution to implement a thermal storage system for space heating or cooling a building.

[0024] The present invention makes use of a reservoir of water wherein the volume of water is preserved, to reduce the cost of operating the heating, ventilation and air conditioning (HVAC) system of a building.

[0025] In accordance with a preferred embodiment of the invention are described. In the following description, details are provided to describe the preferred embodiment. It shall be apparent to one skilled in the art, however, that the invention may be practiced without such details. Some of these details may not be described at length so as not to obscure the invention.

[0026] Modern buildings are designed with a variety of services that require owners to store bodies of water separately for each service. For fire safety purposes, buildings are required to be equipped with water-based fire fighting systems such as an automatic sprinkler system and wet riser system. In these systems, a prescribed volume of water must be stored in reserve so that upon activation, the outbreak of a fire may be contained and/or suppressed. In normal circumstances, the water in these reservoirs is otherwise never used.

[0027] The present invention makes use of this otherwise untapped thermal storage to reduce operating costs of a HVAC system.

[0028] Unlike technologies of the prior art, the present invention does not make use of ice storage or other thermal storage media such as phase change materials in the preferred embodiment. The present invention is that of chilled or warmed water in a closed loop circuit system.

[0029] While the preferred embodiments of the present invention are described are directed towards cooling a building, a person skilled in the art of HVAC systems will appreciate that the present invention can also be readily adapted to save energy costs for space heating in building.

[0030] There are many advantages of the preferred embodiments of the invention. One advantage of the preferred embodiments is the non-intrusive use of bodies (reservoirs) of water stored in a building that were intended for services other than the air conditioning system, as a thermal storage medium. These reservoirs will include, but not limited to, water stored for fire fighting purpose and/or water stored for recreational purpose like in a swimming pool. This reduces (but not completely eliminates) the cost of constructing huge tanks for the purpose chilled water storage.

[0031] Another advantage is that the strategies and techniques are able to secure the integrity of the said water bodies and not to compromise their original intended uses.

[0032] Yet another advantage is that the energy storage capacities of water may be increased beyond the commonly-accepted air conditioning practice. This involves extending the working range of chilled water beyond the typical 10°C temperature differential (Δt).

[0033] FIG. 1 shows a schematic diagram to link these water bodies to the HVAC system. The water in the storage medium is isolated from, and not connected for flow, into any segment of the chilled water circuitry used for air conditioning. Instead, heat transfer is achieved by the use of a suitable heat exchanger (4) between the thermal storage medium (1) and the chilled water circuitry. By using these existing water bodies, the cost of erecting additional water storage tanks especially for thermal storage purpose is reduced substantially.

[0034] In the present invention, the temperature of the water in the thermal storage is changed and this water is then used to moderate the load in the air conditioning system.

[0035] In the charging mode, the circuitry may be arranged either to allow the chiller(s) (20) or another temperature changing means such as a heater, to perform charging or changing the temperature of the storage medium (1) while meeting the load. Alternatively, other dedicated chiller(s) (201) may serve to solely charge the water storage (FIG. 2). This may be done at

night when the electrical tariff rates are lower and will result in considerable savings for the user.

[0036] The present invention provides for either a single or a two-stage discharging of the stored thermal energy. The first stage discharge is as in the art, that is, to use the heat capacity of the stored cooled water within the usual 10°C temperature differential (Δt) for the cooling load. However, unlike the prior art, the thermal storage medium does not enter into the circuit but does so indirectly via the heat exchange (4).

[0037] The second stage, another method and objective of the present invention, is intended to extend the temperature differential of the storage medium beyond the temperature range of 10°C. The present invention may be practised with either a one- or two-stage discharging of the thermal storage (1). In both cases, the water or thermal storage medium of the present invention circulates in a closed circuit and does not mix with the water or thermal storage medium of the airconditioning system. Heat exchange takes place through the heat exchanger (4). This method of the present invention preserves the integrity of the thermal storage and is novel and inventive over current methods of the art.

[0038] The cooling duty shall be performed by two groups of heat exchangers (22) A and (16) B (FIG. 1). The heat exchangers B is a pre-cooling arrangement such that it reduces the load on heat exchangers (22) A.

[0039] As an illustration, consider the ventilation component of the cooling load. Fresh air is typically introduced into a building to meet the ventilation requirements of the occupants. The intake of fresh air into a building may be pre-cooled or moderated at its entry location by the heat exchangers (16) B. This reduces the load on heat exchangers A (22). Thus, the present invention is able to moderate the load of the air conditioning system.

[0040] In stage I (FIG. 6), the water in thermal storage is piped downstream to heat exchangers (22) extending the returning segment of the chilled water circuitry. The cooling duty of the chiller is therefore partially removed by the discharging of stored energy of the water tanks (1). The chiller will

sense that the temperature of the returned chilled water is lower. As the chiller has been programmed to respond accordingly, it may operate at a reduced capacity or be even cycled off to save energy. This is effective when the temperature of the water inside the thermal storage (1) falls within the normal working ranges from 5° to 15°C. Beyond this range, the thermal storage does not influence the operations of the chillers in a direct manner.

[0041] In the second stage, the working range of chilled water is to be extended. Since the temperature of the water in the thermal storage is now above 15°C, it is no longer suitable for cooling the bulk of the load in the main chilled water circuit. However, unlike the methods of the prior art where this is disregarded, this water above 15°C remains useful in the present invention as it can still pre-cool some selected components of the cooling load in a second stage cooling.

[0042] This second stage cooling is performed by operating valves (13, 15) to form a closed loop separated from the main chilled water circuit (FIG. 7). This may be done manually (guided by a temperature reading by time of day for that season of the year). However, the best way to do this is by electromechanical means well known in the art, wherein the valves are operated automatically when the water reaches a selected temperature such as 15°C.

[0043] This second chilled water circuit will feed the heat exchanger (16) to moderate or pre-cool the selected components of the cooling load. In the example, incoming fresh air is pre-cooled by the heat exchanger (16) which is now fed with water in a closed loop. The residual thermal capacity of the water in storage remains suitable for the pre-cooling function and is thus raised to a higher temperature.

[0044] In this two-stage discharging, the temperature (of water) in storage could be raised from as low as 4°C to as high as the ambient temperature. The temperature differential is therefore stretched beyond the typical 10°C range by this novel and inventive method.

[0045] The advantage of the present invention in providing non-intrusive use of bodies or reservoirs of water stored in a building that were originally

not intended for use as part of the air conditioning system may invite scrutiny from the relevant regulatory authorities. These authorities may be convinced, to allow the non-intrusive use of these water bodies as thermal storage medium, if the integrity of the water may be preserved. In the case of the non-intrusive use of water stored for fire fighting purpose, fire safety must not be compromised and the water supply it needs must be made available in an emergency.

[0046] With regards to this advantage, the present invention also provides strategies and techniques to preserve the integrity of the water bodies in an emergency. Examples of an emergency include the triggering of a fire alarm, temperatures dropping to freezing or a reduction of volume in the water tank. When an emergency happens, the operations of the pump (3) and/or heat exchanger (4) shall be switched off by electromechanical means connected to sensors. Further, the motorized valves (6) may be closed by electromechanical, hydraulic or pneumatic means. These measures serve to disrupt the operations of the circuit to preserve the volume of water in the thermal storage tank. The volume of water in the tank may then be used for their original intended purpose such as to supply the fire sprinkler system.

[0047] If the user chooses not to deploy electromechanical or electronic sensors, the method of the present invention to preserve the integrity and volume of water in the thermal storage is to install a pump (3) for the water storage tank in such in a manner that it requires a suction lift (FIG. 3). When a reduction in the volume of the water in the storage tank is mechanically detected, this method of the present invention will cause the pump to lose its prime, thereby disrupting its operations.

[0048] FIG. 3 shows two water storage tanks, linked by an interconnecting pipe. The pump (3), arranged such that a suction lift is needed, is operated to circulate the water from one tank to another but shall be in no case cause the volume of water to be reduced.

[0049] Along the suction pipe (2), a branch pipe (8) is created. This branch pipe has a diameter markedly smaller than the suction pipe and is

connected to the suction pipe just below a one-way valve (7). The latter is sometime referred to as a check valve or a foot valve.

[0050] This branch suction pipe (8) shall be positioned precisely at the normal water level. The diameter of this pipe is critical and is sized so small that the flow of water through it is insignificant compared to the larger suction pipe (2).

[0051] While one or two tanks are described and illustrated, a person skilled in the art will appreciate that the thermal storage of the present invention can comprise bodies of water that are contained in one or more compartments, or one or more tanks that are linked by interconnecting pipes.

[0052] In the case where water is stored in a single tank or in a compartment of a tank but not linked to other compartments, the piping arrangement is shown in FIG. 4.

[0053] Similarly, the pump (3) is arranged such that a suction lift is required. Water is then moved to a heat exchanger (4) for the charging or discharging of the thermal storage. The delivery pipe (5) is positioned in the same tank such that water circulation is optimally achieved.

[0054] Along the suction pipe (2), a branch pipe (8) is created so that it can detect any significant reduction in the volume of water in the tank. As the volume that has to be maintained is important, some explanation of the volumes involved is necessary as it dictates the placement of a branch suction pipe, an element of this invention.

[0055] The tank(s) had been sized to store a certain volume of water to serve a purpose other than for the air conditioning system. When this minimum volume of water is stored in a tank, the water level is defined as the normal level.

[0056] In cases where the tank(s) store exactly the required volume of water, the actual water level coincides with the normal level. For the purpose of this invention, it is necessary to then top-up the water volume to the level of the overflow pipe. The branch suction pipe (8) is then submerged just below the water surface.

[0057] When the water tank(s) had been over sized, more water may be stored and the water level will exceeds the normal level. The branch suction pipe (8) when placed at the normal water level is already submerged just below the water surface.

[0058] The diameter of the branch suction pipe (8) is so sized that flow through it is insignificantly low so that no vortex formation occurs. However, when the water level falls, the branch suction pipe becomes exposed to air. This will draw air into the suction line and cause the pump to lose its prime.

[0059] A person skilled in the art will appreciate that above description of the present invention provides non-intrusive methods to extend the use of existing bodies of water in buildings as thermal storage for air conditioning.

[0060] While one advantage of the present invention is to make use of existing reservoirs of water in a building where the integrity of the water contained must be maintained, the present invention also offers other advantages. A person skilled in the art will appreciate that the other advantages of the present invention of extending the useful range of the thermal storage may be applied to other thermal storage media such as phase-change materials.

[0061] If a user is not restricted to utilizing existing bodies of water in a building, the methods taught in the present invention may be applied to new thermal storage tanks built to take advantage of the present invention. In such cases, water in these reservoirs need not be preserved and elements of the present invention (eg control mechanisms, piping, etc) to maintain volume need not be installed.

[0062] The methods of the present invention also allow the energy storage capacity of water beyond the typical 10°C, the commonly accepted range in air conditioning system. Under the present invention, the useful range of the water bodies may be extended from 15°C to as high as 25°C to 28°C.

[0063] The methods of the present invention also maintain and secure the integrity of the existing water bodies while making use of them to reduce the load on the air conditioning system. Thus the present invention overcomes, or at least alleviates, the problems and limitations of the prior art.

[0064] A person skilled in the art will also appreciate that the methods taught in the present invention for air conditioning (cooling) a building can also be applied to provide space heating a building while reducing energy costs. A thermal storage as described above may be readily modified to warm or increase the temperature of the water (or thermal storage media) in temperate regions during the colder months. The thermal storage may be warmed by heating means such as dedicated electrical or gas heaters, or by waste heat generated by the building's plant machinery.

[0065] The elements of the present invention may be readily retrofitted into existing HVAC systems at minimal cost to practice the invention, as the user deems fit. This makes the present invention cost-effective to install, and is likely to result in considerable energy savings.

[0066] In summary, the present invention teaches a method of modifying existing bodies of water in a building for thermal storage by linking them to the HVAC system. The temperature of the thermal storage is then changed (either chilled or heated) at lower electrical tariff rates at night and then this water is allowed to moderate the load of the system to reduce energy costs. This is achieved while the volume of the water in the thermal storage is preserved and the useful range of the thermal storage is extended beyond 10°C.

[0067] It will be appreciated that although only a few preferred embodiments have been described in detail, various modifications and improvements can be made by a person skilled in the art without departing from the scope of the present invention.

Claims

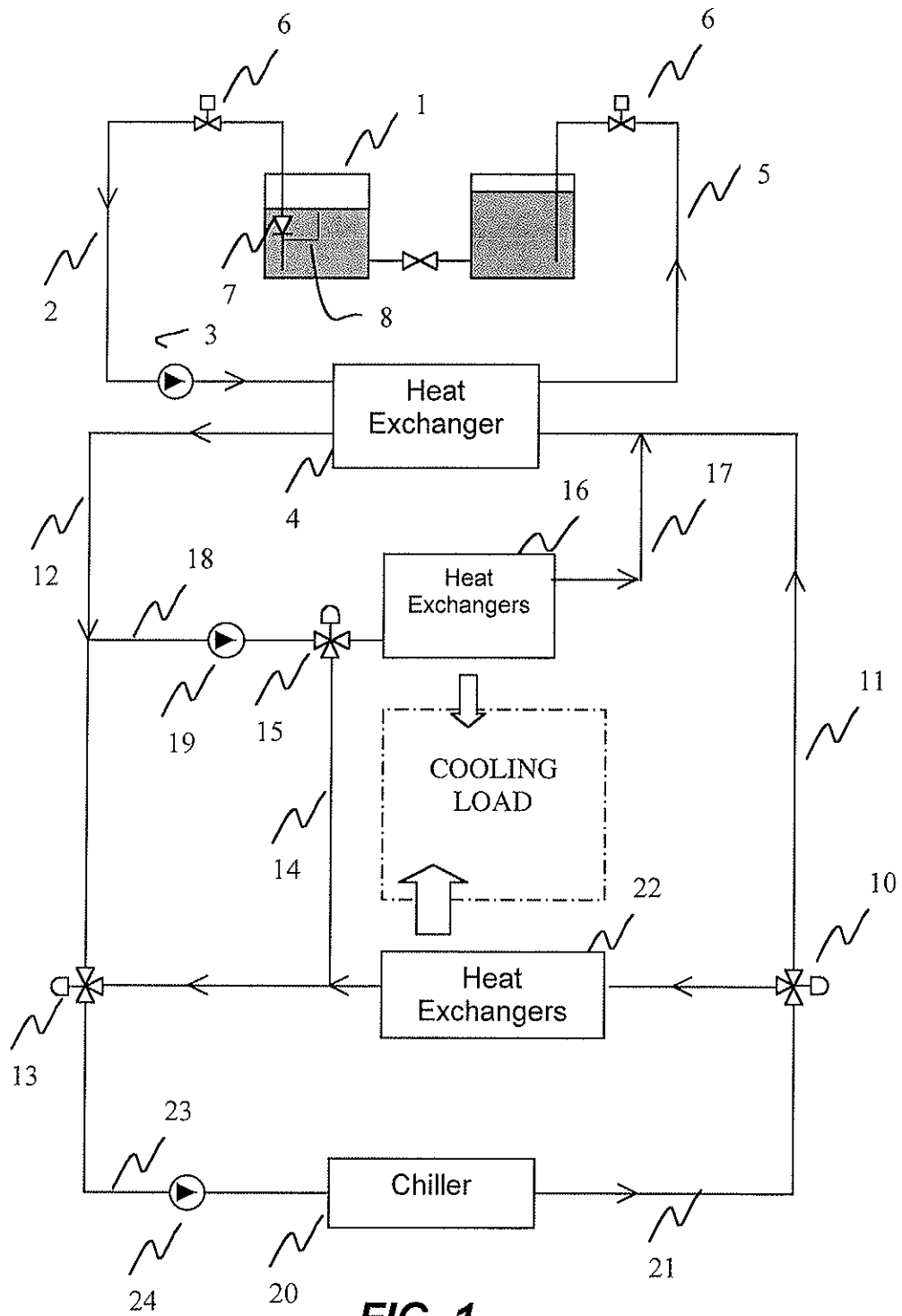
1. A method of using at least one thermal storage means to reduce load and electrical power costs in at least one air conditioning system, wherein the at least one thermal storage means comprising at least one existing body of water in at least one building, the method comprising:
modifying the at least one existing body of water;
linking the at least one existing body of water to the air conditioning system;
changing the temperature of the water in the at least one existing body of water;
allowing the water in the at least one existing body of water to moderate the load in the at least one air conditioning system;
whereby the volume and integrity of the water in the at least one existing body of water is maintained at a predetermined level, wherein the water in the at least one existing body of water is terminated from moderating the load in the at least one air conditioning system when the volume of the water in the at least one existing body of water falls below the predetermined level,
and
thereby extending the useful temperature differential of the water beyond 10°C.
2. The method of Claim 1, wherein the modifying further comprising:
installing plumbing fixtures and machinery to the at least one existing body of water,
and
extending the volumetric capacity of the at least one existing body of water by linking it to other bodies of water.
3. The method of Claim 1, wherein the linking the at least one existing body of water to the air conditioning system further comprising at least one heat exchanger, the linking with the heat exchanger as a closed circuit, wherein the water in the at least one existing body of water does not mix with that of the at least one air conditioning system.

4. The method of Claim 1, the changing of the temperature of the water in the at least one existing body of water further comprising linking a temperature changing means to the at least one existing body of water.
5. The method of Claim 4, the changing of the temperature of the water comprises decreasing the temperature of the water and the temperature changing means comprises a chiller.
6. The method of Claim 4, the changing of the temperature of the water comprises increasing the temperature of the water and the temperature changing means comprises a heating means.
7. The method of Claim 1, the allowing of the water to moderate the load in the at least one air conditioning system further comprises moderating the load in at least one stage.
8. The method of Claim 1, the allowing of the water to moderate the load in the at least one air conditioning system further comprises moderating the load in two stages.
9. The method of Claim 5, the moderating of the load in at least one stage further comprises moderating the load indirectly through a temperature changing means.
10. The method of Claim 5, the moderating of the load of the load in at least one stage further comprises moderating the load directly, not through a through a temperature changing means.
11. A system of using thermal storage to reduce the load and electrical power costs in an air conditioning system, the system comprising:
at least one thermal storage;

at least one air conditioning system;
wherein
the at least one thermal storage is connected indirectly to the at least one air conditioning system through at least one heat exchanger,
whereby
the thermal storage contributes to the moderation of a load connected to the at least one air conditioning system, and
the volume and integrity of the at least one thermal storage is maintained at a predetermined level, wherein the water in the at least one existing body of water is terminated from moderating the load in the at least one air conditioning system when the volume of the water in the at least one existing body of water falls below the predetermined level;
and
the useful temperature differential of the thermal storage is extended beyond 10°C.

12. A system according to Claim 11, the thermal storage comprising at least one existing body of water.
13. A system according to Claim 11, whereby the moderation of a load by the thermal storage is achieved by linking the thermal storage to at least one temperature changing means in series with the load.
14. A system according to Claim 11, whereby the moderation of a load by the thermal storage is achieved by linking the thermal storage directly to the load, bypassing the at least one temperature changing means.
15. A system according to Claim 11, wherein the thermal storage comprises one existing body of water, the volume and integrity of water in the one existing body of water preserved by mechanically arranging and at least one pump and a system of pipes to circulate water within the one existing body of water, whereby any reduction of water beyond a predetermined volume is prevented.

16. A system according to Claim 15, the prevention of any reduction of water is achieved by electromechanical means.
17. A system according to Claim 15, the prevention of any reduction of water is achieved by making the at least one pump lose its prime.
18. A system according to Claim 11, wherein the thermal storage comprises more than one existing bodies of water, the volume and integrity of water in the existing bodies of water preserved by mechanically arranging at least one pump and a system of pipes to circulate water among the more than one existing bodies of water whereby any reduction of water beyond a predetermined volume is prevented.
19. A system according to Claim 18, the prevention of any reduction of water is achieved by electromechanical means.
20. A system according to Claim 18, the prevention of any reduction of water is achieved by making the at least one pump lose its prime.



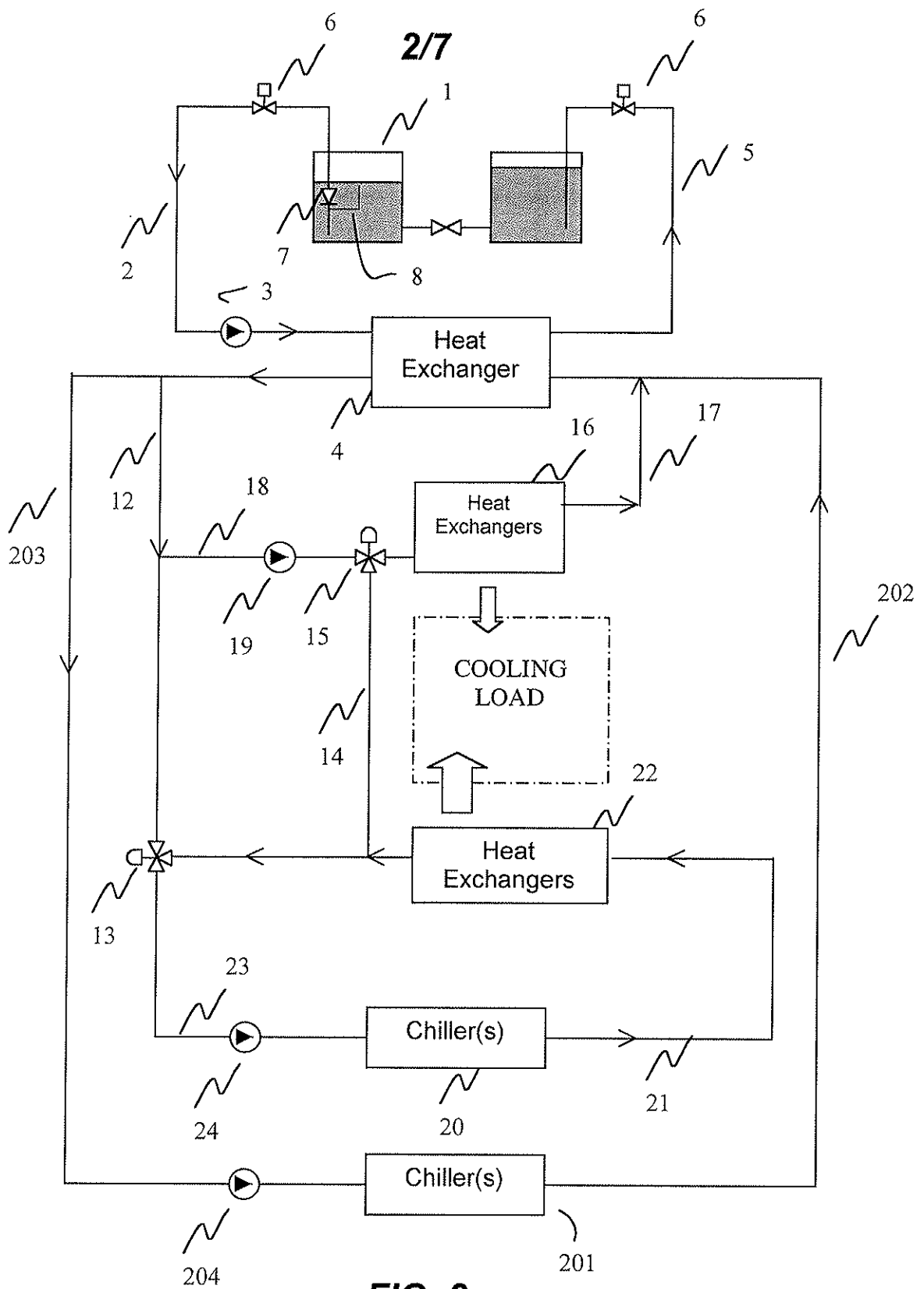


FIG. 2

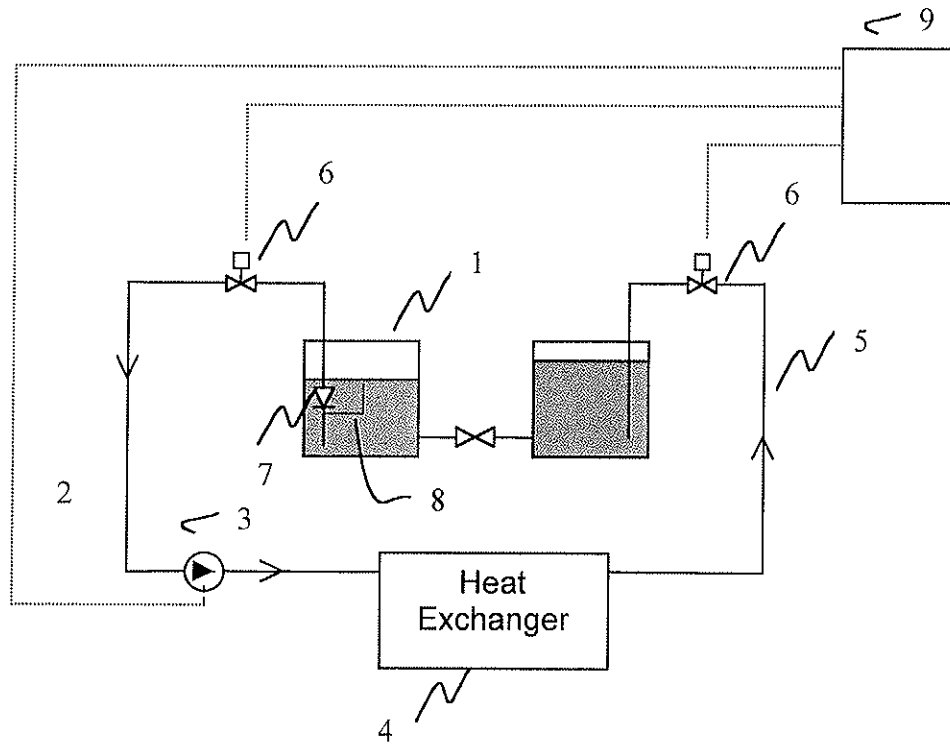


FIG. 3

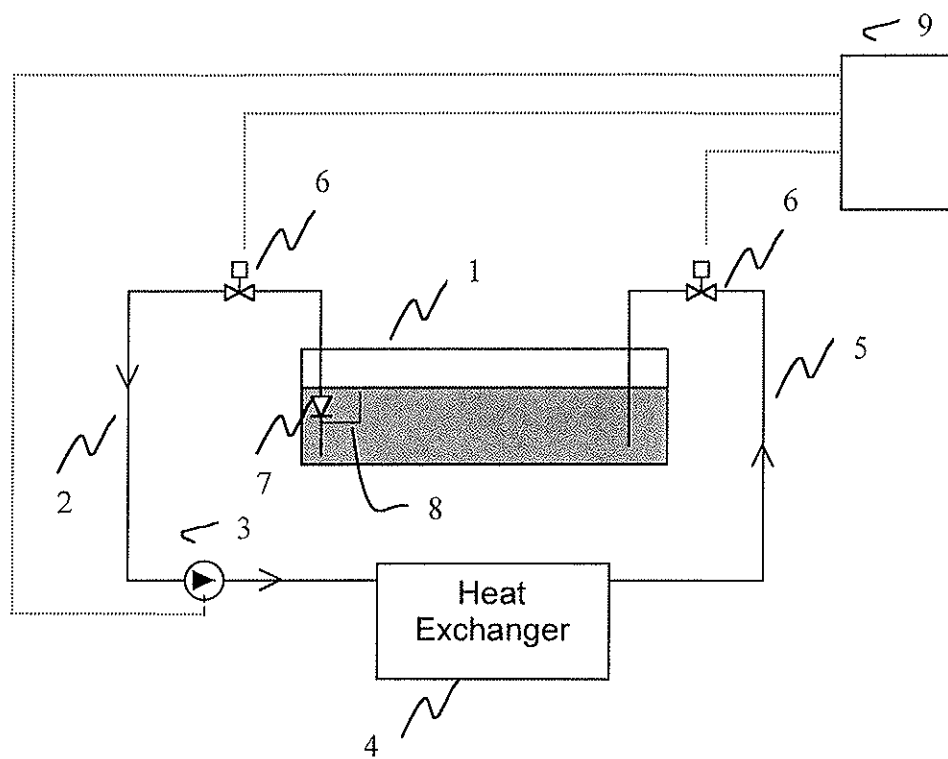


FIG. 4

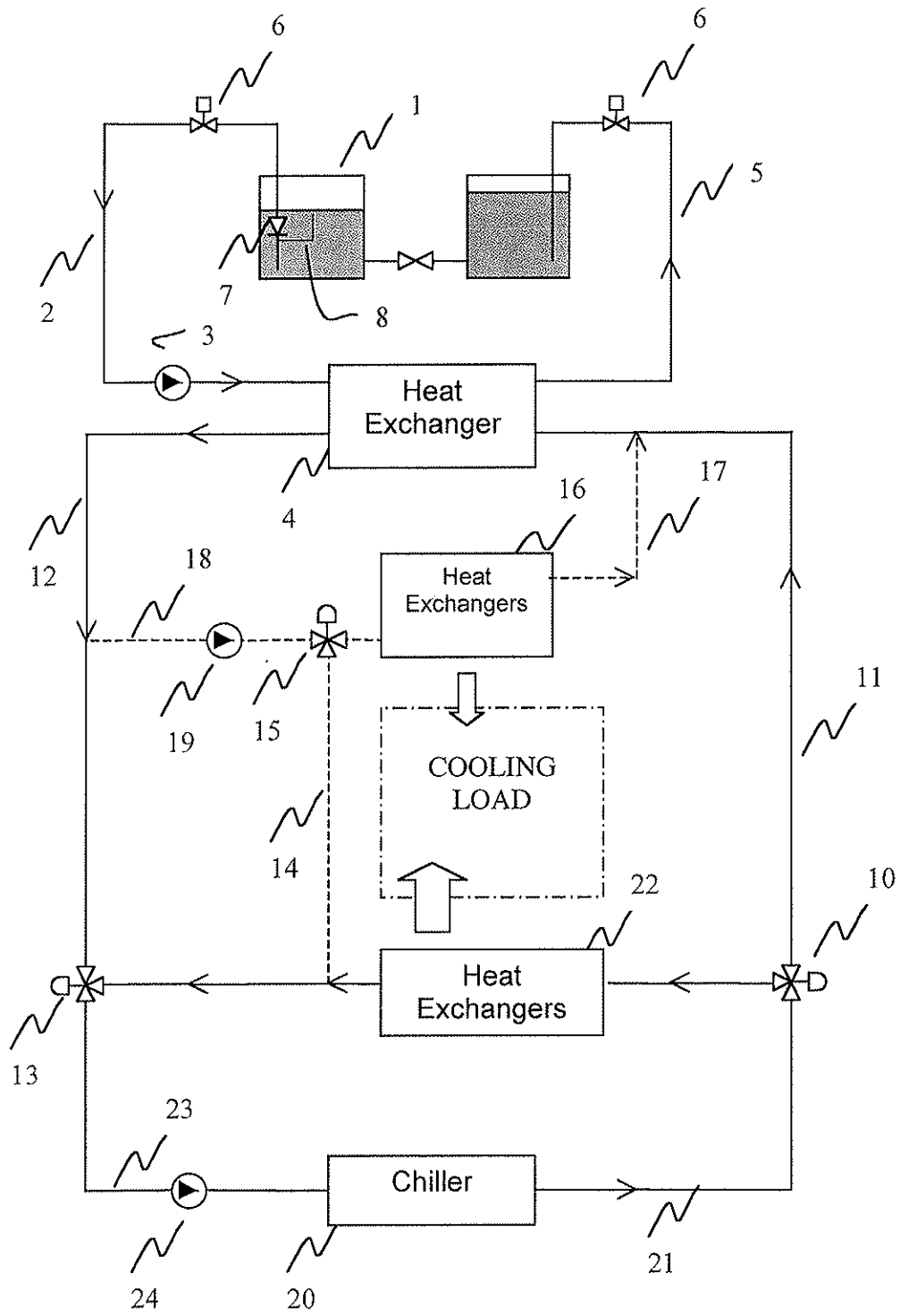


FIG. 5

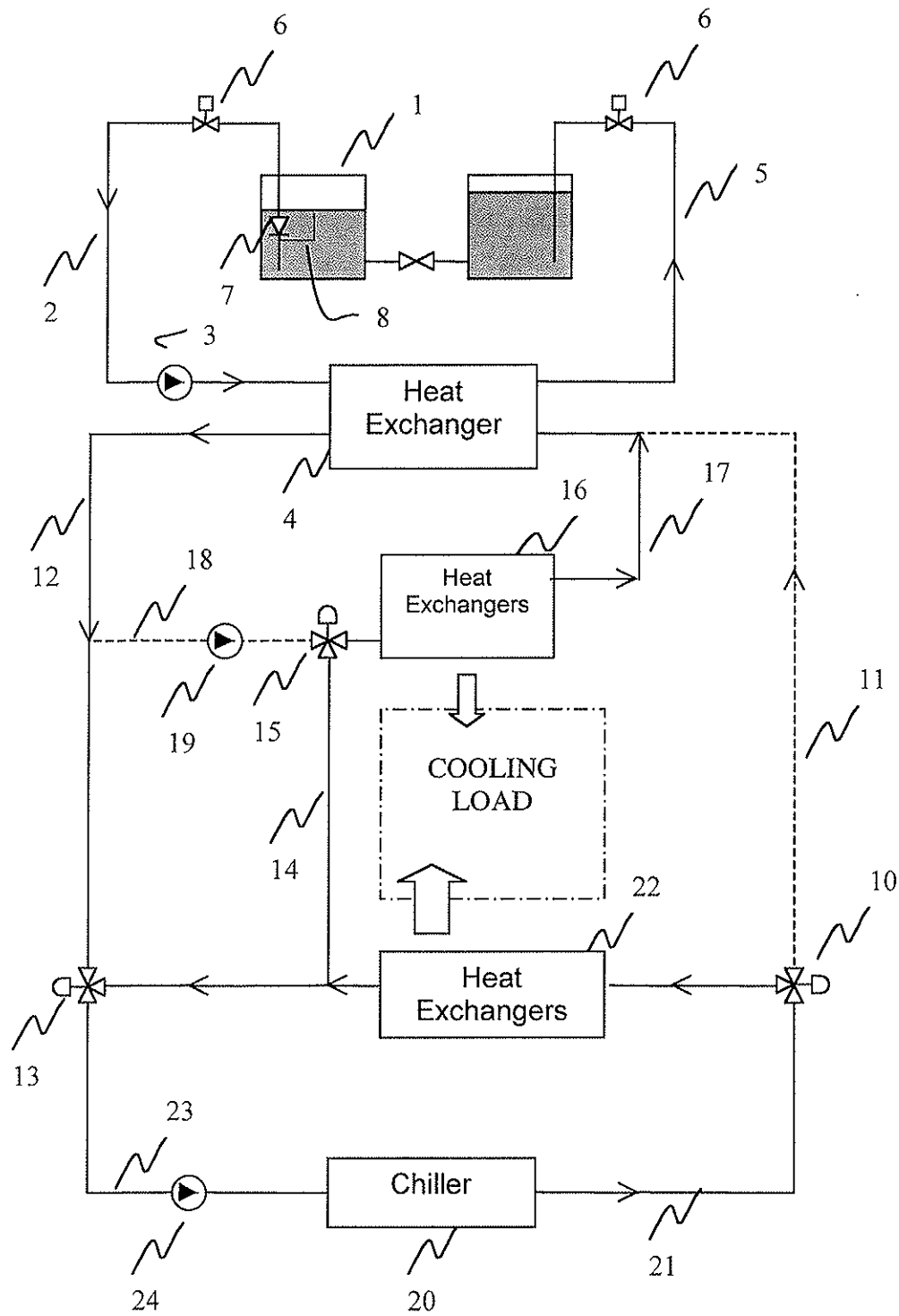


FIG. 6

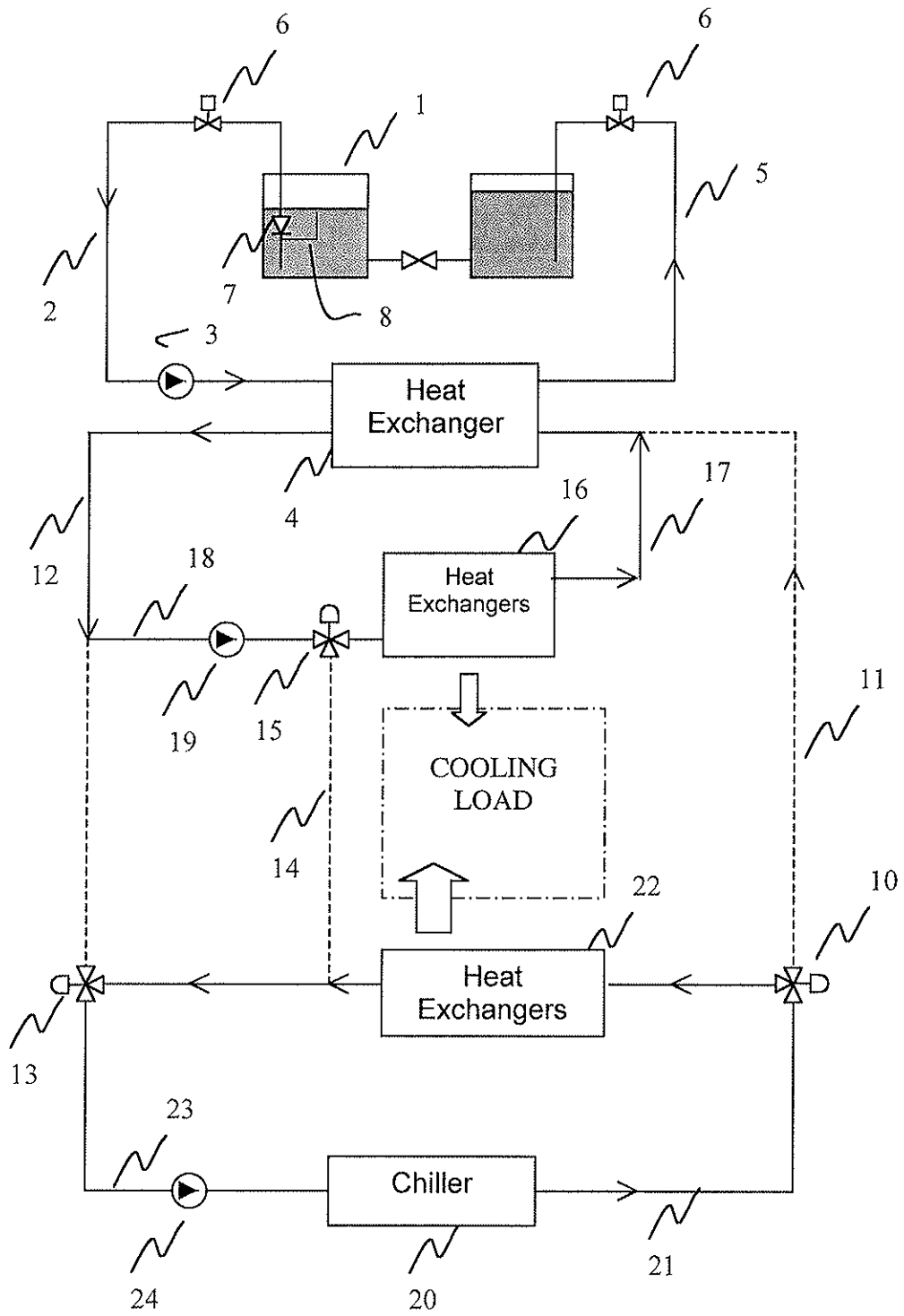


FIG. 7