PATENT APPLICATION FORM (CONVENTION AND NON-CONVENTION)

COMMONWEALTH OF AUSTRALIA

Regulation 9

Patents Act 1952

604871

LODGED AT SUB-OFFICE

1 3 APR 1988

Sydney

APPLICATION FOR A STANDARD PATENT OR A STANDARD PATENT OF ADDITION

(a) Insert full name(s) of applicant(s)

I/We (a) UWE ROCKENFELLER

(b) Insert address(es) of applicant(s)

of (b) 1453 Rawhide Road, Boulder City, Nevada 89005, U.S.A.

(c) Delete as appropriate

hereby apply for the grant of a (c) Standard Patent ~~Patent of Addition~~ for an invention entitled (d)

(d) Insert title of invention

CHEMICAL ENERGY STORAGE SYSTEM

which is described in the accompanying (c) ~~provisional~~ complete specification.

(e) For a Convention application — details of basic application(s) —

(e) for Convention cases only

NUMBER	COUNTRY	DATE OF APPLICATION
07/038,323	U.S.A.	April 14, 1987

(f) For Patents of Addition only.

(f) For Patents of Addition (Section 72):

I/We request that the Patent may be granted as a Patent of Addition

(g) Insert number of 'parent/main' application/or patent as appropriate.

(h) Insert name of applicant/patentee of 'parent/main' application or patent as appropriate.

the Patent applied for on Application No. (g)

to

Patent No. (g) in the name of (h)

I/We request that the term of the Patent of Addition be the same as that for the main invention or so much of the term of the patent for the main invention as is unexpired.

My/Our address for service is ARTHUR S. CAVE & CO., Patent and Trade Mark Attorneys, 1 Alfred Street, Sydney, New South Wales, Australia 2000.

(i) Insert day, month and year form signed.

Dated this (i) 23rd day of March 1988.

(j) Signature of applicant or Australian attorney.

(j) Uwe Rockenfeller

UWE ROCKENFELLER (Signature)

(k) Seal, if any.

(k)

To:

Commissioner of Patents

ARTHUR S. CAVE & CO.

PATENT AND TRADE MARK ATTORNEYS

SYDNEY

APPLICATION ACCEPTED AND AMENDMENTS

2-10-90

A.S.C. — 1

AUSTRALIA

PATENT DECLARATION FORM (CONVENTION)
COMMONWEALTH OF AUSTRALIA
"Patents Act 1952–1973"

Form 8

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION UNDER PART XVI FOR A PATENT OR PATENT OF ADDITION

To be signed by the applicant(s) or in the case of a Company, to be signed by a person authorised by the Company

In support of the Convention application made for a patent ~~of addition~~ for an invention entitled

(a) Insert title of invention.

(a) CHEMICAL ENERGY STORAGE SYSTEM

(b) Insert full name(s) of declarant(s).

I/~~We~~ (b) Uwe Rockenfeller

(c) Insert address(es) of declarant(s).

of (c) 1453 Rawhide Road
Boulder City, Nevada 89005, U.S.A.

do solemnly and sincerely declare as follows:-

1. I am/~~we are~~ the applicant~~(s)~~ for the patent ~~of addition~~.

(OR, IN THE CASE OF AN APPLICATION BY A BODY CORPORATE:)

~~1. I am/we are authorised by ..... the applicant for the patent of addition to make this declaration on its behalf.~~

2. The basic application(s) as defined by Section 141 of the Act was/were made in the following country or countries on the following date(s) namely:-

(d) Insert country in which basic application(s) was filed.
(e) Insert date of basic application(s).
(f) Insert number of basic application.

in (d) U.S.A. on (e) April 14, 1987 No. (f) 07/038,323
by (g) Uwe Rockenfeller
in (d) ..... on (e) ..... No. (f) .....
by (g) .....
in (d) ..... on (e) ..... No. (f) .....
by (g) .....

(g) Insert full names of applicant(s).

3. I am/~~we are~~ the actual inventor~~(s)~~ of the invention referred to in the basic application.

~~(OR, WHERE A PERSON OTHER THAN THE INVENTOR IS THE APPLICANT)~~

(h) Insert full name(s) of actual inventor(s)
(i) Insert address(es) of actual inventor(s).

3. (h) .....

of (i) .....

~~is/are the actual inventor(s) of the invention and the facts upon which I am/We are the Company is entitled to make the application are as follows:-~~

(k) Set out how applicant(s) derive(s) title from actual inventor(s) i.e., assignee of the invention from the actual inventor(s).

(k) .....

4. The basic application~~(s)~~ referred to in paragraph 2 of this Declaration was/~~were~~ the first application~~(s)~~ made in a Convention country in respect of the invention the subject of the application.

Attestation or legalization not required.

Declared at Las Vegas, Nevada this 23rd day of March 19 88

To:

The Commissioner of Patents,
COMMONWEALTH OF AUSTRALIA

ARTHUR S. CAVE & CO.
PATENT AND TRADE MARK ATTORNEYS
SYDNEY

UWE ROCKENFELLER
(Signature of Declarant)

A.S.C.—4

(12) PATENT ABRIDGMENT (11) Document No. AU-B-14586/88
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 604871

(54) Title
CHEMICAL ENERGY STORAGE SYSTEM

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(56) Prior Art Documents
US 4638646
US 4458500
US 4186794

(57) Claim

1. Apparatus for alternatively charging and discharging thermal energy and comprising:

a first vessel or chamber containing a liquid solution of a compound selected from the group consisting of alkali and alkaline earth metal hydroxide, lithium chloride, lithium bromide, calcium chloride and calcium bromide, and mixtures thereof said solution having an initial concentration of between 30% and 70%, by weight of said compound, said liquid selected from the group consisting of water, an alcohol having between 1 and 8 carbon atoms and, glycerol and glycol ethers, and a first space above the level of said liquid solution;

a second vessel or chamber containing said liquid without said compound therein, and a second space above the level of said liquid;

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both said first and second vessels being closed to atmosphere and capable of holding a vacuum, conduit means comminicating between said first space and said second space for allowing liquid vapor and pressure changes to pass therebetween, and valve means cooperating with said conduit means for controlling communication between said spaces, heating means for heating said solution to a temperature of above about 32°C, and cooling means for cooling said liquid to a temperature below about 12.5°C,

means for pumping said solution to solution distribution means for directing said solution into said first space, and means for pumping said liquid to liquid distribution means for directing said liquid into said second space;

first heat exchange means cooperating with said first vessel for transferring heat from solution therein, and second heat exchange means cooperating with said second vessel for transferring heat to liquid therein,

said first exchange means being adapted to heat said solution during charging and cool said solution during discharging, and said second heat exchange means being adapted to cool said liquid during charging and heat said liquid during discharging.

7. A heat exchange process for alternately charging and discharging a thermal energy collection system comprising a first vessel or chamber containing a liquid solution of an alkali and alkaline earth metal hydroxide, lithium chloride, lithium bromide, calcium chloride or calcium bromide, a second vessel or chamber containing said liquid only without said compound, a first space in said first vessel above the liquid

.../3

solution level and a second space in said second vessel above the liquid level, and means for pumping said liquid solution to solution distribution means for spraying said liquid solution into said first space and said liquid to liquid distribution means for spraying said liquid into said second space, both said first and second vessels being closed to atmosphere and capable of holding a vacuum, conduit means communicating between said first space and said second space for allowing liquid vapor and pressure changes to pass therebetween, valve means cooperating with said
conduit means for selectively terminating communication between said spaces, first heat exchange means for heating and cooling said liquid solution and second heat exchange means for heating and cooling said liquid, characterized by:

(a) charging said system by opening said valve and heating said solution in said first vessel to a temperature of above about 32°C while concurrently cooling the liquid in said second vessel to a temperature below about 12.5°C and continuing said respective heating and cooling until the concentration of the compound in said first vessel is between 6% and 25% greater than said initial concentration,

at the end of said charging, terminating said heating of said solution and said cooling of said liquid and closing said valve means, and

(b) selectively discharging said system by opening said valve, exposing said cooled liquid in said second vessel to heat exchange means for recovering the relatively low thermal energy thereof while pumping said liquid to said liquid distribution means and spraying said liquid in said second

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space, and concurrently exposing said heated solution in said first vessel to heat exchange means for cooling said solution while pumping said solution to said solution distribution means and spraying said solution into said first space.

AUSTRALIA

PATENTS ACT 1952

604871

COMPLETE SPECIFICATION

(ORIGINAL)

FOR OFFICE USE

This document contains the amendments made under Section 49 and is correct for printing

Application Number:
Lodged:

Complete Specification Lodged:
Accepted:
Published:

Priority:
Related Art:

TO BE COMPLETED BY APPLICANT

Name of Applicant:	UWE ROCKENFELLER
Address of Applicant:	1453 Rawhide Road, Boulder City, Nevada 89005, U.S.A.
Actual Inventor:	UWE ROCKENFELLER
Address for Service:	ARTHUR S. CAVE & CO. Patent & Trade Mark Attorneys Level 10 10 Barrack Street SYDNEY N.S.W. 2000 AUSTRALIA

Complete Specification for the invention entitled CHEMICAL ENERGY STORAGE SYSTEM.

The following statement is a full description of this invention including the best method of performing it known to me:-

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ASC 49

CHEMICAL ENERGY STORAGE SYSTEM

BACKGROUND OF THE INVENTION

With the high cost of electrical energy required to operate air conditioners or heat pumps for cooling buildings, and particularly with the heavy demands for commercial building cooling systems at peak use hours, attention has been directed to various types of thermal energy storage systems. Such energy storage is advantageous since the building cooling and/or heating and process cooling may be generated and stored during off-peak hours at night when most businesses are normally closed, with the ambient outside temperatures being cooler and municipal power requirements reduced.

Most state of the art thermal energy storage systems are based on a solid to liquid phase change using energy storage in a narrow temperature range. Water based systems using ice storage are especially desirable because of low fluid costs and availability. However, the disadvantages of such systems include low evaporator temperature requirements because thermal gradient forces evaporator temperatures to a level far below 32°F, also reducing the chiller efficiency, incomplete or low phase change, often in the order of about 50% to 55%, and low overall energy density of 80 BTU/lb. However, due to the exceptional environmental acceptability qualities and large availability, water is preferred above more corrosive, volatile, expensive and less readily available energy storage materials.

SUMMARY OF THE INVENTION

The present invention provides an apparatus for alternatively charging and discharging thermal energy and comprising:

a first vessel or chamber containing a liquid solution of a compound selected from the group consisting of alkali and alkaline earth metal hydroxide, lithium chloride, lithium bromide, calcium chloride and calcium bromide, and mixtures thereof said solution having an initial concentration of between 30% and 70%, by weight of said compound, said liquid selected from the group consisting of water, an alcohol having between 1 and 8 carbon atoms and, glycerol and glycol ethers, and a first space above the level of said liquid solution;

a second vessel or chamber containing said liquid without said compound therein, and a second space above the level of said liquid;

both said first and second vessels being closed to atmosphere and capable of holding a vacuum, conduit means communicating between said first space and said second space for allowing liquid vapor and pressure changes to pass there between, and valve means cooperating with said conduit means for controlling communication between said spaces, heating means for heating said solution to a temperature of above about 32°C, and cooling means for cooling said liquid to a temperature below about 12.5°C,

means for pumping said solution to solution distribution means for directing said solution into said first space, and means for pumping said liquid to liquid distribution means for directing

said liquid into said second space;

first heat exchange means cooperating with said first vessel for transferring heat from solution therein, and second heat exchange means cooperating with said second vessel for transferring heat to liquid therein,

said first exchange means being adapted to heat said solution during charging and cool said solution during discharging, and said second heat exchange means being adapted to cool said second heat exchange means being adapted to cool said liquid during charging and heat said liquid during discharging.

The present invention also provides a heat exchange process for alternately charging and discharging a thermal energy collection system comprising a first vessel or chamber containing a liquid solution of an alkali and alkaline earth metal hydroxide, lithium chloride, lithium bromide, calcium chloride or calcium bromide, a second vessel or chamber containing said liquid only without said compound, a first space in said first vessel above the liquid solution level and a second space in said second vessel above the liquid level, and means for pumping said liquid solution to solution distribution means for spraying said liquid solution into said first space and said liquid to liquid distribution means for spraying said liquid into said second space, both said first and second vessels being closed to atmosphere and capable of holding a vacuum, conduit means communicating between said first space and said second space for allowing liquid vapor and pressure changes to pass therebetween, valve means cooperating with said conduit means

for selectively terminating communication between said spaces, first heat exchange means for heating and cooling said liquid solution and second heat exchange means for heating and cooling said liquid, characterized by

(a) charging said system opening said valve and heating said solution in said first vessel to a temperature of above about 32°C while concurrently cooling the liquid in said second vessel to a temperature below about 12.5°C and continuing said respective heating and cooling until the concentration of the compound in said first vessel is between 6% and 25% greater than said initial concentration,

at the end of said charging, terminating said heating of said solution and said cooling of said liquid and closing said valve means, and

(b) selectively discharging said system by opening said valve, exposing said cooled liquid in said second vessel to heat exchange means for recovering the relatively low thermal energy thereof while pumping said liquid to said liquid distribution means and spraying said liquid in said second space, and concurrently exposing said heated solution in said first vessel to heat exchange means for cooling said solution while pumping said solution to said solution distribution means and spraying said solution into said first space.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1. is a schematic sectional view of a first embodiment of the system of the invention used in direct heat

transfer;

Fig. 2. is a schematic sectional view of the system of the invention using a direct exapansion system; and

Fig. 3. is a schematic sectional elelvation illustrating a system for use in an indirect heat transfer system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The basic invention comprises charging the energy storage system by heating an aqueous salt solution and cooling water in separate vessels to a liquid temperature differential of at least 30°F, and preferably 50°F or

more up to about 180°F differential. The vessels are separated although the space above each liquid in the respective vessels are in communication until the desired vapor mass transfer is completed. Thereafter the spatial communication is terminated until it is desired to discharge the energy stored in the system as will be described hereinafter.

In Fig. 1 there is shown an illustration of a first embodiment of the chemical thermal storage system of the invention. The apparatus illustrated schematically comprises a container 10 having two cavities or vessels 12 and 14 separated by a baffle or wall 24. The container must be air-tight so that the two cells or cavities can selectively maintain different vapor pressures. It will be appreciated that although a single container 10 is shown having the two vessels, different containers may be used, the important consideration being that two vessels or cavities are required for holding two different liquids of the system with means for transferring water vapor and communicating vapor pressure differentials between the vessels.

In the preferred embodiment shown, a valve 26 communicates between the spaces of the two vessels above the liquid levels. The valve, conveniently located in wall 24, is preferably a butterfly valve with an orifice of several inches and associated with convenient means for opening and closing the valve. A first liquid composition

16 is located in first vessel 12 and fills the cavity only partially leaving a space 20 above the liquid level. Similarly, in second vessel 14, liquid 18 only partially fills the cavity leaving a second space 22 above the liquid level. It is the spaces 20 and 22 which are in communication via valve 26 which can be selectively opened or closed to allow for water vapor to pass between the two spaces thereby maintaining vapor pressure differential between the two vessels when the valve is closed.

In the first vessel 12 is a liquid solution of an alkali or alkaline earth metal hydroxide or lithium or calcium chloride or bromide or mixtures thereof having initial concentrations of between about 30 and about 70%, and preferably between about 40% and 60%, by weight. In the second vessel 14 is liquid 18. The preferred solvent in vessel 12 and liquid in vessel 14 is water although lower alcohols, glycerol, alkylene, glycol ethers and aqueous solutions or mixtures thereof may also be used. Lower alcohols are those having between 1 and 8 carbon atoms with methanol and ethanol being preferred. Suitable glycol ethers include ethylene glycol dimethyl ether, diethylene glycol diethyl ether, etc. Most preferred salts are the alkali or alkaline earth metal hydroxides especially those of sodium, potassium, cesium, magnesium, lithium, strontium and calcium. Mixtures of these hydroxides may also be used together with lithium chloride or lithium bromide or calcium chloride as well as nitrate

salts of those metals as corrosion suppressing additives, in systems where corrosion may be a problem. Organic additives, such as long chain alcohols having 7-12 carbon atoms or glycol and its derivatives may be used to increase the sorption rates, increase the differential pressure and serve as freeze point suppressants in vessels 12 and 14. For this purpose, plastic vessels or containers which are resistant to the aqueous hydroxide solutions are to be used as are plastic tubing or conduits. Other materials that are lined or coated with compositions which are not susceptible to corrosion when exposed to the strong hydroxide compositions may be used.

The apparatus also includes suitable conduits, pumps and spray nozzle systems for handling the liquids in the respective cavities. Thus, conduits 30 and 32, and pump 34 direct aqueous solution 16 from vessel 12 to a heat exchanger, for example, a condenser of a heat pump or chiller or a waste heat source (not shown) for heating the solution to a desired temperature of at least 30°F and preferably at least 50°F higher than the temperature of water in second vessel 14. Preferred solution temperatures are between about 85° and about 130°F although higher temperatures may be used. The heated solution is then directed to first space 20. A preferred method of returning the heated aqueous solution to the first vessel incorporates a nozzle or spray nozzle system 36 which simply sprays the heated aqueous composition in the form

of droplets or a fine mist into first space 20 above the surface of liquid 16 in vessel 12. Any suitable spray nozzle means may be used for this purpose. Similarly, in second vessel 14, water 18 is pumped to a heat exchanger by pump 44 via line 42 where it is cooled, for example, by an air conditioning or heat pump evaporator, cooling tower or other evaporative cooling means or an air to air means after which the cooled water is directed via pipe 40 to second space 22 above the water level using a spray nozzle means 46.

In operating the above-described apparatus in a storage system of the invention, preferably, during the night, or otherwise at relatively low ambient temperature conditions and when area or municipal use loads are at below peak or high requirements, aqueous solution 16 is heated with condenser heat from a building heat pump system, or otherwise heated conveniently to a temperature of above about 85°F up to about 130°F. At the same time, water 18 is cooled to a temperature of below about 55°F, and preferably below 35°F, using an evaporator from a building heat pump or air conditioning system. Because the vapor pressure of the aqueous solution, for example 42% NaOH, by weight, at 120°F is higher than the vapor pressure of water at 34°F, the solution will desorb water in the form of water vapor via open valve 26 into second space 22 which condenses into the liquid water 18. This process continues until a solution concentration of

approximately 52% of NaOH, by weight, is achieved. At that point, the system is charged, and valve 26 is closed to separate the first and second spaces in the two vessels and maintain vapor pressure differential which thereby allows the charged system to remain stored for an indefinite period of time.

When it is desired to utilize the stored energy in the system created by the above-described charging process, the cold water is circulated to a heat exchanger for the building, for example, passed through a cooling coil in an air handler for cooling the building. During this discharge period, again, the water is pumped via pipe 42 using pump 44 to the building air handler or other heat exchange cooling means, and returned via pipe 40 to second vessel 14 using the spray nozzle device 46. The water thus becomes heated as it absorbs or picks up building heat through the heat transfer system during this discharge phase. Concurrently, hot aqueous solution 16 is pumped via pipe 32 and pump 34 to outside air heat exchangers or coolers such as evaporative coolers, cooling towers and the like thereby cooling the aqueous solution which is then returned via pipe 30 and discharged into first space 20 using a spray apparatus 36.

During this discharge cycle, valve 26 must be opened and because of the difference in vapor pressure between the first and second spaces, 20 and 22 respectively, water is evaporated in second space 22 to provide

substantial cooling of the liquid in second vessel 14. At the same time, the evaporated water is passed into first space 20 where it is absorbed into solution 16, which causes a heat of condensation and solutions in first vessel 12, which heat is again exchanged by the outside cooling means (not shown) previously discussed. Alternatively, the heat of condensation and solutions in first vessel 12 may be used for heating purposes, for example in a dual temperature storage capability for building heating and cooling.

In Fig. 2 there is illustrated another variation or embodiment of a system according to the invention in which a coolant, such as a refrigerant may be directly cooled or condensed at low temperature during discharge of the energy storage system of the invention. Again, a container 10 having two vessels or cavities as illustrated in Fig. 1 may be used with a divider 24 separating the two cavities. The liquid solution 16 and water 18 in the respective containers are substantially like that previously described as is the change of vapor pressure and exchange of water vapor between the cavities 20 and 22, respectively, through valve 26, in both the charging and discharging phases of the operation of the system. In this embodiment, the water is cooled during the charging phase by direct exposure to evaporator coils of an air conditioning system evaporator. For example, the air conditioning system of the building may utilize a cooling

conduit 66 which is exposed directly in second cavity 22 through which cold refrigerant is directed during the charging phase. At that time, water 18 will be pumped via pump 60 and conduit 58 and sprayed through spray nozzle apparatus 46 over the cold pipe or coil 66 to be cooled. Concurrently, with valve 26 open during the charging phase, aqueous solution 16 is heated by pumping the solution via pump 54 and conduit 52 through spray nozzle apparatus 36 over heated pipe or coils 56 from a condenser 75 or other heating means including a heat exchanger of the HVAC (heating ventilation air conditioning) equipment condensing the refrigerant. In that case, hot refrigerant may be directed into pipe or coil 56 via pump 74 from the heat exchanger 75. Once the vapor mass transfer between the liquid solution 16 and water 18 is achieved during this charge phase, further heating and cooling, respectively is terminated and valve 26 is closed thereby again maintaining the energy charged in the respective liquids stored until its use is desired.

During discharge, valve 26 is opened, and the respective liquids are pumped through their respective nozzle sprayers over the heat exchange conduits present in the spaces in the respective vessel. Refrigerant directed via conduit or coil 66 is cooled by evaporation of water as water is sprayed over the coil in space 22, the water gradually becoming heated as it picks up heat as it cools the refrigerant from heat exchanger 72. Similarly, in

this discharge phase of operation, heat from solution 16 is removed by heat exchanger 75 which similarly pumps a coolant via coil 56 present in space 20.

A third apparatus configuration utilizing an indirect heat transfer system is illustrated in Fig. 3. In this apparatus, substantially like that described in Fig. 2, a heat exchanger 76 is used for directly heating and cooling liquid 16 in the charge and discharge phases, respectively of the operation of the system by pumping a heat transfer fluid with pump 74. The heat exchanger illustrated utilizing water with the system is somewhat different in that pump 77 will direct a heat transfer material such as water, ammonia, methanol, glycol-water mixtures, and the like through remote heat exchanger 71, 73 and 79 at various locations throughout a building in which the system is to operate. Pump 77 simply pumps the secondary cooling material via pipe 70 to the respective heat exchangers, with the pipe 70 being exposed in space 22 over which water is sprayed as previously discussed regarding the apparatus shown in Fig. 2.

The specific types of heat exchangers and apparatus used within the purview of the scope of the system described herein are not so important, and other types of systems may be used to achieve the same purpose. Thus, the specific design of the systems shown and described herein are for the purpose of illustration only and the invention is not be ne necessarily limited thereto. These

as well as other modifications, variations and advantages of the system within the purview of the invention will be evident to those skilled in the art.

The claims defining the invention are as follows:

1. Apparatus for alternatively charging and discharging thermal energy and comprising:

a first vessel or chamber containing a liquid solution of a compound selected from the group consisting of alkali and alkaline earth metal hydroxide, lithium chloride, lithium bromide, calcium chloride and calcium bromide, and mixtures thereof said solution having an initial concentration of between 30% and 70%, by weight of said compound, said liquid selected from the group consisting of water, an alcohol having between 1 and 8 carbon atoms and, glycerol and glycol ethers, and a first space above the level of said liquid solution;

a second vessel or chamber containing said liquid without said compound therein, and a second space above the level of said liquid;

both said first and second vessels being closed to atmosphere and capable of holding a vacuum, conduit means comminicating between said first space and said second space for allowing liquid vapor and pressure changes to pass therebetween, and valve means cooperating with said conduit means for controlling communication between said spaces, heating means for heating said solution to a temperature of above about 32°C, and cooling means for cooling said liquid to a temperature below about 12.5°C,

means for pumping said solution to solution distribution means for directing said solution into said first space, and means for pumping said liquid to liquid distribution means for directing said liquid into said second space;

first heat exchange means cooperating with said first vessel for transferring heat from solution therein, and second heat exchange means cooperating with said second vessel for transferring heat to liquid therein,

said first exchange means being adapted to heat said solution during charging and cool said solution during discharging, and said second heat exchange means being adapted to cool said liquid during charging and heat said liquid during discharging.

2. Apparatus of claim 1 including means for directing the solution successively to said first heat exchange means and said solution distribution means, respectively, and means for directing said liquid successively to said second heat exchange means and said liquid distribution means, respectively.

3. Apparatus of claim 1 or claim 2, wherein said first heat exchange means includes a first heat exchange pipe exposed in said first space and wherein said solution distribution means directs said solution over the first heat exchange pipe in said first space.

4. Apparatus of any one of claims 1 to 3 wherein said second heat exchange means includes a second heat exchange pipe exposed in said second space and wherein said liquid distribution means directs said liquid over said second heat exchange pipe.

5. Apparatus of any one of claims 1 to 4, wherein said first heat exchange means include evaporative or air to air cooling means and first supplemental heat transfer means comprising a

first conduit loop having heat transfer liquid therein and a pump cooperating therewith for pumping heat transfer liquid through said first conduit loop, said first conduit loop extending between said first space and said exaporative or air to air cooling means.

6. Apparatus of any one of claims 1 to 5, wherein said second heat exchange means includes a heat pump evaporator and second supplemental heat transfer means comprising a second conduit loop having a heat transfer liquid therein and a pump cooperating therewith for pumping said heat transfer liquid through said second conduit loop, said second conduit loop extending between said second space and said evaporator.

7. A heat exchange process for alternately charging and discharging a thermal energy collection system comprising a first vessel or chamber containing a liquid solution of an alkali and alkaline earth metal hydroxide, lithium chloride, lithium bromide, calcium chloride or calcium bromide, a second vessel or chamber containing said liquid only without said compound, a first space in said first vessel above the liquid solution level and a second space in said second vessel above the liquid level, and means for pumping said liquid solution to solution distribution means for spraying said liquid solution into said first space and said liquid to liquid distribution means for spraying said liquid into said second space, both said first and second vessels being closed to atmosphere and capable of holding a vacuum, conduit means communicating between said first space and said second space for allowing liquid vapor and pressure changes to pass therebetween, valve means cooperating with said

conduit means for selectively terminating communication between said spaces, first heat exchange means for heating and cooling said liquid solution and second heat exchange means for heating and cooling said liquid, characterized by:

(a) charging said system by opening said valve and heating said solution in said first vessel to a temperature of above about 32°C while concurrently cooling the liquid in said second vessel to a temperature below about 12.5°C and continuing said respective heating and cooling until the concentration of the compound in said first vessel is between 6% and 25% greater than said initial concentration,

at the end of said charging, terminating said heating of said solution and said cooling of said liquid and closing said valve means, and

(b) selectively discharging said system by opening said valve, exposing said cooled liquid in said second vessel to heat exchange means for recovering the relatively low thermal energy thereof while pumping said liquid to said liquid distribution means and spraying said liquid in said second space, and concurrently exposing said heated solution in said first vessel to heat exchange means for cooling said solution while pumping said solution to said solution distribution means and spraying said solution into said first space.

8. A process of claim 7 comprising providing elements of said first heat exchange means in said first space and providing elements of said second heat exchange means in said second space, and during said charging and discharging spraying said solution and said liquid over said elements of said first

and second heat exchange means, respectively.

9. An apparatus for transfering heat, substantially as herein described with reference to the drawings.

10. A heat exchange process substantially as herein described with reference to the drawings.

DATED this 15th day of August, 1990.

UWE ROCKENFELLER
By His Patent Attorneys
ARTHUR S. CAVE & CO.

14586/88

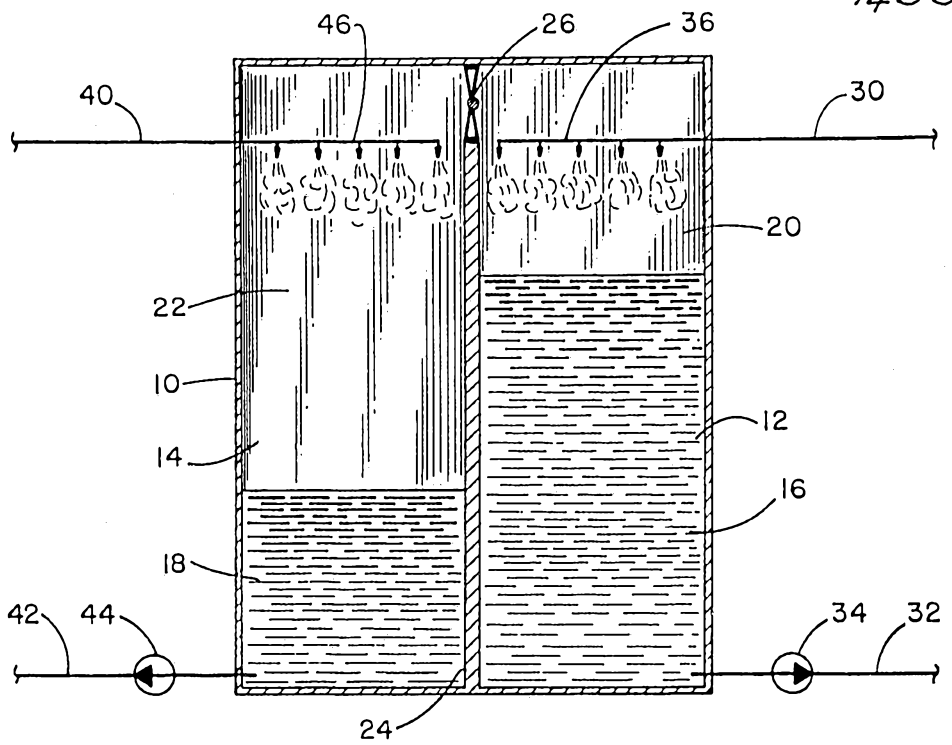

FIG. 1

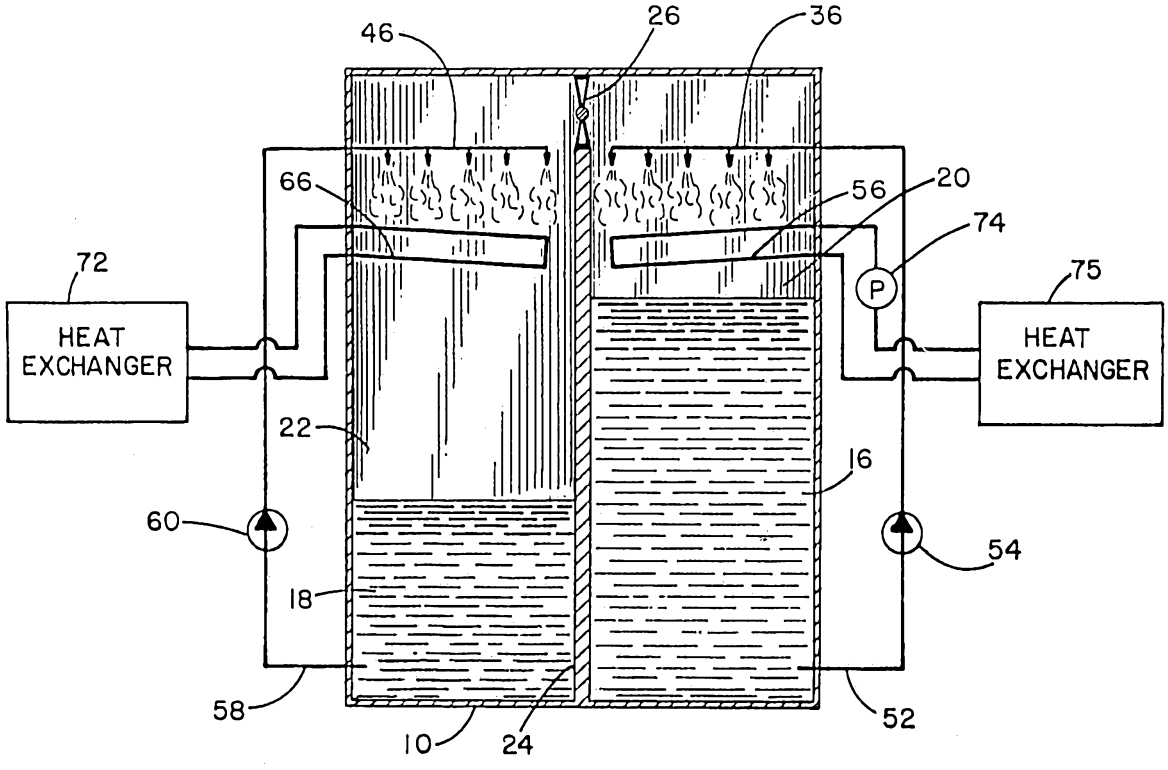

FIG. 2

14586/88

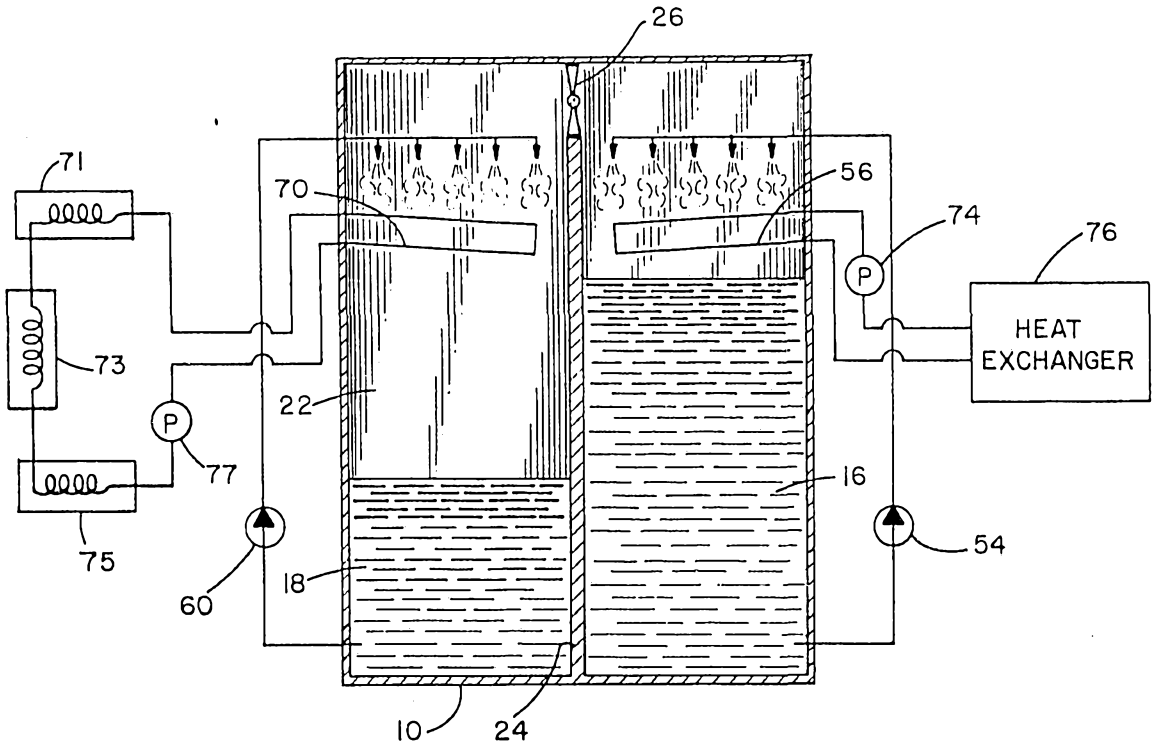

FIG. 3