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AMMONIA/WATER REFRIGERATION SYSTEM

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OBJECTIVE

The objective of this group project has been to get on experience of the operation and testing of the intermittent refrigeration ammonia-water system.

This report, describes the operation and the problems of the existing unit at TREEO Center; few possible modifications are also suggested. The chapter VI of the report gives design calculations of a 3 ton ammonia-water intermittent absorption refrigeration system.

INTRODUCTION.

Since the warmest seasons of the year correspond to periods of high insolation, it is interesting to note that solar energy is most available when cooling is most needed. This natural mtch between the solar and cooling load cycle suggests that solar energy is well suited for cooling application. The main cause for the need of cooling in developing countries is preservation of food and medicine. This could be achieved by using low grade heat available from solar energy. The importance of solar energy greatly increases for remote places where electricity or other conventional source of energy is ~~most~~ not available.

Out of the various possible systems, such as absorption refrigeration (continuous and intermittent), vapor-compression, desiccant, etc., the intermittent absorption-refrigeration system appears to be more promising for developing countries. This is because the system comprises of less number of components than the continuous system for the same cooling load. Further, it does not need any rotating part and has advantage of simplicity of operation and maintenence.

BASIC ABSORPTION REFRIGERATION CYCLE.

Absorption refrigeration is based on the relationship between the equilibrium concentration of a refrigerant in a solution and the solution's temperature and pressure. Solutions used for absorption refrigerant have a high equilibrium concentration of refrigerant at low temperatures and a low equilibrium concentration at high temperatures.

An absorption refrigeration machine uses heat energy to provide cooling. ~~When a~~ Liquid mixture of refrigerant flows from the generator through a condenser, expansion valve, and evaporator then into an absorber where it recombines with the absorbent.

An absorbent is a liquid which combines chemically with the refrigerant at low temperatures. In the combination process, heat absorbed by the refrigerant is released.

1.- Intermittent ammonia-water absorption:

Intermittent ammonia-water absorption system is simple, both in design and operation. It's principle of operation can be explained by considering a unit of two tanks connected at the top by a pipe and the control valves (Figure 1).

The left tank in the figure contains an ammonia-water solution. If warm water is circulated from a flat plate collector or from a hot water storage tank through the heating coil in this tank, ammonia is driven out of the solution. This ammonia vapor is condensed in the other tank using a cooling coil or air cooling. This is the charging period or the generation-condensation cycle.

With the heating water turned off, the ammonia flows to the water to be reabsorbed. This produces boiling in the right tank, lowering its temperature,

This is the cooling period or the evaporator-condenser cycle. The control valve determines the refrigeration temperatures and the desired cooling rates. The generation-condensation cycle takes about 1/4 of the time to charge the system allowing 3/4 time for the evaporator-condenser cycle or cooling period. For this reason this system is referred to as an intermittent systems.

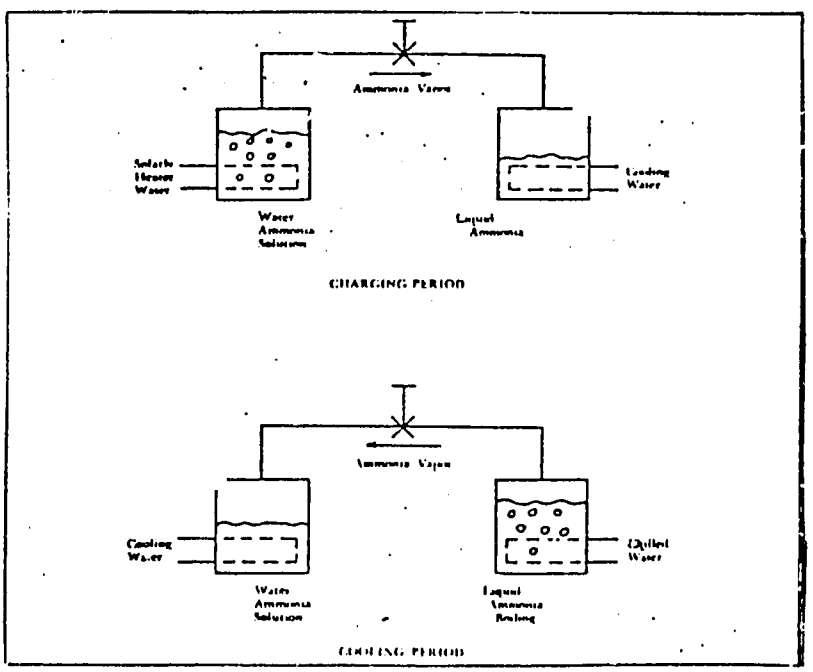


Figure 1. SCHEMATIC DIAGRAM OF INTERMITTENT ABSORPTION REFRIGERATION SYSTEM

2.- Continous absorption refrigeration system:

The solution in the absorber is at a low temperature and enters the absorber with a refrigerant concentration below the equilibrium concentration for the conditions in the absorber. The refrigerant vapor returning from the evaporator will then go into the solution until an equilibrium condition is reached. During this process some heat will be released and the absorber must be cooled. This refrigerant solution of high concentration is pumped from the absorber into the heated generator. As a result, the refrigerant will be driven out of the solution as a vapor and flows to the condenser. The solution remaining in the generator returns to the absorber through a valve to complete the solution cycle.

The absorber-generator operates on the chance of the solubility of the refrigerant with temperature and pressure. In the heated, elevated pressure and temperature generator, the refrigerant solubility is low, while the refrigerant concentration is high and the refrigerant is driven out of the solution. In the cool, low-pressure absorber, the refrigerant solubility is quite high, while the refrigerant concentration in the solution is low.

Only two solutions satisfy these criteria closely. These are the ammonia-water solution with the ammonia as refrigerant and the lithium bromide-water solution with the water serving as the refrigerant.

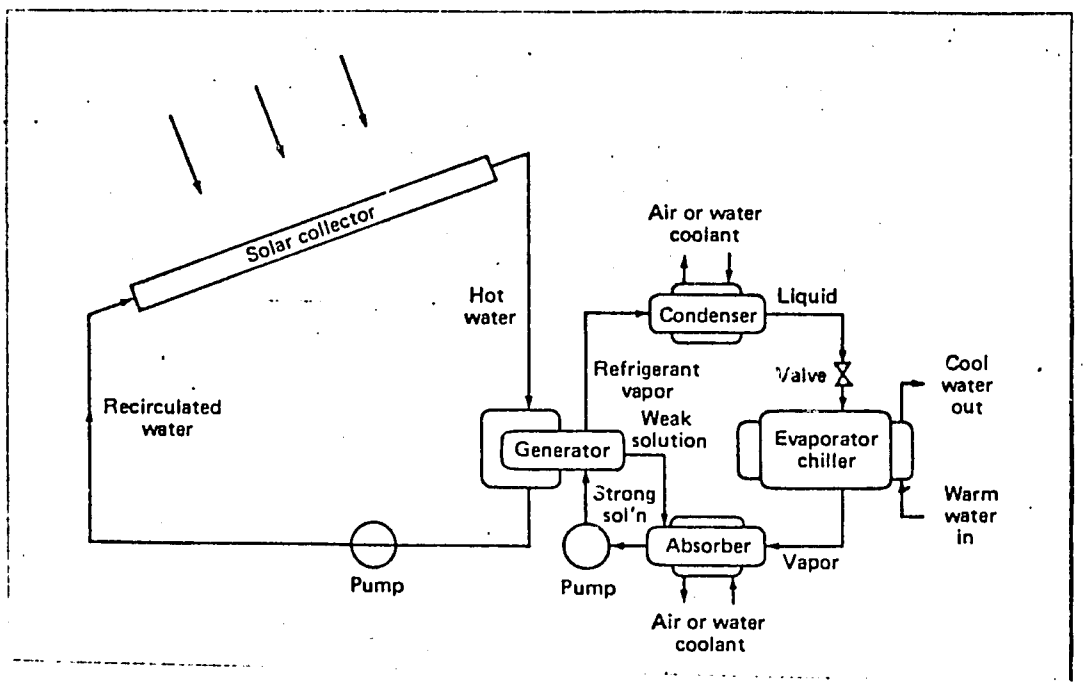


Figure 2. SCHEMATIC DIAGRAM OF A CONTINUOUS ABSORPTION REFRIGERATION SYSTEM.

CHARACTERISTICS OF THE REFRIGERANT ABSORBENT PAIR:

Desirable characteristics for the refrigerant-absorbent pair are:

1.- The absence of a solid-phase absorbent.

2.- An absorbent that has a small affinity for the refrigerant.

3.- A refrigerant more volatile than the absorbent so that separation occurs easily in the generator.

4.- A high degree of stability for long-term operations.

5.- A refrigerant that has a large latent heat so that the circulation rate can be kept at the minimum.

6.- Should have low viscosity to promote heat and mass transfer.

7.- A low corrosion rate and nontoxicity for safety reasons.

There are two solution that satisfy all these requerirments. Ammonia-water and water-lithium bromide are the two pairs which have found extensive commercial use.

EXPERIMENTAL PERFORMANCE.

In order to get hands on experience on the operation and testing of the intermittent absorption refrigeration ammonia-water system, experiments have been carried out with the help of ice-ball unit available at TREEO Center. The schematic diagram of the experimental set up is shown in Figure 3.

The unit was charged in the last session. The pressure and temperature of tank however, did not correspond to the concentration, reported to have been used in the generator. Also the balancing of the tanks did not show the reported weight of the solution in the generator. This could be due to the water vapour condensation along with the ammonia vapour in the condenser. So we drained the tanks and charged the unit again. The reader may refer to the old reports (TAET projects) for details of this process.

The concentration is chosen 60% because the cooling load is fixed to be equivalent to the evaporation of 5 lb. of ammonia vapour corresponding to generation temperature of 160°F and condenser temperature of 80°F. Therefore, 20 lb. of solution is filled in the generator out of which 12 lb. is ammonia, 8 lb. is water.

Generation and Condensation:

1.- Heat is added to the generator tank. The valves 1, 2 and 3 are

closed. Because of heat, ammonia vaporises and passes through valves 4 and 5 to the condenser.

2.- The condenser tank is kept cooled by the water from the mains. The ammonia vapour gets condensed and the heat of solution is removed by water.

Thus heat is added to the generator and removed from the condenser. This process is known as charging. It is stopped by closing the valve 5 when the pressure (as recorded by the two pressure gauges) in the two tanks remains the same, for a fixed generator temperature.

Evaporation and absorption:

1.- The generator is then allowed to cool down to the ambient temperature; so the pressure is also decreased. This now acts as the absorber.

2.- The condenser is kept inside an insulated box and measured quantity of water is poured into the box. This now acts as the evaporator.

3.- Valve 4 is closed; 3 and 5 are opened. Because of the pressure difference, ammonia vaporises (thus causing cooling in the evaporator) and flows into the absorber.

Thus cooling effect is produced in the evaporator and heat of solution in the absorber is taken out by cooling water. The process is

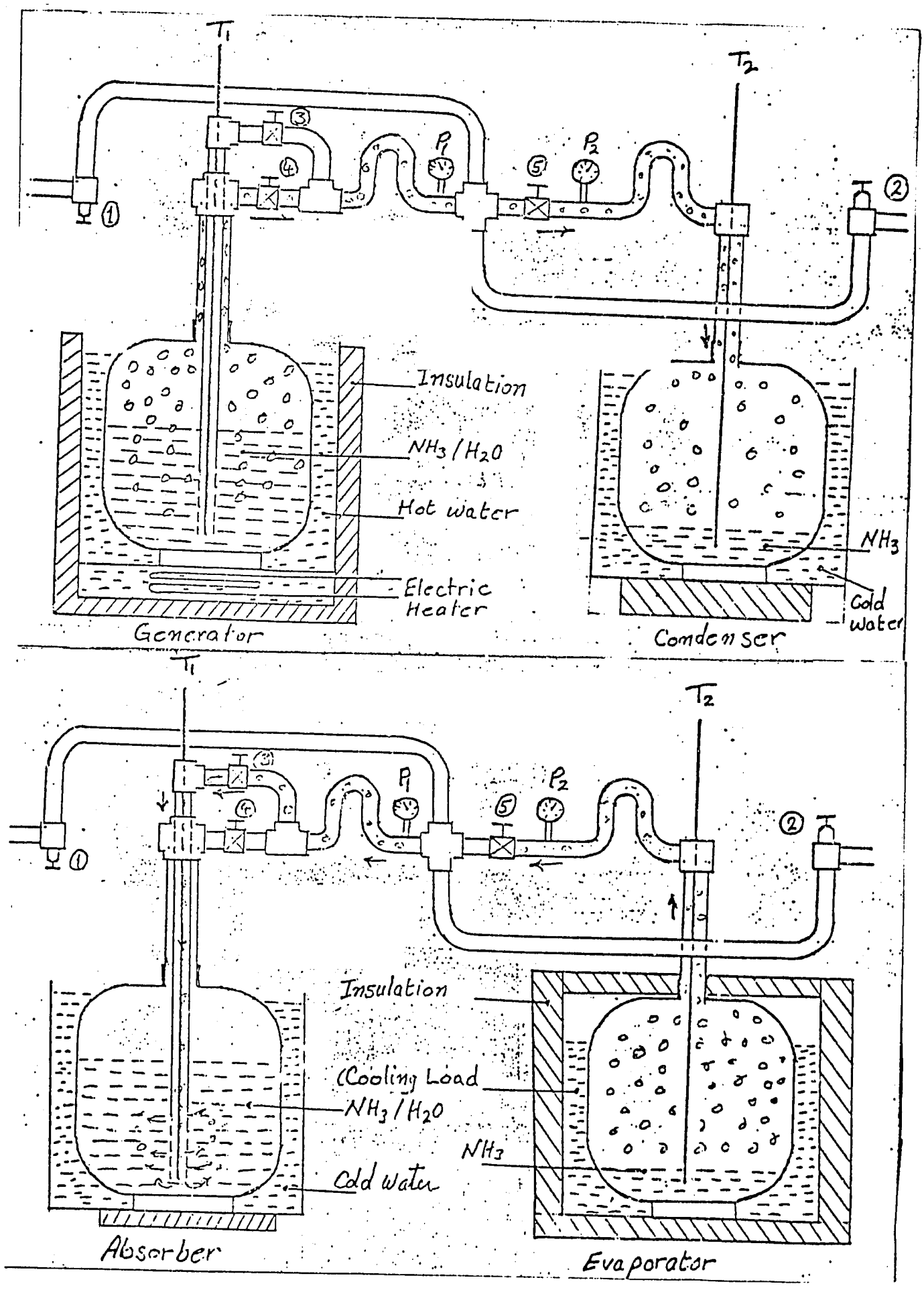

T1
T2
P1
P2
Insulation
NH3 / H2O
Hot water
Electric Heater
Generator
NH3
Cold water
Condenser
Insulation
Cooling Load
NH3 / H2O
Cold water
Absorber
NH3
Evaporator

Figure 3.

known as discharging. This is continued till the pressure of both tanks remains equal again.

Discussion:

The esperiments are carried out for three generation temperatures ie., 160°F, 150°F and 140°F. The temperature of the evaporator is plotted against time to get the cooling curves in each case. The Figs. 4 to 7 show these variations. Since the design temperature is considered to be 160°F, obviously cooling would be less for other temperature. The objective is not to make quantitative estimates out of this experiment. Because the unit, being a demostrative one, suffers from a number of shortcomings. Nevertheless, it can be seen from the Figs. 4 to 7 that the temperatures of the evaporator and water in the insulated box drop down to below freezing point of water. The system thus works on principle. It may be mentioned that the unit produced a lot of ice during the experimentations. The table 3 gives the temperatures of different units of the system.

Precautions:

In order to improve the performance of the existing system, certain precautions are necessary.

1.- During charging, heat the generator till the pressure remains constant for some time at the given generator temperature.

This is just to ensure complete charging corresponding to that temperature.

2.- In a properly designed unit, condensation of ammonia vapor (in the condenser) occurs at the same rate as the generation (in the generator). But in the existing unit, this could hardly be expected. Therefore, effective cooling of the condenser must be guaranteed so that the vapors get liquefied as far as possible.

3.- After charging, the generator (which would be absorber during discharging) tank must be cooled to ambient temperature.

4.- During discharging, the valves should be opened slowly, other wise absorber would get heated because of heat of solution. Also the accumulation of ammonia vapor (before it gets chance to be absorbed) would lead to rise in pressure rapidly so that flow of vapor from the evaporator is prohibited. All this comes into picture because of the poor heat transfer from the tanks.

Modification:

The modifications, here suggested, are in direct response to the difficulties that we faced while trying to quantifity the experimental results. In other words, these are immediate steps, we feel, need to be undertaken. However, a lot of other modifications could be incorporated if the unit is redesigned.

1.- Balance: In order verify the quantity of ammonia vaporising, proper balancing method should be taken. The existing pivotting is not good enough because of the friction.

2.- In order to judge the effectiveness of the condenser, there should be a liquid level indicator.

3.- A provision must be made to trap the water vapor from the ammonia vapor. In our experimentation we saw that a continuous operation of the system for three generator temperatures led to transfer of almost half a litre of water from the generator to the condenser. Condenser should be always at a higher alevation than the generator and separate drainage (which can be operated at will) should be provided from the condenser to the generator.

If these are attended to, even this demonstrative unit would perform quite well.

PRELIMINARY DESIGN CALCULATIONS.

(for 3-ton Air Conditioning System)

The design calculations for the solar powered, intermittent ammonia-water absorption air conditioning system are presented in four parts namely, the evaporator design, the generator design, the condenser design and the absorber design. The design condition and parameters selected for this design are given below in tabular form:

Unit	Temperature (°F)	Pressure (psig)	Ammonia Concentration (x)
Generator	160	140	0.60
Condenser	80	140	1.00
Evaporator	40	60	1.00
Absorber	80	60	0.47

This unit is designed to provide a total of 72,000 Btu of air conditioning per cycle, the total time per cycle being three hours. This cycle is shown in Figure 8. The design calculations of these units are given seperately as follow.

1.- Evaporator design:

Latent heat of vaporization of ammonia at 40°F and 60 psig

is 491 Btu/lb. Therefore the amout of ammonia which must be vaporised in the evaporator is $(3 \times 24{,}000)/491 = 147$ lb. It is assumed that 147 lb. of ammonia must vaporise in two hours in order to provide cooling of 72,000 Btu. Therefore

$q = 72{,}000 / 2$; $q = 36{,}000$ Btu/hr

Chilled water flow rate:

$$q = m\, Cp\, \Delta t$$

assume $\Delta t = 10\ ^{o}F$, Cp for water = 1 Btu/lb ^{o}F

therfore $m = q / (Cp \times \Delta t)$

$= 3{,}600$ lbs/hr

Hence, flow rate $= 3{,}600 / (3.34 \times 60)$

$= 7.2$ gal/min

Heat Exchanger Design:

Assume the value of $U = 100$ Btu/hr ft^2 and the diameter of the pipe = 0.5 " . Therefore, area required is given by the equation

$$q = U \times A \times \Delta t$$

$$36{,}000 = 100 \times A \times 10$$

$$A = 36\ ft^2$$

Assume the length of tube = 5 ft.

Number of tubes $= A / \pi D L$

$= 36 / (3.1416 \times 5 \times 0.5/12)$

$= 55$ tubes

2.- Generator Design:

The initial charge required in the generator is 60 % ammonia concentration. This mixture requires 360 lb. of ammonia and 240 lb. of water. The final charge at the end of generation is 453 lb. of ammonia and water solution at a concentration of 47 % . To vaporise the 147 lb. of ammonia, the amount of heat required is divided into two parts:

1.) Heat required to warm up the solution ,

2.) Heat required to generate the ammonia vapor at 160°F.

Design conditions of generator is as follows: (Fig. 8)

Initial temperature	=	80 °F
Average solution weight = (600 + 453)/ 2	=	526 lb.
Final temperature	=	160 °F
Enthalpy at 80°F and 60 psig of solution	=	- 4 Btu/lb
Enthalpy at 120°F and 140 psig of solution	=	65 Btu/lb
Enthalpy of ammonia vapor at 160°F and 140 psig	=	696 Btu/lb

Therefore, $Q = 526\,(65 - (-4)) - 147\,(696 - 65)$

$= 130{,}521$ Btu

It is assumed that the generation will be complete in one hour

Therefore,

$q = 130{,}521 / (1.0)$

$q = 130{,}521$ Btu/hr

Hot water flow rate required

$m = q / (Cp \times \Delta t)$

Take Δt = 10 ^{o}F

So, m = 13,052 lbs/hr

and flow rate = (13,052 / (3.34 x 60))

= 26.10 gal/min.

Heat transfer area required is

$$A = q / (U \times \Delta t)$$

$$= 130.50 \ ft^2$$

Assume the size of tube = 0.5 " diameter and length 5 ft.,

then number tubes = $a / (\pi \times D \times L)$

= 199 tubes

Diameter of shell;

area of shell = (area of tubes) x (number tubes) x (space between two tubes) / (0.75)

where 0.75 implies the space allowance of 25 %.

So, $A_{shell} = \pi/4 \times (0.5/12)^2 \times 199 \times (2/0.75)$

$= .72 \ ft^2$

Hence $D_{shell} = \pi/4 \times D^2_{shell}$

= 0.96 ft.

3.- Condenser Design:

The condensation of 147 lbs. of ammonia vapor is completed one hour.

The amount of heat required is

$$Q = 147\ (696 - 132)$$
$$= 82{,}908 \text{ Btu}$$

where 132 is the enthalpy of pure ammonia liquid at $80^{o}F$

It's assumed the time one hour;

Therefore, $q = 82{,}908$ Btu/hr.

Cooling water required is:

$$m = 82{,}908 / 10$$
$$= 8{,}291 \text{ lb/hr}$$

volume flow rate $= 8{,}291 / (8.34 \times 60)$
$= 16.56$ gal/min.

Heat transfer area is :

$$A = q / (U \times \Delta t)$$
$$= 8{,}291 / (100 \times 10)$$
$$= 82.91 \text{ ft}^2$$

Number tubes required:

Diameter of the tube $= 0.5$ " and length 5 ft.

So, number tubes $= A / (\pi/4 \times 0.5/12 \times 5)$
$= 126$ tubes

Area of shell $= 0.00136 \times 126 \times 2/0.75$
$= 0.46 \text{ ft}^2$

Diameter os shell = 0.76 ft.

4.- <u>Absorber Design</u>:

The amount of heat required to be removed from the absorber consists of two parts ;

1.) To cool down the solution from 160 °F to 80 °F

2.) To remove the heat of solution.

Therefore, total heat to be removed is

$$q = 403 \times (65-15) + 147 \times (653 - (-4))$$

$$= 23556 + 97334$$

It is assumed that time for cooling the solution is 0.25 hours and for removal of heat of solution is 0.75 hours

So, $q_{cool-down} = 23556 / 0.25$

$= 94224$ Btu/hr.

$q_{heat-sol} = 97334 / 1.75$

$= 55603$ Btu/hr.

Cooling water required for both cases:

$m_{cool-down} = 94224 / 10$

$= 9422$ lbs/hr.

corresponding flow rate $= 9422 / (8.34 \times 60)$

$= 18.80$ gal/min.

$$m_{heat\text{-}sol} = 55608 / 10$$

$$= 5561 \text{ lbs/hr.}$$

corresponding flow rate $= 5561 / (8.34 \times 60)$

$$= 11.10 \text{ gal/min.}$$

<u>Coefficient of performance</u>:

Theoretical coefficient of performance (COP)

$$COP = Q_{evaporator} / Q_{generator}$$

$$= 72{,}000 / 130{,}521$$

$$= 0.55$$

TABLE 1

ABSORPTION SYSTEM COMPARISON

SYSTEM	Lithium Bromide/Water ($LiBr-H_2O$)

ADVANTAGES

Coefficient of performance (COP), 0.6 to 0.7, is higher than that of ammonia-water system. Higher COP means less collector area required.

Operates at lower pressures.

It has a high stability, affinity, latent heat and safety.

DISADVANTAGES

Lithium bromide crystallizes at high generator temperature (LiBr crystallizes at 200°F for 35°F absorber temperature). This dictates careful control of generator temperature at high level.

The pairs are those associated with low pressure and with the high viscosity of the lithium bromide solution. The lithium bromide crystallizes at moderate concentrations.

Requires slightly higher generator operating temperature than does the water-ammonia system (generator temperature must be above 130°F for water-ammonia).

SYSTEM Water-Ammonia (H_2O-NH_3)

ADVANTAGES

Ammonia and water constitute a particular pair for an absorption-refrigerant system because it is attributed to both the pressure temperature concentration relationships of the combination and the high latent heat of ammonia. The temperatures needed to operate the system are farly low, so that there are several alternatives for obtaining the neccesary solar heated water.

Has no upper temperature limit and has a slightly (10°F) lower temperature at which the system will operate.

Since ammonia is the refrigerant, the system could be used as a refrigerator-freezer (system can produce temperature below 32°F).

DISADVANTAGES

The time frame between charging and the time when cooling of the tank begins is so large that it is difficult to mantain a continuously low temperature of the tank being cooled.

For almost all concentrations of water-ammonia, a small percentage of water will remain in the ammonia as it passes from the condenser. Another component, called a rectifier, is required to remove this water.

System is under high pressure (up to 200 psi), thus requiring large, heavy, and costly machinery.

Corrosion characteristics of water-ammonia solution are less severe,

although generally inbibitors are used for this system. No copper bearing material can be used in water-ammonia system, has to be completely built of steel or iron.

- -

ECONOMICS OF SOLAR AIR CONDITIONING.

The only solar air conditioning system commercially available today are of the lithium bromide absorption type. Residential and commercial units may be purchased which have generator operating temperatures of 175°F to 200°F, compatible with the advanced flat-plate collectors marketed today.

SYSTEM COSTS.

Approximate costs are described on the next table to show why solar air conditioners are more expensive than conventional ones.

TABLE 2

Typical costs for a 3-ton residential solar absorption air conditioning system are as follows:

Collectors:

500 sq ft @ $ 15/sq ft	$ 7.500.oo
Installation @ $ 10/sq ft	$ 5.000.oo

Storage:

1,000-gal insulated tank for hot water storage, @ $ 2/gal installed	$ 2.000.oo

Air Cooler:

3-ton unit, including all heat exchangers

and outdoor cooling tower, installed.	$ 3.500.oo
Pipes, insulation, pumps, controls, and interconnection of components.	$ 5.000.oo
Contractor design fee and profit.	$ 2.000.oo
TOTAL	$ 25.000.oo

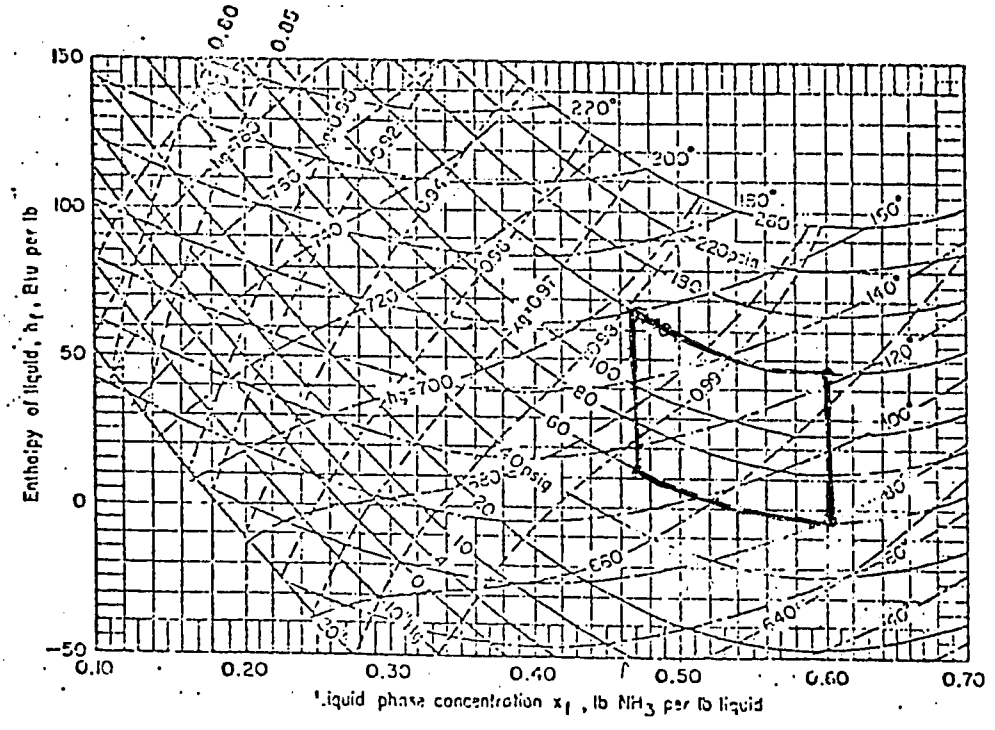
CONCLUSION.

These results demonstrate that technically solar absorption refrigeration is feasible.

The future of the solar absorption refrigeration is a very good proposition in industrial applications.

A considerable ammount of solar energy can be collected even on cloudy days by flat plate collectors.

There are many possible modifications of the basic ammonia-water solution cycle including many temperatures level plants with multiple absorbers, pumps, and heat exchangers, and two-stage plants with reabsorption of the ammonia vapors from the low stage generator.



Enthalpy of liquid, h_f, Btu per lb
Liquid phase concentration x_f, lb NH_3 per lb liquid
150
100
50
0
-50
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.60
0.05
220°
200°
180°
160°
140°
120°
100°
80°
60°
40 psig
220 psig
h_g=700

Figure 8.

TABLE 3

TEMPERATURES OF DIFFERENT UNITS OF THE SYSTEM

Sl. No.	Generator Temperature (^{o}F)	Condenser Temperature (^{o}F)	Evaporator Temperature (^{o}F)	Absorber Temperature (^{o}F)
1	160	72	25	76
2	160	75	33	79
3	150	71	28	75
4	140	68	30	72

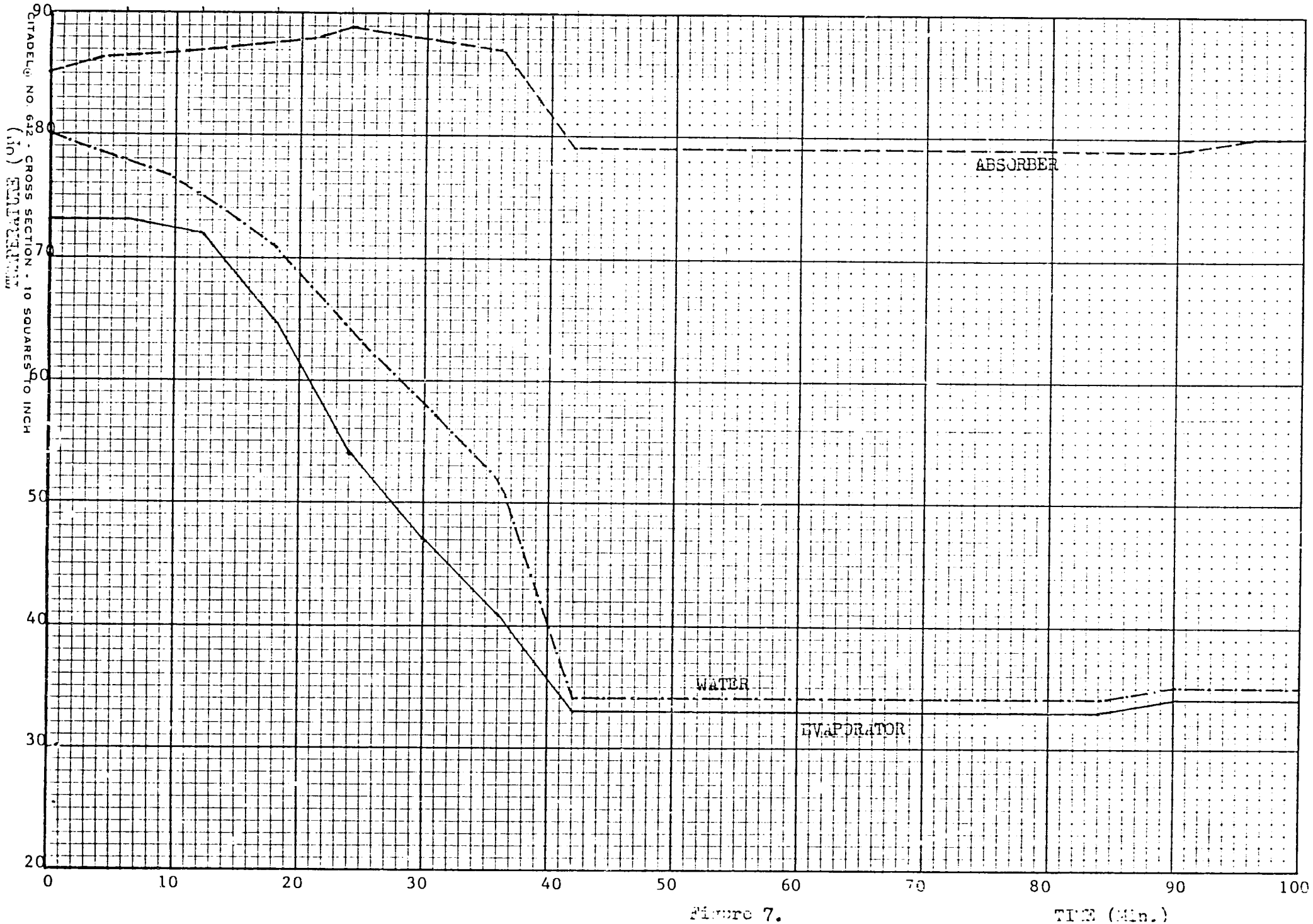

CITADEL® NO. 642 - CROSS SECTION - 10 SQUARES TO INCH
TEMPERATURE (°F)
90
80
70
60
50
40
30
20
0
10
20
30
40
50
60
70
80
90
100
ABSORBER
WATER
EVAPORATOR
TIME (Min.)

Figure 7.

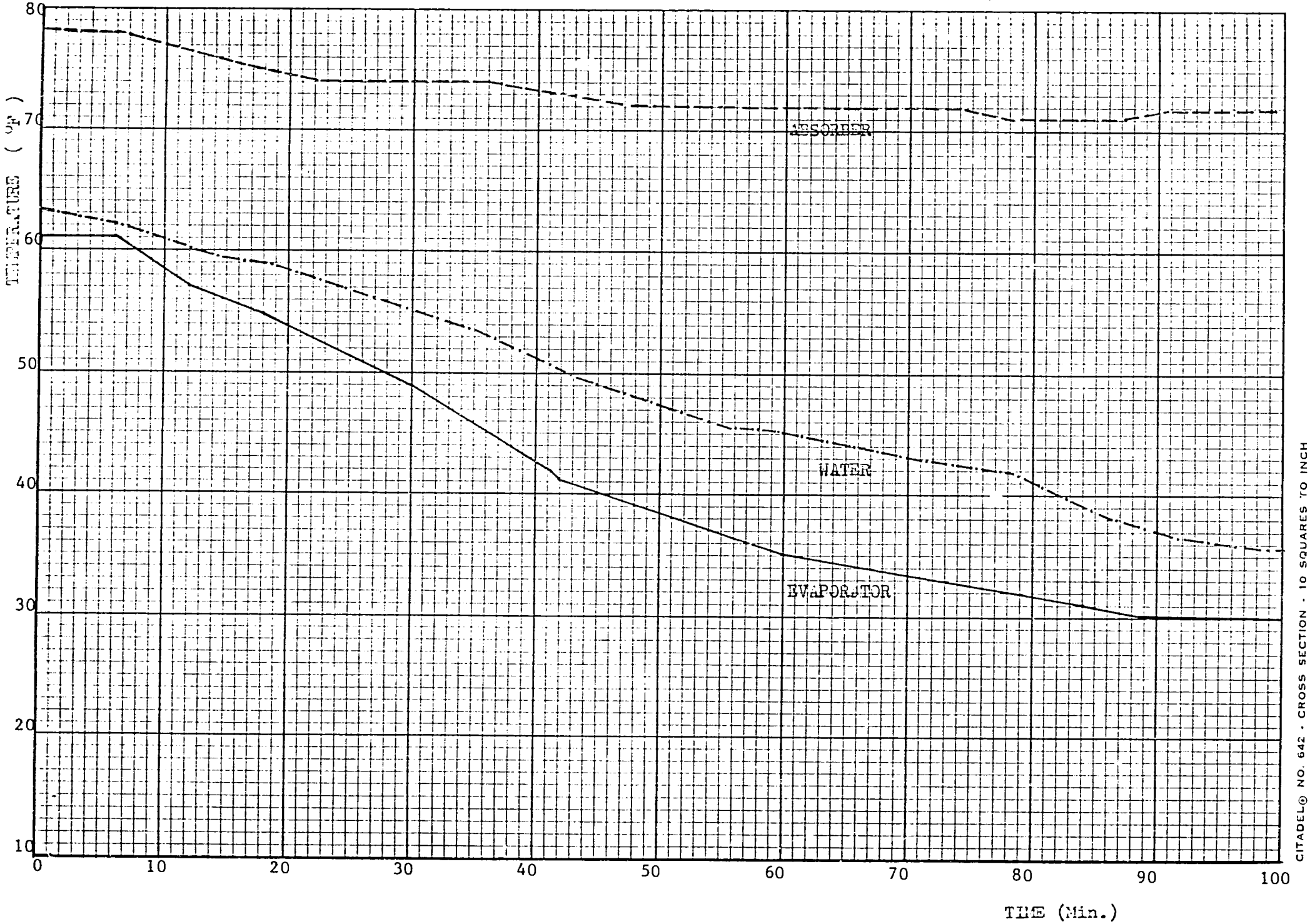

TEMPERATURE (°F)
80
70
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
TIME (Min.)
ABSORBER
WATER
EVAPORATOR
CITADEL® NO. 642 - CROSS SECTION - 10 SQUARES TO INCH

Figure 6.

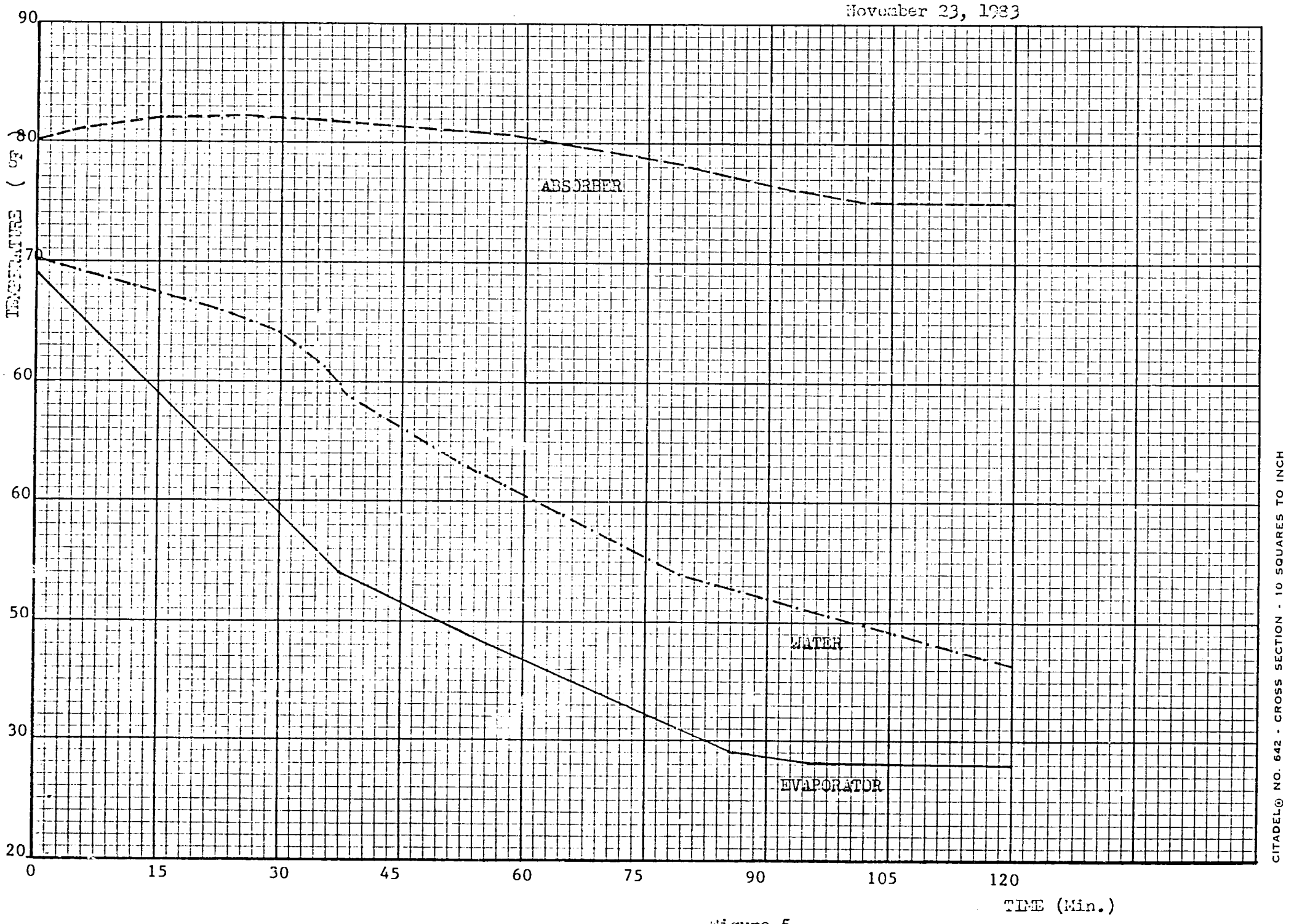

November 23, 1983
TEMPERATURE (°F)
90
80
70
60
60
50
30
20
0
15
30
45
60
75
90
105
120
TIME (Min.)
ABSORBER
WATER
EVAPORATOR
CITADEL® NO. 642 - CROSS SECTION - 10 SQUARES TO INCH

Figure 5.

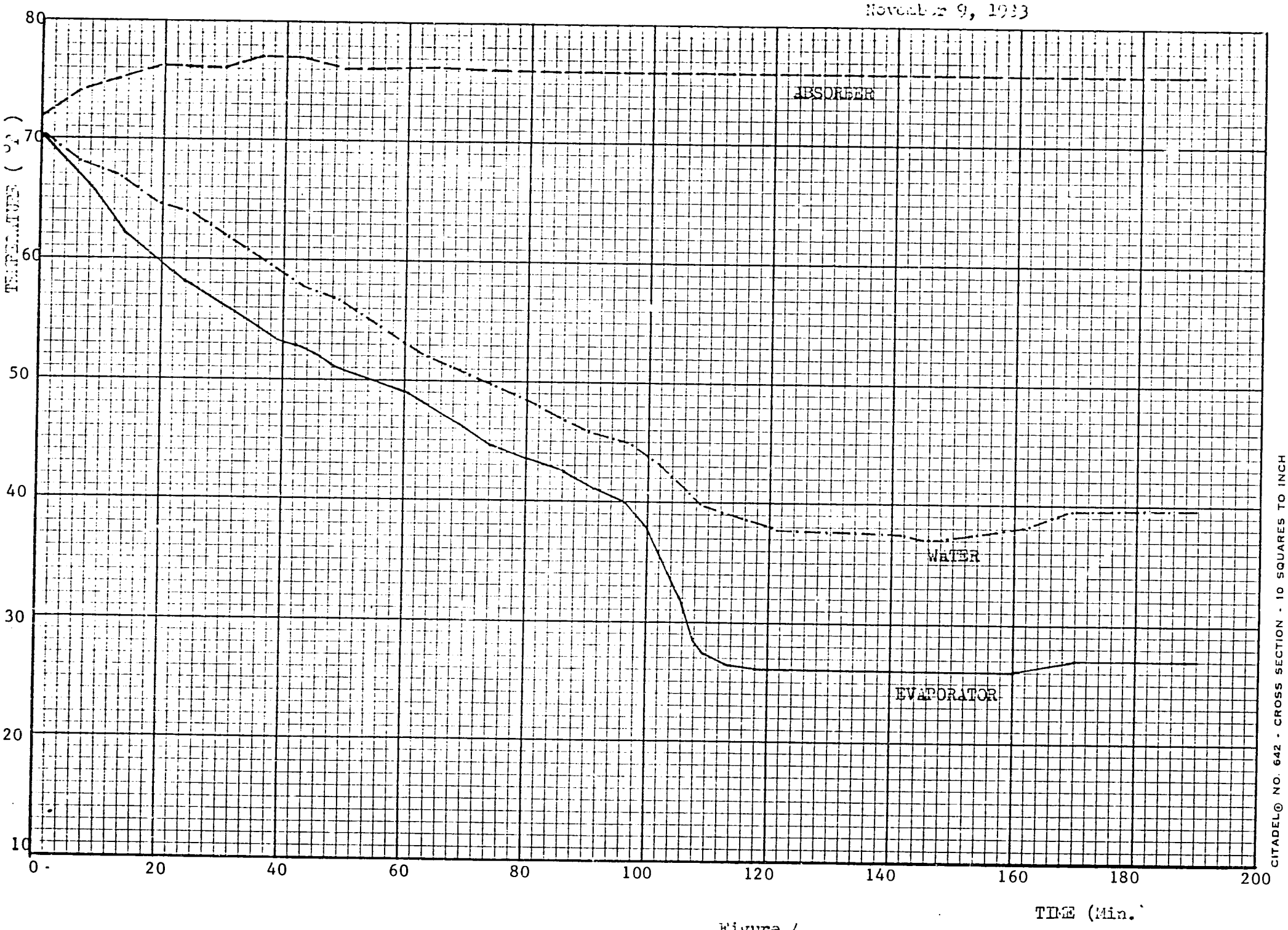

November 9, 1933
ABSORBER
WATER
EVAPORATOR
TEMPERATURE (°F)
80
70
60
50
40
30
20
10
0
20
40
60
80
100
120
140
160
180
200
TIME (Min.)
CITADEL® NO. 642 - CROSS SECTION - 10 SQUARES TO INCH

Figure 4.

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Ammonia-water Refrigeration/Air Conditioning System.

Refrigeration/Air Condition (technically same)
<10F> 40F →

Importance
- preservation of food, medicine
  (hot countries 1/4 of veg. crop is otherwise spoiled)
- health of billion people can be improved
- efficiency of industries in developing countries
- comfort cooling

Conventional :-

- works with electricity only and are expensive
- the pricipal is based upon the evaporation of a liquid in closed system.
- Earlier gas-fired refrigerators were available which uses Ammonia - were in use over a century in U.S.A
- now halocarbon are in use

Objective

- Systems which works with low-temps.
- low temps. easily obtained with inexpensive flat plate collectors - works on cloudy days also
- Using solar energy.

Air Condition system can be integrated with hot water system.

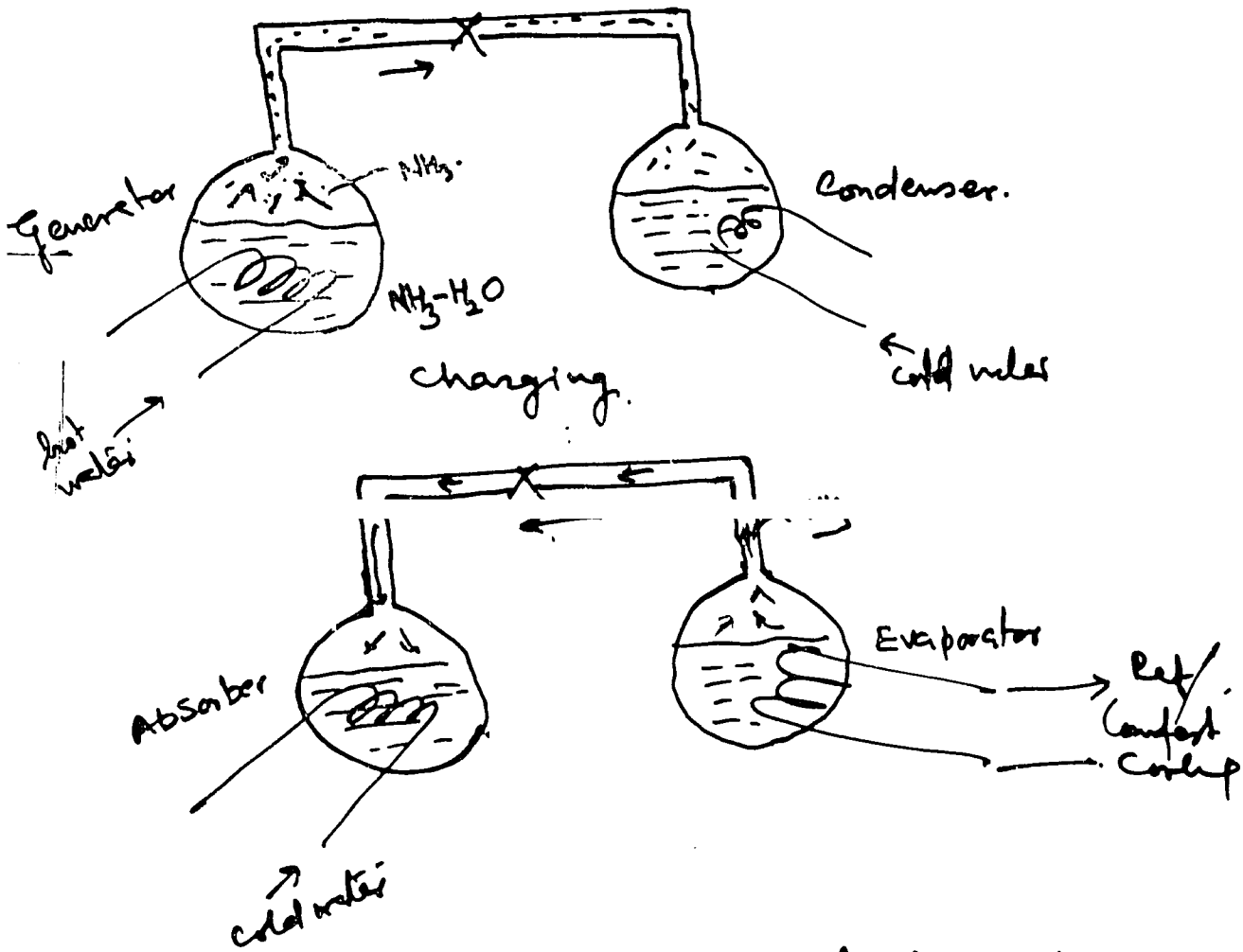
- in winter, hot water.
- in summer, comfort cooling.

Solar house cooling has the adv. - it is needed most when radiation is intense.

Early works using Solar Energy.

- Chinnappa, Trombe & Foex, Study on ice-making using concentrators
- Dr Farber et al studied NH_3-H_2O system for cooling.

Basic Absorption Ref. System.



Intermitten system - needs only two major components.

- It can be made continous, - using more components. Fig -

Absorption-refrigerant pairs -

- in literature many pairs are given
- NH_3-H_2O & LiBr-H_2O ~~used~~ two best.
- information for these easily available
-

Experimental

Fig. —

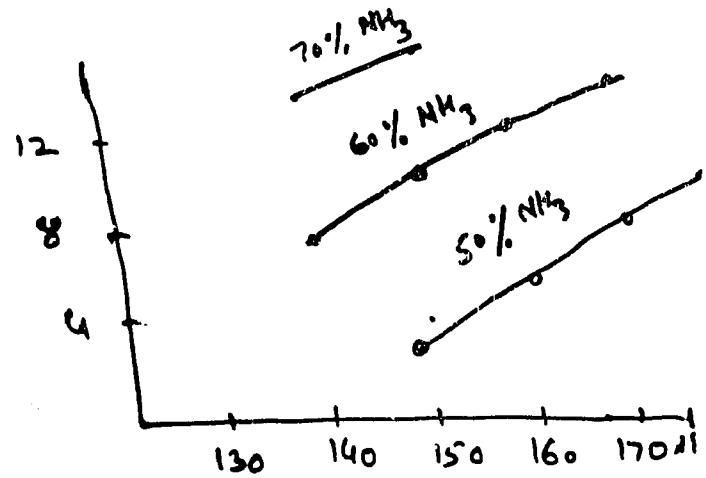
Diff. Temp.

140°F, 150°F, 160°F

- ammonia generation. ~~is more~~ increases with increase in temp.
- therefore cooling is more, when ammonia generated is more.

- In literature Dr. Farber et al.

Exp. with 60% NH_3



Result — System works good.

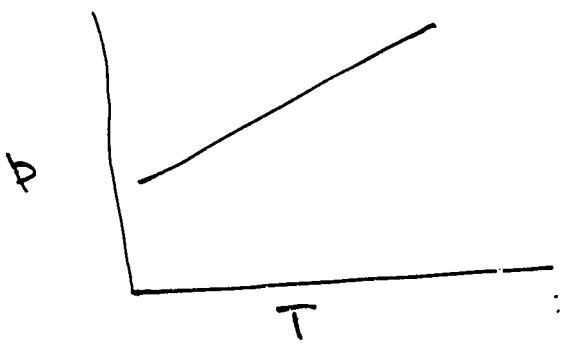
- very useful for making ice with Solar Energy.
- Solar Energy received in a day can be used for generating NH_3-vapor in day and cooling in night.

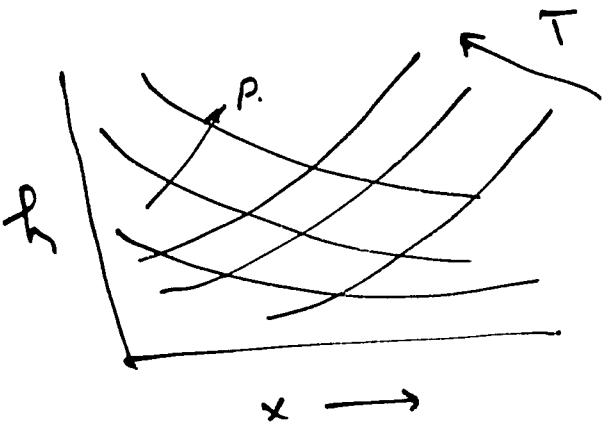
(Village refri.).

Design.

Important information required.

1) p–T relation
2) h–x relation.



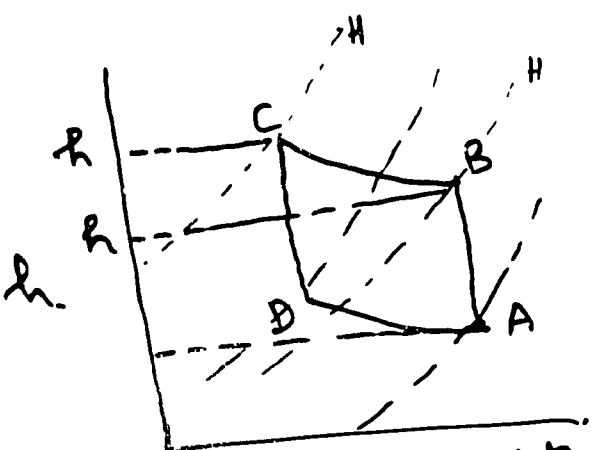


- Known for NH_3-H_2O & LiBr.H_2O.
- Research in progress for other systems.
  like NH_3-salt. (~~Ammonia~~ ia-thiocyanite).

Other information Req.

- generator temp.
- Temp. of evap. (for air cond. 40F, refr. 10-30F)
- Temp of absorber.

on. p–h.
Enthalpy-Conc.



AB- warm up.
BC - generation.
CD- cool down
DA - absorption.

- Calculations for 3 Ton system.

Adv. of NH_3-H_2O system.

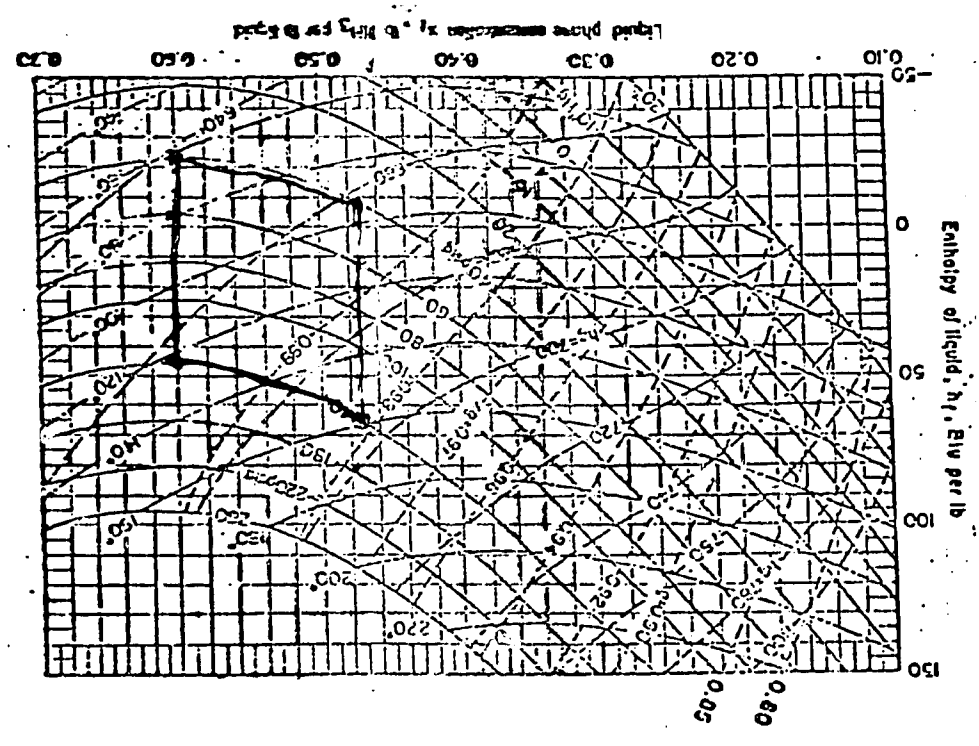
- high latent heat, results in small size
- high boiling & condensing heat trf coefficient
- no freezing problem in contrast to system using LiBr-H_2O.
- Chemically stable, non-explosive, non inflammable.

Overall safety record is good. — Transported by truck & pipe line. One pipe line 1800 mi. long.

only Disadv. is toxicity, — but it is not severe.

Comparison

NH_3-H_2O	LiBr-H_2O
Reqs. temp > 130	→ Reqs high temp > 190°F. - needs concentrator or very expensive flat plate collectors.
→ inexpensive flat plate collectors	
→ Can be used for ref. & air cond.	→ Can be used for air-cond. only, (because of freeze problem)
→ Cop 0.5 – 0.6	→ LiBr crystallizes at high generator temp.
	→ Cop 0.6 – 0.7


Liquid phase concentration x_l, lb NH_3 per lb liquid
Enthalpy of liquid, h_l, Btu per lb
0.10
0.20
0.30
0.40
0.50
0.60
0.70
-50
0
50
100
150
0.05
0.60

41

Typical Cost
for 3 Ton Solar abs. A/C

Collectors.

500 sq ft @ $15/sq ft ——— $7,500

Installation @ 10/sq ft ——— 5,000

Storage

1000 gl. insulated tank for hot water

@ $2/gal. Installed ——— 2.000

Air-Cooler

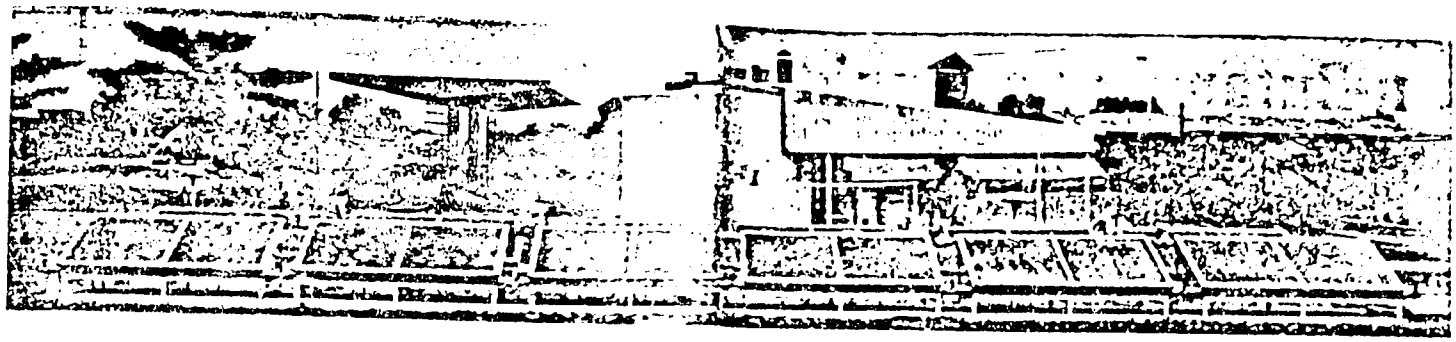
3 ton unit, including all heat exchanger and outdoor cooling tower, installed — 3,500

Pipes, insulation, pumps, control, & interconnection of components ——— 5,000

Contractor design fee & profit — 2,000

Total $25,000

- Initial investment is high
- Operating cost negligible



A Solar Refrigerator for Village Use

"Village-Size Solar Refrigerator" is the second phase of a solar powered refrigerator project, sponsored by the Overseas Development Administration (ODA), UK., which commenced in March 1982. The work is being carried out at the Asian Institute of Technology (AIT) under the supervision of Dr. R.H.B. Exell and a research associate of the Energy Technology Division, Mr. Somchai Oeapipatanakul.

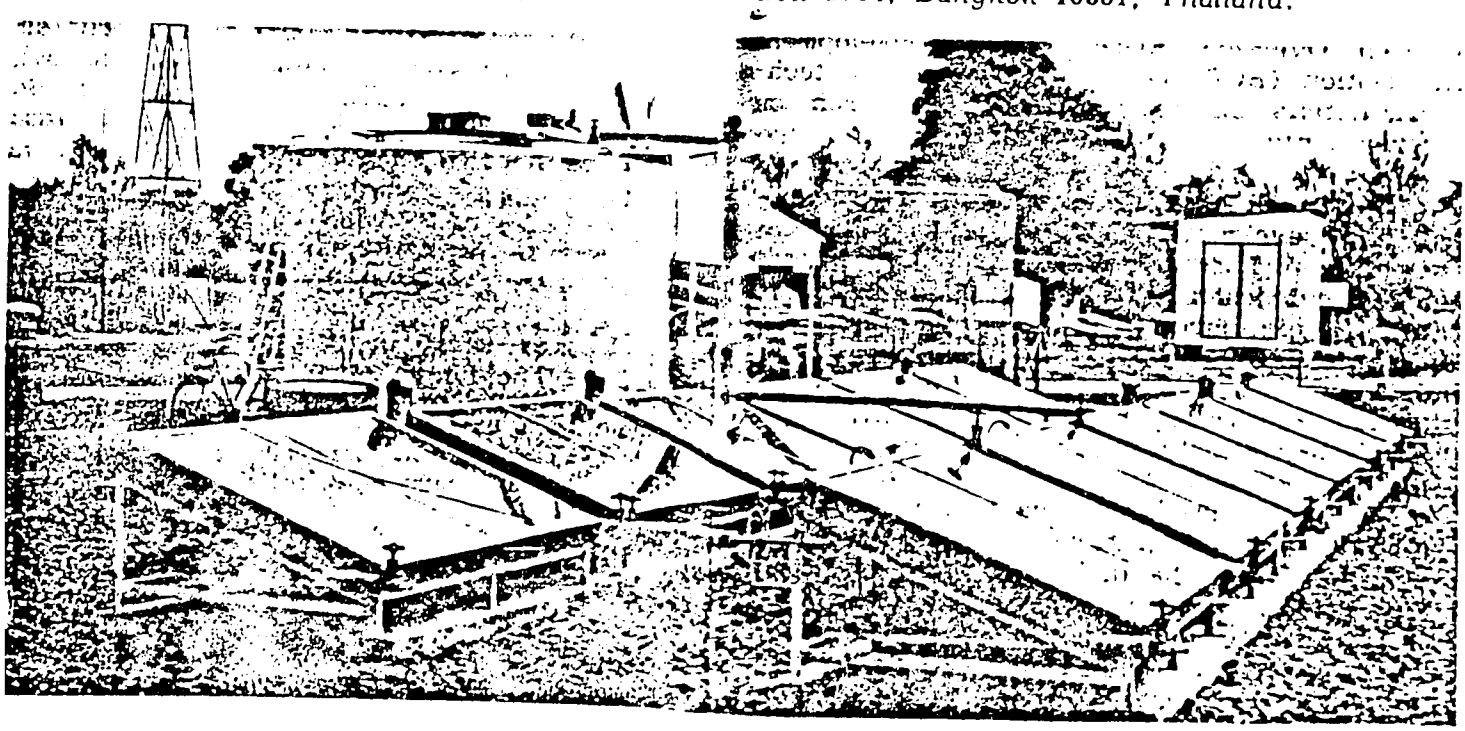
The ultimate objective of the work is to develop a village-size refrigerator with a collecting area of about 25 m² that can provide 0.5 m³ of food storage space below 10°C or make about 100 kg of ice per day under favourable conditions. Such a system would be useful in small vaccine storage units in rural health centres, in medium-size stores for agricultural products or in ice-making machines in villages.

The system is designed to be simple, requires no electrical or mechanical energy, and can be manufactured locally. The introduction of a liquid seal to the system enables it to operate automatically. It consists of twelve collectors each having a 2 m² collecting area.

An intermittent ammonia-water absorption cycle is used in this system. Solar energy is collected by solar collector panels containing ammonia solution at 46% concentration. This energy is used to boil the ammonia solution. Liquid ammonia is condensed in a condenser which is immersed in a tank of stagnant water and collected in a receiver. The cooling effect and absorption of ammonia takes place in the evening when the temperature of the solar collector falls. Ice is formed in an ice can which is in contact with a flooded evaporator coil.

A model based on this design has been constructed on the AIT campus, and the system performance is now being investigated.

Contributed by Mr. Somchai Oeapipatanakul, Energy Technology Division, AIT, P.O. Box 2754, Bangkok 10501, Thailand.



The solar-powered refrigerator recently developed at AIT