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PREPARED FOR

NATIONAL CONCIL FOR RESEARCH IN KHARTOUM - SUDAN

STUDY FOR POTABLE WATER AND SALT PRODUCTION IN UM SAFARI

(SHIMAL KURDUFAN)

by

Jean CLAIN

SI/SUD/82/804/11-01/32.1.C.

* This report has not been cleared with Unido wich does not, therefore necessarily share the views presented.

MARCH 1983

C O N T E N T S

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T H A N K S

I want to thank warmly all the persons who gave me a friendly welcome and helped me, specially:

- Professeur AHMED EL AGIB
  President National Council Research
- Doctor YAHA HASAN HAMID
- Doctor HASSAN WARDI
- Doctor SID AHMED
- Doctor EL TAYED IDM'S EISA
- Engineer HUSHAM SABER

and also the staff of rural water administration in el obeid.

- Ministry MARASNI AL RAHMAN
- Doctor LOTFI WAHDAM
- Doctor MOKAMEO SHARIF
- Engineer AHMED KABASHI.

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ACTUAL SITUATION OF SALT PRODUCTION AND REQUIREMENTS OF FRESH WATER

The salt is made in Umsafari by the local villagers probably with the same processes for centuries.

The people drill wells down to the brine level. The depth varies from 30 to 50 meters. The diameter just allows the passage of one man.

Then, the brine is extracted manualy with animal skin recipient and rope down to the ground level.

The brine is placed in plastic reservoirs and transported by donkeys to the village. Then the brine is evaporated in iron recipients, heated by wood, then dried by sun and sold to the merchants. The wells are close to one another (10 to 20 meters) and the total area of the wells operation is approximatively 2 kilometers by 200 meters.

The cost of the produced salt was in 1979 around 70 ponds/ton.

The cost of the wood is around 120 ponds for one truck (5 tones) It is coming from an area located 30 kilometers away.

Nobody knows the quantity of salt produced by year.

The price of the fresh water : 51,6 PT per liter - coming from 12 kilometers away by truck.

After three or for years operation the wells are abandonned, because they do not produce enought brine, and they are refilled with earth.

The salinity of each well is different. Certain salinities are very low, others very hight.

For the moment the salinity is just tested with the human tongue.

The brine contents sodium chloride and also other salts like = Calcium sulphate, Magnesium sulphate - etc.. all the others salt are crystallized by evaporation in the final product.

The object of the mission of the expert was to propose the modernization of this process.

TARGETS TO REACH

The proposed new process has many aspects :

1/ To produce purer salt (NaCl) by natural solar energy. evaporation

2/ To produce potable water during the phase of brine concentration.

3/ To discontinue to burn wood thereby not depleting the vegetation.

4/ A model for an integrated solar energy plant.

There are many different processes to realize these operations, but we take in account that in Umsafari there is no energy available based on fuel or electricity except the sun and the wind.
The wind will be utilized for brine pumping operations and the sun for brine evaportion giving fresh water and salt.

The big interest of this experimental plant is an inovation in solar energy technology and to be a model for other integrated development centers.

3/

PROCESS TO BE PUT INTO OPERATION

A/ FLOW SHEET

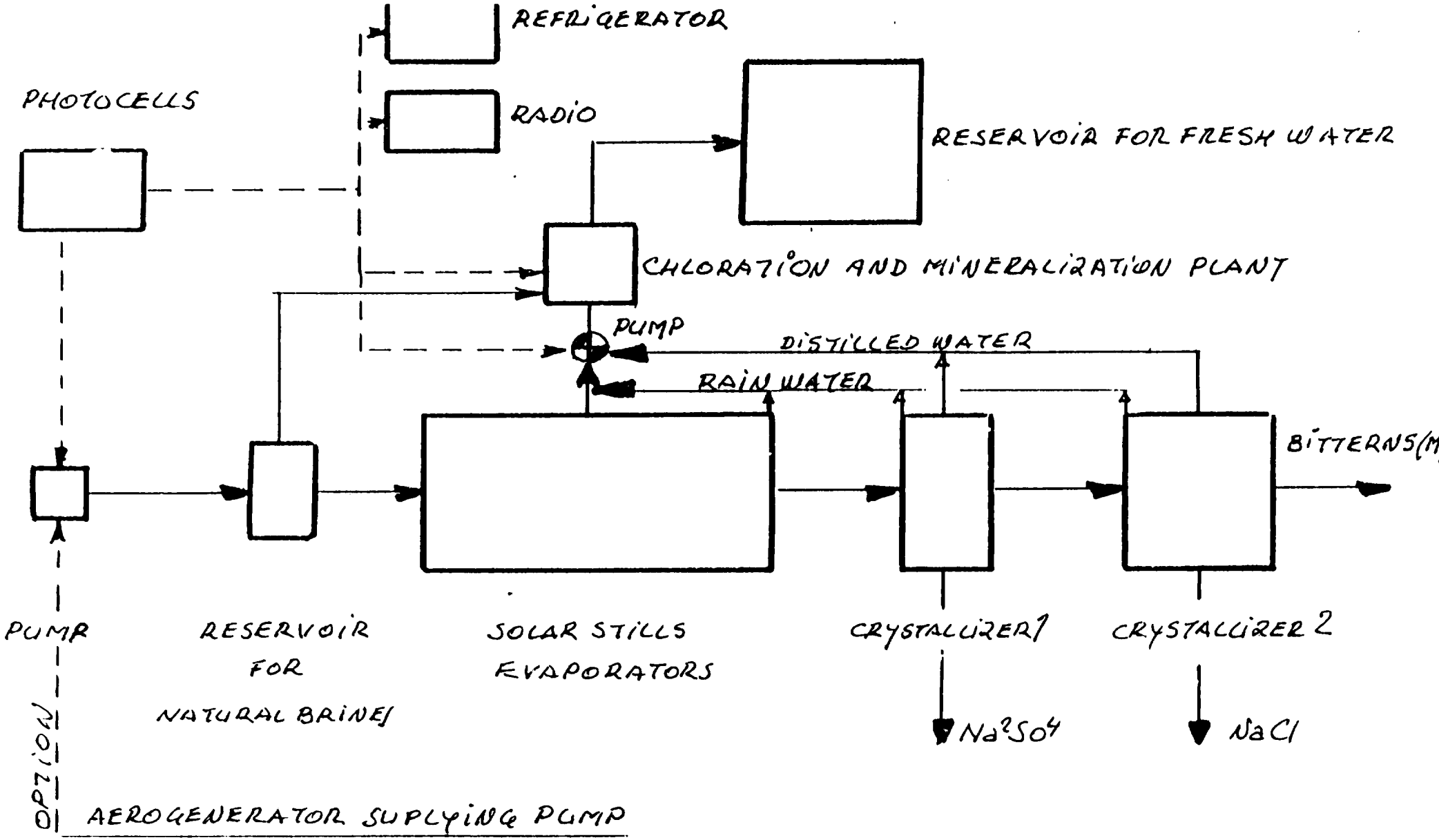
The principle of the process is to concentrate the natural brine to saturation point by solar evaporation and to recover the distillated water.

And in a second phase to crystallize the salt by solar evaporation, but the fresh water evaporated will be recovered or not.

The salt will be harvested manually many times a year from the crystallizers

The brine contains NaCl and Na_2SO_4. Due to the difference of the solubilities Na_2SO_4 will settle out first. In consequence we will have two crystallizers ponds in serie and we will control the densities during the operation when the brine flows from the first crystallizer into the second.

After the crystallization of NaCL, the bittern which will still contain magnesium salts will be discarded.


REFRIGERATOR
PHOTOCELLS
RADIO
RESERVOIR FOR FRESH WATER
CHLORATION AND MINERALIZATION PLANT
PUMP
DISTILLED WATER
RAIN WATER
BITTERNS(M
PUMP
RESERVOIR FOR NATURAL BRINE
SOLAR STILLS EVAPORATORS
CRYSTALLIZER 1
CRYSTALLIZER 2
Na_2SO_4
NaCl
OPTION
AEROGENERATOR SUPLYING PUMP AND OTHER MOTORS OR MULTIPACES WIND WILL CARRYING PUMP

B/ DESCRIPTION OF THE PLANT

1/ NATURAL BRINES PURPING

This problem is not easy to solve.
There are many wells with different salt concentrations.
The distance between two varies 10 to 20 meters. Sometimes more.
The daily extraction of brine from one well is around 150 to 300 liters per day.
After two or three years operation they are abandonned, because they are dry.
The problem is how to collect the brine from the different wells in one reservoir close to the plant.
Such a pumping system will be portable and flexible from one point to an other. The pipe line from the pump to the reservoir will be also flexible.
Three pumping systems are possible

1/ Hand Pump
2/ Immerged pump driven by an electric motor, photocells giving energy
3/ Immerged pump driven by wind mill or by an electric motor.

The wind mill wich is not movable will stay always in the same place and is equiped with an electrical generator.
The electricity is sent to the pumps by electric cables.
This solution is also correct wher there will be only one big well instead of many small ones.

2/ EVAPORATORS

From the reservoir tne natural brine will flow by gravity to the evaporators which will be solar stills
The total surface will be from 10 000 to 12 000 SQ meters.
The size of each unit is not yet determined but probably 4 m^2 (4 x 1 M).There will be many different series (100 for instance).
The brine discharged at the end of each serie will be saturated.

Due to the fact that the natural brine at the inlet will never have the same concentration the quantity of saturated brine at the outlet will varie accordingly.
The evaporation factor α (ratio between evaporation on brine and evaporation on fresh water) will change also according to the brine concentration.

The higher the brine concentration will be, the lower the fresh water quality will be.
Other consideration must be given : the gypsum ($CaSO_4$) will settle out on the surfaces of the solar stills because of its own solubility.

The design of the stills must allow a clearing of the surfaces.

3/ CRYSTALLIZERS

From the evaporators the brine will go by pumping or if possible by gravity over the two crystallizers surfaces. The crystallizers will be constructed on the natural soil conveniently leveled.
Dikes will hold the brine, the depth will be
10 to 15 centimeters.

If the natural soil is not tight enough, then the soil will be covered by polyethylene.

An other solution, more expensive, is to built concrete pans.

The total surface will be divided into pans.

Some gates will be installed to allow the discharge of the bitterns according to the prevailing winds. The crystallizers can also be covered with solar stills, but precautions have to be foreseen to facilitate harvesting of salt in the crystallizers.

It is important to notice that during the rainy season the depression of the Umsafari oassis is covered by rain water coming directly from the ground or by the water catchment.
Sometimes the water level influences the brine wells.
The new plant must be located on a site wich is always dry. throughout the year.

C/ CALCULATIONS

The calculation for the size of the different elements of the plant pumps evaporators, crystallizers) is determined by the balance of materials.

1/ Pumps will transport liquids(containing fresh water, NaCl Salt and other salts).
2/ In evaporators freshwater is distilled and brine concentrated
3/ In crystallizers - fresh water is evaporated and NaCl deposited
4/ In the discharged bitterns, others salts and some NaCl are contained.

The guiding element for the study is the quantity of fresh water to be evaporated in the evaporators.
The quantities necessary for the Umsafari are given as:

Summer time:

. 4 litres/person/day x 4000 persons	: =	16000 L
. 5 litres/cattle/day x 1600 catels ..	: =	8000 L
Total fresh water needed.....	: =	24000 L/D

Winter time :

3 liters/person/day x 4000 persons	=	12000 L
4 liters/cattle/day x 1600 cattle	=	6400 L
Total ..	: =	18400 L

According to the results of the study of Mr HASSAN AHMED EL BADRI and Mr ALA'A EL DEAN BEZID SAHAD the production of fresh water in solar stilts is

Somertime : 2,65 litre/SQ/M
Wintertime : 1,50 litre/SQ/M

The total evaporators surface in the solar stills must be:

$$\text{Summer time} = \frac{24000\ L}{2,65} = 9\ 057\ SQ/M$$

$$\text{Wintertime} = \frac{16.400}{1,50} = 12.267\ SQ/M$$

The figure of 12.000 SQ/M is adopted.

The evaporators will give :

Summer time = 12.000 x 2,65 = 31. 800 L.

Wintertime = 12 000 x 1,50 = 18. 000 L.

We must notice that during july and august there are heavy rains
The total yearly rain is (average for the last 10 years) 334.6 mm.
If we can reclaime only 80 % of this fresh water that would mean:
0,334 m x 12 000 m2 x 0,8 = 3 206 m3

Due to the fact that this rain falls in a short period of time, a storage system must be studied.

The problem now is to know how to produce 24 000 L/day of fresh water :

1/ how much brine to pump
2/ what will be the surface of the crystallizers
3/ what will be the production of salt per day.

The results of the brine samples analysis taken on site are helping us for this calculations.
The data is given in annexe II.
We summarize the results in the following table:

samples	densities	weight of salts	relatives volumes	Observations
1	1,050	74,99 qt	450 l	
2	1,139	205,83 qt	154 l	
3	1,160	219,87 qt	135 l	
saturated	1,214	321,60	100 l	

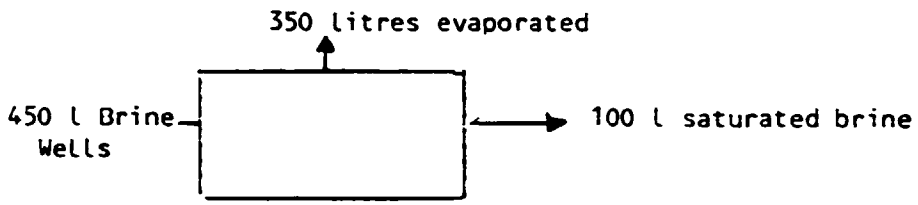
We must explain what is"the relative volume ".
If you take a sample of brine, mesuring 450 litres and having a densi
of 1,050 and you leave it under evaporation element :
When the density is 1,139 the remaining volume is 154 litres.
When the density is 1.160, the remaining volume is 135 litres.
and when the density is 1,214 (saturation) the remaining volume is
100 litres.

In an otner way :

1/ to increase the density from 1 050 to saturation it is
necessary to have an evaporation : 450 - 100 = 350 litres
2/ from 1.139 to saturation an evaporation = 154 - 100 = 54 litres
3/ from 1,160 to saturation an evaporation = 135 - 100 = 35 litres

In the present case the quantity of evaporated water is fixed
and the quantities of brine in inlets and outlets must be
determined.

1/ DENSITY - 1050



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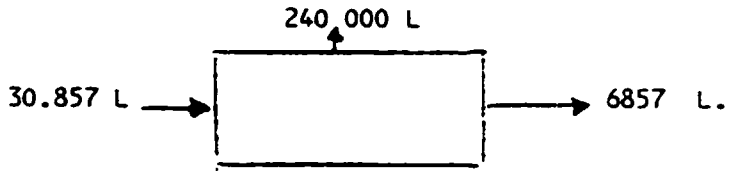
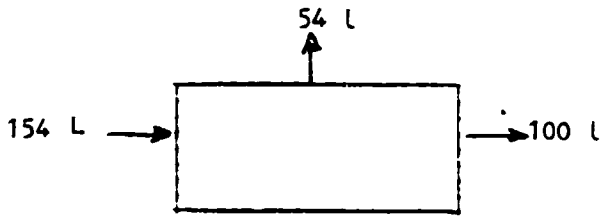


2/ DENSITY - 1.139



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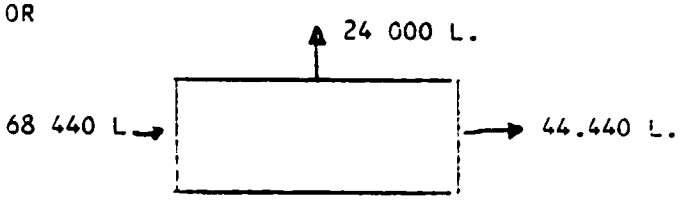
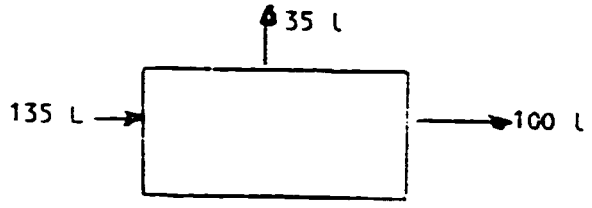


3/ DENSITY - 1.160



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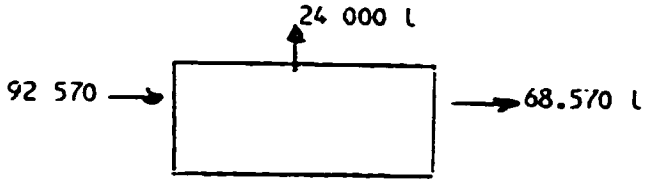

CRYSTALLIZERS

PRODUCTION OF SALT

Total quantities of salt contained into the brine

1/ 6857 litres x: 0, 321 = 2.201 kg
2/ 44.440 litres x 0, 321 = 14.265 kg
3/ 68.570 litres x 0, 321 = 22.011 kg

We can reclaime only fifty per cent of these quantities after the deposit of SO^4Na^2.

Thats mean

1/ 2,201 x $\frac{50}{100}$ = 1,100 T x 365 days = 401 Tons.

2/ $14,265 \times \frac{50}{100}$ = 7,13 T x 365 days = 2 603 T

3/ $22,\ C10 \times \frac{50}{100}$ = 11,00 x 365 days = 4 010 T

The bitterns containing Na_2SO_4 and NaCl can be :

- evaporated in crystallizer to crystallize salts.

TOTAL SURFACES OF CRYSTALLIZERS

Quantities of water evaportaed on crystallizers.

1/ Inlet = 6857 litres
Outlet = 0,30 x 6857 - 2057 L
Evaporation = 6857 - 2057 = 4 800 L/Day.

The evaporation in open air is 12 mm/Day on fresh water i.e. 6 mn/day on brine (or 6 litres/square metre)
Surface = $\frac{4\ 800\ L}{6\ l}$ = 800 SQ/M

2/ Inlet : = 44. 440 Litres
Outlet =44 440 x 0,30 = 13 332 L.
Evaporation = 44.440 - 13.332 = 31. 1082 L
Surface = $\frac{31.108}{6}$ = 5148 SQ/M.

3/ Inlet : = 68. 570 L
Outlet : = 68 570 x 0,3 = 20.571 L
Evaporation = 68 570 - 20 571 = 47 999 L
Surface = $\frac{47\ 999}{6}$ = 8 000 SQ/M

We can see when the brine is heavy concentrated the quantities of fresh water evaporated from the crystallizers is more important that from the evaporators.
We can imagine a recuperation of this fresch water also by solar stills but :

1/ it is necessary to do a movable system allowing the harvest of the crystallized salt or one gate system.

2/ Inside the solar stills the evaporation is less than in open air because of the absence of wind

In consequence the surface of the crystallizers covered by solar stills must be increased (in the ration $\frac{6 \text{ mm}}{2,65}$).

We can resume the different cases according the brine densities

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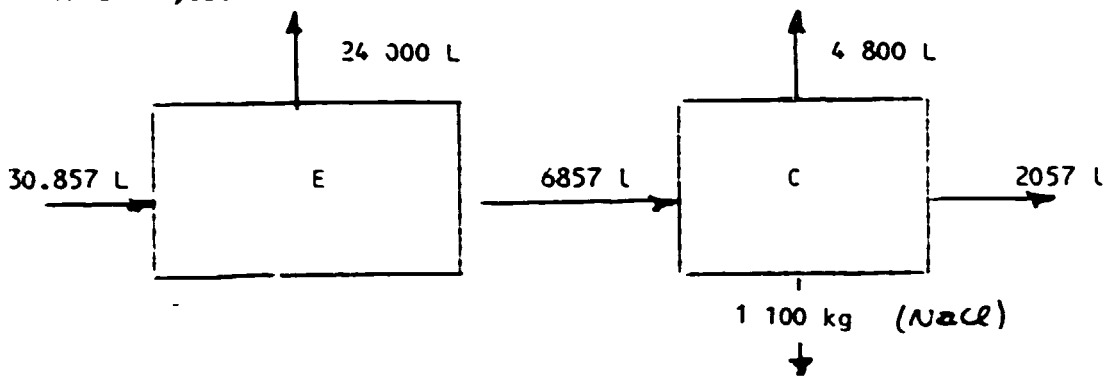
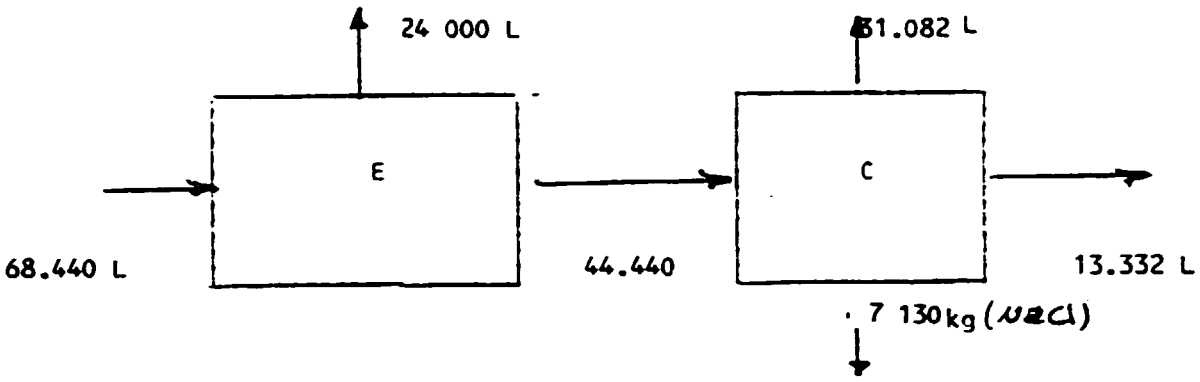
We have fixed the total surface of the two crystallizers. To know the exact surface of each of them it is necessary to do a more accurate brine study. It is not easy in the laboratory because the deposit of Na_2SO_4 will be greatly influenced by the local weather conditions and specially by the daily and nightly temperature variations. But we think it will be possible to do this study in the pilot plant.

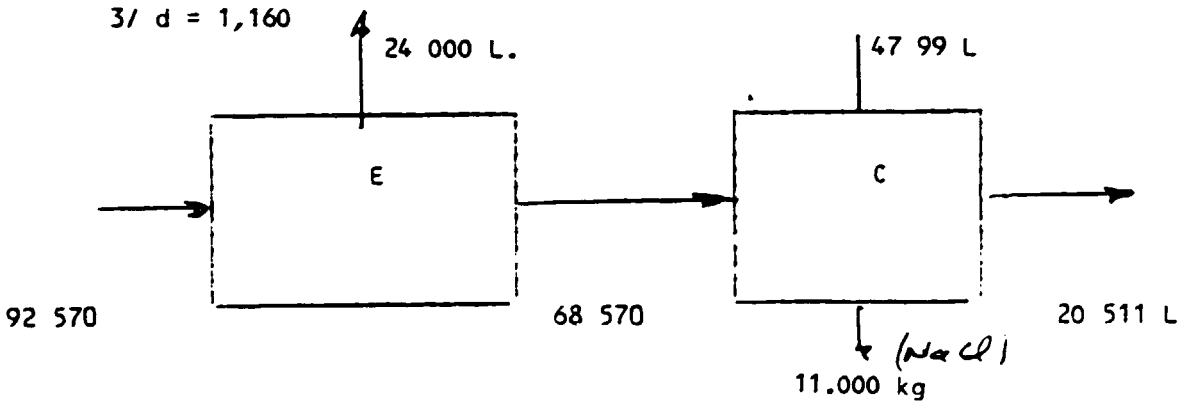
1/ d = 1,050



2/ d = 1,139



3/ d = 1,160



STUDIES TO MAKE FOR BETTER DEVELOPMENT OF THIS PROCESS

1/ GEOLOGICAL SURVEY

For the moment nobody knows the capacity of the deposit of brine - in Umsafari - The wells cover a small surface (2 kilometre by 200 metres around) and maby it is possible to find brine in the center of the depression located in south of Umsafari.

The soil of this big surface is covered by a layer of calcium carbonate and calcium sulfate wich generaly points to the presence of NaCl.

Perhaps, also, it is possible to find brine under the village or on the other side.

A general survey must be done in Umsafari and in the mean time in Shershar - (and it must be a resistivity study).

but also it would be very interesting to drill a test bore hole on site.

The actual wells are not deep because they are made manualy and when the worker is at the brine level he canot dig deeper due to the presence of water which disturbs his action. The works can be done by a drilling machine mounted directly on truck platform . The hole is narrow and can be deep.

We know that Unicef who is working in south Kordofan for finding fresh water has a program of 2500 bore holes for 1985.

May be it should be interesting to contact this Administration because we follow the same way = to give potable water to the villagers and ask them to drill test bore holes in the Um Safari area.

The price of one bore hole is around 2 000 US $.

This geological survey should be ordered now because, before spending money on the new process, it is necessary to know better the quantity of brine, its availability and the concentration of salt in it.

2/ METEOROLOGICAL DATA

The knowledge of the climate is a basis for this study of the plant and specialy rain and evaporation data is essential.

We sugest to put up a meteorological station close to the village.

We are giving in Annexe 1 the detail drawings and instructions for this construction.

To record the data, a villager, having a certain basic instruction, can do these works.

3/ BRINE WELLS STUDIES

It is very interesting to check, once a month, the densities of the brine in the three wells in wich we took some brine samples - to see if the salinity(expressed in density) varies along the year - and also if the rainy season has got an influence on the salinities. At the same time, we can check also the level of the water table in the ground.

Date	Well N°	Density	Water Level M	Observations

4/ TECHNOLOGY

The described plant may be is not the best solution. It will be interesting to do a complete technological study to determine what is the best way, for example:

1 - For brine pumping: Is a wind mill better than photocells to give electric energy ?

2 - For evaporator: Is is better to heat the brine before inlet to increase evapoaration? Is this solution possible by solar pannels ?

3 - Due to the big sandwinds, some sand will crystallize into the salt layer in crystallizers.

4 - Is it better to cover the crystallizers by solar stills? (But it will not simplify the harvest operation). A good solution has to be found.

5 - Is it possible to crystallize the salt in artificial evaporators heated by solar energy? And is this economical ? Another possibility is to crystallize the salt by cooling. Has this technology been worked out?

6 - On account of the different solubilities of NaCl and SO_4Na_2 what will be the composition of the salt crystallized from the brines after leaving the crystallizer ponds ?

5/

RECOMMANDATIONS

A/ We sugest to begin the studies as soon as possible, because it will take time for their realizations.

For the geological survey it will be good to contact Unicef for the realization of test bore hole and to decide who can do the resistivity study.

For the meteorological data, on one hand it will be necessary to purchase the equipment (evaporimeter, tank, raingauge, thermometers etc) and on the other hand to construct on the site a platform, fence, door etc.

B/ In order not to lose time we sugest also, just after the completion of the geological survey, to begin the construction on site of the first phase of the plant.
For example, a series of evaporators having a 1000 m^2 surface area

- With this first small plant we can make one year operation and draw the conclusions of our observations for the construction of the rest of the final plant.

- On one hand, it will be safer - because the characteristics of the total plant will be drawn from this / experience and from studies.

- On the other hand the realization, even of a small plant, will be an encouragment for the local people. Certainly the production of fresh water and salt will be not sufficient, but enought to convince every body that the / new process is suitable.

- the detail drawings of this plant must be done as soon as the decision for the construction is taken.
An other reason to built the / first phase of the works is to draw better conclusions than those given by the pilot in Khartoum.
The production of fresh water was 2,65 Litres/ m^2 in sommer and 1,5 L/m^2 in Winter, but it is sure that the climatic conditions, specially for temperature, are better in Umsafari than in Khartoun.
That means for the same daily production of fresh water - The surface of the solar stills plant will be smaller at the Umsafari.

C/ One important aspect about the logistic of this project cannot be neglected:

- First of all the transport facilities, NCR must have at least two new landrovers . They are no roads from Khartoum to Umsafari and from Elobeid to Umsafari, but only tracks.

- It takes 7 to 10 hours driving - and along the way they are no possibility for re-fueling and to repair in case.

- Secondly, at the village itself, it is necessary to forsee lodging facilities, like caravaning - for instance - and also reserves of drinking water and washing water.

6/

POSSIBLE ALTERNATIVES FOR OPERATINGS

This project will be included in a solar community development center in Umsafari - The overall objective is to use solar energy to modernize an indigenous industry of salt and produce potable water, and hence bring about economic revival of an area wich was once well known for its animal wealth and wich has been struck very hard by the desert encroachment and inhabitants migration to towns.

The objective is consequently to etablish a rural community centre for literacy and extension work which leads to raising the social Hygiène and productivity standards, hence to settlement of nomads. The others aspects of the program will be also the etablishment of solar electric energy storage batteries, for operation of radio, television ets, and community centre lighting facilities. When the programme is completed, managing the operations must be given to the Community itself but due to the sophistication of certain parts the local people will not be able to realize the maintenance of the functional equipment. At least at the begining.

Many possibilities must be studied. In any case we think that the government and its technical services must be concerned with the problem of brine supply.

- Research on underground brine resources
- Drilling wells
- Installation and maintenance of all the pumping system (Windmills, generators, photocells, pumps, cable, pipelines

Maybe it is possible to find local people receiving a technical knowledge and who will work, salaried by the government, and be responsible for the daily maintenance operations and controls of the plant.

But all the initiative of brine supply must be held by the Government Administration and its technicians.

Then the brine can be sold to the villagers to make water and salt. The brine cost will be corres ponding to the expenses without anyprofit.

The form of the groupment could be a cooperative.

Operations and maintenance of solar stills, reservoirs, and crystallizers and also harvest and bagging of salt could be done by people salaried by the cooperative .

During the first period the brine could be borrowed from the present wells, by the owners. The government will operate the pumping by flexible system. When the wells will be dry theyl will be abandonned. From the beginning no permission will be given for new wells drilled by villagers.

The total expenses for operation and maintenance of the total plant (except pumping) will constitue the operating cost of the water and salt produced comprising:

Salaries

Charges

Spare parts

Provision

Overhead

Contingengies etc...

The potable water would not be sold (gift of god) but free and distribued to the families according to a certain mode (contingent)

Only the price of the final salt will be fixed.

The cooperative could store the bags of salt and sell it to the merchants with benefit at the second stage.

Many others possibilities are existing and can be studied. But the target is to give the maximum of responsabilities of the local people.

7/

C O N C L U S I O N S

- This project has a great human and social interest.

- Technicaly speaking it is feasable and will be a good example for many other places not only in Sudan, but in other desertic countries.

- Different studies must be done now to make some good calculations of the futur plant characteristics, but in the mean time a first phase could be studied.

- If necessary, a new mission of a Unido expert can take place after the completion of the proposed studies -

OTHER POSSIBILITIES TO PRODUCE SALT IN SUDAN

The most important possibilities are along the Red sea, north and south of port Sudan.

There are already small producers along the coast which make solar salt. (The production of Red sea saltworks is around 110.000 t/year). The final product is certainly good for human consumption, but not pure enough for the chemical industry.

Generally the consumption per capita and per year is about 5 and 7 kg. That means for Sudan, with a population of 19 million, a yearly consumption of between 95,000 and 133,000 tons.

A certain amount of salt is also consumed by the leather, textiles and confectioneries industries.

Salt is eaten by goats, sheep, and cattle also. This consumption is not known.

The salt from brine wells produced and utilized in the deserts is not controlled. Due to this lack of information, a general study for production/consumption of salt in the Sudan is not easy. Only a few things are sure from now:

1. The quantities presently produced are insufficient for the future because - of population increases
   - of the establishment of new chemical industries.

2. The quality of the salt produced is not sufficient to be used by chemical plants, especially in electrolysis plants where caustic soda and chlorine are produced.

3. The best locations for producing better salt in large quantities are along the Red Sea shore (climate and lands).

A general study should be undertaken now.

ANNEX 1

INSTRUCTIONS FOR WEATHER STATION

WEATHER STATION

On each saltworks a weather station must be installed to collect the meteorologic data.

Its location must be in a dry place close to the crystallizers area, but far away from buildings, houses, and walls in order not to disturb the wind and sun effects.

The equipments must be protected by a fence all around the spot. The disposition of equipment are shown on drawing n° 1 the list is.:

Evaporimeter on fresh water
Evaporimeter on brine (25 beaumé)

Rain gauge
Thermometer (dry bulb)
(wet bulb)
Hygrometer

These three instruments should be in a special shady place.

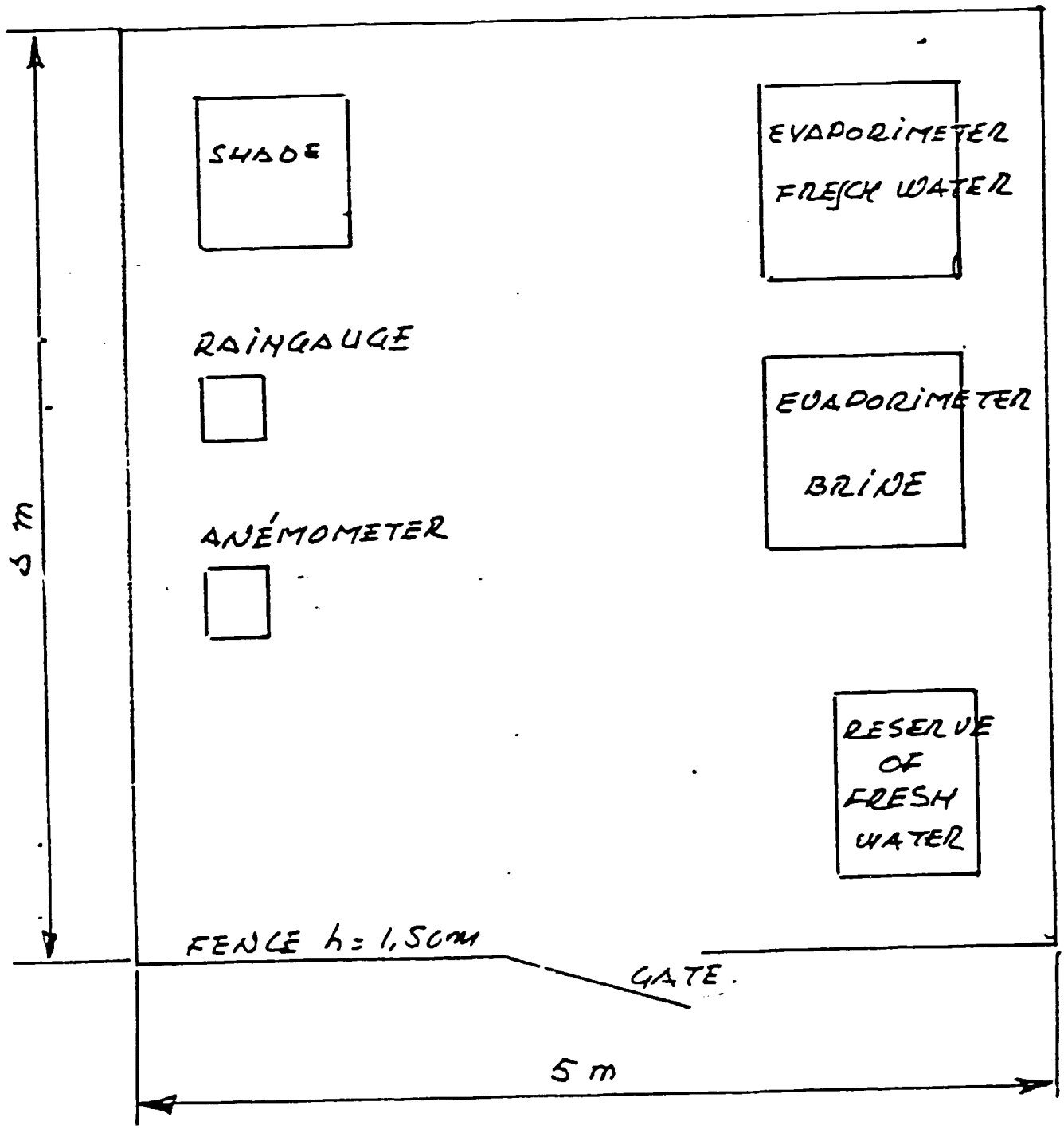
Anemometer (at the high of evaporimeter tank).

Thermometers, hygrometers, and anemometer could be, graph recorder type "
If not, the readings must be done three times a day (7 a.m., 1 p.m, 7 p.m).

Barometer and sun-recorder could be also installed.
The evaporimeter tank must have the sizes indicated on drawing n° 2.
The daily data must be writen on the chart, shown on drawing n° 3.

Raingauges could be located also in different places of the saltworks, because there are some different rain quantities according to the sites.

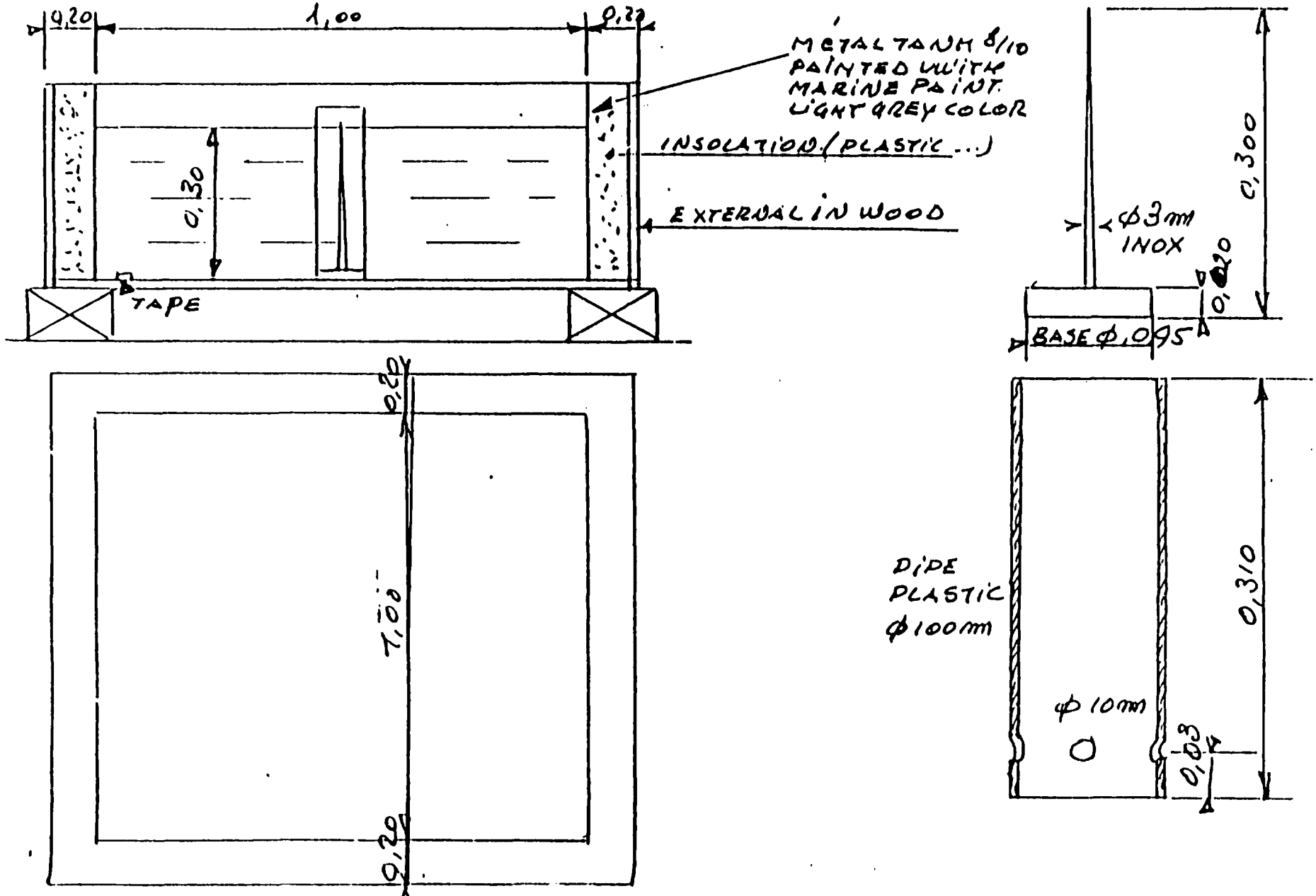
WEATHER STATION



VAPORIMETER = EVERY MORNING PUT FRESH WATER FOR COMPENSATION OF EVAPORATION - 1 liter = 1 mm

FOR BRINE EVAPORIMETER PUT ALSO FRESH WATER FOR COMPENSATION AND NOT BRINE

ΕΥΑΠΟΜΕΤΡΗΤΗΡΙΟ ΤΑΝΚ



LOCATION OF THE STATION :

MONTH :

DATES	HOURS	TEMPERAT.		H%	H%	WINDS		RAINS	EVAPOR		OBSERVATIONS
		DRY	WET	CALCUL	RECORD	Dir	Velo		F.W.	BR.	
1	7am										
	1p.m										
	7p.m										
2											
Etc											

A N N E X 2

REPORTS ON THE PHYSICAL AND CHEMICAL EXAMINATION OF WATER.

THE DEMOCRATIC REPUBLIC OF THE SUDAN
MINISTRY OF HEALTH
CHEMICAL LABORATORIES

Our Ref.: CL/ 5/3/1/2 النمرة :
Your Ref.:
Telephone : KHARTOUM 78369—Ext. 60
Tel. Address: KIMIA, KHARTOUM.
From : THE GOVERNMENT ANALYST

المعامل الكيماوية
وزارة الصحة
الخرطوم

P.O. Box 287
KHARTOUM
تلفون : ٧٨٣٦٩ الخرطوم توصيلة — ٦٠
تلغرافيا (كيميا) الخرطوم
من اخصائي التحليل

Date: [illegible] March 198[illegible]

Urgent

REPORT ON THE PHYSICAL AND CHEMICAL EXAMINATION OF WATER

تقرير عن تحليل عينة ماء

NAME & ADDRESS OF SENDER The National Council for Research-Council for Research Energy

SENDER REF. No. .... LAB. REF. No. [illegible handwritten Arabic]

SOURCE OF SAMPLE Well No. 3(Marked L) LOCALITY 1730 (82-83)

NATURE OF SAMPLE Untreated DATE OF SAMPLING ....

APPEARANCE ....

Result of examination of filtered sample

COLOUR .... TURBIDITY ....

ODOUR .... TASTE ....

CONDUCTIVITY .... pH ....

TOTAL SOLIDS DRIED AT at 180°C		mg/l
TOTAL HARDNESS as $CaCO_3$	2300	mg/l
TOTAL ALKALINITY as $CaCO_3$	1500	mg/l
EXCESS ALKALINITY as Na_2CO_3	Nil	mg/l
CALCIUM as Ca	400	mg/l
MAGNESIUM as Mg	315	mg/l
CHLORIDE as Cl	23000	mg/l
SULPHATE as SO_4	29045	mg/l
NITRATE as NO_3	320	mg/l
NITRITES as NO_2	35	mg/l
FLUORIDE as F	--	mg/l
AMMONIA as N	--	mg/l
ALBUMINOID NITROGEN as N	--	mg/l
ARSENIC as As	--	mg/l
LEAD as Pb	--	mg/l
SODIUM as Na	22000	mg/l
POTASSIUM as K	280	mg/l
D (15°C)	1.049	

FORM A.XXXXX

A.M. El-Hilali,
GOVERNMENT ANALYST

THE DEMOCRATIC REPUBLIC OF THE SUDAN
MINISTRY OF HEALTH
CHEMICAL LABORATORIES

Our Ref. : CL/ S/B/2/2 : النمرة
Your Ref. :
Telephone : KHARTOUM 78369—Ext. 60
Tel. Address: KIMIA, KHARTOUM.
From : THE GOVERNMENT ANALYST
Date: 1 March 1983

المعامل الكيماوية
وزارة الصحة
الخرطوم
Urgent

P.O. Box 287
KHARTOUM
تلفون : ٧٨٣٦٩ الخرطوم توصيلة — ٦٠
تلغرافيا (كيميا) الخرطوم
من اخصائي التحليل

REPORT ON THE PHYSICAL AND CHEMICAL EXAMINATION OF WATER

تقرير عن تحليل عينة ماء

NAME & ADDRESS OF SENDER The National Council For Research - Council for Rese Ener
SENDER REF. No. ..... LAB. REF. No. 1728(82-83)
SOURCE OF SAMPLE Well No. I(Marked H) LOCALITY ابار هيارك - سكاد كردفان
NATURE OF SAMPLE Untreated DATE OF SAMPLING .....

APPEARANCE .....

Result of examination of filtered sample

COLOUR	TURBIDITY	
ODOUR	TASTE	
CONDUCTIVITY	pH	
TOTAL SOLIDS DRIED AT at 180°C		mg/l
TOTAL HARDNESS as $CaCO_3$	4200	mg/l
TOTAL ALKALINITY as $CaCO_3$	2500	mg/l
EXCESS ALKALINITY as Na_2CO_3	Nil	mg/l
CALCIUM as Ca	400	mg/l
MAGNESIUM as Mg	780	mg/l
CHLORIDE as Cl	90000	mg/l
SULPHATE as SO	49850	mg/l
NITRATE as NO_4	200	mg/l
NITRITES as NO_3	40	mg/l
FLUORIDE as F_2	--	mg/l
AMMONIA as N	--	mg/l
ALBUMINOID NITROGEN as N	--	mg/l
ARSENIC as As	--	mg/l
LEAD as Pb	--	mg/l
SODIUM as Na	64000	mg/l
POTASSIUM as K	560	mg/l
REMARKS: D ($15^{\circ}C$)	1.139	

A.M. El-Hindi,
For/ GOVERNMENT ANALYST

THE DEMOCRATIC REPUBLIC OF THE SUDAN
MINISTRY OF HEALTH
CHEMICAL LABORATORIES

Our Ref.: CL/5/C71/2 النمرة : المعامل الكيماوية P.O. Box 287
Your Ref.: KHARTOUM
Telephone: KHARTOUM 78369—Ext. 60 وزارة الصحة تلفون : ٧٨٣٦٩ الخرطوم توصيلة — ٦٠
Tel. Address: KIMIA, KHARTOUM. تلغرافيا (كيميا) الخرطوم
From: THE GOVERNMENT ANALYST الخرطوم
Date: 1 March 1983. من اخصائي التحليل

Urgent

REPORT ON THE PHYSICAL AND CHEMICAL EXAMINATION OF WATER

تقرير عن تحليل عينة ماء

NAME & ADDRESS OF SENDER The National Council For Research-Council for Research Energy
SENDER REF. No. .... LAB. REF. No. 1729 (C2-83)
SOURCE OF SAMPLE Well No.2(Marked M) LOCALITY [illegible]
NATURE OF SAMPLE Untreated DATE OF SAMPLING ....

APPEARANCE ....

Result of examination of filtered sample

COLOUR .... TURBIDITY ....
ODOUR .... TASTE ....
CONDUCTIVITY .... pH ....

TOTAL SOLIDS DRIED AT at 180°C		mg/l
TOTAL HARDNESS as $CaCO_3$	6200	mg/l
TOTAL ALKALINITY as $CaCO_3$	3500	mg/l
EXCESS ALKALINITY as Na_2CO_3	Nil	mg/l
CALCIUM as Ca	560	mg/l
MAGNESIUM as Mg	1165	mg/l
CHLORIDE as Cl	20000	mg/l
SULPHATE as SO_4	69215	mg/l
NITRATE as NO_3	Nil	mg/l
NITRITES as NO_2	0.6	mg/l
FLUORIDE as F	--	mg/l
AMMONIA as N	--	mg/l
ALBUMINOID NITROGEN as N	--	mg/l
ARSENIC as As	--	mg/l
LEAD as Pb	--	mg/l
SODIUM as Na	58000	mg/l
POTASSIUM as K	900	mg/l

REMARKS: D $(15^{0}C)$ 1.157

A... El-[illegible],
[illegible] GOVERNMENT ANALYST

A.../N.N.

M. of H. Form No. 115

THE DEMOCRATIC REPUBLIC OF THE SUDAN
MINISTRY OF HEALTH
CHEMICAL LABORATORIES

Our Ref.: CL/ 5/3/1/2 : النمرة
Your Ref.:
Telephone: KHARTOUM 78369—Ext. 60
Tel. Address: KIMIA, KHARTOUM.
From: THE GOVERNMENT ANALYST

المعامل الكيماوية
وزارة الصحة
الخرطوم

P.O. Box 287
KHARTOUM
طلفون: ٧٨٣٦٩ الخرطوم اوصيلة — ٦٠
تلغرافيا (كيميا) الخرطوم
من اخصائى التحليل

Date: 1 March 1983

Urgent

REPORT ON THE PHYSICAL AND CHEMICAL EXAMINATION OF WATER

تقرير عن تحليل عينة ماء

NAME & ADDRESS OF SENDER The National Council For Research - Council for Research Energy

SENDER REF. No. ..... LAB. REF. No. ١٣٠ صبارى - كان رقم

SOURCE OF SAMPLE Well No.4(Sher shar) LOCALITY 1721 (82-83)

NATURE OF SAMPLE Untreated DATE OF SAMPLING .....

APPEARANCE .....

Result of examination of filtered sample

COLOUR	TURBIDITY	
ODOUR	TASTE	
CONDUCTIVITY	pH	
TOTAL SOLIDS DRIED AT at 180°C		mg/l
TOTAL HARDNESS as $CaCO_3$	800	mg/l
TOTAL ALKALINITY as $CaCO_3$	3000	mg/l
EXCESS ALKALINITY as Na_2CO_3	2330	mg/l
CALCIUM as Ca	200	mg/l
MAGNESIUM as Mg	75	mg/l
CHLORIDE as Cl	58000	mg/l
SULPHATE as SO_4	80960	mg/l
NITRATE as NO_3	730	mg/l
NITRITES as NO_2	15	mg/l
FLUORIDE as F	--	mg/l
AMMONIA as N	--	mg/l
ALBUMINOID NITROGEN as N	--	mg/l
ARSENIC as As	--	mg/l
LEAD as Pb	--	mg/l
SODIUM as Na	66000	mg/l
POTASSIUM as K	840	mg/l

REMARKS: D (15^{20}C) 1.147

Abdel Rahim,

A N N E X 3

CLIMATIC DATE FROM EL OBEID - WEATHER STATION

ELOBEID WEATHER STATION

EVAPORATION (TANK) EXPRESSED IN MILLIMETRES

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Averages
J	335,6	373,9	366,3	353,4	391,4	356,8	374,6	428,8	354,0	342,2	367, 7
F	386,9	390,5	402,3	402,4	410,2	391,8	382,2	394,3	430,9	387,9	397, 9
M	513,4	527,6	406,6	540,0	493,8	530,9	508,2	501,3	465,6	459,8	494, 7
A	487,9	545,6	367,2	460,7	408,6	515,2	521,2	500,3	513,5	495,3	481, 6
M	485,5	373,6	483,3	481,3	410,5	471,5	467,4	453,7	435,1	450,0	451, 2
J	429,3	458,1	392,8	404,9	436,7	460,0	435,1	379,3	331,5	324,0	405, 2
J	317,3	326,3	248,8	316,9	277,0	288,2	253,0	315,8	219,8	179,3	274, 2
A	266,6	291,9	212,7	197,2	261,5	214,8	168,0	226,5	291,4	242,9	237, 3
S	267,9	492,0	220,3	215,4	213,0	286,2	238,8	233,0	258,7	216,3	264, 2
O	330,9	361,4	373,6	406,8	315,0	385,7	333,5	396,2	340,2	593,5	383, 7
N	339,7	412,8	402,8	442,5	375,6	400,4	399,8	357,7	332,1	375,2	383, 9
D	406,2	374,4	352,5	387,4	369,8	267,1	383,1	337,2	322,2	363,5	356, 3
TOTAL	4567,2	4928,2	4 203,2	4620,9	4363,1	4 568,6	4444,9	4524, 1	4 295,0	4429,9	4 497, 9

EL OBEID - WEATHER STATION RAIN (EXPRESSED IN MILLIMETRES

	1972	1983	1974	1975	1976	1977	1978	1979	1980	1981	AVERAGES
JANUARY	-	-	-	-	-	-	-	-	-	-	
FEBRUARY	-	-	-	-	-	-	-	-	-	-	
MARCH	-	-	-	-	-	-	-	-	4,6	2,8	0,7
APRIL	-	9,1	-	-	2,3	-	7,7	-	-	-	1,9
MAY	14,1	15,3	-	3,9	-	18,3	42,5	21,2	12,0	28,0	14,5
JUNE	42,2	20,3	6,8	8,5	6,0	4,3	9,5	13,1	40,0	30,3	18,1
JULY	50,9	110,9	208,1	87,2	176,8	72,9	130,5	50,2	138,0	112,0	113,7
AUGUST	148,0	15,5	93,0	59,1	135,2	210,4	164,1	154,3	75,4	65,4	112,0
SEPTEMBER	18,3	105,9	38,4	42,9	89,2	7,6	77,1	31,2	87,5	46,0	54,4
OCTOBER	63,4	16,5	0,3		23,1	0,1	36,8	6,8	7,4	30,6	18,5
NOVEMBER	-	-	-	-	-	-	-	7,6	-	-	0,8
DECEMBER	-	-	-	-	-	-	-	-	-	-	-
TOTALS	336,9	293,5	346,6	201,6	432,6	303,6	468,2	284,4	364,9	315,1	334, 6

UNITED NATIONS INDUSTRIAL DEV LOPMENT ORGANIZATION

PREPARED FOR NATIONAL CONCIL FOR RESEARCH IN KHARTOUM

SUDAN

STUDY FOR DRINKABLE WATER AND SALT PRODUCTION IN UMSAFARI

(SHIMAL KURDUFAN)

by

Jean CLAIN

SI/SUD/82/804/11-01/52.1.C.

ADDITIONAL REPORT

This report has not been cleared with UNIDO wich does not, therefore necessarily share views presented.

APRIL 83

C O N T E N T S

I/

I N T R O D U C T I O N

The report of march 1983, was done to examine the general conditions for fresh water and salt production in Umsafari.

The Expert ask N.R.C. to do some studies : geological survey, weather station, brine studies.
and draws the conclusion that : at the begining instead to built the totality of the plant , just make a first phase.

The object of this report is to explain what could be this first phase.

-----oOo-----

II

- DEFINITION OF THE PLANT

The problems to solve are

1/ Pumping of the brine

2/ concentration of the brine into evaporators untill saturation.

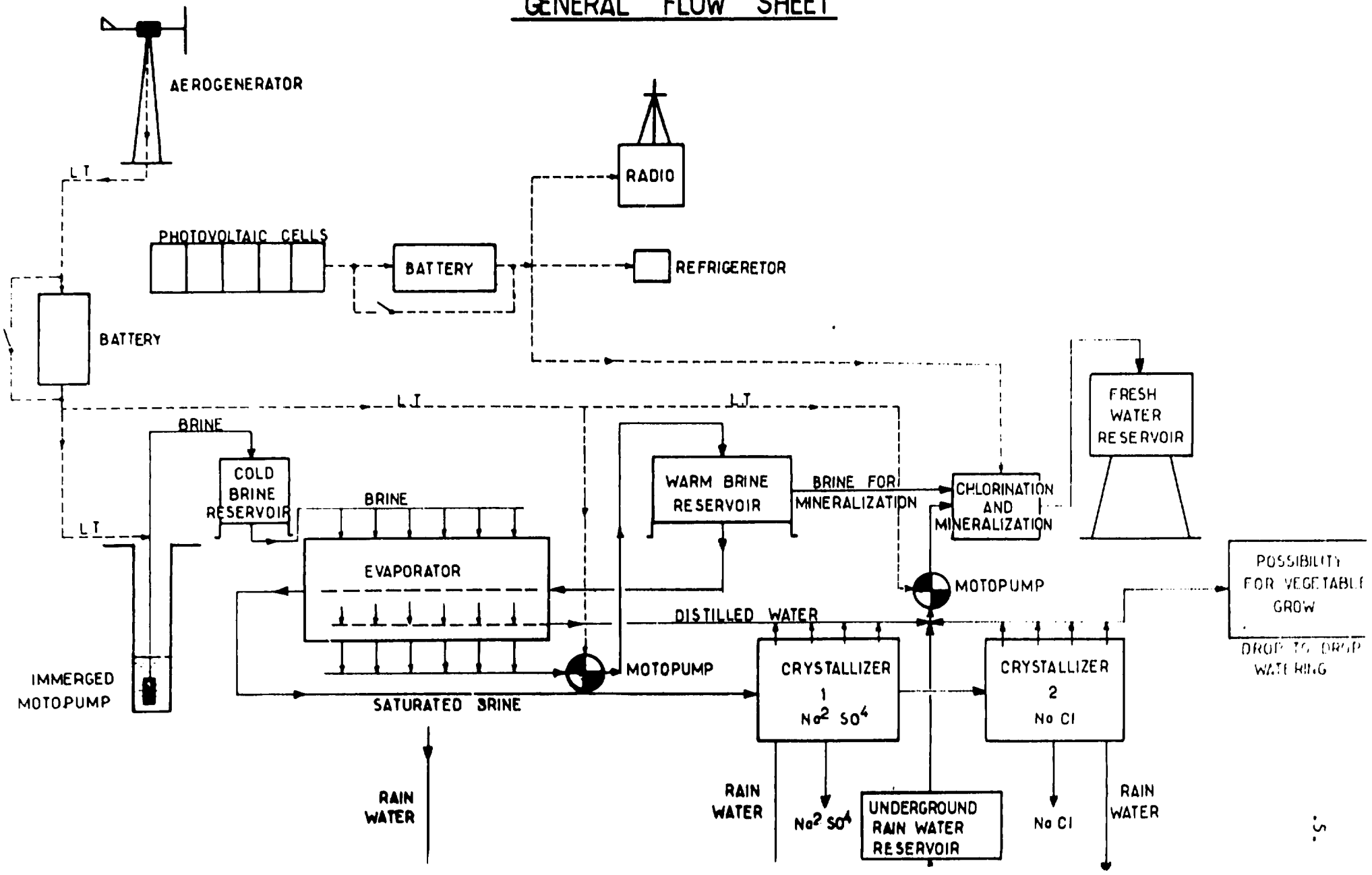
3/ cristallization of different salts into crystallizers and harvestings.

4/ recovery of distilled water, treatment and storage.

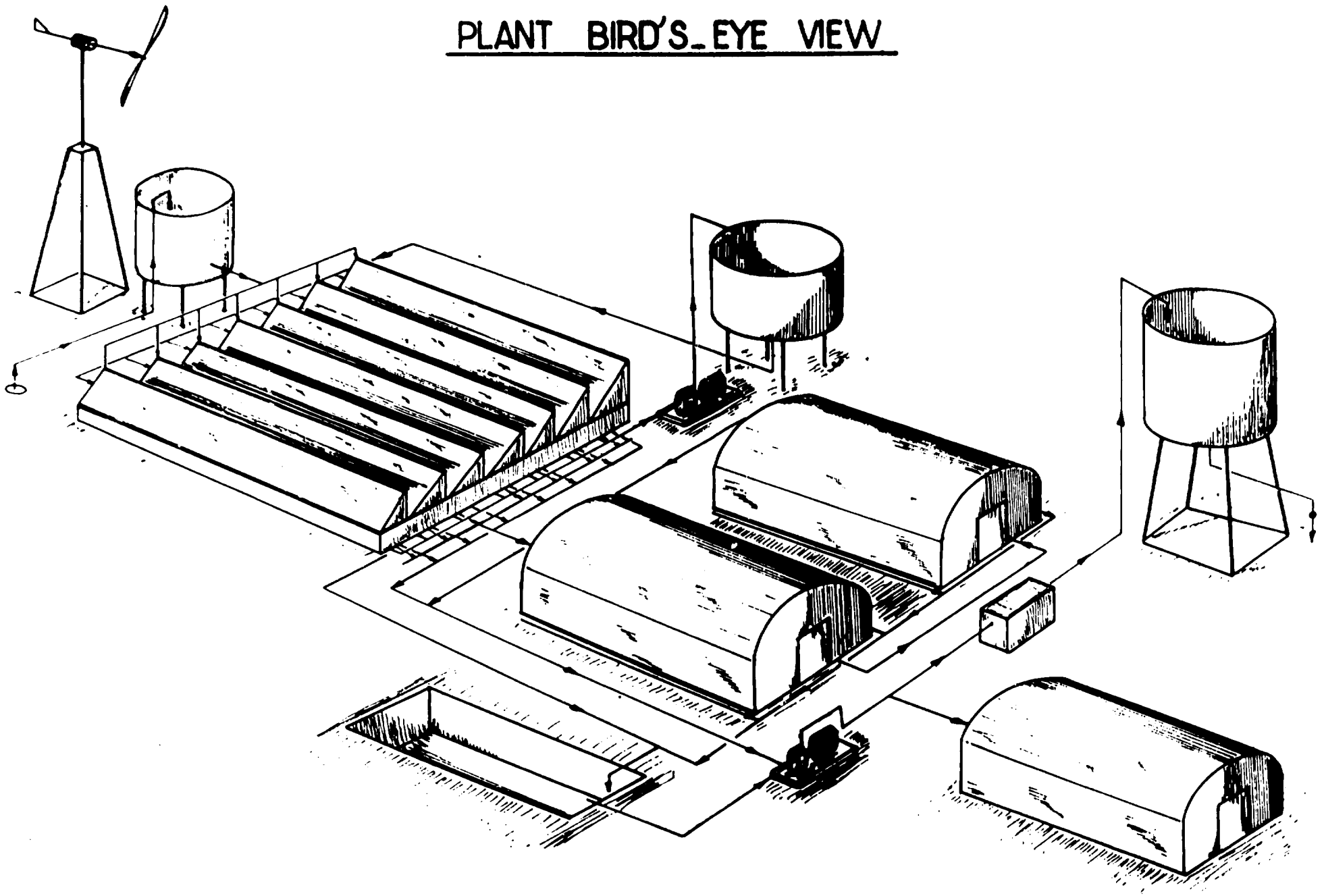
5/ Services, radio, refrigeration

We are giving in the following page the general flow sheet

GENERAL FLOW SHEET



PLANT BIRD'S-EYE VIEW



1/ PUMPING

There five possibilities

A/ Wind energy to move directly the pump
B/ Aerogenerator to drive electric motor
C/ Photovoltaic cells to drive electric motor
D/ Energy whell
E/ Manual pumping.

The first solution is the cheapest, as far as the investments are concerned, but this system is good for small capacities only.

The maintenance of the immerged pump is not easy because it is necessary to desassembly all the pipe and shaft system. The second process is more flexible because the aerogenerator is installed on a fixed point and the electric power distributed by cable.

The electric motor and the pump are both immerged and the discharge pipe is in flexible plastic. We ca mouve the system from one well to an other which is not possible with the case n° 1. The third system is like the seco-d but the electric energy is given by sun and not by wind.

During the day time (9 am to 4 pm) the sky is not very clear due to the presence of sand winds and the efficency of the celles for high capacities, will be not very high. For these reasons we select aerogenerator for pumping system and photocells for radio, light, and freezer and mineralization and chloration plant.

For the energy system (a novel concept which uses gravity as its driving force and its energy source is a small temperature gradient across the wheel) for the moment the energy is only available for small capacitus .

But all these considerations are available for the total plan but for the first which will be 10 % maximum of the total plant. A preliminary manual pumping will be sufficent due to the small capacity of the first phase.

2/ EVAPORATORS

The evaporators must be solar stills because it is the cheapest way t produce fresh water by solar energy.

To increase the efficiency of the system we propose to increase the temperature of the brine before its passage into the solar stills ; and in the mean time to decrease the temperature of the glass cover of the still.

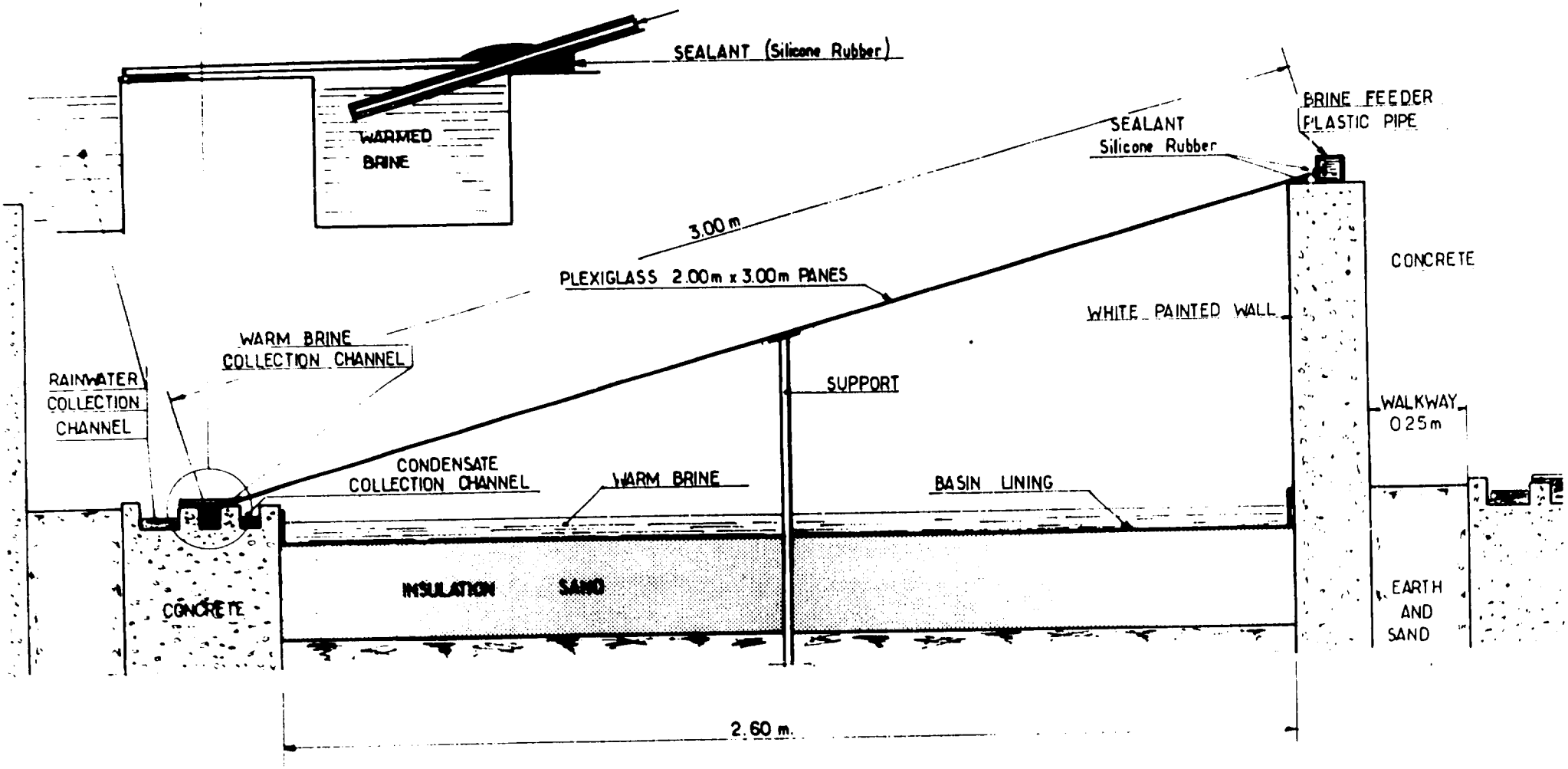
This double operation will be realized by a passage of the cold brine after pumping, in a double glace cover.

The brine will be done only during the day time. At night the cover will be refrigerated by the natural air but the brine will be still warm.

The distilled water and the rain water will be recovered as shown in the following page.

EVAPORATOR CROSS SECTION

BRINE OUTLET DETAIL



3/ CRYSTALLIZERS

Due to the presence of frequent and heavy sandwinds it is not suitable to crystallize the salt in open air.
We propose to cover the crystallizers surfaces with solar stills.
These stills will be cover by plastic and the frame works will be in aluminium.
The height of the stills will allow the easy circulation for men to harvest the salts.
The soil, wich is not tight, will be covered with plastic also
The fresh water will be recovered at the periphery.
The rain fall, also, will be recovered.
But the cover will be not refrigereted by cold brine.
Into crystallizer n° 1, the sodium sulphate will settle down, into the second NaCl will settle down.

4/ RECOVERY OF DISTILLED WATER AND RAIN

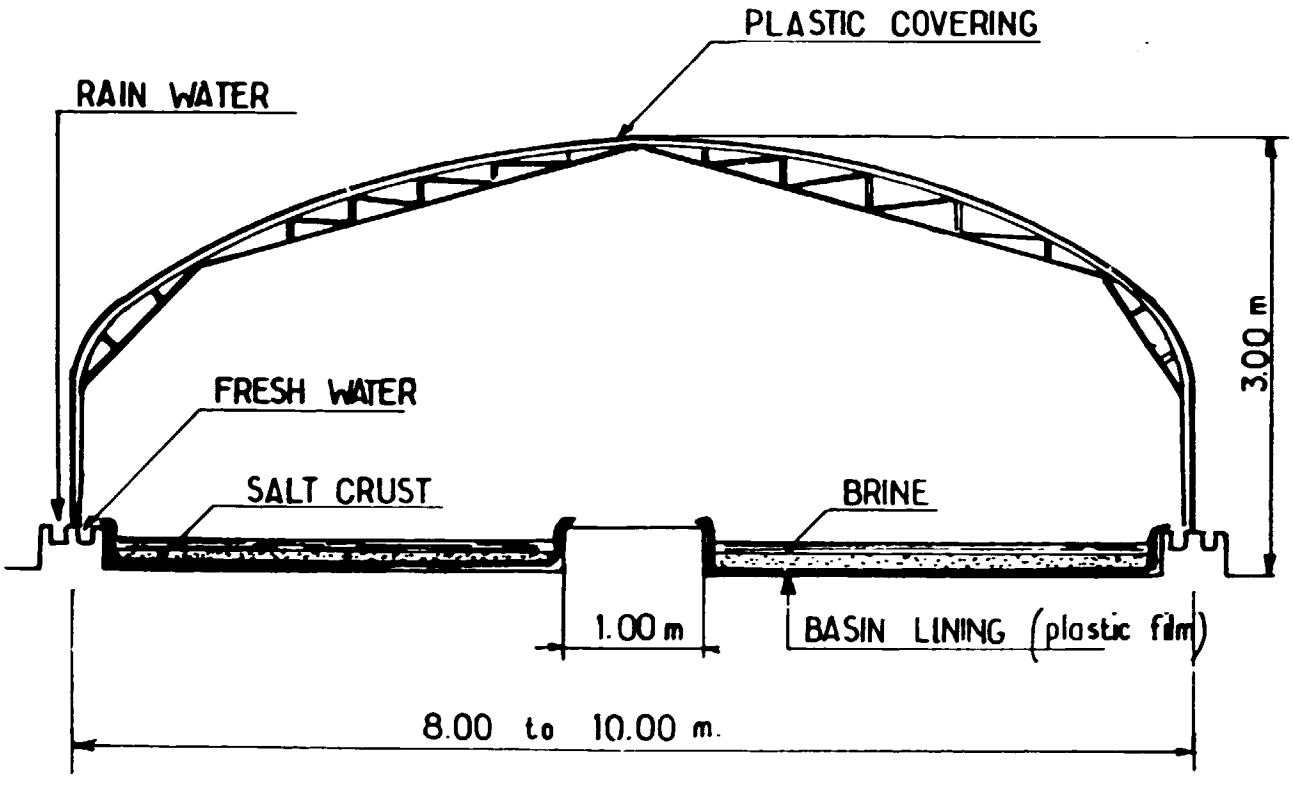
From evaporators distilled water will be recovered in a continous flow ,along days and years, the bassins working in series.
The rain will be recovered during the rainy season only, and stored in a underground reservoir.
The totality of the water, wich is very pure, will be re-mineralize with the natural brine and chlorided with a special chloration plant. (thechloride will be produced from the brine also) and the electric energy given by photovoltaic cells.
The treated water will be stored in a metallic reservoir in altitude and the water will be distributed to the villagers.

5/ SERVICES

We need energy for :
- Radio station
- Refrigerator
- Mineralization and cholaration plant.

The energy will be given by photovoltaic cells.

CRYSTALLIZER



6/ SERVICES

We sugest to utilize
A radio station to communicate with Kartoum (Photo voltaic cells) and a refrigeration station to make ice and keep drugs in security.

III

CLIMATIC STUDY

In our first report we gave data for rain and evaporation for El Obeid weather station.
Here we are giving in addition :
temperature at El Obeid station (10 years)
Global solar radiation in Port Sudan station (10 years)
(no data avaible in El Obeid Station).

For the moment we have no data for wind velocities but we can considere an average figure between 6 and 8 metres/second.

WEATHER CONDITIONS (AVERAGE 1972 - 1981)

STATIONS	ITEMS	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
EL OBEID	RAINS	-	-	0,7	1,9	14,5	18,1	113,7	112,0	54,4	18,5	0,8	-	334,6
EL OBEID	EVAPORATIONS	367,7	397,9	494,7	481,6	451,2	405,2	274,2	237,3	264,2	383,7	383,9	356,3	4 497, 9
EL OBEID	REL.HUMIDITY	21	17	13	15	27	43	63	69	60	39	24	25	35
EL OBEID	AV. TEMPERATURE	22,2	25,6	28,1	31,3	32,1	30,7	28,8	27,7	28,6	29,8	26,2	23,3	27,9
PORT SUDAN	SOLAR RADIATION (CAL/Cm^2/D	356	456	542	616	612	579	549	548	544	499	407	354	497

IV

CALCULATION OF THE MEAN ELEMENTS

I/ for the first we take an evaporators surface of 500 SQ/M. of bassins.

The graph n° 1 gives for

temperature = 27,9.

Global solar radiation = 497 cal/cm2/day

A daily evaporation = 2,8 liter/m2/Day.

The experiment of NCR in 1979, gives an yearly average of

$$\frac{2,65 + 1,50}{2} = 2,07/L/m2/D$$

Probably because the liquid is a brine for wich the evaporation ratio is lowest than for sea water.

Due to the refreshment of the lover by brine coming from the wells and the warm brine in the bassins the efficiency of the process will increase 50 % . The average yearly evaporation will be 3 LITRE/m2/D. (3,8 L/m2/D in sommer time and 2,2 L/m2/D.)

The average daily production of fresh water will be : 3 l/m2/D x 500 m2 = 1 500 L.

II/ According to the location of the wells the salinity is different (1,050 to 1,150) for our calculation we take a density of 1,100).

For this density the relatives volumes are

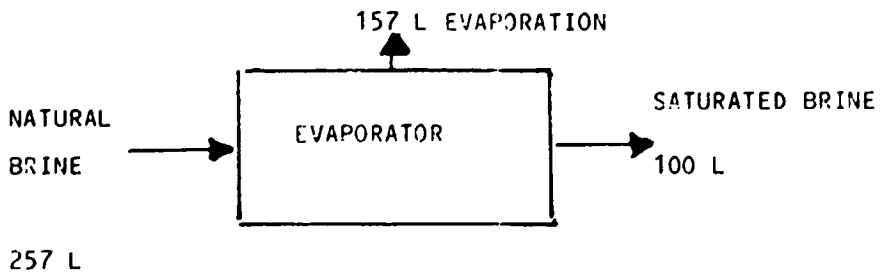
d = 1.100 V 1 = 257 litres

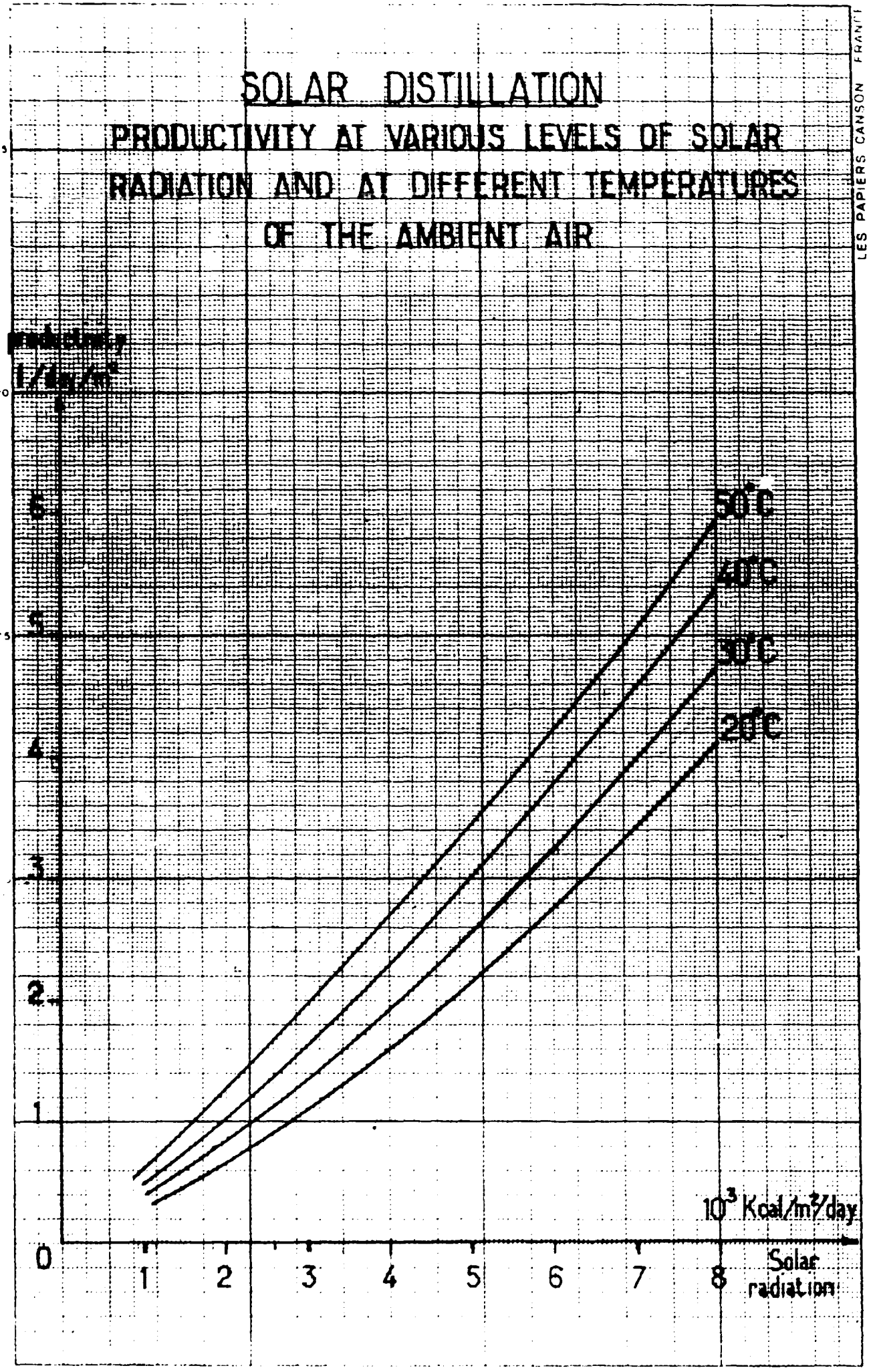
d = 1.214 (saturation V2 = 100 litres.

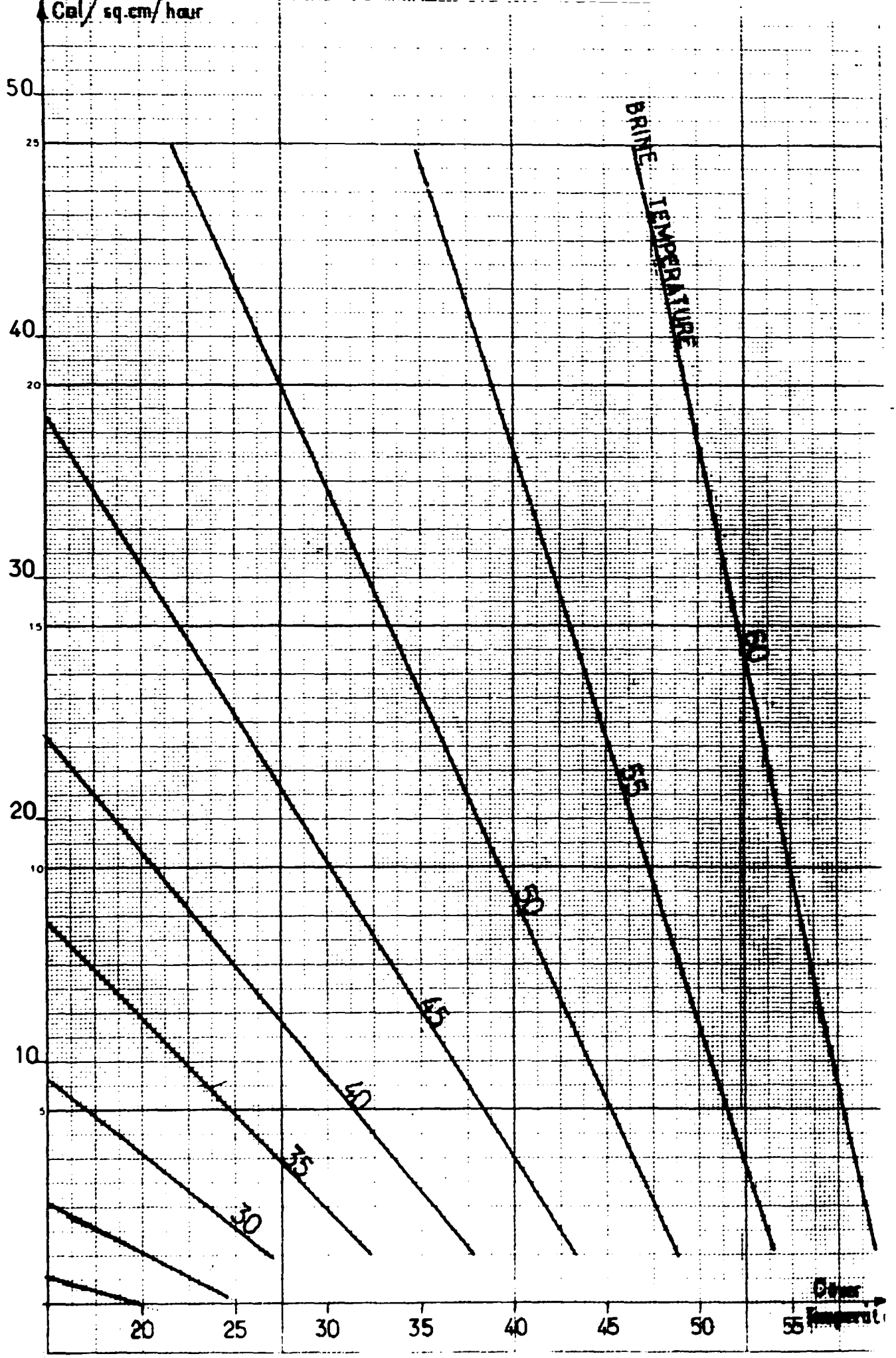
Volume to evaporate = 157 litres.

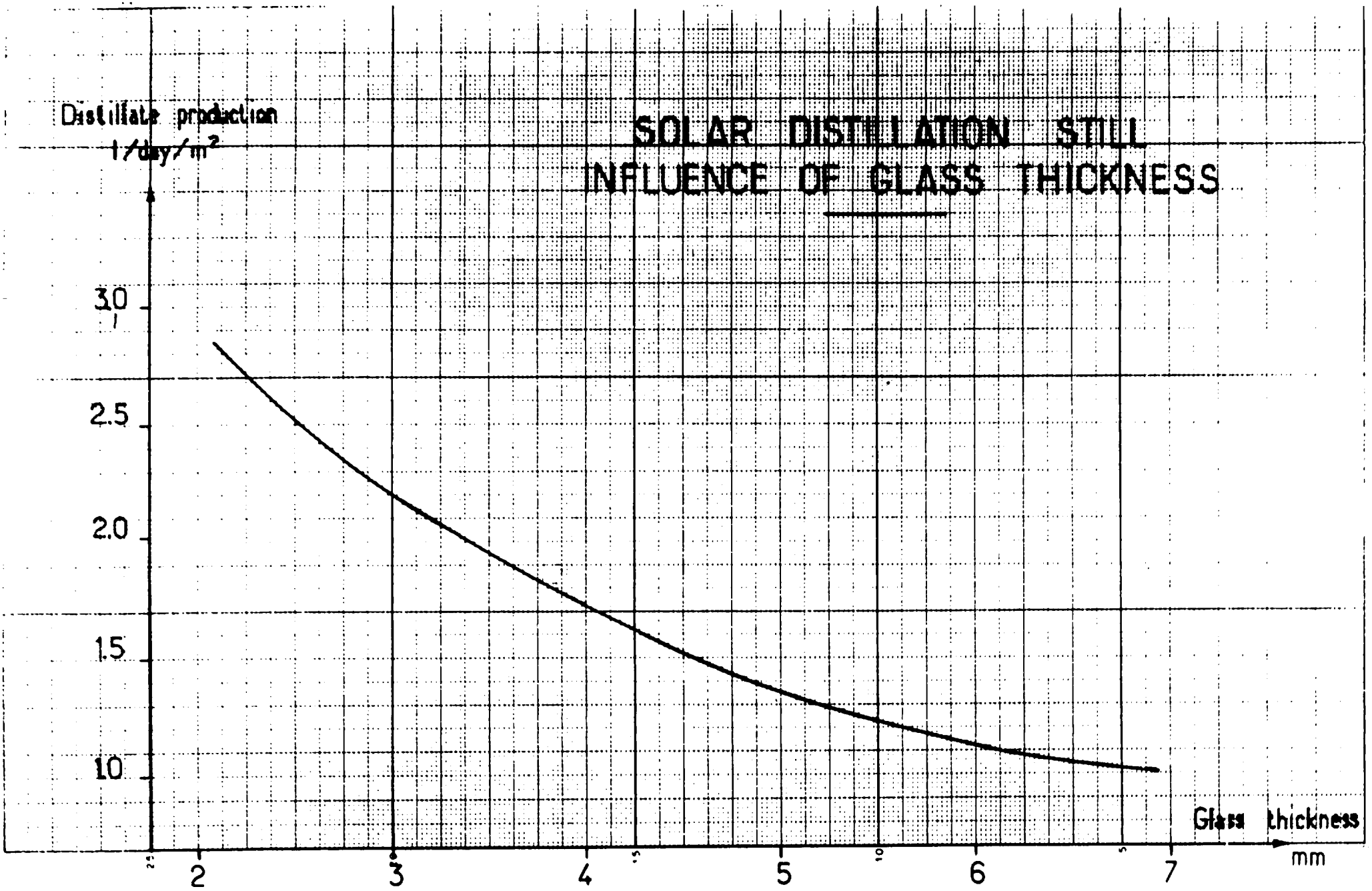
The daily balance.

THEORITICAL

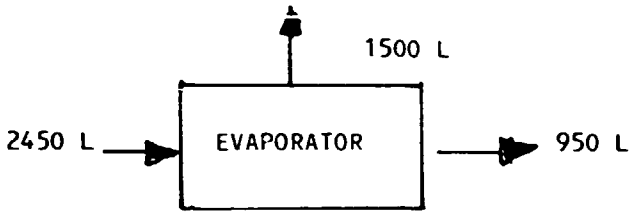



SOLAR DISTILLATION
PRODUCTIVITY AT VARIOUS LEVELS OF SOLAR RADIATION AND AT DIFFERENT TEMPERATURES OF THE AMBIENT AIR
productivity
l/day/m²
6
5
4
3
2
1
0
50°C
40°C
30°C
20°C
1
2
3
4
5
6
7
8
10³ Kcal/m²/day
Solar radiation
LES PAPIERS CANSON FRANCE


Cal/ sq.cm/ hour
50
25
40
20
30
15
20
10
10
5
BRINE TEMPERATURE
60
55
50
45
40
35
30
20
25
30
35
40
45
50
55


SOLAR DISTILLATION STILL
INFLUENCE OF GLASS THICKNESS
Distillate production
l/day/m²
3.0
2.5
2.0
1.5
1.0
2
3
4
5
6
7
Glass thickness
mm

PRACTICAL



If the concentration of the brine is higher than 1,100, then the quantity to pump will be more important.
To be on the safe side we take a daily capacity of
5 000 litres pumping time = 7 hours

Hourly capacity = $\frac{5000}{7}$ = 765 L/H.

Fotal manometrique elevation = 60 M
Power = 12 kg/m/sec.
Pumps efficiency = 50 %
Total power = 1/3 HP
It will be a manual pump at this stage of the project.

SALT PRODUCTION

Daily quantity of saturated brine = 950 L
Salt content = 321 gr/l
Total weight of salt = 950 x 0,321 = 305 Kilos.

According to the presence of hard sand winds we select to locate the crystallizers under solar stills
This type of solar stills will be different from evaporators type.
They will be componend by plastic cover with aluminium fram works. The heigh will allow the manual harvest of the salts.
Under these solar still wich will not be refreshed by brine, like evaporators stills, the daily evaporation will be 2 liter/SQ

PRODUCTION OF SALT

Salt contained into the Brine

950 L x 0,321 = 305 kg.

Percentage of recovery = 50/100

Salt recovered = $305 \times \frac{50}{100}$ = 152 kg/day.

Per year = 152 x 365 = 55.480 kg or 55,48 tons.

CRYSTALLIZERS SURFACES

In let quantity = 950 l.

Out let quantity = 0,30 x 950 = 285 L

Evaporation = 950 - 285 = 665 L;

Necessary surface = $\frac{665}{2}$ = 332 Sq/m

If the size of the solar still is 8 m, the lenght will be

$\frac{332}{8}$ = 42 m.

The soil will be covered by black plastic line

The distance of 42 m will divided in 4 parties working in serie into the first crystallizer the sodium sulphate will crystallize and the purer salt into the last one.

RAIN WATER CATCHMENT

Surface of Evaporators lovers = (200 x 3)	600	Sq/ m
Surface of crystallizers = (42 x 10)	420	Sq/ m
Total	1020	Sq/m

Total annual rain = 0,334 m

Possible recovery (50 %) 0,167 m

Total capacity = 1020 x 0,167 = 170 Sq/m

Capacity of the reservoir = 200 Sq/m
(10 x 10 x 2 m)

This reservoir will be ditched below ground level and the surfaces will be recovered by black polythen. The top will be also recovered.

CAPACITIES OF THE RESERVOIRS

COLD BRINE RESERVOIR

Capacity of the brine Pump = 715/L/H this reservoir is just a buffertank between pump an evaporator. A capacity of 2 cu/M is sufficient. His altitude ist to give a sufficient charge to put the brine on the evaporator covers.
Fourmetres are sufficent.
Tank and framworks will be metallic

WARM BRINE RESERVOIR

This reservoir will distribute the warm brine during the night when the pump will be stoped ie
24 - 7 = 17 hours

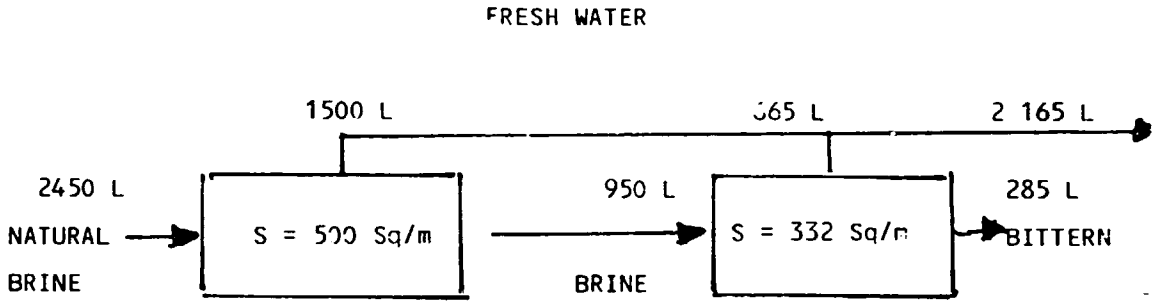
$$\frac{3\,000\ L \times 17\ H}{24} = 3\,540\ L.$$

The capacity of the reservoir = 5 cu/m.
The altitude = 4 M.
Tank and frame works will be metallic.

FRESHWATER RESERVOIR

It is a buffer tank betwen production (24 hours) and utilization (8 or 10 hours)
That's mean a storage of 14 hours maximum
Capacity = 14 x 0,715 L = 10, cu/m.
Altitude = 5 m.
Tank and Framworks will be metallic.

TOTAL DAILY BALANCE



d = 1.100

152 Kg (NaCl)

ANNUAL QUANTITIES

Fresh water = 2165 L x 365 D	=	790	cu/m
Rain	=	170	cu/m
Total		960	cu/m/year

Salt = 0,152 T x 365 = 55 Tons.

CHLORINIZATION PLANT.

The rain water and the distillated water must be

- Re-Mineralized
- Chlorinized

To mineralize we will put a very small percentage of natural brine into the distillated water.
To chlorinize we will utilize a system , making chorine with electricity given by photovoltaic cells.
The system electrolyzes the natural brine given chlorine.

SERVICES

We sugest to utilize
a radio station to communicate with Khartoum (Photo voltaic cell)
and a refrigeration station to make ice and keep drugs in
security.

V

INVESTMENTS

We are giving a preliminary cost estimate for the total plant. At this stage of the study it is not easy.

To obtain a more accurate price it must be necessary to do :

1/ A detailled engineering

2/ a call for tenders

3/ a study for the problem of machinery and equipments transport between Khartoum and Um Safari.

4/ A study for erection costs on site.

Any way our estimation is a rught price allowing the continuation of the project.

INVESTMENTS

(PRICE GIVEN IN SUDANESE PONDS)

1/ PUMPING

a/ Drilling of well by drilling machine fixed on truck		2. 500
b/ Manual Pump. Titan UPM		
Price fob European port	1 400	
Transport on site	420	
Assembly	700	
	TOTAL	2. 520

2/ EVAPORATORS

a/ Massonery		
50 cu/m x 300		15. 000
b/ Plastic cover		
Price Fob European Port		
600 Sq/m x 12	7 200	
Transport on site	2 200	
Assembly	3 600	
	TOTAL	13. 000
c/ Black polythen for soil		
price European port		
550 sq./.m x 0,40	220	
Transport on site	80	
Assembly	150	
	TOTAL	450

3/ CRYSTALLIZERS

a/ Massonry			
10 cv/m x 300			3 000
b/ Plastic cover			
Price Fob European port			
1130 Sq/m x 10 =	11 300		
Transport on site	3 000		
Assembly	2 000		
		TOTAL	16 300
c/ Aluminium frame works			
price Fob European port	1 900		
Transport on site	600		
Assembly	600		
		TOTAL	3 100

4/ 3 METALLIC RESERVOIRS

Price European Port	3 000		
Transport on site	1 000		
Assembly	2 000		
		TOTAL	6 000

5/ UNDERGROUND RESERVOIR (200 cu/m)

Excavation	800		
Black Polythen coverage	100		
		TOTAL	900

6/ 2 PUMPS FOR BRINE CIRCULATION

(Pumps, electric motor and photovoltaic cells)

Price European port = 20. 000			
Transport on site	4. 000		
Assembly	6. 000	TOTAL	30 000

7/ PIPE LINES SYTEM

ESTIMATION	30 000
TOTAL FOR WATER AND SALT PRODUCTION	122 770
Engineering - supervision	13 000
	135 770
Contingencies 30 %	44 230
TOTAL	180.000

RADIO STATION

Portable building and photovoltaic cells

Priee European Port ... =	10 000	
Transport on site ... =	1 500	
Erection and assembly.. =	5 000	
TOTAL		16 500

REFRIGERATOR (200 L)

Price European Port ...	10 000	
Transport on size ...	3 000	
Erection ...	5 000	
TOTAL		18 000
GRAND TOTAL		2 145 00'

C O N C L U S I O N S

The proposition is for the first phase to built on site a pilot plant (500 Sq/m)

After the first experimentations we can built the total plant, in accordance of the results of this experience.

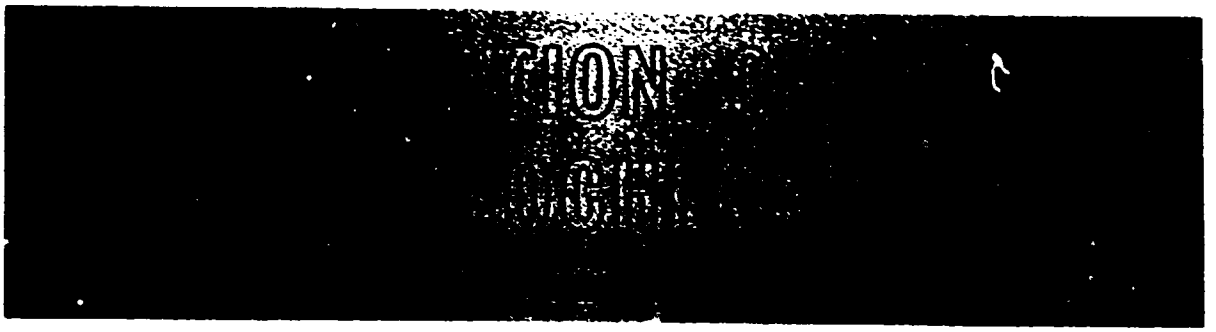
For the first phase the investments for the plant are 180.000 SL or 140.000 US $.

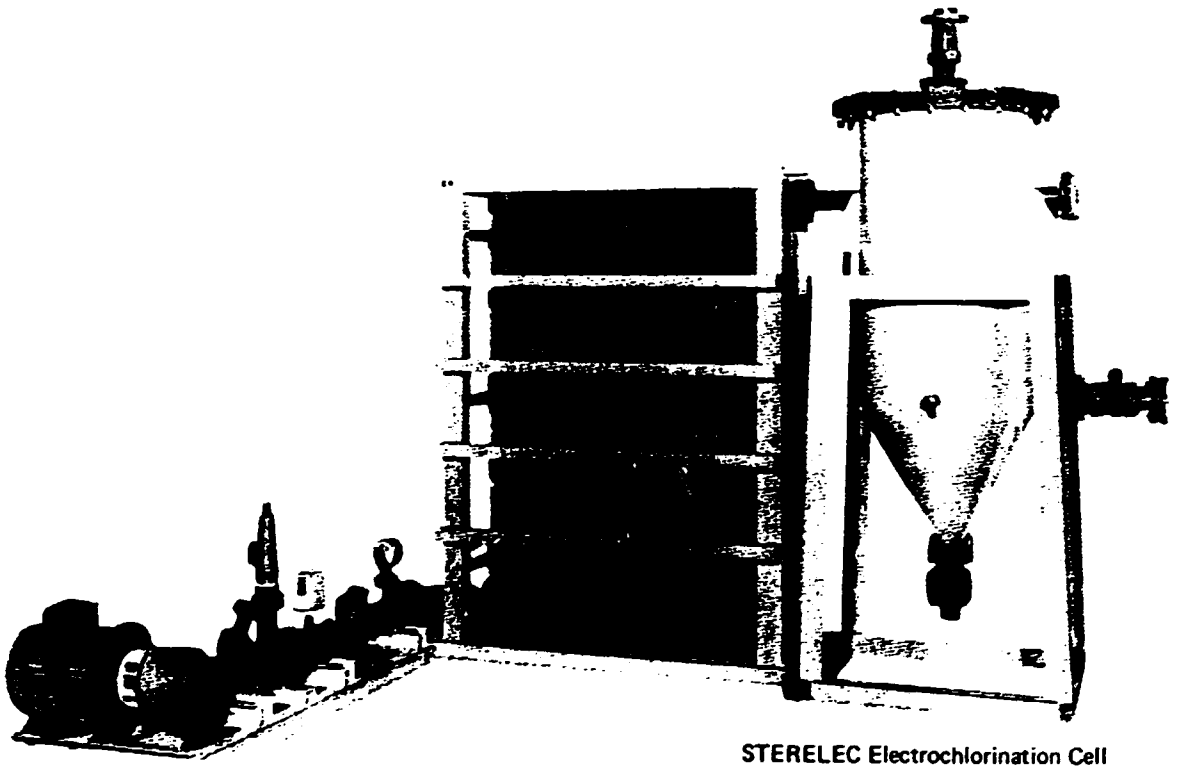
For a surface of

500 + 332 = 832 Sq/m.

$$\text{Unit cost} = \frac{180.000}{832} = 216 \text{ SL/Sq/m}$$

ie = 166 US $ every thinks included.





STERELEC Electrochlorination Cell
ELS 10000 type
Chlorine production : 10 kg per hour
(Power Stations)

A chlorinated solution is produced on-site by electrolysis of sea water or artificial brine.

Main uses :

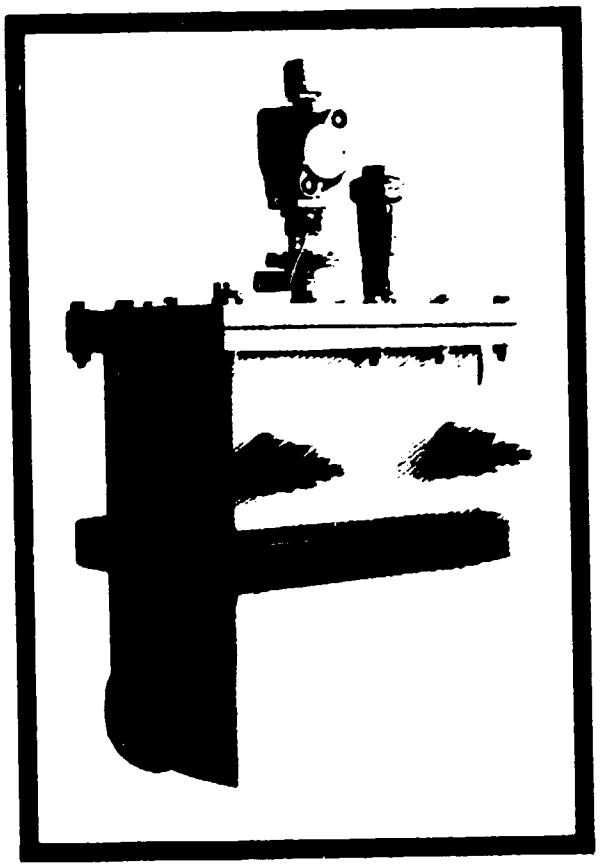
- Sterilization of cooling water systems
- Desinfection of waste water
- Oxidizing of industrial effluents

ecopol

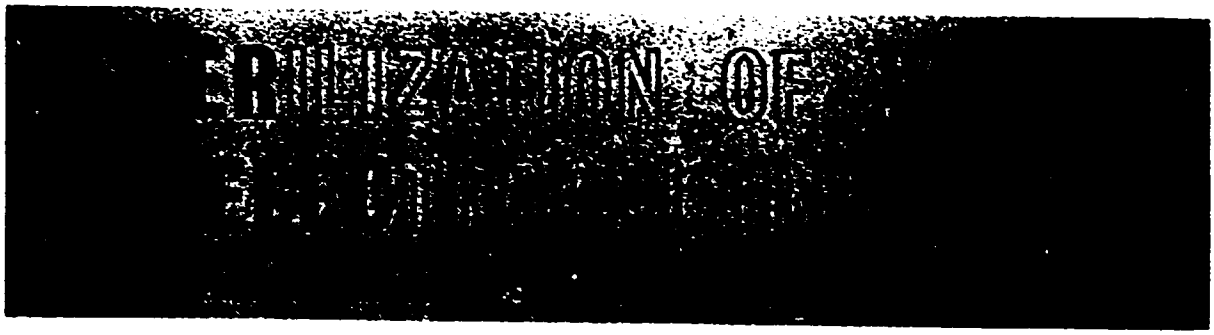
26 Rue du Château des Rentiers
75013 PARIS
Tél. : 584-15-15

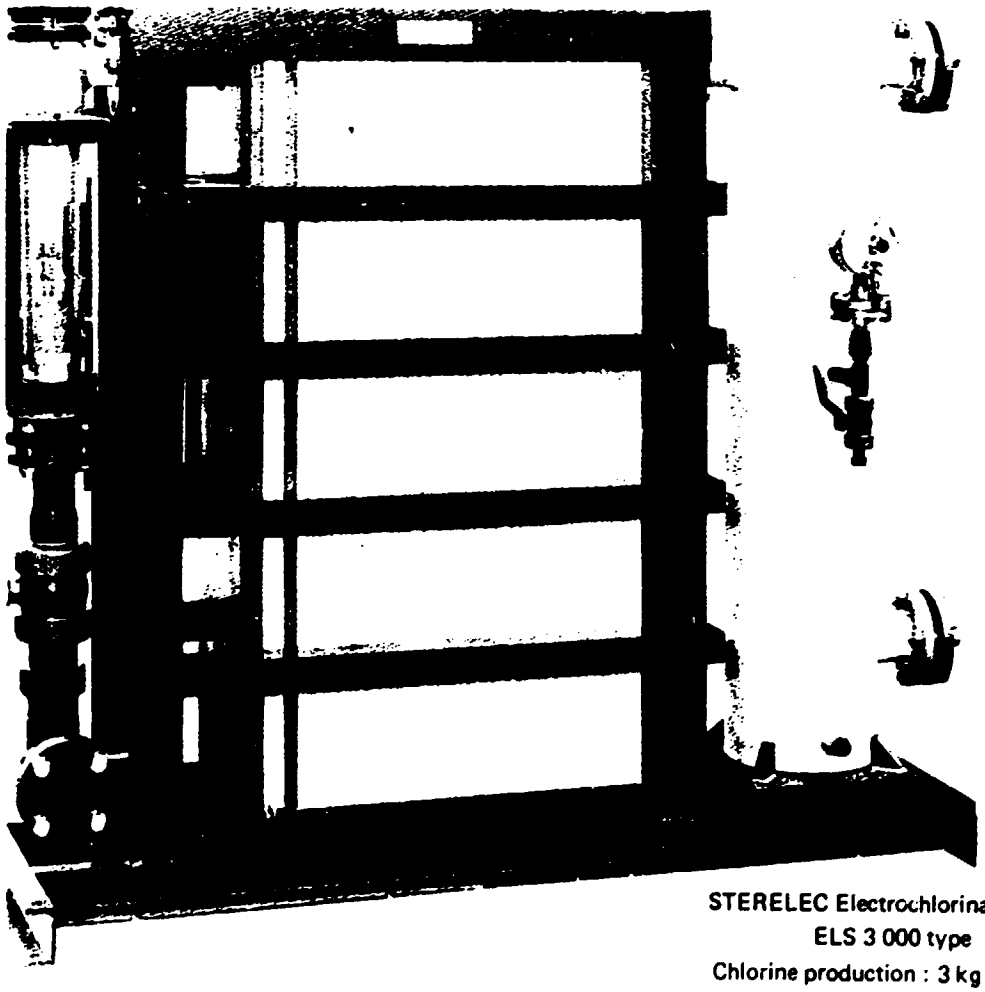
Major applications

- **Industrial circulating seawater equipments of power stations, oil refineries, steel works chemicals factories, offshore platforms ...**
  - ♦ Protection against organic fouling by shellfish, seaweed, slime, mussel, algae ... of strainers, pipelines, valves, pumps, condensers, heat exchangers ...
- **Waste water treatment plants**
  - ♦ Desinfection - Safeguard against beach bacterial pollution.
  - ♦ Chlorination
  - ♦ Deodorization
- **Industrial effluents**
  - ♦ Destruction of cyanides by oxidizing
  - ♦ Deodorization
- **Desalination plants**
  - ♦ Protection of seawater intakes, pumping stations and cooling equipments.
  - ♦ Sterilization of desalted water
- **Shipbuilding industry**
  - ♦ Protection of sea water cooling systems
  - ♦ Sterilization of distillated water
  - ♦ Desinfection of waste water
- **Food processing plants and fishing industry**
  - ♦ Bacterial action in wash-waters
- **Pleasure ports and ponds**
  - ♦ Desinfection of stagnant water
- **Swimming pools water treatment**
- Etc .....



STERELEC Electrochlorination Cell
ELS 300 type
Chlorine production : 300 g per hour
(Food processing industry)





STERELEC Electrochlorination Cell
ELS 3 000 type
Chlorine production : 3 kg per hour
(offshore platforms)

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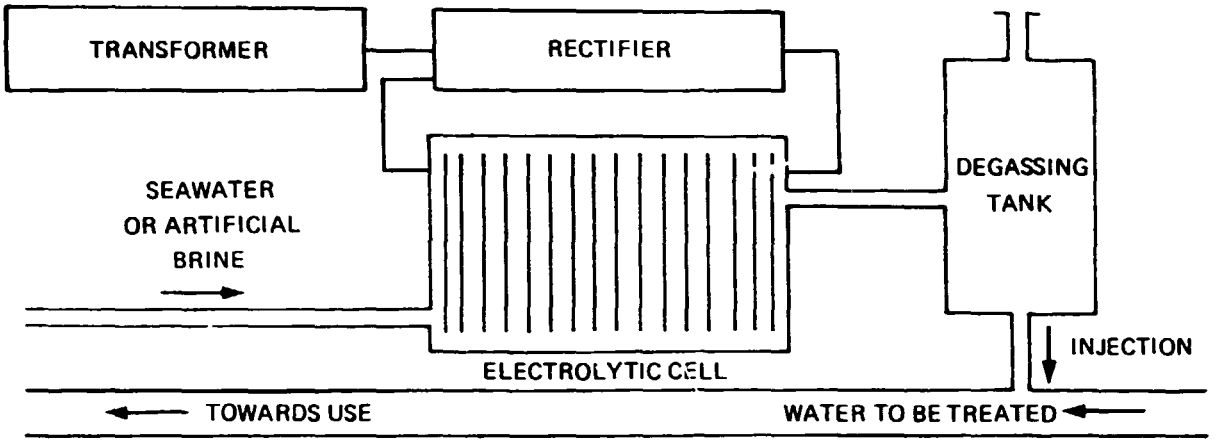
Process

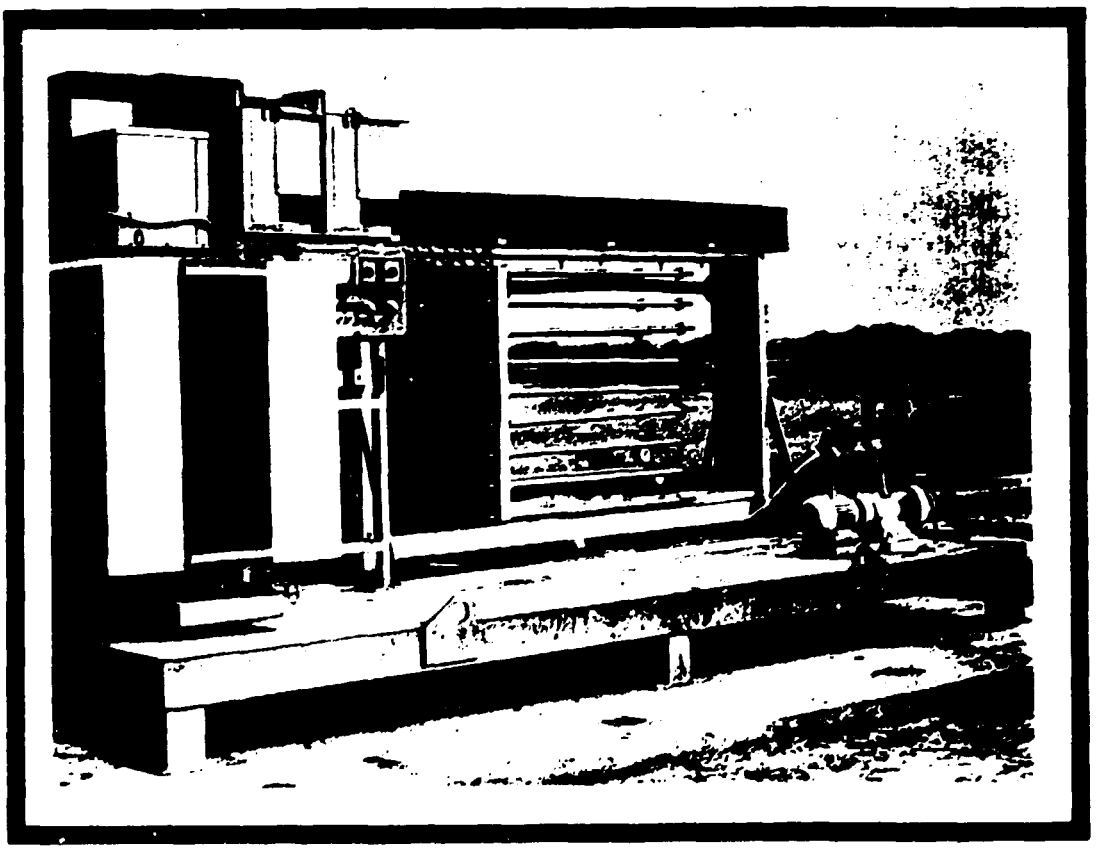


The required concentration of the sterilizing solution electrochemically produced into the cell is adjusted by regulating the electric current applied to the electrodes. The solution is then discharged into the stream to be treated.

Operating convenience and safety

This simple and economic process eliminates difficulties and dangers occured in handling, storage and supply of chemicals such as liquid chlorine.

STERELEC electrochlorination plants are operating automatically. No labour is required. Various sizes and design of electrical power and control units are matching the large range of electrolysis cells. Depending on application, discontinuous injection device for shock treatment and residual chlorine control device are optional equipments.



STERELEC Electrochlorination unit ELP 2750 type adjustable chlorine production up to 5 kg per hour (wastewater treatment mobil unit)

STUDY FOR DRINKABLE WATER AND SALT PRODUCTION

EQUIPEMENTS DOCUMENTATION

by

Jean CLAIN

MAY 1983

This study has been made with the Cooperation of Engineers from :

. Commisariat a l'Energie atomique in Cadarache

. Institut National de la Recherche Agronomique in Montfavet

. Service Technique des Phares et Balises in Aix en Provence.

. Bureau de recherches géologiques et Minières in Orléans.

And the companies

. Solar Force in Paris (Pumps and phtovoltaic cells - Refrigarators - radiostation
. Eoliennes Viau in Perches (wind mills)
. Aerowatt in Paris (aerogenerators)
. Beghin Say in Muntzenhein (Solar stills)
. Ecopol in Paris (chlorination plant).

DESCRIPTION OF THE PROCESS

The originality of process is to give in the meantime, freshwater and salt from brine at a hight salinity pumped from a well,

The only energies used are sun and wind.

The fresh water can be used as drinkable water or as vegetable irragation water (drop to drop process). In the first case the water is remineralized, by a few part of the salt contained into the natural brine and also chlorinized by a small electrolyse given chlorine from the brine.

The general process used to produce distillated water is " solar stills installation " It is composed by two parts = one called evaporators " to concentrate" the natural brine untill saturation point and to produce fresh water.
Second to crystallize the salt and also to produce fresh water
The second is constructed to allow the passage of men to harvest the crystallized salt.

The second originality of the process into the evaporators section is to cover the brine bassins by a double tickness glass (or plastic) The brine coming from the well circulates betwen the two glasses.
The brine is heated before introduction into the bassins
The glass is cooled by brin
This double effect increase the evaporation phenomen, and the efficiency of the bassins.

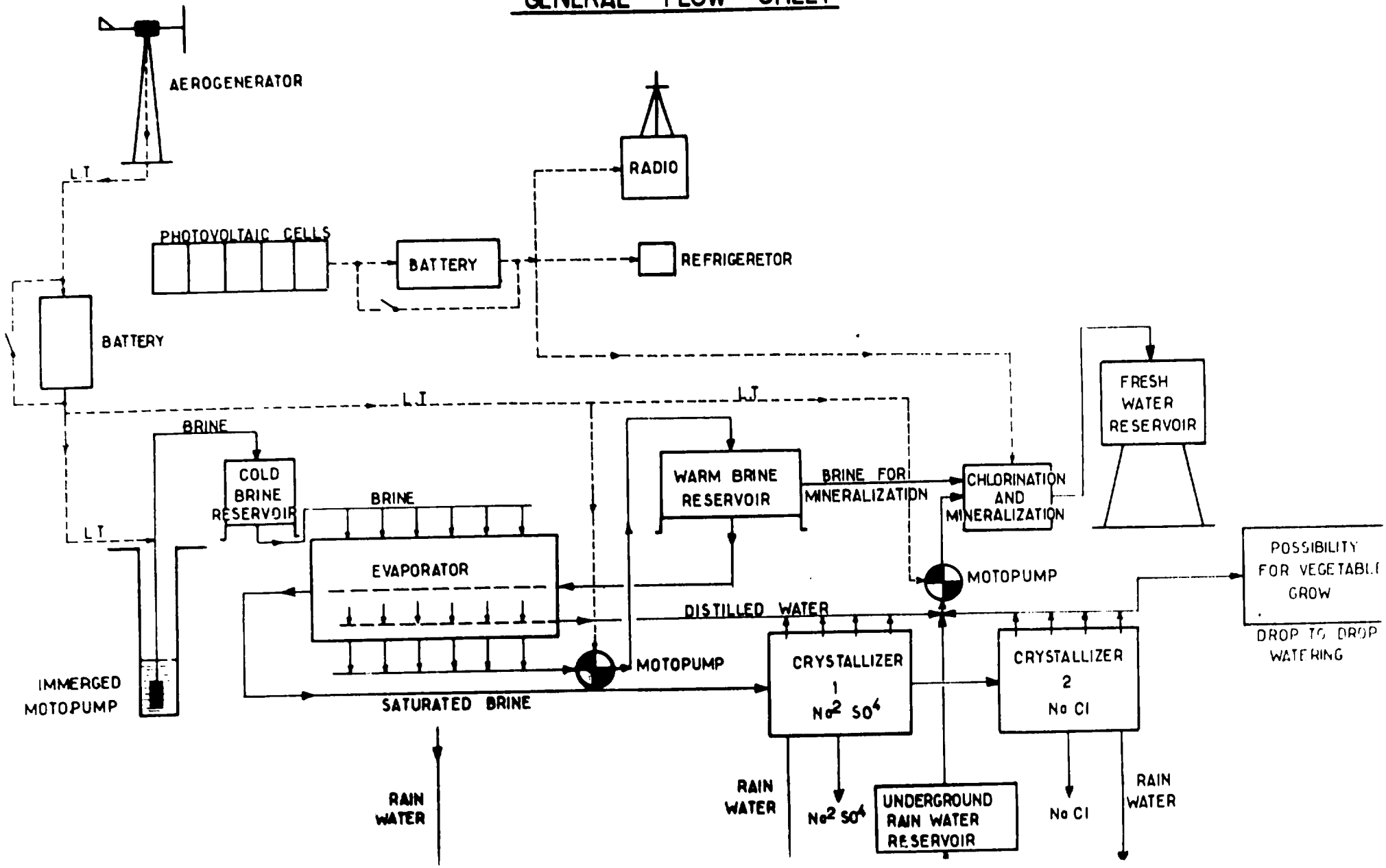
The solar stills are constructed in such a manner to recover the rain water.

The intermediate pumps for brine circulation are moved by photovoltaic cells and we can used also the electric energy produced by these cells for radio station and refrigerator.

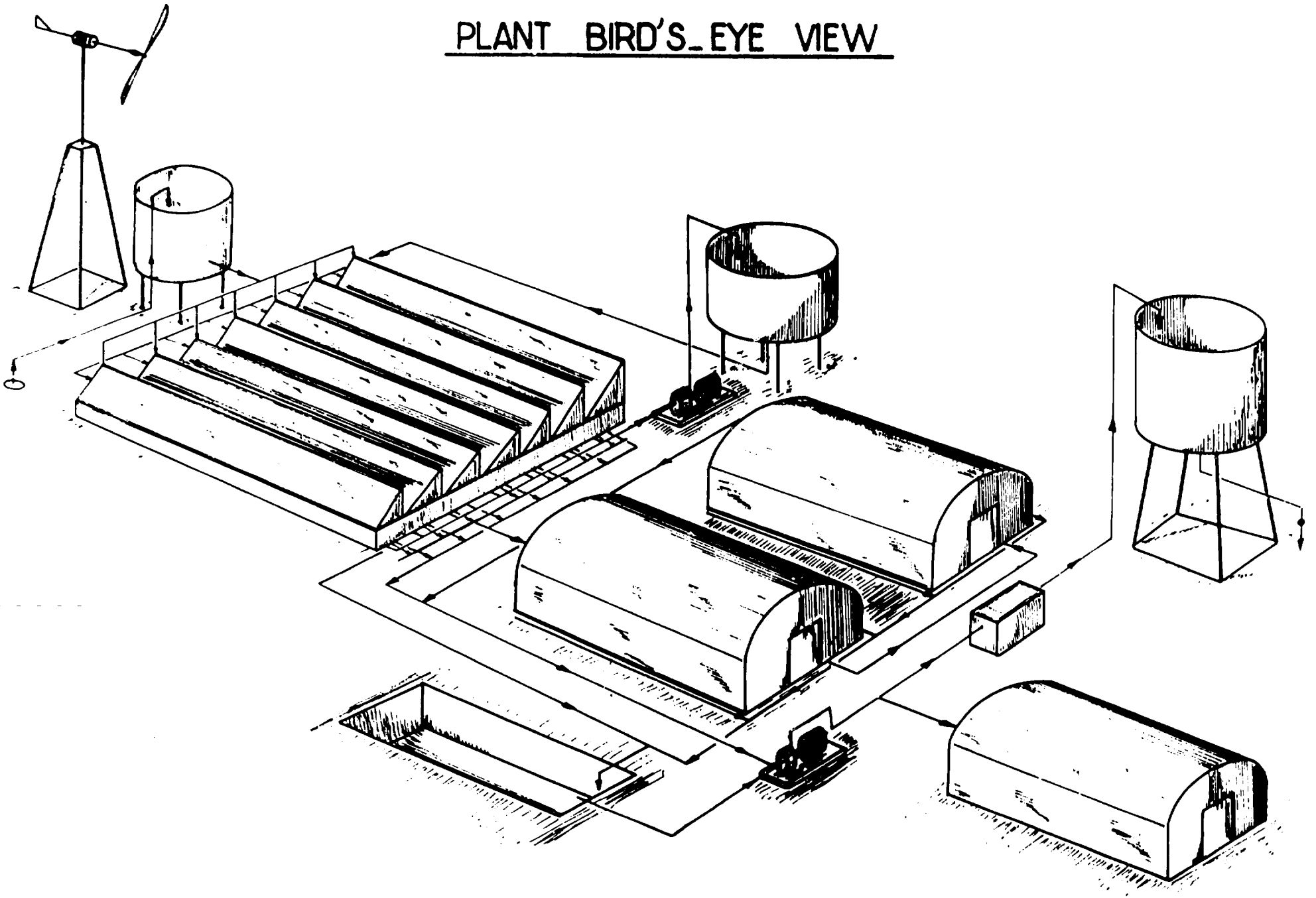
GENERAL FLOW SHEET AND BIRD'S-EYE VIEW

OF THE PLANT

GENERAL FLOW SHEET



PLANT BIRD'S-EYE VIEW



RAINSING UP OF THE BRINE

1/ WIND ENERGY - A/ MULTIPALLS WIND MILL

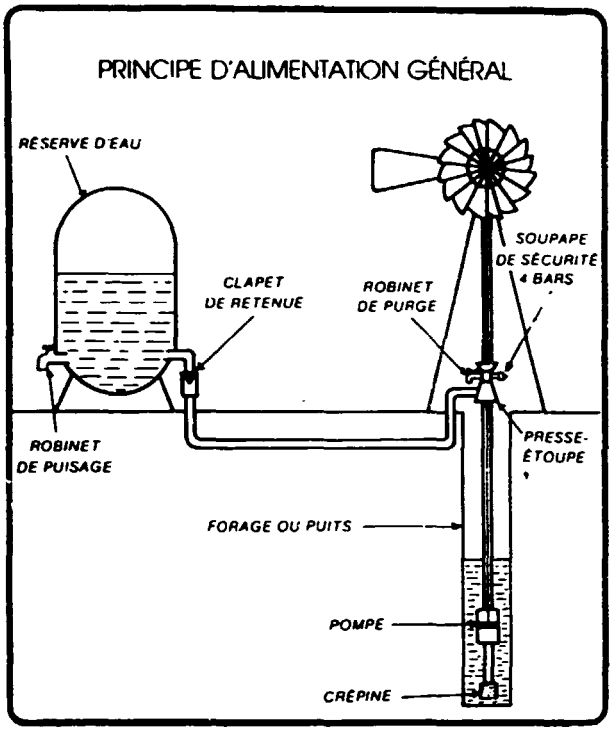
B/ AERO GENERATOR and ELECTRIC MOTOPUMP

2/ PHOTO VOLTAIC CELLS AND ELECTRIC MOTOPUMP

3/ ENERGY WHEEL

4/ MANUAL PUMPING.

MULTIPALLS WINDMILLS



PRINCIPE D'UTILISATION DE L'ÉOLIENNE

- Sur un puits de surface, de 4 à 6 mètres de profondeur, le démarrage de la roue se situe entre des vents de 3 à 5 km/h. Les vents supérieurs à 4 BEAUFORT font entrer l'éolienne en régulation, roue vers les 45 à 50 tours/minute
- Pour augmenter la vitesse, augmenter la tension du ressort, mais respecter une certaine souplesse progressive du gouvernail et s'assurer qu'il vient bien à fond de son ouverture totale. La tension d'un ressort normal est au dynamomètre de 4 kg. Ne jamais dépasser 8 à 10 kg avec des ressorts de remplacement. Ne pas oublier que la souplesse d'un ressort est tributaire de sa section et de sa longueur
- Pour calculer la charge totale de levée maximum en fonction de la profondeur des puits, multiplier la pression manométrique de base par la surface en cm2 du piston, ajouter la capacité en litres d'eau de la tuyauterie et le poids de la tringle. La pression manométrique initiale est de 100 g par mètre linéaire

DÉBITS THÉORIQUES DES POMPES EN FONCTION DES DIFFÉRENTES VITESSES DE ROTATION DE ROUES POUR CARTER TYPE IV

Course 0.4 cm

POMPE DIAMÈTRE 65 mm.

Surface	x	course	=	capacité
33.18 cm2	x	0.4 cm	=	13.27 cl

TOURS/MINUTE	LITRES/HEURE	LITRES/24 HEURES
10	78	1.872
20	156	3.744
25	195	4.680
30	234	5.616
35	273	6.552
40	312	7.488
50	390	9.360
60	468	11.232

POMPE DIAMÈTRE 80 mm.

Surface	x	course	=	capacité
50.26 cm2	x	0.4 cm	=	20.10 cl

TOURS/MINUTE	LITRES/HEURE	LITRES/24 HEURES
10	120	2.880
20	241	5.784
25	301	7.224
30	361	8.664
35	421	10.104
40	482	11.568
50	600	14.400
60	723	17.352

POMPE DIAMÈTRE 100 mm.

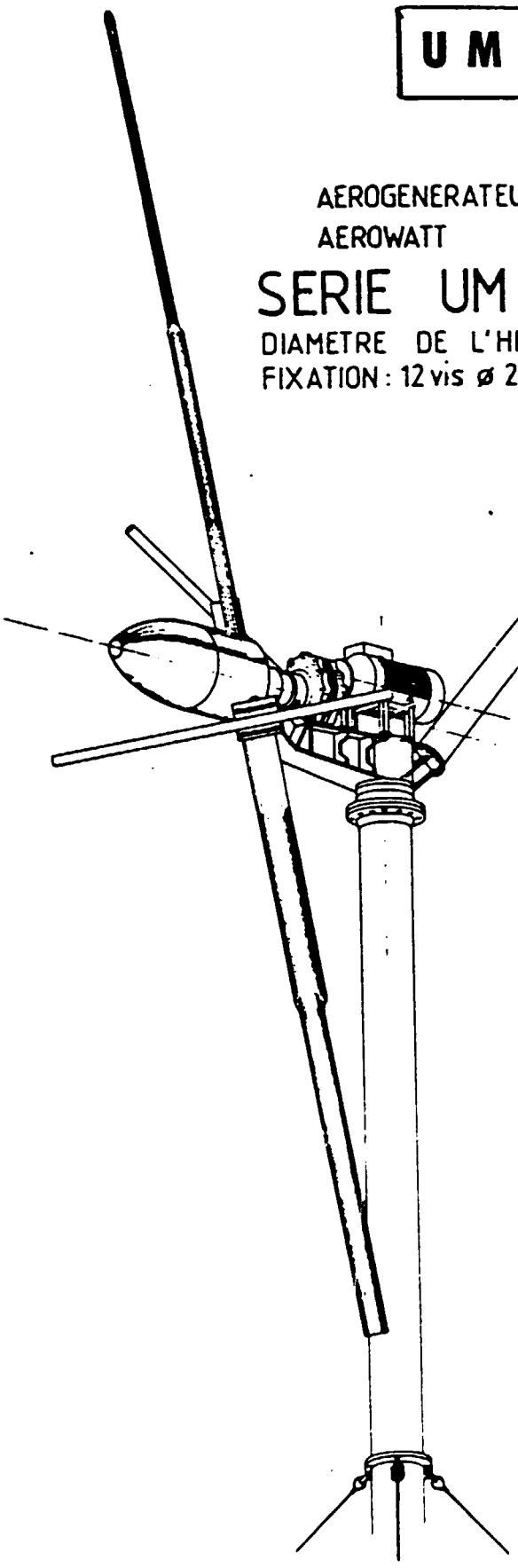
Surface	x	course	=	capacité
78.54	x	0.4 cm	=	31.41 cl

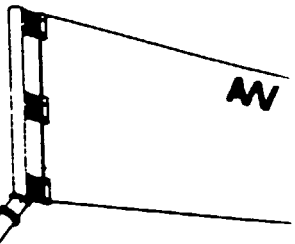
TOURS/MINUTE	LITRES/HEURE	LITRES/24 HEURES
10	188	4.512
20	376	9.024
25	471	11.304
30	565	13.560
35	654	15.696
40	753	18.072
50	942	22.608
60	1 130	27.120

AEROGENERATORS

AEROGÉNÉRATEURS A USAGES MULTIPLES

U M 70





La série UM 7: d'aérogénérateur AEROWATT a été développé à partir de l'expérience de la Société AEROWATT pour apporter une solu tion industrielle aux problèmes pose par les utilisations d'aérogénérateurs qu requièrent pratiquement un type de machir adapté à chacune d'elles.

L'adaptation des machines de la série UM 70 a différents niveaux du gisement éolien s'effectue p le choix d'une parmi trois puissances nominales :

- 2,5 KW,
- 5 KW,
- 10 KW,

auxquelles correspondent les vitesses de vent nomina (à quelques % près) suivantes :

- 7 m/s,
- 8,5 m/s,
- 10,5 m/s.

L'adaptation des machines de la série UM 70 aux différentes utilisatio s'effectue par les organes de couplage :

- BAT : Ensemble de commande et de contrôle pour la char régulée des batteries d'accumulateurs.
- CHA : Coffret d'adaptation pour chauffage éolien direct.
- MOT : Coffret de couplage à des moteurs (par ex pompage)
- RES : Equipement de couplage au réseau.

Description :

Les pales sont construites en bois lamellé-collé, protégées par une couc de polymère de synthèse élastique.

Les pièces mécaniques principales sont réalisées en fonte d'acier, pro gées par couche d'apprêt passée immédiatement après grenailla puis par une couche de peinture.

Les pièces en acier reçoivent les traitements anti-corrosion comp bles avec leurs dimensions.

Les pièces d'usure sont réalisées en acier inoxydable.

Les génératrices électriques sont, soit des alternateurs recevant u protection particulière (double imprégnation, peinture du rotor) pc fonctionner à l'air libre, ou sont des génératrices asynchrones étanch

AW 8208

CARACTÉRISTIQUES DES MACHINES UM 70

Tableau des puissances nominales :

Dimensions :

Diamètre de l'hélice : 7000 mm ± 5

Longueur hors tout : 8200 mm ± 10

Tableau des masses *(kg)* :

Utilisation	Puissance nominale des machines *(kW)*		
	2,5	5	10
BAT	620	655	10
CHA		655	720
MOT	620	655	
RES		655	720

Fixation : bride de 395 mm de diamètre, avec 12 trous de 22 mm sur un diamètre de 350 mm.

Caractéristiques électriques :

Puissance nominale : 2,5, 5 ou 10 kW selon l'adaptation choisie.

Tension nominale : 380 V.

Fréquence nominale : 50 Hz.

Option : 400 V – 6- Hz.

Conditions climatiques :

Les aérogénérateurs AEROWATT de la série UM 70 sont conçus pour fonctionner sous tous les climats.

Plage de température de fonctionnement : – 30°C à + 60°C.

Plage d'humidité : 0 à 95%.

Caractéristiques aérodynamiques :

Tableau des vitesses nominales du vent *(m/s)* :

Ce sont les vitesses de vent au-delà desquelles les performances nominales des machines sont obtenues.

Utilisation	Puissance nominale des machines *(kW)*		
	2,5	5	10
BAT	7,1	8,4	
CHA		8,1	10,4
MOT	6,9	8,4	
RES		8,1	10,4

Tableau des vitesses du vent moyen de début de production *(m/s)* :

C'est la vitesse du vent, V, pour laquelle la machine commence à fournir de l'énergie à l'équipement d'utilisation.

Utilisation	Puissance nominale des machines *(kW)*		
	2,5	5	10
BAT	3,5	4	
CHA		4	4,7
MOT	3,45	3,6	
RES		4,3	5,3

Vitesse du vent moyen de démarrage :

C'est la vitesse du vent pour laquelle la machine commence à tourner, sans toutefois produire aucune énergie : V_d = 3m /s

Vitesse maximale de vent admissible par la machine :
V 60 m/s.

Poussée aérodynamique :
620 daN sous V = 60 m/s.

Tableau des vitesses de rotation nominales N_n *(t/mn)* :

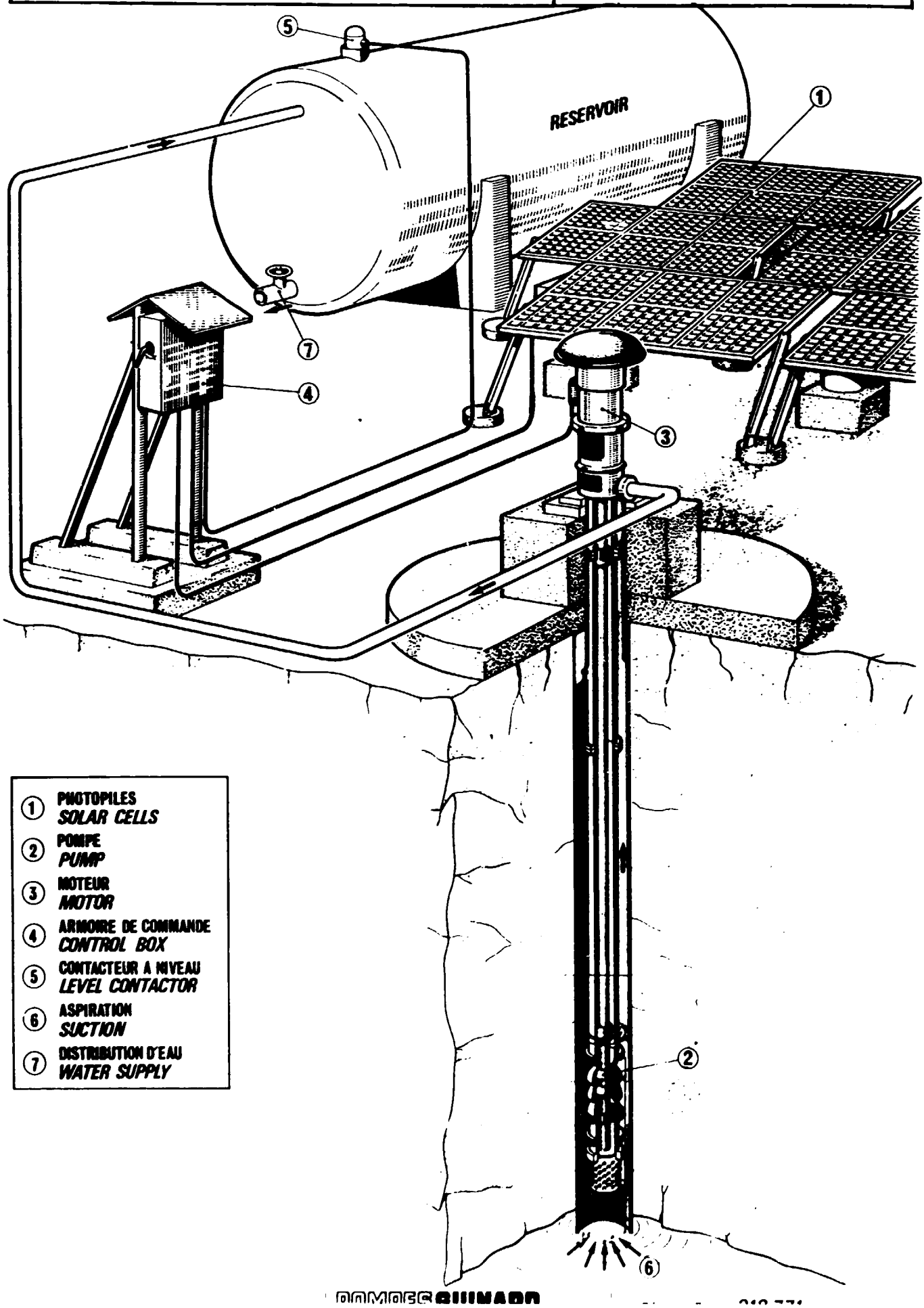
Utilisation	Puissance nominale des machines *(kW)*		
	2,5	5	10
BAT	200	200	
CHA		200	225
MOT	200	200	
RES		200	225

Vitesses de rotation maximales :
1,1 N_n.

AEROWATT
37, rue Chanzy,F.75011 Paris
Tél. (1) 371 3578
Télex : 680160 F Sysna.

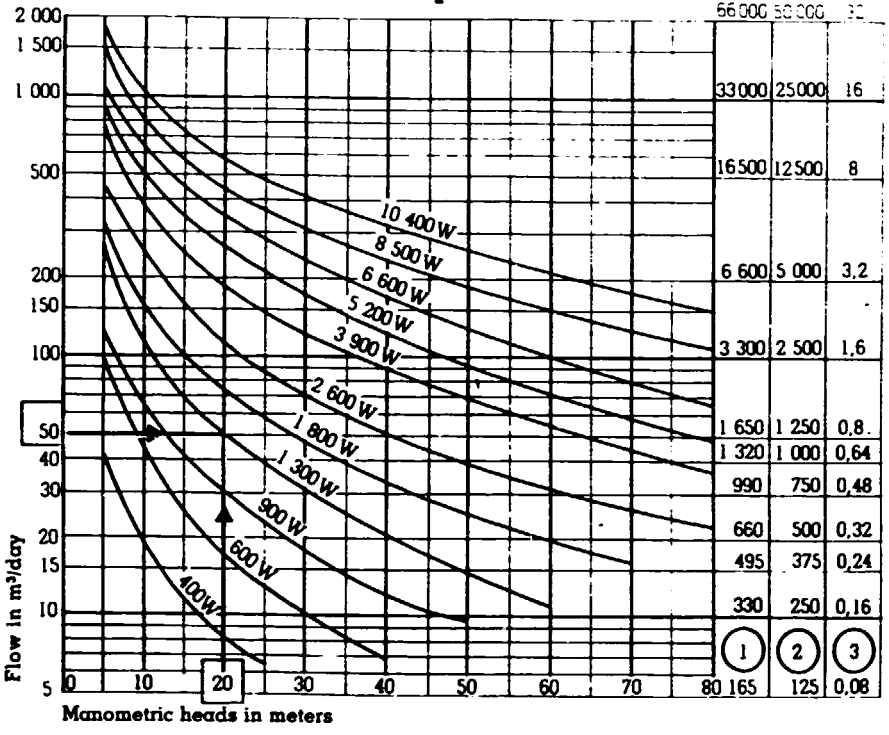
ENSEMBLE DE POMPAGE ALTA X
PUMPING UNIT ALTA X

POMPE DE PUITS OU FORAGE
BOREHOLE OR DEEP WELL PUMP



1. PHOTOPILES *SOLAR CELLS*
2. POMPE *PUMP*
3. MOTEUR *MOTOR*
4. ARMOIRE DE COMMANDE *CONTROL BOX*
5. CONTACTEUR A NIVEAU *LEVEL CONTACTOR*
6. ASPIRATION *SUCTION*
7. DISTRIBUTION D'EAU *WATER SUPPLY*

Alta XF bore-hole Solar Pumps

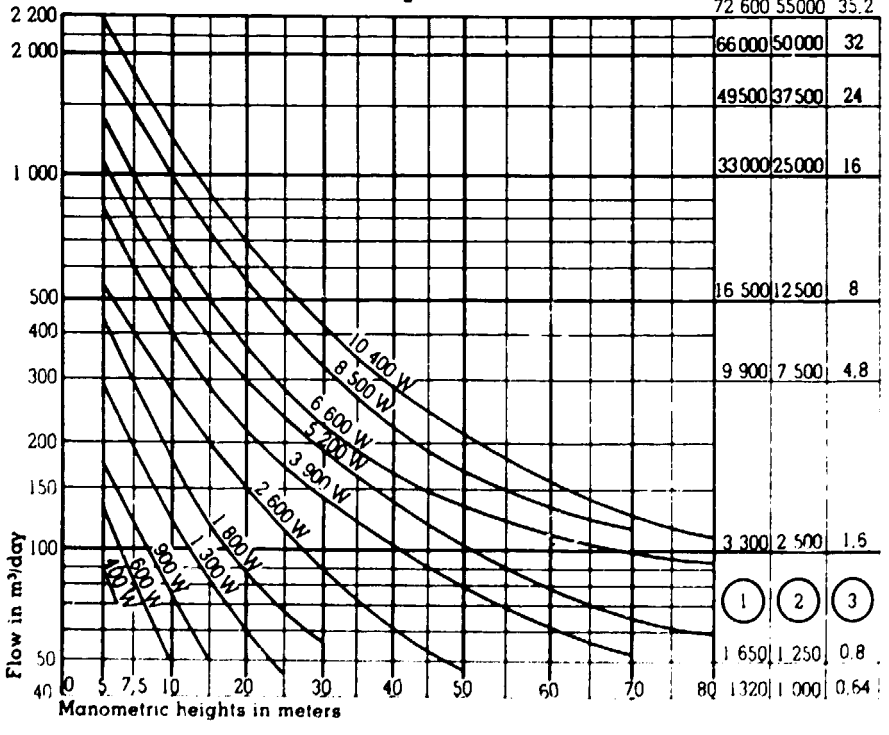


Taking into consideration the dc quantities of water required (flow) c the characteristics of the water place (total manometric height). corresponding type of pump can selected by consulting the chart on left.
The daily flows of the surface c bore-hole pumps are indicated terms of an average sunlight 6 kWh/m²/day. For different amounts sunlight, the flows are practically p portional to the figures given here.
Example:
Bore-hole pump which should produ 50 m³/day
Total manometric head (TMH): 20 m

The selected pump will be an Alta XF 1300 (peak generator power of 1300 W).

(1) **Number of people**
(2) **Number of cattle**
(3) **Vegetable farming surface in hectares (1 h = 2.47 acres)**

Alta XS Surface Solar Pumps



Water needs in tropical climates
(1 liter = 1.05 U.S. quarts)

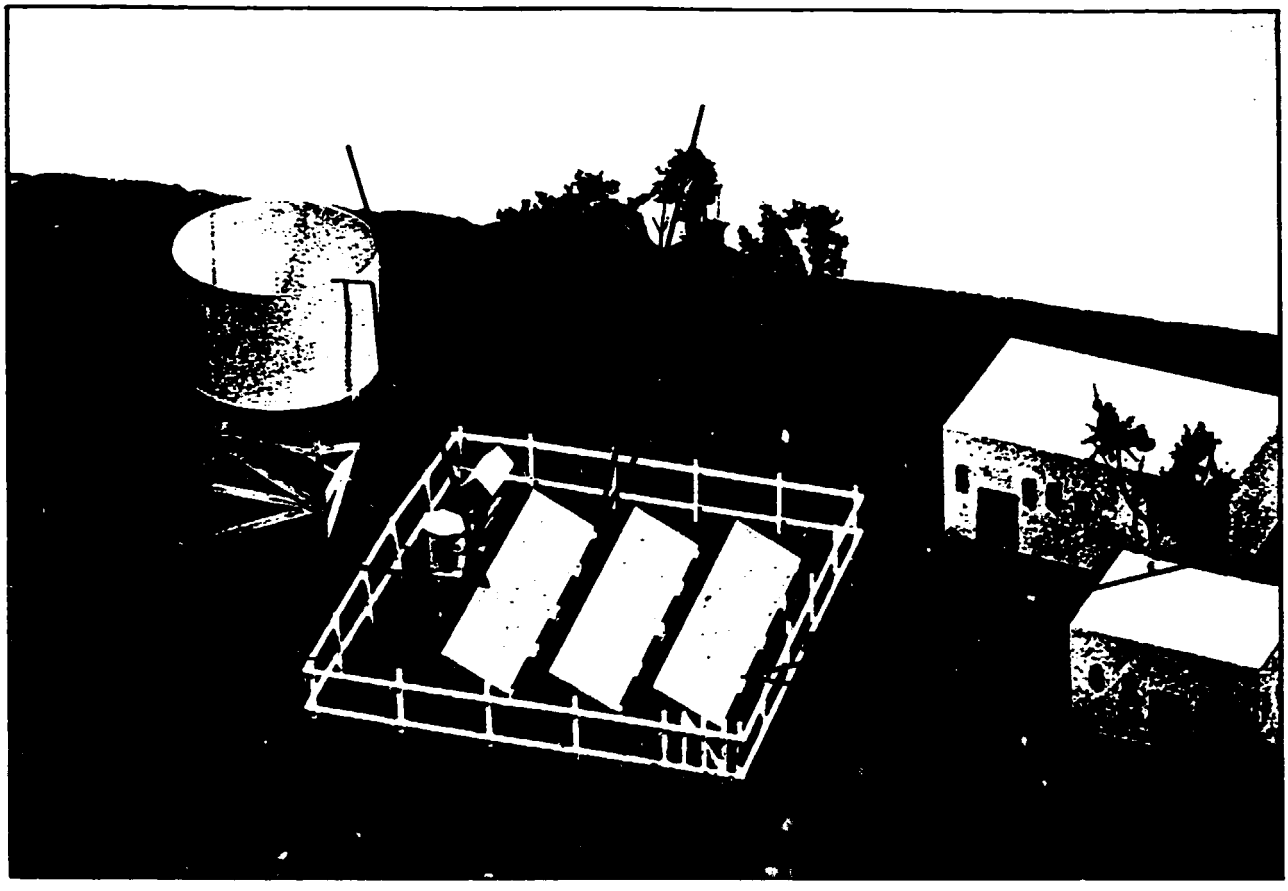
1. Per Person
- 5 liters/day: survival
- 10 liters/day: minimum
- 30 liters/day: normal life conditions in African villages

2. Per animal
- Cattle: 40 liters/day
- Sheep and goat: 5 liters/day
- Donkey: 20 liters/day
- Camel: 20 liters/day

3. Per farmed hectare
- Village farming: 60 m³/day
- Rice: 100 m³/day
- Other cereals: 45 m³/day
- Sugar cane: 66 m³/day
- Cotton: 55 m³/day

(1) **Number of people**
(2) **Number of cattle**
(3) **Vegetable farming surface in hectares (1 h = 2.47 acres)**

GROUND LEVEL DIAGRAM OF A SOLAR PUMP INSTALLATION



SURFACES AND BULKS

PEAK POWER*	PANELS WITH SQUARE CELLS - HIGH DENSITY				PANELS WITH ROUND CELLS			
	Generator bulk			Surface of panels	Generator bulk			Surface of panels
	A (m)	B (m)	S (m^2)		A (m)	B (m)	S (m^2)	
400	3,43	1,1	3,77	3,5	4,51	1,1	4,96	4,7
600	5,73	1,1	6,3	5,8	6,81	1,1	7,5	7
900	8,03	1,1	8,83	8,2	6,81	3,2	21,8	11,7
1 300	6,81	3,2	21,8	11,7	9,11	3,2	29,15	16,4
1 800	9,11	3,2	29,1	16,4	11,41	3,2	36,5	22,2
2 600	11,41	3,2	36,5	23,4	16,01	3,2	51,23	30,4
3 900	11,41	5,3	60,5	35	11,41	7,4	84,43	46,7
5 200	11,41	7,4	84,4	46,7	16,01	7,4	118,47	63,1
6 600	11,41	9,5	109	58,4	16,01	9,5	152,1	79,4
8 500	18,31	7,4	135,5	74,8	18,31	11,6	212,4	102,8
10 400	18,31	9,5	173,9	93,5	18,31	13,7	250,8	126,1

* *defined as the power under sunlight — watt Wc*

DISTANCES OF OBSTACLES

(Fences, trees, houses, hills)

Latitude of the site	Obstacles*	
	North	South
de 0° à ± 10°	$\beta \leq 67°$	$\alpha < 55°$
± 10° à ± 20°	$\beta \leq 77°$	$\alpha < 45°$
± 20° à ± 30°	—	$\alpha < 35°$
± 30° à ± 40°	—	$\alpha < 27°$
± 40° à ± 45°	—	$\alpha < 17°$
EAST WEST obstacles $\gamma \leq 25°$		

**for the southern hemisphere, inverse north and south.*

ENERGY WHEEL

The energy wheel is a novel concept which uses gravity as its driving force, and its energy source is a small temperature gradient across the wheel. The energy wheel consists simply of a wheel with a series of sealed containers around its rim. Diametrically opposite pairs of containers are connected by tubes (see Figures 1 and 2). A low-boiling liquid, such as propane, freon or ammonia is sealed into the bottom container and subjected to a mild increase in temperature. The added heat causes a part of the liquid to vaporize, producing a higher pressure on the surface of the remaining liquid. The pressure forces the liquid up the connecting pipe until it spills into the opposite container at the top of the wheel.

The shift of mass (liquid) causes the top container to become heavier while its opposite member at the bottom of the wheel becomes lighter and the force due to gravity creates a torque, turning the wheel. The forces which cause the Energy Wheel to turn are the same as those which cause an overshot water wheel to rotate. As the filled container nears the bottom, it is in turn subjected to the influence of the heat source. It then discharges its liquid into the original container, which is now at the top, having cooled as it traveled upward. This cycle is repeated over and over so long as there is an adequate temperature difference between its bottom and its top.

The Energy Wheel turns slowly, but produces enormous torque which can be transferred through gearbox or belt arrangement to increase the shaft speed. The Energy Wheel is simple and inexpensive to build. If proper materials and good workmanship are employed, it should be maintenance-free for many years.

Assume a wheel 12 meters in diameter, with a rim comprised of 28 containers (14 pairs), each of which has an inside diameter of 0.3 meters and a length of 1.33 meters, with a volume of 4.0 cubic meters. Assuming 37.7°C as the cool container temperature, the theoretical cycle performance parameters are shown in Table I for three candidate working fluids.

A report prepared by:

Omar G. Hancock, Jr., P. E.
Florida Solar Energy Center
300 State Road 401
Cape Canaveral, Florida 32920

ENERGY WHEEL

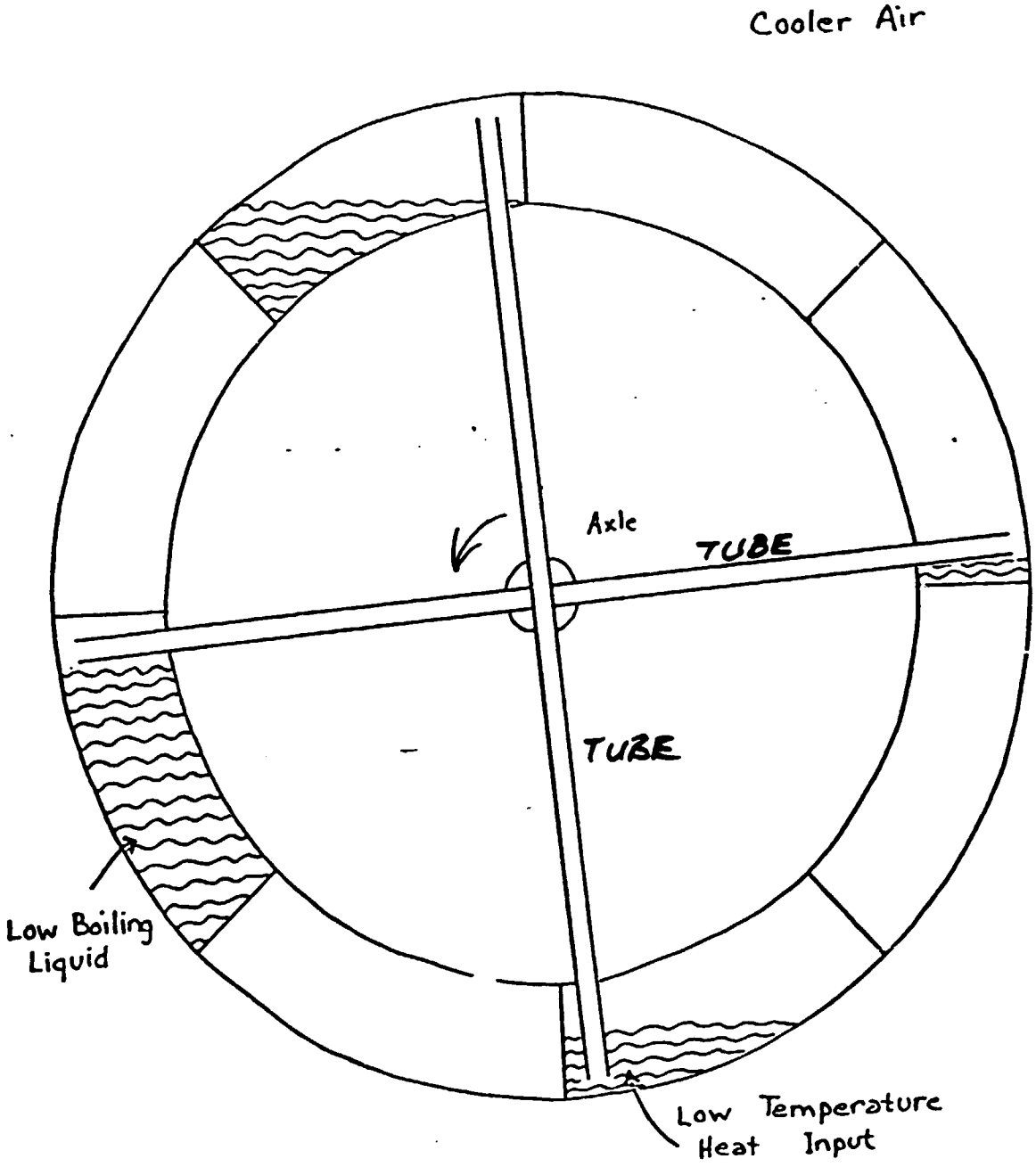


Figure 1

ENERGY WHEEL

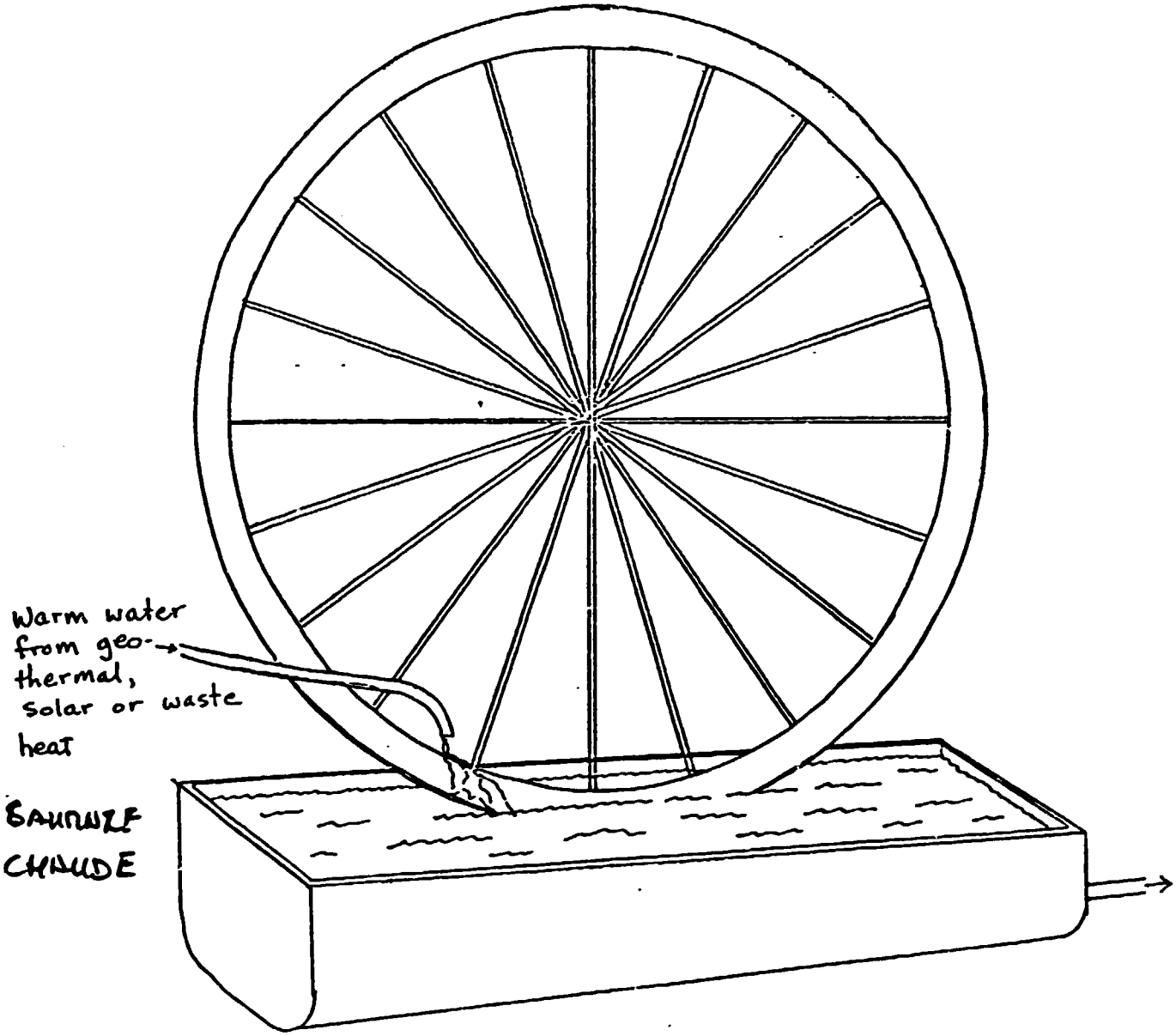


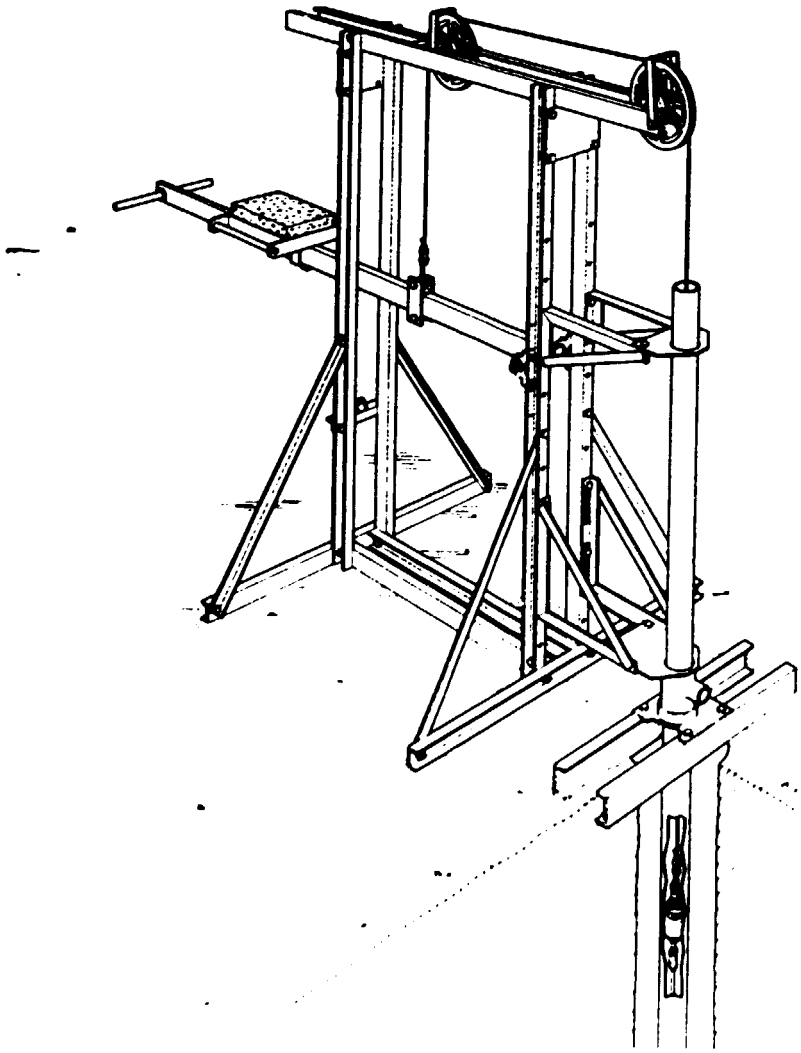
Figure 2

MANUAL PUMP

TITAN
ENGINEERING

NATIONALE 6 BP 407
69651 VILLEFRANCHE-SAONE
TEL.(74)68.61.79
TELEX 370 197 f

...niverselle U.P.
...sions multipl...



spécialement conçue pour les zones héliennes ou équivalentes, la pompe U.P est :

- fiable
- simple
- efficace
- économique

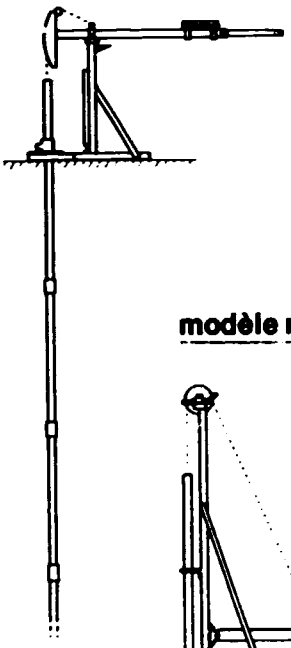
TITAN
ENGINEERING

NATIONALE 6 BP 407
69651 VILLEFRANCHE-SAONE
TEL.(74)68.61.79
TELEX 370 197 f

pompe universelle U.P.M à pistons multiple

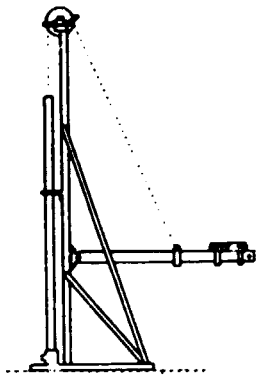
superstructures

modèle léger, type « tête de cheval »



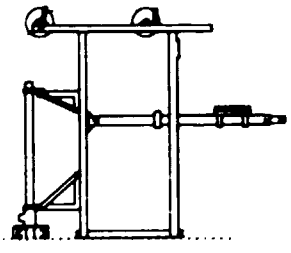
- simple et économique.
- assure une élévation de l'eau de 0,50 m à 0,75 m au-dessus de l'aire de pomp
- conçu pour les forages et adaptable sur les puits.
- poids de 100 kg.

modèle moyen, type « bigue »



- permet, avec son mât de 4 m de hauteur, le montage et le démontage de la por
- assure une élévation de l'eau jusqu'à 3 m au-dessus de l'aire de pompage.
- conçu pour les forages et adaptable sur les puits.
- poids de 150 kg.

modèle lourd, type « motorisable »



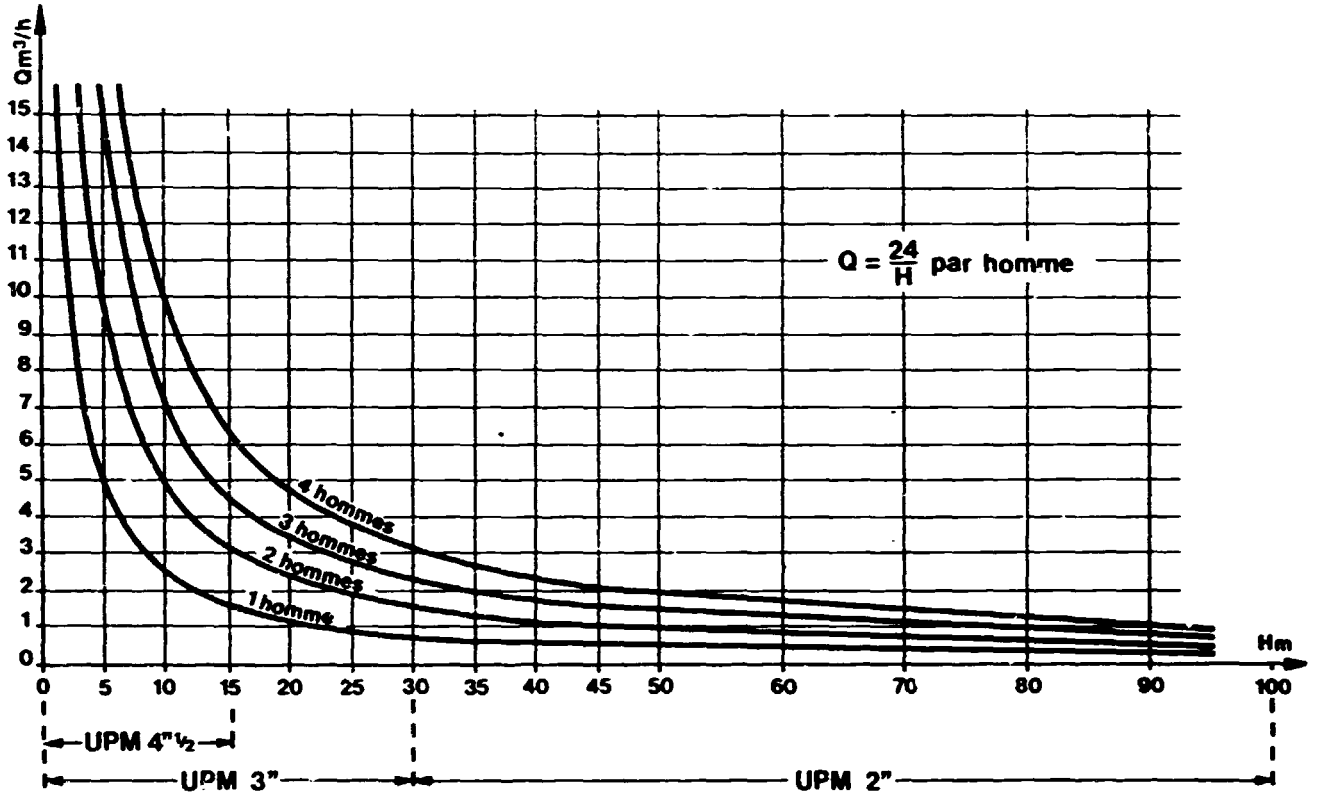
- comme son nom l'indique, ce modèle peut être actionné :
  - soit **manuellement**
  - soit par **traction animale**
  - soit par **moteur thermique, électrique ou solaire.**
- assure une élévation de l'eau entre 1 m et 1,50 m au-dessus de l'aire de pomp.
- conçu pour les forages et adaptable sur les puits.
- poids de 220 kg.

caractéristiques

- **profondeur du point d'eau**
  - UPM 2" : 30m à 100m
  - UPM 3" : 0m à 30m
  - UPM 4"½ : 0m à 15m
- **débit**

  variable avec la profondeur du niveau d'eau et la puissance d'extraction mise en œuvre.
- **courbes de débit**

  pompes U.P.M. 2", 3" et 4"½ avec rendement pessimiste de 0,9



descriptif

colonne d'exhaure

elle constitue la pompe proprement dite et comprend :

- **le corps de pompe** en tubes PVC épais et calibrés, montés par éléments de 3 mètres, assemblés p manchons filetés. Le corps de pompe fait également office de colonne d'eau.
- **le clapet de pied** en PVC, lesté, ne peut s'ouvrir qu'après immersion totale, ce qui évite tout b cage par des objets flottants.
- **les pistons**, de type flottant, en PVC moulé, (un piston tous les 3 mètres), font également office de ège de clapet de refoulement et de guide de tringlerie.
- **les clapets de refoulement** en PVC moulé sont solidaires de la tringlerie de manœuvre.
- **le train de tiges**, en acier étiré, est constitué d'éléments de 3 mètres (assemblés par manchons écrous) recevant chacun :
  - 1 clapet de refoulement,
  - 1 guide piston,
  - 1 piston flottant.

superstructure à balancier

comprenant :

- **la charpente** en profilés d'acier protégés par traitement électro-chimique.
- **les articulations**, au nombre de trois, montées sur roulements à billes étanches et graissés à v
- **le balancier** télescopique et lestable pour les adaptations
  - aux conditions du point d'eau (profondeur et débit),
  - à la puissance d'extraction disponible (une à quatre personnes)

options

commande à pédales ou commande motorisée

colisage (par 10 pompes)

volume 3,31 x 1,11 x 1,88 = 6,9m³ poids brut = 3260kg poids net = 3000kg

matériel breveté OAPI

n°56772 et n°56773 du 23.03.1979

utilisation

- ces 3 superstructures peuvent être actionnées par 1, 2, 3 ou 4 personnes
- ces 3 superstructures conviennent pour les 4 modèles de corps de pompe du tableau ci-dessous

puissance fournie par 1 personne

- égale à 1/10 de cheval
- soit : 12 kg à l'appui,
  3 kg à la remontée.
- cadence : 30 coups à la minute.

caractéristiques

divers	Ø corps de pompe			
	4 1/2"	3"	2"	1 1/2"
hauteur (H) de pompage (en m)				
- mini	5,3	12	24	48
- maxi	15	30	60	120
débit (en m³/heure)				
- mini (1 personne à H maxi)	1,6	0,8	0,4	0,2
- maxi (4 personnes à H mini)	18	8	4	2
poids maxi de montage, pour H maxi (en kg)				
- tubes	54	84	84	160
- tiges	60	66	66	80
poids maxi de démontage, pour H maxi et tubes pleins (en kg)				
- tubes	200	220	220	300
- tiges	53	58	58	70

matériel breveté OAPI

- n° 56 772 et n° 56 773 du 23.03.1979

SOLAR STILLS CONSTRUCTION

EVAPORATORS

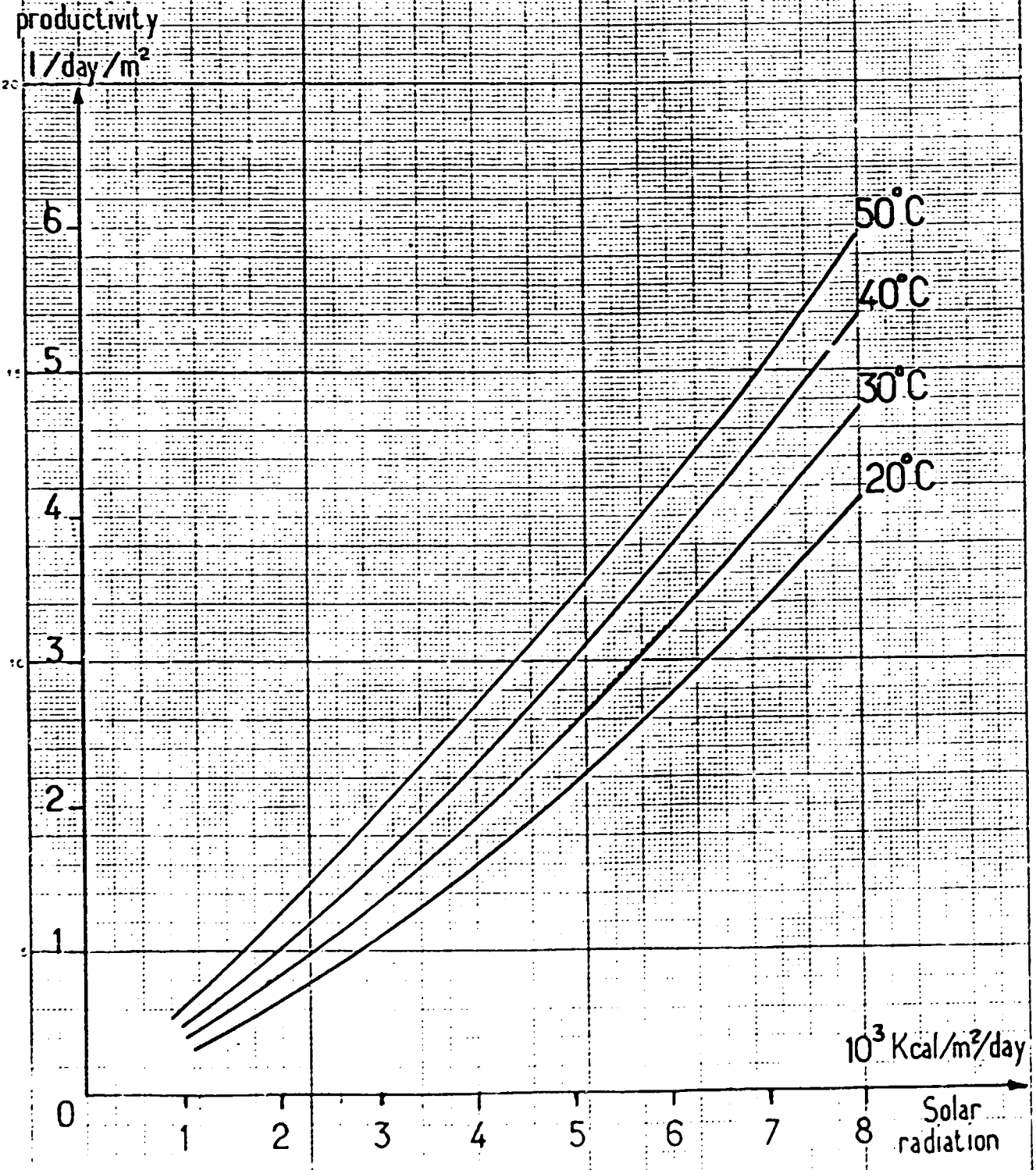
The production of fresh water into solar stills from brine is depending of many weather and local conditions.

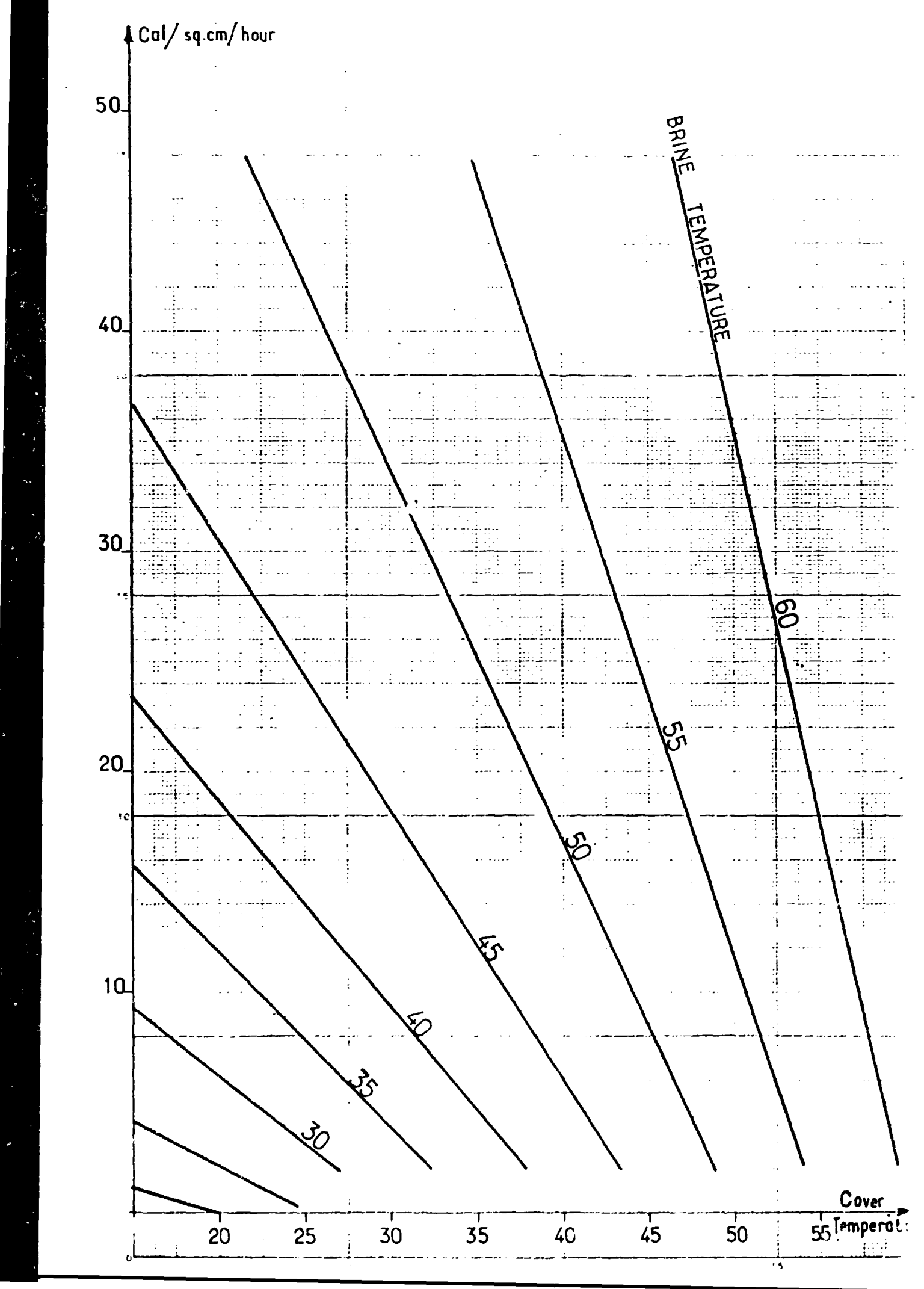
Temperature of the brine
Temperature of the air
Solar radiations
Difference of air temperature
Between night and day ... etc

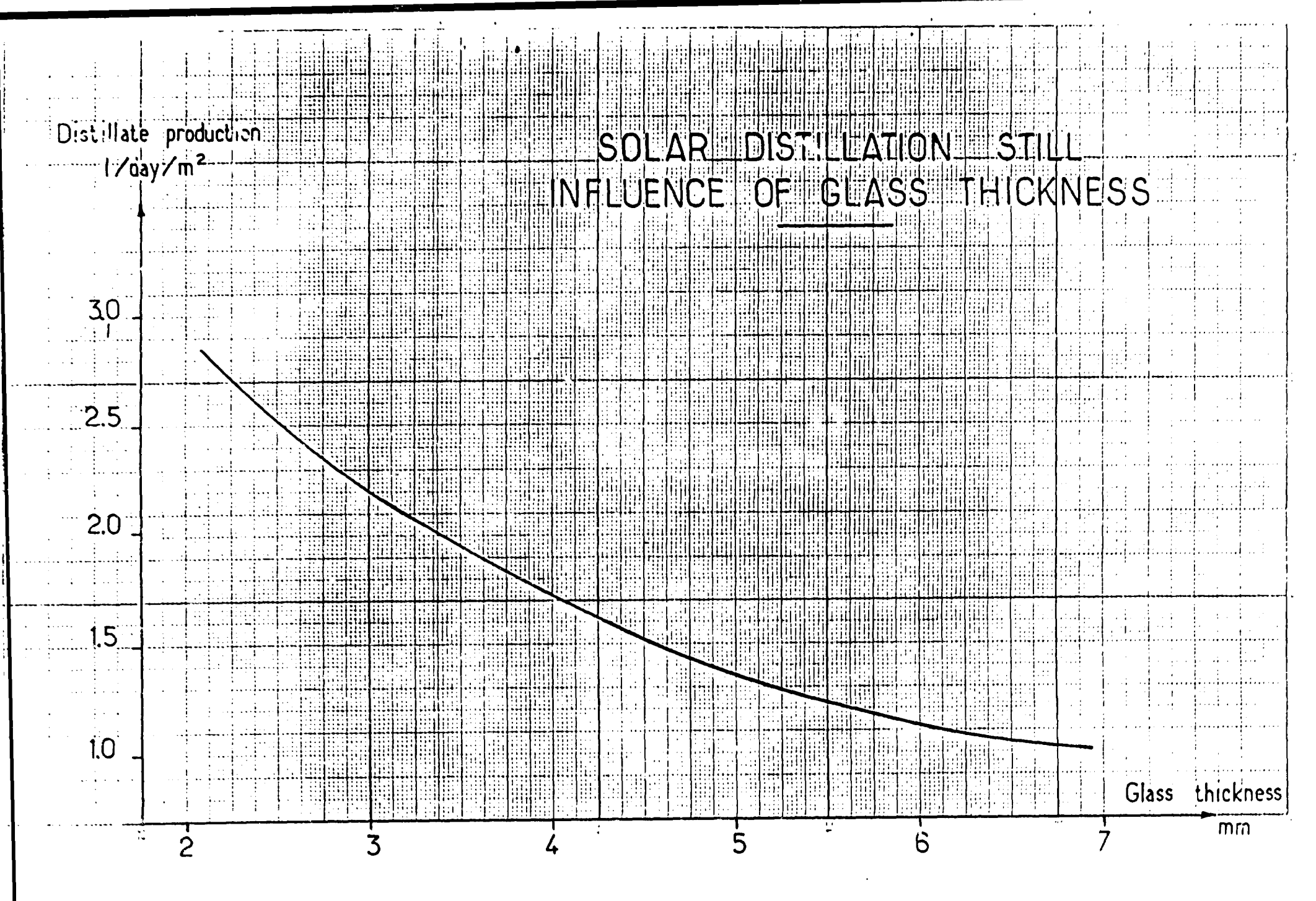
According to the location of the plant all these elements must be studied before erection.

SOLAR DISTILLATION

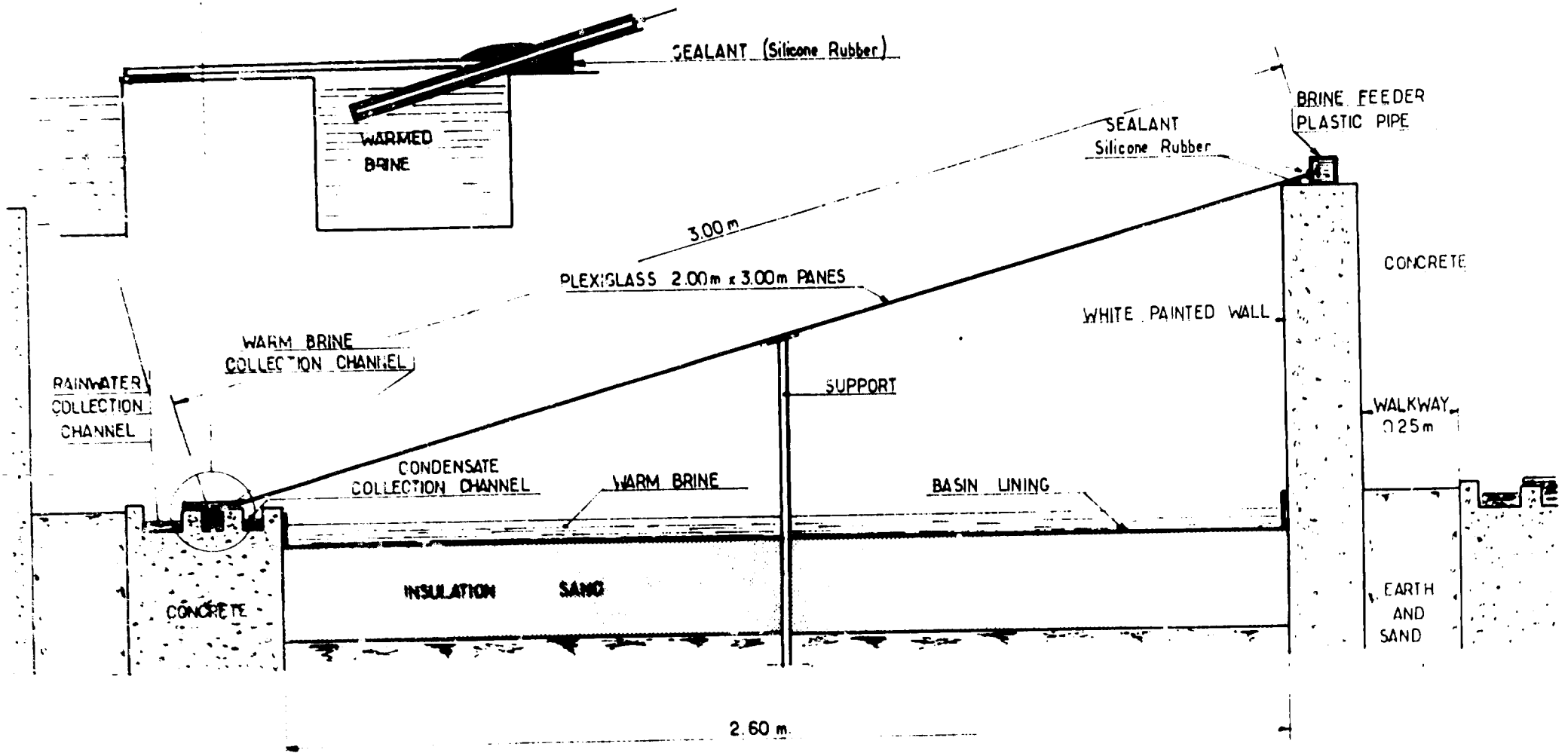
PRODUCTIVITY AT VARIOUS LEVELS OF SOLAR RADIATION AND AT DIFFERENT TEMPERATURES OF THE AMBIENT AIR




Cal/ sq.cm/ hour
50
40
30
20
10
BRINE TEMPERATURE
60
55
50
45
40
35
30
Cover
Temperat
20
25
30
35
40
45
50
55


SOLAR DISTILLATION STILL
INFLUENCE OF GLASS THICKNESS
Distillate production
l/day/m²
3.0
2.5
2.0
1.5
1.0
2
3
4
5
6
7
Glass thickness
mm

EVAPORATOR CROSS-SECTION



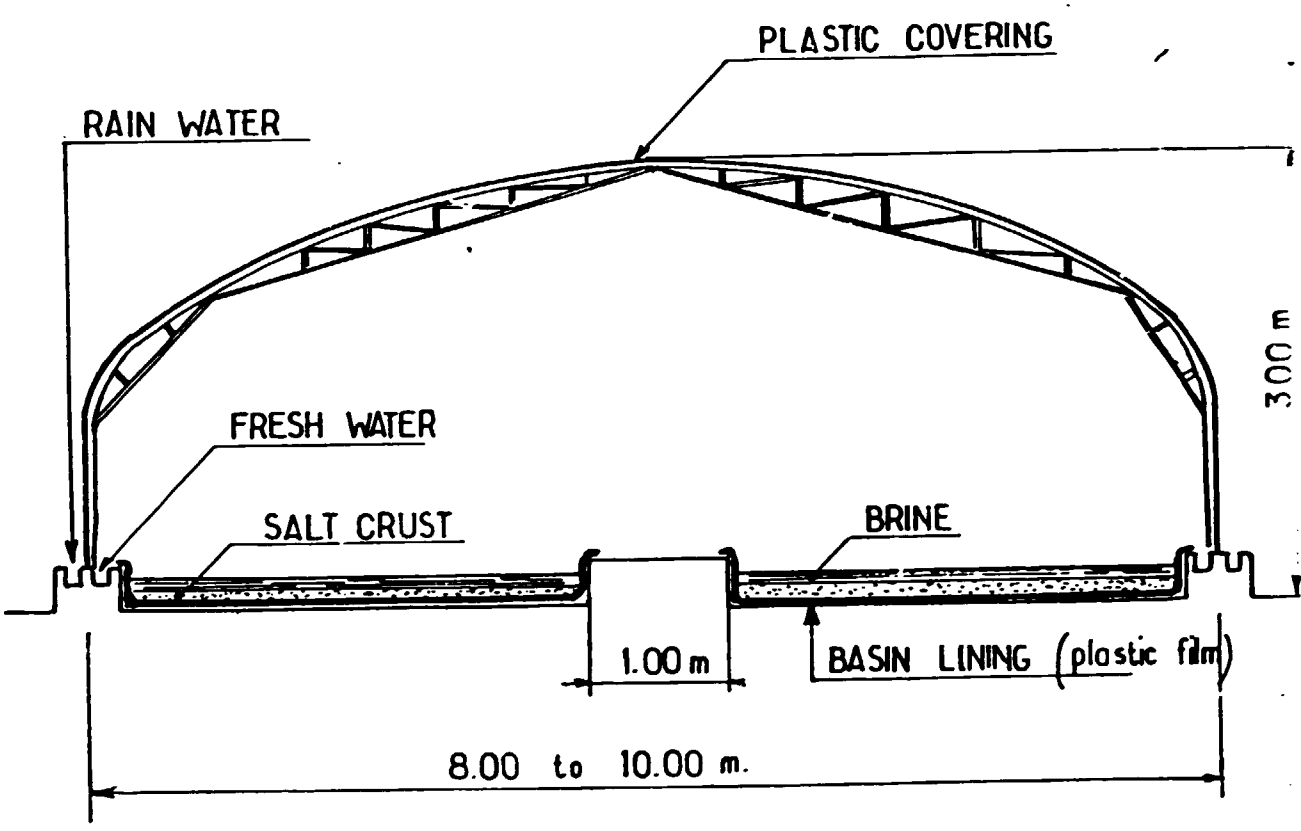
SOLAR STILLS CONSTRUCTION

CRYSTALLIZERS

Generally, the soils of the desertic country are not tight and must be covered by poly then sheets.

Also due to the presence of hard sand wing ; they risk to distroy the plastic or glass covers of solar stills.
A paraweb syste must be installed around the plant to reduce the wing velocity.

CRYSTALLIZER



PARAWEB is one of a group of composite materials, manufactured by Linear Composites Ltd. ICI. Made from continuous high tenacity TERYLENE filaments encased in a tough and durable sheath of ALKATHENE, these composite materials have already demonstrated their high strength and durability in difficult environments, where they have been in use for over 10 years in

eg cargo slings
underwater systems
marine rigging
stays for radio masts

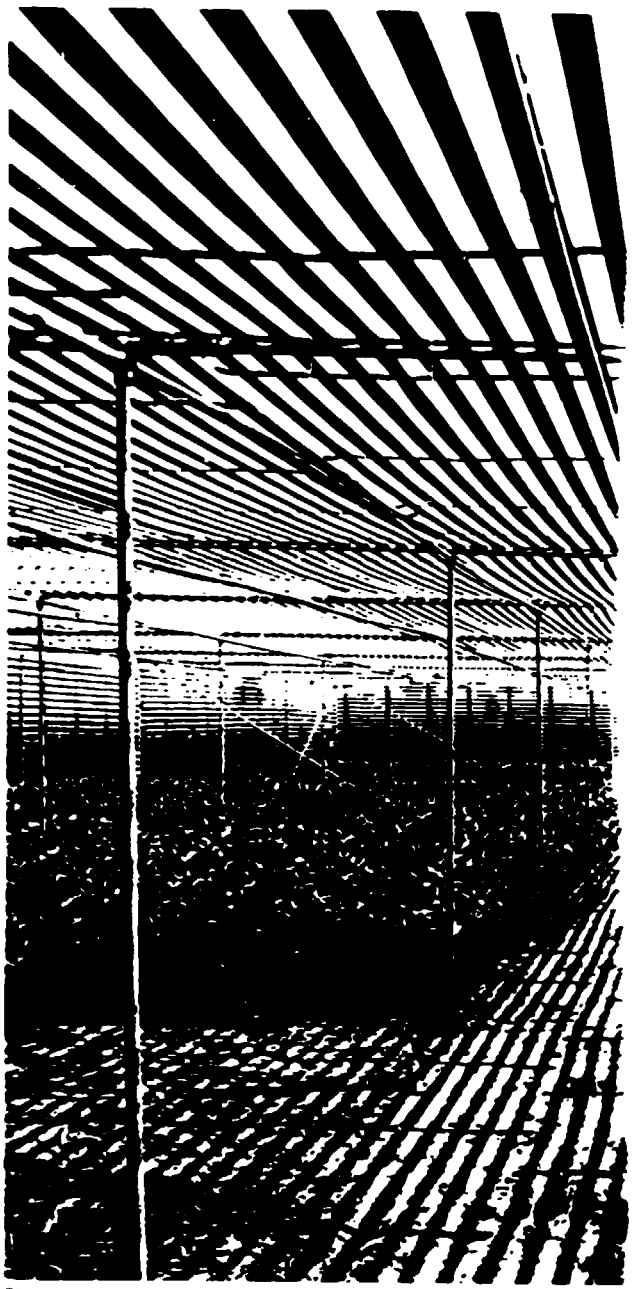
PARAWEB is thus an ideal material with which to construct high durable windbreaks and shadow hall installations.

Whereas sunlight is necessary to promote photosynthetic activity in plants, excessive exposure to strong sunlight at high ambient temperatures leads to leaf discolouration, wilting and burning – particularly in the earlier stages of growth. For this reason many plants benefit from shade, and for some it is essential.

These shadow halls have a simple construction. The framework is normally constructed from galvanised steel tubing. The PARAWEB is tensioned along the top to give shade, and along the sides to give wind protection.

Because of the slatted structure of PARAWEB, plants growing beneath it benefit from the intermittent sunlight obtained as the sun passes over the shade house (the PARAWEB strips should run in a N-S direction). Thus a good balance between good photosynthetic activity and shade protection is obtained, which provides excellent conditions for growth.

PARAWEB shadow halls have been in use for 4 years. Growers with experience using PARAWEB are without exception reporting improvements in yield and quality. The growing process of the crop is faster and more even, blossom setting is well protected, giving better yields.



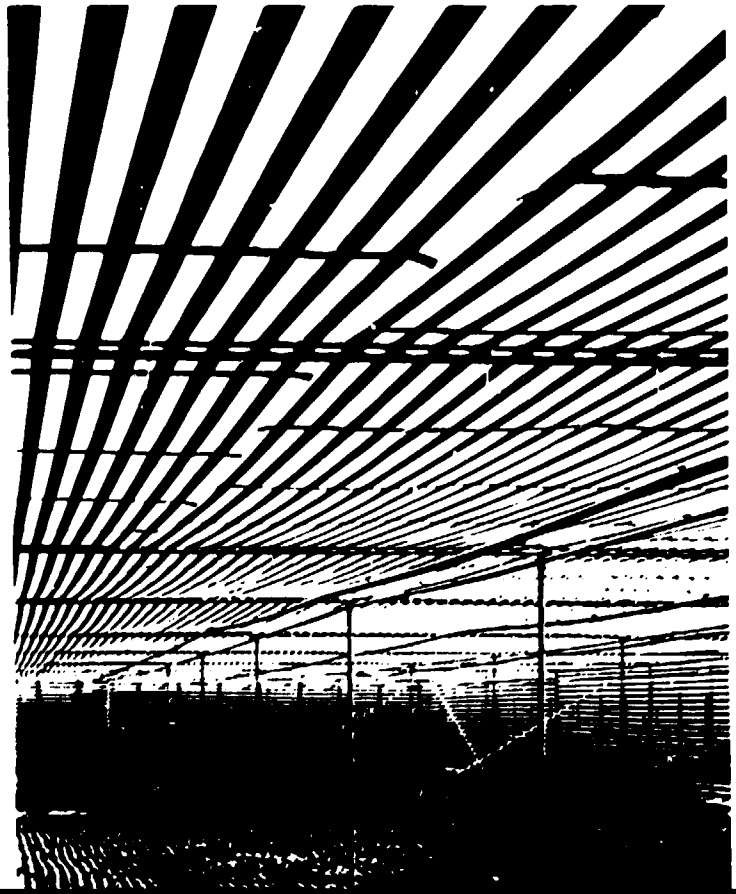
Shadow hall from PARAWEB

In addition to regulating the light intensity, shadow halls made from PARAWEB have other advantages

- They are very tough and durable and will last a long time. This gives low annual costs
- They give excellent protection from wind.
- In winter they protect against a combination of sun, frost and wind
- They protect against hail
- They protect against night frosts
- They permit the free passage of air.
- They permit the free passage of insects for pollination
- They permit the free passage of rain.
- They permit the free passage of snow in winter.

To satisfy various climatic conditions and for different plants three shade screens of varying solid area are now made from PARAWEB. They have the following cover (or shade) factors
35% Width of screens approx 2m
54% and 75% Lengths 30m, 50m, 100m

- high strength: a 1.75m wide section of 54% cover factor material has a breaking load of 3 tonnes.
- high impact strength: able to resist heavy knocks.
- low weight and easy to handle: a 30m roll of the 1.75m wide material weighs only 25kg.
- high stability: maintains shape after tensioning.
- high resistance to environmental attack: PARAWEB is not attacked by frost or water; it does not rot or corrode; the composition of the sheath has been specially formulated to give protection against ultra violet light for many, many years.
- screens from PARAWEB have a pleasing appearance and add to rather than detract from the landscape.



Compared with the money spent on irrigation, disease and pest control and fertilisers the amount spent on wind protection is small. Yet results have shown that protection from wind is highly important and often spectacular, giving higher yields better quality and an earlier crop.

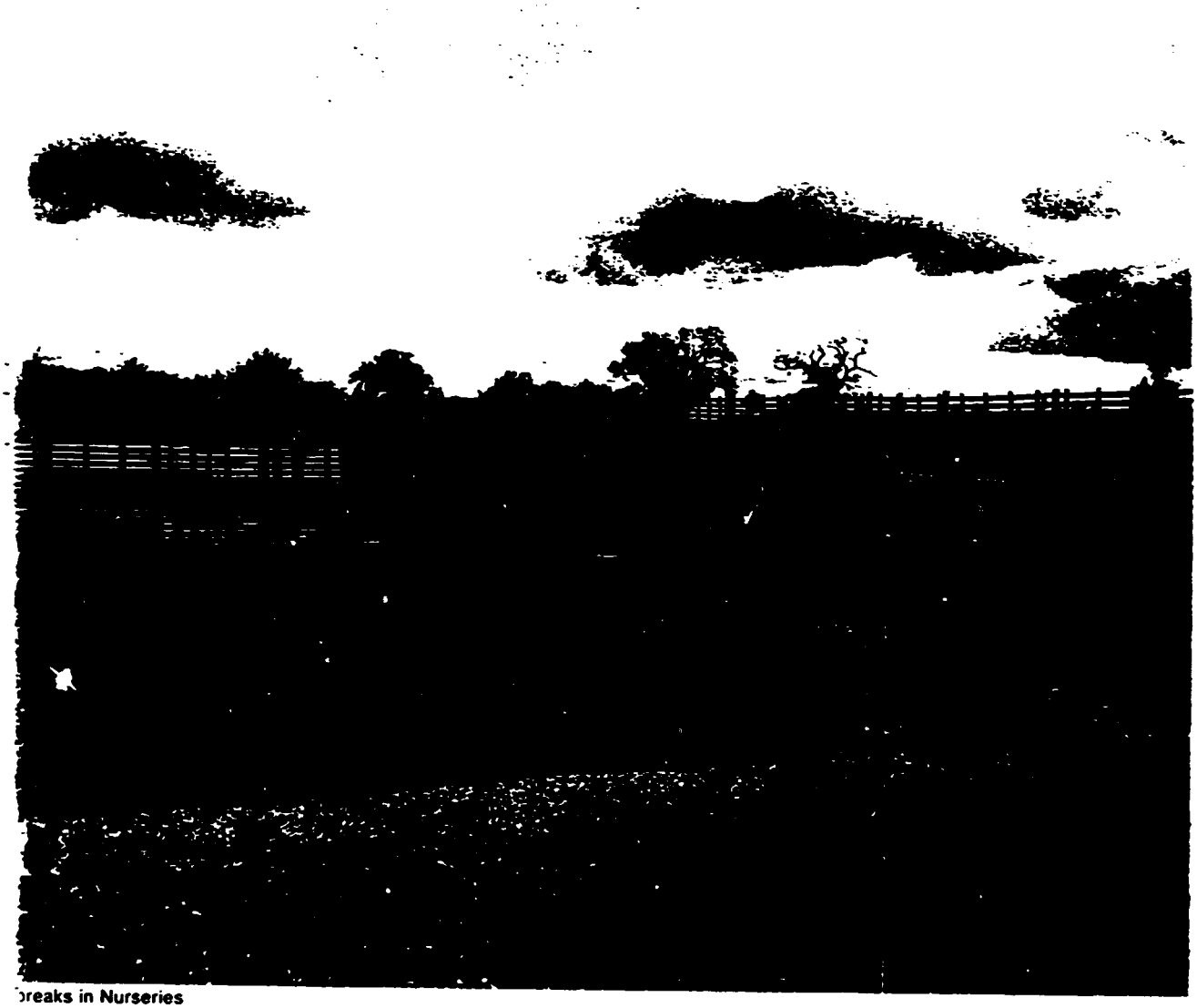
Research throughout the world has shown that, depending on the severity of climatic conditions, yield increases of 20 - 100% can be obtained.

1 Direct damage

- Sandblasting of shoots and seedlings
- Destruction of blossom prior to setting
- Bruising of fruit by leaves or adjacent fruit
- Discolouration of skins
- Increase in losses due to fruit fall.

2 Indirect Damage

- Unfavourable variation of air and soil temperatures and lower humidity, which retards crop maturity.
- Increased evaporation and a consequent increase in moisture loss from the soil, which also retards crop maturity.
- A decrease in photosynthetic activity, leading to lower growth and yield levels.
- Lower activity levels of useful insects (pollinators and predators).
- Distortion of spray patterns from sprinkler systems, leading to wasted water and uneven irrigation.



'breaks in Nurseries

're the lie of the land is favourable, or where natural wind-
<s are present, wind protection will already exist. How-
if this is not the case, then once a decision has been taken
crease wind protection, a choice must be made between
se of natural windbreaks – trees or other plants – and
neered ones. Apart from initial savings in raw materials
possibly labour costs, there are a number of disadvanta-
nherent in natural windbreaks

ley are not 'instant'.
ermanency can be a problem if the layout of the crops is
be altered.
otimum design is difficult due to irregularity in growth.
ney take up more space than engineered ones
ney create heavily shaded areas.
ney are not disease resistant.
ney can harbour insect pests, rabbits, birds, snails, etc.
oots can interfere with drainage pipes and soil cultivation.
ney require maintenance
ney create turbulence if too dense
ney compete for soil moisture and nutrients

PARAWEB windbreaks overcome these disadvantages. They are designed to be approximately 46% permeable, thus permitting slow air to pass through, preventing turbulence and giving good wind reduction over a large area. They have proved to be outstandingly successful.

Wind reduction curve for a PARAWEB windbreak 1.8m high
This curve summarises the results of wind tunnel tests carried out by the University of Nottingham

FRIGESOL 200

The integrated solar refridgerator FRIGESOL 200 is specially adapted for the needs of isolated settlements such as houses, small hospitals, dispensaries, villages... Its 200 litre capacity allows it to stock a large variety of products (especially vaccines).

TECHNICAL SPECIFICATIONS

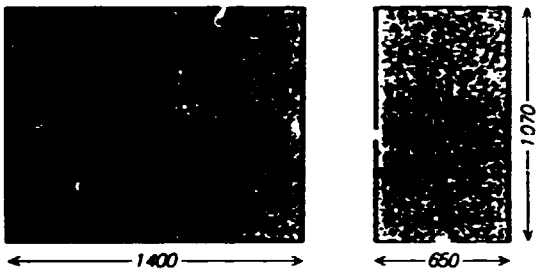
- Capacity 200 litres.
- Rated temperature: 0°C/ + 3°C inside, 45 à 50°C maximum outside.
- Well insulated aluminium case, with lock.
- Double sealing joint.
- 24 V high efficiency hermetic compressor (12 V on request).
- Adjustable thermostat.
- Internal dimensions: 1 100 × 350 × 520 mm.
- External dimensions: 1 400 × 650 × 1 070 mm.
- Weight (without batteries): 115 kg.

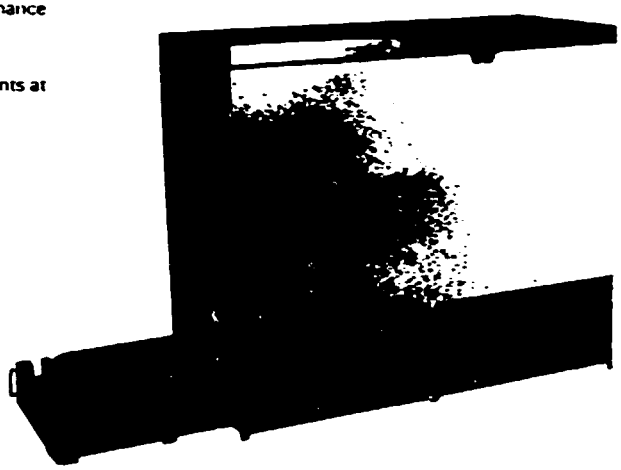
On request: incorporated solar charge regulator; 4 incorporated maintenance free batteries, each 63 or 150 Ah.

Optional

- Ice box or ice maker (2 kg/day max) -- Regulation for preserving contents at − 18°C.

N.B.: These options increase consumption: please consult us.
Only one option can by ordered.





FRIGESOL 40

With a capacity of 40 litres, and because it is compact and easy to use, FRIGESOL 40 is perfectly suitable for the needs of a dispensary (vaccines), health centre or small dwelling.

TECHNICAL SPECIFICATIONS

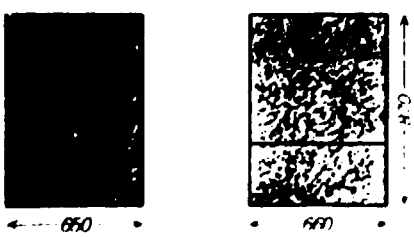
- Capacity 40 litres.
- Rated temperature: 0°C/ + 3°C inside, 45 à 50°C maximum outside.
- Well insulated aluminium case, with lock.
- Double sealing joint.
- 24 V high efficiency hermetic compressor (12 V on request).
- Adjustable thermostat.
- Internal dimensions: 360 × 350 × 320 mm.
- External dimensions: 660 × 650 × 870 mm.
- Weight (without batteries): 58 kg.

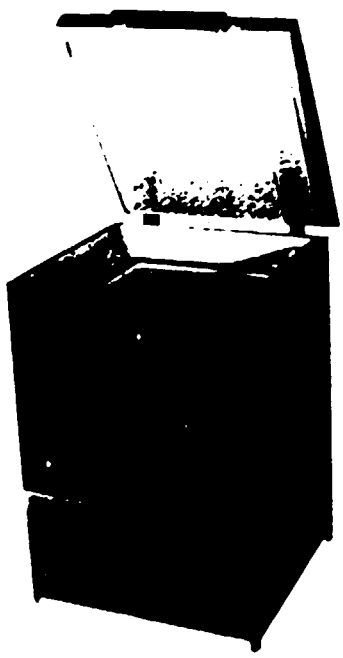
On request: incorporated solar charge regulator; 4 incorporated maintenance free batteries, each 63 or 150 Ah.

Optional

- Ice box or ice maker (1 kg/day max) -- Regulation for preserving contents at − 18°C.

N.B.: These options increase consumption: please consult us.
Only one option can be ordered.





THE GENERATOR

Frigesol refridgerators are designed to be supplied from a 24 V d.c. Genesol solar generator whose characteristics depend on:
- The insolation of the installation site.
- The energy absorbed by the refridgerator to maintain the temperature at 0.5°C inside the case. This energy varies according to the average ambient temperature over 24 hours and the thermal load of the appliance (how many new products are placed in the refridgerator and how long the lid is left open).

The map gives the solar energy in kWh/m²/day received by solar modules inclined at the optimum angle and during the worst month of the year at the site in question. Using these

EXAMPLE OF DETERMINING A GENERATOR

Type: Frigesol 200.
Average load: 2 kgs per day.
Amount of time left open: 20 mns per day.
Average temperature: 30°C.
Consumption approx.: 420 Wh/day.
Installation site: the Cameroons.
Solar energy received (map):
approx. 4100 Wh/m²/day on inclined modules.

Procedure
A. Trace the vertical line corresponding to the climatic zone *(a)*.
B. Trace the horizontal line corresponding to the Frigesol consumption *(b)*.
C. Trace *(c)*: horizontal line passing through the intersection *(E)* of the line *(a)* with the range limit of the modules immediatery above *(c)*.

Results
1. The intersection of *(a)* and *(b)* is situated in the white range 6: 6 FPGC 36 T (total 216 Wc) are needed.
2. Point *(E)* corresponding to the supply of approx. 490 Wh per day. 70 Wh per day are therefore available for various uses (lighting, radio, radiotelephone...). For example, 70 Wh per day allow the use of a 13 W fluorescent strip light, which is equivalent to a traditional 60 W light bulb, for 5 hours 20 mns. per day.

In cases where absolute operating safety is necessary, or if a meteorological study is necessary, please consult our design department.

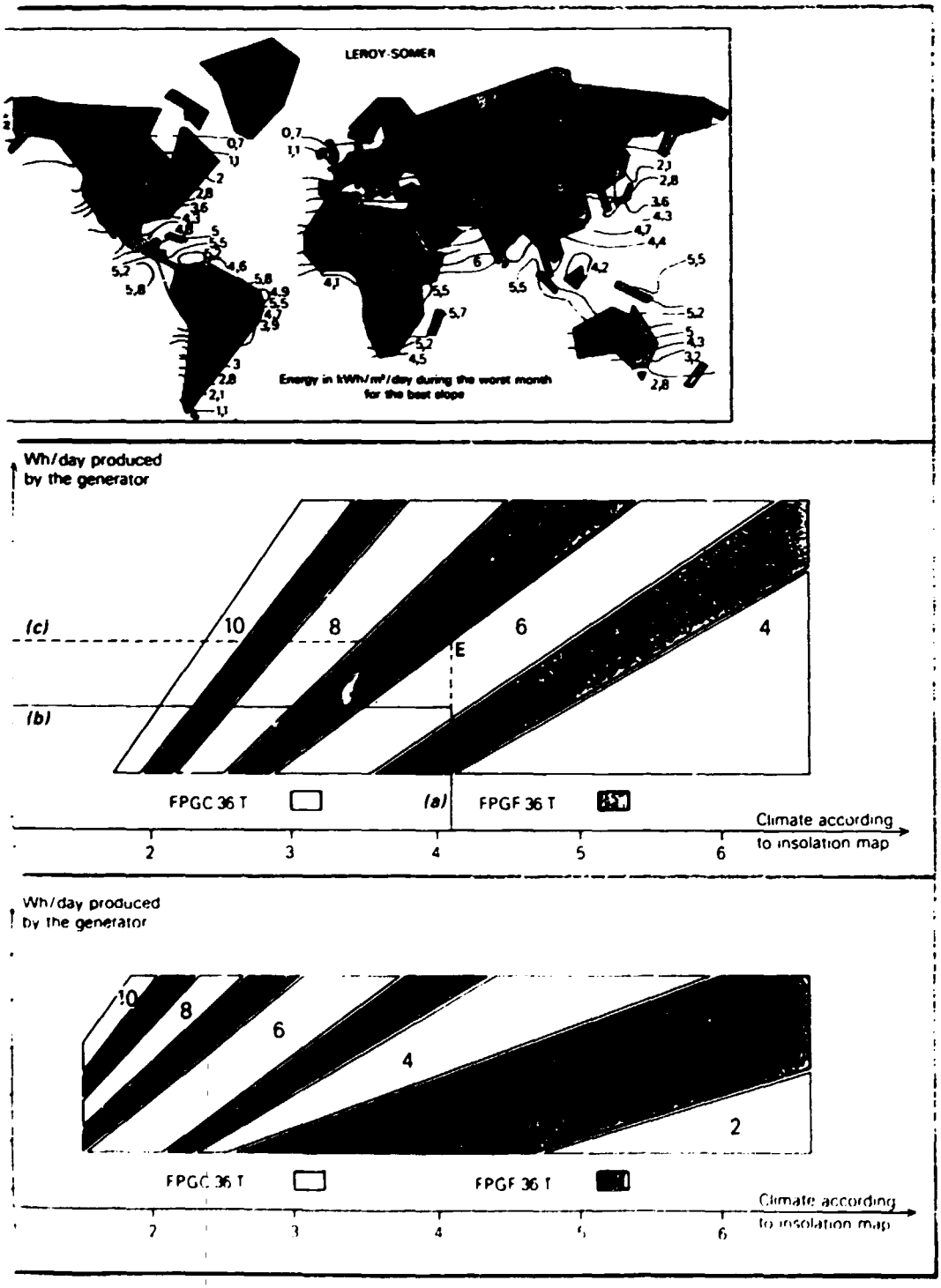
Frigesol 200

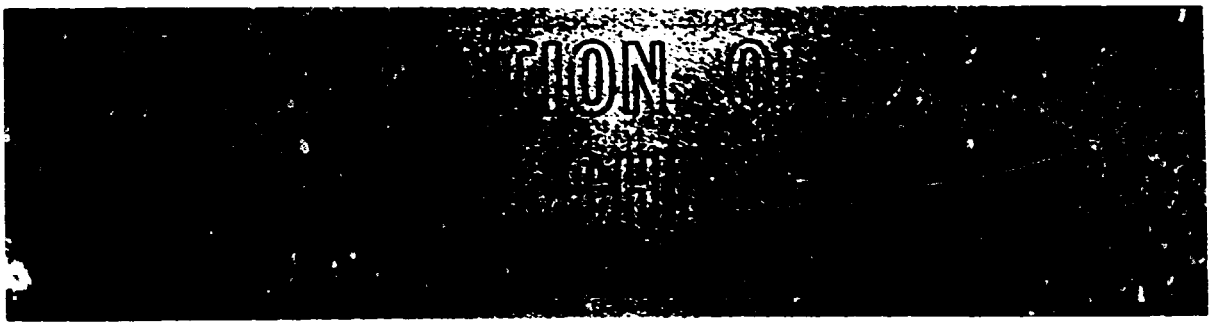
	Consumption in Wh/day for internal temperature of 0.5°C		
Average ambient temperature over 24 hrs	No load Unopened	1 kg load/day 20 mins. opening per day	2 kg load/day 20 mins. opening per day
20°C	195 Wh/j	250 Wh/j	280 Wh/j
32°C	335 Wh/j	405 Wh/j	440 Wh/j
40°C	370 Wh/j	445 Wh/j	480 Wh/j

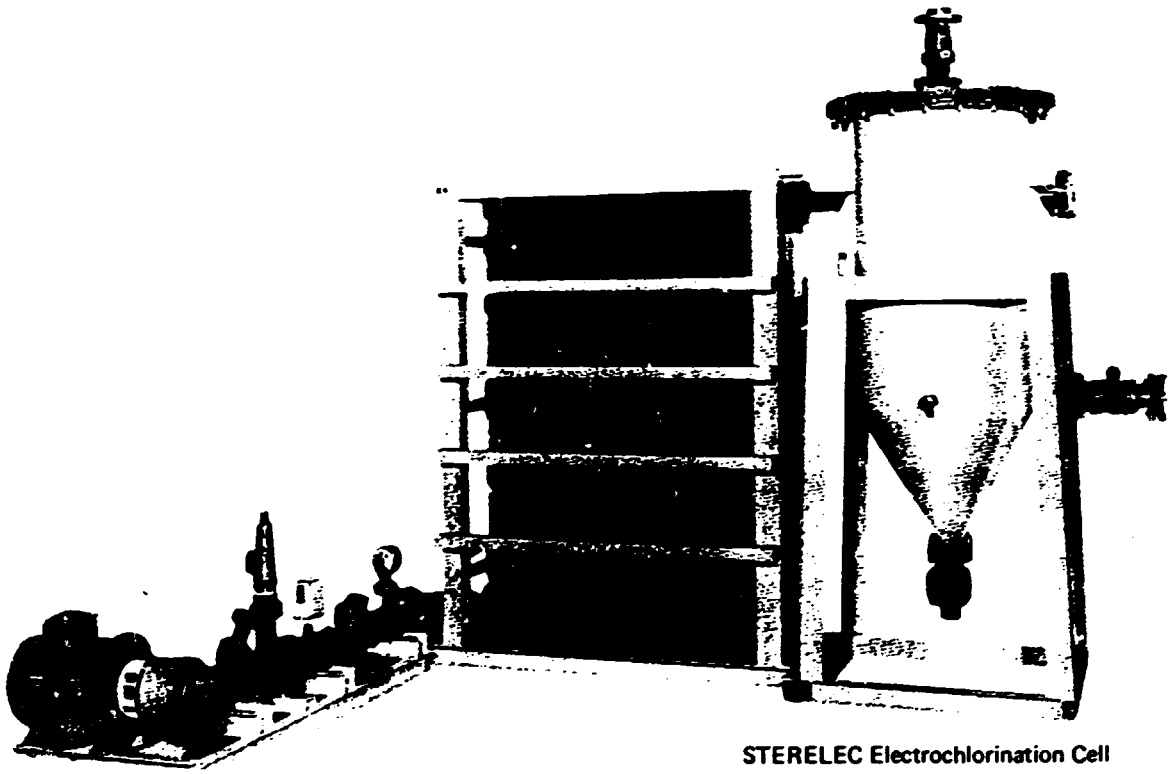
Frigesol 40

	Consumption in Wh/day for internal temperature of 0.5°C		
Average ambient temperature over 24 hrs	No load Unopened	1 kg load/day 20 mins. opening per day	2 kg load/day 20 mins. opening per day
20 °C	110 Wh/j	145 Wh/j	175 Wh/j
32 °C	125 Wh/j	170 Wh/j	205 Wh/j
40 °C	150 Wh/j	195 Wh/j	230 Wh/j

alues, we can ensure good operation, whatever the time of year.
he graphs allow us to calculate the energy provided (Wh/day) by a Genesol generator built om a given number of France-Photon solar modules and subjected to a definite radiation in wh/m²/day. Two types of module can be used : FPGC 36 T (36 Wp) and FPGF 36 T 30 Wp).
1 order to choose a generator, follow the procedure mentioned in the above example. Of ourse, it is possible to slightly alter the dimensions of the generator afterwards if the safety oefficients are respected.







STERELEC Electrochlorination Cell
ELS 10000 type
Chlorine production : 10 kg per hour
(Power Stations)

A chlorinated solution is produced on-site by electrolysis of sea water or artificial brine.

Main uses :

- Sterilization of cooling water systems
- Desinfection of waste water
- Oxidizing of industrial effluents

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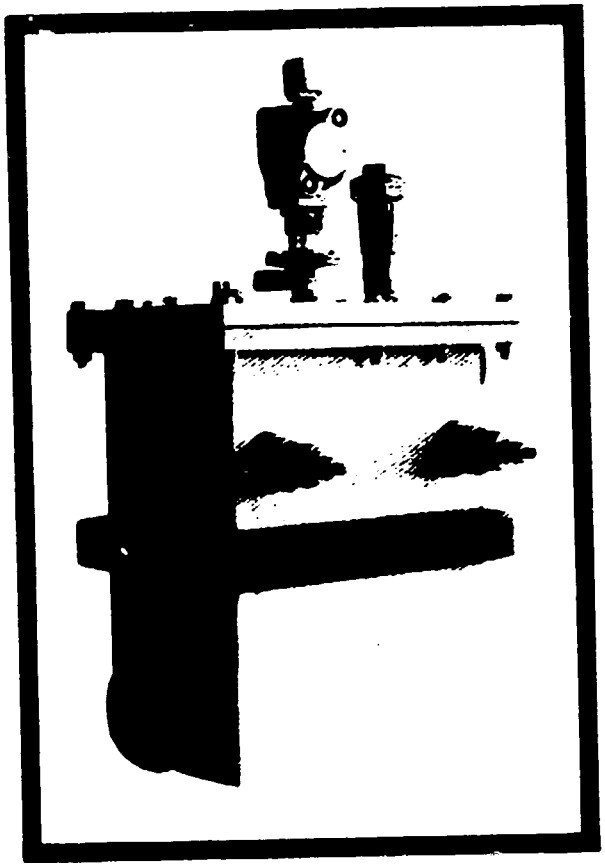
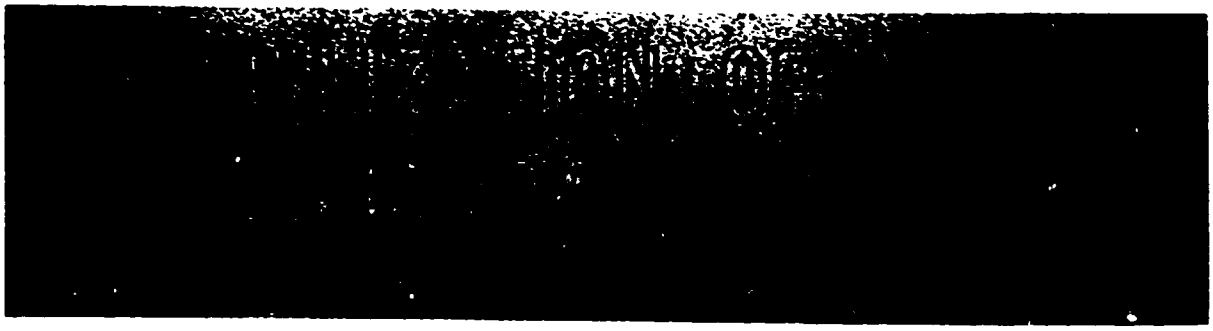
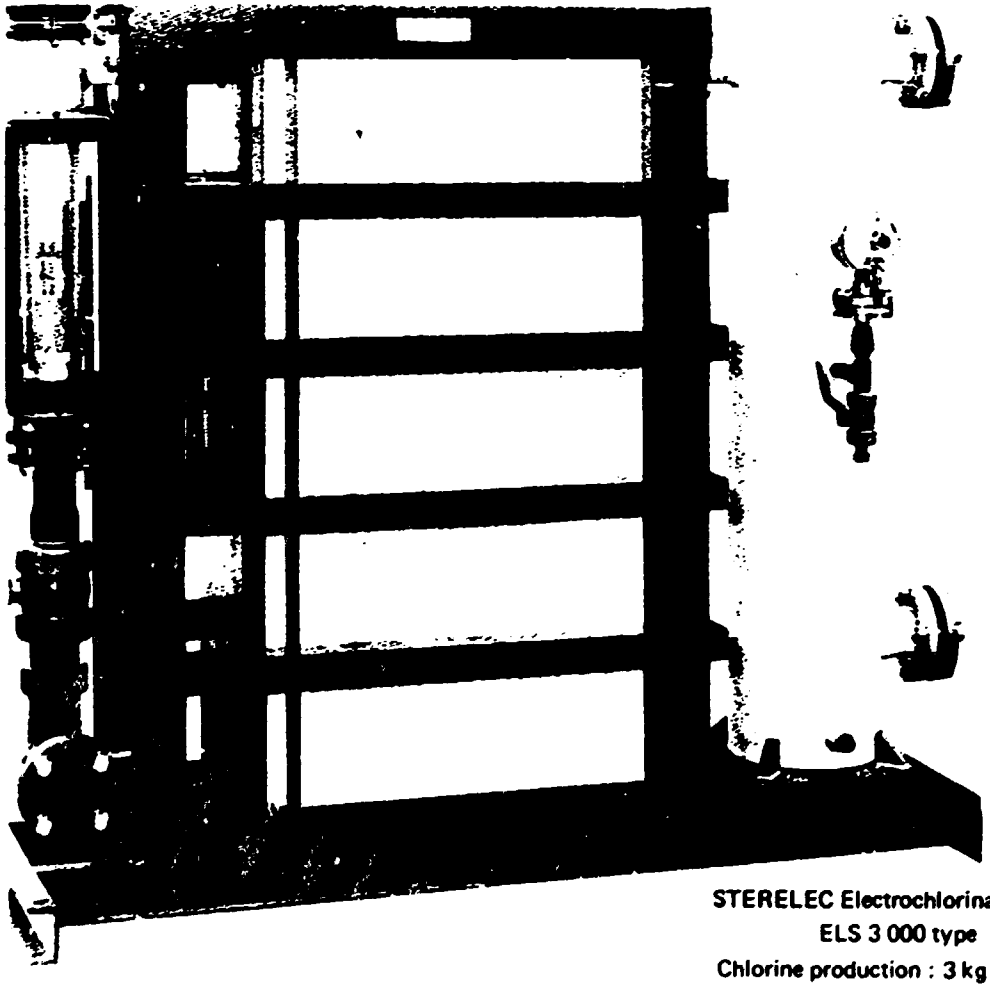
Major applications

- **Industrial circulating seawater equipments of power stations, oil refineries, steel works chemicals factories, offshore platforms ...**
  - ♦ Protection against organic fouling by shellfish, seaweed, slime, mussel, algae ... of strainers, pipelines, valves, pumps, condensers, heat exchangers ...
- **Waste water treatment plants**
  - ♦ Desinfection - Safeguard against beach bacterial pollution.
  - ♦ Chlorination
  - ♦ Deodorization
- **Industrial effluents**
  - ♦ Destruction of cyanides by oxidizing
  - ♦ Deodorization
- **Desalination plants**
  - ♦ Protection of seawater intakes, pumping stations and cooling equipments.
  - ♦ Sterilization of desalted water
- **Shipbuilding industry**
  - ♦ Protection of sea water cooling systems
  - ♦ Sterilization of distillated water
  - ♦ Desinfection of waste water
- **Food processing plants and fishing industry**
  - ♦ Bacterial action in wash-waters
- **Pleasure ports and ponds**
  - ♦ Desinfection of stagnant water
- **Swimming pools water treatment**
- Etc .....



STERELEC Electrochlorination Cell
ELS 300 type
Chlorine production : 300 g per hour
(Food processing industry)





STERELEC Electrochlorination Cell
ELS 3 000 type
Chlorine production : 3 kg per hour
(offshore platforms)

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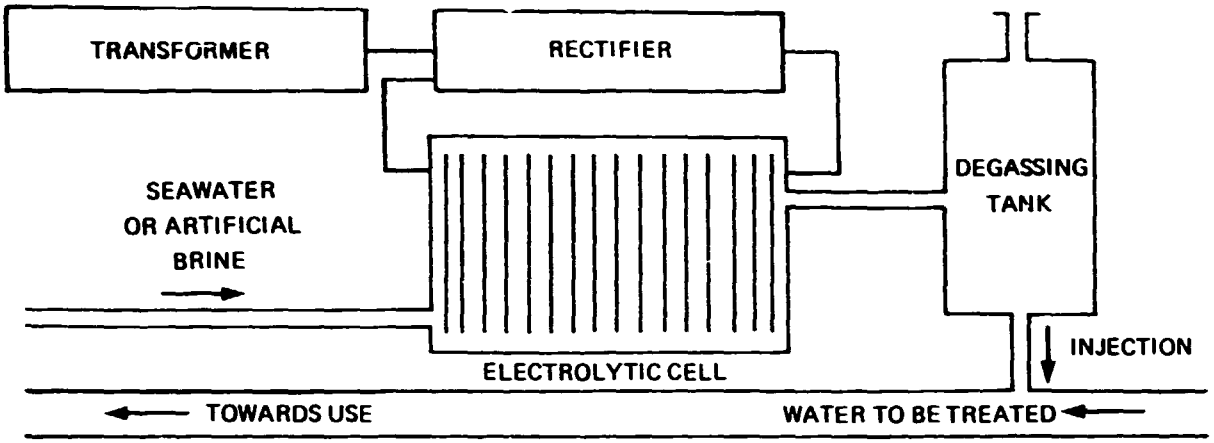
Process

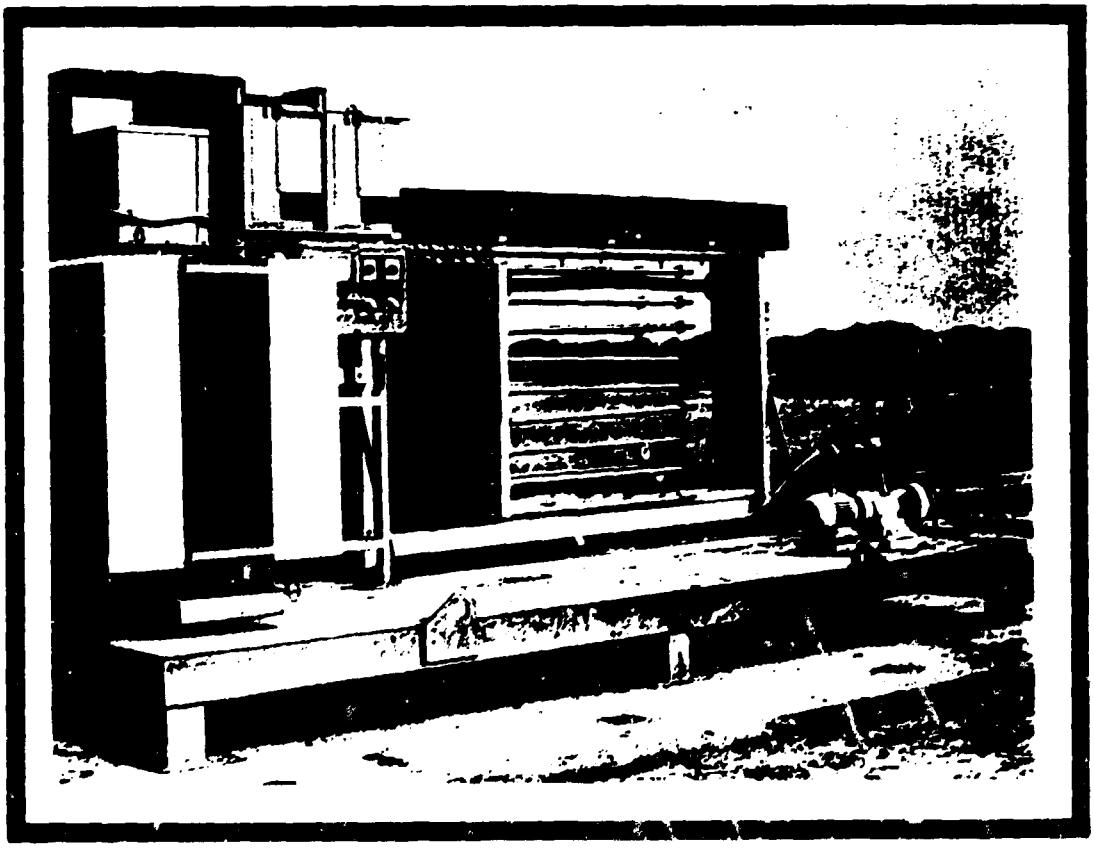


The required concentration of the sterilizing solution electrochemically produced into the cell is adjusted by regulating the electric current applied to the electrodes. The solution is then discharged into the stream to be treated.

Operating convenience and safety

This simple and economic process eliminates difficulties and dangers occured in handling, storage and supply of chemicals such as liquid chlorine.

STERELEC electrochlorination plants are operating automatically. No labour is required. Various sizes and design of electrical power and control units are matching the large range of electrolysis cells. Depending on application, discontinuous injection device for shock treatment and residual chlorine control device are optional equipments.



STERELEC Electrochlorination unit ELP 2750 type adjustable chlorine production up to 5 kg per hour (wastewater treatment mobil unit)

PLASTIC COVER FOR EVAPORATOR/

WITH BRINE CIRCULATION