PN-ABC-897

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

DATE: July 11, 1989

MEMORANDUM

TO: AID/PPC/CDIE/DI, room 209 SA-18

FROM: AID/SCI, Victoria Ose

SUBJECT: Transmittal of AID/SCI Progress Report(s)

Attached for permanent retention/proper disposition is the following:

AID/SCI Progress Report No. 2
(C8-200) "Monitoring and Controlling The Salt Gradient In the Solar Ponds"

Attachment

PN-ABC-897
CR-200
61850

Progress Report No.2

MONITORING AND CONTROLLING THE SALT GRADIENT IN THE SOLAR PONDS

A Research Project
Grant No. 936-5544-G-00-8041-00

Submitted by
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MONITORING AND CONTROLLING THE SALT GRADIENT IN THE SOLAR PONDS

project profile

Country	: Thailand
Grant No.	: 936-5544-G-00-8041-00
Program	: U.S.-Israel CDR Program
Project Title	: Monitoring and Controlling the Salt Gradient in the Solar Ponds
Project Leader	: Surachai Limyingcharoen
Organization	: Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand
Co-Investigators	: Chaturong Boontanjai Jumlong Limtragool Supattra Anutrakulchai Wilhaya Thonkel
Israeli Collaborators	: Yehuda Taitel Arkady Tsinober
Authorized Officer	: Sastri Saowakontha, Vice - President for Research Affairs, Khon Kaen University
Total Project Budjet	: US $200,000
Project Duration	: June 1988 to December 1992
Reporting Period	: December 1988 to May 1989

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1. Background

Salt gradient solar ponds is an alternative approach to harness solar energy in the region where salt, water, and sunshine are plentiful.

The physical and chemical processes in the solar pond interact with the environment where the solar pond is located. There is a need to identify the dominant external effects and the extent of these effects on the performance of the solar pond in order that appropriate operational control action can be developed.

Salt gradient solar pond technology is relatively new. The conditions in the pond are extreme for commercially available instruments which are used to monitor its operating conditions. This results in an additional requirement to develop appropriate measuring instruments which are low cost and robust enough to withstand such conditions.

This project began its activities in June 1988. The construction of two salt gradient solar ponds with a surface area of 50 squarameters each has been planned. Necessary solar pond accessory equipment has been designed and built.

2. Objectives

2.1 Overall objective and specific objectives

This research study is an attempt to study the effects of external disturbances, expecially the tropical meteorological conditions, on the top interfacial boundary of the salt gradiet solar pond. Results of the research should help answer the question 'To what extent do the tropical weather conditions affect the upper interfacial boundary of the salt gradient zone of the solar pond?".

The overall aim of the project is to develop a simple procedure for solar pond operation for less developed countries in the tropical area. This will give LDC's with an additional energy alternative with great potential for future development

Specific objectives are the followings:

i) To develop electronic hydrometer for monitoring solar ponds conditions.

ii) To identify major factors affecting the top interfacing boundary of the salt gradient in solar ponds.

iii) To develop appropriate procedure for solar pond operation in such a way that the effects of external disturbances on the salt gradient are minimised.

2.2 Objectives for this period (December 1988 - May 1989)

i) Review of research works carried out on the solar pond and procurement of equipments.

ii) Continuation of solar pond design and construction of the two 50 m^2 ponds will be carried out at the selected site.

iii) Continuation of the electronic hydrometer design and construction. Disign and construction of a scale-down model scanning carriage.

iv) Visit to Israel by a Thai researcher and visit to Thailand by Israeli collaborators.

v) Review of the first year's work at KKU by all collaborators in correspondence with Israeli counterparts.

3. Materials and Methods

3.1 Review of research works on the solar pond and procurement of equipment.

i) Review of research works on the solar ponds.

Computer search through NTIS for publications on the solar pond was carried out. A list of 20 publications on solar ponds was obtained. Eight titles were selected for further study.

ii) Procurement of equipment

Technical description of major equipment items were specified. Purchase of those technically well specified items were carried out in pursuant to procurement procedures.

3.2 Continuation of solar pond design and construction.

Structural design of the two 50 square meter solar ponds and their accessories was performed by part timely hiring of a civil engineering staffmember. Potential building contractors were approached for cost quotations.

3.3 Continuation of the electronic hydrometer design and construction. Design and construction of a scaled-down model of scanning carriage.

i) Continuation of the electronic hydrometer design and construction

Technical specifications of various types of differential pressure transducers were examined as potential measuring probes for electronic hydrometer. Motorola MPX 2050 pressure sensors were purchased for experimental trial.

ii) Design and construction of a scaled - down model of scanning carriage

Three versions of scaled-down model of the scanning carriage were proposed. One of the three versions was considered more appropriate than the rest. The selected version was built and tested to determine the effect of corrosion when used in solar pond environment.

3.4 Visit to Israel by a Thai researcher and visit to Thailand by Israeli collaborators.

Attempts were made for Dr. Chaturong Boontanjai of the Thai researching team to visit Israel on a study tour and to discuss with the Israeli collaborators on their collaboration and their visits to Thailand. Unfortunately, an appropriate flight schedule within the budget limit was not found. The visit had to be postponed.

3.5 Review of first year's work at KKU by all collaborators in correspondence with Israeli counterparts.

Progress reports were requested from all research participants. A review meeting was held in May 1989.

4. Results / Discussion

4.1 Review of research works on the solar pond and procurement of equipment

i) Review of research works on the solar pond.

No relevant result.

ii) Procurement of equipment

Equipment purchased.

1. Microcomputer. A Macintosh SE micro-computer was purchased for use in both technical and administrative work.

Equipment items with technical specifications ready for purchase :-

1. Graphic printer.
2. Data logger.
3. Interfacing adaptor for data logger.

The microcomputer purchasing took a very long time because the National Computer Committee of Thailand stipulated that any governmental department acquiring a computer system or its software or computer time must submit a proprosal to the committee for approval before proceeding with the procurement procedure.

4.2 Continuation of solar pond design and construction

Selected site for solar pond construction was submitted for approval by the university. The proposed construction site had been approved. The location of the approved site is attached as annex 1.

Engineering drawings and plans of the solar ponds and their accessories are attached as annex 2.

4.3 Continuation of the electronic hydrometer design and construction. Design and construction of a scaled-down model of the scanning carriage.

(i) Continuation of the electronic hydrometer design and construction.

No relevant result

(ii) Design and construction of a scaled-down model of the scanning carriage.

The result and discussion is attached as annex 3.

4.4 Visit to Israel by a Thai researcher and visit to Thailand by Israeli collaborators.

No relevant result.

4.5 Review of first year's works at KKU by all collaborators in correspondence with Israeli counter parts.

It was estimated that the actual research program work carried out was 6 months behind the initial schedule. This was the result of three main causes.

(i) The absence of the principal investigator during his study leave to the Netherlands during August to December 1988.

(ii) Unexpected bureaucratic procedures in purchasing equipment especially the microcomputer.

(iii) The lack of interest of building contractors to engage in smaller construction project due to construction boom and construction materials cost rise in Thailand.

5. Remarks

The cost quotation for solar pond construction exceeded the estimated cost at the time of writing the research proposal. This could lead to a review of the financial plan.

6. Workplan for the Next Period (June - November 1989).

6.1 Solar pond construction

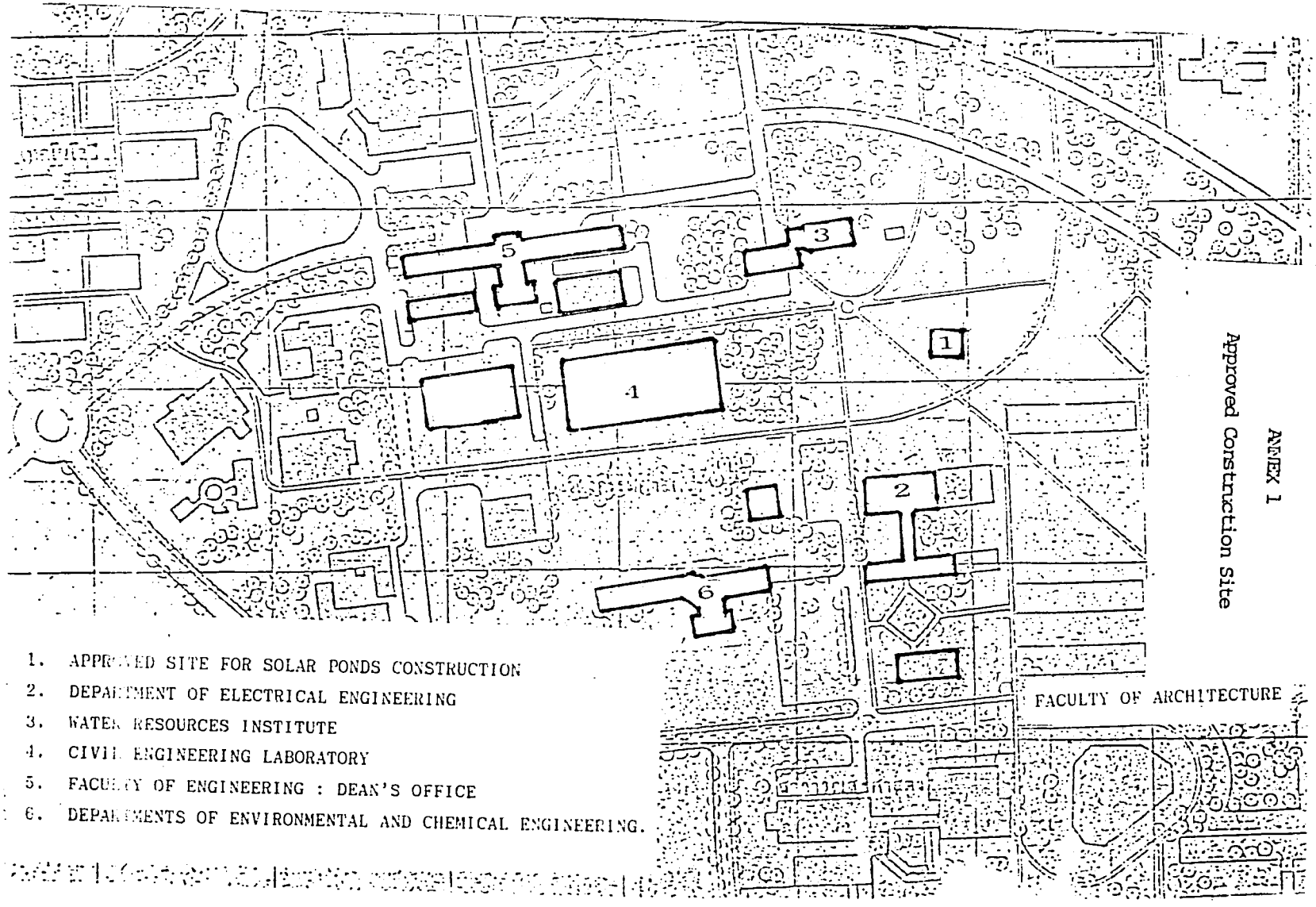
6.2 Continuation on the design and construction of solar pond accessories equipment and installation of measuring instruments.

6.3 Solar pond filling and salt gradient establishment.

6.4 Continuation on the design and construction of electronic hydrometer.

ANNEX 1

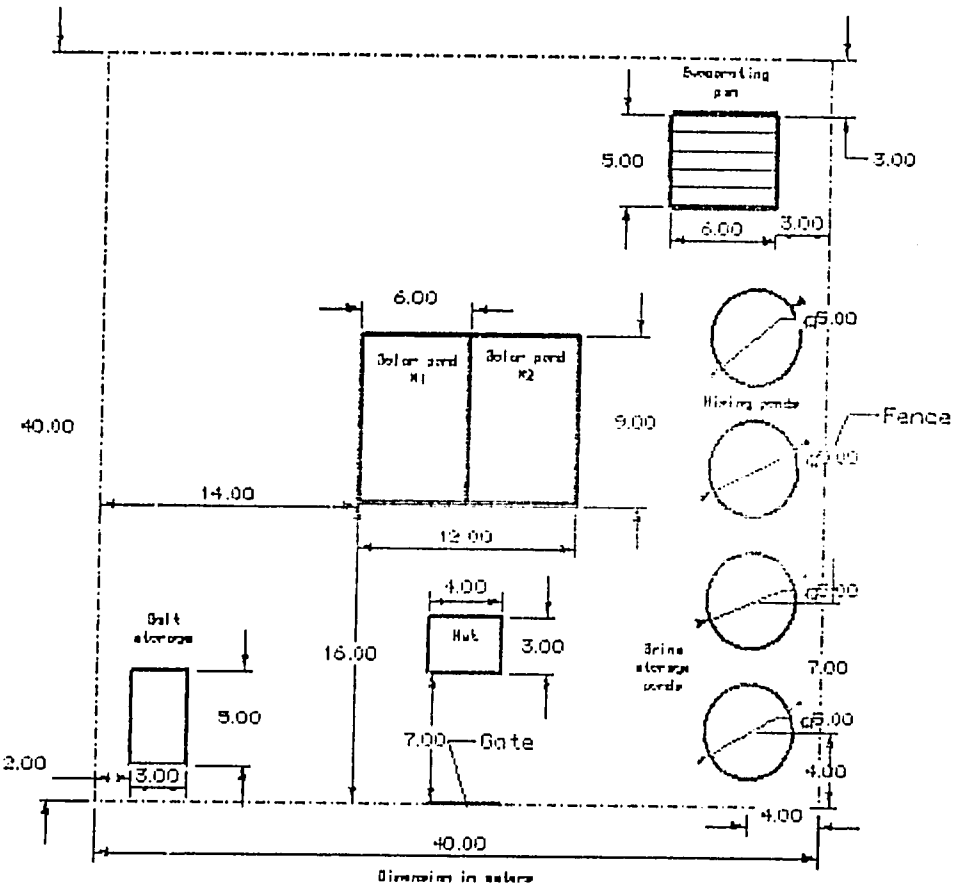
Approved Construction Site



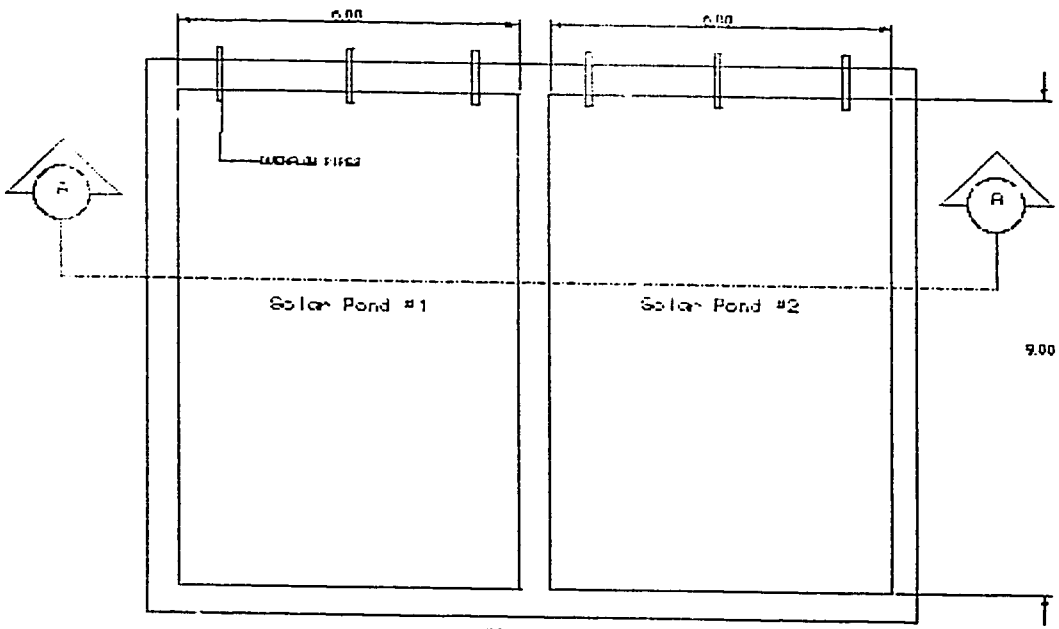
1. APPROVED SITE FOR SOLAR PONDS CONSTRUCTION
2. DEPARTMENT OF ELECTRICAL ENGINEERING
3. WATER RESOURCES INSTITUTE
4. CIVIL ENGINEERING LABORATORY
5. FACULTY OF ENGINEERING : DEAN'S OFFICE
6. DEPARTMENTS OF ENVIRONMENTAL AND CHEMICAL ENGINEERING.

ANNEX 2
Construction Plans for Solar Ponds and Their Accessories
List of Constructions

No.	Description	Quantity
1	Solar Ponds - size 6 m x 9 m x 3 m - double reinforced concrete side walls - with polystyrene foam insulation and ultraviolet resistant PVC liner (1 mm thick) - compact soil at ponds' bottom	2
2	Instrument Hut - size 3 m x 4 m x 2.6 m	1
3	Salt Storage - size 3 m x 5 m x 2.6 m	1
4	Evaporating Pan - size 5 m x 5 m x 0.3 m - brick wall - with ultraviolet resistant PVC liner (0.5 mm thick) - compact soil at bottom	1
5	Mixing Ponds - size diameter 5 m, depth 0.8 m	4
6	Fence & Gate - 40 m x 40 m barbed-wire fence with wire mesh to prevent animals from entering - 4 m x 1.6 m gate	1



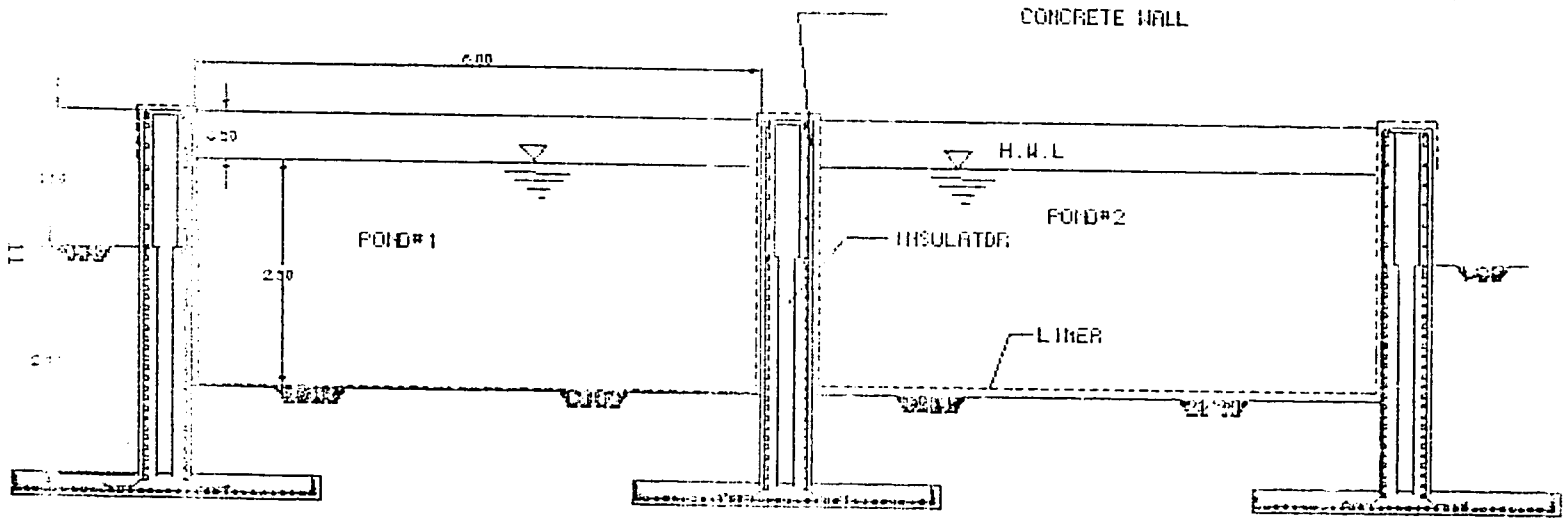
Solar ponds
Lay out plan



Dimension in METERS

Plan Overflow lay out
Engineer Wirote Chaiyadhuma

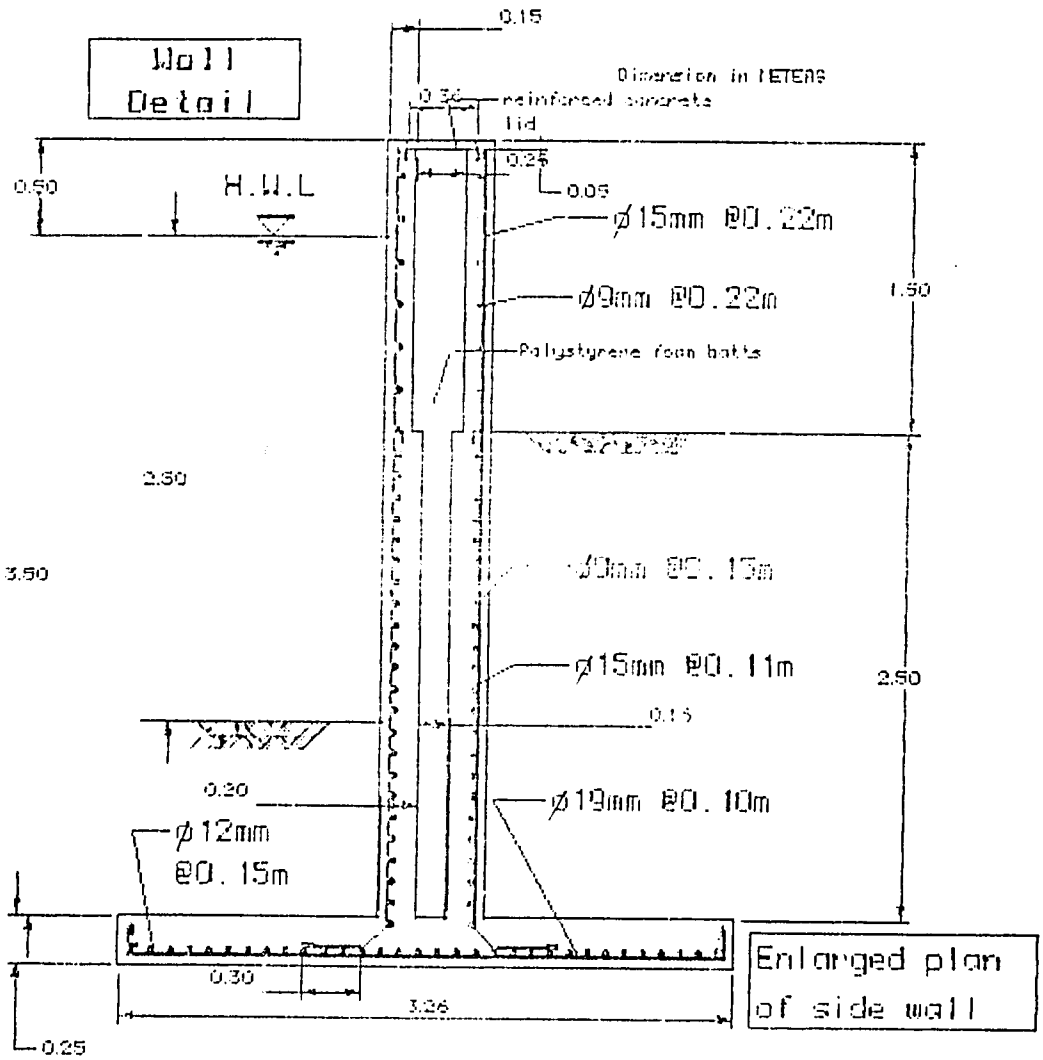
Section A-A

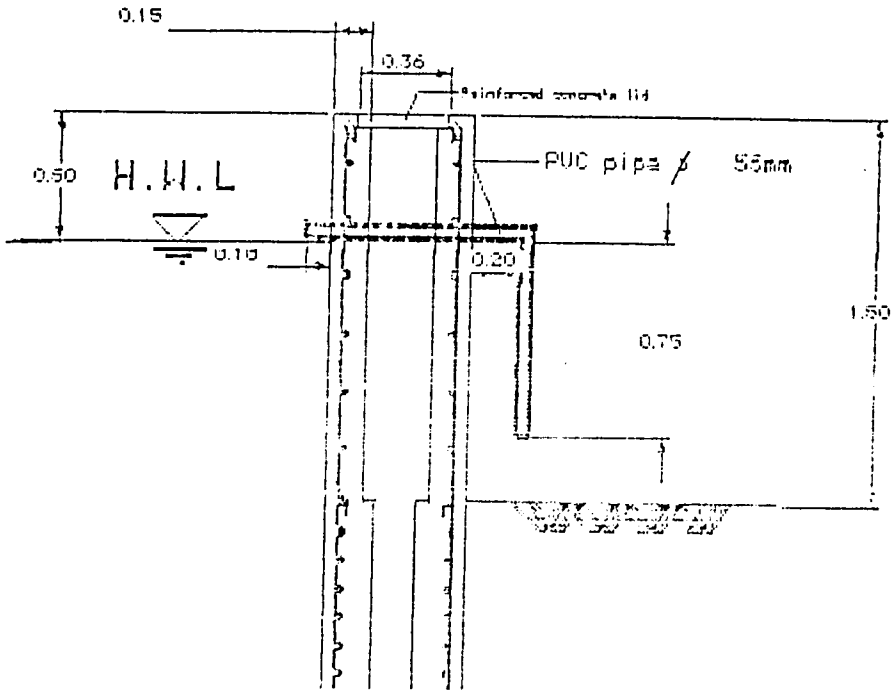


Dimension in METERS

Plan Solar ponds

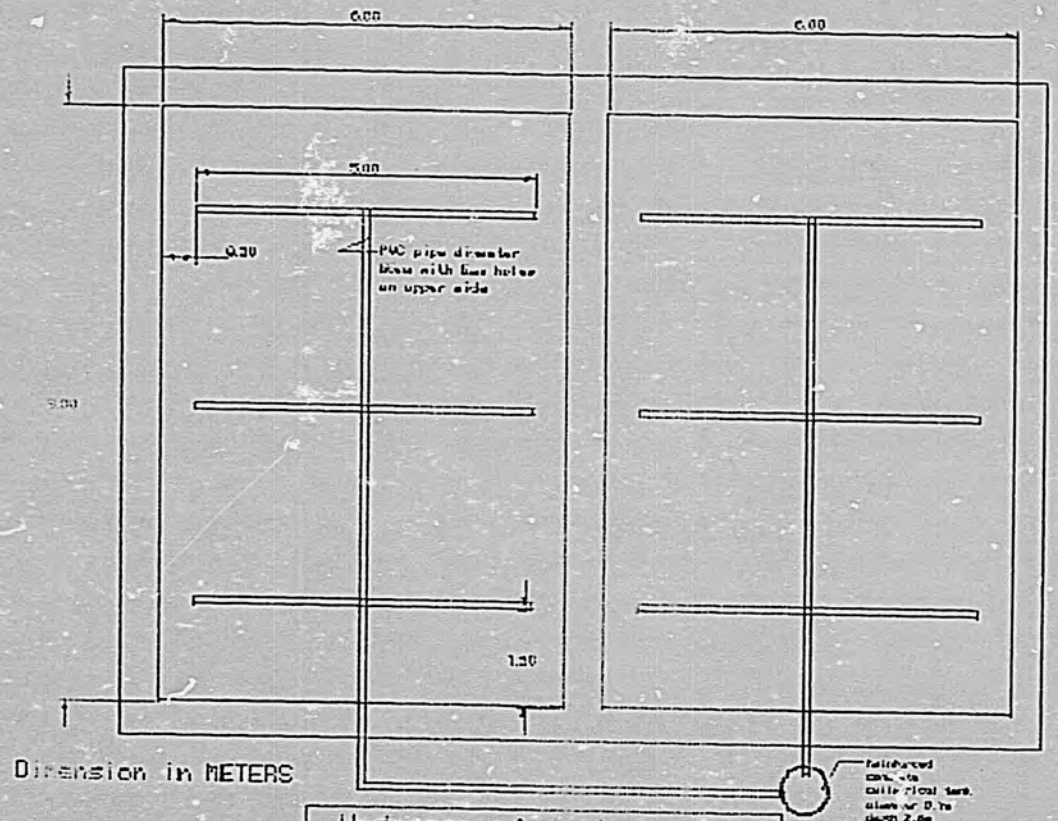
Engineer Wirote Chaiyadhuma


Wall Detail
Dimension in METERS
0.15
0.36
reinforced concrete lid
0.25
0.05
0.50
H.W.L
ø15mm @0.22m
ø9mm @0.22m
1.50
Polystyrene foam batts
2.50
3.50
ø9mm @0.15m
ø15mm @0.11m
2.50
0.15
0.20
ø19mm @0.10m
ø12mm @0.15m
0.30
3.26
0.25
Enlarged plan of side wall



Dimension in METERS

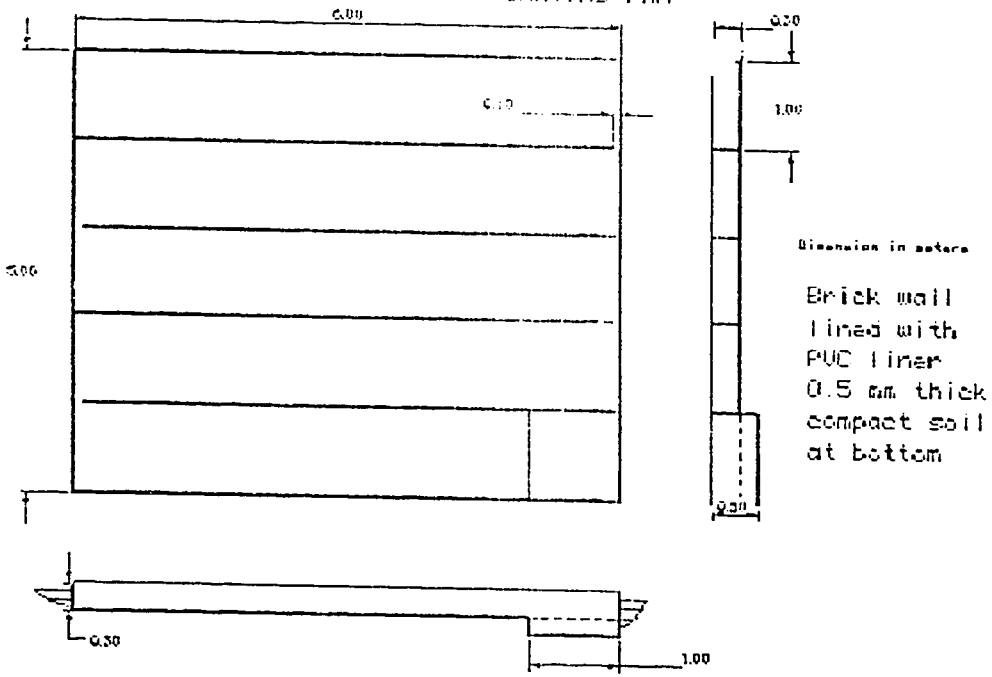
Plan Overflow

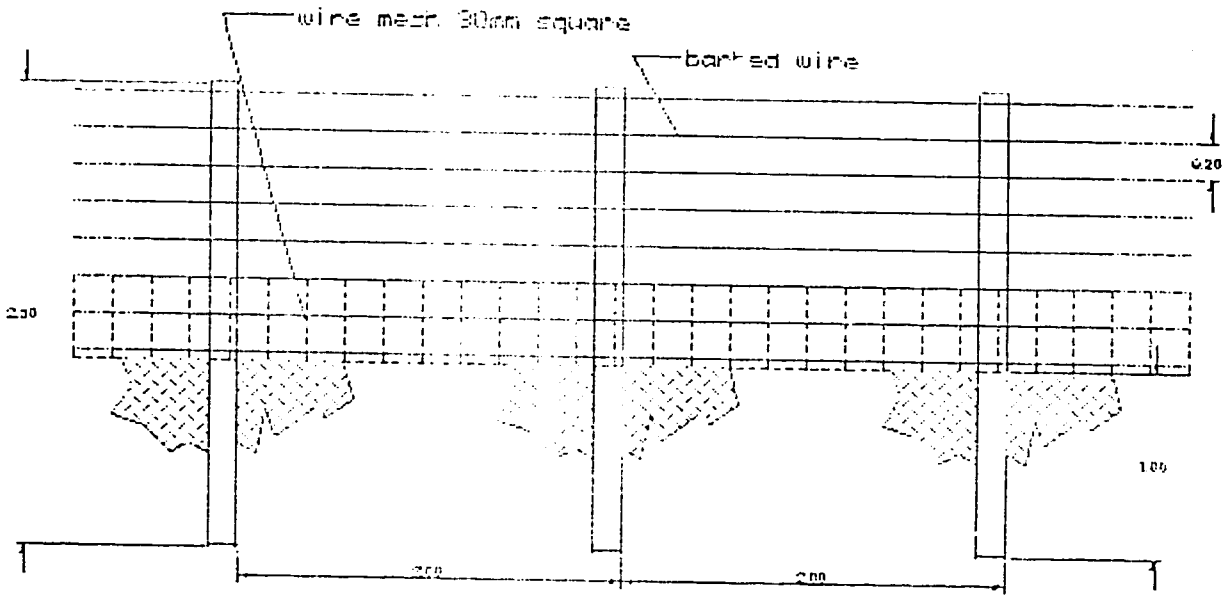


Dimension in METERS

Underground drain system

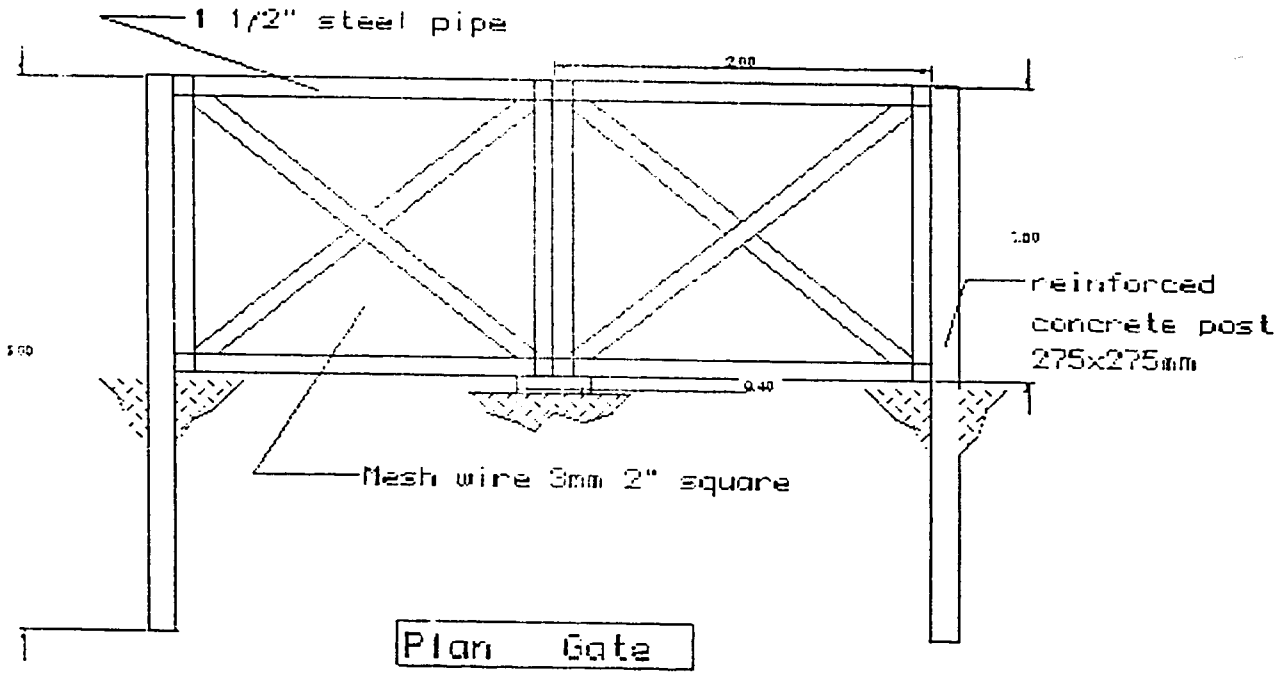
EVAPORATING PAN





Dimension in meters

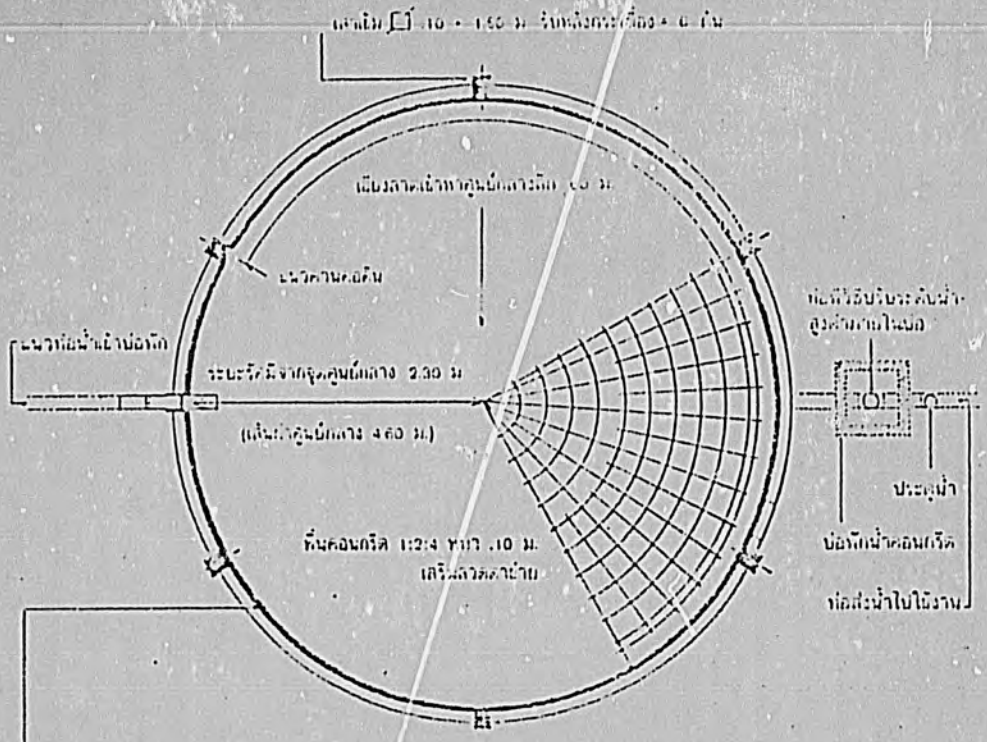
Plan Fence detail


1 1/2" steel pipe
2.00
1.00
reinforced
concrete post
275x275mm
0.40
Mesh wire 3mm 2" square
Plan Gate

BRINE STORAGE AND MIXING PONDS

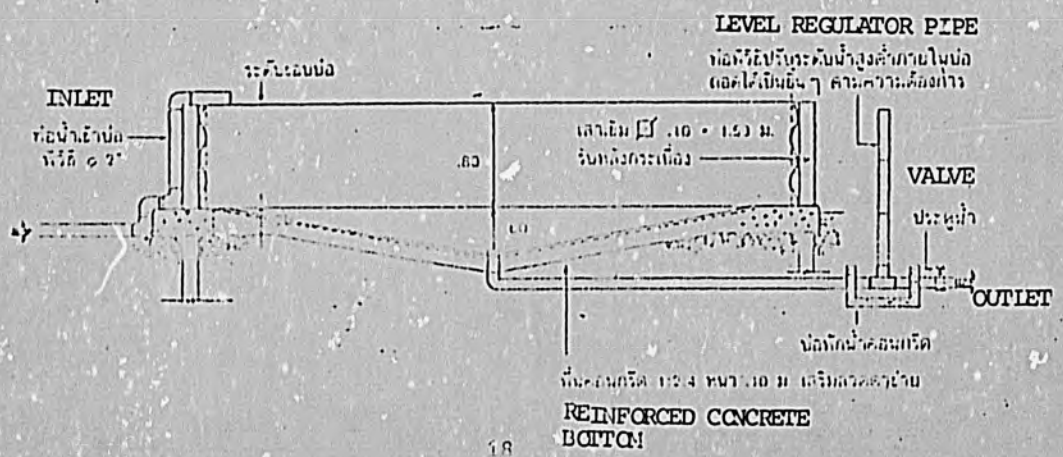
แปลน (PLAN)

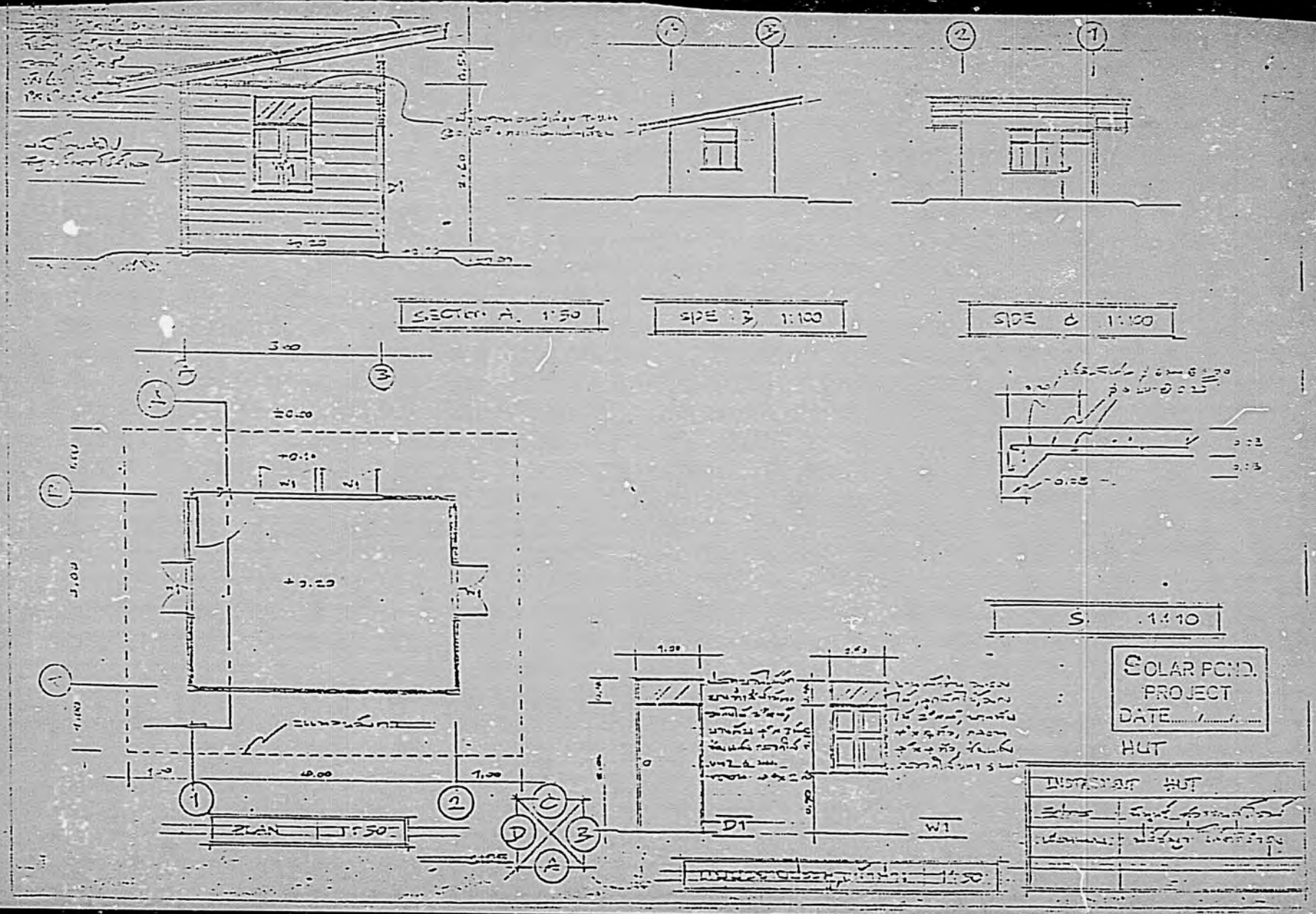
PILES 0.1mx0.1m 1.5m

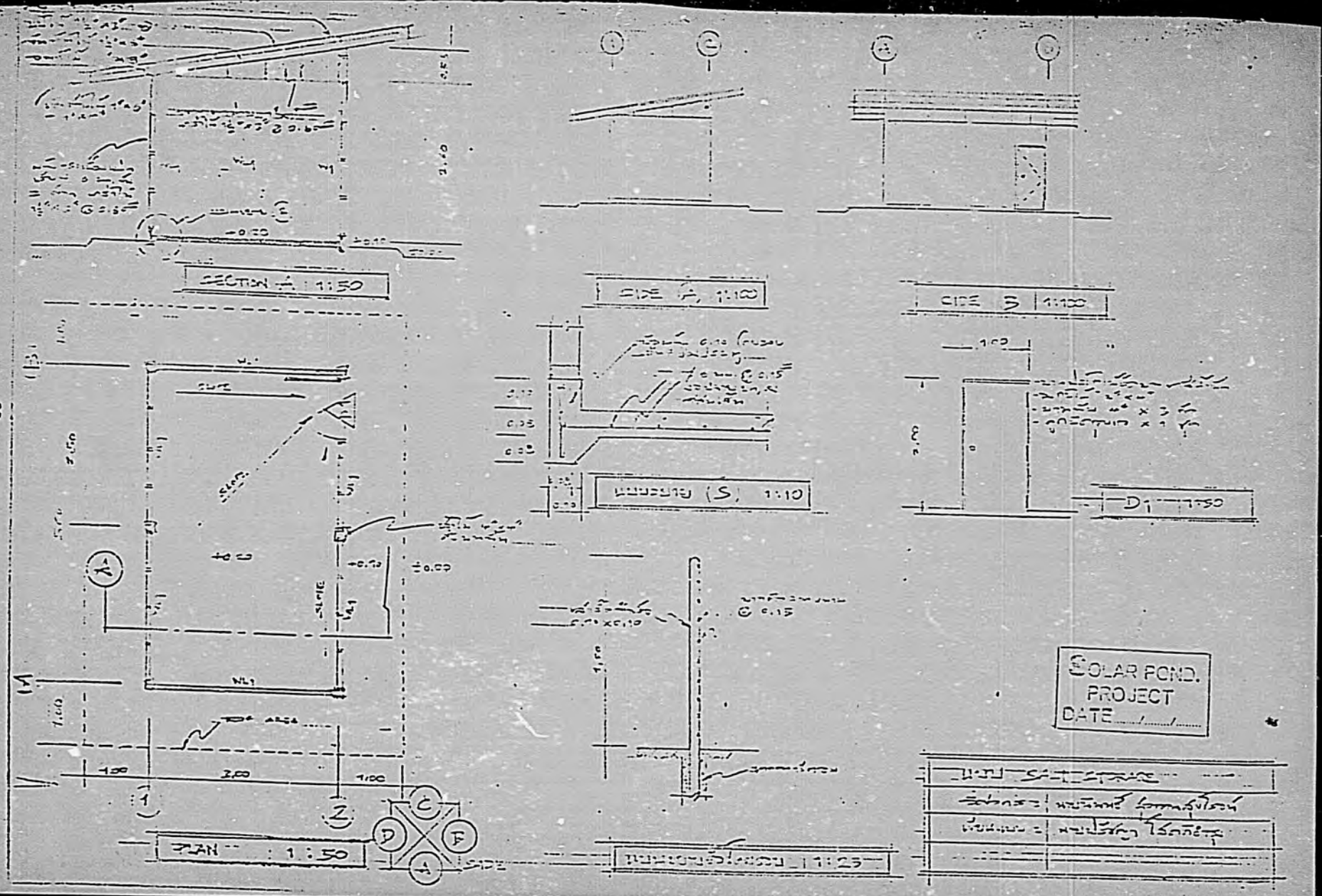


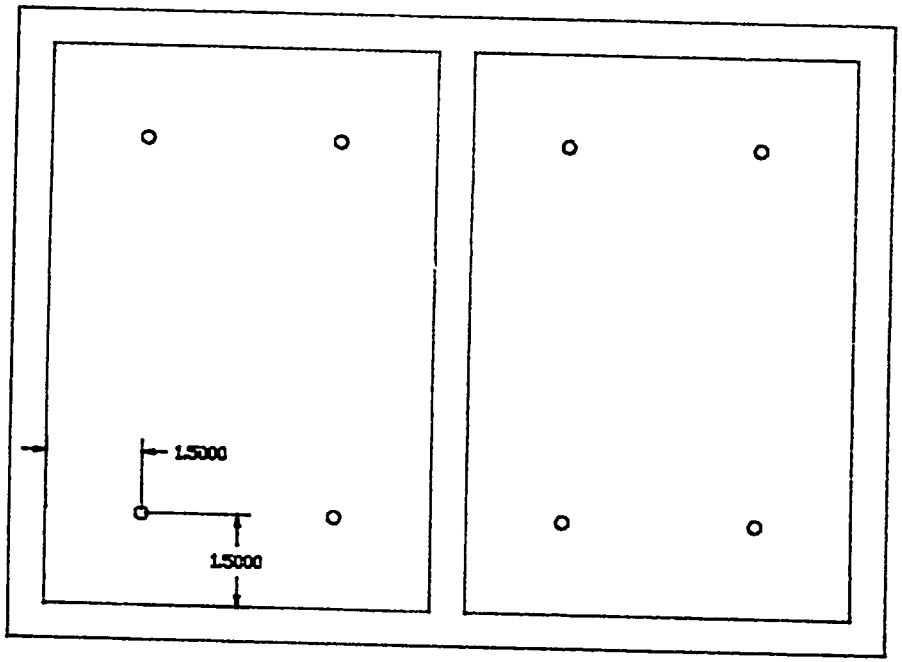
ARC TILES

รูปตัด (CROSS SECTION)

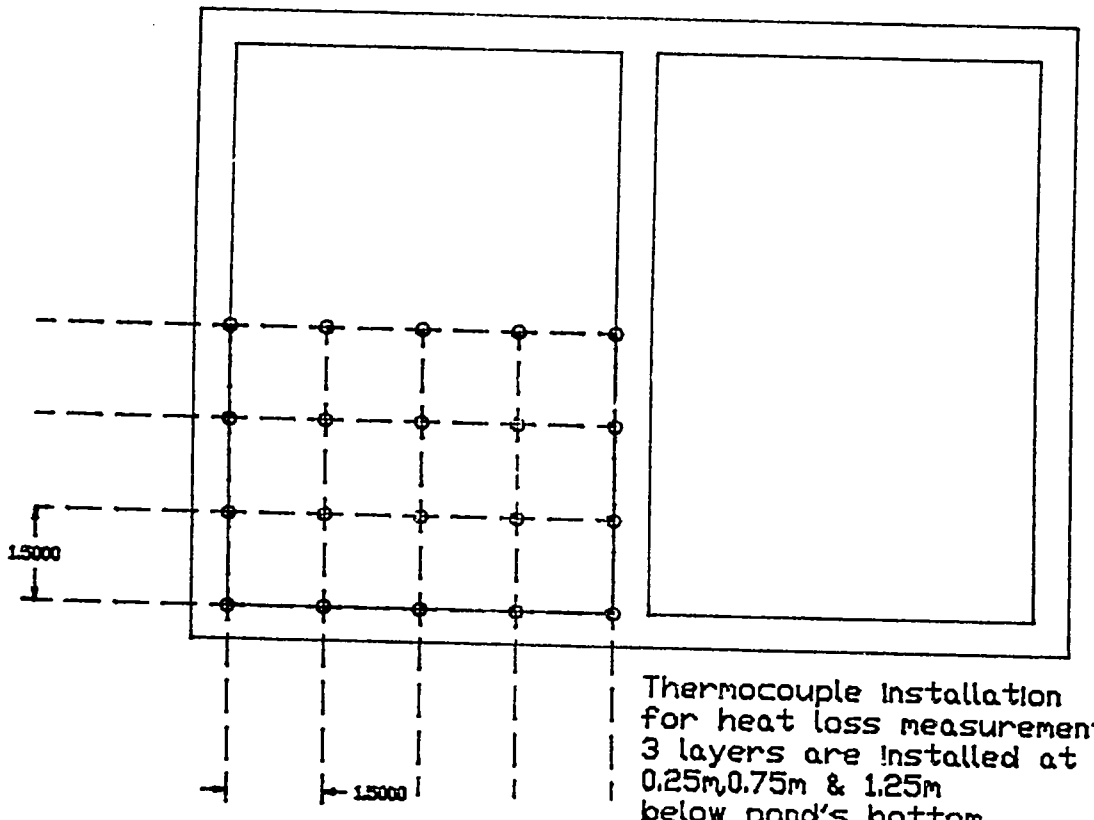



SECTION A 1:50
SIDE B 1:100
SIDE C 1:100
PLAN 1:50
D1
W1
SOLAR POND PROJECT
DATE
HUT


SECTION A 1:50
SIDE A 1:100
SIDE B 1:100
แบบขยาย (S) 1:10
D1 1:50
PLAN 1:50
SOLAR POND.
PROJECT
DATE / /

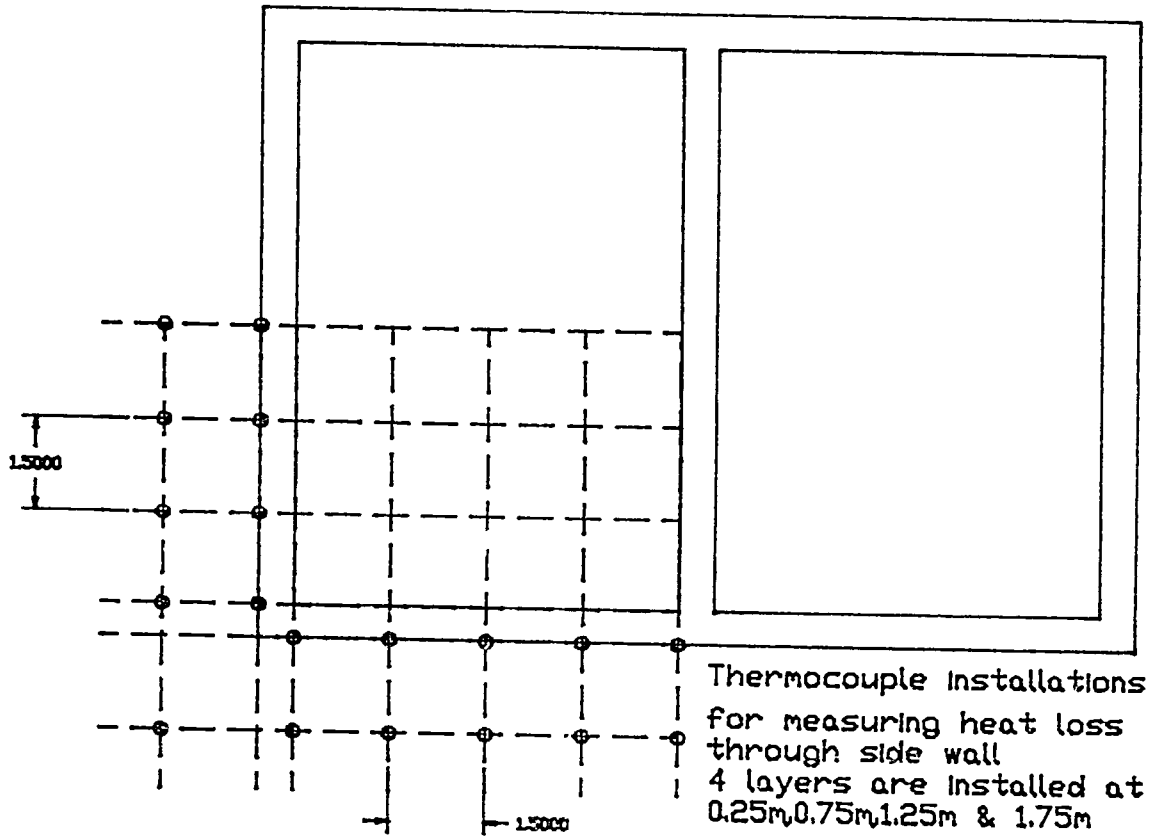


Thermocouple installations for regular measurement
2 layers are installed at 0.25m & 0.75m below the ponds' bottom
totalling 16 measuring points
by
J.Limtragool & S.Limyingcharoen



Thermocouple installation
for heat loss measurements
3 layers are installed at
0.25m,0.75m & 1.25m
below pond's bottom

by J.Limtragool & S.Limyingcharoen



Thermocouple installations
for measuring heat loss
through side wall
4 layers are installed at
0.25m,0.75m,1.25m & 1.75m

By J.Limtragool & S.Limyingcharoen

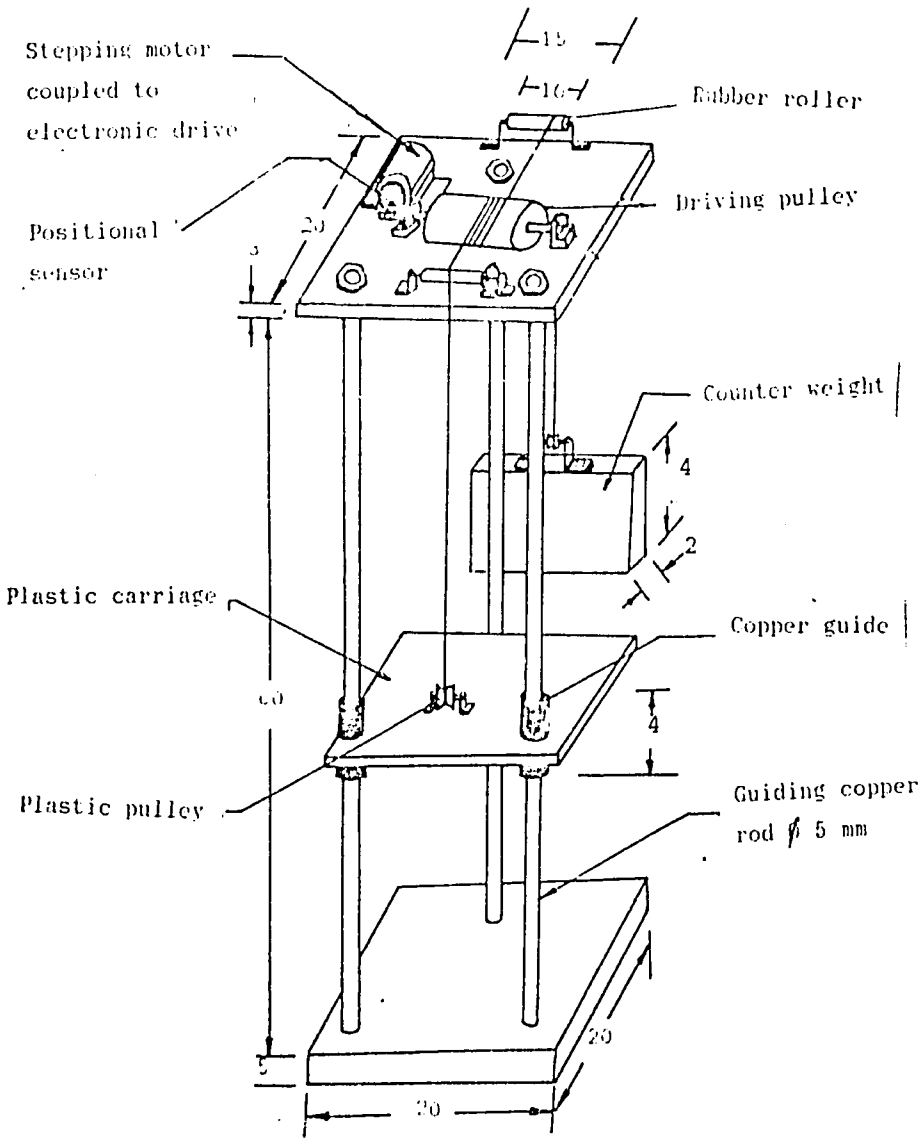
ANNEX 3

SCALED DOWN MODEL OF SCANNING CORRIAGE

1. General Description

A scaled down model of scanning carriage was constructed as in Figure 1. The model driving system is given as a block diagram in Figure 2.

The model was tested to determine the effect of corrosion in heated salt brine for 96 hours.



Dimension in centimeter except otherwise stated

Figure 1 Scanning carriage model

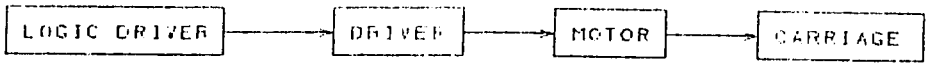


FIG. 2 CONTROL SYSTEM FOR SCALE-DOWN MODEL SCANNING CARRIAGE

2. Test of Scanning Carriage Model

2.1 Objectives

(i) To determine the effect of corrosion of copper in heated salt brine.

(ii) To investigate the movement of the carriage model in the heated salt brine.

(iii) To determine polarisation

2.2 Apparatus & materials

1. Glass cylinder : diameter 0.24 m, Height 0.35 m.
2. Scaled down model of scanning carriage.
3. Three sets of [illegible] V spot light lamps
4. Thermometer [illegible] range.
5. Salt : [illegible] kilograms
6. Freshwater
7. Voltmeters
8. Precision scale.
9. Reference metal (a piece of iron)

2.3 Procedure

1. Dissolve salt in water to make saturated salt brine up to 265 mm high in the glass cylinder.
2. Measure the weight of copper parts of the model using precision scale.
3. Placed the scanning carriage model and place the reference metal in the glass cylinder
4. Placed the thermometer to the carriage which is submerged in the brine.
5. Install spot light lamps to heat the salt brine. Adjust the lamps using a light dimmer and adjust the distance of the lamps stands from the glass cylinder to regulate the temperature of the brine to 80 °C.
6. Measure the voltage between copper parts and the reference metal regularly at [illegible] hour intervals.

7 After 96 hours weigh the copper parts of the model and calculate the weight loss due to corrosion.

5.4 Test Results

1 Results of polarisation measurement is tabulated in Table 1 and plotted in Figure 3.

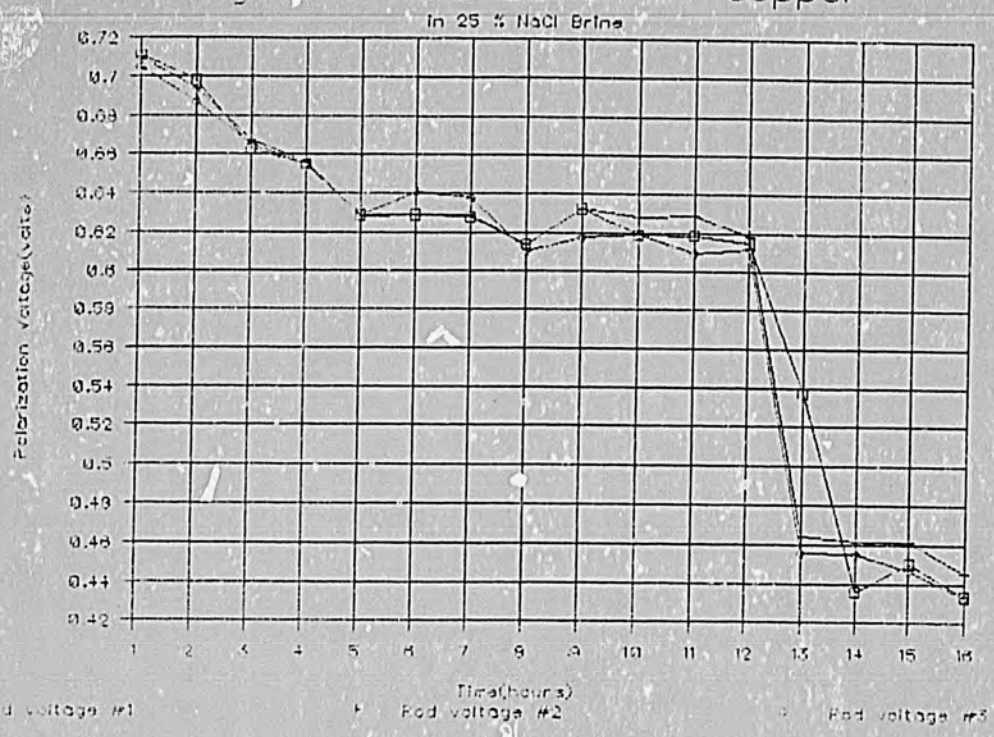
Table 1

Result of Polarisation Test

Time (hours)	Rod voltage #1 (volts)	Rod voltage #2 (volts)	Rod voltage #3 (volts)
1	0.7109	0.7098	0.7050
2	0.6980	0.6940	0.6870
3	0.6629	0.6671	0.6653
4	0.6550	0.6560	0.6550
5	0.6290	0.6281	0.6290
6	0.6290	0.6290	0.6110
7	0.6280	0.6290	0.6380
8	0.6140	0.6140	0.6100
9	0.6325	0.6324	0.6175
10	0.6190	0.6285	0.6190
11	0.6187	0.6291	0.6092
12	0.6152	0.6183	0.6117
13	0.5376	0.4641	0.4556
14	0.4357	0.4616	0.4549
15	0.4505	0.4616	0.4465
16	0.4334	0.4452	0.4327

Note : A piece of iron is used as reference electrode.

Figure 3 Polarization of copper



2 Results of the weight measurement is given in Table 2. From Table 2 and using the dimension of the copper rods the corrosion rate is calculated as 0.643 millimeters/month

Table 2

Result of Corrosion Test (Weight Measurement)

	Weight of Rod # 1 (grams)	Weight of Rod # 2 (grams)	Weight of Rod # 3 (grams)
At start	388.43	388.01	367.96
At end	380.38	385.98	367.94
Lost Weight	0.05	0.03	0.02

2.5 Observations During the Test

1 Salt crystallisation occurred at the surface of the salt brine. These crystals sticked to the guide surface thus causing rough carriage movement. The movement of the carriage was smooth of it is submerged under the brine surface.

2 Using of different metals with high electronegativity in the same pond could lead to a high corrosion rate.

2.6 Discussion

From figure 3 the polarisation voltage decreased with time. This was due to the accumulation of oxide on the surface of the reference metal and the accumulation of hydrogen bubbles on the surface of copper.

Progress Report No. 1

MONITORING AND CONTROLLING THE SALT GRADIENT IN THE SOLAR POND

A Research Project

Grant No. 936-5544-G-00-8041-00

Submitted by

Jumlong Limtragool

Chaturong Boontanjai

Faculty of Engineering

Khon Kaen University

Khon Kaen 40002

Thailand

- 29

MONITORING AND CONTROLLING THE SALT GRADIENT IN THE SOLAR POND

project profile

Country	: Thailand
Grant No.	: 936-5544-G-00-8041-00
Program	: U.S.-Israel CDR Program
Project Title	: Monitoring and Controlling the Salt Gradient in the Solar Pond
Project Leader	: Surachai Limyingcharoen
Organization	: Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand
Co-investigators	: Chaturong Boontanjai Jumlong Limtragool Supattra Anutrakulchai
Israeli Collaborators	: Yehuda Taitel Arkady Tsinober
Authorized Officer	: Sastri Saowakon, Vice President for Research Affair, Khon Kaen University
Total Project Budjet	: US $200,000
Project Duration	: June 1988 to May 1992
Reporting Period	: June 1988 to November 1988

1. Introduction

Salt gradient solar pond is an alternative approach to store solar energy for continuous use in a region with abundant sunshine and few other alternative sources of energy. Thus the utilization of solar pond for production of energy offers tremendous potential for less developed countries particularly those countries in the tropic which have scarce energy resources and little forestry left but long sunshine hours.

This research program will concentrate its activity on the operation and control of solar pond as well as instrument development for future applications in LDC. Two ponds (each having a surface area of 50 m^2) will be used. One pond will be used for the study of boundary layer interfacing between the top convective zone and the salt gradient zone. The second pond will be used for the study of the manipulation or control of the salt gradient which acts as heat insulator for the pond.

2 Objectives

2.1 Overall objective and specific objectives

This research study is an attempt to study the effects of external disturbances, especially the tropical meteorological conditions, on the top interfacial boundary of the salt gradiet solar pond. Results of the research should help answer question "To what extent do the tropical weather conditions affect the upper interfacial boundary of the salt gradient zone of the solar pond?".

The overall aim of the project is to develop a simple procedure for solar pond operation for less developed countries in the tropical area. This will give LDC with an additional energy alternative with great potential for future development.

Specific objectives are the followings:

i) To develop electronic hydrometer for monitoring solar pond conditions.

ii) To identify major factors affecting the top interfacing boundary of the salt gradient in solar ponds.

iii) To develop appropriate procedure for solar pond operation in such a way that the effects af external disturbances on the salt gradient are minimised.

2.2 Objectives for this period (June - November 1988)

i) Research activity planning

ii) Initial survey and data gathering

iii) Preliminary design of the two 50 m^2 solar ponds

iv) Initial design of the hydrometer

3. Progress work for this period (June-November 1988)

3.1 Research activity planning

Meeting of all researchers was held in June 1988. Planning of the research activity at KKU and collaboration with Israeli collaborators were carried out.

3.2 Hiring of staff and procurement of equipments.

An engineer (Mr. Rungroj Changprung, B.E.), and a technician (Mr. Supachai Srikana, Higher Cert. in EE) were hired beginning May 1988. Equipments as listed in the year 1 of the proposed budget [1] are being ordered.

3.3 Initial design of the two 50 m^2 solar ponds were carried out. Expected temperature and salinity variations from the simple solar pond model are shown in Fig.1. Tentative site lay-out of the experimental solar ponds is shown in Fig.2. Structural design of the solar pond is in progress. Once the design is complete construction of the two solar ponds will begin at a designate site.

3.4 The eletronic hydrometer design is in progress in conjunction with literature review on its design and construction. Some electronic circuits were tested in order to develop a suitable design. Initial design of a scanning carriage which will be used with the electronic hydrometer is shown in Fig.3.

4. Workplan for the next period (December 1988-May 1989)

4.1 Extensive review of research works carried out on the solar pond and procurement of equipments.

4.2 Continue on solar pond design and construction of the two 50 m^2 ponds will be carried out at the selected site.

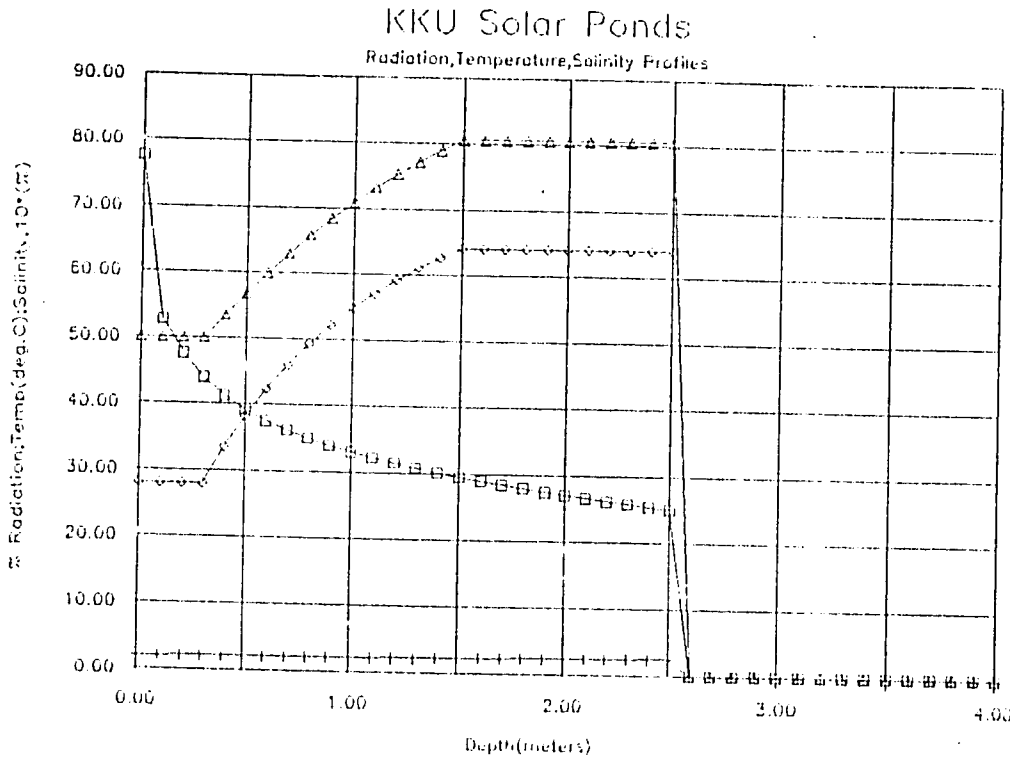
4.3 Continuation of the electronic hydrometer design and construction. Design and construction of a scale model scanning carriage.

4.4 Visit to Israel by a Thai researcher and visit to Thailand by Israeli collaborators.

4.5 Review of the first year's work at KKU by all collaborators in correspondence with Israeli counterparts.

5. References

1) Monitoring and Controlling the Salt Gradient in the Solar Pond, U.S.-Israel CDR Research Proposal, Faculty of Engineering, Khon Kaen University, Khon Kaen 40002, Thailand.



+ Reflected light

◊ Temperature

□ Radiation

Δ Salinity

Fig.1 Temperature and salinity variations in the simple solar pond model

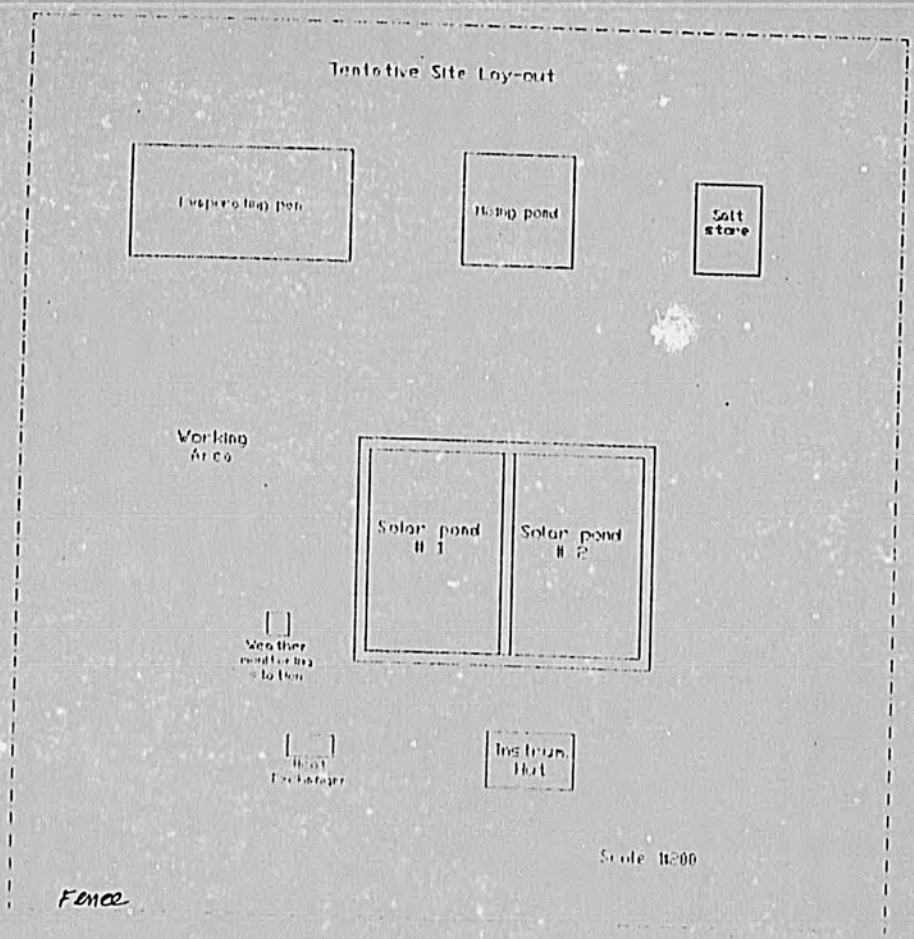
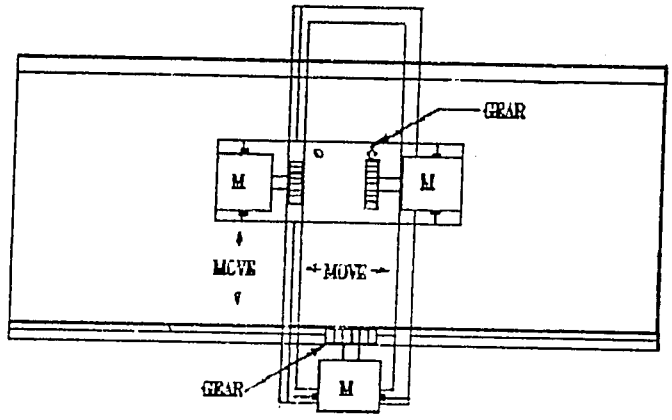
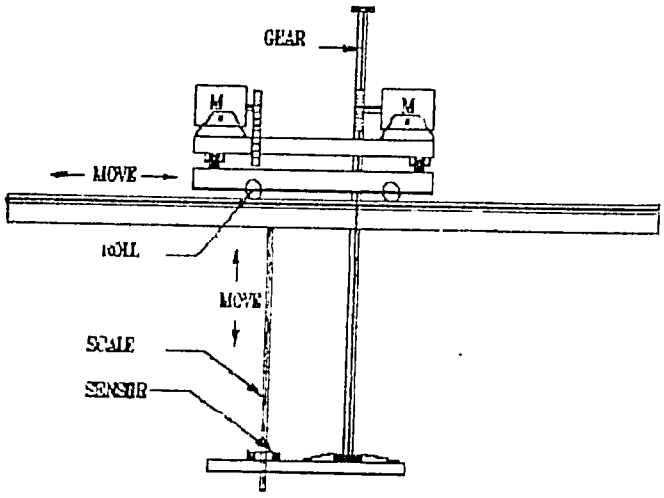


Fig.2 Tentative site lay-out for the two 50 m² solar pond



X-Y POSITION CONTROL

Top View



Front View

Fig.3 Schematic diagram of a scale model scanning carriage