Ingenieurbüro Ruess und Hausherr

- Entwicklung von Mikroprozessor-Systemen
- Mess- und Regeltechnik
- Berechnungen und Simulationen im wissenschaftlich-technischen Bereich

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Ms. Bettie Westerhof
INTERNATIONAL REFERENCE
CENTRE FOR COMMUNITY
WATER SUPPLY AND SANITATION
PO Box 93190

2509 AD TH HAGUE

NETHERLANDS

Switzerland - St.Gallen 20/8/1992

Sea water desalination and irrigation with moist air

Dear Ms. Westerhof

The 28th november 1989 I sent you a report about sea water desalination and irrigation with moist air. I take the liberty of sending you some further information.

During the last two years, we optimized the system from the economical point of view. We were able to reduce the costs from US $ 15.-- to $ 5.-- per square meter.

Therefore the investment for the designed installation of 3000 square meter (1 modul) agricultural area is US $ 15000.--
The required technical equipment we would deliver from Switzerland.

I hope the enclosed information will be usefull to you and remain,

Yours sincerely

K. Ruess

SEA WATER DESALINATION AND IRRIGATION WITH A MIXTURE OF AIR AND WATER VAPOUR

Summary:

The water-jet pump (9) sucks the air through the intake socket (6). The air is moistened in the salt water-jet (11). The energy for the evaporation procedure is mainly taken from the air. Therefore its temperature falls. The air ist reheated by contacting the sun energy absorber (20). The gazes rise and are remoistened in the water-jet (8), which is besides the convection the impulse of the circulation. Thus the air is reheated and remoistened several times.
The nozzle (7) is provided with salt water by the pump (16) and the pipes (10) and (12). The pool (15) gathers the non-evaporated water. The mineral salts do not evaporate. They remain dissolved in the water, but their concentration rises continously. The circuit existing of the pool, the pipe to (13) and from (14) the salt water reservoir (22) as well as the water-level control (14) regulate the concentration of ions in the pool. The reservoir was previously filled with ground water from a well or by a pipeline from the sea or by a tank lorry (1 cargo monthly). As soon as the concentration of the ions is too high, the water has to be changed in the same manner.
Through the intake socket air is sucked in continously. Consequently the heated and moistened air passes through the condensation tubes where the water vapour condenses and the water arrives directly at the roots of the plants.

DESSALEMENT D'EAU DE MER ET D'IRRIGATION A L'AIDE D'UN MELANGE D'AIR ET DE VAPEUR D'EAU

Résumé:

La trompe d'eau (9) pompe l'air par le tubulure d'aspiration (6). Celui-ci s' humidifie dans la douche d'eau salée (11). L'énergie d'évaporation est surtout prise de l'air. Donc sa température baisse. L'air se réchauffe en contactant la surface à absorbtion (20). Il monte et se réhumidifie dans le jet d'eau (8), qui augmente en même temps la circulation d'air. Par conséquence l'air se réchauffe et se réhumidifie de nouveau. La trompe d'eau est alimentée en eau par la pompe (16), le tuyau de conduite (12) et le tuyau d'amenée (10). Le bassin (15) recueille l'eau non évaporée. Les sels minéraux ne s'évaporent pas, ils restent dissous dans l'eau. L'évaporation d'eau augmente la concentration des ions. Le circuit comprenant le bassin, la transmission (13) au réservoir d'eau salée (22), le retour du réservoir ainsi que le réglage de niveau d'eau (14) contrôle la concentration des ions dans le bassin. Le réservoir (22) aura été préalablement rempli par une pompe mise dans les eaux souterraines (fontaine) ou par un tuyau d'amenée de la mer ou par un wagon-citerne (une course par mois). Dès que la concentration d'ions devient trop élevée, l'eau doit être changée de la même façon.

L'air chauffé et humidifié ne peut sortir que par les tuyaux à condensation. L'air étant pompé continuellement par la trompe d'eau. La vapeur d'eau se condense donc et l'eau arrive directement aux racines des plantes par les tuyaux à condensation.

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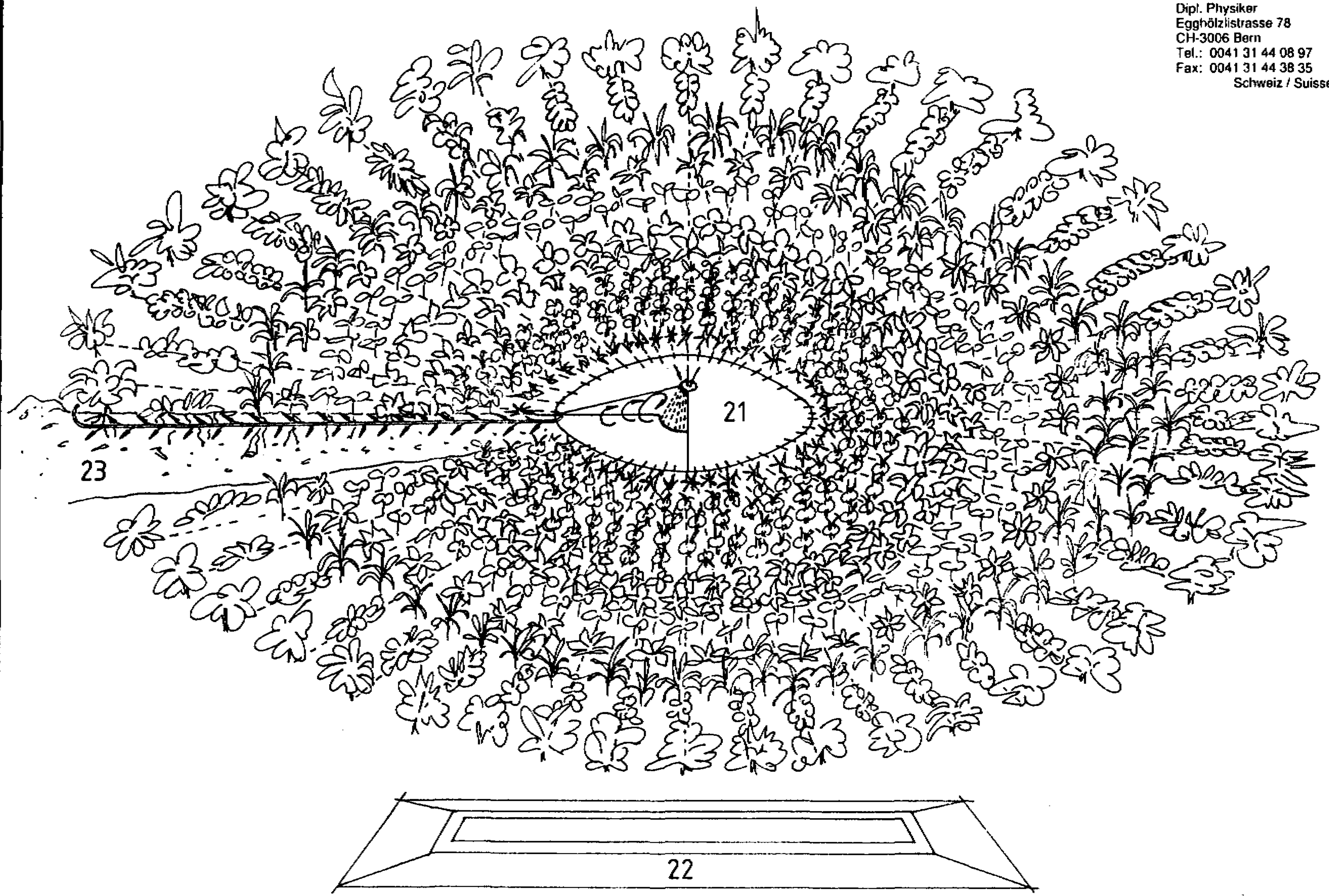

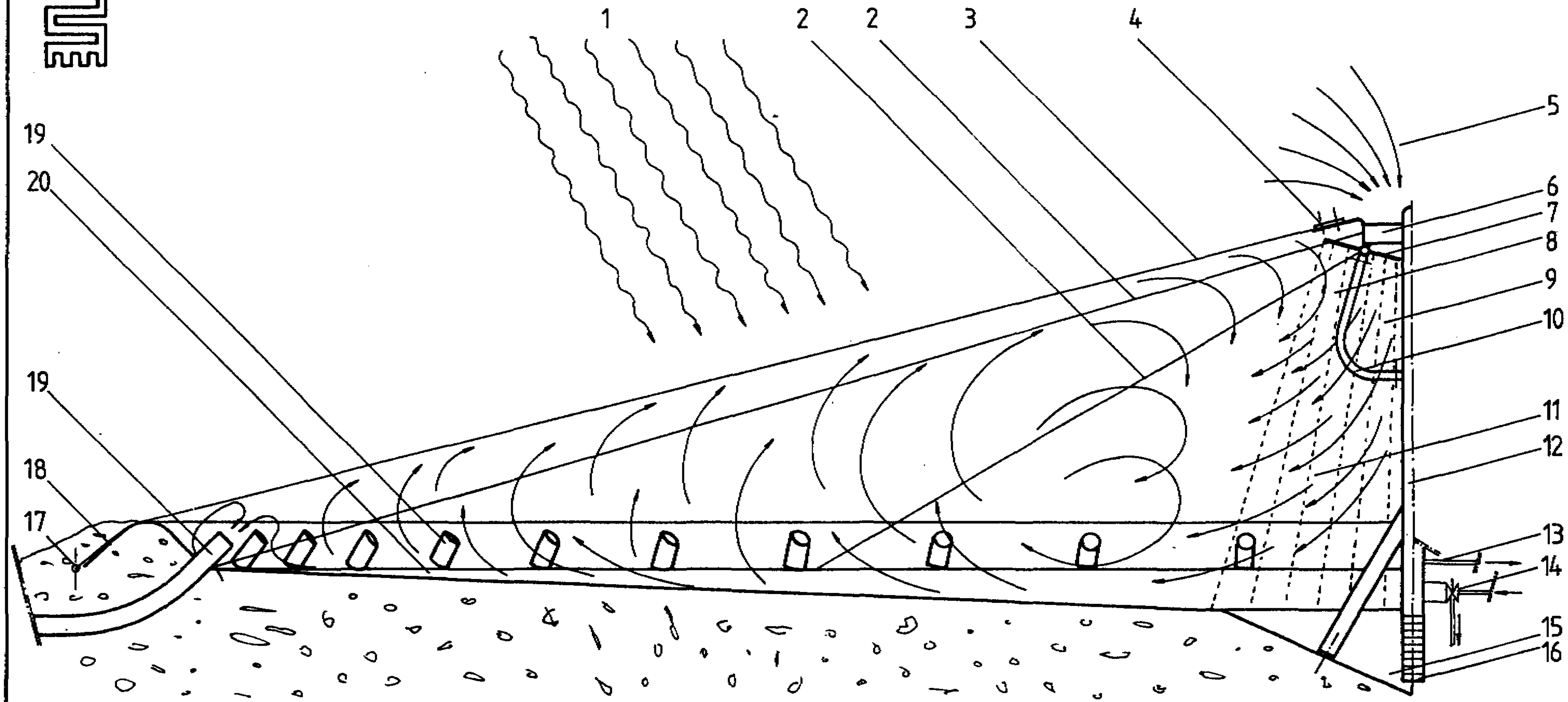

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Stück Nbr. de pièces	Gegenstand Spécification	Pos. Rep.	Material Matière		Modell Modèle	Bemerkungen Observations

II | I | Änderungen: Modifications:

Ersetzt durch / Remplacé par ...
Ersatz für / Remplace ...

Evaporation procedure

CH-Pat. 672227 INT-Pat. 84209

Maßstab / Echelle

Gezeichnet / Dessiné: Zuer.
Geprüft / Contrôlé:
Gesehen / Vu:

Ruess und Hausherr

1-303-792

tableau | **table** | **Liste**

1 **rayonnement solaire**
insolation
Sonneneinstrahlung

2 **étayage**
brace
Abstützseil

3 **feuille diaphane protégée contre les rayonnements ultra violets**
ultra violet protected transparent foil
uv-geschützte transparente Folie

4 **fixation de la feuille diaphane**
fixation of the foil
Folienbefestigung

5 **amenée d'air**
air suction
Luftzufuhr

6 **tubulure d'aspiration**
air intake socket
Luftansaugstutzen

7 **tuyère d'eau salée**
salt water nozzle
Salzwasserdüse

8 **circulation et humidification d'air**
circulation and moistening of air
Zirkulation und Befeuchtung der Luft

9 **humidification d'air pompé (trompe à eau)**
moistening of intaken air (water-jet pump)
Befeuchtung der angesaugten Luft (Wasserstrahlpumpe)

10 **tuyau d'amenée à la tuyère (7)**
pipe to nozzle (7)
Zuleitung Düse (7)

11 **humidification**
moistening
Befeuchtung

12 **pilier et tuyau de conduite**
pillar and water pipe
Abstützung und Wasserleitung

13 **transmission au réservoir d'eau salée (22)**
pipe to the reservoir of salt water (22)
Druckleitung zum Salzwasserreservoir (22)

14 **transmission du réservoir (22) et réglage de niveau d'eau**
pipe from the reservoir (22) and water-level control
Zuleitung vom Salzwasserreservoir (22) und Niveauregulierung

15 **bassin d'eau salée**
salt water pool
Salzwasserbecken

16 **pompe à eau salée**
salt water pump
Salzwasserpumpe

17 **fixation de la feuille diaphane**
fixation of the transparent foil
Folienbefestigung

18 **protection contre la friction de la feuille diaphane**
protection against friction of the transparent foil
Abreibschutz der transparenten Deckfolie

19 **tuyaux à condensation**
condensation tubes
Kondensationsrohre

20 **absorbtion d'énergie solaire et chauffage d'air**
absorbation of sun energy and air heating
Absorbtion der Sonnenenergie und Erwärmung der Luft

21 **procedure d'évaporation**
evaporation procedure
Luftbefeuchtungseinheit

22 **réservoir d'eau salée**
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Salzwasserreservoir

23 **tuyau à condensation sous-terrain**
condensation tube in the soil
Kondensationsrohr im Erdreich

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SEA WATER DESALINATION AND IRRIGATION WITH A MIXTURE OF AIR AND WATER VAPOUR

CONTENTS

Switzerland-St.Gallen, January 1989

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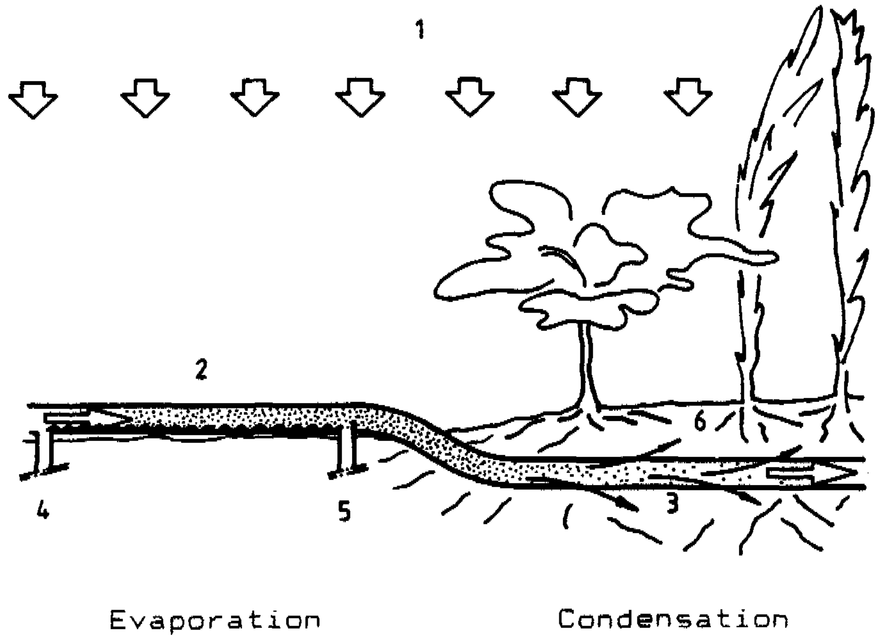


Fig. 1: Sea water desalination and irrigation with a mixture of air and water vapour

1. Summary

This procedure enables the cultivation of plants in hot, arid zones near a salt water source. Irrigation with fresh water is therefore not necessary.

Sea water and air stream in the same evaporation tube (2) in the sea water desalination and irrigation plant. Sun rays (1) heat up the air and salt water (input 4, output 5). The water evaporates partly and only a mixture of air and water vapour is fed into the soil. The soil cools the saturated mixture and water vapour condenses in the tubes. The water arrives directly at the roots of plants (6) through porous or drain pipes (3).

2. Physical principal

Hot air has a higher water vapour capacity than cold air. In a bath room for example, air takes up vapour from the water, until the water vapour capacity is reached. The cold mirrors and windows cool down the humid air and if the water vapour capacity is exceeded, the air has to give up water vapour as condensation.

The same procedure occurs in meteorology. In the Red Sea and the Persian Gulf the hot air takes up a water layer of over 3.5 metre thick each year. This moist, warm air rises. Air pressure differences between the equator and the poles, as well as other forces, move it them around the world. In a higher degree of latidude the subtropic air is cooled down by polar air and if this lower water vapour capacity is exceeded, the vapour condenses, resulting in rain.

3. Technical use

The technical use of these procedures is not new. In the past the Greeks have built heavy condensation wells made of stone. On their walls, the moist air was cooled down to obtain water. As figure 2 shows, these wells were not only functional, they were also artistic, often with dovecots along the top. With the excrement of the pigeons and the water produced, plants were fertilised and watered.

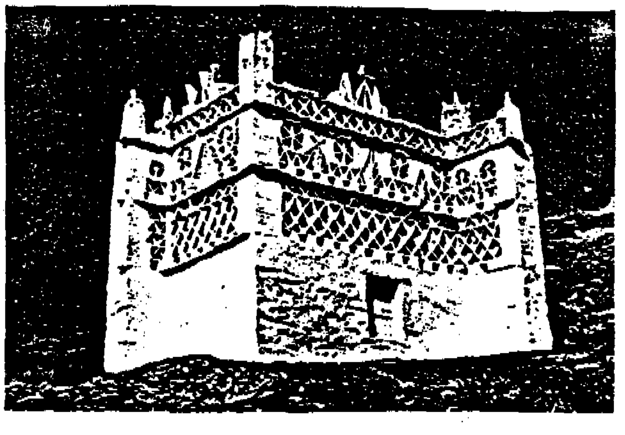


Fig. 2: Oriental condensation well with dovecot to obtain water and fertiliser

(Picture: K. Stadler)

King Herod built the most famous condensation well in Masada. In his time Roman Baths were very fashionable. Besides the great baths and pools for the people a condensation well supplied the King's bath with water (Fig. 3). Calculations have shown that these wells and the condensated water around the rock of Masada obtained a few thousand cubic metres of water a year, enough to survive a siege. In peace time there were other water sources too, the wadis.

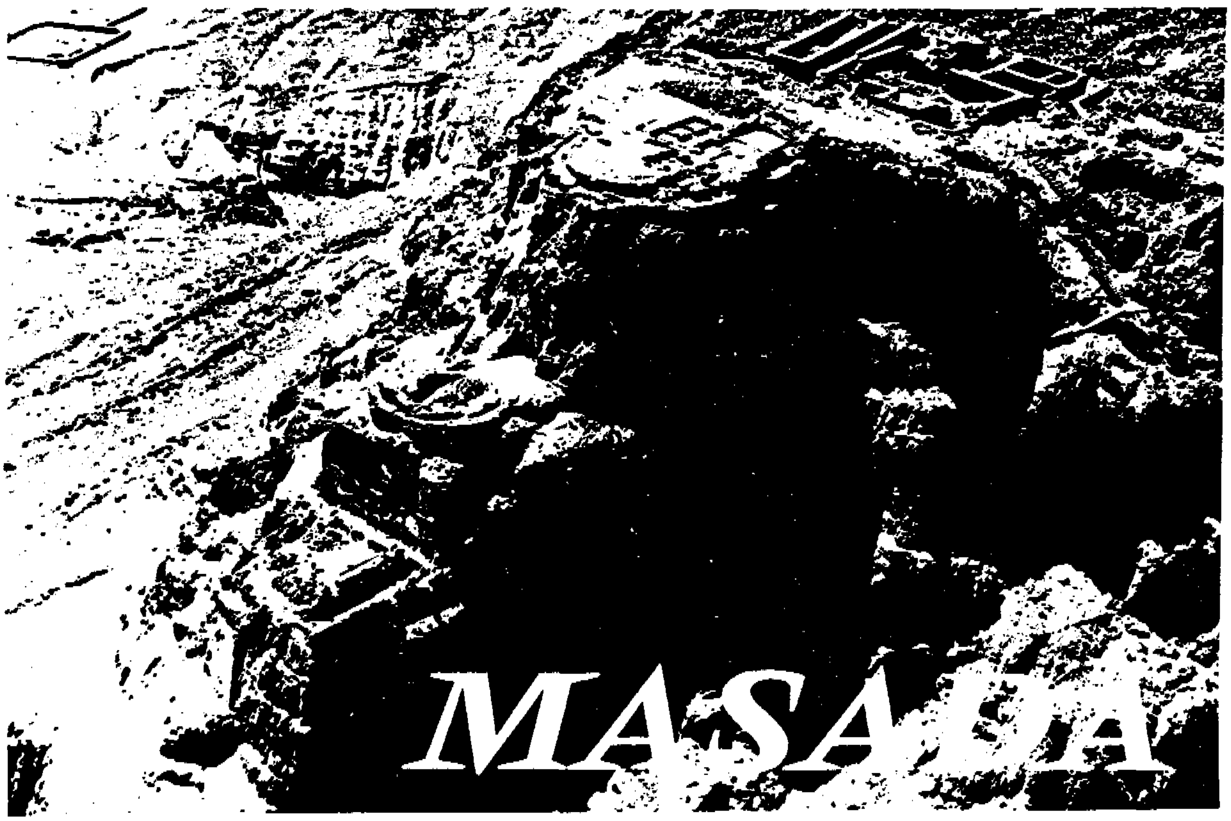


Fig. 3: Condensation well to supply King Herod's bath

(The middle terrace)

4. Irrigation with a mixture of air and water vapour

As we have seen previously, it is not new to obtain water from the air. The idea of heating and moistening air with solar energy and sea water and condensing water vapour directly by the roots of plants, is probably new.

Air and salt water passes through sun exposed tubes. The sun rays are absorbed and heat the air and the water (Fig. 1). Let us suppose that the air reaches a temperature of 40°C and is saturated with water vapour at the end of an evaporation tube. Its vapour capacity is 50 g of water per kilogramme of dry air (Air density = 1.293 kg/m3, normal conditions). After this evaporation process the saturated mixture of air and water vapour is led under the soil, close to the roots of plants. The soil temperature decreases immediately in the first few metres from the surface. Let us suppose that the soil cools the mixture down to 20°C. The water vapour capacity is 15 g/kg. This means that we gain 35 g of water by cooling each kilogramme of mixture. The water arrives at the roots through drains or porous pipes. Water vapour diffuses widely throughout the soil. Experiments have shown this effect. The desalination and irrigation plant can be built as an air circulating system. Instead of the proposed air moistening system other systems can be used (eg. water vapour from industrial process). It is a question of economy and planning whether natural convection or ventilation is employed for the air circulation. In the presented method condensing and distributing the water occurs together. The water arrives at the roots without loss by evaporation into the air (A sprinkle system often has an efficiency less than 50%).

Other irrigation systems such as sprinkler plants and open water channels have partly contributed to the recent increase in malaria, the open water being a breeding ground for the mosquitoes causing the disease. With the subterranean irrigation the soil surface is dry, so that there is no breeding ground for the malaria-causing mosquitoes.

5. Pilot project

Kurt Ruess invented and developed together with Heinz Federer the presented sea water desalination and irrigation method. Since July 1986 a pilot plant has been running in Margrethen (Switzerland). In a sun energy collector field the air is heated and moistened (Fig. 4). In figure 5 the subterranean condensation tubes are shown. A solar generator provides the electric power to drive ventilators and the sea water pump (Fig. 4). The plant works without batteries and without regulation. If the sun is shining, the system starts and produces water. Even if the sun is not shining, water is stored because of the humidity of the soil.

Fig. 4: Evaporation tubes with the solar generator

6. Experimental plants as an indicator of success

Besides the quantity, the quality of the obtained water is important. If the irrigation water is too salty, the soil can not be used after some years, because there is not enough water to wash out the salt in the soil. The quality of the destillate was high. We could not measure salt ions.

Cress is a very salt sensitive plant and served as the salt or quality indicator. Tomatoes need plenty of water and served as the quantity indicator. As a light indicator we planted lettuce. A greenhouse and a damp border in the soil was built to protect the pilot plant from rain water.

In the pilot plant cress and lettuce were grown with success. Conventionally watered tomatoes need more than 600 litres of water per square metre. With the mixture of air and water vapour irrigated tomatoes needed half this amount. This shows the high degree of efficiency of the irrigation system. Figure 6 shows a young tomato plant between the condensation tubes. The picture in figure 7 was taken after 8 weeks and figure 8 and 9 show the plants after 12 weeks.

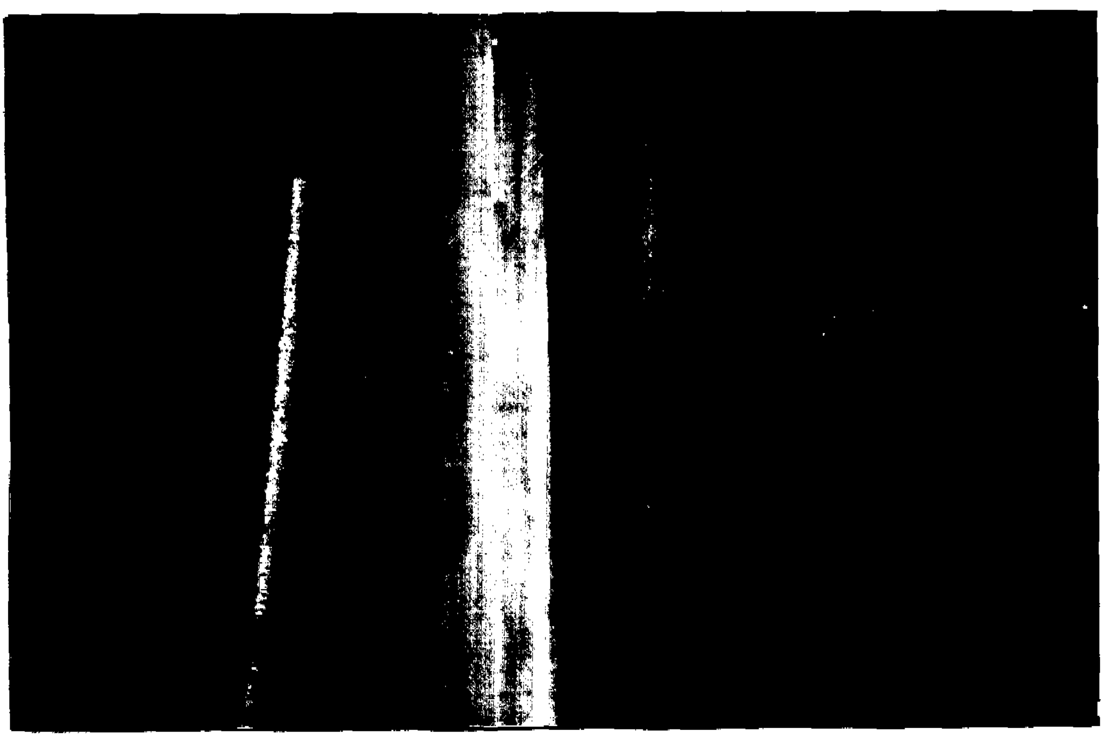


Fig. 5: Condensation tubes in the root space of the plants

(On the right the damp border of the pilot plant is seen)

Fig. 6: Young tomato plant between the condensation tubes

Fig. 7: Tomato plants after 8 weeks

(The greenhouse was built to protect the pilot plant from rainwater)

Fig. 8 and 9: Tomato plants after 12 weeks

7. Development: 1985 to 1989

1985: Principal experiment

Evaporator: Tubes of polyethylene; solar
Condensor: Tubes of polyethylene; water cooling

Fig. 10: Principal experiment 1985

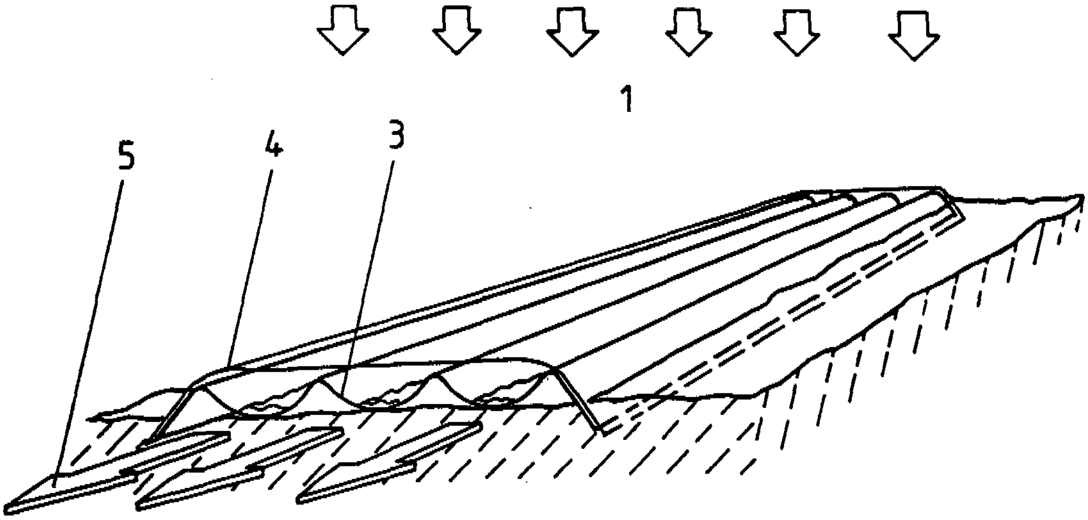
1986/87: Design, constraction and operation of a pilot plant

Evaporator: Tubes of polyethylene; solar
Condensor: Subterranean drains tubes
Energy for pumps
and ventilators: Solar generator

Fig. 11: Pilot plant: Cultivation of tomatoes (Summer 1987)

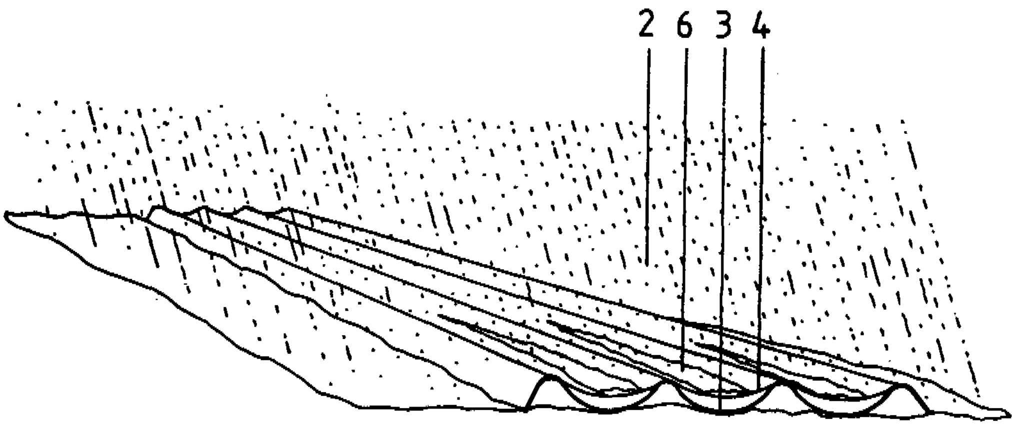
1988: Development of the evaporator

Features: Polyethylene absorber with
ultra violet protected foil
Water collector for rain



1 Solar energy input
3 Polyethylene absorber
4 Ultra violet protected foil
5 Flow of salt water and
mixture of air and water vapour

Fig. 12: Evaporator 1988



2 Rain
3 Polyethylene absorber
4 Ultra violet protected foil
6 Collected rain water

Fig. 13: Evaporator 88 in function as a rain water collector
(The fall leads the water directly to the plants)

1988: Measurements in Diepoldsau (Switzerland)

Measurement of efficency (evaporator and condensor) by variation of salt water and air flow

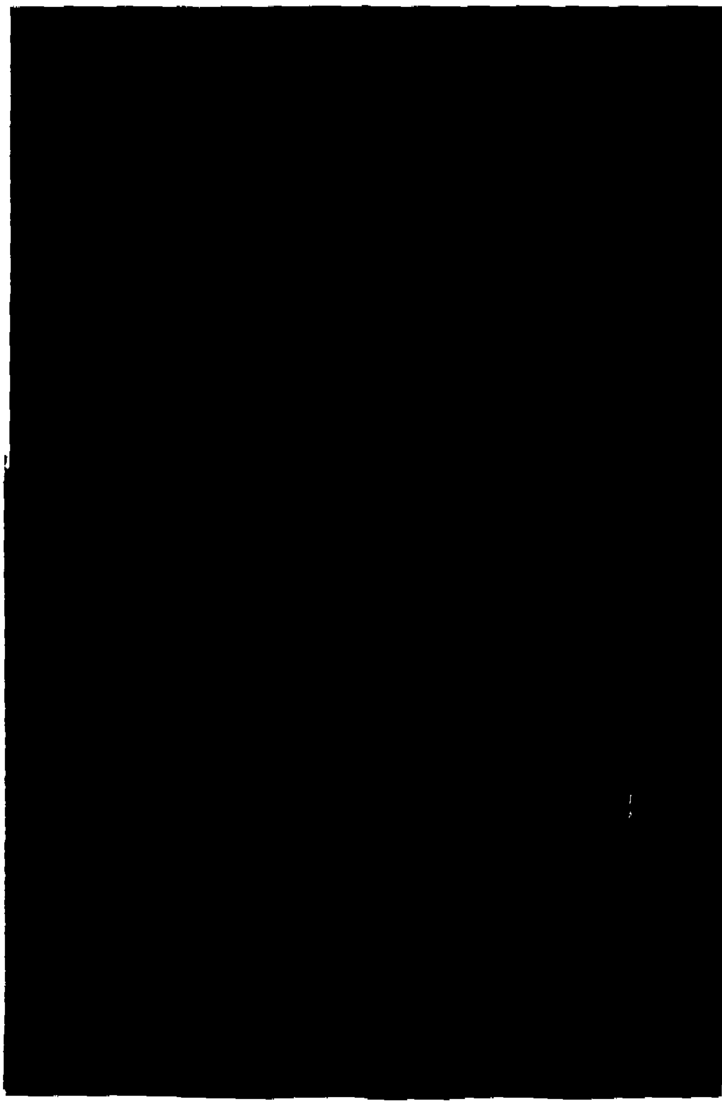


Fig. 14: Evaporator in operation (Summer 1988)

1988/89: Model of a sea water desalination and irrigation plant

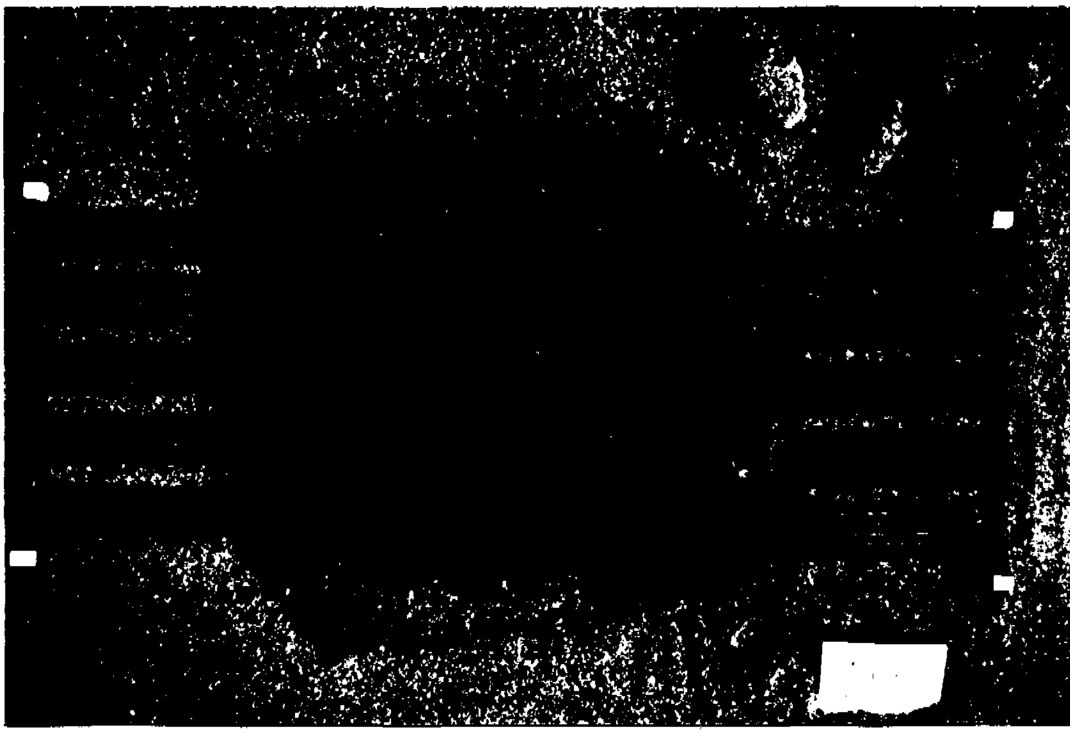
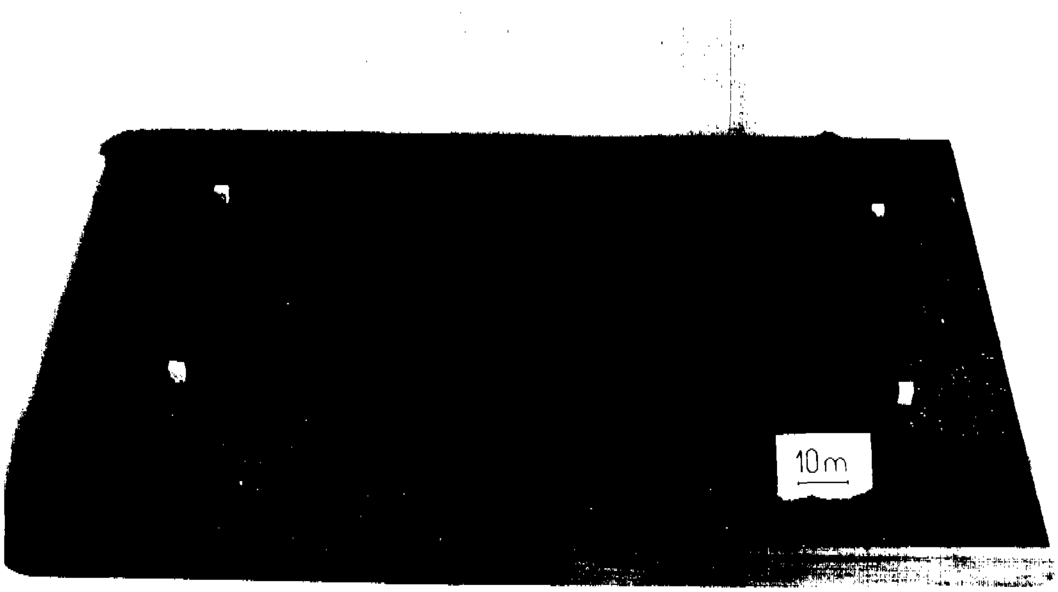


Fig. 15 and Fig. 16: Model of a sea water desalination and irrigation plant



8. Costs

Subterranean irrigation with condensing water vapour is more effective than either sprinkler or drop irrigation. The plants need the most water at high temperatures and with strong sun radiation (also with less humidity, wind,....). With these conditions the desalination and irrigation process has the best efficency and produces the most destillate. Plants search for the water sources and build their roots around the condensor. As the pilot plant 1986 and 87 has shown they needed the half of the water quantity expected. Therefore the water consumation is very low when compared to the amount needed with traditional irrigation plants. Additionally the quality of the destillate was high. We could not measure salt ions.

The large surface of the evaporators has one further advantage. During rain the evaporators act as water collectors (Fig. 13) and lead the water directly to the plants. The condensors act as a drainage system and lead off the excess rain water.

The quantity of destillate, costs for engineering and planning, material and energy are based on the plant measured in Switzerland (1988). Two sizes of plants are recorded.

Cultivation area:		600 m2	3000 m2
(Depends on climate and plants)			
Investment:			
Engineering, planning and material	sFr.	23 500.--	96 000.--
Annual energy costs:			
For pumps and ventilators	sFr.	290.--	1 450.--
(1 kWh à sFr. -.10)			

CONOMY: SEA WATER DESALINATION AND IRRIGATION
WITH MOIST AIR

ROJECT: OASE

ATE :21 th MARCH 1989

METHOD : ANNUAL SUM OF CASH

		VAR:	A	B	C
NPUT:					
Ko	Investment	[sFr]	-96000	-96000	-96000
	Period using < 30 years		10	10	10
1	Profit of harvest / yea	[sFr]	54000	58800	66000
2	Running expense (salary farmer, energy)	[sFr]	-20000	-20000	-20000
	Rate of interest	[%]	7-----------	-----------	-----------
	Rate of price increases (harvest)	[%]	0-----------	-----------	-----------
	Rate of price increases (running expense)	[%]	5-----------	-----------	-----------

EMARKS, CONDITIONS:				
rea:	[m2]	3000-----------	-----------	-----------
Cultivation:		Tomatos	Paprika	Aubergine
arvest / m2 and year	[kg]	12	7	11
rice / kg	[sFr]	1.5	2.8	2
E2: Annual costs for energy	[sFr]	-1450-----------	-----------	-----------

ar C: Amortisazation after 3 years