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Distillateurs de petite et de grande dimension

PRESENT STATUS AND FUTURE OF THE SOLAR STILLS

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SUMMARY

PRESENT STATUS AND FUTURE OF THE SOLAR STILLS

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In the past ten years the problem of developing solar stills has received great attention by part of many workers. A list is given of the laboratories and groups more actively engaged in such studies and an outline is also given of the main goals of such research and of the scientific and technical lines followed at present.

The experience gained with the solar stills so far tried has given interesting information which is useful for the evaluation of the economics of the system and for the design of future models.

Some emphasis is given to the work carried in the Istituto di Merceologia of the Universities of Bologna and Bari, Italy. Seven different models of solar stills have been built and tested and the results are tabulated and the observed drawbacks are indicated.

The present knowledge permits us to state that the solar stills cannot give fresh water for a great number of persons because of the very great surface necessary to obtain appreciable amounts of water and of the very high plant cost.

Little and transportable solar stills may be built and distributed in arid zones in order to give fresh water to one or few persons. Such stills might also be mass-produced.

Solar stills could also be built as structural elements on the roof of the houses or of little buildings, so giving fresh water to the inhabitants.

Some other improvement anyway can be obtained through new research, both on the thermodynamics of the system and on the use of new models and of new construction materials.

PRESENT STATUS AND FUTURE OF THE SOLAR STILLS

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1. Present diffusion of the studies on solar stills.

The solar stills, used for the first time in Chile at the end of the last century in the only large scale plant so far built (1), received a renewed interest around 1930 (2) (3) (4) but became a subject of systematic studies only during the Second World War in the United States by part of Telkes (5).

Dr. Telkes studied the fundamental elements of the thermodynamics of the system and this gave a basis for her own and for the next developments.

After 1950 the studies on solar stills spread greatly in various countries and this was undoubtedly due also to the publicity given by the Office of Saline Water of the U.S. Department of the Interior to the general problem of the demineralization of saline waters.

The results of many workers have been publicized through the Annual Reports and the Research and Development Progress Reports of the Office of Saline Water (6); such Office has also organized a Symposium in Washington, D.C., U.S.A., in November 1957 (7).

At knowledge of the writer the following groups have recently been, or are at the present, engaged in the development of solar stills. The name of the principal investigators is also indicated.

- New York University, Solar Laboratory, New York, N.Y., U.S.A. (Maria Telkes) (5) (8) (9) (10) (11) (12) (13)
- University of California, Richmond, Cal., U.S.A. (E. D. Howe) (14) (15) (16) (17)
- Du Pont de Nemours and Co. Inc. at Daytona Beach, Florida, U.S.A.
- University of Wisconsin, Solar Energy Laboratory, Madison, Wisconsin, U.S.A. (J. A. Duffie)
- Bjorksten Research Laboratories Inc., Madison, Wisconsin, U.S.A. (Risto P. Lappala) (18) (19)
- Denver, Colorado, U.S.A. (George O. G. Löf) (20) (21) (22)
- Centre Etudes Hydrogeologiques du Maroc, Rabat, Morocco (R. Ambroggi) (23)
- Comision Nacional de Energias Especiales, Madrid, Spain (L. Fontan) (24)
- SETUDE, Algiers, Algeria (Cyril Gomella) (25) (26) (27)
- Università di Bari, Istituto di Merceologia, Bari, Italia (Giorgio Nebbia)

- Kyrenia, Cyprus (R. Fitzmaurice) (28)
- Israel Scientific Research Council
- Kenya Ministry of Works, Nairobi, Kenya (Gordon T. W. Blake)
- Egypt, Cairo University and Alexandria University
- Teheran, Iran, Lichtfield, Whiting, Panero, Severud and Associates Cons. Engrs. (Tim de Jong) (29)
- Soviet Union, Energetichskii Institut, Akademiya Nauk, Moscow, S. S. S. R. (V. A. Baum and P. M. Brdlik) (30)
- C.S.I.R.O., Division of Industrial Chemistry, Melbourne, Australia (B. W. Wilson) (31)

The few literature references have been chosen for their character of review of the work of the various groups.

The main purpose of the above groups is (a) to develop new models of solar stills in order to increase the water production per surface unit, (b) to check the use of new construction materials in order to lower the cost of the stills and (c) to study the applicability of solar stills for the production of large amounts of fresh water.

Almost all the present models present a collecting surface of a fraction of one or of a few sq. meters but their development and observation have given an enormous amount of information of great utility for further developments.

At the knowledge of the writer there are two thermodynamic treatments of the efficiency of the solar stills, one developed by Telkes (5) (11) and one outlined by Brdlik (30). These treatments are of great interest although perhaps the complete knowledge of the phenomena related to the working of a solar still requires further refinements on the basis of experimental data.

An excellent review of the various models of the solar stills is contained in one report by Löf (20).

In general the work of the above listed groups proceeds along few common lines:

(a) the testing of solar stills of the roof-type model, varying details of design and the construction materials both for the water tray and the rigid roof; usually in these models the tray contains a thin layer of saline water and the bottom of the tray is insulated.

(b) the development and testing of plastic film stills, especially of inflatable type, using newly developed plastic materials (films of Mylar, Teflon and Teslar) which are rendered wettable with various processes (32).

(c) the development of tilted flat stills, both with rigid glass cover (11) (12) (13) and with plastic film cover (18) (19); in such stills the water is absorbed by a black porous evaporator which allows to keep the water layer perpendicular to the solar radiation; the amount of solar heat which reaches the water is so maximum.

d) the development of deep basin solar stills proposed by Löf. In such stills a great amount of water (a layer of 30 cm. and more) is heated by solar energy within a roof-type solar still placed in the ground; the water heats the surrounding ground until it reaches a rather constant temperature greater than the external one, and begins and continues the distillation, day and night (22).

2. The work on the solar stills at the Università di Bari

In the present paper some emphasis will be given to the work of the writer who became interested in the field in 1953. The experimental work has been carried in the Universities of Bologna and Bari, Italy, and was supported financially by various organizations (33).

During the spring and summer 1953 three units were assembled; each was a roof-type model of solar still built using different construction materials.

The main characteristics of these stills and of those built in the following years are collected in Table 1. Fig. I shows photographs of the same stills.

The first model (Fig. I, No. 1) was an all-plexiglas box, with a tray surface of 0.16 sq. meters, uninsulated, and distilled some hundreds ml. of water per day. With this unit the first difficulties in assembling the plexiglas plates were encountered and also the drop condensation on the plastic surface of the condensing area was met.

The model No. 2 was glass-and-wood, appeared heavy and of low efficiency; better results were obtained with the model No. 3 which combined the easy assembly of plexiglas with a glass wettable condensing surface, mounted in a plexiglas frame (34) (35).

In the next months, between 1953 and 1954, an investigation was carried on the fresh water needs in many sites in Southern Italy and in a few sites abroad and very interesting information was collected (36) (37).

It is the opinion of the writer that a world-wide investigation of the market for solar stills - and, in general, for the equipment using the solar energy - is not still available and should be very useful.

In 1954 a new series of solar stills was built according to a new model (No. 4) with iron tray and frame and glass roof. The three units so prepared were very simple to manufacture and assemble and rather efficient but very heavy (36) (37).

The next No. 5 model was developed in 1955 (38) in order to study the possibility of adapting the solar stills on the roof of houses. Such units, with 10 sq. meter trays, gave a rather low yield of fresh water and this was caused by an insufficient insulation of the bottom of the water tray and by a re-evaporation of the distilled water in the collecting channel which had an insufficient inclination.

All the above models presented a roof inclination of about 45° and the experience of other workers has shown that better results are obtained when such inclination is lowered up to 10° (25).

In 1957 a plexiglas tubular solar still (Model No. 6) was tested. It was similar to other stills tested by Howe (15) (16) (17) and Fitzmaurice (28) and gave very satisfactory results (39) (40). This solution seems one of the best, for simplicity and efficiency.

In 1958 the last model (No. 7) of this series was built. It was a vertical structure still designed for temperate zones with a high water yield for surface unit of occupied ground and a very good insulation of the four trays placed one above the other in a glass cage. As in the Model No. 6 all the external surfaces are condensing ones.

The results obtained with this unit were very interesting and showed that it was possible to obtain appreciable amounts of water also in the months in which the inclination of the sun is low, recovering very high percentages of the low intensity solar energy available in such months.

At the present the experimental work is developing in the field of multiple effect plastic framed solar stills.

3. Future of the solar stills.

A critical survey of the present knowledge in this field shows that the present models, although very ingenious, all suffer from the same drawback; that the amount of water produced is little and appreciable amounts of water are available only with very large, and complicated and expensive units.

The amount of distilled water practically varies in the range from 2 to 5 liters/(sq. meter) day) in the clear days in the simple-effect stills, up to perhaps 10 to 15 liters (sq. meter) (day) in the multiple effect stills of best design, which must still be developed and thoroughly tested.

At present the best models require about 200 sq. meters of tray surface to give one cubic meter of fresh water per day.

The cost of the solar stills (not considering the cost of the ground) per surface unit is still high also in the cheapest models. Such cost is hardly lower than U.S. $ 20 per sq. meter of tray area. The solar stills present the only advanage that the operation and maintainance costs are very low and that the only large expense concerns the building of the unit or of the plant.

The present experience shows that, although the solar stills may not solve the problem of obtaining fresh water on a large scale, e.g. for the needs of a town, they can solve various very important individual problems in arid zones and they remain one of the most interesting, easy and efficient systems for the utilization of solar energy.

With this picture in mind one may consider the possibility also of a mass production of little solar stills to be installed in deserts or in arid zones in order to give fresh water to one or very few persons in emergency conditions.

Along this line it is very interesting the work made in Algeria by Gomella (27) who has developed solar still units with the cement tray and with a low inclination glass cover.

Another approach to the problem is to use the solar stills as structural elements in the buildings in arid zones, arranged on the roofs of the houses. The salt water is charged or pumped in the trays every 2 or 4 days and the fresh water flows by gravity in the collection tank inside the house and under the roof. The concrete solar still developed by the writer in 1955 was designed with this purpose and its operation has suggested various improvements (38).

If the distilled water is to be used for drinking purposes it is necessary to consider the need of adding salts, possibly by mixing with a part of the saline water, and of aeration.

Anyway the problem of the knowledge of solar stills is by no means closed. The literature reports many design of developments of the present models and some new design.

Some improvements may be expected by a more extensive testing of multiple effect solar stills, which so far have been tested only on a limited scale by a few workers (11) (43).

It has been reported (11) that a three-effect unit may give an amount of water double that of the single-effect unit.

Another project considers the possibility of heating the water within pipes exposed to the solar radiation, condensing the vapor in a conventional multiple effect still. This idea had already been quoted in a review by Löf (20) and appears studied also by Soviet workers (30). A detailed calculation of the efficiency of this design has appeared in the literature (44).

The knowledge gained in the experiments carried in the past 10 years on solar stills permits to consider the maturity of the development and the practical applicability of these apparatus, with the limitations outlined above.

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TABLE 1. Characteristics of the seven models of solar stills developed and tested in the Universities of Bologna and Bari, Italy, after 1953.

Model No.	Construction material		Insulation	Tray surface sq.meters	Maximum water production liters/(sq.meters)(day)	Approximate cost of the experimental unit in U.S. dollars per sq.meter	Ref.
	Water tray	Transparent roof					
1 1953	plexiglas	plexiglas	None	0.16	-	-	-
2 1953	wood	glass	cork	2.5	3	60	(34)(35)
3 1953	plexiglas	glass	cork	0.25	4	50	(34)(35)
4 1954 3 units	iron plate	glass	compressed cellulose fibers	1.5 and 3	3	50	(36)(37)
5 1955	concrete	glass	pumice	10	2.5	50	(38)
6 1957	aluminum plate	plexiglas tubular	inner hot air	0.33	4 (a)	40	(39)(40)
7 1958	aluminum plate	glass	inner hot air	1.08 (b)	3.5 (c)	40	(41)(42)

(a) The data of the amount of distilled water have been correlated with solar energy measurements and an efficiency of about 40 % was recorded.

(b) Four trays 0.27 sq.meters each, assembled one above the other within a glass cage.

(c) The data of the amount of distilled water have been correlated with solar energy measurements and an efficiency varying between 25 and 45 % was recorded, according to the inclination of the sun.

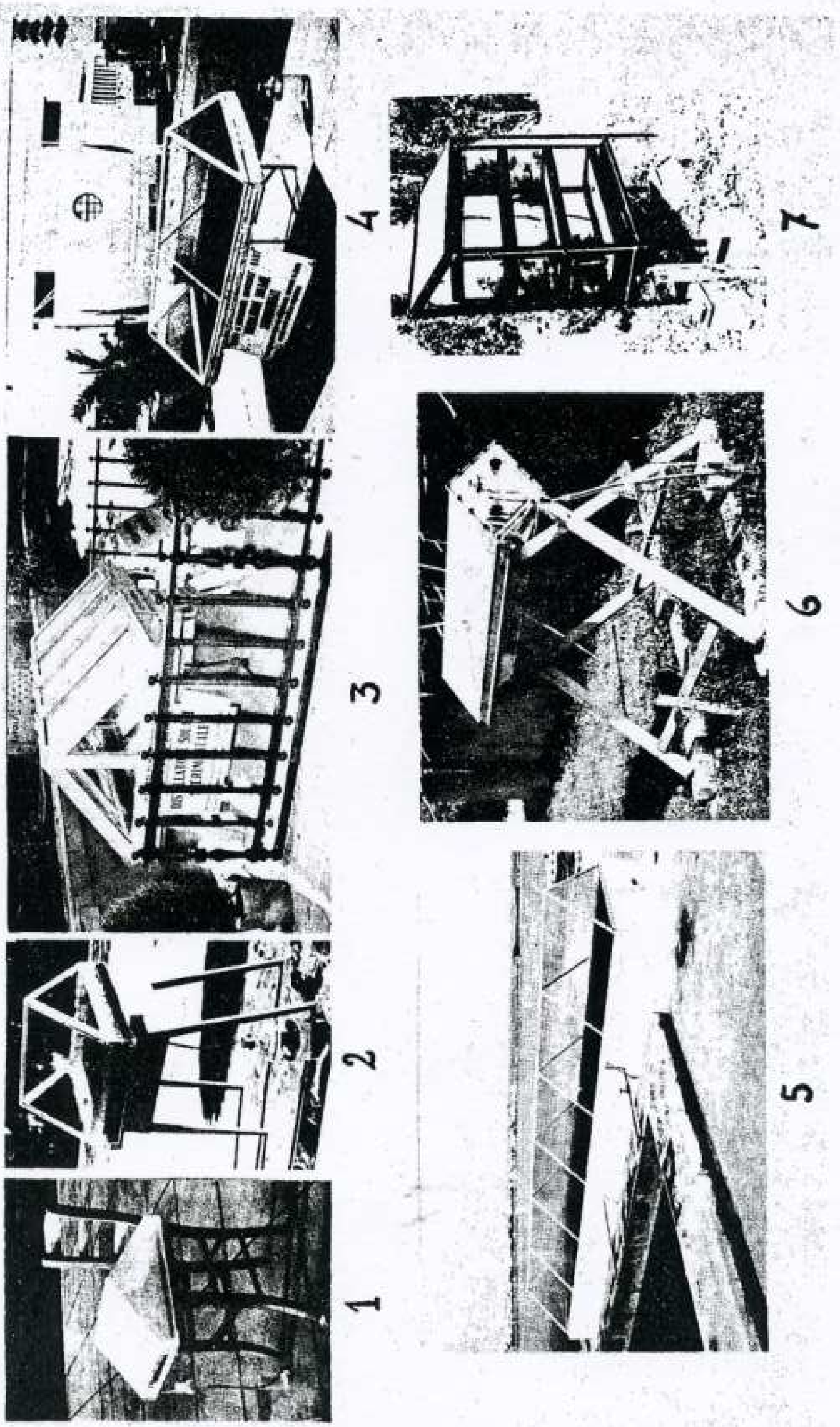

Figure I. Photographs of the seven models of solar stills developed and tested in the Universities of Bologna and Bari, Italy, starting from 1953.