DESIGN, CONSTRUCTION AND EXPERIMENTAL STUDY OF A DOMESTIC SOLAR OVEN CUM DRIER IN THE CLIMATE OF COSTA RICA.

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ABSTRACT

The two solar devices- Solar oven and Solar Drier have been integrated into a single device: Solar Oven cum Drier (SOD) with the objective that the integrated device can be used for around 11 months in a year either for cooking or drying domestic vegetables and spices etc., instead of only 7-8 months only for cooking.

The device have been studied in different modes and in different climates. In brief the maximum plate temperature could reach up to 136 °C (without any load), 115 °C (with 4 lts of water) and 90°C when 1.7 Kg of meat was used for drying purpose.

INTRODUCTION

The necessity of the use of Solar Cookers in order to reduce the consumption of firewood, especially in the developing countries including Costa Rica is well recognised by various institutions and international organizations. Inspite of various efforts made, the widespread of solar cookers have not become possible due to various limitations including the impossibility of using during the period lacking sufficient sunshine, needed for cooking. According to author's opinion, if the use of same solar cooker could be prolonged for few more months to be used for some other purposes which doesn't require high solar intensity, like water heating or drying of domestic agricultural and other products, definitively more people would like to use the same.

With this objective one of the author (SSN) who has worked for last fourteen years on varios types of hot box type solar cookers [1, 2], have designed recently one Solar Oven cum Water Heater and one Solar Oven integrated with Drier. The results on Solar Oven cum water heater were reported in Honduras Conference [3] and in this paper we will be reporting some results related to Solar Oven cum Drier.

CONSTRUCTION

FIGURE 1a shows the schematic drawing of Solar Oven cum Drier and FIGURE 2 shows the same device in two different modes- in the drier (a) and oven (b) mode. As can be seen, it is a conventional hot box solar oven with galvanised iron plate (1) painted black, as an absorbing surface and two normal window glasses as covers, separated by a distance of 2 cms (4) and one reflector (11), but has 11 holes in front (5) of the oven for the entrance of ambient air as well as another holes at the back (9) of the oven for the

the exit of humid air.

To control qualitatively the flow of air, any number of holes could be closed on both sides and rest remained open. Further more when required drying, instead of cooking utensils (3), some trays (6) are kept on the top of the metallic rods (using some simple supports (7) where the products to be dried are placed. The angle of the reflector can be varied using a metalic strip (12) with various holes. To introduce the food to be cooked or products to be dried there ia a door (10) at the back of the device. The whole box has a glasswool insulation on the four sides (8) and below the metallic plate (2). Photos 3 shows the actual device in the dryer (a) and in oven (b) mode.

FUNCTIONING

To use the device as a solar oven (Fig. 2b), all the 22 holes are closed tightly and the rest of the process is same,whereas to use it as a solar drier, during day all the holes are opened and after the sun set (or during rainy period) the holes are closed so that the ambient humid air should not enter in the drier. The rest of the process is similar to conventional solar drier.

EXPERIMENTAL STUDY

Four types of experiments have been performed, for last six months with this device SOD:

- as an Oven but without load (A),
- as an Oven with different quantities of water as a cooking load (B),
- as an Oven with different quantities of actual food as a cooking load (C) and
- as a dryer for drying meat, cauliflower, onion and turmeric (D).

Due to the limitation of the space part of the results will be reported, however the detailed results will be published in another journal. In all the experiments the oven was oriented toward sun every 2-3 hours but the reflector was fixed always at 105 °C. Global solar intensity was measured every 15-30 minutes with portable solar meter as well as with Eppley pyronameter. It is worth mentioning that in the case of study as a drier, for the time being only the quantity and not the quality of the dried products was studied.

(A) AS AN OVEN WITHOUT LOAD:

The experiment was performed on May 4 and 5, 1993. Data measured on May 5, indicate that , the plate temperature was above 100 °C during 4 hours (10 am- 2 pm). On May 4, the partially sunny day, the maximum plate temperature reached up to 103 °C and only during 15 minutes the plate temperature was above 100 °C. This indicate that the foods can be cooked on 5th May whereas it will be partially cooked on May 4. In that case it can be used perfectly for drying different products.

(B) AS AN OVEN, WITH WATER AS A LOAD:

Two to four lts. of water was heated in SOD, in various aluminium utensils. To measure the water temperature, thermowell

system was made on the side of one of the metallic utensil (painted black outside) and a stem dial thermometer was inserted in the water.

The measurements made on May 19, 1993 with four liters of water in 3 metallic black painted aluminium pots indicated that the maximum plate temperature was observed between 100- 106°C. In another experiment performed on May 6, 1993 with better climate, with 2 lts. of water, the plate attained a maximum temperature of 134 °C whereas the water was heated to 96 °C.

(C) AS AN OVEN, WITH ACTUAL COOKING:

In this set of experiments various quantities of food have been prepared and water have been purified. We would like to inform the cooking experiment performed on July 29, 1993. The solar device in the oven mode (all the holes closed) was already exposed to the sun (glass covers not covered) since previous day, so that it could be preheated. At 9 am when the proper experiment was planned, the plate already had attained a temperature of 95 °C, and the oven air temperature was 75°C. At 0905 hr in a Microwave (MW) oven glass, we put 500 ml of water with a cover and a stem dial thermometer. In another utensil of stainless steel, painted black outside, 250 g of grams (chick- pea) soaked in 600 gms of water (previous night) and proper condiments was added (total weight 1300 gms). Both the glass and gram pot were put in the SOD. At 1030 hr the water in the MW glass reached at 69 °C , indicating that the water is already purified (pasteurization of water takes place at 63 °C). At 1030 hr in another stainless steel box, 500 g of meat pieces and 100 gm of potatos alongwith various spices (without extra water and and oil) were put in the solar device. At this time plate temperature already reached to 111 °C. At 1115 hr in another aluminium utensil we put 580 gms of potatos and added condiments (total weight= 800 gms), and the utensil was kept inside the oven. At 1145 hr the 220 gms of hot water from the MW oven glass was added with 160 gms of rice in another aluminium utensil and kept in the oven (total weight 760 gms). The wind velocity was very high. The oven at this moment had 4 items to be cooked. FIGURE 4 shows the plate, water/ food and ambient temperaturea alongwith solar radiation, measured on this day. The maximum plate reached to 114°C and the water temperature reached 89°C. At 14 hr all the items were taken out. Except grams all other items were cooked, whereas grams were cooked almost to 90 percent. The total weight of the cooked meal was 2050 gms and was 3675 gms including utensils. On other day on 27th July, due to low solar intensity the foods were partially cooked, but it would have dried agricultural products.

(D) AS AN OVEN, WITH ACTUAL DRYING:

Finally the device was used as a Solar Drier; that mean all the 22 holes were opened during the day. Onions, meat, cauliflower and turmeric were dried. In the experiment with fresh turmeric (freshly harvested) after being washed and firstly dried inside the room; during August 3- 7, 1993, two kilos of turmeric were distributed equally in 4 trays and were kept inside the SOD at 12 hr on 3rd August. At the same time equal quantity of turmeric (distributed again in 4 trays) were placed outside the solar drier to make the comparision. The inside air temperature, and

temperature of the products in one tray was measured each 30- 60 minutes. Also every 3-4 hours the weight of the products in one tray were measured, from inside and outside the oven. At 5 pm the final weight of the products was found to be 465.8 and 439 gms for products kept outside and inside the oven. As the products were not completely dried it was planned to continue the process for next day. At 5 pm the oven was covered and the holes were closed so that the humid air should not enter in the oven. The trays kept outside the ovens were taken inside the office and covered so as not to receive air humidity. Next day experiments was started at 9 am, again the holes were opened. The experiment was continued for next two days. FIGURE 5 shows the weight of the product, dried inside and outside the SOD, alongwith the solar radiation. It can be seen clearly that after 28 hours of operation, the quantity of the product was 147 gms and 378 g dried inside and outside respectively. In other words the turmeric lost 70.6% and 24.4% of the humidity in two cases. It is worth mentioning that the air temperature inside the oven was varying between 40- 73 °C.

CONCLUSION

Based on our experience with the climate at our specific place and the temperature requirements for cooking and drying of domestic products like vegetables and spices etc., it can be assured that this combined device SOD can be used for 10-11 months in a year as compared to 7-8 months if used only for cooking purpose.

In addition to all the advantages of the device as a solar oven, the device can be used in the house for drying the various products so that these can be stored for more period. Furthermore this can save sufficient conventional fuels for the family and for the country as well can help in maintaining the environment more cleaner.

ACKNOWLEDGEMENT

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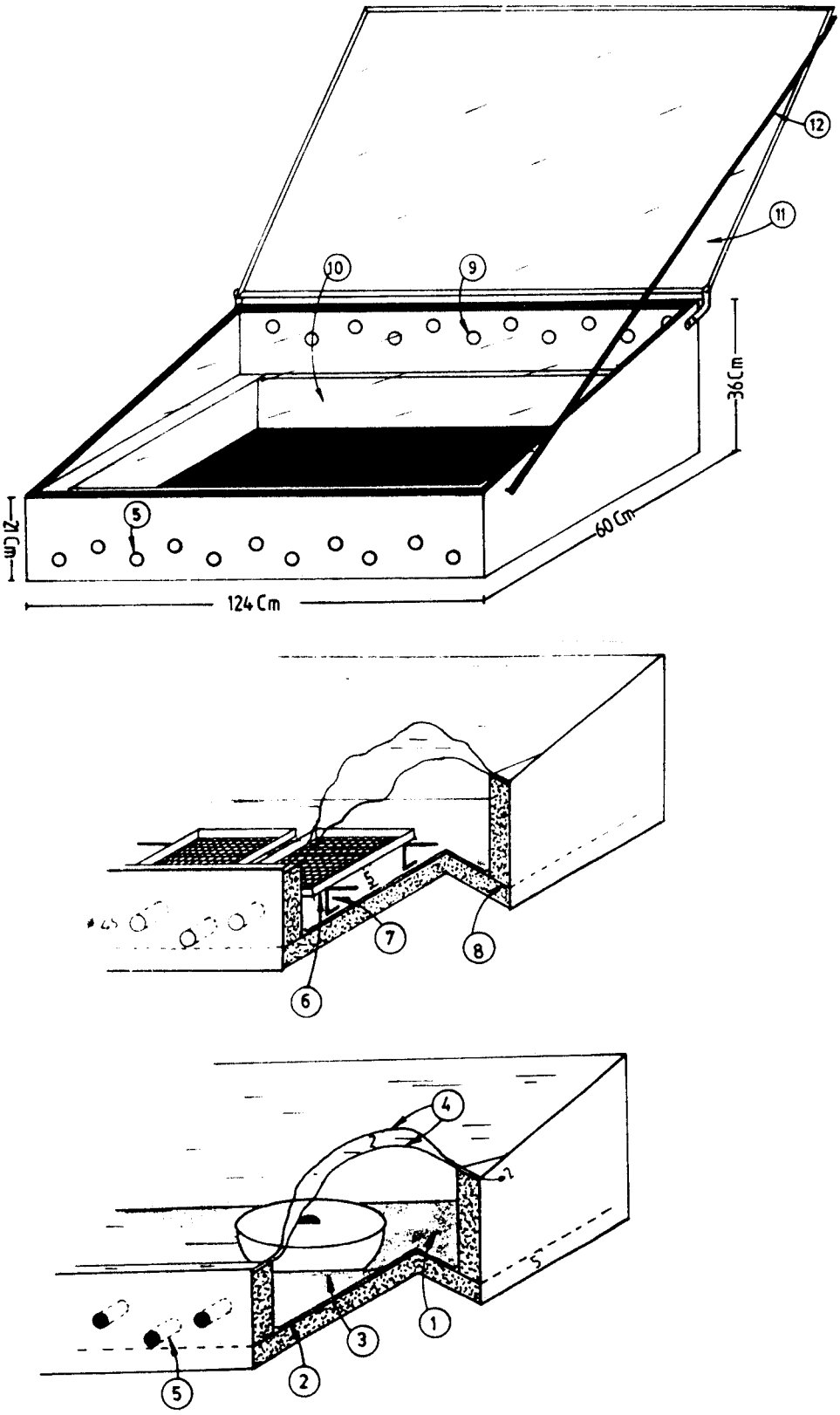


FIGURE 1. SCHEMATIC SCHEME OF SOLAR OVEN CUM DRIER.

FIGURE 2. SOLAR DEVICE IN THE MODE OF DRIER (A) AND COOKER (B). THE COMPONENTS ARE EXPLAINED IN THE TEXT.

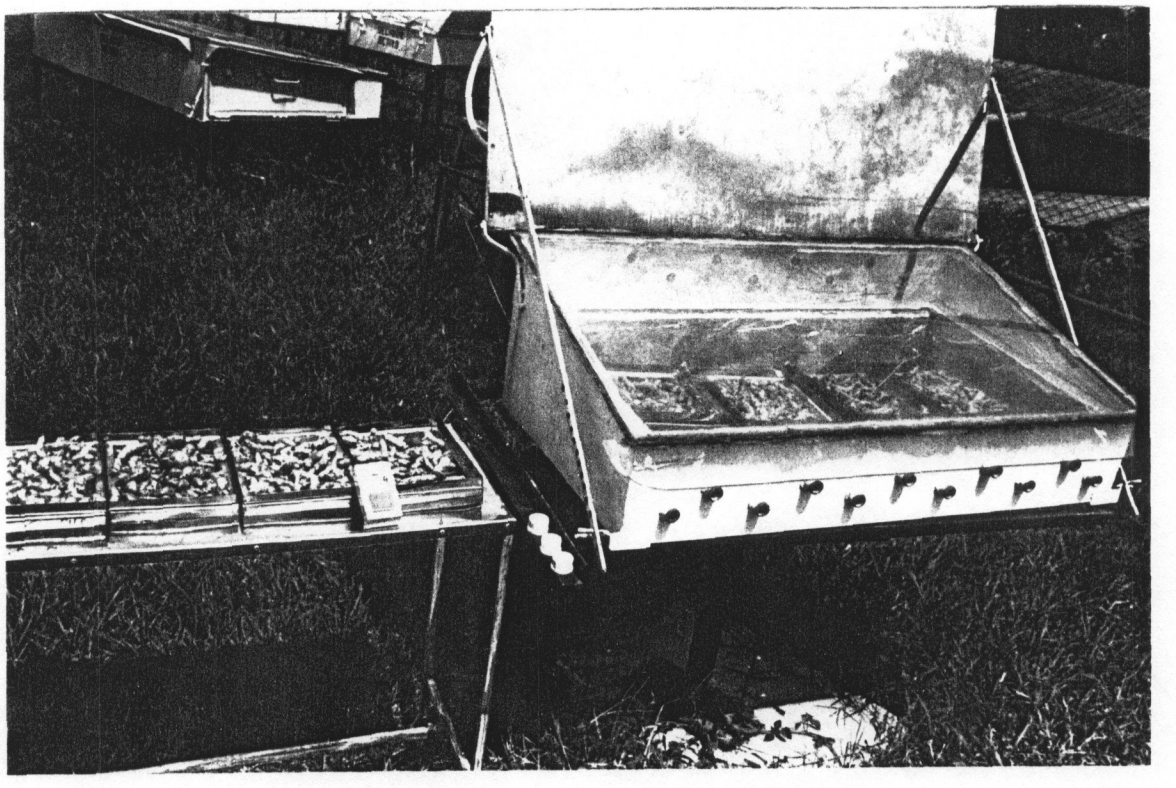
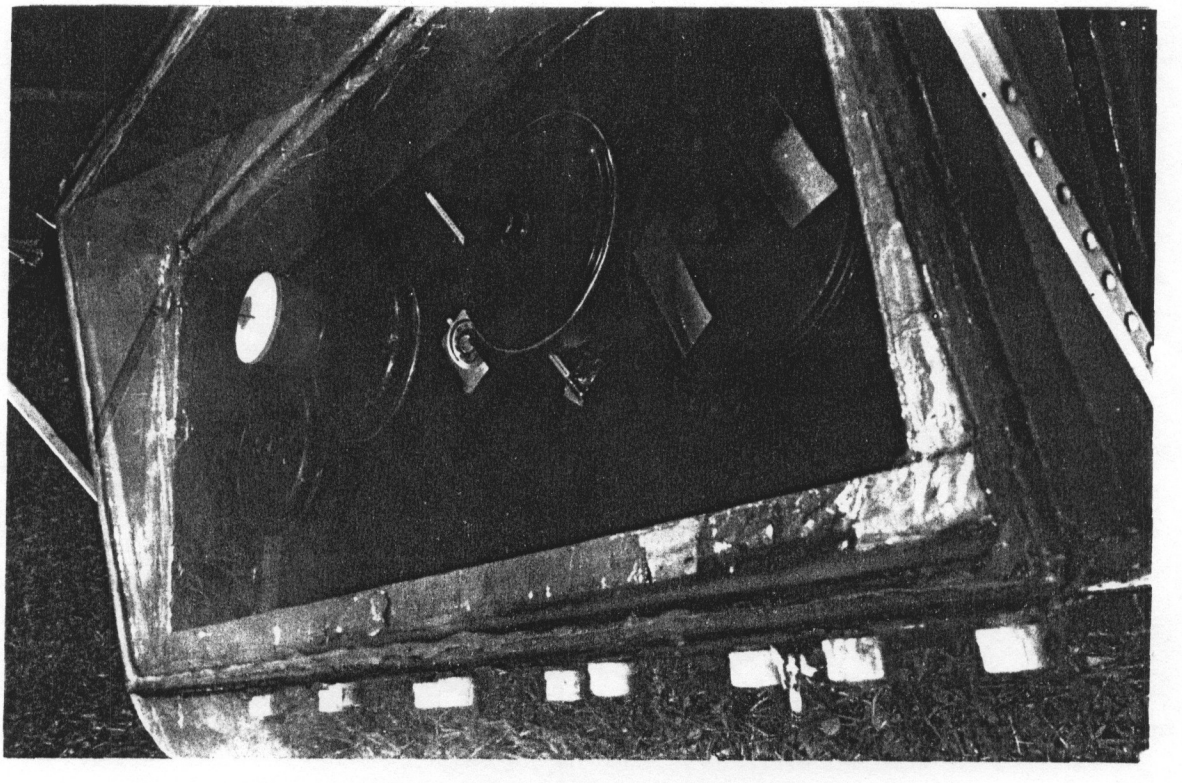


FIGURE 3. ACTUAL SOLAR OVEN CUM DRIER IN THE MODE OF DRIER (A) AND COOKER (B)



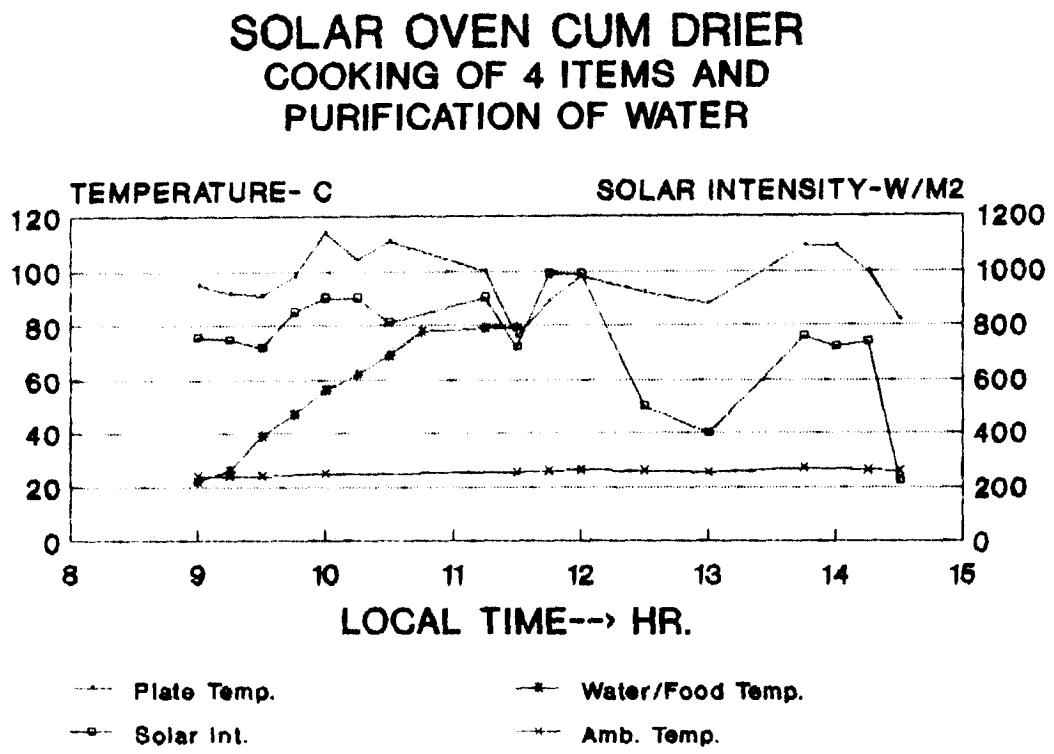


Figure 4.
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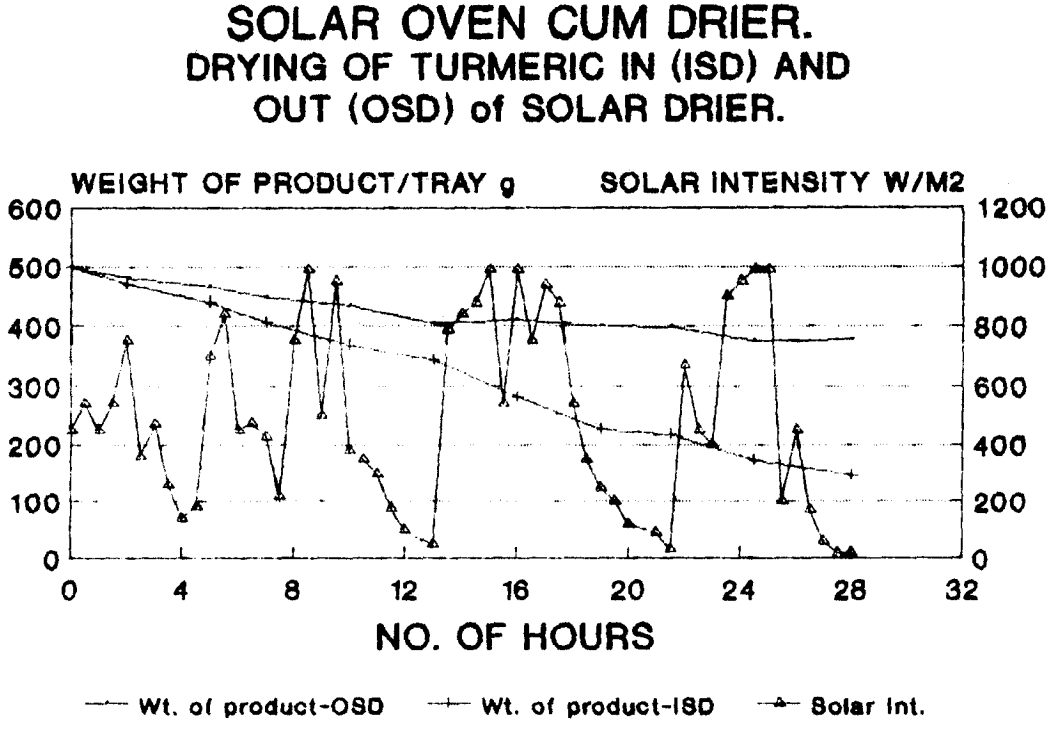

Figure 5.
Expt. was started at 12 hr of Aug.3.
3-6 Aug. 1993. cs03893a.cht