PN-ABD-197

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August 8, 1989

Mr. Alberto Sabadell
Deputy Director--Office of Energy
S&T/EY, Room 520, SA-18
Agency for Internat'l Development
Washington, D.C. 20523

Dear Mr. Sabadell:

Energy Concepts Company is pleased to forward the enclosed Progress Report (3 copies) entitled "Intermittent Solar Ammonia Absorption Cycle (ISAAC) Refrigeration for Lesser Developed Countries." This report is the second semi-annual account of work accomplished on PSTC Grant No. DPE-5542-G-SS-8035-00 (PSTC #6.454).

One ISAAC unit is now successfully operating in Bangkok, Thailand, at the facilities of Pan Siam Engineering, the LDC collaborator. A second one will be set up and tested at a remote user site in Thailand during the next reporting period. The LDC collaborators will monitor and report on the operation of this unit.

All project funds have now been expended. Much important future work has been identified. There is an urgent need for approximately $300,000 of additional funding in order to disseminate this highly beneficial technology to needy areas of the world, as detailed in the progress report.

Yours very truly,

Donald C Erickson

Donald C. Erickson
President, Energy Concepts Co.

Enclosures: 1. Subject report
2. U.S. Patent Application No. 351950

cc: AID Science Advisor (1); AID PPC/CDIE (2); Pan Siam Engineering (1); PATH Bangkok (1); PATH Seattle (1); WHO Geneva (1); Oak Ridge Associated Universities (1)

PROGRESS REPORT

INTERMITTENT SOLAR AMMONIA ABSORPTION CYCLE (ISAAC) REFRIGERATION FOR LESSER DEVELOPED COUNTRIES

PSTC 6.454

Period Covered: March 1989 - July 1989

By: Energy Concepts Co.
627 Ridgely Avenue
Annapolis Md 21401

Principal Investigator: Donald C. Erickson

August 3, 1989

I. INTRODUCTION

This report is the second report of progress accomplished on the project "Intermittent Solar Ammonia Absorption Cycle (ISAAC) Refrigeration for Lesser Developed Countries." The work is sponsored by the Agency for International Development, Program for Science and Technology Cooperation (PSTC No. 6.454, Grant No. DPE-5542-G-SS-8035-00). The Project Officer is Mr. Alberto Sabadell. The objective of this research project is to develop and demonstrate a solar-powered ice-maker suitable for manufacture and use in lesser developed countries (LDCs). The ice-maker is to be simple, reliable, use low cost materials, and not require advanced maintenance or manufacturing skills. The ISAAC ice-maker is based on an existing Energy Concepts design which is described in U.S. Patent 4,744,224. The LDC collaborator on this research project is Mr. S. Boon Rieb, President of Pan Siam Engineering, Bangkok, Thailand. In addition, the World Health Organization and PATH (Program for Appropriate Technology in Health) are participating in the field test and technology transfer activities.

II. OVERVIEW OF PROGRESS

During this reporting period the basic ISAAC design was finalized and a prototype was constructed and shipped to Bangkok, Thailand, where it has been assembled and is currently undergoing testing.

The current design now meets all initial project goals in regard to cost, performance, ease of manufacture, and reliability

of operation. However, additional development effort is called for in several areas, as detailed later in this report. Objectives of further development work include:

1) further reduction in cost by at least a factor of two;
2) a more user-friendly cold box design, including a constant temperature chill box;
3) a constant temperature freeze compartment; and
4) a range of sizes/ice-making capacities.

The remaining work under the current contract comprises transporting the Bangkok unit to a remote health clinic in Thailand, and test-operating it there under actual field conditions.

All the AID contract funds have now been expended. Energy Concepts is presently continuing the work under internal financing. In view of the importance of both the current effort and the needed additional development work, it is urgently recommended that additional AID funding be applied to this project.

The ISAAC solar ice-maker presents profound new implications to Lesser Developed Countries. It is the first technology which truly has the potential of bringing the benefits of affordable ice and refrigeration to the large portion of the world population not serviced by an electric grid. ISAAC technology is uniquely appropriate and low in cost because: it is made locally; makes maximum use of local resources; involves minimal capital outlay; and provides local employment.

III. Thailand Field Test

The seventh ISAAC prototype, designated Mod 3C, was completed and successfully tested at Annapolis in March 1989. With relatively cool evenings (10 to 15°C), it routinely made more than 40 kg of ice per sunny day. In late April it was disassembled, crated, and shipped to Bangkok. It packaged very compactly into a 4 ft x 4 ft x 9 ft box, including many spare parts. The crate weighed less than 700 kg. For that size, it turned out that air freight was approximately the same cost as ocean freight (~$1400).

The unit arrived at Pan Siam Engineering in mid-May, and immediately thereafter two engineers from Energy Concepts arrived, one staying six days and the other eleven days.

It is expected that field assembly will normally require less than two days. Assembly of the first unit stretched out to four days for several reasons:

- the unit was shipped completely disassembled rather than as subassemblies;
- locating replacements for two missing fittings;
- conducting concurrent lectures; and
- beginning construction of a second unit.

Four lectures were presented to Pan Siam Engineering and other interested parties during the assembly period:

- Field Assembly Procedure
- Design and Theory of Operation
- Operation and Maintenance Procedures
- Construction Procedure

The weather pattern was less than ideal for the scheduled work--it was sunny and hot all four days of field assembly, and then the monsoons arrived on the fifth day and the sun was rarely seen the remainder of the visit. Unfortunately this unit was shipped without an auxiliary heater. Thus without either sun or auxiliary heat, it was not possible to produce any ice during the Energy Concepts visit. Pan Siam constructed an auxiliary heater on a priority basis, and within about a week after Energy Concepts departed they were producing 20 to 25 kg of ice per day. Sunny weather has now returned and Pan Siam has reported ice production as high as 40 kg per day. However, the average has been closer to 20 kg, apparently due to the very warm nights in Bangkok. Both Pan Siam and Energy Concepts are exploring ways of upgrading the ice production to a consistent level of 40 kilograms per day, and several improvements have already been identified, e.g. larger evaporator, selective absorption material on thermal wall, and wetted fin tube condenser.

In preparation for this field trip, Energy Concepts visited the cognizant Agency for International Development personnel in Washington, D.C., including the Project Officer. Mr. Sabadell arranged for Energy Concepts and Pan Siam to meet with and brief the cognizant AID personnel at the AID Mission in Bangkok. The Bangkok office of PATH participated in all aspects of the field trip, including arranging the meetings at the AID Mission and also with Thai Health Ministry personnel. The participation of PATH has been and continues to be extremely valuable to this

project, and is gratefully acknowledged, e.g., larger evaporator, selective absorption material on thermal wall, and wetted fin tube condenser.

While in Thailand, Energy Concepts plus Pan Siam and PATH visited the Asian Institute of Technology, to exchange technical information regarding their respective solar refrigeration activities.

During the return trip to Annapolis, Energy Concepts visited the Seattle office of PATH, to brief them on the field trip, and to receive guidance on the field test protocol and on patent and licensing matters.

In retrospect, this field trip was a very successful first one. Energy Concepts learned much valuable information to apply to future field trips. The success in Thailand was due to two factors: the coordinating activities of PATH, and the dedication and professionalism of Pan Siam. It is most fitting and noteworthy that the first significant production of ice was accomplished solely by Pan Siam, after Energy Concepts had left.

V. FUTURE WORK

The remaining work under the current AID contract is to transport the ISAAC unit to a remote location in Thailand, then assemble and test-operate it there under actual field conditions. The presently intended location is a health clinic near Chiang Mai near the northern border of Thailand. PATH/Thailand is coordinating the arrangements necessary within the Thai Health

Ministry, and Pan Siam will provide the necessary transportation and field assembly labor. If possible, Energy Concepts will supply an engineer to assist in this field assembly.

It is intended that the ISAAC unit be operated by personnel normally assigned to the health clinic. PATH/Thailand will take the lead in providing necessary training.

Beyond the completion of the currently contracted work, the further dissemination of this very beneficial technology into areas of the world where it is needed requires several additional activities. It is important not to lose the development momentum established to date.

The needed activities fall into three categories. First is the dissemination of the technology throughout Thailand and southeast Asia, in conjunction with developing a manufacturing and marketing base in Bangkok. This activity is being pursued jointly by Pan Siam Engineering and PATH/Thailand, with assistance from Energy Concepts.

The second category of activity needed is continued technological development. The objectives are to provide a cold box which can be directly implemented into health care centers' current usage patterns; i.e., provide a constant temperature chill compartment for vaccine storage; to develop a cold box for the coldest vaccine storage requirements (constant -20°C); develop a range of sizes targeting several new markets; and further reduce the cost and improve performance. Many promising avenues of further technological development have been identified:

1. A cold box which incorporates separate compartment for

   a) vaccine chill storage (0-5°C)

   b) ice production

   c) ice storage

   This cold box has been designed, and a sketch is included as Figure 1. Construction and testing will commence as soon as financially possible.

2. A constant temperature freeze box, for storing vaccines at - 20°C. This improvement has also been designed, as described in the enclosed U.S. patent application 351950 filed on May 15, 1989. It will require a significant amount of development work, beyond what is possible from internal funds available to Energy Concepts. This capability is necessary for long term storage of measles, yellow fever, and oral polio vaccines.

3. Development of a range of sizes of ISAAC ice-makers. Table 1 depicts the sizes currently contemplated, along with our current estimates of manufacturing cost and performance. Of particular interest is the smallest unit, as it could be portered to areas not serviced by roads. Also of interest is the largest unit, which yields much surplus ice for sale to nearby residents, thus providing a source of income to health clinics or other entities owning the ISAAC.

4. Cost reduction

   Designing for lower cost is a continually ongoing process. Thus far the focus has been on changes which reduce the cost

of manufacture when the units are built one at a time. However, much greater savings are possible when assembly line production, automation, and/or LDC labor rates are applied. As one example, the basic ISAAC presently costs about the same as the retail price of a Hyundai automobile, yet it weighs less than half as much, requires vastly fewer parts, and has virtually no close tolerance or critical performance components. In true volume production, the manufacturing cost should decline to about one quarter of the values tabulated in Table 1. At that level, daily ice would become affordable to virtually all sunbelt inhabitants.

The third category of future work required at this time is the dissemination of this technology into other geographical areas of the world. The pattern established for southeast Asia by Pan Siam Engineering and PATH/Thailand is a very good one. It should be repeated in the following geographical areas:

- Africa
- South America
- Central America/Caribbean
- Middle East
- Southern Asia (India/Pakistan)
- Central Asia (China)
- Australia/New Zealand/Indonesia

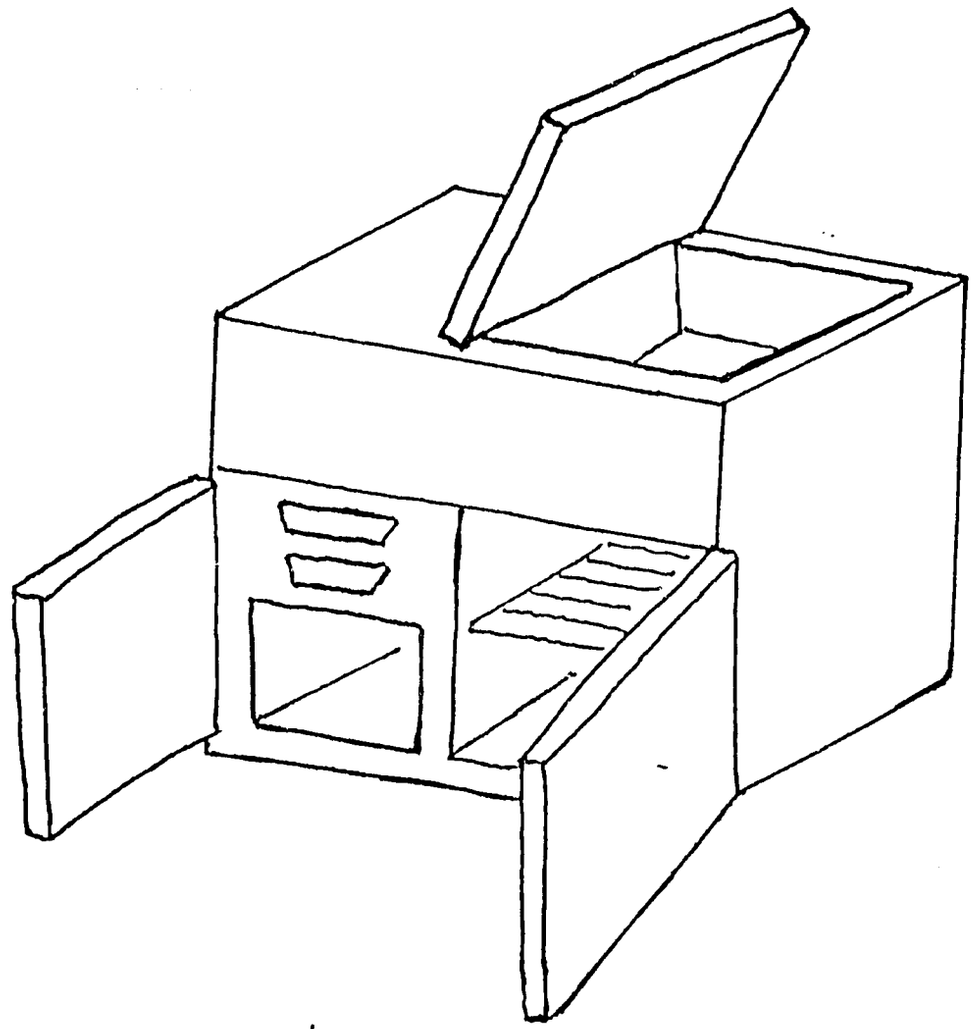
In each geographical area it will be necessary to locate a skilled light manufacturing concern, an established marketing and distribution entity, and a government/health ministry relations coordinating activity. Then Energy Concepts will supply two complete, ready-to-assemble units: one for assembly at the manufacturer's facility, for familiarity of the development team; and the other for assembly at a remote user site. Energy Concepts will supervise assembly of each unit, and will conduct the necessary lectures to train local personnel in theory, design, operation, maintenance, and construction. Further development work in each geographical area would be the responsibility of the local development team, with engineering assistance from Energy Concepts. In this way, the special requirements of each geographical area will be given cognizance, and every area of the sunbelt will have both demonstration units and cognizant personnel close at hand. It should be noted that eventually it will be possible to establish a grassroots manufacturing facility, providing all required training and equipment. However, that would be premature in the demonstration phase.

VI. FINANCIAL STATUS

As indicated above, all project funds were expended in early May. There is an urgent need for more funding to continue the tasks enumerated above. A first recommended action is to increase the current PSTC contract funding to the $150,000 limit, from the current level of $119,333.

The technology development tasks outlined above will require approximately an additional $100,000 of financing.

The further dissemination of ISAAC technology into six additional geographical areas will require approximately $34,000 for each area, each, depending on transportation and shipping costs. This would only cover Energy Concepts expenses, not those of the LDC collaborators.



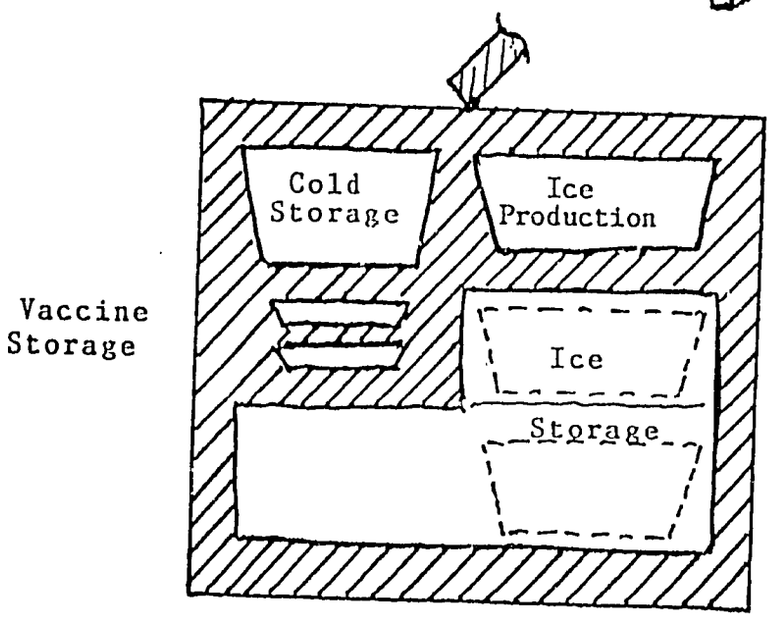


FIGURE 1

ISAAC COLD BOX

TABLE 1

PROJECTED ISAAC SIZES

	Basic ISAAC	Double Size	Half Size	Mini ISAAC
Solar Aperture (M^2)	7	14	3.5	1.8
Total Weight (kg)	550	1050	300	125
Absorbent Weight (kg)	85	170	43	22
Daily Ice Production (kg)	35	75	15	6
MFGR Cost ($)	5500	9000	3500	1500