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MEDIUM TEMPERATURE, HIGH EFFICIENCY TRACKING AND NON-TRACKING SOLAR ENERGY COLLECTORS FOR RURAL AND INDUSTRIAL APPLICATION

FIFTH SEMI-ANNUAL REPORT

July, 1983 to December, 1983

MEDIUM TEMPERATURE, HIGH EFFICIENCY TRACKING AND NON-TRACKING SOLAR ENERGY COLLECTORS FOR RURAL AND INDUSTRIAL APPLICATION

FIFTH SEMI-ANNUAL REPORT

for the period 1 July 1983 to 31 December 1983

submitted by

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January, 1984

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ABSTRACT

In a collaborate research program between the Department of Science and Technology, the Government of India and the Agency for International Development, of the U. S. State Department, it is proposed to develop cost-effective, tracking and non-tracking solar energy collectors and to use these collectors in demonstration systems such as agricultural pumping, industrial hot water and steam production, thermal power and/or space heating and cooling in rural India.

The collector and prototype system development is a three-year effort and constitutes the first phase of this five-year project. The second phase (also proposed for a three-year period but not yet funded) begins after the second year and is devoted to the commercialization of the collectors developed and to system development, demonstration and commercialization appropriate to rural India. The collector and system development will stress the use of appropriate technology, on-site labor and materials and cost-effectiveness relative to the site of intended use. It is intended that this project will lead to the development of a rural solar industry which will help to raise the standard of living in rural India by providing hot water, pumping and electricity as well as to establish an industrial base resulting in jobs and increased income.

The project is a collaborative effort between the Indian Institute of Science, Bangalore, on the Indian side and the University of Houston, Houston, Texas on the U. S. A. side.

SUMMARY OF STAFF

Principal Investigator

Richard B. Bannerot

Faculty Associates

Farrokh Mistree

Stanley J. Kleis

Research Assistant

Halil M. Guven (Ph.D. student) - 1 July 1983 to 31 December 1983

S. Kumar (Ph.D. student) - 1 July 1983 to 31 August 1983

Y. Wu (M.S.M.E. Student) - 1 July 1983 to 31 December 1983

PROGRESS ON OBJECTIVES

OBJECTIVES FOR THE PERIOD 1 JULY TO 31 DECEMBER 1983

The program description outline and timeline taken from the revised proposal, is reproduced as Appendix A of this document. The progress on objectives is presented below in a format paralleling that utilized in the program description outline.

TRIPS: One trip was taken during this reporting period. Dr. Bannerot attende the International Solar Energy Society's "1983 Solar World Congress" in Perth, Australia in August and continued on to India where he spent two weeks. A detailed trip report is attached to this document as Appendix B. The extensiv travel by Mr. Thomas and Dr. Mohan (see Second Semi-Annual Report) completed the objectives of most of the Indian travel planned in the U. S. It also exhausted the budget for this activity.

I. LINEAR FOCUSING

Short Term Review of Concentrators:

Previously completed.

Long Term Review of Concentrators:

Mr. Halil Guven is still maintaining the literature in this area.

Model Development:

The optical and thermal models for the parabolic trough design have been completed. This combined model together with the design optimization program available at the University of Houston have been used to generate information which can be used to set design tolerances as a function of system performance. A major report will be issued on this topic.

Testing Facilities (Review):

Previously completed.

II. SELECTIVE COATING:

Technology Assessment

Previously completed.

III. NON-TRACKING OPTICS

Previously completed.

Collector Design:

No activity was performed in this time period.

IV. THERMAL SYSTEM DESIGN

Tracking

The hardware utilized in the U. S. was assessed by Mr. Thomas during his visit last spring. The main activity at the University will be in the procurement of some of this hardware for the project. The Honeywell flux-tracker which we had planned to use has been withdrawn from the market. The University of Houston is currently negotiating for a replacement system (see Appendix C).

V. FLAT PLATE THERMO-SYPHON SYSTEM DESIGN

A laboratory experiment was designed and built which has been used in a study of storage tank design for use in solar thermo-syphon systems. In the laboratory set-up the solar input to the tank is simulated from a controlled hot water supply. Approximately 50 thermocouples were used to determine the long term thermal stability of several tank designs for various charging and discharging cycles.

VI. MATERIALS EVALUATION AND DEGRADATION

No activity was performed for this time period.

VII. AIR HEATERS TECHNOLOGY ASSESSMENT

No activity was performed for this time period.

VIII. EQUIPMENT SPECIFICATION

One purchase order was issued during this reporting period:

HYDRO-FLEX Corp.	$6,999.60

Seven previous purchase order:

International Technology Corp.	$5,919.50
Glaverbel	9,011.00
Eppley Laboratory	7,776.00
Device and Services	13,106.00
MKS Instruments	1,754.00
Olympic Solar Corp.	4,903.76
Schott Optical Glass	309.00
	$42,770.26

Two additional requests to purchase have been received and are being processed:

Winsmith Gear Box	$5,700.00
Turbine Flowmeter	1,568.00
Total Expenditures plus encumbrances	$57,037.86

LITERATURE SURVEYS

This activity continues. Periodic shipments to the I. I. Sc. have taken place throughout the project.

PLANS FOR THE NEXT SIX MONTHS

The same reporting format will be used here as was used in the previous section.

TRIPS TO THE USA

It is hoped that two Indians will visit at least two solar demonstration sites in the USA in the Spring. This is contingent on the requested no-cost extension and the use of contingency funds from the U. S. $ budget.

I. LINEAR FOCUSING

Short Term Review of Concentrators

Completed as discussed previously.

Long Term Review of Concentrators

Essentially completed.

Model Development

Completed as discussed previously in this report.

Testing Facilities (Review)

Completed as discussed previously.

II. SELECTIVE COATING

Completed as discussed previously.

III. NON-TRACKING

Optics

Completed as discussed previously.

Collector Design

Completed as discussed previously

IV. THERMAL SYSTEM DESIGN

Tracking

This activity for the prototype system has taken place in India. Hardware procurement continues to be the main activity at the University of Houston. As discussed earlier this procurement continues to be a problem due to the withdrawal of the Honeywell hardware.

Non-Tracking

No activity was planned for this period.

V. FLAT PLATE THERMO-SYPHON SYSTEM DESIGN

Data has been obtained on the effect on tank thermal stratification of thermal charging and dischargings. A report is being prepared.

VI. MATERIAL EVALUATION AND DEGRADATION

Completed for the prototype development.

VII. AIR HEATERS TECHNOLOGY ASSESSMENT

No activity is planned at present.

VIII. EQUIPMENT SPECIFICATION

The University of Houston will continue the procurement process. The procedure will be that the IIS will prepare purchase requests which will start the importation clearance process in India. The purchase requests will be sent to the University of Houston. The The University will use them to prepare its own purchase request which will include shipment to India.

IX. LITERATURE SURVEYS

This will continue as described previously.

VARIANCES FROM THE PROPOSED PLAN AND PROBLEMS

No new deviations from the original timeline will occur during the 1 January to 30 June 1984 reporting period. Previous reports have mentioned past deviations involving Tasks III, V, VI and VII. There were delays in the work associated with Tasks II and V. Also, as previously reported Task VI (Materials Evaluation) and Task VII (Air Heaters) have been dropped. These tasks had only a peripheral effect on the project. Task VI was to have taken place throughout the project (see Timeline in Appendix A) and involved the environmental degradation of solar materials. However, due to the reconstruction of a roof area previously used as a test bed at the UH and the subsequent ban on further use of the area, it now appears unlikely the task can be started. Air heating, directly from a solar input, is not considered to be one of the design alternatives considered at this point. Therefore, there is no need to study it at this point.

The purchase of equipment has the potential for causing a problem. As indicated earlier in this report, the total amount expended on and encumbered for equipment for the IISc totals only $57,000 out of a total of $106,000. The IISc has already begun the process of obtaining importation clearance on the rest, but it apparently takes a lot of time.

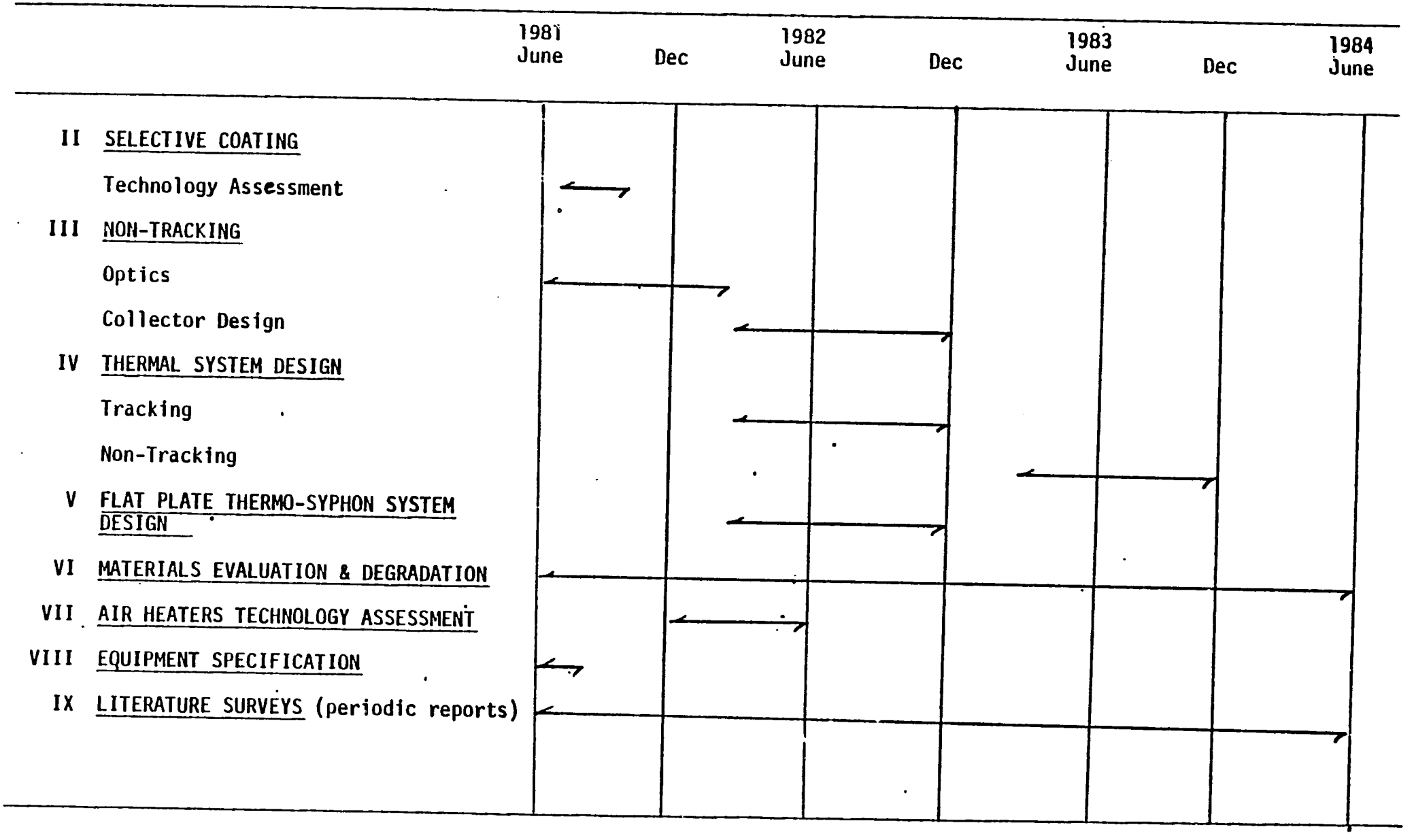
APPENDIX A

PROGRAM DESCRIPTION OUTLINE AND TIMELINE

INDO-US COLLABORATIVE PROJECT ON "MEDIUM TEMPERATURE, HIGH EFFICIENCY TRACKING AND NON-TRACKING SOLAR ENERGY COLLECTORS FOR RURAL AND INDUSTRIAL APPLICATION"

PROGRAM OF CENTRAL CAMPUS OF HOUSTON UNIVERSITY

	1981 June	Dec	1982 June	Dec	1983 June	Dec	1984 June
TRIPS							
to USA	1	2	3	4	5		
to INDIA	1			2		3	
REPORTS							
to AID (UH)		1	2	3	4	5	6
Voucher Submission (UH)	1 2	3 4	5 6	7 8	9 10	11 12	13
I LINEAR FOCUSING							
Short Term Review of Concentrators	←						
Long Term Review of Concentrators	←	→					
Model Development		←	→				
Testing Facilities (Review)			←				


1981
June
Dec
1982
June
Dec
1983
June
Dec
1984
June
II SELECTIVE COATING
Technology Assessment
III NON-TRACKING
Optics
Collector Design
IV THERMAL SYSTEM DESIGN
Tracking
Non-Tracking
V FLAT PLATE THERMO-SYPHON SYSTEM DESIGN
VI MATERIALS EVALUATION & DEGRADATION
VII AIR HEATERS TECHNOLOGY ASSESSMENT
VIII EQUIPMENT SPECIFICATION
IX LITERATURE SURVEYS (periodic reports)

APPENDIX B

TRIP REPORT

APPENDIX B

TRIP REPORT (14 August - 3 September 1983)

The 1983 biennial Congress of the International Solar Energy Society was held in Perth, Australia, 14 August to 19 August 1983. The conference consisted of 87 technical sessions of from 5 to 8 papers each, poster sessions for an additional 200 papers, ten keynote addresses, a large product exhibition and tours of local industries and installations related to solar energy applications. The meeting was attended by more than 800 solar researchers and scientists and people from the solar industry.

The most highly attended sessions were those on evacuated tube collectors and on photovoltaics. The exhibit was dominated by flat plate collectors and photovoltaics. The exhibition was open to the public on the first (Sunday) and last day. Over 5000 people visited the exhibit the first day.

The conference, as would be expected, was dominated by Australian papers, delegates and companies (in the exhibit). The conference was notable for its lack of representation from the U. S. A., an indication of the dramatic drop of government support (DOE) for solar energy. No American companies had hardware in the exhibition.

I stayed in one of six residential colleges on the campus of the University of Western Australia where the conference was held. About 20 other delegates were in the same college so we had lively discussions at breakfast, lunch and dinner and sometimes into the night. These discussions were probably more valuable than the technical sessions themselves since they gave opportunities to discuss details and evaluate new ideas which is not possible in the more

organized technical sessions. Even so, the technical sessions contained many interesting and useful papers which have bearing on the co-operative project involving the UH and IISc. These included sessions on selective surfaces, testing collectors, radiation measurement, industrial applications, performance of materials, evacuated tubular collectors, thermal storage and concentrators. In addition, the first day of the conference was devoted to nine keynote addresses which attempted to review all the major fields of solar energy application.

In summary then, the conference contained useful information and perhaps just as importantly provided a forum for the exchange of ideas and uninhibited one-to-one discussions.

I spent four and a half days in New Delhi, four and a half days in Bangalore (at the IISc), one day in Hyderabad (BHEL) and a half day in Guntur (the Tobacco Research Institute and Nagarajuno University). The most intense time was in Bangalore where I met with the Principal Investigators at the IISc everyday (including Saturday and Sunday). We reviewed the status of the project, confirmed the final equipment list, discussed the timetable for the rest of the project and prepared a draft proposal for a follow-on Phase II. Each of these items will be discussed in more detail following a summary of the activities at the other sites.

The day at BHEL (Hyderabad) was an update for me since I had spent two days there on a previous trip in June, 1981. BHEL has the largest solar R&D group in India. Over 40 engineers are assigned to their Non-Conventional Energy Group which studies wind, bio-gas, bio-mass, waste heat utilization and conservation as well as a wide range of solar technologies (flat plate

and dish concentration, pumping systems, cooling systems, electric thermal power production and photovoltaics). I gave a seminar on advanced topics in non-tracking concentrators and on the USAID (UH-IISc) project.

The tobacco drying system at Guntur is the result of a joint project involving the IISc and Nagarajuna University. The system itself is not related to the IISc-UH project, but it was useful to discuss both systems with the students and faculty in the Physics Department there. I also gave a seminar on non-tracking concentrators.

The activities in New Delhi centered on discussions with the USAID and the Science Office of the U. S. Embassy. I discussed the status of the project with Mr. R. K. Berry (Project Officer) both before and after the trip to Bangalore. In addition, I discussed the project with Mr. Masters (Deputy Director) and Mr. Nachtrieb (Director) of the Project Office. I also had discussions with Mr. D. Johnson and Mr. S. K. Durr of the Embassy Science Office.

The discussions at the IISc Bangalore resulted in the following conclusions and agreements:

The objectives of the originally proposed Phase I (including the construction and testing of a prototype parabolic trough collector) should be realized within the next few months. The location, size and general design of the originally proposed Phase II demonstration system has already been determined. However, the detailed system design, collector construction and deployment and system construction depend upon an additional committment of funds from the G. O. I. (This is part of the originally proposed Phase II, not originally funded.) However, all the imported equipment and parts for

Phase II have been purchased or will be purchased under the Phase I $US budget (reflectors, gearbox and drive, tracker, data acquisition system and other miscellaneous supplies).

The successful demonstration of economic solar thermal technology is marginal. For example, the U. S. Solar Demonstration Program took about seven cycles and close to ten years to develop only a handful of successful concentrating systems (at an expense of over $1 billion). It is important to build upon the successes and not repeat the mistakes, of the U. S. Program. Therefore, we are requesting two additional trips to the U. S. for Indian Investigators to study the details of at least two of the most successful demonstrations: the Coleridge, Arizona solar thermal electric power generating system and the Johnson & Johnson process heat system in Sherman, Texas. These trips should take place after initial prototypes have been produced and tested and the detailed design of the Indian demonstration system (in Mysore) has been completed (Spring, 1984).

Because of the delay in obtaining the G.O.I. support for the demonstration project (requests were submitted several months ago) and the requested travel to the U. S. A. (above), we are requesting a no-cost extension of the USAID project until September 1, 1984.

Discussions were held and a draft proposal written for a new Phase II to demonstrate solar parabolic trough technology in India. The proposal assumes that the original Phase II (to construct a demonstration with the collector developed in Phase I) will be completed under Phase I plus the additional funding from the G. O. I. discussed above. The new Phase II will propose to ungrade the collector performance goals of Phase I (150°C) to 250°C

and include a 50 kw electric (or equivalent sized refrigeration) demonstration system to be built in Bangalore. Working copies of the proposal will be submitted to the USAID by the University of Houston and to the G. O. I. Department of Non-conventional Energy by the Indian Institute of Science within the next month.

APPENDIX C

STATUS OF TRACKING SYSTEM PROCUREMENT

University of Houston
University Park
Houston Texas 77004

Department of Mechanical Engineering

November 23, 1983

Mr. A. Thomas
Regional Instrumentation Centre
Indian Institute of Science
Bangalore - 560012
INDIA

Dear Mr. Thomas:

I have just received your letter of 3 November. I sent a letter to the International Centre for Theoretical Physics on 24 October.

I have also just received the purchase order for the Winsmith Gear Box. However, I am going to hold on to it for awhile until you can comment on the following regarding the tracking system for the Mysore project.

I have discussed our problem with Mr. Schubbe and Mr. Gabel of Honeywell. They confirm that they cannot presently supply the tracker. However, Mr. Gabel indicated that they could respond to a request to bid on a special order. This would cost much more than the original price and probably take a long time.

I have talked to Mr. Murphy, Mr. Gee and Mr. Lewandowski of SERI. Mr. Lewandowski offers the best hope. They have a Honeywell tracker in storage which was removed from a system at SERI. Unfortunately, it was removed without the sensors. Therefore, it is of questionable use. However, I am pursuing this with him to see if we can borrow or buy the tracker.

One of the few installations with the Honeywell tracker is the Ore-Ida system in Oregon. I had heard that they were shutting down the project so I called (Mr. Fogerson) to see if we could salvage the tracker. It turns out that the system was not operating but not abandoned. They are waiting on word from DOE for further funding. They will know early next spring.

I talked to Mr. Schaefer at Acurex about a shadowband tracker. They are currently in a redesign mode on the tracking system and initially said they could not sell us a tracker. However, when he discovered our relatively small requirements, he indicated that he would check into it. He also indicated an interest in quoting a price on the complete drive system including the tracker. I am [illegible]

Based on my conversations with these people, I find that it would be useful if I knew the configuration of the arrays and specifications for power, etc. Could you send me this information at your convenience.

I have enclosed some information on the Heart controller which I saw advertised in Solar Age.

Sincerely yours,

Richard B. Bannerot
Professor

RBB/dh

Enclosure

cc: R. K. Berry