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

SECOND SEMI-ANNUAL REPORT

January, 1982 to June, 1982

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

SECOND SEMI-ANNUAL REPORT

for the period 1 January, 1982 to 30 June, 1982

submitted by

**Richard B. Bannerot, Principal Investigator
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University of Houston Central Campus
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Houston, Texas 77004**

**Prepared for the Agency for International Development under the
Agreement for Projects under USAID Grant Agreement Dated
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July, 1982

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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

Robert M. Nerem

Research Assistant

Gary Kwan (M.S.M.E. student) - 1 January, 1982 to 30 June, 1982

Halil M. Güven (Ph.D. student) - 1 January, 1982 to 30 June, 1982

Student Assistant

Brian Goble (B.S.M.E. student) - 1 June, 1982 to 30 June, 1982

PROGRESS ON OBJECTIVES

OBJECTIVES FOR THE PERIOD 1 JANUARY TO 30 JUNE 1982

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: Completed as Planned

The trips have been completed about as planned.

Mr. Bimleshwar P. Gupta, Manager of the Solar Thermal Program Office at the U. S. Solar Energy Research Institute in Golden, Colorado visited the IIS in Bangalore in January.

Mr. A. Thomas, Principal Scientific Officer at the IIS, and the person responsible for the design, construction and testing of the collector prototypes in Bangalore for the project visited the United States this spring and completed an extensive itinerary. He arrived on 20 March and departed on 19 June. His detailed itinerary is included in this report as Appendix B. During his trip he visited at least eight USDOE Solar Industrial Process Heat Demonstration sites, the two primary American manufacturers of parabolic troughs, seven universities involved in solar research, the National Bureau of Standards, the three major government laboratories working in the solar area (SERI, Sandia, and JPL) as well as many companies which manufacturer equipment for the solar industry. He also attended two major solar conferences (the American Society of Mechanical Engineers Annual Solar Energy Division Conference and the Annual Meeting and Exhibition of the American Section of the International Solar Energy Society) and a short course.

Dr. S. Mohan, Principal Scientific Officer at the IIS, was in the U. S.

during the time that Mr. Thomas was here. His itinerary is included here as Appendix C. Dr. Mohan is responsible for developing the special coatings for the solar hardware to be produced in India. His itinerary included visits to the major laboratories in the U. S. involved in surface chemistry and physics. These included: eight universities, four government facilities, seven commercial organizations and two national meetings.

I. LINEAR FOCUSING

Short Term Review of Concentrators:

The objectives of the short term review have been completed with the visits of Dr. Rao in the fall and Mr. Thomas this spring. Several hundred documents, including government and industrial reports, technical papers and journals have been accumulated, studied and sent to India. Mr. Thomas is preparing a detail technical report of his findings.

Long Term Review of Concentrators:

The literature base described above continues to grow. A Ph.D. candidate in the Department (Halil Güven) is responsible for maintaining this information.

Model Development:

Mr. Güven is also developing a performance model for linear focusing parabolic troughs. He has spent most of his time studying the computer simulations which were obtained from Sandia National Laboratories, Albuquerque. These models, consisting of over 35 separate programs, have been developed by the Sandia Solar Group over the last six years. During that period Sandia was the designated center for the development of parabolic trough technology in the U.S.A. The computer simulations are acknowledged as the best available in technical content. However, they are

not in a form which is useful for design work. A major effort is underway to become familiar with and to document the codes. They will then be put into a more useful form.

Mr. Güven is also working with Dr. Mistree on the design methodology to be utilized. Dr. Mistree has previously developed a highly-interactive, designer-oriented computer software package for design synthesis. The parabolic trough performance simulations will be structured to interact with the design package.

Testing Facilities (Review):

Mr. Thomas visited eight solar demonstration sites and numerous other research facilities which gave him a "hands-on" opportunity at the best test facilities in the U.S. A major objective for this task was to write equipment specifications and to seek first-hand comments and suggestions. This has all been accomplished. Quotations have already been requested for most of the required hardware to construct a test facility in India. Considerable information on the design of test facilities was also received in the way of reports and in some cases detailed construction drawings.

II. SELECTIVE COATING

Technology Assessment:

The visits of Dr. Rao in the fall and Dr. Mohan this spring have completed this task. Contacts have been established with people at various laboratories and industries in the U. S. This is an area in which the IIS had already established itself as a leader. The extensive travels of Dr. Mohan and the information which he obtained probably establishes him as one of the best informed persons in the world in this area.

III. NON-TRACKING

Optics:

The computer simulation program developed in the previous six-months which determines the detailed optical performance of a class of one and two-faceted grooves utilized as non-tracking concentrators has been used to simulate the performance of a wide-range of optical designs. Mr. Kwan is performing this work. This information is currently being analyzed and being put into a form for design studies.

Collector Design:

No activity was performed for this six-month period.

IV. THERMAL SYSTEM DESIGN

Tracking:

Mr. Thomas discussed system design with many people around the U.S.A. He is concentrating primarily on collector design at this time, however.

V. FLAT PLATE THERMO-SYPHON SYSTEM DESIGN

No activity was performed for this time period.

VI. MATERIALS EVALUATION AND DEGRADATION

Materials of interest were identified during the visits of Dr. Rao, Dr. Mohan and Mr. Thomas to various industries and research center in the U.S.A. The development of a test facility at the University of Houston to investigate degradation has been temporarily delayed since the roof of the Engineering Building previously used in a similar study of flat plate collector materials is being resurfaced and will not be available for use until next fall.

VII. AIR HEATERS TECHNOLOGY ASSESSMENT

No activity was performed for this six-month period.

VIII. EQUIPMENT SPECIFICATION

All major items of equipment were identified in the meetings at the IIS in June, 1981. Specifications were developed for much of the equipment during the visits of Dr. Rao, Dr. Mohan and Mr. Thomas. Quotations have been received on some of the equipment.

IX. LITERATURE SURVEYS

As mentioned previously, a large amount of related literature has been sent to the IIS. The process of gathering literature continues at the University of Houston. Periodic shipments are anticipated.

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

None are planned at this time.

TRIPS TO INDIA

Dr. Bannerot will probably not visit India until next summer but this question is not yet decided.

I. LINEAR FOCUSING

Short Term Review of Concentrators

Completed as discussed previously.

Long Term Review of Concentrators

Mr. Güven will be continuing this work at Houston. Mr. Thomas will be using the information obtained on his visit to the U.S.A. to carry on a parallel review at the IIS.

Model Development

Mr. Güven will be continuing his work at the University of Houston.

Testing Facilities (Review)

Completed as discussed previously.

II. SELECTIVE COATING

Completed as discussed previously.

III. NON-TRACKING

Optics

This activity is 80% complete and should be completed by September.

Collector Design

This task will begin in the fall.

IV. THERMAL SYSTEM DESIGN

Tracking

This activity for the prototype system will take place mostly in India. General system design and optimization will be addressed at the end of the fall.

Non-Tracking

No activity was planned for this period.

V. FLAT PLATE THERMO-SYPHON SYSTEM DESIGN

Due to re-roofing of the Engineering Building, experimental work has been delayed.

VI. MATERIAL EVALUATION AND DEGRADATION

Completed for the prototype development.

VII. AIR HEATERS TECHNOLOGY ASSESSMENT

Activity will begin in the fall.

VIII. EQUIPMENT SPECIFICATION

The University of Houston will continue the procurement process. Much of the equipment has been identified but additional work remains to be done. 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 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

Minor deviations from the original timeline will likely occur during the July 1 to December 31, 1982 reporting period. These are detailed in the previous section and involve Tasks III, V and VII. The deviations will be minor delays in the start of work on the specific tasks due primarily to delays in staffing and because additional effort has been expended in support of the extensive travel of Mr. Thomas and Dr. Mohan.

No serious problems have developed nor are they anticipated. However, careful attention will have to be paid to the procurement and shipping of equipment to India as has been previously pointed out.

APPENDIX A

PROGRAM DESCRIPTION OUTLINE AND TIMELINE

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

APPENDIX B
ACTUAL ITINERARY OF MR. A. THOMAS

ACTUAL ITINERARY OF MR. A THOMAS, March 20, 1982 to June 19, 1982

DATE	PLACE	INSTITUTION	CONTACTS
March 20 to March 31	Houston, Texas	Department of Mech. Engineering University of Houston <i>Houston, Texas 77009</i>	Dr. Richard B. Bannerot (713) 749-4462 Dr. Robert M. Nerem, Chairman (713) 749-2437 Dr. A. K. M. Fazle Hussain, Director, Aerodynamics and Turbulence Laboratory (713) 749-4444 (713) 769-7331 Dr. C. E. Donaghey, Chairman, Industrial Engineering (713) 749-2538 Dr. John H. Lienhard, Professor (713) 749-2453 Dr. N. Shamsundar, Associate Professor (713) 749-2683 Dr. F. Mistree, Associate Professor (713) 749-4463 Dr. S. Kleis, Associate Professor (713) 749-4464 Mr. Halil Guven, Graduate Student Mr. Gary Kwan, Graduate Student (713) 749,4470
April 1	Dallas, Texas	Devices and Services 10911 Dennis Road, Suite 405 Dallas, Texas 75229	Dr. Harold Blum, Professor CME Dept. Southern Methodist University Dallas, Texas 75275 (214) 692-3498 Also President, Devices and Services Mr. Tom Ashley, Vice President, Devices & Services (214) 984-3344

DATE	PLACE	INSTITUTION	CONTACTS
	Dallas, Texas	Solar Kinetics Inc. 3300 Century Circle Irving, Texas 75060	Mr. Jeff Johnston, Project Engineer (214) 721-1070
April 2	Sherman, Texas	Acurex, Inc. 1424 Yarborough Sherman, Texas 75090	Mr. Charlie Strong Project Manager, Johnson & Johnson IPH Project (214) 855-1010
April 5	Las Cruces, New Mexico	New Mexico University P. O. Box 3450 Las Cruces, New Mexico 88003	Dr. Tom Mancini, Associate Professor Department of Mechanical Engineering Mr. George R. Conrad, Engineer, Energy Research and Development Section Instrumentation Division (505) 522-9223 Mr. Tom McConnell, Director Solar Collector Test Facility, Ext. 285 Dr. Harry S. Zweibel, Director Solar Energy Project Box 3502/Las Cruces (505) 646-2639 Dr. John F. Schaefer Head, Photovoltaic Division, (505) 646-4240
April 6	Phoenix, Arizona	Arizona State University <i>Tempe, Arizona 15281</i>	Dr. Byard D. Wood, Professor of Engineering (602) 626-3138, <i>Dept of Mech. Eng'g</i>
April 7-8	Tucson, Arizona	The University of Arizona <i>Tucson, Arizona</i>	Dr. McLeod (602) 626-3035, <i>OSC</i> Dr. Dennis L. Larson, Associate Professor, Soil, Water and Engineering Department <i>(602) 626-3463</i> Dr. Fazzalore Dept. of Nuclear Engi. <i>Dr. A. B. Meinel, Optical Science Center</i> <i>(602) 626-3138</i>

Date	Place	Institution	Contacts
April 9-13	Los Angeles California	Jet Propulsion Laboratory California Institute of Technology 4800 Oak Grove, Pasadena, Ca. 91109	Dr. Royal G. Harrison, Manager India Energy System Project Program Development, Energy Application (213) 354-2175
		Dept. of Chemical, Nuclear and Thermal Engineering Boelter Hall, UCLA UCLA Los Angeles, Ca. 90024	Dr. Vijay Dhir, Professor (213) 825-8507
April 14-18	San Francisco, California	Acurex Solar Corporation 485 Clyde Avenue, Mountain View California 94042	Dr. F. A. Tony Schraub, Program Manager Alternate Energy Division (415) 964-3200 Ext. 3347
April 19-26	Denver, Colorado	Solar Energy Research Institute (SERI) 1617 Cole Boulevard Golden, Colorado 80401	Dan Rosen, Manager Electrical Instrumentation and Control
			Mr. Bimleshwar P. Gupta, Manager Solar Thermal Program Office (303) 231-1760
			Dr. John P. Thornton, Group Manager Systems Development Branch (303) 231-1006
			Dr. Lawrence M. Murphy Group Leader Solar Thermal Engineering Development Branch (303) 231-1056
			Mr. Chuck Kutchen (303) 231-7067

Date	Place	Institution	Contacts
April 19-26 (cont.)	Denver, Colorado	Solar Energy Research Institute (SERI) 1617 Cole Boulevard, Golden, Colorado 80401	<p data-bbox="1478 263 2052 324">Mr. Randy C. Gee, Thermal Conversion Branch (303) 231-1174</p> <p data-bbox="1478 388 2083 448">Mr. E. Kenneth May, Thermal Conversion (303) 231-7344</p> <p data-bbox="1478 483 1967 544">Dr. Frank Kreith, Heat Transfer Laboratory (303) 231-1109</p> <p data-bbox="1478 579 2061 668">Mr. Chester V. Wells, Test and Cali- bration Engineer, Measurement, Design and Support Branch (303) 231-1981</p> <p data-bbox="1478 732 2026 792">Mrs. Mary Linskens, Thermal Systems Engineer (303) 231-1272</p> <p data-bbox="1478 828 2044 858">Dr. Charles Berberich (303) 231-1006</p> <p data-bbox="1478 893 2044 924">Dr. Allen Lewandowshi (303) 231-1972</p> <p data-bbox="1478 954 1913 984">Dr. Evergreen (303) 674-8461</p> <p data-bbox="1478 1014 2070 1103">Dr. R. J. Copeland, Principal Engineer Solar Thermal Research Branch (303) 231-1012</p> <p data-bbox="1478 1140 1941 1197">Mr. Rob B. Farrington, Systems Development (303) 231-1938</p>

Date	Place	Institution	Contacts.
April 19-26 (cont.)	Fort Collins, Colorado	Colorado State University Fort Collins, Colorado, 80523	Mr. Chuck Smith, Solar Application Laboratory (303) 491-8325 (office) (303) 484-5719 (home)
	Boulder, Colorado	1455 Oak Circle Boulder, Colorado 803202	Dr. George O. G. Lof, Senior Technical Advisor Solar Energy Application Laboratory (303) 491-8632 (office) (303) 758-2585 (Home)
April 27-May 1	Albuquerque, New Mexico	Hilton Hotel	<p>1. Attended ASME conference on Solar Energy</p> <p>2. Attended 2 days Course on Simulation and Thermal Design of Solar Systems (Dr. William Beckman and Dr. Sandy Klein)</p> <p>Met the following persons during the conference:</p> <p>Dr. William C. Thomas, Professor, Mechanical Engineering Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061 (703) 961-7664</p> <p>Dr. William J. Rice, Professor Chemical Engineering Dept. Villanova University, Villanova, Penna., 1908 (215) 645-4948</p> <p>Mrs. Sherry Rossi, Project Head, Energy Systems Development Vitro Laboratories Division, 14000 Georgia Avenue, Silver Spring, MD. 20910 (301) 871-9522</p>

Date	Place	Institution	Contacts
			Mr. Mitchell D. Graber, Head, Business Development Section, Contract Operations Division
			Foster Wheeler Development Corp., John Blizard Research Center, 12 Peach Tree Hill Road, Livingston, New Jersey, 07039.
May 2-4	Phoenix, Arizona	BDP Center Carrier Corporation, Phoenix, Arizona, Hamilton Test System, 2303 East Thomas Road, Phoenix	Mr. Brad Orbesen (602) 269-2545 Mr. Dean Terry (602) 955-9672 Mr. Torg Anderson (Connecticut office) (203) 727-7333 Mr. Joni Bosh (602) 955-9670
May 4-8	Houston, Texas	University of Houston Central Campus, Houston, Texas 77004	Dr. R. B. Bannerot, Department of Mechanical Engineering (713) 749-4462.
May 9-11	San Francisco, California	Acurex Solar Corporation 485 Clyde Avenue, Mountain View, California, 94062 Cal-Air Conditioning Co. 12484 Whittier Blvd. Whittier, California 90602	Mr. Stanley B. Youngblood Mr. Kailash Koushik, Project Engineer (213) 698-8301
May 12	Los Angeles, California	Jet Propulsion Laboratory California Institute of Technology 4800 Oak Grove Dr., Pasadena, Calif. 91109	Mr. Herman Bank, Staff Engineer Energy Technology, Engineering Section Applied Mechanics Division (213) 577-9223 Dr. Royal G. Harrison, Manager Indian Energy System Project, Program Development, Energy Applications (213) 354-2175

Date	Place	Institution	Contacts
		JPL, Box 458 Edwards, California 93523	Mr. Joe A. Newnham, Group Supervisor Instrumentation Section (805) 277-7521 (805) 942-9866 (213) 354-4321
May 13-14	Albuquerque, New Mexico	Sandia Laboratories <i>Albuquerque, New Mexico</i> <i>78185</i>	<p>Mr. K. Thieumalei Deputy Manager (NCES) BHEL, India</p> <p>Dr. Jim Banas, Head Solar Energy Division (505) 844-6828</p> <p>Mr. Sig Thumborg, Systems Division (505) 844-3733</p> <p>Mr. Bruce D. Hansche, Division 1552, Nondestructive Testing Technology (505) 844-3469</p> <p>Mr. James L. Todd, Solar Energy Projects (505) 844-3404</p> <p>Mr. Ben J. Patterson (505) 846-7680</p> <p>Mr. Wilbur Boyd (505) 844-7473</p> <p>Dr. Richard Pettit (505) 264 - 2109</p> <p>Mr. Roscoe Champion</p>
May 15-17	Sacramento California 95851	PMI Corporation Mechanical Contractor P. O. Box 15264	Mr. Robert N. Marlin Chief Mechanical Estimator (916) 635-4552
	Visalia, California	College of the Sequoias 915 South Mooney Boulevard <i>Visalia, Calif. 93277</i>	Richard S. Cottrell, Architecture-Solar Applications
May 18-21	Atlanta, Georgia	Engineering Experiment Station Georgia Institute of Technology <i>Atlanta, Georgia 30332</i>	Mr. S. H. Bomer, Principal Scientist (404) 894-3656

Date	Place	Institution	Contacts
May 18-21 <i>(cont.)</i>		Georgia Power Company 7 Solar Circle, Shenandoah, Ga.	Dr. Robert A. Cassanova, Associate Laboratory Director, Energy and Medical Science Laboratory Mr. E. J. Ney, Manager, Solar Operations
May 22-23	Tennessee	Oak Ridge National Laboratory P. O. Box Bldg. 4508	Mr. John Casbarro (404) 526-7324 Dr. Stan A. David, Metallurgist
May 24	Dalton, Georgia	The Dow Chemical Company Latex Manufacturing Plant 1468 Prosser Drive S.E. Dalton GA. 30720	Mr. Lottie H. Conner (404) 277-3000 Mr. Jim Geaman
May 25-26	Atlanta, Georgia	Georgia Power Company 333 Piedmont Avenue, Atlanta, Ga. (P. O. Box 4545)	Mr. John Casborro (409) 5267324 Mr. D. G. (Don) Sabin Energy Research Manager (404) 526-7365 Mr. Edward T. Honts Energy Service Organization (404) 526-7363 Herry Energy Consultants, Inc. 880 West Peachtree Street, N.W. Dwight H. Jones General Manager (404) 881-1492, (40) 881-0497 Mr. Glenn L. Bellamy, Project Energy Manager (404) 881-0497 Mr. Carl Bromm, Project Energy Manager (404) 881-0497
May 27	Syracuse, New York	Carrier Tower P. O. Box 4800 <i>Syracuse, New York 13221</i>	Dr. Wendell Biermann, Program Manager (315) 424-4626 Mr. Brad Orbesan, Project Engineer Energy Systems Div. (315) 426-4633

Date	Place	Institution	Contacts
May 28-31	Livingston, New Jersey	Foster Wheeler Development Corp. 12 Peach Tree Hill Road Livingston, N.J. 17039	Dr. A. C. Gangadharan, Vice President, Solar Development Corp. (201) 533-3601 Dr. Gopel Gupta, Project Manager (201) 533-2189
June 1-3	Washington, D.C.	National Bureau of Standards Div. of Building Technology Gaithersburg, MD	Dr. Kent Reed, Solar Test Facility (301) 921-3465
		U. S. Agency for International Development, Washington D.C. 20523	Dr. Robert J. Ichord, Energy Specialist Bureau for Asia (202) 632-2928
		Department of Energy Mail Stop E201 Environment and Impact Division, Washington D.C. 20545	Dr. M.V. Rama Sastry
June 4-9	Houston, Texas	Department of Mechanical Engineering <i>University of Houston</i>	Dr. R. B. Bannerot (713) 749-4462
June 10-16	Albuquerque, New Mexico	Sandia Laboratories <i>Albuquerque, New Mexico</i> <i>78185</i>	Mr. Sig Thumborg (505) 844-3733 Mr. Ben J. Patterson (505) 846-7680 Mr. James L. Todd (505) 844-3404 Mr. Raymond W. Harrigan Mr. Dwane E. Randall Dr. Richard Pettit Mr. Bruce D. Hansche (505) 849-3469 Mr. Bob Alvis, MISR Project (505) 844-8573
June 17-19	Houston, Texas	Public Service Camp of New Mexico Alvarado Square N.M. Univ. of Houston.	Miss Pamela S. McKeever, Energy Conservation Engineer (505) 848-2863/2700 Dr. Richard B. Bannerot (713) 749-4462

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APPENDIX C
ACTUAL ITINERARY FOR DR. S. MOHAN

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ACTUAL ITINERARY OF Dr. S. Mohan
 March 20, 1982 to June 19, 1982

DATE	PLACE	INSTITUTION	CONTACT
March 20-27	Houston, Texas	University of Houston Houston, Texas 77004	Dr. Richard B. Bannerero Dept. of Mech. Engr. (713) 749-4462
			Dr. Alex Ignatiev Dept. of Physics (713) 749-3889
			Dr. John C. Wolfe Dept. of Electrical En
March 28 - April 3	Tucson, Arizona	University of Arizona	Dr. A.B. Meinel Dr. B.O. Seraphin Dr. H.A. McCleod Dr. M.R. Jacobson Optical Sciences Cente (602) 626-3136 Dr. Krishna Seshan Metallurgy Dept.
April 5-6	SanDiego, California	American Vacuum Society Symposium	
April 7-15	Los Angeles, California	UCLA Westwood	Dr. R.F. Bunshah Dr. Chandia Deshponde Dept. of Material Sci. and Engg.
		Dynatech Instruments, Inc Torrance	Mr. Eric Nelson (213) 533-8132
		Telic Corporation Sandia Monica	Dr. John A. Thornton (213) 828-7449
		Highland Plating, Co Hollywood	Mr. Don H. May (213) 469-2289

DATE	PLACE	INSTITUTION	CONTACT
April 16-18	San Francisco, California	Lawrence Berkeley Lab. Berkeley	Dr. Karl M. Lampert Dr. Devendra Sadana
April 19-20	Eugene, Oregon	National Bureau of Mines and Resources Center, Albany	Dr. R. Blinkensderfer
April 21-25	Denver, Colorado	Solar Energy Research Institute, Golden	Dr. A.W. Czandera (303) 231-1104 Dr. Roland Pitts Dr. Terence M. Thomas Dr. Ed Tracy Dr. Shew M. Wong Dr. K. Masterson Dr. Charles Berberick (303) 231-1006 Mr. Bimleshwar Gupta (303) 231-1760
April 26-30	Houston, Texas	University of Houston Houston	Dr. R.B. Bannerot Dr. A. Ignatiev
May 3-5	Minneapolis, Minnesota	Physical Electronics Minneapolis	Dr. G.K. Wehner Mr. Walter Heireli Dr. James M. Burkstran
May 6	Milwaukee, Wisconsin	University of Wisconsin Milwaukee	Dr. R.B. McQuiston Dr. Tong
May 10-11	Cleveland, Ohio	NASA Lewis Research Center Cleveland	Dr. Glen McDonald Dr. T. Spalvins Dr. D.H. Buckley Dr. K. Miyoshi
May 12-13	Ithaca, New York	Cornell University Ithaca	Dr. Sievers Dr. Blakley
May 14-16	Syracuse, New York	Syracuse University Syracuse	Prof. R.W. Vook

DATE	PLACE	INSTITUTION	CONTACTS
May 17-21	Boston, Massachusetts	Mobil Tyco Solar Energy Corp. Waltham	Dr. K.V. Ravi (617) 890-0909
		Lincoln Laboratory Boston	Dr. J.C. Fan (617) 890-5500
		MKS Instruments	Mr. John Betutsch
May 24	New York, New York	Veeco Instruments	Mr. Paul Bunce
May 25-27	Washington, DC	National Bureau of Standards Gaithersburg, Maryland	Dr. D.M. Sanders (301) 921-2817 Dr. Jack Hsia Dr. Lou Holdeman Dr. Albert Feldman
May 28	Knoxville, Tennessee	World Energy Fair	
June 1-19	Houston, Texas	University of Houston	Dr. R.B. Bannerot Dr. A. Ignatiev