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IEA SOLAR R&D

INTERNATIONAL ENERGY AGENCY
PROGRAM TO DEVELOP AND TEST
SOLAR HEATING AND COOLING SYSTEMS

SURVEY OF COMPONENT R&D PROJECTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

APRIL 1978

PREPARED AND DISTRIBUTED FOR THE UNITED STATES
BY THE
U.S. DEPARTMENT OF ENERGY
ASSISTANT SECRETARY FOR CONSERVATION AND SOLAR APPLICATIONS
RESEARCH AND DEVELOPMENT BRANCH OF HEATING AND COOLING

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IEA PROGRAM TO DEVELOP AND TEST
SOLAR HEATING AND COOLING SYSTEMS

TASK II:
COORDINATION OF R&D ON SOLAR HEATING
AND COOLING COMPONENTS

SURVEY OF COMPONENT R&D PROJECTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

APRIL 1978

COMPILED FOR THE IEA
BY THE
AGENCY OF INDUSTRIAL SCIENCE AND TECHNOLOGY, MITI
JAPAN

Under Contract No. EG-77-C-01-2522

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ABSTRACT

One of the purposes of the International Energy Agency, established in 1974, was to promote long-term cooperative efforts in energy R & D. Solar energy was identified as one appropriate energy technology area for international cooperation, and the Program to Develop and Test Solar Heating and Cooling Systems was created with the objective of pooling efforts and experience in order to reduce overall costs of solar energy systems and accelerate the large scale introduction of this technology in the participating countries. One of the five cooperative projects which comprise this multilateral program is "Coordination of R & D on Solar Heating and Cooling Components." An element of this project is the exchange of information on ongoing component R&D projects. Participating countries have submitted descriptive summaries of R & D projects, using a special format. This report is a compilation of 198 project summaries and provides a useful overview of component R & D work underway in eleven countries.

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INTRODUCTION

Frederick H. Morse
Chairman, Executive Committee
IEA Solar Heating and Cooling Program

IEA Background

The oil embargo of 1973 and the almost simultaneous increase in world oil prices severely disrupted the economies of most oil-importing nations and strained their political, strategic, and economic relationships. The United States and certain other members of the Organization for Economic Cooperation and Development (OECD), based on the need demonstrated by that experience, have undertaken to achieve a coordinated approach to decrease their dependence on foreign oil, and to reduce the strategic and economic vulnerability such dependence can cause.

As part of this effort, these OECD members agreed in September 1974 to develop an International Energy Program which included cooperation on energy research and development programs. The International Energy Agency (IEA) was established as an autonomous institution within the OECD to administer, monitor, and execute this International Energy Program.

In addition to the United States, the other OECD members who are participating in the IEA are: Austria, Belgium, Canada, Denmark, Federal Republic of Germany, Great Britain, Greece, Ireland, Italy, Japan, Luxembourg, the Netherlands, Spain, Sweden, Switzerland, and Turkey. Subsequently, New Zealand became a participating member and Norway became an observer. Under special arrangement the Commission of the European Communities also participates.

IEA Solar Heating and Cooling Program

The IEA Committee on Energy R&D established expert groups in a number of technology areas to develop cooperative programs. One of these expert groups was in the area of solar energy, reflecting the attention which has been directed in recent years to solar energy as an alternative to fossil fuels. Based on several meetings and considerable correspondence, the Solar Energy Expert group developed five cooperative projects in the areas of solar heating and cooling of buildings and solar radiation measurement and analysis, which comprise the Program to Develop and Test Solar Heating and Cooling Systems. With heating and cooling of buildings accounting for a significant percentage of the energy consumption in many countries, even a partial replacement of conventional fuels by solar energy would have an important impact on the energy situation. The IEA Solar Heating and Cooling Program addresses some of the remaining technological and economic problems in order to accelerate the wide-scale implementation of this technology in the member countries.

As with all IEA cooperative programs, the details of the solar heating and cooling R&D projects as well as the administrative and management procedure, responsibility of the signatories, and special financial and legal conditions, are contained in an Implementing Agreement. By signing this agreement, the contracting parties (governments or organizations designated by governments) agree to actively participate in one or more of the five project areas, called Tasks.

A lead country, called the Operating Agent, was selected for each project and is responsible for maintaining the schedule and coordinating the work as required to meet the objectives of the project. The five tasks and the respective Operating Agents are:

I. Investigation of the Performance of Solar Heating and Cooling Systems - Denmark

II. Coordination of R&D on Solar Heating and Cooling Components - Japan

III. Performance Testing of Solar Collectors - Germany

IV. Development of an Insolation Handbook and Instrumentation Package - United States

V. Use of Existing Meteorological Information for Solar Energy Application - Sweden

These five Tasks have been summarized in a paper presented at the 1978 International Solar Energy Society Congress in New Delhi.* Only Task II will be described in this report.

Task II Objective

The objective of this Task is to increase the effectiveness of the participants' national R&D programs related to the development of cost-effective components for solar heating, cooling and hot water supply systems, including the following key components of the systems:

a. solar collectors
b. solar thermal energy storage
c. solar air conditioning and cooling units
d. other substantial components, as appropriate.

Task II Approach

Coordination of component R & D is carried out by establishing a framework for the exchange of information and exchange of research personnel, equipment and materials. The following subtasks have been undertaken in order to accomplish the objective:

*Morse, F.H. and Blum, S., "Status of the IEA and CCMS Solar Heating and Cooling Cooperative Programs," presented at the International Solar Energy Society Congress, Jan. 16-21, 1978, New Delhi.

A. Survey of Component R & D Projects

The participants in this Task are exchanging information on the details and results of component R & D projects which are funded in whole or part by the governments of the participating countries. A special two-page format was adopted to facilitate the reporting of information under this exchange. The first page requests descriptive information on the project and the second calls for technical details of the component under investigation. Project summaries are submitted to the Operating Agent who is responsible for their compilation. The compilations are distributed to the participating countries who, in turn, further disseminate the reports to interested parties within their countries; hence the preparation and distribution of this report for the United States.

This survey includes those project summaries submitted by April 1978. The compilation will be updated annually by providing information on new or revised projects.

On the basis of the contributed information, the Operating Agent prepared comments on the key features and research areas emphasized in the reported component R & D projects. Those observations are also contained in this report.

B. Survey and Review of Component R & D Plans

The participating countries in this Task have submitted summaries of their national R & D plans for solar heating and cooling components. The Operating Agent has reviewed the summaries and prepared a brief report on the principal features of these plans. Both the report and compiled plans have been distributed to the participants. This survey will be updated annually.

C. Exchange of Solar Energy Research Personnel, Equipment and Materials

Exchange of solar energy researchers, equipment and materials between the participating countries, especially for the component areas listed above, is being encouraged.* While the initiation of exchanges will be left to the interested experts in the participating countries, the Operating Agent is developing a plan to accelerate and implement such undertakings.

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*One of the purposes of this report is to inform United States researchers of R&D projects underway in other countries. The reader, if interested, is encouraged to contact the designated researcher regarding the possibilities for the exchange of research personnel, equipment and/or materials.

Task II Duration

This Task began in December 1976 and will conclude in December 1979.

Participants

The Republic of Austria
The Government of Belgium
The Ministry of Trade and Industry, Denmark
The Kernforschungsanlage Julich, Germany
The Consiglio Nazionale delle Ricerche, Italy
The Government of Japan - OPERATING AGENT
The Stichting Energieonderzoek Centrum Nederland
The Department of Scientific and Industrial Research, New Zealand
The Ministerio de Industria (Centro de Estudios de la Energia), Spain
The Swedish Council for Building Research
The Office Federal de l'Economie Energetique, Switzerland
The United States Department of Energy

COMMENTS ON
SOLAR HEATING AND COOLING COMPONENT R & D PROJECT SURVEY

T. Sunami
Task II Operating Agent

Introduction

An important element of Task II is the exchange of information on solar component R & D projects in the participating countries. A format for reporting component projects was adopted at the Task II Experts Meeting in October 1976.

The first "Survey of Component R & D for Solar Heating, Cooling and Hot Water Supply Systems" was compiled in September 1977 by the Operating Agent for Task II (Japan) and included project summaries submitted by eight of the twelve Participants. The present, updated survey contains summary reports submitted as of April 1978. The number of countries contributing to this latest compilation has increased to eleven.

One hundred seventy-nine summary reports on one hundred ninety-eight projects have been submitted by the Participants. (Some of the reports list more than one R & D project.) The distribution of these projects by the four major areas of component research--solar collectors, thermal energy storage, air conditioning units, and other substantial units--is found in table 1.

The compilation of component R & D projects will be updated annually with revised or additional project summaries submitted by the Participants.

Solar Collectors

One hundred and eight collector R & D projects from eleven countries were reported. The project summaries cover both air and liquid collectors and include research on the following types of collectors for solar heating, cooling and hot water supply systems: flat plate collectors, with and without selective absorbers; concentrating collectors (with and without tracking mechanisms); vacuum tubular collectors; honeycomb collectors; and V-corrugated collectors.

In general, the majority of the R&D efforts on solar collectors are concerned with:

1. Feasibility studies and economic analysis related to systems.

2. Heat transfer analysis, and suppression of natural convection by the use of honeycomb structures, etc.

3. Studies on selective surfaces.

4. Mass production technology of solar collectors.

5. Testing and evaluation of performance, durability, and reliability of solar collectors.

R & D on solar collector materials and components has been accelerated in recent years, particularly since the oil crisis in 1974, as it is the key component in solar heating and cooling systems. It is noted that emphasis is presently placed upon testing and evaluation, economic analysis and mass production technology for market penetration. While the development of selective surfaces has led to a major improvement in the performance of collectors, especially at higher temperatures, the cost of collectors is still, in general, too high. A partial solution to the cost-effectiveness problem might be found in the optimization of the solar collector subsystem in conjunction with the specific solar heating and cooling system.

Thermal Energy Storage

A total of forty-five projects on solar thermal energy storage from ten countries are included in this compilation. The heat storage component is essential for the utilization of solar energy, since solar insolation is intermittent in nature. Heat storage is generally divided into sensible heat storage and latent heat storage techniques. Both types of storage subsystems and their optimization are included in the projects surveyed. The former has a relatively long history and is represented by water storage units or rock bed storage units.

While latent heat storage using phase change has also been investigated for years, heat transfer problems related to super-cooling, phase separation, etc., of the storage material have impeded the practical application of this method of storage in solar heating and cooling systems. Encapsulation seems to be a common approach to the solution of those major problems.

The application of chemical reaction and photochemical processes for heat storage is also being studied, although their development is still in its early stages. Long term, low cost solar energy storage, seasonal storage, and other related techniques using naturally-occurring media such as ground and lakes are also reported in the R & D survey.

R & D on solar heat storage has been given less attention and is less advanced than solar collector R & D. Because of the importance of thermal energy storage to the performance of solar heating and cooling systems, such R & D efforts should be accelerated and international information exchange and cooperation encouraged.

Air Conditioning Units

Thirty-two air conditioning projects from five countries are included in this compilation. Most of the R&D efforts on air conditioning units reported by the participants involve absorption and Rankine cycle units. Other projects include heat pumps and desiccant units, as well as novel techniques such as the Nitinol engine. Cost reduction is a major objective of many of the projects. Significant results from the R&D on solar air conditioning are anticipated within the next several years.

Other Substantial Units

Thirteen projects are reported in the category of other substantial units for solar heating and cooling. These include controls, heat exchangers, and heat pumps.

TABLE 1: DISTRIBUTION OF COMPONENT R&D PROJECTS

Country	Reports Submitted	Total Projects Included	Component R&D Projects			
			Solar Collectors	Thermal Energy Storage	Air Conditioning Units	Other Substantial Units
AUSTRIA	9	12	7	4	0	1
BELGIUM	2	2	1	1	0	0
DENMARK	4	4	2	1	1	0
GERMANY	22	30	20	4	3	3
ITALY	5	5	5	0	0	0
JAPAN	13	13	7	3	3	0
NETHERLANDS	30	34	16	15	2	1
NEW ZEALAND	7	8	6	2	0	0
SWEDEN	6	7	3	2	0	2
SWITZERLAND	5	5	3	2	0	0
U.S.A.	76	78	38	11	23	6
TOTAL	179	198	108	45	32	13

LIST OF PROJECTS BY COMPONENT

SOLAR COLLECTORS

AUSTRIA

DOMESTIC WATER HEATING AND SPACE HEATING WITH SOLAR ENERGY
Development and testing of economic domestic water heating systems
Prof. Dr. P. V. Gilli, Arbeitsgemeinshaft Sonnenenergie Obere Techstrasse 21/1, A-8010 Graz

SOLAR ENERGY TEST STATIONS IN AUSTRIA
Studies on system energy balance and safety, life-time and economic efficiency of solar collectors
Austrian Solar and Space Agency, ASSA Garnisongasse 7, A-1090 Vienna

DEVELOPMENT OF A PROTOTYPE OF A SEMI-CONCENTRATING COLLECTOR
Construction and testing of a flat-plate collector with concentrating elements
Ing. Walter Jager, Fa. Ing. W. Jager, Villacherstrasse 32 A-9300 St. Veit/Glan

MULTI-COMPONENT SYSTEM FOR DOMESTIC WATER HEATING AND SPACE HEATING AT THE "INSTITUT FUR MOLEKULARBIOLOGIE" OF THE "ÖSTERREICHISCHE AKADAMIE DER WISSENSCHAFTEN" IN SALZBURG
Study on a combined solar energy and heat pump system
Prof. Dr. F. Viehböck, Institut für Allgemeine Physik University of Technology, Karlsplatz 13, A-1040 Vienna

DEVELOPMENT OF A LOW TEMPERATURE SOLAR COLLECTOR
Collector research utilizing mathematical simulation and comparative outdoor collector test methods
Prof. Dr. F. Viehbock, Institut fur Allgemeine Physik

COMPACT SOLAR SYSTEM FOR DOMESTIC WATER HEATING
Development of solar system for domestic water heating for a single family house
Dr. Georg Turnheim, Vereinigte Metallwerke Ranshofen-Berndorf, Postfach 35, A-2560 Berndorf

INSTALLATION OF A SOLAR ENERGY STATION IN MALTA
The thermal performance, life-time and safety study of solar collectors and solar systems for domestic water heating
Dr. George Turnheim, Vereinigte Metallwerke Ranshofen-Berndorf

BELGIUM

FLAT PLATE COLLECTOR DEVELOPMENT
Evaluation of performance, architectural integration in roof structures and design of a solar heated house
Prof. A. Pilatte, Faculte Polytechnique de Mons, rue de Houdain, B - 7000 Mons

DENMARK

DEVELOPMENT AND TESTING OF COMPONENTS FOR SOLAR HEATING SYSTEMS
Measurement of thermal performance and evaluation of the durability of solar collectors
Messrs. P.E. Kristensen and O. Paulsen, Technological Institute, Gregersensvej, DK-2630 Tastrup and Thermal Insulation Laboratory, Bldg. 118, Technical University of Denmark, DK-2800 Lyngby

EVALUATION OF SOLAR COLLECTORS
To establish an outdoor facility for measuring the thermal performance of solar collectors and to evaluate the long term durability of collectors
Messrs. C. Nielsen and O. Paulsen, Thermal Institute Laboratory and Technological Institute

GERMANY

HOT WATER PREPARATION WITH SOLAR ENERGY
Research, construction, and testing of solar absorbers
Dipl. Phys. Birnbreier, Brown, Boveri+Cie AG, Postfach 101332, D-6900 Heidelberg 1

PRODUCTION OF A SOLAR COLLECTOR INSTALLATION FOR HEATING AN OPEN-AIR SWIMMING POOL
Design and construction of solar-heated swimming pool
Dr. F. Weil, Brown, Boveri + Cie. AG, Postfach 351 D-6800 Mannheim

DEVELOPMENT OF SELECTIVE SOLAR ABSORBERS ON THE ALUMINUM ROLL-BOND HEAT EXCHANGER BASIS
Development of a long-term stability selective coating for aluminum solar absorbers
Dipl. Phys. W. Scherber, Dornier-System GmbH, Postfach 1360, D-7790 Friedrichshafen

HEAT PIPE SOLAR ABSORBER
Development of heat pipe solar collector for solar sea water desalination
Dr. Ing. Gehrke, Dornier System GmbH, Postfach 1360 D-7990 Friedrichshafen

DEVELOPMENT OF HIGH TEMPERATURE RESISTANCE SOLAR ABSORBER AREAS
Investigation of properties and limits of use of various coatings for solar absorbers
Dipl. Phys. Scherber, Dornier-System GmbH, Postfach 1360 D-7990 Friedrichshafen

HOT WATER PREPARATION WITH SOLAR ENERGY USING SYNTHETIC SOLAR COLLECTORS

Development and testing of reasonably-priced synthetic solar collectors

Dr. Ing. H. Kleinwachter, Entwicklungs- und Forschungs labor, Industriestrasze 8, D-7850 Lorrach-Haagen

DEVELOPMENT OF AN INDUSTRIAL PROCESS FOR PRODUCTION OF In_2O_3 COATINGS FOR IMPROVEMENT OF THE k VALUE OF INSULATING GLASS PANES

Development of a process for large-scale industrial production of high efficiency transparent coatings

Dr. H.J. Glaser, Infrastop-Labor, Flachglas AG Delog-Detag Postfach 669, D-4650 Gelsenkirchen

DEVELOPMENT OF LARGE-SCALE INDUSTRIAL PRODUCTION METHODS FOR COMPONENTS OF SOLAR HEATING SYSTEM

Development of flat solar collectors for large-scale industrial production

Dr. E. Huszmann, Jenaer Glaswek Schott+Gen., Hattenbergstr. 10, D-6500 Mainz

FLAT-PLATE SOLAR ENERGY COLLECTOR

Development of various flat plate collectors of high efficiency

Dr. E. Huszmann, Jenaer Glaswerk Schott+ Gen., Hattenbergstr. 10, D-6500 Mainz

SOLAR COLLECTORS FOR FLAT ROOFS

Analysis of various alternatives for economical and technically feasible integration and installation of solar collectors in flat roofs

Prof. Dr. Ing. W. Dalhoff, Klaus Esser KG, Postfach 2909 D-4000 Dusseldorf 1

SERVICE WATER HEATING BY SOLAR ENERGY

Investigation of influence of solar system installation on annual oil consumption

Dipl. Ing. F. Reinmuth, Kraftanlagen AG, Im Breitspiel 7 D-6900 Heidelberg 1

DEVELOPMENT OF ECONOMICAL SOLAR HEATING SYSTEMS WITH REASONABLY PRICED COLLECTORS

Development and construction of simple flat collectors

Mr. J. Lorenz, M.A.N. - Neue Technologie Maschinenfabrik, Augsburg-Nurnberg AG, Dachauer Str. 667, D-8000 Munchen 50

MODULAR SOLAR HOUSE HEATING SYSTEM - PHASE 1

Investigation, development and design work on collectors and related system analysis

Dipl. Ing. H. Grallert, Messerschmitt-Bolkow-Blohm GmbH, Postfach 801169, 8000 Munchen 80

MODULAR SOLAR DOMESTIC HEATING SYSTEM - PHASE 2

Development of collectors for high operating temperatures

Dipl. Ing. Grallert, Messerschmitt-Bolkow-Blohm GmbH, Postfach 801169, D-8000 Munchen

DEVELOPMENT OF LARGE-SCALE INDUSTRIAL PRODUCTION METHODS FOR COMPONENTS OF SOLAR HEATING SYSTEMS

Development of airtight solar collector housing

Dr. Feasel and Dr. Ing. Moller, Metallgesellschaft AG, Postfach 3724, D-6000 Frankfurt/M 1

DEVELOPMENT OF LARGE-SCALE INDUSTRIAL PRODUCTION METHODS FOR COMPONENTS OF SOLAR HEATING SYSTEMS

Development of production methods for components of solar heating systems, in particular high efficiency solar collectors

Dr. Ing. Moller, Metallgesellschaft AG, Postfach 3724 D-6000 Frankfurt/M 1

DEVELOPMENT OF LARGE-SCALE INDUSTRIAL PRODUCTION METHODS FOR COMPONENTS OF SOLAR HEATING SYSTEM

Development of solar collectors with selective absorbers on aluminum Roll-Bond heat exchangers

Dr. Ing. Moller, Metallgesellschaft AG, Postfach 3724, D-6000 Frankfurt/M 1

DEVELOPMENT OF LARGE-SCALE INDUSTRIAL PRODUCTION METHODS FOR COMPONENTS OF SOLAR HEATING SYSTEMS

Further development of aluminum Roll-Bond Absorbers

Dr. Ing. Moller, Metallgesellschaft AG, Postfach 3724, D-6000 Frankfurt/M 1

RATIONAL USE OF ENERGY AND UTILIZATION OF SOLAR ENERGY IN BUILDING

Development of high efficiency solar collectors

Dr. H. Horster, Forschungslaboratorium, Philips GmbH, Aachen, Postfach 1980, D-5100 Aschen

SOLAR HEATING SYSTEM FOR UNTERENSINGEN GYMNASIUM (HIGH SCHOOL)

Development of energy saving sanitary installation for a gymnasium using solar hot water supply system

Messrs. Staub and Mayor, Fa. Solarheiztechnik GmbH, Unterensingen, Kelterstr. 43, D-7441 Unterensingen

ITALY

EVALUATION AND TEST PROCEDURES FOR SOLAR COLLECTOR

Construction of outdoor-indoor test facilities for solar collector testing

dott, ing. Gino Cherubini, CRAIES, Lungadige Galtarossa, 8 37100 Verona

FLAT-PLATE SOLAR ENERGY COLLECTOR

Development of flat-plate solar energy collector with rubber absorber

Ing. Attilio Angioletti, Ing. Edoardo Robecchi, Industrie Pirelli S.p.A., P. za Duca d'Aosta, 3 20100 Milan

EFFECT OF PHYSICAL AND OPERATIVE PARAMETERS ON SOLAR COLLECTORS HEAT TRANSFER COEFFICIENTS

Study and evaluation of solar collectors relating to their heat transfer phenomena

S. Salvigni, Instituto di Fisica Technica, Facolta' di Ingegneria, Viale Risorgimento No. 2, 43136 Bologna

DESIGN OF NON-FOCUSING COLLECTORS: TEMPERATURE RANGE: 90-130°C

Study and design of simple non-focusing solar collectors for retrofit systems and to supply heat to absorption cooling machines

Prof. Ing. Giorgio Beccali, Instituto di Fisica Technica, Facolta' di Ingegneria, Viale delle Scienze, 90128 Palermo

RADIATIVE EXCHANGE COMPONENTS

Development and economic study of selective surfaces

Prof. Ing. Claudio Pisoni, Fisica Technica e. Impianti Termotecnici, Facolta' Ingegneria-Universita-Genova Via all'Opera Pia, 11 , I 16145 Genova

JAPAN

RESEARCH AND DEVELOPMENT OF SOLAR COLLECTORS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS IN MULTI-FAMILY RESIDENCE

Development of solar collector for driving a solar heat actuated air conditioner (Rankine cycle engine)

Mr. T. Fukunaga, Ishikawajima-Harima Heavy Industries Co. Ltd. 2-16 3 Toyosu, Koto-ku, Tokyo 135-91

SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM FOR LARGE BUILDING

Development of new and economic solar collectors for solar heating, cooling and hot water supply system in large building

Mr. K. Shimokawa, Kawasaki Heavy Industries, Ltd., 2-14, Higashi Kawasakicho, Ikuta-ku, Kobe

DEVELOPMENT OF TUBULAR EVACUATED SOLAR COLLECTOR

Development of high efficiency tubular evacuated solar collector

Mr. K. Kobayashi, Mitsubishi Electric Corp., 2-3 Marunouchi 2-chome, Chiyoda-ku Tokyo

GLASS HONEYCOMB COLLECTOR

Development of glass honeycomb collectors for solar heating, cooling and hot water supply systems

Mr. K. Watanabe, Nippon Sheet Glass Co., Ltd., 4-8 Dosho-machi, Higashi-ku, Osaka

DEVELOPMENT OF TUBULAR EVACUATED SOLAR COLLECTOR

Development of high efficiency solar collectors for solar heating, cooling and hot water supply systems

Mr. K. Hinotani, Research Center, Sanyo Electric Co., 1-18-13, Hashiridani, Hirakata, Osaka

RESEARCH AND DEVELOPMENT OF SOLAR ENERGY SPACE HEATING, COOLING AND HOT WATER SUPPLY SYSTEM

Development of solar collectors and collector materials on aluminum Roll-Bond absorbers, as well as large-scale production technologies

Mr. Y Asano, Showa Aluminum K.K., 480 Inuzuka, Oyama Tochigi 323

RESEARCH AND DEVELOPMENT OF PLASTIC MATERIALS FOR SOLAR COLLECTOR

Development of selective transparent plastic film, plastic honeycomb and selectively absorbing coating materials

Mr. M. Inoue, Toray Industries, Inc., 2-2 Nihonbashi-Marunouchi, Chuo-ku, Tokyo

NETHERLANDS

DEVELOPMENT OF AN AIR-COOLED COLLECTOR

Development and testing of a simplified, easy to install air-cooled collector

Ing. J.M. van Heel, Bouwcentrum, Binnemilieutechniek, Weena 700-Postbus 299, Rotterdam

DEVELOPMENT OF AN INTEGRATED COLLECTOR HEAT-STORAGE SYSTEM FOR LOW-COST HOUSING PROJECTS

Development of an inexpensive and durable air-cooled collector combined with heat storage

Ing. J. M. van Heel, Bouwcentrum

DEVELOPMENT OF AN INTEGRATED SOLAR BOILER SYSTEM

Fabrication studies of solar collectors with durable selective coatings

Mr. J.B. Mulder, Calcol B.V., Binnenhoek 34, P.O. Box 7 Tiel

NATURAL CONVECTION IN FLAT PLATE SOLAR COLLECTORS

Investigation of free convective heat loss across parallel plates in solar collectors

Ir. W.M.M. Schinkel, Heat Transfer Group, Applied Physics, Delft University of Technology, P.O. Box 5046 2600 GA-Delft, Lorentzweg 1, Delft

FLAT PLATE SOLAR COLLECTOR WITH HALOGINATED CARBONS AS THE HEAT TRANSFER MEDIUM

Development of liquid heating collectors with fluorocarbons as heat medium

Ir. M.F.G. van der Jagt., Delft University of Technology, Laboratory for Refrigerating Engineering, Mekelweg 2 Delft

SPECTRAL SELECTIVE LAYERS FOR PHOTOTHERMAL CONVERSION OF SOLAR ENERGY

Investigation on improvement of selectivity and durability of some spectral selective surfaces for low and high temperature application

Dr. M. van der Leij, Heat Transfer Group, Applied Physics, Delft University of Technology, P.O. Box 5046, 2600 GA-Delft, Lorentzweg 1, Delft

HEAT TRANSFER IN FINNED AIR COLLECTORS

Analysis of heat transfer to inclined finned plates of air heating collector and its design

Mr. J. J. Feijen, Lab. Heat Technology, Eindhoven University of Technology, Postbox 513, Eindhoven

DEVELOPMENT OF ECONOMICAL SOLAR DOMESTIC WATER HEATING AND SPACE HEATING SYSTEMS, IN PARTICULAR SOLAR COLLECTORS

Development of low, medium and high temperature liquid flat plate collectors

Mr. M. Baardman, Energie Besparende Systemen E.B.S., 5360 AB Post Office Box 95, Grave

HEAT PIPE COLLECTOR FOR LOW TEMPERATURES

Application of the heat pipe principle to design a low temperature solar collector

Prof. Dr. Ir. J. C. Francken, Technical Physics Laboratory, University of Groningen, Zernikelaan, Nijenborgh 18, 9747 AG Groningen

INVESTIGATION OF THE PHYSICAL PROPERTIES OF SPECTRAL SELECTIVE LAYERS

Studies on optimal selective absorption layers for use in different types of solar collectors

Ir. M. Sikkens, Technical Physics Laboratory, University of Groningen, Zernikelaan, Nijenborgh 18, 9747 AG Groningen

DEVELOPMENT OF DURABLE SELECTIVE COATINGS OF HIGH PERFORMANCE COLLECTORS

Development of flat plate solar collectors with glass lined absorber plate with high efficiency and durability

Ir. C. den Ouden, Institute of Applied Physics TNO-TH, P.O. Box 155 Delft

PRODUCTION AND DEVELOPMENT OF FLAT PLATE ALUMINUM AND STAINLESS STEEL SOLAR COLLECTORS

Development of high efficiency, durable, easily installed and low-cost collectors

Ir. J.Th. Rutgers, Nijs & Vale B.V., Nijverheidsweg 19, P.O. Box 95, Nijmegen

RESEARCH AND DEVELOPMENT ON SOLAR-THERMAL COMPONENTS

Research and development of flat plate collectors, heat pipe configurated tubular collector, and line concentrating Fresnel strip mirror collector with sun tracking mechanism

Dr. Ir. S.H.A. Begemann, N.V. Philips Gloeilampenfabrieken, Energy System Department, Building TAM-3, Eindhoven

SOLAR WATER HEATING SYSTEMS

Research and development of water heating solar collectors

Mr. C. J. Taylor, Van Leer South Africa (Oty) Ltd., Amsterdamseweg 206, P.O. Box 25, Amstelveen

DEVELOPMENT OF A LOW-COST FLAT PLATE COLLECTOR

R & D of a high temperature-resistant liquid collector for heating, cooling and hot water supply systems

Ir. J. A. Ouwejan/H.P. Sombroek Zaandam B.V., Aris van Broekweg 9, P.O. Box 180, 1500 ED Zaandam

RESEARCH AND DEVELOPMENT ON FLAT PLATE AND CONCENTRATING SOLAR COLLECTORS

Research and development of solar collectors with optimal cost performance properties

Mr. G. Brouwer, Raadgevens Technies Buro, Van Heugten B.V. St. Annastraat 145, P.O. Box 305 Nijmegen

NEW ZEALAND

DEVELOP LOW COST SOLAR COLLECTOR
Development of low cost solar collector for mass production
Dr. R.F. Benseman, Physics & Engineering Lab., DSIR
Private Bag, Gracefield, Lower Hutt

DEVELOP PACKAGED SOLAR WATER HEATER
Production of a packaged ground-mounted solar collector/ tank for use in schools
Dr. R. F. Benseman, PEL, DSIR

INTEGRATED SOLAR WATER HEATING SYSTEM
Materials study, evaluation and design of solar collector
Mr. K. Jones, L.J. Fisher & Co., Box 2183, Auckland

DEVELOP SOLAR WATER HEATER FOR DOMESTIC USE
Development of solar water heater for domestic use
Mr. John Fogarty, John Fogarty Ltd., 89 Crinan St., Ivercargill

PRECOMMERCIAL DEVELOPMENT OF DSIR SOLAR WATER HEATING PANELS
Tooling and design for factory production of solar heating panels
Mr. K. Kibblewhite, Morrison Industries Ltd., Private Bag, Hastings

DEVELOP ECONOMIC DOMESTIC SOLAR WATER HEATER
Study on cost reduction of solar equipment
O.M. Kendon, Zip Holdings Ltd., Box 30-669, Lower Hutt

SWEDEN

RESEARCH AND DEVELOPMENT OF SEMICONCENTRATING COLLECTORS FOR APPLICATION IN EXISTING BUILDINGS
Development and testing of a semiconcentrating solar collector for tap hot water production in existing buildings
Messrs. R. Roseen, H. Zinko, AB Atomenergi, Fack, 611 01 Nykoping

SOLAR ENERGY AND BUILDINGS - THERMAL EMISSIVITY OF SURFACES
Studies on emissivity measurement of selective surface materials
Messrs. B. Carlsson, H. Stymne and G. Wettermark, Division of Physical Chemistry, Royal Institute of Technology Fack, S-100 44 Stockholm 70

AMPLITERM
Development of energy saving system for residential houses with air-liquid solar collector
Mr. G. Jansson, AB Svenska Flaktfabriken, Equipment Division, Fack, 551 84 Jonkoping

SWITZERLAND

DEVELOPMENT OF A SOLAR COLLECTOR USING GLASS TILES
Development of aesthetic solar collector by the use of transparent tiles
Battelle, Geneva Research Center, 7 Route de Drize 1227 Geneva

STUDY OF PASSIVE SOLAR COLLECTOR SYSTEMS
Material and structural research for passive walls and comparison of their solar gain
Messrs. A. Faist and J.B. Gay, Ecole Polytechnique Federale Lausanne, Groupe Energie Solaire, 14, Avenue de l'Eglise Anglaise, CH 1006 Lausanne

THE SEMI-TRANSPARENT SOLAR WALL COLLECTOR CONCEPT
Development of semi-transparent solar wall air collector
Messrs. A. Faist and J.B. Gay, Ecole Polytechnique Federale de Lausanne, 14, Av. Eglise-Anglaise, 1001 Lausanne

U.S.A.

NONIMAGING COLLECTOR DEVELOPMENT
Development and demonstration of improved performance stationary concentrating collectors capable of operating at 300-350^{o}F at greater than 40% efficiency
Mr. K. A. Reed, Argonne National Laboratory, Argonne, Illinois 60439

DEVELOPMENT OF IMPROVED COVER PLATE FOR SOLAR ENERGY COLLECTORS
Development of honeycomb core cover plates with plastic or thin glass skins for material and collector evaluation, fabrication development and technology transfer
Mr. T. D. Chikalla, Battelle, Pacific Northwest Laboratories, Battelle Blvd., Richland, Wash. 99352

DEVELOPMENT OF LOW TEMPERATURE BLACK LIQUID SOLAR COLLECTOR
Development of an efficient, cost-effective, and reliable low temperature, non-concentrating, black-liquid collector
Dr. Karl Landstrom, Battelle Columbus Labs, 505 King Avenue, Columbus, OH 43201

TRANSPARENT GLASS HONEYCOMB STRUCTURES FOR ENERGY LOSS CONTROL
Development of glass honeycombs for suppressing natural convection and radiation losses within flat plate collectors
Mr. H. Buchberg, University of California, School of Engineering and Applied Sciences, Los Angeles, California 90024

VISCOSITY STABILIZED SOLAR PONDS (PHASE 1)
Investigation of the use of various thickeners to increase the viscosity of water in salt gradient solar ponds
Mr. L.H. Shaffer, Center for the Environment and Man Inc., 275 Windsor St., Hartford, Conn. 06120

RESEARCH ON EVACUATED TUBULAR SOLAR COLLECTORS UTILIZING A HEAT PIPE

Solar collector design on heat pipe tubular absorber with selective coating and anti-reflecting film in vacuum encapsulation

Mr. U. Ortabasi, Corning Glass Co., Lighting Products Division, Corning, New York 14380

DOUBLE-EXPOSURE COLLECTOR SYSTEM

Design of double-exposure collector system and comparison with conventional flat-plate collectors

Drexel University, 32nd and Chestnut, Philadelphia, PA 19104

RESEARCH ON FLAT PLATE SOLAR COLLECTORS EMPLOYING THE HEAT PIPE PRINCIPLE FOR HEATING AND COOLING OF BUILDINGS

Investigation of modular flat plate collectors with heat pipes

Mr. W. Bienert, Dynatherm Corp., 1 Industry Lane, Cockeysville, Md. 21030

DEVELOPMENT OF SOLAR HEAT SUPPLY SYSTEM WITH FIXED MIRROR CONCENTRATORS

Design of an efficient receptor/heat exchanger in fixed mirror strip system

Dr. R.J. Williams, Georgia Institute of Technology, College of Engineering, Atlanta, GA 30332

STUDY OF CORROSION AND ITS CONTROL IN ALUMINUM SOLAR COLLECTORS

Investigation of corrosion mechanism of aluminum and aluminum alloys used in solar collectors and its control

Mr. J. Giner, Giner Inc., 14 Spring St., Waltham, Mass. 02154

LOW COST SOLAR AIR HEATERS

Improvement of thermal performance of flat plate air heating collectors by jet air impingement

Mr. D.R. Rask, Honeywell, Inc., 2600 Ridgeway, Minneapolis, Minn. 55413

OPTIMIZATION OF COATINGS FOR FLAT PLATE SOLAR COLLECTORS

Investigation and development of absorber coatings and antireflection coatings for flat plate collectors

Mr. R.J.H. Lin, Honeywell Inc., 2600 Ridgeway, Minneapolis, Minn. 55413

ANALYSIS, DESIGN, FABRICATION, AND TESTING OF MODERATELY CONCENTRATING SOLAR ENERGY COLLECTORS

Development of V-trough moderately concentrated solar collector capable of driving refrigeration machines

Messrs. J.R. Howell and R.B. Banerot, University of Houston, Dept. of Mechanical Engineering, 3801 Cullen Blvd., Houston, Texas 77004

EXPOSURE TESTING AND EVALUATION OF SOLAR COLLECTOR MATERIALS

Establishment of comprehensive objective criteria for test and evaluation of materials which are candidates for solar collectors

Mr. J. Gilligan, IIT Research Institute, 10 West 35th St., Chicago, Illinois 60616

FIXED TILT SOLAR COLLECTOR EMPLOYING REVERSIBLE VEE-TROUGH REFLECTORS AND VACUUM TUBE RECEIVERS

Development of a solar collector with vacuum receiver and a twice-a-year reversible vee reflector

Dr. M. Selcuk, Jet Propulsion Lab., 277/202, Pasadena, CA 91103

INFLATED CYLINDRICAL CONCENTRATORS FOR INDUSTRIAL PROCESS HEAT

Development of a cost effective non-tracking concentrating collector capable of producing industrial process steam at 170°C using thin fiber plastics

Mr. William C. Dickinson, Lawrence Livermore Laboratory, P.O. Box 808, Livermore, CA 94550

LOW COST SOLAR COLLECTORS OF PACKED BED DESIGN

Investigation of naturally occurring black materials for low cost solar collector absorbers

Mr. D.R. Simpson, Lehigh University, Dept. of Geological Sciences, Bethlehem, PA 18015

OPTIMIZATION OF THIN-FILM TRANSPARENT PLASTIC HONEYCOMB COVERED FLAT PLATE SOLAR COLLECTOR

Design for efficient high temperature flat plate collector with cellular structure

Mr. R. K. Wedel, Lockheed Research Laboratory, 3215 Hanover Street, Palo Alto, CA 94303

INTEGRATED SOLAR COLLECTOR ROOF STRUCTURES

Continuous operational study of integrated solar collectors with selective surfaces

Dr. J.D. Balcomb, Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, N.M. 87545

INTEGRATED ZEOLITE COLLECTORS

Development of an integrated collector utilizing the absorption and desorption of water from molecular sieve zeolites

Dr. D.I. Tchernev, Massachusetts Institute of Technology, Cambridge, MA 02139

PERFORMANCE CHARACTERISTICS OF THERMIC DIODE SOLAR PANELS

Development of thermic diode solar panel as passive solar collection and storage device

Mr. S. Buckley, Massachusetts Institute of Technology, Cambridge, MA 02139

ADDITION OF SOLAR AIR-HEATERS TO PRE-ENGINEERED METAL BUILDINGS

Modification of an existing solar heated building which utilizes the metal skin of the building as the major component of the collector

Dr. R.E. Forbes and Dr. R. McClendon, Mississippi State University, Drawer ME, Mechanical Engineering, Mississippi State, MS 39762

MEDIUM TEMPERATURE AIR HEATERS BASED ON DURABLE TRANSPARENT FILMS

Design, construction and performance testing of a low-cost, non-concentrating flat plate collector

Mr. G.C. Ball, Monsanto Research Corp., Dayton Laboratory, Dayton, OH 45407

DEVELOPMENT OF METHODS FOR EVALUATION AND TEST PROCEDURES FOR SOLAR COLLECTORS AND THERMAL STORAGE DEVICES

To develop standard test methods for determining the thermal performance of solar collectors and thermal storage devices for solar heating, cooling and hot water supply systems

Dr. J. E. Hill, National Bureau of Standards, Gaithersburg, Maryland 20767

A DEMONSTRATION SALT GRADIENT SOLAR POND

Establishment of the operational parameters of a salt gradient solar pond

Dr. H.C. Bryant, University of New Mexico, Department of Physics and Astronomy, Albuquerque, NM 87131

DEVELOPMENT OF A DRAINABLE EVACUATED, TUBULAR, SELECTIVITY COATED, LIQUID COOLED SOLAR COLLECTOR ARRAY

Development of a method to drain the SUNPAK evacuated tubular liquid cooled collector to avoid problems of freezing, boiling, and nighttime heat loss

Messrs. Y.K. Pei and D.C. Beekley, Owens-Illinois, P.O. Box 1035, Toledo, OH 43666

EVALUATION OF AN ALL-GLASS, EVACUATED, TUBULAR, NON-FOCUSING, NON-TRACKING SOLAR COLLECTOR ARRAY

Evaluation of an advanced evacuated tubular collector for air heating

Mr. K. Moan, Owens-Illinois, P.O. Box 1035, Toledo, Ohio 43666

DEVELOPMENT OF VERY LOW COST, NON-CONCENTRATING COLLECTORS

Development of concrete air heating collectors which are also used to construct south-facing walls

P.R. Payne, Payne, Inc., 1933 Lincoln Dr., Annapolis, MD 21401

DEVELOPMENT OF A FREEZE-TOLERANT SOLAR WATER HEATER USING CROSS-LINKED POLYETHYLENE

Material research and testing on freeze-tolerant solar collector absorbers

Mr. J. M. Bradley, Polyset Inc., 7 Summer St., Manchester, Mass. 01944

IMAGE COLLAPSING CONCENTRATORS

Development of wide angular Fresnel lenses and cylindrical rod geometries with subreflecting mirrors to improve concentration ratios and optical aperture efficiencies

C. J. Sletten, Solar Energy Technology, Inc., Civil Terminal Building, L.G. Hanscom Field, Bedford, MA 01720

IMPROVEMENT OF SOLAR AIR HEATERS

Improvement of thermal performance of air heating collectors

Mr. B. E. Cole-Appel, Solaron Corp., 4850 Olive St., Commerce City, Colo. 80022

HIGH TEMPERATURE LIQUID HEATERS (170-230°F) FOR SOLAR HEATING AND COOLING APPLICATIONS

Design of a low-cost, light-weight, flat plate collector with high performance over wide range of temperature levels and insolation values

R.A. Newton, Solation Products, Inc., 111 West Road, Cortland, NY 13045

DOUBLE ABSORBER PLATE SOLAR AIR HEATERS

Cost reduction and reliability studies on the Sun Systems Air Heater

Dr. Elliot Berman, Sun Systems, Inc., 170 Granite Avenue, Dorchester, MA 02124

STRUCTURAL INTEGRITY OF SOLAR COLLECTORS

Analytical and design studies of collectors and support structures, to define wind load requirements and increase structural efficiency

Mr. Howard L. Chevalier, Texas A&M Research Foundation, F.E. Box H, College Station, TX 77843

ENGINEERING ANALYSIS AND TESTING OF WATER-TRICKLE COLLECTORS

Evaluation and testing of water-trickle collectors

Mr. J. T. Beard, University of Virginia, School of Engineering, Charlottesville, Virginia 22901

METHODS FOR REDUCING HEAT LOSSES FROM FLAT PLATE COLLECTORS

Investigation of convection suppression in honeycomb and corrugated absorbers

Mr. K.G.T. Hollands, University of Waterloo, Department of Mechanical Engineering, Toronto, Canada M5S1A4

GROOVED FOAMGLAS SOLAR AIR HEATER

Optimization and testing of a cost-effective hybrid air to water solar collector system

Mr. J.L. Loth, Dept. of Aerospace Engineering, West Virginia University, Morgantown, WV 26506

AN INTERFEROMETRIC STUDY OF NATURAL CONVECTION CHARACTERISTIC OF FLAT PLATE AND VEE-CORRUGATED SOLAR COLLECTORS

Investigation of heat transfer relationship for natural convection between solar collector absorber plates and transparent cover

Messrs. J. Mitchell and M.M. El-Wakil, University of Wisconsin, Solar Energy Laboratory, 1500 Johnson Drive Madison, Wisconsin 53706

THERMAL ENERGY STORAGE

AUSTRIA

DOMESTIC WATER HEATING AND SPACE HEATING WITH SOLAR ENERGY
Development and testing of economic domestic water heating systems
Prof. P.V. Gilli, Arbeitsgemeinschaft Sonnenergie, Obere Techstrasse 21/1, A-8010 Graz

SOLAR ENERGY TEST STATIONS IN AUSTRIA
Studies on systems for space heating, domestic hot water heating, and swimming pool heating
Austrian Solar and Space Agency, Garnisongasse 7, A-1090 Vienna

DEVELOPMENT OF A PROTOTYPE OF AN INEXPENSIVE PLASTIC STORAGE SYSTEM
Development of a low temperature storage system with high economic efficiency, long life-time and good insolation
Prof. Dr. Erich Panzhauser, Institut fur Hochbau und Entwerfen 1, University of Technology, Karlsplatz 13 A-1040 Vienna

COMPACT SOLAR SYSTEM FOR DOMESTIC WATER HEATING
Development of solar system for domestic hot water heating for a single-family house
Dr. George Turnheim, Vereinigte Metallwerke Ranshaofen-Berndorf, Postfach 35, A-2560 Berndorf

BELGIUM

SOLAR ENERGY AND LOW LEVEL CYCLIC ENERGY FLOW (20 to 100°C) STORAGE AS CHEMICAL BOND ENERGY OF COMPOUNDS UNDERGOING THERMAL DECOMPOSITION
Research on materials used for reversible reaction by means of solar heat or low level heat.
Prof. J. Bougard and Mr. R. Jadot, Faculte Polytechnique de Mons, rue de Houdain, 7000 Mons

DENMARK

HEAT STORAGE IN A SOLAR HEATING SYSTEM USING SALT HYDRATES
Development of an energy storage sub-system using sodium sulfate as a storage medium, with new techniques
Mr. S. Furbo, Thermal Insulation Laboratory, Bldg. 118 Technical University of Denmark, DK-2800 Lyngby

GERMANY

LONG TERM ACCUMULATOR FOR DWELLING PREMISES AND SOLAR HOUSE ARCHITECTURE

Development of long term accumulator for low temperature heat with water as storage medium

Dr. Ing. B. Dietrich, Energietechnik GmbH, Freihofstr. 31, D-4307 Kettwig

MODULAR SOLAR DOMESTIC HEATING SYSTEM - PHASE 1

Investigation, development and design of storage media and storage container

Dipl. Ing. Grallert, Messerschmitt-Bolkow-Blohm GmbH, Postfach 801169 D-8000 Munchen 80

MODULAR SOLAR DOMESTIC HEATING SYSTEM - PHASE 2

Demonstration and optimization of water accumulator

Dipl. Ing. Grallert, Messerschmitt-Bolkow-Blohm GmbH, Postfach 801169 D-8000 Munchen 80

RATIONAL USE OF ENERGY AND UTILIZATION OF SOLAR ENERGY IN BUILDINGS

Design, testing and evaluation of energy storage sub-system

Dr. H. Horster, Philips GmbH, Forschungslaboratorium, Aachen, Postfach 1980, D-5100 Aachen

JAPAN

RESEARCH AND DEVELOPMENT OF HEAT STORAGE FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS IN MULTI-FAMILY RESIDENCE

Development and evaluation of thermal storage phase change media and system integration

T. Fukunaga, Ishikawajima-Harima Heavy Industries Co. Ltd., 2-16, 3 Toyosu, Koto-ku, Tokyo 135-91

SOLAR HEAT STORAGE

Development of heat storage system utilizing latent heat from the collector which is supplied to a Rankine cycle engine

Mr. J. Kai, Mitsubishi Electric Corp., 2-3 Marunouchi 2-chome, Chiyoda-ku, Tokyo

SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM FOR LARGE BUILDINGS

Development of economical and innovative heat storage equipment

Yasuo Tanaka, Toyo Netsu Kogyo Kaisha, Ltd., 2-5-12 Kyobashi, Chuoku, Tokyo

NETHERLANDS

DEVELOPMENT OF A CONCRETE HEAT STORAGE SYSTEM
Development of a low-cost, durable, concrete heat storage system
Ing. J. M. van Heel, Bouwcentrum, Binnenmileiutechniek Weena 700-Postbus 299, Rotterdam

DEVELOPMENT OF AN INTEGRATED COLLECTOR HEAT-STORAGE SYSTEM FOR LOW COST HOUSING PROJECTS
Development of an air cooled collector combined with heat storage
Ing. J.M. van Heel, Bouwcentrum

SOLAR BOILERS FOR DOMESTIC HOT WATER SUPPLY AND SOLAR HEATING INSTALLATIONS FOR SWIMMING POOLS
Improvement and integration of hot water storage tanks
Ir. P.G.S. Rutten, Bronswerk B.V. Heating and Airconditioning Dept., Brabantsestraaat 10, P.O. Box 28 Amersfoort

DEVELOPMENT OF AN INTEGRATED SOLAR BOILER SYSTEM
Fabrication of storage boiler
Mr. J.B. Mulder, Calcol B.V. Binnenhoek 34 P.O. Box 7, Tiel

USE OF SOIL AS A STORAGE MEDIUM FOR SEASONAL STORAGE OF SOLAR ENERGY IN RELATION WITH THE SOIL COMPOSITION AND THE BOUNDARY CONDITIONS
Investigation of various soil conditions and solar heating systems to achieve long term heat storage to provide 100% solar heating to a group of houses
Ir. W.J. Heijnen, Delft Soil Mechanics Laboratory, Stieltjesweg 2, P.O. Box 69, Delft

HEAT STORAGE IN PHASE CHANGE MATERIALS
Design, construction and testing of a thermal energy storage system based on phase change materials
Ir. H. van Ooijen, Heat Transfer Group, Applied Physics Delft University of Technology, P.O. Box 5046, 2600 GA-Delft Lorentzweg 1, Delft

INTEGRATION OF WATERTANK STORAGE, HOT WATER BOILER AND AUXILIARY HEATER
Development of an integrated storage-heater unit of cost-effective design
Mr. J.P. Simon Thomas, Eindhoven University of Technology, Laboratory of Heat Technology, P.O. Box 513 Eindhoven

SEASONAL STORAGE OF SOLAR HEAT IN THE GROUND
Development of economically viable and practicable methods for the seasonal storage of solar heat in the ground
Mr. L.S. Fischer, Eindhoven University of Technology, Laboratory of Heat Technology P.O. Box 513 Eindhoven

RESEARCH AND DEVELOPMENT ON SOLAR-THERMAL COMPONENTS

Reversible chemical reaction for long term energy storage (100 - 400°C)

Dr. Ir. S.H.A. Begemann, N.V. Philips Gloeilampenfabriken, Energy System Department, Building TAM-3, Eindhoven

INVESTIGATION ABOUT USING THE SOIL AS A NATURAL HEAT SOURCE FOR HEAT PUMPS

Research, simulation, and calculations related to use of soil as media for heat storage and extraction of heat for use in heat pumps

Ir. P.G.M. Nievergeld, TNO, Central Technical Institute, Laan van Westenenk 501, P.O. Box 342, Apeldoorn-Zuid

COMPUTER SIMULATION OF A HEATING SYSTEM CONSISTING OF A HEAT PUMP IN COMBINATION WITH SOLAR COLLECTORS

Evaluation of heat storage system with heat pump system

Ir. H. van der Ree, Central Technical Institute, TNO, Laa van Westenenk 501, P.O. Box 342, Apeldoorn-Zuid

DEVELOPMENT OF A THERMAL STORAGE SYSTEM BASED ON ENCAPSULATED P.C.M MATERIALS

Development of a short term storage system with encapsulated phase change materials

Ir. C. den Ouden, Institute of Applied Physics TNO-TH, P.O. Box 155, Delft

DEVELOPMENT OF A REACTION VESSEL OF A THERMAL STORAGE SYSTEM USING THE HEAT OF ADHESION

Design of a reaction vessel or room which uses the heat of adhesion for short or long term storage

Ir. C. den Ouden, TNO, Institute of Applied Physics, P.O. Box 155 Delft

PHOTOCHEMICAL STORAGE OF SOLAR ENERGY FOR HEATING OF HOUSES AND BUILDINGS

Development of photochemical storage of solar energy in organic model system at low temperature

Dr. A. Mackor, Institute for Organic Chemistry TNO, P.O. Box 5009 3502 JA Utrecht

SOLAR ENERGY AS A COMPLEMENTARY SOURCE OF ENERGY FOR DOMESTIC HEATING AND HOT WATER SUPPLY

Analysis and design of solar heat storage system for domestic heating and hot water supply

Ir. A.C. Koelewijn, VEG-Gasinstituut n.v., Wilmersdorf 50, P.O. Box 137, Apeldoorn

NEW ZEALAND

SOLAR SPACE HEATING OF HOUSES IN NEW ZEALAND
Design of solar energy storage in the floor and wall
Prof. H. Marshall, School of Agriculture, University of Auckland, Private Bag, Auckland

DEVELOP PACKAGED SOLAR WATER HEATER
Production of packaged ground-mounted solar collector/tank system for school
Dr. R.F. Benseman, PEL, DSIR, PEL

SWEDEN

ENERGY STORAGE BY MODIFIED USE OF SALT HYDRATES
Study of the prevention of phase separation in latent heat energy storage materials
Mr. H. Hedman, AB Atomenergi, Studsyik, Fack S-611 01 Nykoping

SOLAR ENERGY AND BUILDINGS--STORAGE OF LOW TEMPERATURE HEAT IN SALT HYDRATE MELTS
Investigation of salt hydrates for use as latent heat storage material
Messrs. B. Carlsson, H. Stymne and G. Wettermark, Division of Physical Chemistry, Royal Institute of Technology Fack, S-100 44 Stockholm 40

SWITZERLAND

HYBRID FLUID HEAT STORAGE UNIT
Evaluation of the performance of a hybrid heat storage using air as heat charging fluid and water as heat discharging fluid
Mr. A. Faist, Ecole Polytechnique Federale de Lausanne 14, Av. de l'Eglise Anglaise 1001 Lausanne

THERMAL ENERGY STORAGE BY LATENT HEAT OF FUSION
Development of energy storage units using the latent heat of fusion in hot water preparation
Prof. Ph. Javet, Ecole Polytechnique Federale, Institut de Genie Chimique, 140, rue de Centre, CH 1025 St-Sulpice

U.S.A.

EXPERIMENTAL AND COMPUTER STUDIES OF THERMAL STRATIFICATION IN WATER STORAGE TANK
Study of thermal stratification in storage tank and computer simulation and verification of liquid storage tank performance
The University of Alabama, P.O. Box 1247, Huntsville, AL 35807

INVESTIGATION OF METHODS TO TRANSFER HEAT FROM SOLAR LIQUID HEATING COLLECTORS TO HEAT STORAGE TANKS

Development of optimized criteria for cost-effective methods of transferring heat from solar collector to winter storage system

Mr. F. deWinter, Altas Corp. 2060, Walsh Ave., Santa Clara, CA 95050

HYBRID THERMAL STORAGE WITH WATER

Studies of the engineering and cost data related to design of hybrid thermal storage systems

Mr. M. Moriarity, Atomics International, 8900 DeSoto Avenue, Canoga Park, CA 91304

DEVELOPING AND UPGRADING OF SOLAR SYSTEM THERMAL ENERGY STORAGE SIMULATION MODELS

Standardization, upgrading, and validation of existing thermal energy storage models

Mr. R.T. Haelsig, Boeing Computer Services Company, P.O. Box 24346, Seattle, WA 98124

SOLID PHASE ABSORBENT AIR CONDITIONING STUDIES

Design, construction, and testing of a solar air conditioner using a solid phase inorganic salt as the absorbent, and water as the refrigerant, with dehydrated inorganic salts providing energy storage, as well

Mr. P.O'D. Offenhartz, EIC Corporation, Newton, MA 02158

THERMAL ENERGY STORAGE BY MEANS OF SATURATED AQUEOUS SOLUTIONS

Investigation of sensible heat storage systems using saturated aqueous solutions and design of engineering prototype for off-peak air conditioning application and solar space heating/cooling

Mr. K.W. Kauffman, Franklin Institute Research Labs, 20th and Race Streets, Philadelphia, PA 19103

SELF-CONTROLLING, SELF-PUMPING HEAT CIRCULATION SYSTEM STUDY

Evaluation of self-pumping methods and devices will be studied and selected schemes recommended for development

G.P. Wachtell, Franklin Institute Research Laboratories, 20th and Race Streets, Philadelphia, PA 19103

TWO-COMPONENT THERMAL STORAGE MATERIAL STUDY-PHASE II

Development of a storage medium consisting of micro-encapsulated phase change material in a packed bed with a water heat transfer medium

Mr. A.T. Tweedie and Mr. E.M. Mehalick, General Electric Co., Advanced Energy Programs, P.O. Box 8555, Philadelphia, PA 19101

DEVELOPMENT OF METHODS OF EVALUATIONS AND TEST PROCEDURES FOR SOLAR COLLECTORS AND THERMAL STORAGE DEVICES

Development of standard test methods for determining thermal performance of solar collectors and thermal storage devices for heating and cooling of buildings

Dr. J. E. Hill, National Bureau of Standards, Gaithersburg, Maryland

RESEARCH ON SOLAR ENERGY STORAGE SUBSYSTEM UTILIZING THE LATENT HEAT OF PHASE CHANGE OF CERTAIN ORGANIC MATERIALS

Development of heat storage subsystem utilizing latent heat of melting and solidification of organic waxes

Messrs. J.A. Bailey and J.C. Mulligan, North Carolina University, Dept. of Mech. & Aerospace Engineering, Raleigh, NC 27607

ANNUAL COLLECTION AND STORAGE OF SOLAR-HEATED WATER FOR THE HEATING OF BUILDINGS

Evaluation of a low cost system for annual collection, storage and utilization of solar heater water

Mr. J.T. Beard, University of Virginia, Dept. of Mech. Engineering, Charlottesville, Virginia 22901

AIR-CONDITIONING

DENMARK

SOLAR-POWERED REFRIGERATION BY A SOLID-ABSORPTION SYSTEM

Development of solar-powered, solid-absorption system for production of block ice, cold storage and air-conditioning

Mr. P. Worsoe-Schmidt, Refrigeration Laboratory, The Technical University of Denmark, Bldg. 402, DK-2800 Lyngby

GERMANY

MODULAR SOLAR HOUSE HEATING SYSTEM - PHASE 1

Theoretical and experimental investigation on the development of modular solar house system with refrigeration subsystem for air conditioning

Dipl. Ing. H. Grallert, Messerschmitt-Bolkow-Blohm GmbH Postfach 801169, 8000 Munchen 80

MODULAR SOLAR DOMESTIC HEATING SYSTEM - PHASE 2

Preparation of two complete research installations for demonstration of equipment

Dipl. Ing. Grallert, Messerschmitt-Bolkow-Blohm GmbH Postfach 801169, 8000 Munchen 80

RATIONAL USE OF ENERGY AND UTILIZATION OF SOLAR ENERGY IN BUILDING

Theoretical and experimental investigations in integrated energy systems with a heat pump subsystem

Dr. H. Horster, Philips GmbH, Forschungslaboratorium Aschen, Postfach 1980, D-5100 Aschen

JAPAN

R & D OF SOLAR HEAT ACTUATED AIRCONDITIONER FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM IN MULTI-FAMILY RESIDENCE

R & D on solar heat actuated Rankine cycle air-conditoner

Mr. Shinya Kameda, Ishikawajima-Harima Heavy Ind. Co. Ltd.,

DEVELOPMENT OF A LARGE SCALE ABSORPTION MACHINE OPERATED IN SINGLE EFFECT BY SOLAR ENERGY AND IN DOUBLE EFFECT BY AUXILIARY HEAT SOURCE

Development of LiBr-water absorption machine with the combination of single and double effect for solar cooling

Messrs. T. Ozono and K. Ooka, Kawasaki Heavy Industries, Ltd., Osaka Works, 1-35, 4-chome Shimaya, Konohana-ku Osaka

DEVELOPMENT OF AN AIR CONDITIONING UNIT DRIVEN BY A SOLAR POWERED RANKINE-CYCLE ENGINE

Development of an air conditioning unit driven by a solar powered Rankine cycle engine

Mr. E. Nishiyama, Mitsubishi Electric Corp., 2-21 Marunouchi, Chiyoda-ku, Tokyo

NETHERLANDS

SOLAR POWERED ABSORPTION REFRIGERATING SYSTEMS
Research and development of solar powered absorption cooling systems for air conditioning and food storage
Ir. C. Keizer, Delft University of Technology, Laboratory for Refrigerating Engineering, Mekelweg 2, Delft

RESEARCH AND DEVELOPMENT ON SOLAR-THERMAL COMPONENTS
Research and development of solar powered air-conditioning unit with absorption machine and Stirling cycle
Dr. Ir. S.H.A. Begemann, N.V. Philips Gloeilampenfabrieken, Energy Systems Dept., Building TAM-3, Eindhoven

U.S.A.

DEVELOPMENT OF A SOLAR DESICCANT DEHUMIDIFIER
Development of solar desiccant dehumidifier featuring a rotary bed of granular silica gel and a rotary regenerator
AirResearch Manufacturing Co. of California, 2525 W. 190th Street, Torrance, CA 90509

SOLAR HEATING AND COOLING SYSTEMS DESIGN AND DEVELOPMENT
Design, development, and delivery of prototype heating and cooling systems for single family, multi-family and commercial applications. Cooling subsystems of 3, 25, and 75 ton Rankine cycle machines are to be developed.
Mr. James Clark, AirResearch Manufacturing Co. of California, 2525 W. 190th Street, Torrance, CA 90509

UNITARY SOLAR HEATING/COOLING SYSTEM PACKAGE DEVELOPMENT
Development of residential 3-ton unitary absorption system and 25-ton commercial absorption chiller
Mr. R.H. Merrick, Arkla Industries, Inc., P.O. Box 534, Evansville, IN 47704

ENGINEERING, DESIGN, CONSTRUCTION AND TESTING OF A SALT WATER ABSORPTION COOLING UNIT FOR USE WITH A SOLAR COLLECTOR HEAT SOURCE
Development and testing of a 3 ton evaporatively cooled absorption chiller
Mr. R. Merrick, ARKLA Industries, Inc., 950 E. Virginia Street, P.O. Box 534, Evansville, IN 47704

SINGLE FAMILY ABSORPTION CHILLER
Investigation of optimal chemical system for absorption chiller and design and construction of prototype chiller
Mr. W.J. Biermann, Carrier Corp., Energy Systems Division, P.O. Box 4800, Syracuse, NY 13221

PROTOTYPE ENERGY RECOVERY AND SOLAR SYSTEM

Design and construction of 15 ton absorption chiller and testing of machine in experimental house

Mr. W.J. Biermann, Carrier Corp.

HIGH TEMPERATURE SOLAR POWERED WATER CHILLER DEVELOPMENT

Development of a high temperature solar powered air cooled water chiller using high speed Rankine turbine

Mr. R.A. English, Carrier Corp.

SOLAR DESICCANT AIR CONDITIONING WITH SILICA GEL

Design, construction, testing, and demonstration of a realistic desiccant air conditioning system for use with low temperature solar collectors

Mr. P. Lunde, Center for the Environment and Man Inc., 275 Windsor St., Hartford, CT 06120

SOLID PHASE ABSORBENT AIR CONDITIONING STUDIES

Design, construction, and testing of a solar air conditioner using a solid phase inorganic salt as the absorbent, and water as the refrigerant.

Mr. P. O'D. Offenhartz, EIC Corporation, Newton, MA 02158

DEMONSTRATION OF A SOLAR STEAM ENGINE FOR HEATING AND COOLING

Construction of a solar-Rankine air-conditioner with a heat rate of 14,000 Btu/hr-ton when operated in conjunction with 300^{o}F solar collectors

Mr. G. G. Martin, Energy Technology, Inc., Cleveland, Ohio 44128

SOLAR HEATING AND COOLING SYSTEMS DESIGN AND DEVELOPMENT

Development of 3 and 10 ton Rankine cycle chillers as part of design and development of single family and commercial solar heating and cooling systems

General Electric Co., Space Systems Div., Valley Forge, PA

ASSESSMENT OF SOLAR POWERED COOLING OF BUILDINGS

Comparative review and evaluation of solar powered cooling subsystems

Mr. H. Curran, Hittman Associates, Inc., 9190 Red Branch Road, Columbia, Maryland 21045

SOLAR HEATING AND COOLING SYSTEMS DESIGN AND DEVELOPMENT

Development of 3, 25 and 75 ton Rankine cycle cooling units for single-family, multi-family and commercial applications as part of development of prototype heating and cooling systems

Honeywell, Inc., Energy Resources Center, 2600 Ridgway Parkway, Minneapolis, MN

DEVELOPMENT OF A SOLAR DESICCANT DEHUMIDIFIER

Design, construction, and testing of a desiccant air conditioning system that can be operated with flat plate solar collectors

Messrs. A. Lavan and D. Gidaspow, Illinois Institute of Technology, 3110 S. State Street, Chicago, IL 60616

SOLAR DESICCANT AIR-CONDITIONER (SOLAR-MEC) DEVELOPMENT

Design optimization and hardware performance improvements of solar desiccant air conditioning system

Mr. R.A. Macriss, Institute of Gas Technology, 3424 South State Street, Chicago, IL 60616

DEVELOPMENT OF NEW FLUIDS FOR SOLAR ABSORPTION COOLING

Identification and evaluation of new candidate fluid systems for solar absorption cooling

Mr. R.A. Macriss, Institute of Gas Technology, 3424 South State Street, Chicago, IL 60616

DEVELOPMENT OF SOLAR-DRIVEN ABSORPTION AIR-CONDITIONING AND HEAT-PUMPS

Design, fabrication and testing of absorption chillers in operating regimes that are particularly suitable for solar energy applications

Kim Dao, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720

NITINOL ENGINE PROJECT

Design and fabrication of heat engine based on the thermoelastic shape memory capable of operating at temperatures obtainable from flat plate collectors

Messrs. M. Walig and R. Banks, Lawrence Berkeley Lab., University of California, Berkeley, CA 94720

DESIGN OF A SOLAR RANKINE COOLING UNIT

Design, construction, and testing of 77 ton solar powered Rankine cycle/vapor compression cycle cooler

Dr. J. Balcomb, Los Alamos Scientific Lab., Los Alamos, N.M. 87545

SOLAR COOLING COMPONENT MOOELING AND OPTIMIZATION

Detailed analysis on system performance of absorption cycle with solar components

Dr. R. Allen, University of Maryland, Mechanical Engineering Dept., College Park, Maryland 20742

INTEGRATED ZEOLITE COLLECTORS

To develop an integrated collector for solar heating and cooling systems utilizing the absorption and desorption of water from molecular sieve zeolite

Dr. D.I. Tchernev, M.I.T. Lincoln Laboratory, P.O. Box 73, Lexington, MA 02173

AIR CONDITIONING USING A REGENERATIVE GAS CYCLE

Demonstration of the applicability of regenerative gas expansion cycle (Vuilleumier cycle) to provide air conditioning

Mr. M. S. Crouthamel, RCA, Gov't & Comm. Sys., Front and Cooper St., Camden, N.J. 08102

TEST AND EVALUATION OF SOLAR POWERED TURBO COMPRESSOR RANKINE CYCLE FOR BUILDING AIR CONDITIONING

Demonstration of Rankine cycle turbo compressor air conditioning system at flat plate collector temperatures

Mr. F. Biancardi, United Technologies Research CTR., 400 Main St., East Hartford, CT 06018

OTHER SUBSTANTIAL UNITS

AUSTRIA

DEVELOPMENT OF A MEASUREMENT AND CONTROL SYSTEM FOR SOLAR ENERGY SYSTEMS

Study of technical and economic parameters influencing the operation of solar systems

Prof. Dr. Roland Stickler, Institut fur Physikalische Chemie, University of Vienna, Währigerstrasse 42, A-1090 Vienna

GERMANY

PRODUCTION OF SOLAR COLLECTION INSTALLATION FOR HEATING AND OPEN AIR SWIMMING POOL

Use of heat pump with solar collectors for swimming pool heating

Dipl. Phys. Birnbreier, Brown, Boveri & Cie AG, Postfach 101332, D-6900 Heidelberg

DEVELOPMENT OF CONTROL SYSTEMS FOR SOLAR HEATING SYSTEMS IN SERVICE WATER AND HEATING INSTALLATIONS

Development of control systems for extraction of heat from solar collectors and use of the heat for service water preparation, building heating, swimming water heating

Ing. Meyer, Klockner + co., Abt. Warmetechnik, Werk Heckingen, Postfach 100105, D-4100 Duisburg

RATIONAL USE OF ENERGY AND UTILIZATION OF SOLAR ENERGY IN BUILDINGS

Design, testing, and evaluation of heat pump system for heat recovery and air conditioning in an experimental house

Dr. H. Horster, Philips GmbH, Postfach 1980, D-5100 Aachen

NETHERLANDS

RESEARCH AND DEVELOPMENT ON OTHER SUBSTANTIAL SOLAR ENERGY COMPONENTS

Research on system control, thermal performance and optimization of the solar system components

Mr. G. Brouwer, Raadgevens Technies Buro, van Heugten B.V. St. Annastraat 145, P.O. Box 305 Nijmegen

NEW ZEALAND

DEVELOP LOW COST SOLAR COLLECTOR

Development of a solar operated heat pump and a control system to optimize savings

Mr. O.M. Kendon, Zip Holdings Ltd., Box 30-669, Lower Hutt

SWEDEN

AMPLITERM

Development of an energy saving system based on a combination of solar collectors and heat pump for heating of residential houses

Mr. G. Jansson, AB Svenska Flaktfabriken, equipment Division Fack 551 84 Jonkoping

PLASTIC CONVECTORS

Design and construction of prototypes of plastic convectors in low temperature solar heating system

Mr. A. Johansson, AB Atomenergi, Fack S-611 01 Nykoping

U.S.A.

DEVELOPMENT OF SOLAR POWERED HEAT PUMP UTILIZING PIVOTING TIP VANE ROTATING EQUIPMENT

Development of pivoting tip vane rotating expander/compressor for use in a residential solar Rankine heat pump

Dr. J. Eibling, Battelle Memorial Institute, Columbus Ohio 43201

DIRECT CONTACT LIQUID-LIQUID HEAT EXCHANGERS FOR SOLAR HEATED AND COOLED BUILDINGS

Studies on the direct contact liquid-liquid heat exchangers in solar heating and cooling systems

Mr. J. Ward, Colorado State University, Ft. Collins, Colorado 80523

DEVELOPMENT OF ELECTRONIC CONTROLLER AND EVALUATION OF CONTROL ALGORITHMS FOR SOLAR HEATING AND COOLING SYSTEMS

Development of relatively inexpensive electronic controller capable of operating a solar heating and cooling system in a near-optimized manner

Dr. M. Wahlig, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720

ADAPTIVE CONTROL FOR ENERGY CONSERVATION

Simulation studies of adaptive control techniques in energy conservation strategies for the operation of building and HVAC systems

Mr. D. R. Farris, Los Alamos Scientific Lab., Los Alamos N.M. 87545

DEVELOPMENT OF SOLAR DRIVEN HEAT PISTON DUAL LOOP HEAT PUMP

Design, development, modeling, and testing of components for a free piston expander-compressor suited for Rankine cycle driven vapor compression cycles in solar heating/cooling systems driven by low temperature flat plate collectors

Dr. S. Shelton, Scientific-Atlanta, Inc., Atlanta, GA 30340

COMMERCIAL BUILDING UNITARY HEAT PUMP SYSTEM WITH SOLAR HEATING

Parametric studies of heat pump model for 2 building types in three geographic areas

Mr. E. Drucker, Syracuse University, Syracuse, N.Y. 13210

PROJECT SUMMARIES

SOLAR COLLECTORS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Arbeitsgemeinschaft Sonnenenergie	**ADDRESS:** Obere Techstrasse 21/1 A-8010 Graz Austria
NAME OF PRINCIPAL RESEARCHER Prof. Dipl.Ing. Dr. P.V. Gilli	

TITLE OF PROJECT

Domestic Water Heating and Space Heating With Solar Energy

OBJECTIVE AND NATURE OF THE PROGRAM:

Development and testing of a system for economic domestic water heating with solar energy. For a 4-person household with a daily hot water consumption of about 250 l at 45°C a collector surface of 6 to 8 m^2 was found most economic; storage volume 0.4 to 0.6 m^3.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The final report on this study contains important data for an economic use of solar energy for domestic water heating in Austria.

PERIOD OF PROJECT:

1976 - 1977 (2 years)

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 52.000.--

IMPORTANT REPORTS OR PUBLICATIONS:

ARGE Sonnenenergie (Prof. Dr. P.V. Gilli e.a.) "Wärmeversorgung von Wohnbauten mit Sonnenenergie"

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Austrian Solar and Space Agency, ASSA	**ADDRESS:** Garnisongasse 7 A-1090 Vienna Austria
NAME OF PRINCIPAL RESEARCHER various	

TITLE OF PROJECT

Solar Energy Test Stations in Austria

OBJECTIVE AND NATURE OF THE PROGRAM:

At present there are nine solar energy test stations in Austria, two collector test station, two systems for space heating, three systems for domestic water heating and two systems for swimming-pool heating. Within the framework of this project energy balance of the systems, their safety in operation, lifetime and economic efficiency are studied.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The systems have been in operation since June/July 1976; data and measurements are being evaluated.

PERIOD OF PROJECT: 1976 - (open)

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 375.000.--

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Fa. Ing. W. Jäger	ADDRESS: Villacherstrasse 32 A-9300 St. Veit/Glan Austria
NAME OF PRINCIPAL RESEARCHER Ing. Walter Jäger	

TITLE OF PROJECT

Development of a Prototype of a Semi-Concentrating Collector

OBJECTIVE AND NATURE OF THE PROGRAM:

In order to make better use of solar radiation when the sun's position is low, a flat-plate collector with a number of concentrating elements, which are to guarantee a high absorption capacity of the collector even when the sun's position is low, was constructed.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The results of this study showed that this flat-plate collector with concentrating elements and without tracking does not have a better average thermal efficiency than a normal flat-plate collector.

PERIOD OF PROJECT:

1 year (1976)

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 10.000.--

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [x] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT x SYSTEM ANALYSIS
NAME OF ORGANIZATION Institut für Allgemeine Physik University of Technology	ADDRESS: Karlsplatz 13 A-1040 Vienna Austria
NAME OF PRINCIPAL RESEARCHER Prof.Dr.F.Viehböck	

TITLE OF PROJECT Multi-Component System for Domestic Water Heating and Space Heating at the"Institut für Molekularbiologie" of the "Österreichische Akadamie der Wissenschaften" in Salzburg.

OBJECTIVE AND NATURE OF THE PROGRAM:

In order to study the combination of Solar Energy and Heat Pump Systems as well as the combination of Solar Heating with conventional stand-by heaters during cold spells and/or cloudy periods a Solar Energy Installation was designed for the Institute of molecular biology in Salzburg. This installation serves as a demonstration plant for the utilization of Solar Energy under specific climatic conditions. The main purposes of this demonstation plant are:

- long term test of solar collector performance and corrosion behaviour
- gaining experience on the joint operation of solar collector and heat pump systems
- extensive data collection and evaluation for providing technical and economical bases for further evaluation of solar heating and eventual cooling of buildings in Austria.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The system has been operating since January 1978; the measurements are being evaluated.

PERIOD OF PROJECT:

1975

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 7.500.--
(Part of the project:'Solar Energy Test Stations in Austria')

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT x SYSTEM ANALYSIS
NAME OF ORGANIZATION Institut für Allgemeine Physik University of Technology	ADDRESS: Karlsplatz 13 A-1040 Vienna Austria
NAME OF PRINCIPAL RESEARCHER Prof.Dr.F.Viehböck	

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PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The system has been operating since January 1978; the measurements are being evaluated.

PERIOD OF PROJECT:

1975

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 7.500.-- (Part of the project:'Solar Energy Test Stations in Austria')

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Institut für Allgemeine Physik University of Technology **NAME OF PRINCIPAL RESEARCHER** Prof. Dr. F. VIEHBÖCK	**ADDRESS:** Karlsplatz 13 A-1040 Vienna Austria

TITLE OF PROJECT

Development of a Low Temperature Solar Collector

OBJECTIVE AND NATURE OF THE PROGRAM:

Research was done in the field of solar energy conversion as well as in the field of collector construction by means of mathematical simulation methods and comparative outdoor collector test methods. Moreover, the performance of collectors in complex systems consisting of collector batteries, storage and conventional auxiliary heating systems was studied.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Within the framework of this study results were obtained which are of significant importance for the development of an "Austrian" collector.

PERIOD OF PROJECT:

1975 - 1976

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 20.000.--

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR	[ ] MATERIAL RESEARCH
[x] THERMAL ENERGY STORAGE	[x] COMPONENT DEVELOPMENT
[ ] AIR CONDITIONING UNIT	x SYSTEM DEVELOPMENT
[ ] OTHER SUBSTANTIAL COMPONENTS	

NAME OF ORGANIZATION
Vereinigte Metallwerke Ranshofen-Berndorf

ADDRESS:
Postfach 35
A-2560 Berndorf
Austria

NAME OF PRINCIPAL RESEARCHER
Dr. Georg Turnheim

TITLE OF PROJECT

Compact Solar System for Domestic Water Heating

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a solar system for domestic water heating in a single family house consisting of 4.12 qm of flat-plate collectors with selective coating ($\alpha/\varepsilon \sim 4$), a vacuum-enameled annular water jacket boiler with a capacity of 250 l and a cartridge heater of 1.2 kW.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

With this plant 70 - 90% (in summer) and 10 - 20% (in winter) of the total energy requirements of a 4-person household can be covered by solar energy under the climatic conditions in Austria.

PERIOD OF PROJECT:

10.5.1977 - 30.11.1977

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 15.500.--

IMPORTANT REPORTS OR PUBLICATIONS:

ASSA-Information Service 4/1977.

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Vereinigte Metallwerke Ranshofen-Berndorf	ADDRESS: Postfach 35 A-2560 Berndorf Austria
NAME OF PRINCIPAL RESEARCHER Dr. Georg Turnheim	

TITLE OF PROJECT

Installation of a Solar Energy Station in Malta

OBJECTIVE AND NATURE OF THE PROGRAM:

Within the framework of this project thermal performance, life-time and safety in operation of solar collectors and solar systems for domestic water heating are studied under mediterranean climatic conditions and essential meteorological parameters such as global radiation, wind velocity and humidity are measured.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

PERIOD OF PROJECT:

5.7.1977 - 1.5.1978

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 7.600.--

IMPORTANT REPORTS OR PUBLICATIONS:

Country : BELGIUM		
	Components	**Type of research**
	Solar collector Heat storage Air conditionning and cooling Other substantial components	Material research **Component development**

Organization : FACULTE POLYTECHNIQUE DE MONS	Address: rue de Houdain, B 7000 MONS
Researcher : Prof. A. PILATTE	

Title of project : Flat plate collector development.
Evaluation of performances.
Architectural integration in roof structures.
Design of a solar heated house.

Objective : As part of a national R & D program on energy, the research on water solar collectors is aimed to the determination of an optimum design (technical and economical) for solar collectors in Belgium.

Working program :

a) Field tests on differents types of flat plate solar collectors in order to determine their dynamic and static characteristics.
b) Improvment and development of solar energy collectors for hot water and air systems.
c) Formulation of mathematical models describing the behavior of collectors in order to achieve system optimization.
d) Integration of solar collectors in a roof structure.
e) Design and construction of an experimental house.
f) Rational use of solar radiation data for solar heating purposes.

Present status :

The following collectors have been studied so far

a) Type :

1) flat plate water collectors (natural and fored circulation);
2) flat plate air collectors.

b) $\alpha\tau$: $.68 \leq \alpha\tau \leq .86$

c) $4 \leq F_R U_L \leq 8$ W/m^2 K (20 - 70 °C)

d) $2 \leq C \leq 9$ Wh/cm^2°K

e) water, water + ethylene glycol, air.

f) i. absorber : $0,9 \leq \alpha \leq 0,95$
$0,15 \leq \varepsilon \leq 0,95$

ii. Cover plates : 2 glass cover or 1 glass cover $.76 \leq \tau \leq .91$

iii. Insulation : glass wool or urethane foam.

g) live time : unknown.

h) Cost : 80 ≤ Price ≤ 250 U.S. \$/m^2.

Period and funding :

The research program started at the end of 1975 and will last 3 years.
The amount of money engaged in the described research is of the order of 200000 \$ US. These are goverment funds and do not include the additional money and efforts spent by the universities and private companies.

COUNTRY: DENMARK

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Technological Institute and Technical University of Denmark.	ADDRESS: Technological Institute Gregersensvej DK-2630 Tåstrup.
NAME OF PRINCIPAL RESEARCHER P.E. Kristensen and O. Paulsen	Thermal Insulation Laboratory Bldg. 118 Technical University of Denmark DK-2800 Lyngby

TITLE OF PROJECT: Development and test of components for solar heating systems

OBJECTIVE AND NATURE OF THE PROGRAM:

This project is a part of a project on developing and demonstrating solar heating systems in Denmark. The objective of this project is to measure the thermal performance and to evaluate the durability of solar collectors on the Danish market, as well as assisting companies in developing new collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT

Measurements of solar collectors thermal performance has been started.

PERIOD OF PROJECT: 1/4-77 - 1/1-80.

FUND IN $ U.S. TOTAL FOR THE PERIOD: 110.000

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY: DENMARK	
COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Thermal Insulation Laboratory and Technological Institute	ADDRESS: Thermal Insulation Laboratory Bldg. 118 Technical University of Denmark DK-2800 Lyngby. Technological Institute Gregersensvej DK-2630 Tåstrup.
NAME OF PRINCIPAL RESEARCHER C. Nielsen, O. Paulsen	

TITLE OF PROJECT: Evaluation of solar collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this project is to establish an outdoor facility for measuring the thermal performance of solar collectors and to evaluate the long term durability of solar collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
The test facility for outdoors measurements of five collectors has been constructed. Long term measurements on solar collectors especially with respect to durability have been started.

PERIOD OF PROJECT 1/9-76 - 1/9-79

FUND IN $ U.S. TOTAL FOR THE PERIOD 112.000

IMPORTANT REPORTS OR PUBLICATIONS:

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	

Name of Organisation: Brown, Boveri + Cie AG Name of Principal Researcher Dipl.Phys. Birnbreier	Address: Postfach 101332 D-6900 Heidelberg 1

Title of the Project: Hot water preparation with solar energy

Objective and Nature of the Project, Present Status

1. Aim

Experimental checking and extension of the results of a study on the possibilities of utilization of solar energy in central Europe which was prepared in advance by BBC.

2. Schedule

a) Execution of basic investigations on solar absorbers.
b) Design and construction of solar absorbers for calorimetric measurement.
c) Construction and testing of solar absorbers.

Continuation overleaf /

Period of the Project: 15.3.74 - 31.12.75

Fund in $ US: 236,000,-   Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Hot water preparation with solar energy

Objective and Nature of the Project, Present Status:

- Continuation ....

d) Development of selectively absorbing coatings.

e) Development and trial of hot water preparation systems with solar absorbers.

f) Carrying out measurement and evaluation of results.

3. Relationship with other projects

These projects will supply results for the system study commenced under ET 4045 for industrial utilization of solar energy.

4. Progress

The project was completed at the end of 1975. A report was sent to the BMFT.

- A methematical analysis of the efficiency of solar collectors was carried out which included the effect of design variables as well as operating influences such as wind velocity, sky temperature, air temperature, etc. The concept of a system for hot water preparation with solar collectors was systematically analysed.
- Solar collectors with single and double glass coverings and an absorber area of 1.5 m^2 were designed; 26 units were constructed. The experimental investigation covered determination of the efficiency under stationery conditions and under open air conditions. A simple reproduceable method of testing solar collectors was proposed.
- Investigations on selective coatings covered methematical analyses as well as testing of chromium oxide and tin oxide coatings in collectors. The development of silicon coatings was terminated as it was not possible to find any economical production method.

Title of the Project:

Hot water preparation with solar energy

Objective and Nature of the Project, Present Status:

- Continuation ....

- Seven test installations were constructed at various points in Germany and Austria. The results show that in the "non-heating period" approximately 80% of the energy requirement for hot water preparation in households can be provided by solar energy. Recommendations on the layout of solar installations are given.

Country : Federal Republic of Germany	
Components	**Type of Research**
☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☒ Heat Pump ☐	☐ Materials Research ☒ Component Development ☒ Systems Development ☒ Production Research
Name of Organisation: Brown, Boveri + Cie. AG Name of Principal Researcher Dr. F. Weil	Address: Postfach 351 D-6800 Mannheim

Title of the Project: Production of a solar collector installation for heating an openair swimming pool

Objective and Nature of the Project, Present Status

1. Aim

Planning, design and erection of a solar collector installation for heating an openair swimming pool.

2. Schedule

a) Erection of a solar collector installation for endurance tests and demonstration purposes, consisting of 1100 collectors.

b) Development of production methods for solar collectors in mass production.

Continuation overleaf /

Period of the Project: 19.12.74 - 31.12.76

Fund in $ US: 716,000,- Government Contribution: 100%

Important Reports or Publications:

Title of the Project: Production of a solar collector installation for heating an openair swimming pool

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Relationship with other projects

The project is based on initial test series of ET 4025. Tests on the solar collector installation will be carried out within the framework of project ET 4124 A.

4. Progress

Planning, erection and commissioning of the solar collector battery have been completed.

Country : Federal Republic of Germany	
Components	Type of Research
☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ ☐	☒ Materials Research ☒ Component Development ☐ ☐
Name of Organisation: Dornier-System GmbH Name of Principal Researcher Dipl. Phys. W. Scherber	Address: Postfach 1360 D-7790 Friedrichshafen

Title of the Project: Development of selective solar absorbers on the aluminium roll bond heat exchanger basis

Objective and Nature of the Project, Present Status

1. Aim

Development of a long-term stability selective coating for aluminium solar absorbers which is suitable for reasonably priced large-scale industrial production.

2. Schedule

a) Summary of known and new absorber coatings for aluminium backing material.

b) Uniform endurance tests under simulated and actual operating conditions.

c) Investigation of degradation and optimization of coating properties.

d) Development of rational and production compatible manufacturing methods.

Continuation overleaf /

Period of the Project: 15.11.75 - 31.12.77

Fund in $ US: 204,640,- Government Contribution: 100%

Important Reports or Publications:

Title of the Project: Development of selective solar absorbers on the aluminium roll bond heat exchanger basis.

Objective and Nature of the Project, Present Status:

- Continuation ....

e) Production of prototypes of selective collectors and comparative functional tests in the field.

3. Relationship with other projects

This project forms the second sub-programme of the overall project of Metallgesellschaft AG: "Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors".

4. Progress

Two new selective coatings for aluminium absorbers have been developed and their properties compared with the known coatings such as copper oxide, copper manganese oxide (Tabor), black nickel and black chromium. One of the new coatings makes a particularly favourable impression. It is a special anodic coating which can however be produced with conventional materials. The alpha/epsilon values are 0.94/0.15, the production costs correspond to those of a normal anodic coating (approx. 10 DM/m^2) and corrosion resistance is very much better than is the case with the other selective aluminium coatings.

Laboratory work is completed apart from the long-time tests. Prototype production of original rollbond sheet will be commencing shortly. In a second phase the coating will be transferred to a new aluminium material with improved high temperature stability developed by Metallgesellschaft.

Country : Federal Republic of Germany	
Components	**Type of Research**
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	
Name of Organisation: Dornier System GmbH Name of Principal Researcher Dr.Ing. Gehrke	Address: Postfach 1360 D-7990 Friedrichshafen

Title of the Project: Heat pipe solar absorber

Objective and Nature of the Project, Present Status

1. Aim

Adaptation of the heat pipe solar absorbers which have been developed for installations for solar sea water desalination to the requirements of a domestic heating system. A prototype installation has been erected and tested at least over 1 full heating period.

2. Schedule

a) Examination of the solar energy equipment range and energy requirement.
b) Layout of the complete system and of the components.
c) Design and construction of the prototype installation.

Continuation overleaf /

Period of the Project: 15.10.74 - 31.12.77

Fund in $ US: 256,285.60 Government Contribution: 84%

Important Reports or Publications:

Title of the Project: Heat pipe solar absorber

Objective and Nature of the Project, Present Status:
- Continuation ....

d) Adaptation of the absorbers to the roof structure.
e) Test installation and fitment of a data collection system.
f) Test operation execution and evaluation of the data.

3. Relationship with other projects

The work supplies part of the basic data for system study Et 4045.

4. Progress

The installation of about 70 m^2 heat pipe collectors in an inhabited test house in Essen has taken place. The solar energy is transported by means of a water primary circuit to a central water accumulator of all together 7.2 m^3 installed in the cellar. A water-water heat pump boosts the efficiency during low sun radiation in the winter months. In the summer the four families in the house are supplied with hot service water, in the winter the solar system operates the floor heating of the 210 m^2 flat of the landlord.
In the meantime a fully automatic CAMAC data acquisition system has been installed for monitoring the energy budget.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☒ Materials Research
☐ Heat Storage	☐ Component Development
☐ Air Conditioning and Cooling Unit	☐
☒ Collector Coatings	☐
☐	

Name of Organisation:	Address:
Dornier-System GmbH Name of Principal Researcher Dipl.Phys. Scherber	Postfach 1360 D-7990 Friedrichshafen

Title of the Project: Development of high temperature resistance solar absorber areas

Objective and Nature of the Project, Present Status

1. Aim

The properties and limits of use of various coatings for solar absorbers are being investigated. On the basis of the results it is intended to determine the economically justifiable field of use.

2. Schedule

a) Representation of known and new absorber coatings (interference filters, semi-conductor filters, structure-filters).

b) Uniform endurance tests at 400 and 600°C on the undertakings own and commercial coatings.

Continuation overleaf /

Period of the Project: 1.10.74 - 31.12.77

Fund in $ US: 419,995.60 Government Contribution:100%

Important Reports or Publications:

Title of the Project: Development of high temperature resistance solar absorber areas

Objective and Nature of the Project, Present Status:

- Continuation ....

c) Degradation investigations and optimization of coating properties.

d) Development of rational production methods.

e) System related comparison of the processes with regard to the economic rational use in solar collectors and solar power stations.

3. Relationship with other projects

This project supplies part of the basic data for the system study on industrial utilization of solar energy under identification ET 4045.

4. Progress

A large number of test specimens for the various absorber types were produced and investigated. Here it has been found that the main problem lies in the longterm stability at operating temperatures (300 - 600°C). Almost all coatings used evidenced in the 1000 hour test at 400°C considerable degradation of the alpha/epsilon value and even the interference filters are not sufficiently stable at 600°C.

In view of these difficulties it was necessary to develop completely new coating systems. Two of these new concepts appear particularly interesting at present:

- Stabilized semi-conductor filters for the lower temperature range up to 400°C max. Simple production by galvanic methods.

Title of the Project:

Development of high temperature resistance solar absorber areas

Objective and Nature of the Project, Present Status:

- Continuation ....

- Structure filters with ceramic protective coating with perfect longterm stability up to 600°C. As the production process is still somewhat costly, it is being endeavoured at present to change over to simple techniques such as spraying, rolling, galvanizing.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	

Name of Organisation:	Address:
Entwicklungs- und Forschungs labor	Industriestraße 8 D- 7850 Lörrach-Haagen
Name of Principal Researcher Dr.Ing. Hans Kleinwächter	

Title of the Project: Hot water preparation with solar energy using synthetic solar collectors

Objective and Nature of the Project, Present Status

1. Aim

Development and test of reasonable priced synthetic solar collectors. Basic element extendable in modular fashion. Fields of application: from the special instance of swimming pool heating to any orientatable roof collector.

2. Schedule

a) System layout, on the basis of a synthetic flexible tube which is transparent on top and dark and absorbent underneath as basic element.

b) Production of a prototype I, suitable only for horizontal level surfaces; measurements.

Continuation overleaf /

Period of the Project: 1.7.75 - 30.6.77

Fund in $ US: 266,640,- Government Contribution: 100%

Important Reports or Publications:

Title of the Project:	Hot water preparation with solar energy using synthetic solar collectors

Objective and Nature of the Project, Present Status:

- Continuation ....

c) Production of several prototypes II with chamber type partitioning of the flexible tube. Also suitable for use on inclined surfaces; measurements.

d) System study of frame type mounted optionally orientatable collectors. Optimization of system parameters. Selective coatings.

e) Production of a prototype III. Optionally orientatable light synthetic collector; measurements; final report.

4. Progress

The various potential manufacturers of extruded tubular film have been contacted. Ideal would be a "transparent window film", a film produced in an extrusion process, dark on the bottom, but transparent on the surface. In principle it is possible, but conditional on tool costs (special extrusion die) of approx. DM 80,000.-- and would only be profitable with large quantities. Chosen first of all was a special PE-PA composite film backed on the base side with a dark coating from Messrs. Sengewald in Künsebeck/ Westf. This composite film subsequently had to be replaced by a 20 myu thick pure U.V. stabilized PE film as the PA was found not to be U.V. stable. As insulation materials were chosen a combination of foamed PE flexible tube with inserted bubble film (Messrs. Alkor, Munich). As infra-red reflector a metalized polyester film is used.
Various laboratory models were made up. As inlet and outlet connections modified plastic fittings were used and these were adapted to the collector. Various alternatives for welding and bonding of the tube ends were tried out. The fact that longterm strength cannot be obtained by welding the tube ends lead to development of mechanical clamping strips. For level regulation of the water in the collectors a special level vessel has been developed.

Title of the Project: Hot water preparation with solar energy using synthetic solar collectors

Objective and Nature of the Project, Present Status:

- Continuation ....

An electronic system with differential temperature sensors and facility for setting of desired temperature values has been constructed.

The flexible pipe type basic module collector was subdivided ductwise in various ways with the aim of being able to install it in an inclined position as well. Meandershaped weld seams and mechanical bracing were provided.

Various multi-tube collectors of synthetic rubber and PVC were constructed and are at present being tested. Special water connections for these collectors have been designed.

A measurement system which provides chart recordings of the overall radiation, of different collector temperatures and of the air temperature has been constructed. In order in the winter months as well to be able to carry out comparative measurements on different variant and film combinations, a reasonably priced sun simulator is in preparation. With it, it will also be possible to carry out accelerated U.V. aging of the films. During the further progress of the project specially U.V. stable and selectively transparent films should be used for construction of the various collectors.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☒ Materials Research
☐ Heat Storage	☐ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	

Name of Organisation:	Address:
Infrastop-Labor Flachglas AG Delog-Detag	Postfach 669 D-4650 Gelsenkirchen
Name of Principal Researcher Dr. H.J. Gläser	

Title of the Project: Development of an industrial process for production of In_2O_3 coatings for improvement of the k value of insulating glass panes

Objective and Nature of the Project, Present Status

1. Aim

Development of a process for large-scale industrial production of high efficiency transparent coatings on an In_2O_3 base for energy conserving insulating glazing.

2. Schedule

Stage I

From the findings already obtained through laboratory investigations a semi-industrial process should be developed for In_2O_3 coating for pane sizes up to 1 x 1 m^2. The installation for metal coating necessary for this work is

Continuation overleaf /

Period of the Project: 1.11.75 - 30.6.77

Fund in $ US: 266,320,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Development of an industrial process for production of In_2O_3 coatings for improvement of the k value of insulating glass panes

Objective and Nature of the Project, Present Status:

- Continuation ....

available. For subsequent oxidation of the metal coating it is necessary to install a suitable oxidation and forming furnace with which tests for semi-industrial production of In_2O_3 coated glass panes can be carried out.

Stage II

Subsequent thereto work is intended for application of the method to a large-scale industrial plant for pane sizes up to 1.5 x 2.5 m^2. Here as well the coating plants for metal coating are already available. The oxidation and forming furnace must be designed on the basis of the experience from the semi-industrial plant.

3. Progress

Stage I of the project is nearing conclusion.

It has been possible to apply the coating of a sub-oxidic In/Sn alloy developed on laboratory scale to the semi-industrial spraying plant for pane sizes up to 1 x 1 m. For this purpose it was necessary to find a suitable process for the preparation of extended cathodes as well as the coating parameters, in particular matching the composition of the spray atmosphere. The coatings produced with the semi-industrial plant have the same specifications (coating thickness, transmission behaviour, specific electrical resistance and IR reflection) as those developed on laboratory scale. At present an endeavour is being made to increase the spray rate by a factor of 2 to double the number of cathodes. The coating tools for this purpose have in the meantime been made available and are being commissioned.

Title of the Project: Development of an industrial process for production of In_2O_3 coatings for improvement of the k value of insulating glass panes

Objective and Nature of the Project, Present Status:

- Continuation ....

A furnace for the forming of the coated panes with the dimensions of 1 x 1 m has been designed and commissioned. Gas supply during the forming process has been optimized so that it is possible today to produce panes with dimensions of 1 x 1 m with the specifications which were achieved on laboratory scale. Still open are k value measurements on panes with dimensions of 77 x 77 cm as well as aging and abrasion tests of the coating. These operations should be concluded by February 1977.

It is intended after carrying out these operations to decide by means of profitability calculation in comparison with alternative developments whether it is advisable to embark on stage II of the project.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☒ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	

Name of Organisation:	Address:
Jenaer Glaswek Schott + Gen.	Hattenbergstr. 10 D-6500 Mainz
Name of Principal Researcher Dr. Eckart Hußmann	

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems. Third sub-programme of Metallgesellschaft.

Objective and Nature of the Project, Present Status

1. Aim

Transparent glass covering for large-scale industrially produced flat solar collectors with suitable mechanical, thermal and corrosion resistant properties together with their attachment to the collector system.

2. Schedule

a) Definition of load instances.

b) Calculation of thermal and mechanical load capacity.

c) Experimental investigation of load instances.

d) Optimization of covering and connection to case.

Continuation overleaf /

Period of the Project: 1.1.76 - 30.6.79

Fund in $ US: 53,120,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems. 3rd sub-programme of Metallgesellschaft.

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Progress

The load instances mentioned under a) are:

1. Snow load.
2. Wind load.
3. Hail.
4. Thermal strains and
5. Mechanical stresses.

Load instances 1, 2 and 3 could be obtained from the literature on the subject and defined.
The thermal strains are being determined experimentally and by calculation.
The mechanical stresses resulting from pressure increase with sealed case from temperature rise have been determined experimentally and by calculation.
Test collectors have been constructed to investigate the tightness of the joint of the cover with the case.
(Co-operation with Metallgesellschaft).

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	

Name of Organisation: Jenaer Glaswerk Schott+ Gen.	**Address:** Hattenbergstr. 10, D-6500 Mainz
Name of Principal Researcher Dr. E. Hußmann	

Title of the Project: Flat-plate solar energy collector

Objective and Nature of the Project, Present Status

1. Aim

It is intended to develop various flat-plate solar collectors with particularly high efficiency to permit improved utilization of the high percentage of diffused radiation present in our climate.

2. Schedule

a) Development of IR reflecting glass covers and of non-reflective coatings.

b) Development of alpha/epsilon coating systems

c) Development of honeycomb structures to reduce radiation output and convection losses.

Continuation overleaf /

Period of the Project: 15.11.75 - 15.11.78

Fund in $ US: 578,960,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Flat-plate solar energy collector

Objective and Nature of the Project, Present Status:
- Continuation ....

d) Development of glass hollow fibre absorber panels with very efficient heat dissipation.
e) Development of an evacuated all glass flat-plate collector based on glass hollow fibre absorber panels.

3. Progress

A field test installation with automatic data collection system for evaluation on a computer as well as appropriate detailed simulation programmes have been prepared and tried out.
A solar simulation test stand is under construction.
Thus the conditions have been provided for testing the developments stated in the schedule above.
It has been possible to apply IR reflecting - transparent to solar radiation - coatings on different types of glass and to render these non-reflective. Prototypes with covering systems of this type have been constructed and tested. The high no-load temperatures occurring with such collectors involve material problems whose solution is being worked on at present.
In technical literature contradictory opinions have been expressed on the effectiveness of honeycomb structures for suppression of convection. A number of tests on different honeycomb structures have shown that under suitable conditions the convection can be suppressed to a large extent. More recent publications confirm our own investigations. Test collectors with honeycomb structures evidenced the properties expected.
Glass hollow fibre absorber panels have been produced and tested. They can be regarded as good absorbers. The technical problems with series production of such absorber panels have not yet been solved.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	

Name of Organisation:	Address:
Klaus Esser KG	Postfach 2909 D-4000 Düsseldorf 1
Name of Principal Researcher Prof.Dr.Ing. W. Dalhoff	

Title of the Project: Solar collectors for flat roofs

Objective and Nature of the Project, Present Status

1. Aim

The first sub-aim is to prepare a systematic summary in which the various alternatives for economical and technically favourable integration of solar collectors in flat roofs are examined.
In the second step it is intended that work be commenced on combining the solar collectors with the domestic installation.

2. Schedule

a) Preparation of a flat roof analysis sub-divided into gradient, roof type and construction.

Continuation overleaf /

Period of the Project: 1.1.76 - 30.9.77

Fund in $ US: 241,811.20 Government Contribution: 50%

Important Reports or Publications:

Title of the Project:
Solar collectors for flat roofs

Objective and Nature of the Project, Present Status:
- Continuation ....

b) Analysis of the percentage distribution of the various roof types and construction.
c) Analysis of the solar collectors suitable for flat roofs
d) Investigations on fixing standard solar collectors onto the various flat roof types and constructions.
e) Development and investigation of solar collectors with integrated mounting and its fixing to flat roofs.
f) Investigation of the economical and technically feasible connection of the flat roof solar collectors to the domestic installation.

3. Relationship with other projects

This project provides results on the economical and technically feasible integration of solar collectors in flat roofs and thus indirectly contributes to the projects in progress under the following code numbers

- ET 5052 Solar domestic heating
- ET 4066 A Modular solar house heating system
- ET 4148 A Heat pipe solar absorber

4. Progress

The flat roof analysis broken down into flat roof, flat inclined roof, roof types and constructions has been prepared. The analysis of the percentage distribution of the various roof types and constructions shows that the flat roof enjoys market shares in West Germany of over 75% especially in some building groups, e.g. school buildings, office buildings, industrial buildings, this figure being approximately 45% in the case of 1 and 2 family houses. Solution estimates for integration of solar collectors in flat roofs have been prepared and are at present being tested on prototypes.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☒ Systems Analysis
☒ Service Water Heating	☐
☐	

Name of Organisation:	Address:
Kraftanlagen AG	Im Breitspiel 7 D-6900 Heidelberg 1
Name of Principal Researcher Dipl.Ing. F. Reinmuth	

Title of the Project: Service water heating by solar energy

Objective and Nature of the Project, Present Status

1. Aim

During the course of enlarging a dwellinghouse a solar system has been installed. By means of a measurement programme it is intended to investigate what influence the installation of the solar system has on the annual oil consumption of the whole building.

2. Schedule

At various points of the system heat meters are being installed. The service hot water and heating water circuit will be monitored. The incident solar energy and the outside temperature will be recorded. A comparison

Continuation overleaf /

Period of the Project: 26.7.76 - 30.6.78

Fund in $ US: 13,860,- Government Contribution: 100%

Important Reports or Publications:

Title of the Project: Service water heating by solar heating

Objective and Nature of the Project, Present Status:

- Continuation ....

will be made with measurements of the German meteorological office.

In this way it will be possible to compare the results of the test year with the average values of the meteorological office. By this means it will be possible to provide a rational statement on the influence of the solar system on the fuel oil consumption.

3. Progress

The solar system has not yet been completed. The measuring devices necessary for the test programme have been ordered. Installation will be carried out by approximately 1.3.77.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	

Name of Organisation: M.A.N. - Neue Technologie Maschinenfabrik Augsburg-Nürnberg AG	Address: Dachauer Str.667 D-8000 München 50
Name of Principal Researcher J. Lorenz	

Title of the Project: Development of economical solar heating systems with reasonably priced collectors

Objective and Nature of the Project, Present Status

1. Aim

Development and construction of simple flat collectors consisting of as few as possible, series produceable parts and trial in an optimized system as regards efficiency, operating behaviour and reliability.

2. Schedule

a) Layout and construction of prototype collectors which are suitable for series production.

b) Trial of prototype collectors as regards efficiency, operating behaviour and reliability in an optimum system.

c) Series production tests with selected collector types.

Continuation overleaf /

Period of the Project: 1.1.77 - 31.12.78

Fund in $ US: 180,800,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Development of economical solar heating systems with reasonably priced collectors.

Objective and Nature of the Project, Present Status:

- Continuation ....

d) Construction of collectors which can also be used as roof cladding.

3. Progress

The preliminary work started as from 1.1.1977.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☒ Heat Storage	☒ Component Development
☒ Air Conditioning and Cooling Unit	☒ Systems Development
☐	☐
☐	

Name of Organisation:	Address:
Messerschmitt-Bölkow-Blohm GmbH	Postfach 801169 8000 München 80
Name of Principal Researcher Dipl.Ing. H. Grallert	

Title of the Project: Modular solar house heating system - Phase I

Objective and Nature of the Project, Present Status

1. Aim

Theoretical and experimental investigations on the development of a modular solar house system which can be marketed in collaboration with other companies and in particular is suitable for use in temperate zones. A variant of the system is to be applied in combination with refrigeration systems for air conditioning.

2. Schedule

a) Investigation, development and design work on collectors, storage media, storage containers, heat exchangers as well as measurement and control units.

b) System layout from technical and economic points of view.

Continuation overleaf /

Period of the Project: 15.11.74 - 30.12.76

Fund in $ US: 478,500,- Government Contribution: 80%

Important Reports or Publications:

Title of the Project: Modular solar house heating system - Phase I

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Progress

In the first development phase the emphasis was on carrying out thorough technical and economic system analyses which were the starting point for the necessary component development. These analyses include estimation of the weather effects, a design study, investigation of all collector design parameters, the regulation system, heat requirement and consumption characterization, system cost estimation and optimization, complete simulation of the solar thermal and of the conventional heating system as well as thermal and mechanical computation of all components. As essential result it was established inter alia that the use of selective absorber coatings and that of IR effective cover glass coatings is at present still uneconomical in comparison with simple two-plate collectors (flat construction) and that only the small heat accumulator adapted to the heat requirement over approximately 1 week is suitable as cubic hot water tank for use in 1 and 2 family houses. Taking into account the cost increase which is expected to rise still further in the case of the fossil fuels it was possible with the aid of static meteorological data to demonstrate profitable use of the solar thermal heating system, in particular for hot service water preparation even in central European latitudes.
From the investigations of construction for the critical individual components two collector generators with 3 or 7 test modules of two-plate flat construction were derived and satisfactorily tried out as regards heat transfer and longterm durability on the openair test rig constructed for the purpose. For the version accepted in Autumn 1975 as regards performance production investigations were carried out with plastic and metal frames from the point

Title of the Project:
Modular solar house heating system - Phase I

Objective and Nature of the Project, Present Status:
- Continuation ....

of view of series production. Here it was found that production costs were considerably lower for the metal frame construction particularly in comparison with PU rigid foam frames. In addition, when using load supporting plastic components additional thermal expansion processes occur. Both constructions were followed through as far as the prototype and used in complete tests.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☒ Heat Storage	☐ Component Development
☒ Air Conditioning and Cooling Unit	☒ Systems Analysis
☐	☐
☐	

Name of Organisation:
Messerschmitt-Bölkow-Blohm GmbH

Address:
Postfach 801169
D-8000 München 80

Name of Principal Researcher
Dipl.-Ing. Grallert

Title of the Project:
Modular solar domestic heating system - Phase 2

Objective and Nature of the Project, Present Status

1. Aim

Continuation of the work commenced in Project ET 4066 A (first development phase) with the aim of applicational execution and optimization of solar heating systems for preferred use in the domestic field. Aim otherwise as in Phase 1.

2. Schedule

a) Further development of collector for higher operating temperatures.
b) Optimization of system layout.
c) Preparation of two complete research installations for demonstration of subsequent equipment and original

Continuation overleaf /

Period of the Project: 1.1.76 - 30.6.77

Fund in \$ US: 562,300,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Modular solar domestic heating system - Phase 2

Objective and Nature of the Project, Present Status:
- Continuation ....

equipment with a solar domestic heating system.

d) Investigation of the installation parameters and of the standardization of solar heating systems.

e) Basic operations for going over to series production.

3. Progress

The emphasis of the second development phase is the installation and operation of systemwise balanced solar heating systems in two typical applications.
In an existing inhabited single family terraced house in Höhenkirchen near Munich a combined solar heating system was installed for room heating and water heating with 35 m^2 effective collector area and 4 m^3 water accumulator. With the installation commissioned in June 1976 important results were collected for simplification of the system technology and the installation outlay.
The use of solar energy resulted by the end of the year in a saving of more than 900 litres of fuel oil.
On the basis of the practical experience already gathered the development trend is towards pre-installed system sections, reduced equipment outlay and carefully insulated housing sections.

Although strict economy with combined systems is not yet attainable today, the monovalent solar heating system with electrical emergency heating seems to be an interesting solution for the future.
To examine selectively effective coatings 8 additional test collectors were tried out. Production problems in the reproduction of SnO_2 or black chromium coatings in some cases produced worse results than expected. Attention should be paid to condensate corrosion in the case of black chromium

Title of the Project:

Modular solar domestic heating system - Phase 2

Objective and Nature of the Project, Present Status:

- Continuation ....

coatings on aluminium. With selective coatings of this type no-load temperatures over 200°C are reached. If the cost of the coating can be reduced by more than half, use in one and two plate collectors appears attractive.

Country : Federal Republic of Germany	
Components	**Type of Research**
☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ ☐	☐ Materials Research ☒ Component Development ☐ ☐
Name of Organisation: Metallgesellschaft AG Name of Principal Researcher Dr. Feasel, Dr.Ing. Möller	Address: Postfach 3724 D-6000 Frankfurt/M 1

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors. Development of airtight solar collector housings.

Objective and Nature of the Project, Present Status

1. Aim

Development of an airtight solar collector housing which protects the selectively coated absorber from condensate corrosion and atmospheric corrosion. Development of the roof fixing in system suited to the collector housing.

2. Schedule

a) Material selection for the housing
   - Geometrical layout of the housing
   - Development of roof fixing in systems
   - Development of installation and assembly aids
   - Mechanical and thermal stability tests.

Continuation overleaf /

Period of the Project: 1.1.76 - 30.6.79

Fund in $ US: 365,840,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors. Development of airtight solar collector housings.

Objective and Nature of the Project, Present Status:

- Continuation ....

b) Sealing and insulation system
   - Selection of suitable glass qualities (see ET 4051 F)
   - Development and trial of permanently elastic sealing systems for the special application conditions (no-load temperatures)
   - Optimum design of siccatives
   - Development of sealing systems for absorber outlet sockets.

c) Trial of the complete housing system.

3. Relationship with other projects

Development is taking place in collaboration with the JENAer Glaswerke Schott & Gen. (ET 4051 F).

4. Progress

As housing materials titanium zinc, aluminium and PU integral foam have been chosen. Housings of these materials are at present being checked for their thermal and mechanical stability. Systematic analysis of the gutter dimensions has been commenced and based thereon initial sample roof fixings of titanium zinc have been produced.

The thermal and mechanical loading of the glass cover under a wide variety of collector operating conditions has been determined in a computer programme. Tests to confirm these results have been commenced (see ET 4051 F).

The initial tests on the adhesive strength of sealing compounds on the selected housing materials have been commenced.

Specimen housings with selected sealing systems are at present being tried out under simulated climatic conditions.

Country : Federal Republic of Germany	
Components	Type of Research
☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ ☐	☐ Materials Research ☒ Component Development ☐ ☐
Name of Organisation: Metallgesellschaft AG Name of Principal Researcher Dr. Ing. Möller	Address: Postfach 3724 D-6000 Frankfurt/M 1

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors. Project management.

Objective and Nature of the Project, Present Status

1. Aim

Making up a working party for development of production methods for components of solar heating systems, in particular high efficiency solar collectors for the medium temperature range up to 100°C, in co-operation with industrial and small-scale companies together with technical colleges. Co-ordination of the overall project.

2. Schedule

a) Development of selective solar absorbers on the basis of aluminium rollbond heat exchangers.

Continuation overleaf /

Period of the Project: 15.11.75 - 30.6.79

Fund in $ US: 240,000,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors. Project management

Objective and Nature of the Project, Present Status:

- Continuation ....

b) Development of solar collector housings.

c) Development of components for the solar heating system.

d) System and component trial.

e) Preparation of production for tested prototypes.

f) Trial production of the developed systems.

3. Relationship with other projects

Developments are taking place in collaboration with Messrs. Dornier System GmbH, JENAer Glaswerke Schott & Gen., Mainz and Klöckner & Co., Abt. Wärmetechnik, Hechingen as well as the divisions of Metallgesellschaft AG, mentioned in detail in the individual projects.

4. Progress

The companies mentioned under 3 have been obtained for co-operation in the working party.
Dornier System GmbH is responsible for the development of high efficiency selective coatings on aluminium and aluminium alloy absorbers. The airtight collector housing is being developed in collaboration with JENAer Glaswerke Schott & Gen., the processing division of Rheinische Zinkwalzwerke and the chemical division of Metallgesellschaft AG.
JENAer Glaswerke Schott & Gen. are responsible for selection of the glass qualities and the glazing processes. The development of permanently elastic, temperature resistant adhesive sealing systems for airtight incapsulation of the collector housing is being carried out by the chemical division of Metallgesellschaft AG. The metal collector housing together with the roof fixing in systems is being developed by Rheinische Zinkwalzwerke.

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors. Project management

Objective and Nature of the Project, Present Status:

- Continuation ....

Messrs. Klöckner & Co. Wärmetechnik is responsible for development of the heater side components of the solar heating system and their trial.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	

Name of Organisation:	Address:
Metallgesellschaft AG	Postfach 3724 D-6000 Frankfurt/M 1
Name of Principal Researcher Dr. Ing. Möller	

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors. Development of selective solar absorbers on the basis of aluminium roll-bond heat exchangers

Objective and Nature of the Project, Present Status

1. Aim

Development of an effective and market compatible absorber system on the basis of selectively coated aluminium rollbond heat exchangers.

2. Schedule

(is restricted to the work share of Metallgesellschaft AG)

a) Absorber material selection.
b) Optimization of absorber channel system.
c) Construction of a pilot coating installation and application of the coating process developed by the Dornier system on laboratory scale to this installation.

Continuation overleaf /

Period of the Project: 15.11.75 - 30.6.78

Fund in $ US: 80,024,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors. Development of selective solar absorbers on the basis of aluminium rollbond heat exchangers.

Objective and Nature of the Project, Present Status:

- Continuation ....

d) Selective coating of absorbers and testing of coatings.

e) Layout of an installation for large-scale industrial coating of aluminium absorbers with selective coatings.

3. Relationship with other projects

Development is being carried out in collaboration with Dornier System GmbH, Friedrichshafen (ET 4051 G).

4. Progress

Material selection has been completed. For pressureless operating systems pure aluminium absorbers can be used, for pressure carrying systems there is an aluminium material with an AlMn 1.5 base.

Thermally and flow optimized absorber channel systems are available.

Dornier System GmbH have developed a suitable selective coating (see report ET 4051 G).

The pilot installation for selective coating of rollbond absorbers using the process developed by Dornier System is under construction. Coating tests will be commencing in the first quarter of 1977.

Country : Federal Republic of Germany	
Components	**Type of Research**
☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ ☐	☐ Materials Research ☒ Component Development ☐ ☐
Name of Organisation: Metallgesellschaft AG Name of Principal Researcher Dr. Ing. Möller	Address: Postfach 3724 D-6000 Frankfurt/M 1

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors. Development of components for the solar heating system.

Objective and Nature of the Project, Present Status

1. Aim

Further development of aluminium rollbond absorbers from refrigeration engineering for the requirements of a solar heating system and adaptation of the system components to the rollbond absorber with regard to its electro-chemical behaviour.

2. Schedule

a) Material selection with regard to the thermal and mechanical loads of the absorber to be expected in the solar system.
b) Mechanical and corrosion testing of the material.

Continuation overleaf /

Period of the Project: 1.3.76 - 31.12.78

Fund in $ US: 223,040,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Development of large-scale industrial production methods for components of solar heating systems, in particular solar collectors. Development of components for the solar heating system.

Objective and Nature of the Project, Present Status:

- Continuation ....

c) Determination of the rolling and heat treatment conditions for the cladding of the material selected.

d) Transfer of these results to large-scale industrial production.

e) Rolling tests for production of rollbond test specimens from materials in accordance with a).

f) Further development and trial of electro-chemical neutral rollbond parting agents.

g) Selection and trial of aqueous and non-aqueous heat carrier media.

h) Establishment of thermal characteristic data for various absorber types.

3. Relationship with other projects

Development is being carried out in co-operation with Klöckner & Co. Abt. Wärmetechnik (ET 4051 E).

4. Progress

a) Material selection has been concluded (see programme section ET 4051 B).

b) The mechanical and technical tests on Al99.3 and AlMn 1.5 have to a large extent been completed. Initial results from the creep-rupture tests with AlMn 1.5 at temperatures up to 150°C and up to 10 bar internal pressure are available. Chemical corrosion tests have been commenced.

c) Determination of the rolling and heat treatment conditions on industrial scale has been concluded.

d) A start has been made on application of the results from c) to large-scale industrial production.

e) Solar systems for selection and trial of aqueous and non-aqueous heat carrier media are under construction.

Country : Federal Republic of Germany	
Components	Type of Research
☒ Solar Collector ☒ Heat Storage ☒ Air Conditioning and Cooling Unit ☒ Heat Pump ☐	☐ Materials Research ☒ Component Development ☐ ☐
Name of Organisation: Philips GmbH Forschungslaboratorium Aachen Name of Principal Researcher Dr. H. Hörster	Address: Postfach 1980 D-5100 Aachen

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status

1. Aim

Analysis and evaluation of a wide variety of methods of rational use of energy and utilization of solar energy in buildings as regards economical use. Theoretical and experimental investigations in integrated energy systems in a test house with considerably modified building structure. Development of analysis method based on hourly meteorological data. Development of solar collectors of high efficiency.

Continuation overleaf /

Period of the Project: 18.6.74 - 31.12.77

Fund in $ US: 3935,882,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status:
- Continuation ....

2. Schedule

a) System analysis: investigation of various methods for optimization of solar and energy systems. Collation and investigation of meteorological data.
b) Development of high efficiency collectors. Investigation on selectively reflecting and absorbing coatings.
c) Designing an energy experimental house with considerably reduced energy requirement.
d) Designing the technical equipment of the experimental house consisting inter alia of heat pump system (for heat recovery, energy utilization from the ground, air conditioning), solar system (for hot water preparation, heating), controlled ventilation with heat recovery and a complete data collection system.
e) Test procedure and evaluation.

3. Relationship with other projects

Programme execution will take place in conjunction with RWE Essen and will make a contribution to the system study on industrial utilization of solar energy under reference ET 4045.

4. Progress

Hourly meteorological data from various meteorological stations were recorded on tape and evaluated. Solar data such as diffused, direct radiation for various orientation, intensity energy dependence on monthly and annual average were determined. The method of thermal analysis for optimization of energy systems was investigated. Several methods which describe the thermal behaviour of solar systems over the year were compared with one another. A

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status:

- Continuation ....

method of data compression was developed. Investigation of solar collectors was continued. Several configurations of cylindrical evacuated collectors were analysed and measured. Selectively absorbing coatings were investigated. Development and test of a specially effective selective absorber with alpha greater than equal 0.95 and epsilon less than equal 0.1 were commenced.

The energy experimental house was measured by means of automatic data collection. The specific energy requirement of the 75/76 heating season as well as the performance data of the individual energy systems of ventilation, heat pump and solar collector were established.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☐ Component Development
☐ Air Conditioning and Cooling Unit	☒ Systems Analysis
☐	☐
☐	

Name of Organisation:	Address:
Fa. Solarheiztechnik GmbH Unterensingen	Kelterstr. 43 D-7441 Unterensingen
Name of Principal Researcher Staub, Mayor	

Title of the Project:

Solar heating system for Unterensingen gymnasium (high school).

Objective and Nature of the Project, Present Status

1. Aim

It is the intention to develop an energy saving sanitary installation for a gymnasium which will be supplied all the year round by using solar energy and electrical energy. For this purpose it will above all be necessary to integrate solar components in the service water treatment system supplied with electrical auxiliary energy and to carry out suitable trials.

2. Schedule

Using solar collectors an insulated low pressure accumulator with a capacity of approximately 1 m3 will be heated and used to supply hot water to the showers and wash basins of

Continuation overleaf /

Period of the Project: 20.1.76 - 31.12.76

Fund in $ US: 14,640.- Government Contribution: 100%

Important Reports or Publications:

Title of the Project: Solar heating system for Untersingen Gymnasium (high school).

Objective and Nature of the Project, Present Status:
- Continuation ....

the gymnasium. Where no solar heat can be extracted from the low pressure accumulator, the service water accumulator will be heated with an electrical flow-type heater. The service water accumulator is set to a constant shower water temperature (approximately 40^{o}C). Measurement will be carried out by the municipal authorities of the shower water consumed and the current consumption for the flow-type heater.

By means of these measurements it is intended to establish to what extent a combination of solar energy with electrical energy is possible and economical.

3. Progress

The installation was commissioned a short time ago. Measurement results are not yet available. Possibly further measurement of the energy loss occurring as a result of heat exchangers etc. would be advisable. For this purpose, however, additional calorimeters would have to be installed.

Country: ITALY

Components	Type of Research
X Solar Collector Heat Storage Air Conditioning and Cooling Unit Collector Coatings	Material Research X Component Development
Name of Organisation: CRAIES Name of Principal Researcher: dott. ing. Gino Cherubini	Adress: Lungadige Galtarossa, 8 37100 - Verona

Title of the Project: Evaluation and test procedures for solar collectors

Objective and Nature of the Project

The objective of this project is to construct outdoor-indoor facilities, to measure the thermal performances and to evaluate the long term durability of solar collectors.

Present Status

The test facilities for outdoor and indoor measurements have been constructed; instantaneous efficiency, thermal performances and long term measurements on solar collectors have been started.

Period of the Project: 1. 7. 1977 - 31. 12. 1980

Fund in $ US: - Current Year (1977) 53.000 - Government Contribution: 13%
- Total for the Period : unknown

Important Reports or Publications: New Contract - no report available.

COUNTRY: Italy	
COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] HEAT STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION: INDUSTRIE PIRELLI S.p.A.	ADDRESS: P.za Duca d'Aosta, 3 20100 MILAN
NAME OF PRINCIPAL RESEARCHER: Ing. Attilio ANGIOLETTI Ing. Edoardo ROBECCHI	

TITLE OF PROJECT: Flat-plate solar energy collector

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a flat-plate solar energy collector with absorber made of rubber. Advantages: modularity, no corrosion, expected lower cost, easier installation.

PRESENT STATUS:

First sample on test.

PERIOD OF THE PROJECT: C.N.R. - Progetti Finalizzati Energetica 1976 ÷ 1979

FUND IN $ U.S. 32.000 december 1976 - november 1977
for year 1978 to be defined

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY: ITALY

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTORS ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION ISTITUTO DI FISICA TECNICA	ADDRESS: ISTITUTO DI FISICA TECNICA FACOLTA' DI INGEGNERIA Viale Risorgimento n° 2 40136 - B O L O G N A
NAME OF PRINCIPAL RESEARCHER S. Salvigni	

TITLE OF PROJECT: Effect of phisical and operative parameterc on solar collectors heat transfer coefficients

OBJECTIVE AND NATURE OF THE PROGRAM:
Aims of this project are: a - to get a deeper knowledge of heat transfer phenomena in solar collectors; b - to give an evaluation of the influence of heat transfer coefficients on solar collectors efficiency.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
An analysis of current literature has been made and the most used formulas for calculation of internal heat transfer coefficients in solar collectors have been compared.
None of available relations is able to account for the various phenomena taking place inside solar collectors.
A test facility for direct measurement of heat transfer coefficients has been therefore set in construction.

PERIOD OF PROJECT: 1/7/1977 - 31/12/1977

FUND IN \$ U.S. : 9.000

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY : ITALY	
COMPONENTS	**TYPE OF RESEARCH**
[X] SOLAR COLLECTORS [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Istituto di Fisica Tecnica Facoltà di Ingegneria - Palermo	ADRESS: Istituto di Fisica Tecnica Facoltà di Ingegneria viale delle Scienze 90128 PALERMO - ITALIA
NAME OF PRINCIPAL RESEARCHER Prof. Ing. Giorgio Beccali	

TITLE OF PROJECT: Design of non-focusing collectors. Temperature range : 90°-130°C

OBJECTIVE AND NATURE OF THE PROGRAM:

The mean objective of this project is to study and design very simple non-focusing solar collectors for retrofit use in existing heating systems and to supply heat to air conditioning absorbing units. The collectors will be designed with plane mirrors and polygonal cross-section.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT

Development of prototypes

PERIOD OF PROJECT: 1/1/77 - 31/12/77

FUND IN $ U.S. TOTAL FOR THE PERIOD 11.000

IMPORTANT REPORTS OR PUBLICATIONS:

FORMAT OF SURVEY ON COMPONENTS FOR SOLAR HEATING,

COOLING AND HOT WATER SUPPLY SYSTEMS

Country: ITALY

	Components	Type of Research
	[X] Solar Collector Heat Storage Air Conditioning and Cooling Unit Other Substancial Components	[X] Materials Research Component Development

Name of Organisation: ISTITUTO DI FISICA TECNICA E IMPIANTI TERMOTECNICI Facoltà Ingegneria- Università -Genova

Address: Via all'Opera Pia, 11
I 16145 - GENOVA (Italy)

Name of Principal researcher: prof.ing. Claudio PISONI

Title of Project: Radiative exchange components.

Objective and Nature of the Program: As part of a national R.e D. program on solar energy, the research is aimed to the development of selective solar surfaces,after a survey of the existing procedures to obtain selective coatings. It is intended to employ an electroplating technique to obtain new absorber coatings, and determine the economic feasibility of their use.

Present Status: A survey of the "state of the art" of selective surfaces for solar absorbers has been accomplished and will be published by the National Council of Research. An electroplating technique has been set up to obtain coating of various material. Few test specimens have been produced to be investigated on the basis of their radiative properties.

Period of the Project: 1.7.1977 ÷ 31.12.1981.

Fund in \$ U.S. : for the current year: 14.000 .

Government Contribution: 100% .

Country: JAPAN		March 1978
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** ☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☒ Materials Research ☒ Component Development

Name of Organization: Ishikawajima-Harima Heavy Industries Co., Ltd.	Address: 2-16, 3 Toyosu, Koto-Ku Tokyo, JAPAN 135-91
Name of Principal researcher: Shinya Kameda	

Title of Project:
R & D of solar collector for solar heating, cooling and hot water supply system in multi-family residence.

Objective

The primary objective is to develop a solar collector for driving a solar heat actuated airconditioner at the middle temperature-level.

Summary

a) Type:

i) Flat plate collector (F.P.C)

ii) Compound Flat Mirror Collector (C.F.C)

b) $\alpha \cdot \tau$:

$\alpha \cdot \tau = 0.9 \times 0.876 \times 0.876 = 0.691$ for F.P.C.
$\alpha \cdot \tau = 0.95 \times 0.876^2 = 0.729$ for C.F.C.

c) Overall heat loss coefficient: U_1 W/m^2K

$U_1 = 60$ (temp. range, 70°C to 110°C) for F.P.C.
$U_1 = 45 \sim 55$ (temp. range, 60°C to 120°C) for C.F.C.

d) Heat capacity (fluid included): C W/m^2K

$C = 8.3$ for F.P.C.
$C = 5.0$ for C.F.C.

e) Heat transfer fluid: Water

f) Material:

i) Absorber:

$\alpha = 0.9$, $\varepsilon = 0.1$ for F.P.C.
$\alpha = 0.95$, $\varepsilon = 0.1$ for C.F.C.

ii) Cover plate:

2 - pane glass, $\tau = 0.876$ for F.P.C.
1 - pane glass, $\tau = 0.876$ for C.F.C.

iii) Insulation:

The bottom of the flat plate collector is insulated with 50 mm glass wool and 50 mm of urethane foam batts forming an outer layer of insulation.

g) Expected life time: 20 years

h) Estimated cost:

		C.F.C.	F.P.C.
Now	:	270 $\$/m^2$	170 $\$/m^2$
Future	:	130 $\$/m^2$	90 $\$/m^2$

Period of the project: 1974-1980

Fund in US$: Current year (1978): 37,900 $.
Up to date total : 273,400 $.

Formal of Survey on Components for Solar Heating Cooling and Hot Water Supply Systems

Country: Japan

Check the mark x in the head of line, corresponding to the respective components and type of research:	Components	Type of Research
	[x] Solar Collector	[ ] Materials Research
	[ ] Heat Storage	
	[ ] Air Conditioning and Cooling Unit	[x] Component Development
	[ ] Other Substantial Components	

Name of Organization:
Kawasaki Heavy Industries, Ltd.

Address:
2-14, Higashi Kawasakicho, Ikuta-Ku, Kobe, Japan

Name of Principal researcher:
Kenji SHIMOKAWA

Title of Project:
Solar Heating, Cooling and Hot Water Supply System for Large Building

- **Objective and Nature of the Program:**

The objective of our program is to develop components of innovative but economical solar collector for heating, cooling and domestic hot water supply system for large building.

- **Present Status or Summary of Significant Accomplishment:**

Fourty large flat-plate solar collectors (2m x 7.5m) have been installed on the experimental building of Department of Energy Engineering, Oita University in 1977.
The Experiment will be made from April, 1978 for a couple of years.

a) type: Flat plate
b) $\alpha\tau$: 0.85
c) over all heat loss coefficient u,: $3.8 w/m^2K$
   Temperature Range $55^{\circ}C$ to $85^{\circ}C$
d) heat capacity (fluid included) c: $1.94\ wh/m^2k$
e) heat transfer medium: water
f) material:
   i) absorber $\alpha = 0.96$ $\varepsilon = 0.92$
      Pipe on Sheet Copper with black paint
   ii) cover plate 2 pane $\tau = 0.83$
   iii) insulation glass wool (50^{mm}) : polyethylene form (25^{mm})

g) expected life time: 20 years
h) estimated cost: 125 US/m^2

- Period of the Project: 1974 - 1980

- Fund in $US: - Current Year: $200,000.-
  - Total for the Period: not available

- Important Report or Publications: none

Format of Survey on Components for Solar Heating Cooling and Hot Water Supply Systems

Country: Japan

Check the mark X in the head of line, corresponding to the respective components and type of research:	Components	Type of Research
	[x] Solar Collector	[ ] Materials Research
	[ ] Heat Storage	[x] Components Development
	[ ] Air Conditioning and Cooling Unit	
	[ ] Other Substantial Components	

Name of Organization: Mitsubishi Electric Corporation Name of Principal researcher: Keiji Kobayashi	Address: 2-3 Marunouchi 2-chome Chiyoda-ku, Tokyo

Title of Project:

Development of tubular Evacuated Solar Collector

- Objective and Nature of the Program:

The object of this program is to develop a high efficiency solar collector. A high efficiency solar collector was made in 1977 and the type of solar collector was tubular evacuated solar collector.

The object of this solar collector is as follows.

a) Efficiency: $\eta = 0.5 \sim 0.6$ (at 0.086 $m^2.h.°C/W$)

b) Overall heat loss coefficient: $F'U_L = 1.7 \sim 2.1$ ($m^2.h.°C/W$)

- Present Status or Summary of Significant Accomplishment:

Three Solar Collector were made for performance test and 11 tubes Mounted in a panel.

a) Type: Tubular evacuated. Collector tube size
   dia. : 70 mm
   length: 1200 mm

b) Overall heat loss coefficient: $F'U_L = 2.6$ ($m^2.h.°C/W$)

c) Efficiency: $\eta = 0.45$ (at 0.086 $m^2.h.°C/W$)

d) Materials

1) Selective surface: Black Nickel $\alpha = 0.88$ $\varepsilon = 0.13$

2) Cover: Glass

3) Reflector: Al $R = 0.85 \sim 0.90$

e) Heat transfer medium: Water

f) Expected life time: 15 years

- Period of the Project: 1975 - 1980

- Fund in $ US: 4,700 (FY 1977)

- Important Reports or Publication: None

Country: Japan		
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** x Solar Collector Heat Storage Air Conditioning and Cooling Unit Other Substantial Components	**Type of Research** Materials research x Component Development

Name of Organization: NIPPON SHEET GLASS CO. LTD., Name of principal researcher: K. Watanabe	Address: 4-8, Dosho-machi Higashiku Osaka, Japan

Title of Project:

Glass Honeycomb Collector

Objective and Nature of the program:

The use of transparent glass honeycomb structures placed between the top cover and the absorber plate is expected to be an effective means of supressing convection losses, and also of decreasing radiation losses. As to the collector models designed to utilize the glass honeycomb effectively, simulation studies on the thermal efficiencies are performed, and some proto-type collectors are constructed. Their practical performances are measured by out door test. At a stage in which the performances of a certain proto-type collector reaches the feasible level to realize the final goal, studies on the manufacturing and fabricating technologies will be undertaken.

The final goal of the project is to develop the collectors for the space heating, cooling and hot water supplying systems, whose cost-performances may compete with that of traditional energy sources. The temporary goal to be reaches in 1977 FY is to make sure the feasible level of the thermal performance of the glass honeycomb collector and it's design know-how.

Present Status or Summary of Significant Accomplishment:

Sollector efficiency of proto- type No.5(1000 x 2000mm), measured by out door test, was 63% at the following conditions

solar incident : 800w/M
ambient temp. : 30°c
absorber temp. : 90°c

Outlines of the proto-type No.5 are as follows.

a) type and configuration:

Flat plate collector with glass honeycomb structure (cylindrical cellular structure) placed between non-selective abcorber and single glass cover (with anti-reflrction treatment)

b) $\alpha\tau$:

θ	0°	20°	40°	60°
$\alpha\tau$	0.83	0.82	0.79	0.62

θ =incident angle

c) overall heat loss coefficient:2.44w/mk
(ambient temp:30°c absorber temp:90°c)

d) heat capacity C : not measured

e) heat transfer medium:water

f) materials

i) absorber : $\alpha = \epsilon$ =0.95, black paint coating
ii) cover : =0.91, single sheet glass with anti-reflection treatment
iii) glass honeycomb : tublar arrangement type
thickness =0.25mm
diameter of tube =13mm
aspect ratio :5

g) expected life time : 15 years

h) estimated cost: 150$/m²

Period of the Project

1974 1978 FY

Fund in $US :

Current Year :10,000$ in 1977 FY

Total for the period : not settled

Important Reports or Publications : none

Format of Survey on Components for Solar Heating
Cooling and Hot Water Supply Systems

Country: Japan		
Check the mark x in the head of line, corresponding to the respective components and type of research:	**Components** ☒ Solar Collecter ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☐ Materials Research ☒ Component Development

Name of Organization:
Research Center, Sanyo Electric Co.

Name of Principal Researcher:
K. Hinotani

Address:
1-18-13, Hashiridani, Hirakata, Osaka

Title of Project:

Development of Tubular Evacuated Solar Collector

Objective and Nature of the Program:

Two hundred eighty two evacuated tubular solar collectors have been mounted on the solar test house built in the March of 1977 for continuous operational study. The measurements will be made to evaluate the performance of the collectors in conjunction with the cooling, heating and hot water supply system employed in the solar test house. While the measurements is carried out, the development of the collectors will be continued in this year to improve the cost effectiveness, mass producibility and efficiency, by replacing the absorber plate by different types of absorber plates.

Present Status or Summary of Significant Accomplishment:

The 282 evacuated tubular solar collectors were manufactured and installed on the solar test house.

a) Type and configuration: Tubular and evacuated, the size of the collector tube is 100 mm dia. and 2000 mm long.

b) $\alpha\tau$: 0.79

c) Overall heat loss coefficient: $U = 0.6$ (W/m^2K) (at 90 C)

d) Heat capacity (fluid included): $C = 7.1$ (W/m^2K)

e) Heat transfer medium: water

f) Material
1) absorber; $\alpha = 0.9$; $\varepsilon = 0.1$
2) cover plate: one pane (glass tube), $\tau = 0.88$
3) insulation: evacuated

g) Expected life time: 15 years

h) Estimated cost: $\$110/m^2$

<u>Period of the Project:</u> 1974 - 1980

<u>Fund in $ US:</u> 1977 FY - $59,000

<u>Important Reports or Publication:</u> none

Country: Japan		
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** X Solar Collector Heat Storage Air Conditioning and Cooling Unit Other Substantial Components	**Type of Research** X Materials Research X Component Development

Name of Organization: SHOWA ALUMINIUM K.K. Oyama Plant	Address: 480 Inuzuka, Oyama Tochigi 323 JAPAN
Name of Principal Researcher: Yuichiro Asano	

Title of Project:

Research and development of solar energy space heating, cooling and hot water supply system. (Research and development of metallic materials)

- Objective and Nature of the Program:

Aim of Research

Research and development of technologies, solar energy collectors and materials listed below necessary to supply of such solar energy collectors made of aluminum or other metals and used in the solar energy space heating, cooling and hot water supply systems that may be economically feasible from the point of costs in comparison with the conventional fossil fuels or petrified fuels.

(1) Development of solar energy collectors and collector materials principally made of metals and used in heating, cooling and hot water supply systems which are inexpensive, durable and efficient in energy collecting.

(2) Development of mass production technologies for the solar energy collectors and collector materials mentioned above.

Scope of Studies:

In relation with the materials for use in aluminum or other metal collector panels, the conventional materials with not only be evaluated and reviewed but also new alloy materials will be studied and developed for the purpose of the prevention of aqueous corrosion.
Further, plating, anodizing and chemical treating processes will be studies to develop economical treating processes for selective coatings.
In addition, a variety of collectors including the type of collectors which can be used themselves an independent roofing will be developed and subjected to the long-term field testing to evaluate the economical feasibility and durability.
Mass production technologies will also be studied and established for type of collectors used in various applications.

-Present Status or Summary of Significant Accomplishment

Solar Collector

item \ Type	A	B
a) type	flat plate, extruded aluminum flame, black painted absorber	flat plate, extruded aluminum flame, selective absorber
b) $\alpha\tau$	$F_R\alpha\tau$=0.838 (1 glass cover) =0.734 (2 glass covers)	$F_R\alpha\tau$=0.801 (1 glass cover) =0.720 (2 glass covers)
c) overall heat loss coefficient U_l[W/m^{2}K]	F_RU_l=7.29 (1 glass cover) =6.77 (2 glass covers)	F_RU_l=4.88 (1 glass cover) =3.94 (2 glass covers)
d) heat capacity C [Wh/m^{2}K]	not measured	
e) heat transfer medium	water or other liquids	
f) material 1) absorber	black paint α=ε=0.95 aluminum Roll Bond plate	selective anodizing coating =0.93, =0.10 copper tube in extruded aluminum fin-tube
2) cover plate	1 or 2 3mmt glass cover, τ=0.876	
3) insulation	50mm fiber glass	
g) expected life time	20 years (requires inhibitor)	20 years
h) estimated cost [$/m^2]	80 (1 glass cover)	100 (2 glass covers)

-Period of the Project: 1980

-Fund in $ US:

Current Year (FY 1977) 89,000
Total for the Period unknown

-Important Report or Publication: none

Format of Survey on Components for Solar Heating, Cooling and Hot water Supply Systems

Country: Japan

Components	Type of Research
☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Materials Research ☒ Component Development

Name of Organization:

Toray Industries, Inc.

Name of Principal researcher:

M. Inoue

Address:

2-2 Nihonbashi-muromachi
Chuo-ku, Tokyo

Title of Project:

Research and development of plastic materials for solar collectors

- Objective and Nature of the Program:

The objective of this program is to develop plastic materials for solar collectors, such as selectively transparent plastic films for covering, transparent thermal insulator including plastic honeycombs or tubings, and selectively absorbing coating materials. This program also includes evaluation of their performances in solar collectors of practical size.

Temporary goal in 1977 is to improve durability of these materials, and final goal is to develop low-cost and long-life solar collectors containing several plastic materials, and also to establish mass production technologies.

- Present Status or Summary of Significant Accomplishment:

Materials for solar collector

1) absorber: selectively absorbing paint (containing dispersed metal oxide particles)

$\alpha = 0.90, \ \varepsilon = 0.20$

2) cover : selectively transparent polyester film (with In_2O_3 layer)

$\tau = 0.78, \ \varepsilon_{eff} = 0.20$

3) transparent thermal insulator: evaluation is in progress.

- Period of the Project: from 1974 to 1980
- Fund in $ US: - Current Year $ 66,300
  - Total for the Period
- Important Reports or Publications: none

Country :	THE NETHERLANDS

	Components :	Type of Research :
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation :

BOUWCENTRUM

Name of Principal Researcher :

Ing. J.M. van Heel

Address :

BOUWCENTRUM
BINNEMILIEUTECHNIEK
Weena 700-Postbus 299
ROTTERDAM-Holland
tel. 010-116181 ext. 2601

Title of Project :

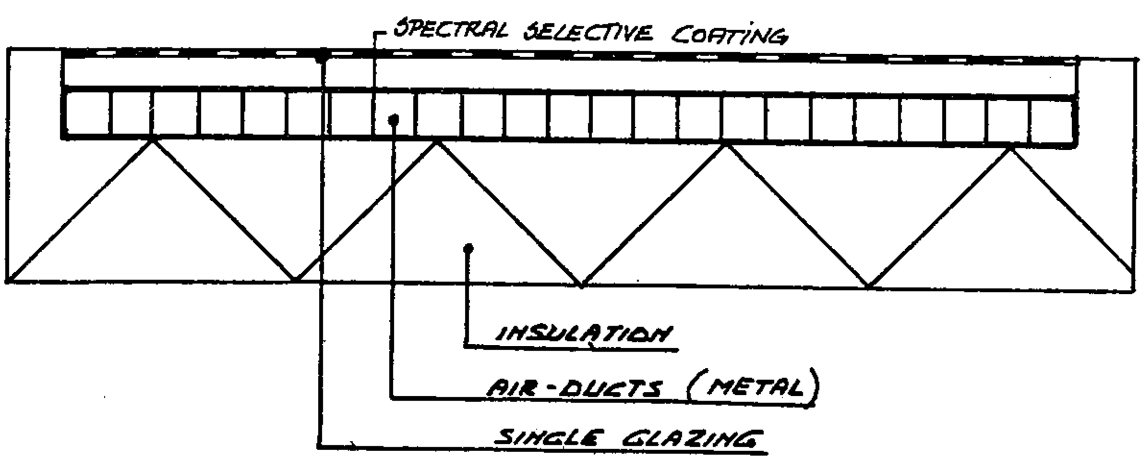
DEVELOPMENT OF AN AIR-COOLED COLLECTOR

- Objective and nature of the program

The most important difficulties concerning liquid-cooled collectors are: corrosion, freezing and over heating of the liquid (water). When we use an air-cooled collector these problems do not occur. The purpose of this study is to examine an air-cooled collector which is not difficult to make and easy to install in all kinds of constructions.
This collector consists of a number of square metal ducts closely attached to each-other and placed in a plastic casing. Bottom and sides of the ducts are insulated. The top is covered with a single glass pane. The surface of the ducts is provided with a selective coating.

- Present status

A prototype of this collector has been built and has been tested for several months. A computer model has been made. We have made some progress in making this collector suitable for mass-production. The study is being carried out in connection with an E.E.C. assignment. The final report, which can be expected in March 1978, will contain more details. The study is being carried out with the assistance of the Institute of Applied Physics in Delft (Holland).



AIR-COOLED COLLECTOR

Country : THE NETHERLANDS

Components :

☒ Solar Collector
☒ Heat Storage
☐ Air Conditioning and Cooling Unit
☐ Other Substantial Components

Type of Research :

☒ Material Research
☒ Component Development

Name of Organisation :

BOUWCENTRUM

Name of Principal Researcher :

Ing. J.M. van Heel

Address :
BOUWCENTRUM
BINNENMILIEUTECHNIEK
Weena 700-Postbus 299
ROTTERDAM-Holland
tel. 010-116181 ext. 2601

Title of Project :
DEVELOPMENT OF AN INTEGRATED COLLECTOR HEAT-STORAGE SYSTEM FOR LOW-COST HOUSING PROJECTS

- Objective and nature of the program

The aim of this study is to develop a type of collector which is not expensive to make, is durable and requires hardly any maintenance. We, therefore, chose an air-cooled collector combined with heatstorage.
The collector consists of a concrete slab with metal ducts incorporated in the surface of the slab. The air to be heated flows through the metal ducts. The slab can be covered with prefabricated double glass or evacuated tubes with a selective coating on the inside of the tubes. Another possibility is to use a movable insulation screen between the glass panes. Back and sides are insulated. This type of collector can be combined with an air-heating system for heating the house. For hot-water supply this collector can be connected with an air-heated boiler.

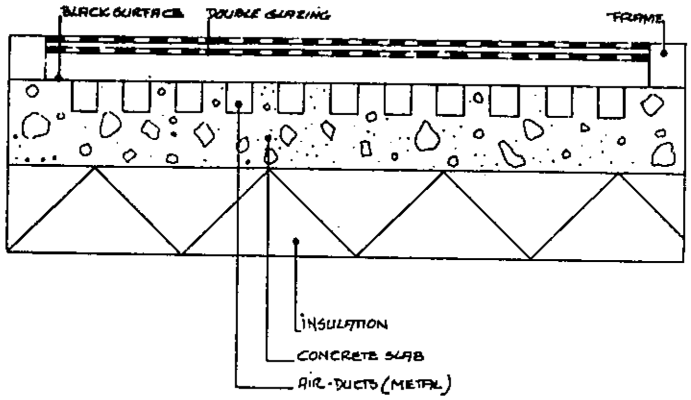
- Present status

This collector is being studied at the moment in connection with an EEC assignment. A prototype has been built and has been tested for several months. A computer model has been made. The final report concerning this study, can be expected in March '78. This study is being carried out in co-operation with the Institute of Applied Physics in Delft (Holland).

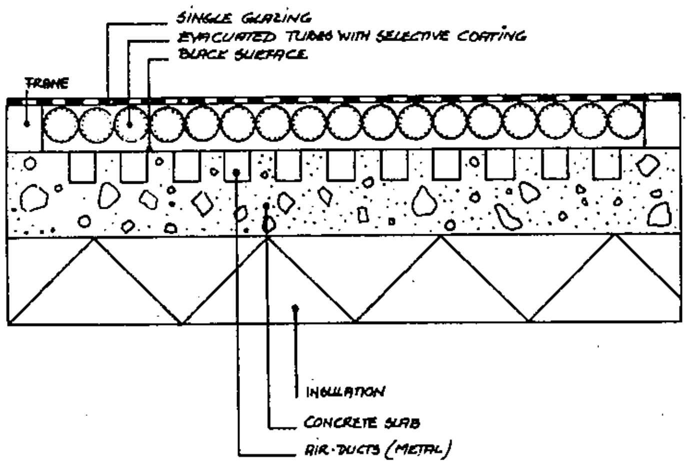
see continuation 1

continuation 1: BOUWCENTRUM

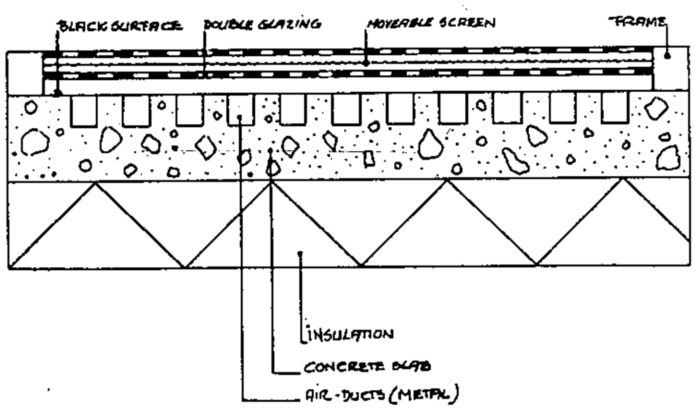
Title: Development of an integrated collector heat-storage system for low-cost housing projects.



AIR-COOLED COLLECTOR IN COMBINATION WITH STORAGE.



AIR-COOLED COLLECTOR IN COMBINATION WITH STORAGE



AIR-COOLED COLLECTOR IN COMBINATION WITH STORAGE

Country :	THE NETHERLANDS	
	Components :	Type of Research :
	☒ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation :	Address :
CALCOL B.V.	Binnenhoek 34, P.O. Box 7 TIEL tel. 03430-5244
Name of Principal Researcher : Mr. J.B. Mulder	

Title of Project :

DEVELOPMENT OF AN INTEGRATED SOLAR BOILER SYSTEM

- Remarks

Calcol B.V. is a joint-venture started in 1977 of the following three Dutch firms:

1. DRU, Koninklijke Fabrieken Diepenbrock & Reigers B.V.,Hutteweg 24, Ulft. (Fabrication of the solar collectors).
2. Koninklijke Metaalwarenfabrieken Daaldrop B.V.,Binnenhoek 34, Tiel. (Fabrication of the storage boilers).
3. Van Swaay Installaties B.V.,Bredewater 24, Zoetermeer (P.O. Box 220) (System design and automatic control)

General contact person for the overall Solar Boiler System design is:
Mr. W.H. Wijckerheld Bisdom of Van Swaay Installaties B.V., tel. 079-219363.

- Objective and nature of the program

Development of integrated Solar Boiler Systems with different capacities for hot tap water supply.

- Present status

Because this cooperation has just started in 1977, these complete Solar Boiler Systems are not yet ready for delivery in large quantities. However, the flat plate solar collectors to be used, are already produced by DRU-Ulft in hundreds for space heating projects in The Netherlands. The Institute of Applied Physics TNO-TH-Delft has done the necessary research and development of durable selective coatings of high performance for the DRU-collectors. For more detailed information of these collectors is referred to the "format" and the "attached sheet" of this institute.

Country :	THE NETHERLANDS

	Components :	Type of Research :
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation :
Heat Transfer Group, Applied Physics
DELFT UNIVERSITY OF TECHNOLOGY

Name of Principal Researcher :
Ir. W.M.M. Schinkel

Address :
Lorentzweg 1
P.O. Box 5046. 2600 GA-DELFT

tel. 015-783222

Title of Project :

NATURAL CONVECTION IN FLAT PLATE SOLAR COLLECTORS

- Objective and nature of the program

The objective of this study is to find a set of accurate equations for predicting free convective heat loss across parallel plates in solar collectors. Therefore we need both accurate measurements of the local heat transfer coefficient as theoretical knowledge of the fluid flow in fluid layers.
With a model consisting of two differently heated isothermal plates and adiabatic side walls the local heat transfer coefficient is measured using a holographic interferometer. Parameters are: temperature differences between the plates, aspect ratio and angle of inclination. The emphasis is on end side effects. Furthermore the effect of the use of honeycombs on the heat transfer is studied. With a model consisting of a constant heat flux hot plate, an isothermal cold plate and adiabatic side walls flow vizualisation experiments are performed.
The governing equations are solved using a finite difference technique.
This is done both for laminar flow and turbulent flow.

- Present status

A first set of measurements of the local heat transfer have been performed.
The results of these measurements show that heat transfer measurements using a holographic interferometer are accurate and reproducible. Furthermore these measurements show that the end side regions have a considerable contribution to the mean heat transfer coefficient. For the vertical case and laminar flow the governing equations are solved.
The results are in good agreement with results known from literature and own measurements.

- Period of the project: 3 years

- Fund in \$ US: - Current year : \$ 24,000
- Total for the period: \$ 90,000

- Important reports or publications:

"Free convection in inclined air filled enclosures" (offered for 6th Int. Heat Transfer Conference, 1978).

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation.:
Laboratory for refrigerating engineering
DELFT UNIVERSITY OF TECHNOLOGY

Name of Principal Researcher :
Ir. M.F.G. van der Jagt

Address :
Mekelweg 2
DELFT

tel. 015-786912 or 786667

Title of Project :
FLAT PLATE SOLAR COLLECTOR WITH HALOGINATED CARBONS AS THE HEAT TRANSFER MEDIUM

- Objective and nature of the program

In the majority of flat plate solar collectors water is functionating as the heat transfer medium, because of its many advantages compared with other media. Fluoro carbons, however, have some important advantages compared with water, such as:
- no freezing problems
- increased efficiency by automatic adaption to the available solar load
- a possible increased efficiency because of
  . a better heat transfer
  . a lower collector temperature by use of a medium evaporating at a constant temperature.

It is very important to choose the right fluoro carbon with pressure-losses as low as possible. In general an evaporating medium should satisfy the following requirements:
- acceptable pressure (< 5 bar)
- large heat of vaporization
- low specific volume in the gasphase
- not expensive
- not dangerous (poisonous, explosive).

The first experiments will be carried out to compare two heating systems which are filled with R11 and water, respectively.

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☐ Component Development

Name of Organisation :
Heat Transfer Group, Applied Physics
DELFT UNIVERSITY OF TECHNOLOGY

Name of Principal Researcher :
Drs. M. van der Leij

Address :
Lorentzweg 1
P.O. Box 5046. 2600 GA-DELFT

tel. 015-783248

Title of Project :

SPECTRAL SELECTIVE LAYERS FOR PHOTOTHERMAL CONVERSION OF SOLAR ENERGY

- Objective and nature of the program

The aim of this project is to improve the radiation efficiency and durability of some spectral selective surfaces for low temperature and for high temperature application. The first spectral selective surfaces studied are: iron oxide on steel 37, chromate conversion coating on zinc and zinc plated steel, zinc oxide on zinc and zinc plated steel, tungsten oxide on nickel and stainless steel and lead sulphide powder in a Silicon resin layer on aluminium.
Iron oxide and chromate conversion coating were produced by chemical immersion, black zinc oxide by anodic treatment, tungsten oxide by reactive sputtering and the last one by spraying like paint.
In the second phase intensive investigation is now going on concerning cobalt oxide on nickel plated steel and heavily doped tinoxide on glass or ceramic base. These oxides are known as very durable and stable.
Cobalt is first deposited electrochemically on the nickel substrate and then oxidized in air of 400°C during a few hours. An alternative and cheaper method of oxidizing will be tried out. Also the effect of doping iron or nickel in the cobalt oxide, is being studied.
To optimize these oxides, knowledge about physical properties of semiconductors is necessary: the effect of temperature on charge carrier density and mobility, the effect of the change carrier density and the effect of the stoichiometry on the optical properties and so on.

- Present status or summary of significant accomplishment:

If iron oxide was covered with a very thin layer (100 nm) of Silicon resin (for example Dow 805), the solar normal total absorptivity increased from 0.83 to 0.93. The thermal hemispherical total emissivity could be kept low (about 0.10) if the steel substrate was polished very well. Additionally the thin Silicon resin coating will also protect the iron oxide surface against humidity and other possible chemical or mechanical attacks. With such a protective coating iron oxide seems to be the best among the cheapest spectral selective surfaces up till now. No change in the spectral selectivity was found after heating in air at 180°C, for two weeks at a stretch. The chromate conversion coating and the black zinc oxide on zinc plated steel show good spectral selectivity (solar absorptivity: 0.93 - 0.96 and emissivity: 0.10 - 0.14), but are not stable after air heating at 180°C. However, after heating at 80°C for two weeks, no degradation was found.

To determine the radiation and optical quantitites of our spectral selective surfaces different experimental equipment were built. The following measurements can be done in our group:

see continuation I

continuation 1 - SPECTRAL SELECTIVE LAYERS FOR PHOTOTHERMAL CONVERSION OF SOLAR ENERGY

a. the directional hemispherical spectral reflectivity (wavelength region: 0.3 - 12 micron), at temperatures to 350°C with an integrating sphere reflectometer coupled to a spectrophotometer; the solar total absoptivity can be calculated,

b. the specular spectral reflectivity between 2.5 and 40 micron at angle of 20°, with a Beckman Acculab VI spectrophotometer,

c. the directional total emissivity (400°C and to 75° from the normal) with a radiometer; the hemispherical total emissivity can be calculated,

d. the solar normal total absorptivity by calorimetric method; a small solar simulater source, type ELH from General Electric, is available,

e. the hemispherical total emissivity to 150°C by electric heating of the sample.

At the end of 1977 an ellipsometer will be add, to measure the spectral refractive index and the absorption coefficient.

- <u>Period of the Project:</u> 4 years

- <u>Fund in $ US:</u>
  - Current Year $ 60,000.--
  - Total for the Period $ 250,000.--

- <u>Publications:</u> Paper presented at the Dutch I.S.E.S. meeting of 13th of April 1977. Paper accepted by Solar Energy 1977. Paper offered to J. Electrochem. Soc. 1977. Paper offered to ISES conf. 1977 in Delhi.

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation :

Lab. Heat Technology
EINDHOVEN UNIVERSITY OF TECHNOLOGY

Name of Principal Researcher :

J.J. Feijen

Address :

Postbox 513
EINDHOVEN

tel. 040-472136

Title of Project :

HEAT TRANSFER IN FINNED AIR COLLECTORS

- Objective and nature of the program

Objective:
Establishing the physical laws governing the heat transfer to inclined finned plates, and applying this knowledge to the design of air collectors.

Aspects to study:
- Fundamental: Velocity and temperature profiles and heat transfer in laminar and turbulent flow along fins on inclined plates, entrance phenomena; transition from laminar to turbulent flow.
- Technical : Engineering correlations; optimal design.

Short range goal (December 1978):
Experimental verification of the calculations for laminar flow conditions; determination of the point of transition to turbulent flow; measurement of the heat transfer in turbulent flow.

Present status of knowledge:
Computations have been performed on the heat transfer and velocity field for inclined finned plates in laminar flow. Numerical instabilities appear to occur at heat fluxes well below the fluxes that occur in actual practice. Nevertheless a definite tendency to thermal stratification between the fins could be established. The stratification reduces the heat transfer coefficient and probably delays the transition to turbulent flow.

Period of the project:
The project is scheduled for the year 1976-1978, with an average effort of 1 man, technical assistance included. The findings proceed from the autonomous means of the EUT, and correspond to roughly $ 30,000 per year, overhead included.
Only preliminary internal reports are available so far.

Country : THE NETHERLANDS

	Components :	Type of Research :
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☒ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation :
ENERGIE BESPARENDE SYSTEMEN E.B.S.
(Energy Saving Systems)

Name of Principal Researcher :
Mr. M. Baardman

Address : A. van Gelderweg 111
5361 CV GRAVE

5360 AB Post Office Box 95

Tel.: 08860 - 3992

Title of Project : DEVELOPMENT OF ECONOMICAL SOLAR DOMESTIC WATER HEATING AND SPACE HEATING SYSTEMS, IN PARTICULAR SOLAR COLLECTORS

- Objective and nature of the program

Development of effective and reasonably priced flat plate collectors in the following ranges:

low temperatures 20 - 60°C (RENOR® - LP)
medium temperatures 60 - 100°C (RENOR® - MP)
high temperatures 100°C and higher (RENOR® - HP)

Development of effective and reasonably priced solar energy systems for hotwater supply and space heating (ST-system®).

Schedule

- Development of high absorptance, low emittance coatings on stainless steel absorbers.
- Development of solar absorbers on the basis of several materials.
- Cover material selection.
- Collectors easy to build in roofs.
- Development of a "solar transformation" system (ST-system®), in particular domestic water heating, with automaticcally filling and draining with respect to freezing, boiling and failure.

Research

Research has been carried out by Raadgevend Technisch Bureau Van Heugten B.V. te Nijmegen.

- Present Status or Summary of Significant Accomplishment:

- A number of domestic heating and space heating systems has been installed.
- Testing of the ST-system® has been carried out by T.N.O. the Netherlands.
- The following types of solar collectors are produced:
  RENOR-LP® flat plate, stainless steel black painted absorber, optional: single glass, single polycarbonate, double coverplate.
  RENOR-MP® flat plate, stainless steel spectral selective absorber, optional: single glass, single polycarbonate double coverplate.

The absorber material can be:
Steel : type NSP
Stainless Steel: type SSP
Copper : type CP
Plastic: type NP
The first three types can be coated with a spectral selective coating.

Period of the Project:
- Funds : about $ US 400.000,--

see attached sheet

ATTACHED SHEET

ENERGIE BESPARENDE SYSTEMEN E.B.S.

Title: Development of economical solar domestic water heating and space heating systems, in particular solar collectors

1. Solar collector

a) Type	: RENOR-LP, flat plate, stainless steel, black painted absorber.
b) $\alpha.\tau$	: 0,82
c) Overall heat loss coëfficiënt W/m^2K: (T-ambient=20^oC, T absorber= 60^oC)	: 7,5
d) Heat capacity, Wh/m^2K	: 2,0
e) Heat transfer medium	: water
f) Material absorber	: stainless steel α= ε = 0,97
cover plate	: single polycarbonate
g) Expected life time	: min. 15 years
h) Estimated cost (\$ US/m^2)	: 100

2. Solar collector

a) Type	: RENOR-MP, flat plate, stainless steel, selective absorber.
b) $\alpha.\tau$	: 0,77
c) Overall heat loss coëfficiënt W/m^2K: (T-ambient=20^oC, T absorber= 90^oC)	: 4,7
d) Heat capacity, Wh/m^2K	: 2,0
e) Heat transfer medium	: water
f) Material absorber	: stainless steel α= 0,92 ε= 0,24
cover plate	: single polycarbonate
g) Expected life time	: min. 15 years
h) Estimated cost (\$ US/m^2)	: 100

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation : Technical Physics Laboratory, UNIVERSITY OF GRONINGEN	**Address :** Zernikelaan Nijenborgh 18 9747 AG GRONINGEN Tel.: 050 - 115950
Name of Principal Researcher : Prof. Dr. Ir. J.C. Francken	

Title of Project :

HEAT PIPE COLLECTOR FOR LOW TEMPERATURES

- Objective and Nature of the Program:

Objective: Application of the heat pipe principle in order to arrive at the design of a low temperature solar collector, featuring:
- high overall efficiency
- low weight (fast response)
- manufactured using mass production techniques, and
- made of cheap materials.

Short range goal: Manufacture of a prototype collector according to the following

Description: The prototype heat pipe collector consists of an array of heat pipe elements, cooled by a common heat exchanger. Each element is composed of two separate parts, made of thin metal sheet and joined by some suitable technique. At present, mainly for experimental reasons, aluminium sheet is used. The parts are bonded using a glueing technique, as customary in the airplane industry. A cross-section of a heat pipe element is shown in figure 1. The inner side of the upper (flat) part is provided with a capillary coating. The heat pipe being oriented at a rather large angle with the horizontal (angles around 45^{o}), most fluid is collected in the crevice at the bottom and is drawn by the capillary forces into the evaporating structure.
By operating the pipe with its long axis at a small slant, the back flow of the fluid in the crevice is gravity aided.
A front view of the collector and another cross-section, are given in figure 2.
The heat from the condensor parts of the heat pipes is removed with the aid of an exterior heat exchanger, operated with turbulent flow in order to cope with the concentrated heat flux delivered by the heat pipe array.
From measurements on heat pipe elements the expected properties of the completed collector, composed of 16 elements, have been calculated. Using the following data (cf. figures 1 and 2).

$L = 0.60$ m $\quad b = 0.07$ m
$h = 0.10$ m $\quad w = 0.025$ m $\qquad Re = 6000$ (Reynolds number)

and a thickness of 1 mm of the evaporator fluid, it has been computed that the collector efficiency will be $F' = 0.956$ with a smooth condensor surface. Using a grooved condensor surface, a value of $F' = 0.966$ can be expected.
These collector efficiencies are in the range of good conventional collectors.
However, the main advantages of the heat pipe collector are:
- small dependence of its properties on the metal employed, enabling the use of thin steel sheet as a construction material.

see continuation 1

Continuation 1 - Title: HEAT PIPE COLLECTOR FOR LOW TEMPERATURES
(University of Groningen)

- small heat capacity, resulting from both the light construction and the small amount of fluid needed.
- the "diode effect" of the heat pipe, reducing losses at low plate temperatures.

- Present Status:

The prototype has been constructed and will be tested in an experimental outside test stand.

- Period of the Project:

Start 1974. Completion prototype 1978.
Outside funds 1976 - 1977 U.S. $ 8000,-.

- Reports:

J.C. Francken - The Heat Pipe Fin - A Novel Design of a Planar Collector. (Published Report: 1975).

D.A.M. Jaspers Focks - Measurements on a Heat Pipe Fin (in Dutch) (Internal report Nr. 16, 1976);

S.J.A. Boelema - The Application of the Heat Pipe Principle on a Solar Collector (in Dutch) (Internal Report Nr. 22, 1976).

- Papers:

J.C. Francken - The Heat Pipe Fin, A Novel Design of a Planar Collector. (1975 Int. Solar Energy Congress, ISES 75, abstract nr. 34/8).

J.C. Francken - A Heat Pipe Collector for Low Temperatures. (Proceedings Int. Solar Energy Congress, Isec 77, paper 0249, 1978).

Figure 1

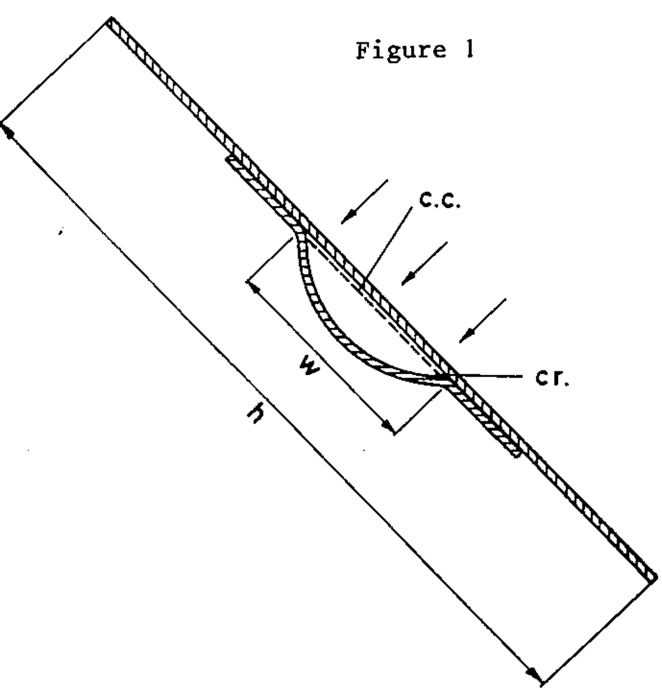
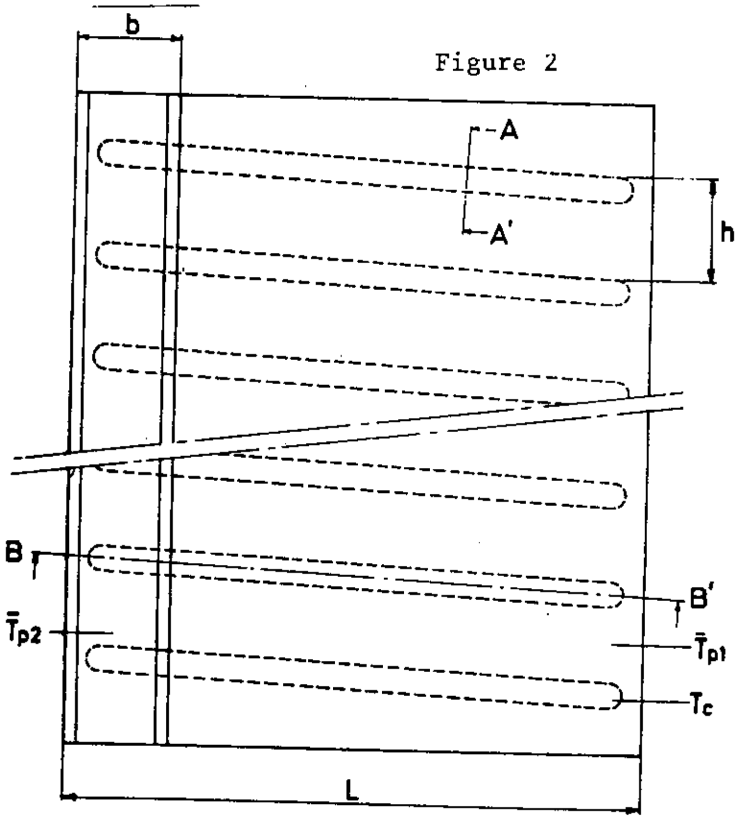


Figure 2



Country :	THE NETHERLANDS

	Components :	Type of Research :
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☐ Component Development

Name of Organisation :
Technical Physics Laboratory
UNIVERSITY OF GRONINGEN

Name of Principal Researcher :

Ir. M. Sikkens

Address : Zernikelaan
Nijenborgh 18
9747 AG GRONINGEN

THE NETHERLANDS.

tel.: 050-115709.

Title of Project: INVESTIGATION OF THE PHYSICAL PROPERTIES OF SPECTRAL SELECTIVE LAYERS.

Objective: The preparation of optimal selective absorption layers for use in different types of solar collectors.

Description: Selective absorption and reflection at the surface of solids can be achieved in several ways. Up till now the most promising approach is the combination of a thin layer of a metal oxide on top of a highly reflective substrate.
The physical mechanism responsible for the selective properties of such layers is qualitatively known, in some cases.
It is the aim of the project to gain better insight in this matter and, also, to extend the investigations to layers of metal carbides on reflective substrates.
In order to obtain reproducible and interpretable results, the layers will be made by reactive sputtering in a suitable gas atmosphere. This atmosphere has to be free from contaminating gases. The sputtered layer will then be transferred, in vacuüm, to another part of the processing chamber, where the optical properties will be analysed with the aid of an ellipsometer.
This analyses will give the so called "complexe index of refraction": $\tilde{n} = n + ik$, as a function of the wavelength. From these results, both the absorption factor (for sunlight) and the emission factor (for thermal radiation) can be computed for different values of layer thickness.
Apart from these experiments under strictly controlled conditions, measurements are being made on technical layers, using a calorimetric method (ref. 1). Further equipment is being developed in order to extend these measurements to higher temperatures.

Present Status: preliminary equipment tested; ultimate set-up in construction.

Period of Project: Start 1975; Completion phase I: end 1979.

Outside funds: 1976-1977: U.S. $ 20.000.

Reports

M. Sikkens - Apparatus for determining the complex index of refraction of selective absorbing materials with the aid of ellipsometry. (in Dutch) (Internal Report nr. 58, 1975).
M. Sikkens - Investigation of the optical properties of materials to be used in solar collectors (in Dutch) (Internal Report nr. 58a/1975-'76).

Paper

J.L. Verster, M. Sikkens, F. Bosscher - A calorimetric method for determining the absorptance for visible and near infrared radiation of surfaces. (Internal Report nr. 19/1977; submitted for publication in Br. J. of Physics E: Scientific Instruments).

Country :	THE NETHERLANDS	
	Components :	Type of Research :
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation : INSTITUTE OF APPLIED PHYSICS TNO-TH	Address : P.O. Box 155 DELFT tel. 015-569300
Name of Principal Researcher : Ir. C. den Ouden	

Title of Project :

DEVELOPMENT OF DURABLE SELECTIVE COATINGS FOR HIGH PERFORMANCE COLLECTORS

- Objective and nature of the program

The objective of the research program is to develop flat plate solar collectors with a high efficiency and high durability, and which can be used for a variety of applications. In this program a glass lined absorber plate (steel based) is developed.
For the glass lining an enamel with a high solar absorption is used. This enamel layer is coated with a thin tinoxide layer by spraying an organic tin solution against the heat enamel after the firing procedure. On the efficiency of the procedure the composition of the enamel is of large influence. The selective surfaces prepaired along this line has an absorptivity of at least 0.9 and an emmissivity less than 0.2.

- Present status

For several demonstration-projects in The Netherlands a few hundred of solar collectors with this selective surface are already made and installed. For the specifications of these collectors, if mounted in a case and covered with 1 coverplate, see attached sheet.
The product-development of high performace collectors with this absorber (steel-glass-enamelled-tinoxide layer) is continued. This development is carried out in cooperation with Dutch industries.

- Period of the project: 1975 - 1978

- Fund in $ US: - 1977: ≃ 30,000
  - Total for the period: ≃ 150,000

- Important reports or publications

Dutch patent no. 75.04277

see attached sheet

ATTACHED SHEET

INSTITUTE OF APPLIED PHYSICS TNO-TH-DELFT

Title: Development of durable selective coatings of high performance collectors

Solar collector

a) Type flat plate. Dimensions 1650 x 800 x 94 mm

b) $\alpha\tau \simeq 0.78$

c) Overall heat loss coëfficient U_l [W/m^2.K] (temp. range θ [°C])
4-5 (30-70°C).

d) Heat capacity (fluid included) $C \simeq 3.8$ Wh/m^2.K

e) Heat transfer medium (water/glycol)

f) Material
   i) absorber: two 0.8 mm steel sheets, seam welded, and pressure expanded covered with a coating of black glass enamel with a doped tinoxide layer. $\alpha \simeq 0.92$; $\varepsilon < 0.2$
   ii) cover plate: glass, single 4 mm $\tau = 0.85$
   iii) insulation: glasswoll, 5 cm

g) Expected life time: 20 years

h) Estimated cost ($US/m^2): $US 100/m^2

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation : NIJS & VALE B.V.	**Address :** Nijverheidsweg 19 P.O. Box 95 NIJMEGEN tel. 080-772146
Name of Principal Researcher : Ir. J.Th. Rutgers	

Title of Project : PRODUCTION AND DEVELOPMENT OF FLAT PLATE ALUMINIUM AND STAINLESS STEEL SOLAR COLLECTORS

- Objective and nature of the program

Development of a high efficient, durable, easy built-in and cheap collector

- Present status or summary of significant accomplishments

Since the beginning of the project (in 1975) Nijs & Vale B.V. has produced about 3000 m^2 of sun collectors.

- Period of the project: Start in 1975.

- Fund in $US: - In 1975 and 1976 about $US 50,000 (total)
  - Current year about $US 10,000

- Important reports or publications: No.

see attached sheet

ATTACHED SHEET

NIJS & VALE B.V.

Title: Production and development of flat plate aluminium and stainless steel solar collectors

1. Solar collector

a) Type	: Flat plate, aluminium Roll-Bond absorber sheet, single glass. Dimensions: 1650 x 800 x 94 mm
b) $\alpha.\tau$	: 0.79
c) Overall heat loss coefficient	: 8 W/m^2K
d) Heat capacity	: 1.75 Wh/m^2K
e) Heat transfer medium	: Water + glycol
f) Material	: - absorber, blackened by electro-chemical way $\alpha = \varepsilon = 0.95$ - cover plate, single glass (float) thickness 4 mm, $\tau = 0.83$ - insulation: 5 cm glasswool
g) Expected life time	: 15 à 20 years
h) Cost	: $ 80/m^2

2. Solar collector

a) Type	: Flat plate, aluminium Roll-Bond absorber sheet, single glass. Dimensions: 1650 x 800 x 94 mm
b) $\alpha.\tau$	: 0.75
c) Overall heat loss coefficient	: 4.6 W/m^2K
d) Heat capacity	: 1.75 Wh/m^2K
e) Heat transfer medium	: Water + glycol
f) Material	: - absorber, selective black $\alpha = 0.9$, $\varepsilon = 0.1$ - cover plate, single glass (float) thickness 4 mm, $\tau = 0.83$ - insulation: 5 cm glasswool
g) Expected life time	: 15 à 20 years
h) Cost	: $ 90/m^2

3. Solar collector

a) Type	: Flat plate, stainless steel Dimensions: 1845 x 1175 x 68 mm
b) $\alpha.\tau$	: 0.81
c) Overall heat loss coefficient	: 8 W/m^2K
d) Heat capacity	: 3.8 Wh/m^2K
e) Heat transfer medium	: water
f) Material	: - absorber, matt black $\alpha = 0.92$ - cover plate: fiber glass $\tau = 0.88$ insulation: 3 cm glasswool
g) Expected life time	: over 20 years
h) Cost	: $ 100/m^2

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☒ Heat Storage ☒ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation : N.V. PHILIPS GLOEILAMPEN FABRIEKEN	**Address :** Commercial Dept. Light - Solar Collectors Building EK-p EINDHOVEN tel. 040- 756716
Name of Principal Researcher : (Contact Person) Dr. Ir. S.H.A. Begemann	

Title of Project :

R&D ON SOLAR-THERMAL COMPONENTS

- Solar Collectors

Flat plate collectors (Eindhoven)

Improved top-insulation through application of layer of evecuated tubes.
. Absorber - steel (copper or aluminium optional)
. Cover - glass
. Insulation - polyisocyanurate
glasswool
evacuated glass tubes
. Maintenance free first 10 years
. Life time dependent on maintenance after 10 years
. Performance: $\alpha\tau = \pm 70\%$
$K = \pm 2.2\ W/m^2 {}^\circ C$ at $\Delta\tau = 40^\circ C$
. Other info proprietary.

Tubular collector (Achen-Germany)

Absorber & heat exchanger inside vacuum. Heat pipe configuration
. Material - glass
. Insulation - vacuum
. Maintenance free first 10 years
. Life time dependent on maintenance after 10 years
. Performance: $\alpha\tau = \pm 80\%$
$K = \pm 1.7\ W/m^2 {}^\circ C$ at $\Delta\tau = 80^\circ C$
. Other info proprietary.

Concentrating collectors (Eindhoven)

Line concentrating fresnell strip mirror with solar powered automatic tracking.
. Temperature max. $300^\circ C$
. Material - glass
. Life time - 10-20 years
. Other info proprietary

- Heat Storage (Achen-Germany)

a. Reversible chemical reactions for long term energy storage ($100-400^\circ C$)
b. Latent heat storage for low grade (roomtemp.) heat.
. Other info proprietary

see continuation 1

- Air conditioning & Cooling (Eindhoven)

a. Absorption - COP 1.5
b. Stirling cycle - COP 1.8 independent of temp. difference at $400^{\circ}C$ source temperature.

Capacity - < 20 kW
Other info proprietary.

Country :	THE NETHERLANDS	
	Components :	Type of Research :
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation :	Address :
ROYAL PACKAGING INDUSTRIES VAN LEER B.V.	Amsterdamseweg 206 P.O. Box 25, AMSTELVEEN For the attention of: Mr. R.R. Alker tel. 020-5402556
Name of Principal Researcher : Richard A. Roberts R.P.I. Van Leer B.V., Passfield (UK)	

Title of Project :

SOLAR WATER HEATING SYSTEMS

- Objective and nature of the program

Continuous research and development of materials, components, solar heating systems as well as production processes which serve the purpose to supply solar collectors suitable for various climatic conditions and applications, in first instance water heating, and by which proprietary is achieved.
R&D activities should always be geared to economic criteria, such as the relationship: final costprice per square meter and salability, since RPI Van Leer B.V. is an operating company for which R&D is a mean and not an objective.

- Present status

For three years collectors are manufactured and sold in South Africa as well as abroad. Feed back from the market is evaluated and taken into account for further R&D, if considered to be worthwhile. The present execution has been tested by TPD/TNO-Delft in the Netherlands.
See attached leaflet and documentation material.

- Publications

Only promotion material and public relation issues available.

Attached sheet (Royal Packaging Industries Van Leer B.V.)

Solar collector

a. Type: Flat plate, envelope type, circumferentially resistant welded, and spot welded with regular intervals.
Overall dimensions: 1812 x 1167 x 55 mm
$2 m^2$ collector surface.

b. $\alpha . \tau = 0.785$

c. Overall heat loss coëfficient U_l:

Measurements outdoors:

$U_l = 5\ W/m^2K$ (Average value at $\Delta T_{wl} = 0$ at different speeds)

Measurements indoors:

At wind speed of 1 m/sec: $U_l = 4.82 + 0.022 \times \Delta T_{wl}$
(ΔT_{wl} = temperature difference water in collector, ambient temperature)

At wind speed of 3 m/sec: $U_l = 6.06 + 0.026 \times \Delta T_{wl}$

At wind speed of 5 m/sec: $U_l = 6.45 + 0.031 \times \Delta T_{wl}$

From the observations the following overall formula could be derived:

$$U_l = (4.82 + 0.022\ \Delta T_{wl}) \times V_{wind}^{0.19}$$

if: $5 \leq \Delta T_{wl} \leq 80^0C$ and
$0.5 \leq V_{wind} \leq 10$ m/sec

d. Heat capacity: $3.8\ Wh/m^2K$

e. Heat transfer medium is water. Collector has successfully past tests at -15^0C

f. Material

i) Stainless steel absorber plate with matt black epoxy coating
$\alpha = 0.9$ and $\varepsilon = 0.9$

ii) Coverplate made of Tedlar coated fibre glass
One piece; fibre oriented sheet $1.2\ kg/m^2$
τ for fibre glass = 87% reducing to 80% with time.

iii) Insulation by 23 mm thick rigid polyurethane foam with a density of $15\ kg/m^3$.
Thermal conductivity in s.i. units is $0.03\ W/m^2K$.

g. The expected life-time is "unknown".

h. Estimated cost are US\$ $70/m^2$.

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation :	Address :
SOMBROEK ZAANDAM B.V.	Aris van Broekweg 9 P.O. Box 180 1500 ED ZAANDAM tel. 075-172851
Name of Principal Researcher : Ir. J.A. Ouwejan/H.P. Sombroek	

Title of Project :

DEVELOPMENT OF A LOW-COST FLAT PLATE COLLECTOR

- Objective and nature of the program

a. Research and development of a high temperature-resistant collector, used in heating, cooling and hot water supply systems.

b. Integration of this collector with heatpumps and absorption cooling units to obtain a wider field of applications.

c. Development of a complete solar boiler system including controlunit and stainless steel boiler.

d. Other research activities:
1. Integration in a roofstructure
2. Optimum and economic design and construction
3. Measurements of the thermal performance and durability
4. Foaming of a high temperature-resistant insulation
5. Measurements of low-cost spectral selective surfaces.

- Present status or summary of significant accomplishments

Collector has been evaluated by the Institute of Applied Physics TNO-TH.
Collector and complete solar boiler system is being tested.

- Period of project

The Zoner project started in 1976

- Fund in US$

In 1976 and 1977 about $ 50.000 (total)
In 1978 about $ 35.000.

see attached sheet

ATTACHED SHEET

SOMBROEK ZAANDAM B.V.

Title: Development of a low-cost flat plate collector

a. Type: Flat plate, aluminium Roll Bond absorber sheet, double covered, with glass and foil. Dimensions: 2100 x 900 x 60 mm.

b. $\alpha.\tau = 0,72$

c. Overall heat loss coefficient
$Ul = 2,8 + 0,016 \cdot \Delta T$ (wind speed V = 5 m/s)

d. Heat capacity
$C = 1,75\ Wh/m^2K$

e. Heat transfer medium
Water

f. Material

I Aluminium absorber plate
Selective black coated
$\alpha = 0,94$
$\varepsilon = 0,52$

II Coverplates
- polyethyleenterephthalaat foil $\tau = 0,90$, thickness 100 μm
- floatglass $\tau = 0,85$, thickness 5,0 mm

III Insulation by 50 mm thick phenol formadehyde foam with a density of 60 kg/m^3
Thermal conductivity: $\simeq 0,03\ W/m^2K$

g. Expected life-time
15 - 20 years

h. Estimated cost
US\$ $70/m^2$

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation :
Raadgevend Technies Buro
VAN HEUGTEN B.V.

Name of Principal Researcher :
Mr. G. Brouwer

Address : Raadgevend Technies Buro
VAN HEUGTEN B.V.
St. Annastraat 145,
P.O. Box 305
NIJMEGEN - THE NETHERLANDS
tel. 080-228317

Title of Project :

R&D ON FLAT PLATE- AND CONCENTRATING SOLAR COLLECTORS

- Objective and Nature of the Program:

Research and development in the field of solar collectors with optimal costperformance properties, dependant on the specific applications.

We distinguish:

- low temperature : 20 - 60°C
- medium " : 60 - 100°C
- high " : 100°C and higher.

The research activities cover the following items:

- for flat plate collectors and for concentrating collectors:
  - = coverplates
    - transmittance
    - coating for infrared reflection
    - anti-reflection coating
    - number and thickness of plates
    - material
  - = absorber
    - absorptance
    - spectral selective surface
    - finefficiency, collectorefficiency
    - heat transfer fluid
    - heatcapacity, fluid included
    - pressuredrop
    - material, thickness
    - geometries
    - connections
  - = insulation edge and bottom.
- only for plate plate collector:
  - performance
  - dynamics
  - convection suppresion
  - dimensions
  - esthetics
  - facade and roofintegration
  - draining aspects
  - universal connections
  - temperatures

 see continuation 1

- partial shading influences i.e. shed construction
- implementation of the control
- costs

- only for concentrating collector:
  - performance
  - concentrating ratio
  - fixed, rotation about north-south axis with continuous adjustment
  - parabolic mirror, fresnel cover.

With meteorological data (reference year) optimization studies of collector constructions resulted in extensive calculationprocedures (computer programs).
In order to gain more experience with reference to solar collectors practical investigations, research and study results were added.

The implementation of solar collectors in different kinds of installations has been worked out, i.e.:
- domestic hotwater supply, households etc.
- heating of water at different temperature levels, agriculture, industry etc.
- swimming pool heating
- heating
- cooling
- solar collectors added to heatpump heating.

Testing procedures with the instantaneous results of calculations and measurements in practice have been carried out for a lot of different solar collectors.

- Present status or summary of significant accomplishment
  - In November 1975 the research and development lead to the first commercial Dutch solar collector introduced to the market.
  - A great number of solar collectors has been tested in a testing configuration.
  - A number of domestic heating systems has been installed.
  - Computerprograms have been developed and used in performance calculations for flat plate and focussing solar collectors.
  - Several solar energysystems of different applications are worked out and have been realized.

- Period of the project:
  - Funds: about $ US: 60.000 a year.

- Publications:

1. "Het gebruik van zonnewarmte voor verwarmingsdoeleinden"
G. Brouwer (Verwarming en Ventilatie, november 1975).

2. "Warmwatervoorziening in woningen en andere projekten door middel van zonnewarmte kollektoren"
P.H.H. Leijendeckers (Postakademiale kursus "De zon als verwarmingsbron", T.H. Delft, maart/april 1976).

3. Nota "Doelmatig energiegebruik"
P.H.H. Leijendeckers, E.H. Lysen, a.o. (Vereniging Milieudefensie, november 1975).

4. "Zonnewarmte installaties"
G. Brouwer (Verwarming en Ventilatie, juni 1977)

continuation 2 R & D FLAT PLATE- AND CONCENTRATING SOLAR COLLECTORS (VAN HEUGTEN B.V.)

Attached sheet:

ad. a)	: Many solar collectors of flat plate and concentrating type are being developed.
ad. b) -f)	: Properties depend on temperature and type of collector.
ad. g)	: Minimal 20 years.
ad. h)	: Estimated cost: 70 US $/m2 - 40 US $/m2.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: NEW ZEALAND

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIAL RESEARCH [ ] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Physics & Engineering Lab., DSIR	ADDRESS Physics and Engineering Lab, DSIR, Private Bag, Gracefield, Lower Hutt, N.Z.
NAME OF PRINCIPAL RESEARCHER R.F. Benseman	

TITLE OF PROJECT

Develop low cost solar collector.

OBJECTIVE AND NATURE OF THE PROGRAMME:

To develop collector that is:

(a) Made principally of steel
(b) Proof against frost and overnight freezing
(c) Designed for quantity production
(d) Incorporates the heat exchanger in the collector panel
(e) Operates in thermosyphon mode.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Panel now manufactured in New Zealand by Morrison Industries Ltd.

PERIOD OF PROJECT: 3 years (1974=77)

FUND IN $ NZ N.A.

IMPORTANT REPORTS OR PUBLICATIONS:

Patented: NZ Application No. 177715
US Application No. 544,797
British Application No. 3015/75

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: NEW ZEALAND

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION PEL, DSIR	ADDRESS PEL
NAME OF PRINCIPAL RESEARCHER R.F. Benseman	

TITLE OF PROJECT

Develop packaged solar water heater

OBJECTIVE AND NATURE OF THE PROGRAMME:

To produce a packaged ground-mounted solar collector/tank that will temper water for hand washing. Unit to be constructed of steel, yet compatible with copper plumbing systems. Intended for use in schools.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Six units constructed and now on field test. One unit to Fiji for evaluation.

PERIOD OF PROJECT: 1976-77

FUND IN $ NZ N.A.

IMPORTANT REPORTS OR PUBLICATIONS:

Patents being applied for.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: NEW ZEALAND

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION L.J. FISHER & CO.	ADDRESS Box 2183, Auckland, New Zealand
NAME OF PRINCIPAL RESEARCHER K. Jones	

TITLE OF PROJECT

Integrated solar water heating system.

OBJECTIVE AND NATURE OF THE PROGRAMME:

(a) To examine alternative materials for solar collector construction.
(b) To test and evaluate components - collectors, pumps, controllers, etc.
(c) To design an aesthetically acceptable roof line collector.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Investigations complete

PERIOD OF PROJECT: 1975-77

FUND IN $ NZ 30,000

IMPORTANT REPORTS OR PUBLICATIONS:

Report to N.Z. Energy Research and Development Committee
Contract No. 3029

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: NEW ZEALAND

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION John Fogarty Ltd.	ADDRESS 89 Crinan St., Invercargill, NEW ZEALAND
NAME OF PRINCIPAL RESEARCHER John Fogarty	

TITLE OF PROJECT

Develop solar water heater for domestic use.

OBJECTIVE AND NATURE OF THE PROGRAMME:

Develop a solar water heater, for domestic use. System to use steel panels, heat exchanges, and pump for circulation.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Prototype built and tested. Advanced prototype being constructed.

PERIOD OF PROJECT: 1977-78

FUND IN $ NZ 4000

IMPORTANT REPORTS OR PUBLICATIONS:

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: NEW ZEALAND

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Morrison Industries Ltd.	ADDRESS Morrison Industries Ltd., Private Bag, Hastings, New Zealand.
NAME OF PRINCIPAL RESEARCHER K. Kibblewhite	

TITLE OF PROJECT

Precommercial development of DSIR solar water heating panels.

OBJECTIVE AND NATURE OF THE PROGRAMME:

Tooling and design for factory production of solar heating panel developed by the New Zealand Department of Scientific and Industrial Research.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Commercial units have just gone on to New Zealand market.

PERIOD OF PROJECT: 3 years

FUND IN $ NZ 10,000

IMPORTANT REPORTS OR PUBLICATIONS:

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: NEW ZEALAND

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [X] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Zip Holdings Ltd.	ADDRESS Box 30-669 Lower Hutt, N.Z.
NAME OF PRINCIPAL RESEARCHER O.M. Kendon	

TITLE OF PROJECT

Develop economic domestic solar water heater

OBJECTIVE AND NATURE OF THE PROGRAMME:

Object was to reduce overall cost of solar auxillary equipment, including installation costs. Specifically
(a) to develop a solar operated pump
(b) simplify design and manufacture of collectors
(c) produce a control system to optimise savings.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

(a) Temporarily shalved
(b) and (c) units produced and tested in prototype - factory production planned.

PERIOD OF PROJECT:

FUND IN $ NZ 13,000

IMPORTANT REPORTS OR PUBLICATIONS:

Country: Sweden		
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** ☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☐ Materials Research ☒ Component Development

Name of Organization: AB Atomenergi Name of Principal researcher: R Roseen, H Zinko	Address: Fack 611 01 NYKÖPING Sweden

Title of Project:
Research and development on semiconcentrating collectors for applications in existing buildings.

The aim of the project is to develop and test a semi concentrating solar collector for tap hot water production in existing buildings. This type of collector is applicable to about 50 % of all houses in Sweden.

Design

The solar collector operates with a concentration factor of 1.5 - 2. The load carrying parts and insulation are designed to allow simple production in foamed plastic. The absorbators and reflectors are made of aluminium.

Test program

The test of the first generation prototypes started in August 1977. The test program includes test in an artificial sun in France and test at normal conditions at Studsvik. The test program follows the ASTM Draft E-21.10.

Period of the project

The project started 1977-07-01 and it will be finished 1978-06-30. The total funds is 94 000 $ US.

Publication

There are no results or publications available as yet.

Sweden

Division of Physical Chemistry
Royal Institute of Technology

Bo Carlsson
Hans Stymne
Gunnar Wettermark

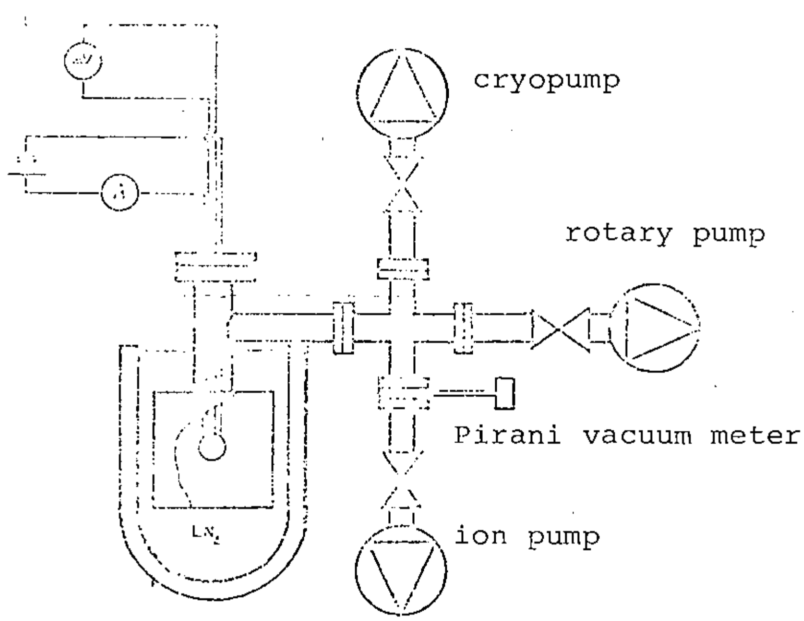
Address:
Fack
S-100 44 Stockholm 70
Sweden

Title of Project:

"Solar Energy and Buildings"

Thermal emissivity of surfaces

A device for high precision determination of the thermal emissivity of various surfaces (*e.g.* selective black coatings) has been constructed (see figure). The sample to be tested is attached to both sides of a circular probe having a small heat capacity. The probe consists of two brass discs between which a manganine heating coil and a Ni-NiCr thermoelement is situated. The probe is suspended into a high vacuum chamber - supported by manganine threads connected to the heating coil. The chamber is cooled to boiling liquid nitrogen temperature. The current through the heating coil is regulated to maintain a steady state temperature of the probe. The EMF of the thermoelement is determined in a compensated measuring bridge so that very small temperature changes can be displayed on a high gain recorder. Heat losses from the sample edges and the supporting threads as well as the heat dissipation in the supporting threads are compensated for.



Country: Sweden		
Check the mark x in the head of line, corresponding to the respective components and type of research:	**Components** ☒ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☒ Other Substantial Components	**Type of Research** ☐ Materiols Research ☒ Component Development

Name of Organization:	Address: AB Svenska Fläktfabriken Equipment Division Fack 551 84 JÖNKÖPING SWEDEN
Name of Principal researcher: Gösta Jansson	
Title of Project: AMPLITERM	

AMPLITERM is an energy saving system, based on a combination of solar collectors and heat pump. It is mainly intended for heating of private houses.

Liquid is used as an absorbing medium. It circulates through collectors of a special type, absorbing heat from direct and indirect solar radiation and/or from outdoor air, which is made to flow across the panel. Three different ways of operating can be separated:

1. High solar intensity. The air flow through the collectors is shut off, and the liquid absorbs solar energy. The temperature of the liquid after the collectors is high enough for use, and the liquid is pumped directly to the storage tank.

2. Low solar intensity. Outdoor air is streaming through the collectors. The liquid is absorbing energy from both solar radiation and air. The temperature of the liquid after the collectors is higher than it should have been without support from solar energy, but not high enough to be used for heating. Therefor, the liquid is pumped to the heat pump, where the temperature level is increased with a good COP. In another liquid circuit the high temperature energy is transfered to the storage tank.

3. No solar radiation. Outdoor air is streaming through the collectors. The liquid is absorbing low temperature energy from the air, and the temperature level is increased by means of the heat pump.

Format of Survey on Components for Solar Heating,

Cooling and Hot water Supply Systems

Country: Switzerland

Check the mark X in the head of line, corresponding to the respective components and type of research:	Components	Type of Research
	[X] Solar Collector [ ] Heat Storage [ ] Air Conditioning and Cooling Unit [ ] Other Substantial Components	[ ] Materials Research [X] Component Development

Name of Organization: BATTELLE, Geneva Research Center	Address: 7, route de Drize 1227 - GENEVA Switzerland
Name of Principal researcher:	

Title of Project:

Development of a solar collector using glasstiles.

- Objective and Nature of the Program:

The objective is to develop a solar collector which can be easily integrated into a traditional roof without distrubing the building's aesthetics.

The project includes the design and testing of transparent tiles having adequate optical and thermal properties. These tiles cover a flat plate absorber which transmits the collected heat to a water circulating system. Methods for giving an appropriate apparent colour to the complete collector while keeping a good efficiency are also studied.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR	[x] MATERIAL RESEARCH
[ ] THERMAL ENERGY STORAGE	[x] COMPONENT DEVELOPMENT
[ ] AIR CONDITIONING UNIT	
[ ] OTHER SUBSTANTIAL COMPONENTS	

NAME OF ORGANIZATION
Ecole Polytechnique Fédérale Lausanne

NAME OF PRINCIPAL RESEARCHER
A. FAIST and J.-B. GAY

ADDRESS :
Groupe Energie Solaire
14, Avenue de l'Eglise Anglaise
CH 1006 - LAUSANNE

TITLE OF PROJECT : Study of passive solar collector systems.

OBJECTIVE AND NATURE OF THE PROGRAM :

The goal of this research is to compare the solar gains of different passive walls. The study involves material, as well as structural research.

Order, as well as proper choice of the physical properties of the different layers are investigated. Systems or subsystems which may be applied to new or existing buildings are considered.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

started in may 1977

PERIOD OF PROJECT : 1 year renewable

FUND IN SFR. : CURRENT YEAR 15'000.- (Swiss Francs)
TOTAL FOR THE PERIOD

IMPORTANT REPORTS OR PUBLICATIONS : --

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY :

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR	[ ] MATERIAL RESEARCH
[ ] THERMAL ENERGY STORAGE	[X] COMPONENT DEVELOPMENT
[ ] AIR CONDITIONING UNIT	
[ ] OTHER SUBSTANTIAL COMPONENTS	

NAME OF ORGANIZATION Ecole Polytechnique Fédérale de Lausanne

NAME OF PRINCIPAL RESEARCHER
A. Faist and J.-B. Gay

ADDRESS :
14, Av. Eglise-Anglaise
1001 LAUSANNE

TITLE OF PROJECT :

The semi-transparent Solar Wall Collector Concept

OBJECTIVE AND NATURE OF THE PROGRAM :

The aim of this research is to develop a new type of a semi-transparent solar wall air collector.
The collector consist of three sheets of glass with proper transmittance properties. Air is blown between the two inner glasses and collects between 17 and 20% of the solar energy, in addition the amount of solar radiation transmitted through the wall collector is 23% of the total incident energy.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :
The termal properties of the system have been optimised and analysed with the aid of a computer model. A full seale model has been built and tested. The prediction of the model are in very good agreement with measurements.

PERIOD OF PROJECT :
June 1976 - December 1978

FUND IN SFR. : CURRENT YEAR 120'000.-- /an.
TOTAL FOR THE PERIOD

IMPORTANT REPORTS OR PUBLICATIONS :
- Etude d'un capteur semi-transparent à air - Rapport interne EPF-L J.-B. GAY
- The semi-transparent solar wall collector concept. A. Faist & J.-B. Gay - International Solar Building Technology Conference - London (July 1977).

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

Argonne National Laboratory

NAME OF PRINCIPAL RESEARCHER

Kent A. Reed

ADDRESS:

Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

TITLE OF PROJECT

Nonimaging Collector Development

OBJECTIVE AND NATURE OF THE PROGRAM:

Develop and demonstrate improved performance stationary concentrating collectors capable of operating at 300-350°F at greater than 40% efficiency.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Prototypes demonstrated that meet the objective, larger collectors presently being built.

PERIOD OF PROJECT:

July 1976 - October 1978

FUND IN $ U.S.

FY-1977 $250,000
FY-1978 $307,000

IMPORTANT REPORTS OR PUBLICATIONS:

ANL-SOL-77-01, "Status Report for Nonimaging Collectors (Compound Parabolic Concentrators)", W.Schertz; "Performance of a Stationary Concentrating Collector for Heating, Cooling, and Process Heat Applications", W.Schertz, "Conceptual Design of a 5x CPC for Solar Total Energy System"*, R.Cole; "Performance and Testing of a Stationary Concentrating Collector"*, R.Cole; "CPC Thermal Collector Test Plan"*, Kent A. Reed; "Dependence of the Solar Absorptance of Selective Absorber Coatings on the Angle of Incidence"*, Kent A. Reed; "Long-Term Average Performance Predictions for Compound Parabolic Concentrator Solar Collectors", R.Cole. *All four papers presented at the Concentrating Solar Collector Conference Exhibit/Workshop, Atlanta, GA, 9/26-28/77.

Argonne National Laboratory (Data Sheet)

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Stationary Concentrating Collector

A tubular evacuated receiver located at the base of a cusp shaped reflector, designed to be stationary all year.

b) XXX Optical efficiency 60%.

c) overall heat loss coefficient U_ℓ (W/m^2K) (temp. range θ (°C))

Heat loss coefficient = $U_\ell = .75 \frac{W}{m^2K}$

Temperature range, $T \lesssim 150°C$ above ambient

d) heat capacity (fluid included) C (Wh/m^2K)

Heat capacity = 1.12 $Wh/m^2/K$ (with water)

e) heat transfer medium (water, air, ...)

Water or ethylene glycol

f) material
- i) absorber (α, ε) α = .85, ε = .03-.04
- ii) cover plate (number, τ, ...) cover T_1 = .92, glass tube T_2 = .90-92
- iii) insulation (thickness, ...) vacuum, about 10^{-7} torr
- iv) mirror reflectivity ρ = .85.

g) expected life time t

20 year goal.

h) estimated cost (\$ US/m^2)

\$70-110/m^2

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIAL RESEARCH [ ] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Battelle	**ADDRESS:** Pacific Northwest Laboratories Battelle Blvd. Richland, WA 99352
NAME OF PRINCIPAL RESEARCHER T. D. Chikalla/N. R. Gordon	

TITLE OF PROJECT

Development of Improved Cover Plates for Solar Energy Collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

The objectives of this program are to develop honeycomb core cover plates with plastic or thin glass skins. The properties aimed for are (i) high transmission of solar energy (ii) reflection of internal thermal radiation (iii) high thermal insulation (iv) high structural integrity (v) light weight (vi) low initial cost and (vii) low maintenance.

The planned tasks for this project are (i) materials properties evaluation and selection (ii) fabrication development (iii) solar collector evaluation and (iv) technology transfer.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Processes have been developed for fabricating efficient cover plates using plastic skins with transparent honeycomb cores.

PERIOD OF PROJECT: 28 months (starting date: 5/18/76)

FUND IN $ U.S. current year = $80,000

Total for the period = $208,000

IMPORTANT REPORTS OR PUBLICATIONS:

"An Improved Solar Cover Plate Incorporating A Honeycomb Core Between Plastic Skins" by N. R. Gordon (in preparation)

Battelle (Data Sheet)

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Not applicable

b) $\alpha\tau$ = 0.78 to 0.91

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ (^oC))

Not applicable

d) heat capacity (fluid included) C (Wh/m^2K)

Not applicable

e) heat transfer medium (water, air, ...)

Not applicable

f) material
- i) absorber (α, ε) Not applicable
- ii) cover plate (number, τ, ...) *
- iii) insulation (thickness, ...) Not applicable

*Two plastic skins bonded to a transparent honeycomb core.

g) expected life time t = 20-50 years

h) estimated cost ($ US/m^2) = $14.85-$19.84 (preliminary estimates)
(Cost for cover plate only)

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Battelle Memorial Institute Columbus Laboratories	**ADDRESS:** 505 King Avenue Columbus, Ohio 43201
NAME OF PRINCIPAL RESEARCHER D. Karl Landstrom	

TITLE OF PROJECT

Development of Low Temperature Black Liquid Solar Collector

OBJECTIVE AND NATURE OF THE PROGRAM: The program objective is to develop an efficient, cost effective, and reliable low temperature, non-concentrating, black-liquid collector suitable for use as a thermal energy source for heat pumps or other low temperature applications. The proposed system incorporates a black-liquid to absorb solar energy directly in the heat transfer medium. This type of collector has the potential of significantly lower costs than a conventional flat-plate collector, while offering comparable performance in the temperature range suitable for heat pump operation. System analysis using a mathematical model of the black-liquid collector and associated conventional systems will be utilized in the research effort. One or more full-scale test models of a black-liquid collector will be built and subjected to standardized testing.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Mathematical models of black-liquid systems completed and tested. Small scale models built and tested. Several candidate black-liquids tested. One full-scale collector under construction.

PERIOD OF PROJECT:

September 1977 - October 1978

FUND IN $ U.S.

$123,000

IMPORTANT REPORTS OR PUBLICATIONS:

Publication planned 2nd half 1978

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

An unglazed, black-liquid flat plate collector. Solar absorbing liquid (black-liquid) is circulated through a transparent plastic collector.

b) $\alpha\tau = 0.82$ (Estimated from mathematical model)

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ (^oC))

$U_l = 10.8\ W/m^2K$

d) heat capacity (fluid included) C (Wh/m^2K)

$C = 12\ Wh/m^2K$

e) heat transfer medium (water, air, ...)

Water base, approximately 5% absorbing material

f) material
- i) absorber (α, ε) $a = e = 1.0$
- ii) cover plate (number, τ, ...) no cover plate *per se*
- iii) insulation (thickness, ...) 1" Styrofoam $R = 1\ m^2K/W$

g) expected life time t minimum of 10 years

h) estimated cost (\$ US/m^2) \$54-75/m^2

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
University of California

NAME OF PRINCIPAL RESEARCHER
H. Buchberg

ADDRESS:
School of Engineering & Applied Science
Los Angeles, CA 90024

TITLE OF PROJECT
Transparent Glass Honeycomb Structures for Energy Loss Control

OBJECTIVE AND NATURE OF THE PROGRAM:
The objective of this study is to develop glass honeycomb for suppressing natural convection and radiation losses within flat plate solar collectors. The study consists of four main tasks: (i) Studies of honeycomb arrays made up of corrugated and plain thin glass sheets, (ii) further studies with honeycomb arrays of thin walled glass cylinders, including prototype collector performance under hazy and cloudy conditions, (iii) Scaled-up collector experiments and studies of possible methods for large-scale manufacture of glass honeycombs, including measurement of outdoor performance of a 3ft. x 6ft. collector using the optimum honeycomb design, (iv) design application studies, including the use of a liquid-heating honeycomb collector to run air absorption refrigeration cycle.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Prototype collector design and preliminary testing completed.

PERIOD OF PROJECT:
24 months, (starting date: 9/1/74)

FUND IN $ U.S.
Current year $110,000
Total for the period

IMPORTANT REPORTS OR PUBLICATIONS:
Transparent Glass Honeycomb Structures for Energy Loss Control, Final Report, Report No: SAN/1084-75/1

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Center for the Environment and Man, Inc. **NAME OF PRINCIPAL RESEARCHER** L. H. Shaffer	**ADDRESS:** 275 Windsor Street Hartford, Conn. 06120

TITLE OF PROJECT

Viscosity Stabilized Solar Ponds (Phase I)

OBJECTIVE AND NATURE OF THE PROGRAM: The overall objective of the project is to investigate the use of various thickeners to increase the viscosity of water so that it will not convect when heated from the bottom. This will make possible an alternate approach to the salt gradient solar pond. The first phase of the study is an investigation of various natural, semi-synthetic and synthetic polymeric materials which might be useable for this purpose. One or two of the most promising materials will also be maintained at 75°C. Samples will be tested for viscosity and light-transmission at periodic intervals. The result of Phase I will be a listing of several thickeners showing the most promise, their specific properties, and recommendations as to the feasibility of proceeding to Phase II: building and testing a prototype viscosity stabilized pond.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Test formulations prepared and aging experiments are initiated.

PERIOD OF PROJECT: 6 months, (starting date: 5/1/76)

FUND IN $ U.S. Current year $37,718

Total for the period

IMPORTANT REPORTS OR PUBLICATIONS:
New Contract -- No Report Available.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Corning Glass Company

ADDRESS:
Lighting Products Division
Corning, New York 14830

NAME OF PRINCIPAL RESEARCHER
U. Ortabasi

TITLE OF PROJECT
Research on Evacuated Tubular Solar Collectors Utilizing a Heat Pipe

OBJECTIVE AND NATURE OF THE PROGRAM: The objective of this project is to conduct an integrated program of solar collector research and to develop a tubular thermal collector having significantly better performance characteristics and cost benefits than existing flat-place collectors. The first phase of the project includes the design, building, testing, and costing of a tubular evacuated collector constructed from mass producible glass components. The principle feature of the solar collector is a strong, clear glass tube incorporating an integral cusp reflector and vacuum encapsulating a tubular absorber in its focal area in addition, both flow-through and heat-pipe tubular absorbers, vacuum insolation, selective absorber coatings, and anti-reflecting films will be examined.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Prototype testing has been completed.

PERIOD OF PROJECT: 17 months (starting date: 5/1/75)

FUND IN $ U.S. Current year

Total for the period: $371,843

IMPORTANT REPORTS OR PUBLICATIONS:

Evacuated Tubular Solar Collector Analysis, Technical Paper; ISES Meeting 1975.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Drexel University

ADDRESS:
32nd and Chestnut
Philadelphia, PA 19104

NAME OF PRINCIPAL RESEARCHER

TITLE OF PROJECT
Double-Exposure Collector System

OBJECTIVE AND NATURE OF THE PROGRAM:
The program objectives are (1) to evaluate the performance of double-exposure collectors (DEC's) mounted in mirrored enclosures in comparison with conventional flat-plate collectors, (2) to study alternative fixed-mirror and adjustable-mirror designs for both winter and year-round solar energy applications and (3) to perform a detailed DEC system design.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Initial testing of DEC's has shown excellent performance relative to conventional collectors.

PERIOD OF PROJECT:

30 September 1977 to 29 September 1978

FUND IN $ U.S.
$50,436

IMPORTANT REPORTS OR PUBLICATIONS:

Proceedings of the International Solar Energy Congress-77, New Delhi, India, January 16-21, 1978.

<u>Solar Collector</u>

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Roll-bond copper panel (3x8 ft) with selective coating and single glazing on each side is mounted vertically on long side in glass-mirrored enclosure. Horizontal front mirror and vertical rear mirror are adjustable.

b) $\alpha\tau$

= 0.88

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))

U_1 = 6 W/m^2K

d) heat capacity (fluid included) C (Wh/m^2K)

unknown

e) heat transfer medium (water, air, ...)

water-propylene glycol with additives

f) material

i)	absorber (α, ε)	**= 0.98,**	**= 0.3**
ii)	cover plate (number, τ, ...)		**= 0.9**
iii)	insulation (thickness, ...)	**none**	

g) expected life time t

20 years for collector, unknown for glass mirrors

h) estimated cost (\$ US/m^2)

\$200/m^2

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

Dynatherm Corporation

ADDRESS:

1 Industry Lane
Cockeyville, MD 21030

NAME OF PRINCIPAL RESEARCHER

W. Beinert

TITLE OF PROJECT

Research on flat plate solar collectors employing the Heat Pipe principle for heating and cooling of buildings.

OBJECTIVE AND NATURE OF THE PROGRAM:

This project will study the feasibility of modular flat plate collectors employing the heat pipe principle to extract heat from the solar absorber surface and transport this heat to a primary fluid loop (either liquid or gas). The project will concentrate on the heat pipe collector surface and its interface with other module and system components.

A submodule-size heat pipe solar collector will be designed, constructed and tested to determine the overall thermal impedence of a heat pipe solar collector. For this study, solar input will be simulated by electrical resistence strip heaters attached to the collector surface. A part of the submodule studies will be to identify possible failure mechanisms and conduct tests in which the processes leading to failure are accelerated. Based on the preceding studies, a full scale module will be designed and fabricated and then tested under actual solar radiation. Parametric performance studies and economic analysis will be conducted as part of this program.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Modified Roll-Bond Panel was found to be suitable for the heat pipe absorber. The thermal performance of the heat pipe collector is about equal to similar conventional collectors.

PERIOD OF PROJECT:

8 months, (starting date: 5/3/76)

FUND IN $ U.S.

Current year $54,000
Total for the period

IMPORTANT REPORTS OR PUBLICATIONS:

Heat Pipes Applied to Flat-Plate Solar Collectors, Final Report, Report No: COO/2604-76/1

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Georgia Institute of Technology

NAME OF PRINCIPAL RESEARCHER
J. R. Williams

ADDRESS:
College of Engineering
Georgia Institute of Technology
Atlanta, GA 30332

TITLE OF PROJECT
Development of Solar Heat Supply System with Fixed-Mirror Concentrator

OBJECTIVE AND NATURE OF THE PROGRAM:

Design, development, and small-scale demonstration of a solar heat supply system using a fixed-aperture moving-receiver collector. The system utilizes the faceted fixed-mirror concentrator concept. The program has resulted in a collector design incorporating economical materials and design geometry adaptable to mass-production techniques.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Engineering drawings for new economical design complete. Testing was hampered by the instrumentation and operational difficulties. New mirrors to be installed.

PERIOD OF PROJECT:

7/1/75 to 7/31/77

FUND IN $ U.S.
$160,922.00

IMPORTANT REPORTS OR PUBLICATIONS:
Williams and Hutchins, IECEC Record, 1975, pp. 195-201.

Georgia Institute of Technology (Data Sheet)

Solar Collector

a) type:
Faceted fixed mirror concentrating collector. Sun tracking receiver currently equiped with Corning CORTEC-FL collectors for experimental evaluation of concentrator. Simple non-evacuated collector proposed for commercialization.

b) $\alpha\tau$:
For commercial design $(\alpha\tau)(\rho\gamma)$ estimated at 0.67 by manufacturer, Scientific-Atlanta, Inc., (S/A).

c) overall heat loss coefficient:
For CORTEC-FL collector, from manufacturers data: $\frac{A_R U_L}{Ac}$ estimated as .05 $W/m^2C°$ at ΔT = 127C°

For commercial receiver, from analytical projections by S/A:

ΔT(°C)	AR UL/Ac
150°C	.30
300°C	.32
400°C	.35

d) heat capacity:
unknown

e) heat transfer medium:
commercial heat-transfer oil: Thermionol 66 (Monsanto)

f) material:
i) absorber:
copper with black chrome coating $\alpha \approx 0.9$ $\epsilon \approx 0.1$
ii) cover plate:
borosilicate glass (Pyrex) $\tau \approx 0.9$ one cover
iii) insulation:
hard vacuum ($<10^{-4}$ Torr)

g) expected life time:
30 years

h) estimated cost:
concentrator including commercial collector < $161.00/ft^2$ depends on quantities.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIAL RESEARCH [ ] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Giner, Inc. **NAME OF PRINCIPAL RESEARCHER** José Giner, Ph.D.	**ADDRESS:** 14 Spring Street Waltham, MA 02154

TITLE OF PROJECT

Study of corrosion and its control in aluminum solar collectors.

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of the program is to develop both corrosion control and corrosion monitoring methods applicable to aluminum solar collectors using water-glycol mixtures as the heat transfer fluids. An intermediate objective is to ascertain the extent of the corrosion problems under various conditions directly relevant to the actual operation of an existing solar heat collector system.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Baseline corrosion characteristics of aluminum alloys in ethylene glycol and porpylene glycol solutions have been obtained under relevant conditions. Corrosion problems do exist for such systems. Investigations on corrosion inhibition and corrosion monitoring are in progress.

PERIOD OF PROJECT:

24 months, (starting date: 6/1/76)

FUND IN $ U.S.

Current year: $104,296.71
Total for 24 months: $203,277.00

IMPORTANT REPORTS OR PUBLICATIONS:

Four quarterly progress reports and one annual report have been submitted to date. A semi-annual report (September 1, 1977 - February 28, 1978) will be submitted shortly.

GINER, Inc. (Data Sheet)

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Any type of collector made of aluminum using fluid as heat transfer medium.

b) $\alpha\tau$

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))

d) heat capacity (fluid included) C (Wh/m^2K)

e) heat transfer medium (water, air, ...)

Water or glycol based antifreeze.

f) material

i) absorber (α , ε)

ii) cover plate (number, τ , ...)

iii) insulation (thickness, ...)

g) expected life time t

h) estimated cost ($ US/m^2)

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

Honeywell, Inc.

ADDRESS:

2600 Ridgway Parkway
Minneapolis, MN 55413
MN17-T103

NAME OF PRINCIPAL RESEARCHER

D. R. Rask

TITLE OF PROJECT

Low Cost Solar Air Heaters

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this program was to improve the thermal performance of a flat plate air heating collector by increasing the heat transfer coefficient between the absorber plate and the moving air stream. The method for achieving increased heat transfer is through jet impingement. The entering air stream passes through a perforated plate, thus forming a large number of air jets which impinge on the back side of the absorber plate.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The final report draft was mailed 10/77, but the final report has not been printed yet. The jet impingement concept improved the Y-intercept efficiency by 13 percent over that of the baseline parallel plate collector.

PERIOD OF PROJECT:

12 months: 6/29/76 to 6/29/77
No cost extension to 10/15/77

FUND IN $ U.S.

Total $112,791

IMPORTANT REPORTS OR PUBLICATIONS:

D. R. Rask, "Jet Impingement Solar Air Heater", Flat Plate Solar Collector Conference, February 28 - March 2, 1977; Orlando, Florida.

Honeywell, Inc. (Data Sheet)

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Flat Plate

b) $\alpha\tau = 0.81$

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))

$$\eta = .75 - 4.94 \frac{t_{in} - t_{amb}}{Q} ; \quad U_1 = 5.36 \quad W/m^2 - {}^oK$$

d) heat capacity (fluid included) C (Wh/m^2K) ; Not Tested

e) heat transfer medium (water, air, ...)

Air

f) material

i) absorber (α, ε) Black chrome $\alpha = .93$; $\epsilon = .06$

ii) cover plate (number, τ, ...) 2 glass; $\tau = .93$ (each)

iii) insulation (thickness, ...) 2 inches fiberglass on back, 1 inch on sides

g) expected life time t > 20 years

h) estimated cost (\$ US/m^2) 68.48 (manufacturers cost)
To date, only prototypes have been fabricated.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIAL RESEARCH [ ] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Honeywell Inc.

NAME OF PRINCIPAL RESEARCHER
R.J.H. Lin

ADDRESS:
2600 Ridgway Parkway
Minneapolis, MN 55413

TITLE OF PROJECT

Optimization of Coatings for Flat Plate Solar Collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

The broad objective was to investigate and develop coatings which would enhance the performance and economic feasibility of flat plate solar collectors.

The primary coatings of interest were electro-chemical and paint type absorber coatings and chemically etched and organic antireflection (AR) coatings.

The specific objectives were to improve and optimize the optical performance, durability and cost of the best coatings identified in the previous program (NSF-C-927).

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: 1) Selective paint on aluminum provided $\alpha = 0.92$ and $\varepsilon = 0.10$. 2) Dipped Teflon AR coating on glass increased solar transmission by 4.9%. 3) Cost of black chrome was reduced by $\sim$ 30%. 4) Single layer and double layer etched AR coatings on glass increased solar transmission by 6% and 7.2%, respectively. 5) Black nickel on nickel plated substrate provides $\alpha = 0.96$ and $\varepsilon = 0.07$.

PERIOD OF PROJECT:

12 months (6/28/76 - 6/27/77)

FUND IN $ U.S.

$153,827

IMPORTANT REPORTS OR PUBLICATIONS:

Optimization of Coatings for Flat Plate Solar Collectors, Final Report, Report No. C00-2930-12.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION University of Houston **NAME OF PRINCIPAL RESEARCHER** J. R. Howell/R. B. Bannerot	**ADDRESS:** Dept. of Mechanical Engineering 3801 Cullen Blvd. Houston, TX 77004

TITLE OF PROJECT

Analysis, design, fabrication, and testing of moderately concentrating solar energy collectors.

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this two-year study is to continue development of the V-trough moderately concentrating solar collector to optimize its design for thermal performance and mass production manufacturability. The emphasis of the project will be divided between the two general areas of thermal performance improvement and manufacturing studies.

The expected end product of this study is a design for a cost-effective, mass-producable moderately concentrating collector capable of driving an absorption or Rankine-cycle refrigeration machine at acceptable overall efficiency.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Prototypes constructed and testing in progress

PERIOD OF PROJECT:

27 months, (starting Date: 3/18/76

FUND IN $ U.S.

Current year $25,000 1 Oct 77 - 30 June 78
Total for the period $94,532

IMPORTANT REPORTS OR PUBLICATIONS:

Bannerot, R. B. and Howell Jr., "Analysis, Design, Fabrication and Testing of Moderately Concentrating Solar Energy Collector," Six-Month Progress Report; December 1976-May 1977; ORO/5100-77/2, June, 1977, University of Houston.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIAL RESEARCH [ ] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION IIT RESEARCH INSTITUTE	**ADDRESS:** 10 W. 35th Street Chicago, Illinois 60616
NAME OF PRINCIPAL RESEARCHER John E. Gilligan	

TITLE OF PROJECT

Exposure Testing and Evaluation of Solar Utilization Materials

OBJECTIVE AND NATURE OF THE PROGRAM: The optical and physical properties of materials which are currently being used or are potentially useful in solar energy applications are being determined prior to and following outdoor weather exposure conditions. Exposures durations are 1 (accelerated only), 3, 6, 12, 24, 48 and 72 months at each of three sites. The objectives of the current program include maintaining a current awareness of Solar Utilization (SU) materials obtaining these materials and characterizing them optically and mechanically, developing models of degradation and from these useful lifetime prediction methods/techniques, developing and improving test devices and evaluation procedures, and, ultimately, to publish the results of this program in order to provide appropriate data for the selection of cost-effective materials.

The materials involved include cover plates and films, absorber coatings and surfaces, reflective materials, and miscellaneous specialty surfaces.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: All mechanical measurements on all samples exposed up to one year have been completed. Optical measurements are approximately 75-80% complete. Correlations of properties vs. exposure have been attempted for a large number of materials and have

(Continued on next page)

PERIOD OF PROJECT:

37 months (1/15/75 - 2/28/78)

FUND IN $ U.S.

Current year $295,000
Total for the period $466,500

IMPORTANT REPORTS OR PUBLICATIONS: IITRI Report No. C6342-1 (Semi Annual), "Exposure Testing and Evaluation of Solar Utilization Materials".

"Outdoor Testing of Solar Energy Utilization Materials", J.E. Gilligan and

(Continued on next page)

Continuation of PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

been very successful in many instances. New exposure devices have been devised. Nearly 500 solar-related companies have been contacted and more than 40 different materials have been added to the original 88.

Continuation of IMPORTANT REPORTS OR PUBLICATIONS:

J. Brzuskiewicz, Presented to 22nd Annual Technical Meeting, Institute of Environmental Sciences, Environmental Technology'76, Philadelphia, Penn., April 26-28, 1976; pp. 303-307 in IES 1976 Proceedings.

"The Weatherability of Solar Energy Utilization Materials: Preliminary Discussions," J.E. Gilligan and J. Brzuskiewicz Presented to Conference on Sharing the Sun '76, Winnipeg, Manitoba, Canada, August 15-20, 1976.

"An Extended Test Program for Solar Collector Optical Materials", (Invited), J.E. Gilligan, J. Brzuskiewicz and J.E. Brzuskiewicz, Presented to Flate Plate Solar Collector Conference, Orlando, Fla. Feb. 28-March 2, 1977.

"Weather Testing of Solar Utilization Materials", (Invited), J.E. Gilligan, J. Brzuskiewicz, and S.J. Gaumer, Presented to ERDA Concentrating Collector Conference, Georgia Tech., Atlanta, Ga., September 26-28, 1977.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Jet Propulsion Laboratory	**ADDRESS:** 4800 Oak Grove Drive Bldg. 277, Room 202 Pasadena, California 91103
NAME OF PRINCIPAL RESEARCHER M. K. Selcuk	

TITLE OF PROJECT

Fixed Tilt Solar Collector Employing Reversible Vee-Trough Reflectors and Vacuum Tube Receivers.

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective is to develop a solar collector concept using a vacuum tube receiver and a twice a year reversible vee reflector. A series of experiments are being conducted on a test bed collector and an analytical thermal model is developed for optimization studies. A prototype will be constructed using the optimized configuration. Optimization studies include generation of an economic analysis model, verification of thermal analytical model using test data, preliminary analysis of energy cost and analysis of results of an economic model to the optimized design.

The second phase of the project aims to collect test data for one year starting October 1977.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The first phase of the project is completed. Early test results and mathematical analyses including optimization studies are completed.

PERIOD OF PROJECT:

First phase is 12 months plus 4 month extension.
Second phase is 12 months.

FUND IN $ U.S.

First Phase $183,000
Second Phase $ 50,000

IMPORTANT REPORTS OR PUBLICATIONS:

The final report is completed. Additional papers are presented at ASME 1976 Winter Annual Meeting, U. of Miami - ERDA Forum 1976, ERDA Concentrating Collector Conference, ASME 1977 WAM (see listing).

Jet Propulsion Laboratory (Data Sheet)

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Evacuated tubular with asymmetric vee-trough concentrators

b) $\alpha\tau$

$\alpha\tau$ = 0.855 normal incidence

τ = 0.89 including the effects of wall curvature and variation of the direction of the incoming beam

α = 0.93

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ (^oC))

@ 52^oC U_L = 1.48 $W/m^{2o}k$

@ 126^oC U_L = 2.15 $W/m^{2o}k$

@ 232^oC U_L = 2.73 $W/m^{2o}k$

d) heat capacity (fluid included) C (Wh/m^2K)

Negligibly Small

e) heat transfer medium (water, air, ...)

Therminol 44

f) material

i) absorber (α, ε) α = 0.93; τ_{aver} = 0.89

ii) cover plate (number, τ, ...) single tube wall

iii) insulation (thickness, ...) vacuum

g) expected life time t + 20 years

h) estimated cost ($ US/m^2) US $100/$m^2$ aperture area basis

LIST OF PUBLISHED PAPERS AND PRESENTATIONS

1. Selçuk, M. K., "A Fixed Collector Employing Reversible Vee-Trough Concentrator and a Vacuum Tube for High Temperature Solar Energy Systems," Proceedings 11th Intersociety Energy Conversion Engineering Conference, 1976, State Line, Nevada, Paper No. 769222.
2. Selçuk, M. K., "Fixed Flat Plate Collector with a Reversible Vee-Trough Concentrator," ASME Paper No. 76-WA/HT-12, New York, NY, December 1976.
3. Selçuk, M. K., "A Vacuum Tube Vee-Trough Collector for Solar Heating and Air Conditioning Applications," ERDA University of Miami Forum, Miami Beach, Florida, December 1976.
4. Selçuk, M. K., "The Vee-Trough/Vacuum Tube Solar Collector: Analysis and Performance Evaluation," ISES 1977, Orlando, Florida (Presentation only).
5. Selçuk, M. K., "Experimental Evaluation of a Fixed Collector Employing Vee-Trough Concentrator and Vacuum Tube Receivers," ASME Winter Annual Meeting, November 27-December 2, 1977, Atlanta, Georgia.
6. Selçuk, M. K., "A Fixed, Moderately Concentrating Collector with Reversible Asymmetric Vee-Trough and Vacuum Tube Receiver," ERDA Concentrating Collector Conference, Atlanta, Georgia, September 26-28, 1977.
7. Selçuk, M. K., "A Fixed Tilt Solar Collector Employing Reversible Vee-Trough Reflectors and Vacuum Tube Receiver," Final Report, DOE/JPL-1024-77/1, December 1977.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Lawrence Livermore Laboratory	**ADDRESS:** P.O. Box 808 Livermore, CA 94550
NAME OF PRINCIPAL RESEARCHER William C. Dickinson	

TITLE OF PROJECT

Inflated Cylindrical Concentrator for Industrial Process Heat

OBJECTIVE AND NATURE OF THE PROGRAM:

The program objective is to develop a cost effective concentrating collector capable of producing industrial process steam at 170°C. This unique collector uses a non-tracking design and weatherable thin film plastics to achieve the low cost per unit area.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Analytical models of the optical and thermal characteristics have been developed. The first collectors are being tested.

PERIOD OF PROJECT:

October 1977 - September 1978

FUND IN $ U.S.

$125,000.00

IMPORTANT REPORTS OR PUBLICATIONS:

An Inflated Cylindrical Solar Concentrator for Producing Industrial Process Heat, J.W. Gerich, Lawrence Livermore Laboratory, UCID-17612 Rev. 1, December 19, 1977.

Lawrence Livermore Laboratory (Data Sheet)

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Tabor type concentrating collector, formed by inflating a horizontal thin film plastic cylinder which is clear on the upper portion and metalized as a reflector on the lower portion. The receiver tube also has an inflated thin film plastic jacket surrounding it for heat transfer suppression.

b) $\alpha\tau$

$\tau\alpha = 0.79$

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))

$$U_1 = 4.6 \frac{W}{m^2K}$$

d) heat capacity (fluid included) C (Wh/m^2K)

For the receiver tube (per meter of length)

$C = 1.5 \frac{W\text{-}hr}{m\text{-}K}$

e) heat transfer medium (water, air, ...)

Water

f) material

i) absorber (α, ε) $\alpha = 0.95$, $\varepsilon = 0.15$

ii) cover plate (number, τ, ...) $\tau_1 = 0.83$, $\tau_2 = 0.95$

iii) insulation (thickness, ...) None

g) expected life time t

Three to five years for plastic cylinder (easily replaceable).

Twenty years for receiver tube and other components.

h) estimated cost ($ US/m^2)

$75/$m^2$

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Lehigh University

ADDRESS:
Dept. of Geological Sciences
Bethlehem, PA 18015

NAME OF PRINCIPAL RESEARCHER
D. R. Simpson

TITLE OF PROJECT
Low Cost solar collector of packed bed design.

OBJECTIVE AND NATURE OF THE PROGRAM:
The objective of this study is to investigate experimentally the use of naturally occurring black materials for solar collector absorbers. Primary candidates are coke and black volcanic scoria, which offer the potential of lower absorber cost than conventional metallic materials.

The research will involve the construction and testing of several air-and-water heating collectors to determine thermal efficiency and pressure drop, as a function of particle size, for the different materials.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Collector design and prototype fabrication completed.

PERIOD OF PROJECT: 12 months, (starting date: 5/16/76)

FUND IN $ U.S. Current year $34,180

Total for the period

IMPORTANT REPORTS OR PUBLICATIONS:
New Contract - No report available

Lehigh University (Data Sheet)

<u>Solar Collector</u>

a) type (<u>flat plate</u>, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration
Pebble Bed

b) $\alpha\tau$ Not Measured

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))
Not Calculated

d) heat capacity (fluid included) C (Wh/m^2K)
Not Measured

e) heat transfer medium (water, <u>air</u>, ...)

f) material
i) absorber (α , ε) Pebble Bed Coke or Scoria
ii) cover plate (number, τ , ...) 2
iii) insulation (thickness, ...) 4" Fiberglas

g) expected life time t Unknown - It was a test mode 1

h) estimated cost (\$ US/m^2) Not Calculated

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Lockheed Research Labs.	**ADDRESS:** 3251 Hanover Street Palo Alto, CA 94304 Dept. 52-32, Bldg. 205
NAME OF PRINCIPAL RESEARCHER R.K. Wedel	

TITLE OF PROJECT

Optimization of Thin-Film Transparent Plastic Honeycomb Covered Flat-Plate Solar Collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective is to develop an optimized plastic honeycomb. Teflon was investigated as a high temperature plastic. Various methods to fabricate low temperature plastic honeycombs were investigated. Various honeycomb/cover combinations were tested. Analytical optimization studies were performed. Thermal protection methods for low temperature honeycombs were studied. Performance of various honeycomb collectors were measured.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Final Report written: Lexan honeycomb is optimum plastic honeycomb based on cost and performance.

PERIOD OF PROJECT:

May 1976 - August 1977

FUND IN $ U.S. $121,000

IMPORTANT REPORTS OR PUBLICATIONS:

SAN/1256-76/1

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Los Alamos Scientific Laboratory

ADDRESS:
P.O. Box 1663
Los Alamos, NM 87545

NAME OF PRINCIPAL RESEARCHER
J.D. Balcomb

TITLE OF PROJECT
Integrated Solar Collector Roof Structures

OBJECTIVE AND NATURE OF THE PROGRAM:
Forty LASL-3 Liquid Collectors have been rack mounted for continuous operational study. Several seal materials, desiccant techniques, condensation controls, and coolants will be studied in these forty collectors. Air-cooled collectors have been built and will be placed in operation with a rock-filled storage tank. Excellent selective surfaces were obtained ($\alpha = 0.9, \epsilon = 0.1$) by thin deposits of black chrome oxide on bright nickel on 6-in. square samples of mild steel substrate. The first attempts to plate an entire collector produced an uneven appearance but quite good operation. The second fully plated collector shows excellent thermal behavior characterized by an average $\alpha = 0.92$ and average $\epsilon = 0.15$. The study of this collector is continuing with high priority. Materials tests will be performed on coolants such as paraffinic oils, sealants, foam insulators, and other potentially inexpensive selective surfaces.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Performance testing of the 40-panel array using two viscocity Paraffinic Oils and industrial coordination on optimizing black chrome surfaces for 415 collectors completed.

PERIOD OF PROJECT:
24 months, (Starting date: 7/1/74)

FUND IN $ U.S.
Current year $225,000

Total for the period

IMPORTANT REPORTS OR PUBLICATIONS:
0 Integrated Solar Energy Collector, Final Summary Report, Report No: UC-62
0 Research on Integrated Solar Collector Roof Structures, Technical Paper No: LA-UR-75-1335.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

M. I. T. Lincoln Laboratory

ADDRESS:

P. O. Box 73
Lexington, MA 02173

NAME OF PRINCIPAL RESEARCHER

Dr. D. I. Tchernev

TITLE OF PROJECT

INTEGRATED ZEOLITE COLLECTORS

OBJECTIVE AND NATURE OF THE PROGRAM: The objective of the program is to develop an integrated collector for solar heating and cooling systems utilizing the adsorption and desorption of water from molecular sieve zeolites. The specific tasks are to design, construct, and test a prototype of such a collector, capable of providing hot water during the day and chilled water at night, which will act as one-for-one replacement for existing hot water solar collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: Non-integrated zeolite collectors for solar heating and cooling have been developed under a previous project. Integration of the evaporator and condenser with the collector will be the goal of the present project.

PERIOD OF PROJECT:

(Proposed) November 1977 - October 1978

FUND IN $ U.S.

(Proposed) $150,000

IMPORTANT REPORTS OR PUBLICATIONS: Proceedings of "Zeolite 76" Conference (to be published).

Final Report NSF/RA-770017.

M.I.T. Lincoln Laboratory (Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar heating and cooling

b) type of refrigerator (absorption, ...; working medium, ...)

adsorption; zeolite and water vapor

c) capacity of refrigerator (tons)

~ 0.05 per collector (15-20 sq. feet)

d) temp. range 0 ($^{\circ}$C)

cooling, 5-10°C; heating, 40-50°C

e) C.O.P.

0.4 (total including collector)

f) heat exchanger

liquid to vapor

g) auxiliary heat source

none

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Massachusetts Institute of Technology

ADDRESS:
Rm. 3-457, M.I.T.
Cambridge, Mass. 02139

NAME OF PRINCIPAL RESEARCHER
Shawn Buckley

TITLE OF PROJECT
PERFORMANCE CHARACTERISTICS OF THERMIC DIODE SOLAR PANELS

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this program is to develop a design procedure for Thermic Diode Solar Panels. The procedure will be similar to "F-Chart" methods of active solar systems; it will allow thermic diodes to be quickly sized for different building heat loads and different climates. Hardware testing of thermic diodes will verify that the computer codes match experimental results.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Computer codes have been verified against experimental results; beginning of comparison with F-chart is completed. Thermic diodes show about the same heat delivered as an active system.

PERIOD OF PROJECT:

12 months (Starting Date: 7/1/77)

FUND IN $ U.S.

$53,170

IMPORTANT REPORTS OR PUBLICATIONS:

"Thermic Diode Solar Panels For Space Heating", S. Buckley
Solar Energy, to be published, Spring 1978.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Mississippi State University, Mechanical, ~~Agricultural, and Biological Engineering~~

NAME OF PRINCIPAL RESEARCHER
Dr. Richard E. Forbes & Dr. Ronald McClendon

ADDRESS:
Drawer ME
Mechanical Engineering
Mississippi State, MS 39762

TITLE OF PROJECT

Addition of Solar Air-Heaters to Pre-Engineered Metal Buildings

OBJECTIVE AND NATURE OF THE PROGRAM:

The work will consist of the modification of an existing solar heated building from "once through" heating to a recirculation model of heating. The air heaters utilize the metal skin of the building as the major component of the collector. Corrugated fiberglass is used for glazing. The building was previously used in the solar livestock shelter program. A rock bed is used for heat storage and electrical supplemental heat is used.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

All modifications were completed during Feburary 1978 and testing has been performed during the winter months of 77-78.

PERIOD OF PROJECT:

25 September 1977 - 24 September 1978

FUND IN $ U.S.

$36,385

IMPORTANT REPORTS OR PUBLICATIONS:

None yet.

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Flat plate air-heater using metal skin of building for absorber plate. Corrugated fiberglass glazing. Caldwell relective black paint. Horizontal air flows through the channels (collector length is 24 feet) by induced draft fan. Flow rate is approximately 2 CFM per square foot. Material cost of collector was less than $1.00 per square foot.

b) $\alpha\tau$

$\tau \simeq .8$ (estimated)
$\alpha \simeq .9$
$\tau\alpha \simeq .72$

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ ($^\circ C$))

Unknown

d) heat capacity (fluid included) C (Wh/m^2K)

Unknown

e) heat transfer medium (water, air, ...)

air

f) material
- i) absorber (α, ε) $\alpha = .90$, $\varepsilon = .60$
- ii) cover plate (number, τ, ...) $\tau_1 \simeq .8$
- iii) insulation (thickness, ...) 3.5 inches urea formaldehyde (also serves as building insulation) $R \simeq 25$

g) expected life time t

limited by fiberglass glazing only ($\simeq$10 years plus)

h) estimated cost ($ US/m^2)

collector only estimated at $3.00 - $4.00 per square foot.
$32.29 - $43.05 per square meter

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Monsanto Research Corporation

ADDRESS: Dayton Laboratory
Dayton, Ohio 45407

NAME OF PRINCIPAL RESEARCHER
George L. Ball

TITLE OF PROJECT

MEDIUM TEMPERATURE AIR HEATERS BASED ON DURABLE TRANSPARENT FILMS

OBJECTIVE AND NATURE OF THE PROGRAM:

To design, build and performance test a new potentially low-cost, non-concentrating flat plate solar air heater for the medium (120-170°F) temperature range. These objectives are to be realized through use of low-cost, reinforced, specially outdoor stabilized polyvinylchloride (PVC) film for both the glazing and absorber.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
The preferred film composition for use over the expected temperature range has been selected and film will be made in the second quarter of 1978.

PERIOD OF PROJECT:

October 1, 1977 to October 31, 1978

FUND IN $ U.S.

106,657

IMPORTANT REPORTS OR PUBLICATIONS:

None

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Flat plate wherein the glazing and absorber are respectively clear and black scrim reinforced PVC.

b) $\alpha\tau$

To be determined

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))

To be determined

d) heat capacity (fluid included) C (Wh/m^2K)

To be determined

e) heat transfer medium (water, air, ...)

Air

f) material
- i) absorber (α, ε)
- ii) cover plate (number, τ, ...)
- iii) insulation (thickness, ...)

To be determined in design studies

g) expected life time t

5 to 10 years for films
20 years for other components

h) estimated cost (\$ US/m^2)

\$15/m^2

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION National Bureau of Standards	**ADDRESS:** Gaithersburg, Maryland
NAME OF PRINCIPAL RESEARCHER J. E. Hill	

TITLE OF PROJECT

Development of Methods of Evaluation and Test Procedures for Solar Collectors and Thermal Storage Devices

OBJECTIVE AND NATURE OF THE PROGRAM:

The objectives of this program are to develop standard test methods for determining the thermal performance of solar collectors and thermal storage devices that are used in systems for heating, cooling, and the heating of hot water in buildings. Also to experimentally verify the proposed test procedures utilizing test facilities at NBS as well as at other selected locations.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

- Adoption of ASHRAE Standard 93-77, Collector Test Procedure
- Experimental Verification of the Standard for Selected Air and Water-Cooled Collectors at NBS

PERIOD OF PROJECT: January, 1974 - September, 1978

FUND IN $ U.S.	CURRENT YEAR	$100,000
	TOTAL FOR THE PERIOD	$795,000

IMPORTANT REPORTS OR PUBLICATIONS:

"Development of Proposed Standards for Testing Solar Collectors and Thermal Storage Devices", NBS Technical Note 899, February, 1976.

Present Status or Summary of Significant Accomplishment (continued):

- Completion of Round-Robin Collector Test Program

Important Reports or Publications (continued):

"A Method of Testing for Rating Solar Collectors Based on Thermal Performance", Solar Energy, Vol. 18, pp. 421-429, 1976.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION University of New Mexico, Alb. NM	**ADDRESS:** Department of Physics and Astronomy 800 Yale Blvd. N.E. Albuquerque, New Mexico 87131
NAME OF PRINCIPAL RESEARCHER Dr. Howard C. Bryant	

TITLE OF PROJECT

A Demonstration Salt Gradient Solar Pond

OBJECTIVE AND NATURE OF THE PROGRAM:

The research has been geared towards establishing the operational parameters of a salt gradient solar pond. This is a solar energy collector and storage system which meets the three basic requirements of long term storage, low cost, efficiency, to provide low temperature heat (not above 100°C). We are primarily interested in space heating, which varies seasonally, and industrial process heating, which poses a constant heating demand. Other applications of solar ponds include crop drying, water desalination and space cooling. The solar pond at UNM has been designed to supply the total heating requirement of a 2000 sq. ft. house in Albuquerque, N.M.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The maximum convective layer temperature obtained to date has been 93°C in August 1977; at this time the solar pond contained $4x10^{10}$ Joules of usable heat. Heat extraction from the solar pond began in November 1977 and has been matched to the heating requirements of a 2000 ft^2 residence in Albuquerque. The heat

(over)

PERIOD OF PROJECT:

Project EG-77-5-04-3977 has been funded for one year, beginning April 1, 1977.

FUND IN $ U.S.

$ 55, 952.00

IMPORTANT REPORTS OR PUBLICATIONS:

F. Zangrando, H.C. Bryant "Heat Extraction from a Salt Gradient Solar Pond," International Conference on Alternative Energy Sources, Miami Beach, Fla., Dec. 5-7, 1977. Also edited version on April 1978 issue of Solar Age.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: (cont.)

extraction has been sucessful and the entire heating requirement for the winter 1977-78 has been matched. Minimum convective layer temperature was 29°C in January 1978. Present temperature is 46°C, with heat extraction still in progress.

University of New Mexico (Data Sheet)

PLEASE NOTE THAT THESE QUESTIONS ARE INAPPROPRIATE TO SALT GRADIENT SOLAR PONDS.

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

The solar pond is a non-concentrating solar system which includes both collector and storage into one. The upper region in the pond is maintained non-convective by the addition of salt, in increasing amounts as one goes deeper into the pond. This upper region behaves as an insulator. Below this region, a convective layer at high salinity constitutes the storage reservoir. Dimensions of the pond are: top diameter, 15m; depth, 2.5m; insulating layer thickness, ~1m; storage volume, $130m^3$.

b) $\alpha\tau$

Maximum transmission through the insulating layer is 0.35 of the incident radiation on a horizontal surface, with 0.27 absorbed within the first centimeter of water (surface).

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ (^oC))

Heat loss from the convective (storage) layer is all by conduction. The overall heat loss coefficient is: ~0.1 W/m^2 °C

d) heat capacity (fluid included) C (Wh/m^2K)

The heat capacity of the brine varies from 0.78 to 1.08 cal/gm°C due to changes in temperature and salinity. In the convective layer, the "heat capacity" per unit area is from $1.7x10^3$ to $2.3x10^3$ Wh/m^2°C (excludes soil and non-convecting layer).

e) heat transfer medium (water, air, ...)

Brine

f) material i) absorber (α, ε)

ii) cover plate (number, τ, ...)

iii) insulation (thickness, ...)

See item a).

g) expected life time t

The lifetime of the liner is guaranteed by manufacturers for 20 years under "normal weathering".

h) estimated cost ($ US/m^2) 202

A maximum of $54/$m^2$ for a pond of this size

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[XX] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [XX] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Owens-Illinois, Inc.

ADDRESS:
P. O. Box 1035
Toledo, Ohio 43666

NAME OF PRINCIPAL RESEARCHER
Y. K. Pei; D. C. Beekley

TITLE OF PROJECT
Development of a drainable evacuated, tubular, selectively coated, liquid cooled solar collector array.

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this program is to establish a practical, cost-effective method for draining the SUNPAK™ evacuated tubular liquid cooled collector so as to avoid the problems associated with freeze-up, boil out and night time heat loss and to provide supporting data and analysis which show the overall impact on system performance and cost effectiveness.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Feasibility studies have been completed and two bank arrays are being installed for system fluid flow studies and thermal performance analysis.

PERIOD OF PROJECT:

October, 1977 - September, 1978.

FUND IN $ U.S.

$150,000

IMPORTANT REPORTS OR PUBLICATIONS:

No publications issued to date.

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Spaced evacuated tubular collector with diffuse radiation backing screen for enhancement of radiation reaching absorber surface.

b) $\alpha\tau$

$\alpha\tau$ = 0.78. Note: Collector intercept affected by F_R, incident angle modifier and radiation enhancement from backing screen. Based on a daily basis:

$$\bar{\eta}. = .59$$

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ (^oC))

$U_l = .79 \; \frac{W}{m^2K}$

d) heat capacity (fluid included) C (Wh/m^2K)

$C = 5.25 \; \frac{Wh}{m^2K}$

e) heat transfer medium (water, air, ...)

Water

f) material
i) absorber (α, ε) α = .85, ε = .055
ii) cover plate (number, τ, ...) τ = .92
iii) insulation (thickness, ...) Hard Vacuum

g) expected life time t = 20 years

h) estimated cost ($ US/m^2)
Current = $216.00/$M^2$

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Owens-Illinois	**ADDRESS:** P.O. Box 1035 Toledo, OH 43666
NAME OF PRINCIPAL RESEARCHER K. Moan	

TITLE OF PROJECT

Evaluation of an All-Glass, Evacuated, Tubular, Non-Focusing, Non-Tracking Solar Collector Array.

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this program is the evaluation of an advanced evacuated solar energy collector using air as the heat transfer fluid. The performance goal is an air exit temperature of 250°F at a collection efficiency of 40%. An advanced liquid-heating collector has been fabricated and is being marketed by Owens Illinois. This collector demonstrates the feasibility of the evacuated, all-glass, tubular design. This program will modify this successful design to utilize air as the collector fluid. The major program emphasis will be on the installation and testing of a multitubular collector array and the evaluation of its air flow characteristics in terms of flow distribution and pressure drop, and its thermal performance in comparison with the liquid collector design.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Collector evaluation system defined and collector test initiated.

PERIOD OF PROJECT:

8 Months, (Starting date: 7/1/77)
Extended 14 months

FUND IN $ U.S.

Current year $111,232

Total for the period

IMPORTANT REPORTS OR PUBLICATIONS:

Evaluation of an All-Glass, Evacuated, Tubular, Non-Focusing, Non-Tracking Solar Collector Array, Task 1 Report, Aug. 10, 1976.

Owens-Illinois (Data Sheet)

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Spaced evacuated tubular collector with diffuse radiation backing screen for enhancement of radiation reaching the absorber surface.

b) $\alpha\tau$

$\alpha\ \tau$ = 0.78

Note: Collector intercept affected by F_R, incident angle modifier and radiation enhancement from backing screen.

$\overline{\eta}_0$ = .58

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))

U = 0.82 Watts/m^2K

Note: The slope of the efficiency curve is slope= -1.05 Watts/m^2K.

d) heat capacity (fluid included) C (Wh/m^2K)

C = 1.62 Watts /m^2K

e) heat transfer medium (water, air, ...)

Air

f) material

i) absorber (α, ε) α = .85, ε = .07

ii) cover plate (number, τ, ..1), τ = .92

iii) insulation (thickness, ...) hard vacuum

g) expected life time t = 20 years

h) estimated cost ($ US/m^2) Current = $216.00/$m^2$

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Payne, Inc. **NAME OF PRINCIPAL RESEARCHER** Peter R. Payne	**ADDRESS:** 1933 Lincoln Drive Annapolis, Maryland 21401

TITLE OF PROJECT

Development of Very Low Cost, Non-Concentrating Collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of low cost concrete air heating collectors which are also structural elements, so that they can be used to construct south-facing walls. Also, to investigate the effectiveness of glazing existing concrete block and cavity masonry walls, so that air ducted through the cavities can be heated. Applicable directly to space heating, and, with a heat exchanger, to providing hot water.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Three walls currently under test and mathematical models well established. An "open face" block, 8"x8"x16", which can be made on a concrete block making machine shows promise. Currently under thermal test by Payne Inc. and structural test by the NCAMA. A new concrete block thermal storage system has been developed as part of the test set-up.

PERIOD OF PROJECT:

October 1977 - September 1978

FUND IN $ U.S.

$129,261

IMPORTANT REPORTS OR PUBLICATIONS:

"Equilibrium temperatures for a collector having high thermal resistance." Payne Inc. Working Paper No. 220-3.

"Transfer of heat from a vertical plate to convective air flow." Payne Inc. Working Paper No. 220-2.

"Integrating concrete and other low-cost solar collectors into present day manufacturing and building practices." Payne Inc. Working Paper No. 220-4.

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Quasi-flat plate. 16"x8"x8" masonry block configured as a collector, with provision for single or double glazing.

Also, conventional cavity walls with external glazing.

b) $\alpha\tau$

Not finally determined.

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^{o}C))

Not finally determined.

d) heat capacity (fluid included) C (Wh/m^2K)

Not finally determined

e) heat transfer medium (water, air, ...)

Air

f) material
- i) absorber (α, ε) Black concrete
- ii) cover plate (number, τ, ...) acrylic (.08) + teflon (5ml)
- iii) insulation (thickness, ...) variable with application

g) expected life time t

Not determined

h) estimated cost ($ US/m^2)

$6.00/$m^2$ for block
$7.25/$m^2$ for glazing (plus cost of laying and manifolding)

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Polyset, Inc.	**ADDRESS:** 7 Summer Street Manchester, MA 01944
NAME OF PRINCIPAL RESEARCHER J. M. Bradley	

TITLE OF PROJECT

Development of a Freeze-Tolerant Solar Water Heater using Crosslinked Polyethylene.

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this study is to examine the feasibility of using carbon-black-impregnated crosslinked polyethylene (XLPE) as a material for solar collector absorbers. This material has the potential for low cost, long service life and ability to withstand repeated freezing of water within the absorber. The initial phase of the study has five tasks.

Extrusion of 2000 ft. of 5/16" OD tubing; freeze-thaw testing of 10 ft. coils of tubing filled with water at pressure between 30 and 240 psi; fabrication of two simple water heating collectors out of coiled tubing; collector performance testing at Los Alamos Scientific Laboratory; reporting.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

All work but the reporting has been completed, and indicates that it is indeed very feasible to build a freeze-tolerant absorber out of carbon-black-reenforced XLPE.

PERIOD OF PROJECT:

16½ months-starting date May 1, 1976 - October 15, 1977

FUND IN $ U.S.

Current year - $53,512
Received to date---$40,134

IMPORTANT REPORTS OR PUBLICATIONS: (7 Progress Reports sent to ERDA)

6/30/76 8/31/76 10/31/76 1/5/77 3/15/77 5/3/77 7/1/77

Polyset, Inc. (Data Sheet)

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Although the absorber surfaces of the collectors built under the present contract are made from the tubes fabricated into the shape of a flat spiral coil, these collectors are really of the "flat-plate" type.

b) $\alpha\tau$

The absorptivity of the absorber surface is approximately 0.95.

The transmissivity of the 1/4" thick untempered glass glazing is $75 \pm 1\frac{1}{2}\%$ according to the manufacturer, Libby Owens Ford.

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ (^oC))

When the ambient temperature is 26.7^0C and no wind is blowing, and the absorber plate is at 71.1^oC the overall heat loss coefficient is about $8.4\ w/m^2K$

d) heat capacity (fluid included) C (Wh/m^2K)

Glazing	3.6	Wh/m^2K
Absorber	2.0	
Collector Fluid	4.0	
Insulation	3.1	
Housing	6.1	
	18.8	Wh/m^2K

e) heat transfer medium (water, air, ...)

Water

f) material

i) absorber (α, ε) Absorptivity & emissivity = .95 approx.

ii) cover plate (number, τ, ...) One glazing transmissivity = $75 \pm 1\frac{1}{2}\%$

iii) insulation (thickness, ...) 0.089 meters

g) expected life time t 25 years

h) estimated cost ($ US/m^2) The absorber can potentially be cheaper than any other capable of handling domestic hot water. The other components of the collector are conventional.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR ~~COLLECTOR~~ Concentrators [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Solar Energy Technology, Inc.	**ADDRESS:** Civil Terminal Building L. G. Hanscom Field Bedford, Mass. 01720
NAME OF PRINCIPAL RESEARCHER Carlyle J. Sletten	

TITLE OF PROJECT

Image Collapsing Concentrators

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of wide angular coverage lenses of stepped (Fresnel) and cylindrical rod geometries with subreflecting mirrors to improve concentration ratios and optical aperture efficiencies. Synthesis of lens and subreflector parameters is accomplished for solar incidence in both elevation and azimuth planes. The nature of SET, Inc. research to date has been mainly analytic with novel lens designs and contour shaping of profiles and subreflectors emphasized using vector formulations and computer methods for optimizing solid angular coverages on non-tracking lens-subreflector systems. Objectives include reducing concentrator weight, cost of fabrication, and optical or heat loss mechanisms while at the same time collecting all of the sun's radiation daily and annually.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

A cylindrical Fresnel lens composed of flat prisms focussing very well over a 60° elevation angle sector has been designed and ray traced. Special subreflectors to correct for aberrations on miniature dielectric rod lenses have been synthesized.

PERIOD OF PROJECT:

October 1977 to April 1979

FUND IN $ U.S.

$57,000

IMPORTANT REPORTS OR PUBLICATIONS:

None as work is just beginning.

Concentrators
Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

stepped cylindrical prism Fresnel lens. Prototype design has: 20 steps, 30 cm x 30 cm aperture area, two-point optically corrected at ± 25° for 60° elevation coverage, step shadowing loss less than 1 decibel, index of refraction 1.523 (acrylic), average Focal length approx. 25 cms. Bal. Concentration Ratio approx 3 without subreflectors. Image collapsing subreflectors for prism lens to reduce effective I and to segment for Rad. Bal. Con. Ratio of approx. 10. Also Image Collapsing Subreflectors for small dielectric rod lenses with aberration correction providing two steradians angular coverage.

Items b through f not applicable because absorbers and receivers are not included in the DOE Grant provisions.

b) $\alpha\tau$

Black circular tubes carrying thermal oils are envisioned for absorber located in focal regions of subreflectors.

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ (°C))

d) heat capacity (fluid included) C (Wh/m^2K)

e) heat transfer medium (water, air, ...)

f) material
i) absorber (α, ε)
ii) cover plate (number, τ, ...)
iii) insulation (thickness, ...)

g) expected life time t

Production models of lenses or dielectric rods can be made of glass or weather resistant plastics. Life times of 5 years or more anticipated.

h) estimated cost ($ US/m^2)

Lens aperture area costs of $50 per m^2 are reasonable.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION SOLARON CORPORATION	ADDRESS: 720 So. Colorado Blvd. Suite 300 Denver, Colorado 80222
NAME OF PRINCIPAL RESEARCHER Bruce E. Cole-Appel	

TITLE OF PROJECT

Improvement of Solar Air-Heating Collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

The goal of this investigation is to increase the rate of heat transfer between the absorber and the air stream. This must be accomplished in a cost-effective manner, i.e., the increase in performance must be greater that the associated increase in collector cost.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The absorber design found to be the most cost-effective improvement has been built and is presently undergoing further evaluation.

PERIOD OF PROJECT:

May 31, 1976 to December 15, 1977.

FUND IN $ U.S.

$99,495.00

IMPORTANT REPORTS OR PUBLICATIONS:

"Flat Plate Air-Heater Improvements", Cole-Appel, B.E., Löf,G.O.G., Shaw, L.E., Proceedings American Section, ISES, Annual meeting, June, 1977, Orlando, Florida
The final report which includes (a) engineering analysis (b) description of absorbers and (c) the test results will be available approximately June, 1978.

Solaron Corporation (Data Sheet)

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Flat plate - air flow beneath absorber plate

b) $\alpha\tau$ 0.78

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))

0.226 W/M^2K 20C to 120C

d) heat capacity (fluid included) C (Wh/m^2K)

6.25 $\frac{wh}{m^2K}$

e) heat transfer medium (water, air, ...)

air

f) material

i) absorber (α, ε) α = 0.95 ε - 0.89

ii) cover plate (number, τ, ...) 2, 0.82

iii) insulation (thickness, ...) 10.2 cm batt and 2.5 cm rigid

g) expected life time t greater than 40 years

h) estimated cost ($ US/m^2) $156.00/$M^2$ - customer price

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

March 16, 1978

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Solation Products, Inc.

ADDRESS: 111 West Rd.
Cortland, NY 13045

NAME OF PRINCIPAL RESEARCHER
Robert A. Newton

TITLE OF PROJECT
High temperature liquid heaters, 170-230^{o}F, for solar heating and cooling applications.

OBJECTIVE AND NATURE OF THE PROGRAM:

To design and develop a flat plate collector which has excellent performance over all usual temperature levels and insolation values, and yet has a lower cost and lighter weight than most contemporary designs.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

All design and mechanical drawings have been completed. The first two prototypes are currently being constructed.

PERIOD OF PROJECT:

October 1977 - September 1978

FUND IN $ U.S.

$98,899.00

IMPORTANT REPORTS OR PUBLICATIONS:

None to date.

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

- Flat plate concentrating, non-tracking, non-evacuated
  Height 2486 mm, Width 1216 mm, Depth 120.7 mm
  Gross area 3.02 m^2, Aperture 2.75 m^2

b) $\alpha\tau$ 0.82

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))

To be determined by test scheduled in early May

d) heat capacity (fluid included) C (Wh/m^2K)

3.73 w/m^2 K (estimated)

e) heat transfer medium (water, air, ...)

water, water-glycol, usual heat transfer fluids, Freon refrigerants

f) material

material	i)	absorber (α, ϵ)	0.93 under 0.10
	ii)	cover plate (number, τ, ...)	1, 5 mm thick
	iii)	insulation (thickness, ...)	50 mm thinest point 100 mm thickest point

g) expected life time t over 15 yrs.

h) estimated cost (\$ US/m^2) $86.00 to distributor

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Sun Systems, Inc. **NAME OF PRINCIPAL RESEARCHER** Dr. Elliot Berman	**ADDRESS:** 170 Granite Avenue Dorchester, Mass. 02124

TITLE OF PROJECT

Double Absorber Plate Solar Air Heater

OBJECTIVE AND NATURE OF THE PROGRAM:

To verify properties of the Sun Systems Air Heater. To carry our engineering and test work to reduce cost and improve reliability.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

A glazing and "half black" absorber plate have been found which yield a collector of superior properties.

PERIOD OF PROJECT:

October 1, 1977 - June 30, 1978

FUND IN $ U.S.

$73,010

IMPORTANT REPORTS OR PUBLICATIONS:

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Flat Plate
Double Glazing
Two Absorber Plates

b) $\alpha\tau$

c) overall heat loss coefficient U_1 (W/m^2K) (temp. range θ (^oC))

d) heat capacity (fluid included) C (Wh/m^2K)

e) heat transfer medium (water, air, ...)

Air

f) material
i) absorber (α, ϵ)
ii) cover plate (number, τ, ...)
iii) insulation (thickness, ...)

g) expected life time t

Twenty Years

h) estimated cost (\$ US/m^2)

\$77/m^2

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[xx] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[xx] MATERIAL RESEARCH [ ] COMPONENT DEVELOPMENT xx Loads and Structural Research

NAME OF ORGANIZATION

Texas A&M Research Foundation

NAME OF PRINCIPAL RESEARCHER

Howard L. Chevalier

ADDRESS:

F.E. Box H
College Station, Texas 77843

TITLE OF PROJECT

Structural Integrity of Solar Collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

To develop analytical design and analysis techniques for solar collector structures and support structures and to develop definition of wind load requirements to obtain an increase in structural efficiency and a resulting saving in cost. Tasks:

1. Conduct theoretical and experimental studies of wind loads.
2. Develop analytical approaches to structural design.
3. Develop wind load design criteria.
4. Conduct on-site measurements.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Wind tunnel tests are being conducted using full-scale collectors and small-scale models of collector installations, computer programs are being developed for design and instrumentation is being installed at an on-site installation.

PERIOD OF PROJECT:

January 1, 1977 through June 30, 1978

FUND IN $ U.S.

$44,544

IMPORTANT REPORTS OR PUBLICATIONS:

"Structural Integrity of Solar Collectors" - progress report

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

University of Virginia

NAME OF PRINCIPAL RESEARCHER

J. T. Beard

ADDRESS:

School of Engineering
Charlottesville, VA 22901

TITLE OF PROJECT

Engineering Analysis and Testing of Water-Trickle Collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

This project used the solar collector test procedure developed by the National Bureau of Standards to evaluate the type of solar water trickel solar collector used in the Thomason Solaris System. Additional tests will also be made to determine the influence of design modifications such as the use of a second cover glazing and various distances of the glazings from the collector surface. In addition, an analytical simulation model will be developed for the water trickle collector which will include provisions for energy transference by evaporation and condensation as well as the customary provisions for radiation, convection, and conduction. The analytical model will be checked against the results of the experimental test program, In addition, thermal performance testing has been conducted on an open fluid film (silicon oil) collector.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Research completed

PERIOD OF PROJECT:

24 months (starting date: 6/21/75)

FUND IN $ U.S.

Current year - None
Total for the period - $107,399

IMPORTANT REPORTS OR PUBLICATIONS:

See Attached

List of technical reports and papers prepared under Prime Contract Number E(40-1)-4927

Beard, J.T., Iachetta, F.A., Lilleleht, L.U., May, R.B., and Huckstep, F.L., "Solar Energy Testing and Analysis." Presented to Conference on Solar Energy for Virginia, August 20, 1975, Science Museum of Virginia, Richmond, Virginia.

Beard, J.T., "Engineering Analysis and Testing of Water-Trickle Solar Collector." ORO-4927-76/1, Division of Solar Energy, Energy Research and Development Administration, March, 1976.

Beard, J.T., Huckstep, F.L., May, W.B., Iachetta, F.A., and Lilleleht, L.U., "Thermal Performance of a Water-Trickle Solar Collector," Proceedings of the Twelfth Southeastern Seminar on Thermal Sciences, University of Virginia (Charlottesville, Virginia, June 6-8, 1976), pp. 55-60.

Beard, J.T., Huckstep, F.L., May, W.B., Jr., Iachetta, F.A., and Lilleleht, L.U., "Performance of a Water-Trickle Solar Collector," Proceedings of Conference: Solar Energy in Cold Climates (University of Detroit, June 7-8, 1976).

Beard, J.T., "Engineering Analysis and Testing of Water-Trickle Solar Collector, Report No. 2," Division of Solar Energy Research, Energy Research and Development Administration, ORO/4927-76/2 (June 1976).

Beard, J.T., Huckstep, F.L., May, W. B., Jr., Iachetta, F.A. and Lilleleht, L.U., "Performance and Analysis of 'Solaris' Water-Trickle Solar Collector," Proceedings of the 1976 Joint Solar Energy Conference: Sharing the Sun, Solar Technologies in the Seventies (Winnipeg, Canada, August 15-20, 1976)

Beard, J.T., Huckstep, F.L., May, W.B., Jr., Iachetta, F.A., and Lilleleht, L.U., "Analysis of Thermal Performance of 'Solaris' Water-Trickle Solar Collector," Paper No. 76-WA/Sol-21, Winter Annual Meeting of ASME, December 5-12, 1976, New York, New York

Beard, J.T., "Engineering Analysis and Testing of Water-Trickle Solar Collector, Report No. 3," ORO-4927-77-1, Division of Solar Energy, Energy Research and Development Administration (January 1977)

Beard, J.T., Messer, R.F., Huckstep, F.L., May, W.B., Jr., and Iachetta, F.A., "Thermal Performance of an Open Fluid-Film Solar Collector," Proceedings 1977 Flat-Plate Solar Collector Conference, Florida Solar Energy Center (Orlando, Florida, February 1977), pp. 67-73.

May, W.B., Jr., "Theoretical Model of the 'Solaris' Open Water Flow Solar Collector," MS thesis, University of Virginia, School of Engineering and Applied Science, Charlottesville, Virginia, April 1977.

Huckstep, F.L., "Performance Parameters for the Water-Trickle Solar Collector," MS thesis, University of Virginia, School of Engineering and Applied Science, Charlottesville, Virginia, May 1977.

Beard, J.T., Iachetta, F.A., Messer, R.F., Huckstep, F.L., and May, W.B., Jr., "Performance and Analysis of Open Fluid-Film Solar Collectors," Proceedings of the 1977 Annual Meeting, American Section, ISES, (Orlando, Florida, June 6-10, 1977), pp. 1-26 to 1-29.

Beard, J.T., Huckstep, F.L., May, W.B., Jr., Iachetta, F.A., and Lilleleht, L.U., "Design and Operational Influences on Thermal Performance of 'Solaris' Solar Collectors," Paper No. 77-WA/Sol-2 (Atlanta, Georgia, November 1977). Accepted for publication in ASME Transactions, Journal of Engineering for Power.

Beard, J.T., Huckstep, F.L., May, W.B., Jr., Dirhan, L.A., Iachetta, F. A., and Lilleleht, L.U., "Engineering Influences on the Thermal Performance of Open-Flow Liquid Solar Collectors," Proceedings of the Miami International Conference on Alternative Energy Sources (Miami Beach, Florida, December 1977).

Beard, J.T.,"Engineering Analysis and Testing of Water-Trickle Solar Collector, Final Report," ORO/4927-78/1, Division of Solar Energy, Energy Research and Development Administration (January 1978).

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION University of Waterloo **NAME OF PRINCIPAL RESEARCHER** K.G.T. Hollands	**ADDRESS:** Dept. of Mechanical Engineering University of Waterloo Waterloo, Ontario, Canada N2L 3G1

TITLE OF PROJECT

"Methods of Reducing Heat Losses from Flat Plate Collectors - Phase 3"

OBJECTIVE AND NATURE OF THE PROGRAM:

The effect of absorber plate emissivity on the performance of honeycomb solar collectors is being examined. Ordinarily, in the honeycomb solar collector the absorber plate is painted black giving it a high emissivity ($\sim .9$). However, it may be desirable, for improved performance, to combine the beneficial effects of a honeycomb with that of a selective surface on the absorber plate. In this instance the plate emissivity will be quite low ($\sim .1$). This study will attempt to establish whether such a combination does in fact give improved importance. Studied will be the effect of the plate emissivity on (i) the ability of the honeycomb to suppress free convection; and (ii) the radiative and conductive heat transfer taking place across the honeycomb when free convection is suppressed. Methods used will be both experimental and analytical.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: Experimental methods of obtaining different plate emissivities have been established; ten honeycombs of different geometries have been obtained for testing; four have been tested. Computer programs modeling the radiant-conductive exchange have been written.

PERIOD OF PROJECT:

July 1, 1977 to October 31, 1978 (16 month)

FUND IN $ U.S.

$59,495.00

IMPORTANT REPORTS OR PUBLICATIONS: "Studies on Methods of Reducing Heat Losses from Flat Plate Solar Collectors - Phase 1, Final Report", Report No. COO-2597-2, Contract No. E(11-1) - 2597, July 1976; Studies on Methods of Reducing Heat Losses from Flat Plate Solar Collectors-Phase 2, Yearly Progress Report", Rep. No. COO-2597-3; Contract No. EY-76-C-02-2597.* 000, January 1977.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION West Virginia University **NAME OF PRINCIPAL RESEARCHER** John L. Loth	**ADDRESS:** Department of Aerospace Engineering College of Engineering West Virginia University Morgantown, WV 26506

TITLE OF PROJECT

Grooved Foamglas Solar Air Heater

OBJECTIVE AND NATURE OF THE PROGRAM:

The program objective is to optimize and test a cost effective hybrid air to water solar collector system. The flat plate collector is capable of producing hot air up to 70°C. The light weight collector uses one single material, such as natural black Foamglas insulation to function as: solar radiation absorber, finned heat transfer surface and thermal insulation. The hot air can be used directly for space heating or when forced thru an indoor ducted finned heat exchanger it can transfer its heat to a domestic hot water tank. The hybrid system efficiency loss may be offset by the advantage of lower collector cost and elimination of freeze up problems.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Four different collector configurations have been constructed; some use a steel frame, some a wooden frame and some form an integral part of the 400 sqft "A" frame roof cover.

PERIOD OF PROJECT:

October 1977 - September 1978

FUND IN $ U.S.

$106,578

IMPORTANT REPORTS OR PUBLICATIONS:

"A Grooved Foamglas Flat Plate Solar Collector," Proceedings of the Flat-Plate Solar Collector Conference, Feb. 28 - March 2, 1977, Orlando Florida. Sponsored by the ERDA Division of Solar Energy. "Hybrid air to water solar collector performance" paper to be presented at the Energy Conversion Conference, Aug. 20-25,'78 San Diego, California.

Solar Collector

a) type (flat plate, tubular, concentrated, ..., evacuated, nonevacuated, ...) and configuration

Grooved Foamglas flat plate solar air heater uses 1-1/2"thick Foamglas insulation backed by 1" polyurethane. Various framing techniques are used and the collector is typically covered by a double glazing of Dupont Tedlar on the inside and Sun-Lite fiberglas on the outside

b) $\alpha\tau$

$\alpha\tau = .76$

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ (^oC))

$$U_l = 5.0 \frac{W}{m^2k}$$

d) heat capacity (fluid included) C (Wh/m^2K)

$C = 6.5 \frac{Wh}{m^2k}$ includes 1" insulation but not the casing

e) heat transfer medium (water, air, ...)

air

f) material

i) absorber (α, ε) $\alpha = .95$ $\varepsilon = .95$

ii) cover plate (number, τ, ...) $\tau_1 = .91$ $\tau_2 = 0.88$

iii) insulation (thickness, ...) 1" polyurethane

g) expected life time t

fifteen to twenty years

h) estimated cost ($ US/m^2)

Estimated cost: materials only, using steel casing: $30/$m^2$

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
University of Wisconsin

NAME OF PRINCIPAL RESEARCHER
J. Mitchell - M.M. El-Wakil

ADDRESS:
Solar Energy Laboratory
1500 Johnson Drive
Madison, Wisconsin 53706

TITLE OF PROJECT
An Interferometric Study of Natural Convection characteristic of Flat Plate and Vee-Corrugated Solar Collectors

OBJECTIVE AND NATURE OF THE PROGRAM: The objective of the study is to obtain heat transfer relationships for natural convection between solar collector absorber plates and the collector transparent cover. The absorber plates will be both flat and of the Vee-corrugated design, a shape particularly favorable for solar air heaters. Mach-Zender interferometers and associated equipment will be used to obtain accurate and detailed values of local and overall heat transfer parameters. Task 1, Experimental Investigation, involves completing the present testing of flat plates; the design, construction and testing of Vee-groove geometrics; and testing of a honeycomb geometry. Task 2, Analytical Studies, consists of solving the governing equations of energy and fluid motion using various finite difference techniques. Task 3, Development of Correlations, will provide heat transfer data in a generalized form, based on the results of Tasks 1 & 2.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Nusselt and Grashaft number correlations for natural convection heat transfer for flat plate collector model is completed.

PERIOD OF PROJECT: 12 months, (starting date: 5/1/76)

FUND IN $ U.S. Current year: $70,360
Total for the Period

IMPORTANT REPORTS OR PUBLICATIONS:
New Contract - No Report Available.

THERMAL ENERGY STORAGE

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Arbeitsgemeinschaft Sonnenenergie	ADDRESS: Obere Techstrasse 21/1 A-8010 Graz Austria
NAME OF PRINCIPAL RESEARCHER Prof. Dipl.Ing. Dr. P.V. Gilli	

TITLE OF PROJECT

Domestic Water Heating and Space Heating With Solar Energy

OBJECTIVE AND NATURE OF THE PROGRAM:

Development and testing of a system for economic domestic water heating with solar energy. For a 4-person household with a daily hot water consumption of about 250 l at 45°C a collector surface of 6 to 8 m^2 was found most economic; storage volume 0.4 to 0.6 m^3.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The final report on this study contains important data for an economic use of solar energy for domestic water heating in Austria.

PERIOD OF PROJECT:

1976 - 1977 (2 years)

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 52.000.--

IMPORTANT REPORTS OR PUBLICATIONS:

ARGE Sonnenenergie (Prof. Dr. P.V. Gilli e.a.) "Wärmeversorgung von Wohnbauten mit Sonnenenergie"

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Austrian Solar and Space Agency, ASSA	**ADDRESS:** Garnisongasse 7 A-1090 Vienna Austria
NAME OF PRINCIPAL RESEARCHER various	

TITLE OF PROJECT

Solar Energy Test Stations in Austria

OBJECTIVE AND NATURE OF THE PROGRAM:

At present there are nine solar energy test stations in Austria, two collector test station, two systems for space heating, three systems for domestic water heating and two systems for swimming-pool heating. Within the framework of this project energy balance of the systems, their safety in operation,lifetime and economic efficiency are studied.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The systems have been in operation since June/July 1976; data and measurements are being evaluated.

PERIOD OF PROJECT : 1976 - (open)

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 375.000.--

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY: AUSTRIA	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Institut für Hochbau und Entwerfen I, University of Technology	ADDRESS: Karlsplatz 13 A-1040 Vienna Austria
NAME OF PRINCIPAL RESEARCHER Prof. Dr. Erich Panzhauser	

TITLE OF PROJECT

Development of a Prototype of an Unexpensive Plastic Storage System

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this project was to develop a low temperature storage system for application in solar systems with a high economic efficiency, long life-time and good insolation. Moreover the storage system was to be easily integrated in already existing solar systems.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

PERIOD OF PROJECT:

1977 -

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 2.000.--

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT x SYSTEM DEVELOPMENT
NAME OF ORGANIZATION Vereinigte Metallwerke Ranshofen-Berndorf	**ADDRESS:** Postfach 35 A-2560 Berndorf Austria
NAME OF PRINCIPAL RESEARCHER Dr. Georg Turnheim	

TITLE OF PROJECT

Compact Solar System for Domestic Water Heating

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a solar system for domestic water heating in a single family house consisting of 4.12 qm of flat-plate collectors with selective coating ($\alpha/\varepsilon \sim 4$), a vacuum-enameled annular water jacket boiler with a capacity of 250 l and a cartridge heater of 1.2 kW.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

With this plant 70 - 90% (in summer) and 10 - 20% (in winter) of the total energy requirements of a 4-person household can be covered by solar energy under the climatic conditions in Austria.

PERIOD OF PROJECT:

10.5.1977 - 30.11.1977

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 15.500.--

IMPORTANT REPORTS OR PUBLICATIONS:

ASSA-Information Service 4/1977.

Country : BELGIUM.

	Components	Type of research
	Solar collector	Materials research
	$\boxed{\text{Heat storage}}$	Component development
	Air conditioning and cooling unit	
	Other substantial components	

Name or organization :
FACULTE POLYTECHNIQUE DE MONS
Name of Principal researcher :
Prof. J. BOUGARD & R. JADOT

Address :
Faculté Polytechnique de Mons,
rue de Houdain,
7000 MONS - BELGIUM.

Title of project : Solar energy and low level cyclic energy flow (20 to 100 °C) storage as chemical bond energy of compounds undergoing thermal decomposition.

Objective and nature of the program :

The aim of the research is double.

1. Presently, the various processes enable the storage of only 0,05 to 0,1 Gcal for each m^3 of "support material". The first aim of the proposed research is to find storage methods with higher capacity.
2. In the most of the storage processes, it is necessary to achieve an effective thermal insulation which results in a high installation cost.

   In the proposed research, we aim to get products which can be stored separately at ambient temperature, and the mixing of which involves an exothermal reaction which returns the stored energy.
   The reverse reaction and the separation of the products will be achieved by means of solar heat or low level heat.

Detailed description of the research program.

1. Searching for products undergoing thermal decomposition yielding storage capacity greater than or equal to 0,4 $Gcal/m^3$.

   Some systems or compounds which exhibit a highly exothermal heat of formation and could possibly be used were already selected by a preliminary study. These are :

- amine aqueous solutions;
- inorganic compounds hydrates;
- organic compounds which produce reversible reactions.

2. Measurement of the storage capacity and physico-chemical properties (boiling temperature, vapor pressure, viscosity, stability, ...) of the various selected compounds and systems.
3. Study of the storage decomposition :

   a) Influence of temperature;

   b) Mutual solubility of the reagents;

   c) Study of the separation methods (theory, pilot installation).
4. Study of the possible impairing of the products and of the process reversibility with the time.
5. Test on a pilot installation involving a complete cycle. Long term economical estimate.
6. Conclusions.

Planning for the proposed researches.

Phase 1	1977 (6 months)	Bibliographical study and theoretical analysis.
	1978	Experimental phase. Study of the reversing of the exothermal reaction (Thermodynamics).
Phase 2	1979	Experimental study of the separation methods (Thermodynamics). Test on pilot installation. Development of energy balances (Chemical Engineering).
	1980 (6 months)	Test on pilot installation. Long term economical estimate (Chemical Engineering). Conclusions.

Period of the project : 3 years

- Fund in $ U.S. for the total period.

Heat storage.

a) Type : storage of energy in chemical bond.

b) Storage capacity 120 Wh/m^3

c) Storage temperature : ambiant temperature.

d) Delivered heat temperature : 80 - 90 °C.

f) Insulation : NO.

g) Expected life time : -

COUNTRY: DENMARK

COMPONENTS	TYPE OF RESEARCH
[ ] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Thermal Insulation Laboratory	ADDRESS: Bldg. 118 Technical University of Denmark DK-2800 Lyngby
NAME OF PRINCIPAL RESEARCHER: S. Furbo	

TITLE OF PROJECT: Heat storage in a solar heating system using salt hydrates.

OBJECTIVE AND NATURE OF THE PROGRAM: The object of the research is to develop an energy storage making use of, for example, sodium sulfate as a storage medium, without having to use small tanks and without getting separation problems.
The new technique consists in adding extra water to the mixture and keeping it in soft stirring. By using big tanks the costs will be reduced considerably.
The project includes the following work: A study of relevant literature for the subject is carried out.
On the basis of the above-mentioned literature study some of the most promising storage systems will be selected. It will be a question of different salt hydrates and different solutions to the problems: supercooling, separation and heat transfer to and from the storage.
The selected systems will be examined carefully. By means of calculation and experiments the thermal performance, durability and approximate construction and working expenses of the storage system will be determined.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT

The project is finished successfully

PERIOD OF PROJECT 1/11-76 - 1/8-77

FUND IN $ U.S. TOTAL FOR THE PERIOD 75.000

IMPORTANT REPORTS OR PUBLICATIONS:

Country : Federal Republic of Germany

Components	Type of Research
☐ Solar Collector	☐ Materials Research
☒ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☐	☐
☐	

Name of Organisation:	Address:
Energietechnik GmbH	Freihofstr. 31 D-4307 Kettwig
Name of Principal Researcher Dr.Ing. B. Dietrich	

Title of the Project: Longterm accumulator for dwelling premises and solar house architecture

Objective and Nature of the Project, Present Status

1. Aim

It is intended that suitable longterm accumulators should be developed for low temperature heat with water as storage medium, that there should be tried out and optimized from applicational and economic aspects. In addition, investigations are envisaged on the architectural design of future solar dwellinghouses with regard to the requirements of solar energy utilization.

2. Schedule

a) Development of various accumulator designs.

b) Structural realisation of various accumulator designs.

Continuation overleaf /

Period of the Project: 1.6.75 - 30.6.78

Fund in $ US: 162,000,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Longterm accumulator for dwelling premises and solar house architecture

Objective and Nature of the Project, Present Status:

- Continuation ....

c) Construction of an installation for carrying out charge and discharge tests.

d) Practical trial of the accumulators.

e) Optimization of charge changeover systems.

f) Evaluation of experience with a view to cost optimization of accumulators.

3. Relationship with other projects

The investigations as under 2 e) will be carried out in collaboration with the nuclear research installation Jülich in conjunction with the "Large area hot water accumulator" project (ET 5200 A).

4. Progress

Investigations have been concentrated until now on the following accumulator variants:

a) Steel containers foam embedded and welded on site in cellars.

b) Cellar lined with pressure resistant thermal insulating material and waterproof films.

c) Underground steel container lined with pressure resistant thermal insulating material and waterproof films.

d) Underground accumulator of reinforced insulating material and film.

e) Underground accumulator of double walled steel container with intermediate thermal insulation.

Title of the Project: Longterm accumulator for dw[illegible] premises and solar house architecture

Objective and Nature of the Project, Present Status:

- Continuation ....

After preliminary investigations on the suitability of thermal insulating materials and films, three different accumulators have been prepared until now and have been put into use. For execution of controlled charge changeover tests a test station has been constructed with which charge and discharge can be varied within wide ranges. On one 40 m^3 accumulator charge changeover tests have been commenced for measurement of the temperature strata and for optimization of the charge and discharge devices.
Investigations on the sub-project of solar house architecture have essentially already been concluded and published.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☒ Heat Storage	☒ Component Development
☒ Air Conditioning and Cooling Unit	☒ Systems Development
☐	☐
☐	

Name of Organisation:	Address:
Messerschmitt-Bölkow-Blohm GmbH	Postfach 801169 8000 München 80
Name of Principal Researcher Dipl.Ing. H. Grallert	

Title of the Project: Modular solar house heating system - Phase I

Objective and Nature of the Project, Present Status

1. Aim

Theoretical and experimental investigations on the development of a modular solar house system which can be marketed in collaboration with other companies and in particular is suitable for use in temperate zones. A variant of the system is to be applied in combination with refrigeration systems for air conditioning.

2. Schedule

a) Investigation, development and design work on collectors, storage media, storage containers, heat exchangers as well as measurement and control units.

b) System layout from technical and economic points of view.

Continuation overleaf /

Period of the Project: 15.11.74 - 30.12.76

Fund in $ US: 478,500,- Government Contribution: 80%

Important Reports or Publications:

Title of the Project: Modular solar house heating system - Phase I

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Progress

In the first development phase the emphasis was on carrying out thorough technical and economic system analyses which were the starting point for the necessary component development. These analyses include estimation of the weather effects, a design study, investigation of all collector design parameters, the regulation system, heat requirement and consumption characterization, system cost estimation and optimization, complete simulation of the solar thermal and of the conventional heating system as well as thermal and mechanical computation of all components. As essential result it was established inter alia that the use of selective absorber coatings and that of IR effective cover glass coatings is at present still uneconomical in comparison with simple two-plate collectors (flat construction) and that only the small heat accumulator adapted to the heat requirement over approximately 1 week is suitable as cubic hot water tank for use in 1 and 2 family houses. Taking into account the cost increase which is expected to rise still further in the case of the fossil fuels it was possible with the aid of static meteorological data to demonstrate profitable use of the solar thermal heating system, in particular for hot service water preparation even in central European latitudes.
From the investigations of construction for the critical individual components two collector generators with 3 or 7 test modules of two-plate flat construction were derived and satisfactorily tried out as regards heat transfer and longterm durability on the openair test rig constructed for the purpose. For the version accepted in Autumn 1975 as regards performance production investigations were carried out with plastic and metal frames from the point

Title of the Project:
Modular solar house heating system - Phase I

Objective and Nature of the Project, Present Status:
- Continuation ....

of view of series production. Here it was found that production costs were considerably lower for the metal frame construction particularly in comparison with PU rigid foam frames. In addition, when using load supporting plastic components additional thermal expansion processes occur. Both constructions were followed through as far as the prototype and used in complete tests.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☒ Heat Storage	☐ Component Development
☒ Air Conditioning and Cooling Unit	☒ Systems Analysis
☐	☐
☐	

Name of Organisation:	Address:
Messerschmitt-Bölkow-Blohm GmbH	Postfach 801169 D-8000 München 80
Name of Principal Researcher Dipl.-Ing. Grallert	

Title of the Project:

Modular solar domestic heating system - Phase 2

Objective and Nature of the Project, Present Status

1. Aim

Continuation of the work commenced in Project ET 4066 A (first development phase) with the aim of applicational execution and optimization of solar heating systems for preferred use in the domestic field. Aim otherwise as in Phase 1.

2. Schedule

a) Further development of collector for higher operating temperatures.

b) Optimization of system layout.

c) Preparation of two complete research installations for demonstration of subsequent equipment and original

Continuation overleaf /

Period of the Project: 1.1.76 - 30.6.77

Fund in $ US: 562,300,-   Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Modular solar domestic heating system - Phase 2

Objective and Nature of the Project, Present Status:

- Continuation ....

equipment with a solar domestic heating system.

d) Investigation of the installation parameters and of the standardization of solar heating systems.

e) Basic operations for going over to series production.

3. Progress

The emphasis of the second development phase is the installation and operation of systemwise balanced solar heating systems in two typical applications.

In an existing inhabited single family terraced house in Höhenkirchen near Munich a combined solar heating system was installed for room heating and water heating with 35 m^2 effective collector area and 4 m^3 water accumulator.

With the installation commissioned in June 1976 important results were collected for simplification of the system technology and the installation outlay.

The use of solar energy resulted by the end of the year in a saving of more than 900 litres of fuel oil.

On the basis of the practical experience already gathered the development trend is towards pre-installed system sections, reduced equipment outlay and carefully insulated housing sections.

Although strict economy with combined systems is not yet attainable today, the monovalent solar heating system with electrical emergency heating seems to be an interesting solution for the future.

To examine selectively effective coatings 8 additional test collectors were tried out. Production problems in the reproduction of SnO_2 or black chromium coatings in some cases produced worse results than expected. Attention should be paid to condensate corrosion in the case of black chromium

Title of the Project:

Modular solar domestic heating system - Phase 2

Objective and Nature of the Project, Present Status:

- Continuation ....

coatings on aluminium. With selective coatings of this type no-load temperatures over 200°C are reached. If the cost of the coating can be reduced by more than half, use in one and two plate collectors appears attractive.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☒ Heat Storage	☒ Component Development
☒ Air Conditioning and Cooling Unit	☐
☒ Heat Pump	☐
☐	

Name of Organisation:	Address:
Philips GmbH Forschungslaboratorium Aachen Name of Principal Researcher Dr. H. Hörster	Postfach 1980 D-5100 Aachen

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status

1. Aim

Analysis and evaluation of a wide variety of methods of rational use of energy and utilization of solar energy in buildings as regards economical use. Theoretical and experimental investigations in integrated energy systems in a test house with considerably modified building structure. Development of analysis method based on hourly meteorological data. Development of solar collectors of high efficiency.

Continuation overleaf /

Period of the Project: 18.6.74 - 31.12.77

Fund in $ US: 3935,882,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status:
- Continuation ....

2. Schedule

a) System analysis: investigation of various methods for optimization of solar and energy systems. Collation and investigation of metecrological data.

b) Development of high efficiency collectors. Investigation on selectively reflecting and absorbing coatings.

c) Designing an energy experimental house with considerably reduced energy requirement.

d) Designing the technical equipment of the experimental house consisting inter alia of heat pump system (for heat recovery, energy utilization from the ground, air conditioning), solar system (for hot water preparation, heating), controlled ventilation with heat recovery and a complete data collection system.

e) Test procedure and evaluation.

3. Relationship with other projects

Programme execution will take place in conjunction with RWE Essen and will make a contribution to the system study on industrial utilization of solar energy under reference ET 4045.

4. Progress

Hourly meteorological data from various meteorological stations were recorded on tape and evaluated. Solar data such as diffused, direct radiation for various orientation, intensity energy dependence on monthly and annual average were determined. The method of thermal analysis for optimization of energy systems was investigated. Several methods which describe the thermal behaviour of solar systems over the year were compared with one another. A

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status:

- Continuation ....

method of data compression was developed. Investigation of solar collectors was continued. Several configurations of cylindrical evacuated collectors were analysed and measured. Selectively absorbing coatings were investigated. Development and test of a specially effective selective absorber with alpha greater than equal 0.95 and epsilon less than equal 0.1 were commenced.
The energy experimental house was measured by means of automatic data collection. The specific energy requirement of the 75/76 heating season as well as the performance data of the individual energy systems of ventilation, heat pump and solar collector were established.

Country; JAPAN		March 1978
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** ☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☒ Materials Research ☒ Component Development

Name of Organization: Ishikawajima-Harima Heavy Industries Co., Ltd.

Address: 2-16, 3 Toyosu, Koto-Ku, Tokyo, JAPAN 135-91

Name of Principal researcher: Shinya Kameda

Title of Project:

R & D of heat storage for solar heating, cooling and hot water supply system in multi-family residence.

Objective

The objective of this task is to evaluate and develop potential thermal storage media and its system arrangement for utilization of solar energy.

Summary

a) Type:

The prototype of phase change heat storage, based on heat of fusion of storage media, such as salt hydrates and paraffin hydrocarbon.

b) Heat capacity:

C ; 87 kWh/m^3 (temp. range, 110°C to 120°C, salt hydrates)
55 kWh/m^3 (temp. range, 90°C to 105°C, paraffin hydrocarbon)

c) Latent heat:

h ; 74 kWh/m^3 (melting point 110°C to 130°C, salt hydrates)
46 kWh/m^3 (melting point 90°C to 105°C, paraffin hydrocarbon)

d) Heat exchanger:

The heat exchanger to transfer the heat from the pressurised water (and oil for experiment only) to the storage media is a shell-tube type with fins and fillers insulated with 100 mm insulation materials.

e) Expected life time: 15 to 20 years

Period of the project: 1974-1980

Fund in US$: Current year (1978): 55,300 $.
Up to date total : 57,800 $

Format of Survey on Components for Solar Heating Cooling and Hot Water Supply Systems

Country: Japan

Check the mark X in the head of line, corresponding to the respective components and type of research:	Components	Type of Research
	[ ] Solar Collector [x] Heat Storage [ ] Air Conditioning and Cooling Unit [ ] Other Substantial Components	[x] Materials Research [x] Component Development

Name of Organization: Mitsubishi Electric Corporation Name of Principal researcher: Junjiro Kai	Address: 2-3 Marunouchi 2-chome Chiyoda-ku, Tokyo

Title of Project:

Solar Heat Storage

- Objective and Nature of the Program:

The object of this program is the development of heat storage utilizing latent heat of fusion to store heat from the collector and supply it to the Rankin-Cycle engine.

The thermal parameters required are as follows,

1) heat capacity: 12 kWh
2) heat rate:
   - input: 12 kW
   - output: 9.3 kW
3) operating temperature range:
   - input: 100 - 80°C
   - output: 90 - 70°C

The research program consists of two items:

1) heat storage materials and their application technology
2) structure of heat storage with high thermal efficiency

Heat storage of testing model is now under construction.

Final goal of this program is the development of the heat storage which satisfies required thermal parameters.

- Present Status or Summary of Significant Accomplishment:

Heat storage to test the heat exchanger and the nucleating system has been constructed.

a) type:	latent heat storage with storage medium of ammonium alum
b) heat capacity c:	9.7 kWh/m^3 (solid, 94-80°C)
c) latent heat h:	107 kWh/m^3 (liquid, 94°C)
d) heat exchanger:	YES, plate fin type heat transfer fluid: water and refrigerant R114
e) heat rate:	input: 8.1 kW output: 7.0 kW
f) insulation:	rock wool, 80 mm thick
g) expected life time t:	under inspection

Thermal parameters of the plate fin type heat exchanger was obtained, and the nucleating system tested was found effective.

Corrosion tests for several materials to construct heat storage were done.

- Period of the Project: 1974 - 1980

- Fund in $ US: - Current Year 21,700 (FY 1977)

- Important Reports or Publications: None

Format of Survey on Components for Solar Heating, Cooling and Hot Water Supply Systems

Country: JAPAN		
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** ☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☐ Materials Research ☒ Component Development
Name of Organization: Toyo Netsu Kogyo Kaisha, Ltd. Name of Principal Researcher: Yasuo Tanaka	Address: 2-5-12 Kyobashi, Chuoku, Tokyo, Japan	
Title of Project: Solar Heating, Cooling and Hot Water Supply System for Large Buildings		

- Objective and Nature of the Program:

The objective of our program is to develop innovative and economical heat storage equipment for solar heating, cooling and hot water supply system for large buildings.

We make use of sensible heat of water for the main system of heat storage. In evaluating the efficiency of heat storage water tank, we found that the performance of this type heat storage equipment was influenced by the flow pattern and that the storage efficiency of the piston flow type water tank was better than that of the mixed flow type water tank concerning the effectiveness of energy storing.

Moreover, to reduce the cost of this type of heat storage system, research will be made on the methods of using such spaces as basements between footings of the building structure and on the improvement of the performance of this type of heat storage tank.

- Present Status or Summary of Significant Accomplishment:

To evaluate the actual performance of the heat storage water tank in a practical system, two 45 m^3 piston flow type water tanks, which will be able to store a large amount of heat on Sundays or Holidays, have been constructed within the experimental building in the compound of Oita University. This experiment will be made beginning April, 1978 for some years.

Characteristics of these heat storage water tanks are as follows,

a). Type and Configuration

Storage medium is water. These tanks made of steel can store chilled water during the summer season or warm water during the winter season only when the system operates with solar energy. Configuration of the tank is 4.5 m in length, 2.5 m in width and 4.8 m in height.

b). Heat capacity

Heat capacity is about 5.8×10^3 Wh/m^3 and temperature range is 10-15 C in summer and 40-45 C in winter.

c). Latent heat

Phase change materials are not used.

d). Heat exchanger

There are not any heat exchangers within these tanks.

e). Heat rate

Same as above.

f). Insulation

Insulation around these tanks consists of 100 mm rigid urethane foam.

g). Expected life time

Expected life time is about 20 years.

- Period of the Project:

This project started in July 1974 and will end in March 1980.

- Fund in $ US:

  - Current year *********** $40,000
  - Total for the period *** figure not available at present stage

- Important Reports or Publications:

Nothing in English

Country :	THE NETHERLANDS

	Components :	Type of Research :
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation :	Address :
BOUWCENTRUM	BOUWCENTRUM BINNENMILIEUTECHNIEK Weena 700-Postbus 299 ROTTERDAM-Holland tel. 010-116181 ext. 2601
Name of Principal Researcher : Ing. J.M. van Heel	

Title of Project :

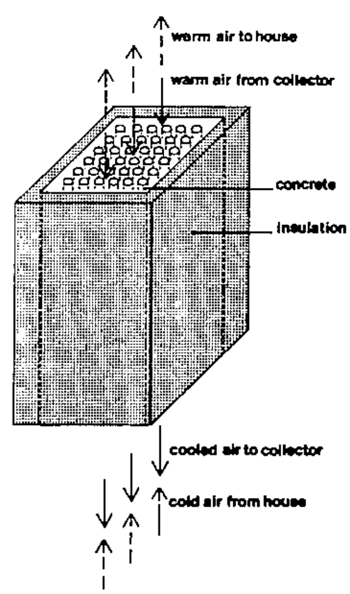
DEVELOPMENT OF A CONCRETE HEATSTORAGE SYSTEM

- Objective and nature of the program

The sun does not shine very often in Holland and therefore we have to develop solar-energy systems based on low-running cost. To achieve this it is necessary to develop durable systems which are not expensive to make and require hardly any maintenance. In this context we have designed a concrete heatstorage system, which has the shape of a square column placed in the centre of the house. To prevent overheating of the house the column is insulated. Inside the column there are tubes through which the air to be heated flows. The measurements of the column are: about 1 m square and 6 m high. For hot-water supply a spiral tube through which water flows is placed inside the column.

- Present status

A preliminary study has been carried out from which we learned that the heatstorage capacity of the concrete column is approx. the same as half that of a water storage system based on the same input data. A simple computer model has been made and this will be developed in the following study.



concrete storage system(principle scheme)

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation :	Address :
BOUWCENTRUM	BOUWCENTRUM BINNENMILIEUTECHNIEK Weena 700-Postbus 299 ROTTERDAM-Holland tel. 010-116181 ext. 2601
Name of Principal Researcher : Ing. J.M. van Heel	

Title of Project : DEVELOPMENT OF AN INTEGRATED COLLECTOR HEAT-STORAGE SYSTEM FOR LOW-COST HOUSING PROJECTS

- Objective and nature of the program

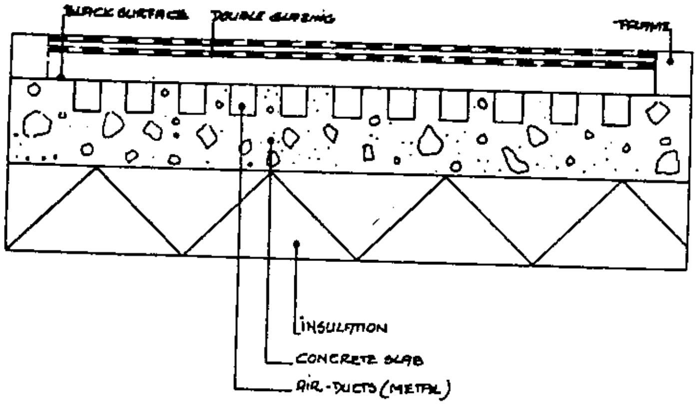
The aim of this study is to develop a type of collector which is not expensive to make, is durable and requires hardly any maintenance. We, therefore, chose an air-cooled collector combined with heatstorage.
The collector consists of a concrete slab with metal ducts incorporated in the surface of the slab. The air to be heated flows through the metal ducts. The slab can be covered with prefabricated double glass or evacuated tubes with a selective coating on the inside of the tubes. Another possibility is to use a movable insulation screen between the glass panes. Back and sides are insulated. This type of collector can be combined with an air-heating system for heating the house. For hot-water supply this collector can be connected with an air-heated boiler.

- Present status

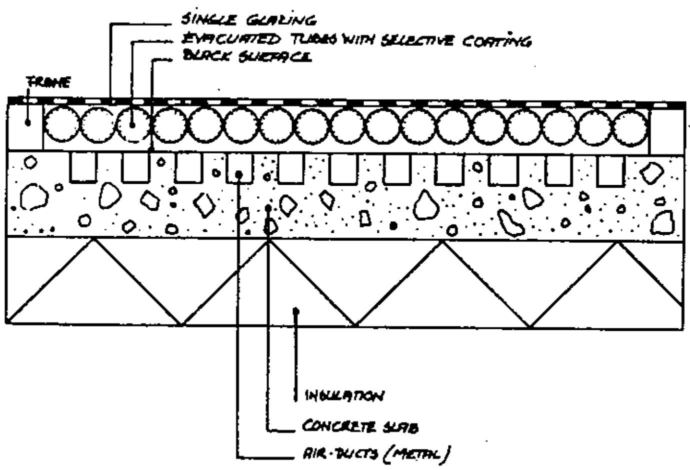
This collector is being studied at the moment in connection with an EEC assignment. A prototype has been built and has been tested for several months. A computer model has been made. The final report concerning this study, can be expected in March '78. This study is being carried out in co-operation with the Institute of Applied Physics in Delft (Holland).

see continuation 1

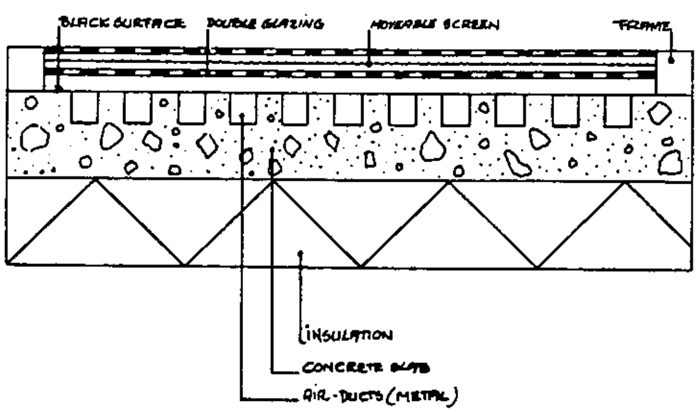
Title: Development of an integrated collector heat-storage system for low-cost housing projects.



AIR-COOLED COLLECTOR IN COMBINATION WITH STORAGE



AIR-COOLED COLLECTOR IN COMBINATION WITH STORAGE



AIR-COOLED COLLECTOR IN COMBINATION WITH STORAGE

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☐ Component Development

Name of Organisation : BRONSWERK B.V. Heating & Airconditioning Dept.	**Address :** Brabantsestraat 10 P.O. Box 28 AMERSFOORT tel. 033-39313
Name of Principal Researcher : Ir. P.G.S. Rutten	

Title of Project : SOLAR BOILERS FOR DOMESTIC HOT WATER SUPPLY AND SOLAR HEATING INSTALLATIONS FOR SWIMMINGPOOLS

- Objective and nature of the program

Bronswerk delivers complete solar boiler packages for the "do it yourself" market, consisting out of three collectors of 1.2 m^2 each, a 160 liter storage tank, all necessary accessories and assembling instructions.
However, assembling by Bronswerk is also possible. A conventional fired boiler for additional heating is not included in the prices of the standard packages, being:
Sollektor 1, natural circulation, price about $ 600,-- + V.A.T.
Sollektor 2, pump circulation, price about $ 700,-- + V.A.T.
Solar heated swimmingpool installations are also installed by Bronswerk.

R&D done by Bronswerk is limited only to the improvement of the hot water storage tanks and integration of storage and additional heating.
The solar collectors with aluminium Roll-bond absorbers (from the USA) are developed by cooperation between the firms Nijs & Vale and Van Heugten. For further data of these collectors see attached sheet of Nijs & Vale.

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation :	Address :
CALCOL B.V.	Binnenhoek 34, P.O. Box 7 TIEL tel. 03430-5244
Name of Principal Researcher : Mr. J.B. Mulder	

Title of Project :

DEVELOPMENT OF AN INTEGRATED SOLAR BOILER SYSTEM

- Remarks

Calcol B.V. is a joint-venture started in 1977 of the following three Dutch firms:

1. DRU, Koninklijke Fabrieken Diepenbrock & Reigers B.V.,Hutteweg 24, Ulft. (Fabrication of the solar collectors).
2. Koninklijke Metaalwarenfabrieken Daaldrop B.V.,Binnenhoek 34, Tiel. (Fabrication of the storage boilers).
3. Van Swaay Installaties B.V.,Bredewater 24, Zoetermeer (P.O. Box 220) (System design and automatic control)

General contact person for the overall Solar Boiler System design is:
Mr. W.H. Wijckerheld Bisdom of Van Swaay Installaties B.V., tel. 079-219363.

- Objective and nature of the program

Development of integrated Solar Boiler Systems with different capacities for hot tap water supply.

- Present status

Because this cooperation has just started in 1977, these complete Solar Boiler Systems are not yet ready for delivery in large quantities. However, the flat plate solar collectors to be used, are already produced by DRU-Ulft in hundreds for space heating projects in The Netherlands. The Institute of Applied Physics TNO-TH-Delft has done the necessary research and development of durable selective coatings of high performance for the DRU-collectors. For more detailed information of these collectors is referred to the "format" and the "attached sheet" of this institute.

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation : Delft Soil Mechanics Laboratory	Address : Stieltjesweg 2, P.O. Box 69 Delft tel. 015-569223
Name of Principal Researcher : ir. W.J. Heijnen	

Title of Project : The use of soil as a storage-medium for seasonal storage of solar energy in relation with the soil composition and the boundary conditions.

The program will be carried out by three orginisations.
Besides the D.S.M.L. the names of the other organisations are:
Institute of Applied Physics TNO-TH-Delft.
Philips Energy Systems - Eindhoven.

Objective and nature of the program:

The objective of the project is to investigate whether the use of soil as seasonal storage for solar energy can be used to make groups of houses 100% solar heated (except electric power for pumping).
Different soil conditions and solar heating systems, with and without heat pumps, will be investigated.

The program consists of:
1. Inventarisation of thermal properties of soils, modeltests and development of calculation model.
2. Comparison between the measured data of the Veldhoven project (Philips) and the calculated data.
3. Investigation of other solutions, for seasonal storage of solar energy in the soil, compared to the used one in Velhoven.
4. Final design of one project consisting of a group of solar houses coupled with a joined seasonal storage system.
   Economic evaluation of different solutions for the seasonal storage system.

Period of project

january 1, 1978 - september 30, 1979

Fund: Fl 719.975 (amount in national currency).
(Approx. rate in January 1978: 1 US$ = 2.25 Dfl.)

Country :	THE NETHERLANDS	
	Components :	Type of Research :
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation : DELFT UNIVERSITY OF TECHNOLOGY Heat Transfer Group, Applied Physiscs	Address : Lorentzweg 1, P.O. Box 5046 2600 GA DELFT tel. 015-786037
Name of Principal Researcher : Ir. H. van Ooijen	

Title of Project :

HEAT STORAGE IN PHASE CHANGE MATERIALS

- Objective and nature of the program

The aim of the project is to design, construct and test a thermal energy storage system based on phase change materials, that can be used in combination with solar heat collectors. Because both the amount of heat gained by the collector system and the amount of heat required by the user fluctuate with time, storage systems will be studied with a heat storage capacity between a few hours and a few days.
The required temperature level of the system depends on the application. For this project the range between 30° and 150°C has been chosen.
Two application items will be studied; the case of space heating and the case of heat storage to drive a solar-powered absorption refrigerator. A fundamental study on the heat transfer to the phase change material, the melting and solidification behavior of the phase change material and the segregation will be performed.
Prototype units will be built and tested. Transient response, heat losses and aging of the systems will be studied.
Emphasis will be on the study of encapsulated materials.

- Present status: The project will start in August 1977.

- Period of the project: August 1977 to August 1980.

-Fund in $US: - Current year $US 12,000.
- Total for the period $US 100,000.

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation : EINDHOVEN UNIVERSITY OF TECHNOLOGY LAB. HEAT TECHNOLOGY	Address : P.O. Box 513 EINDHOVEN tel. 040-472125
Name of Principal Researcher : J.P. Simon Thomas	

Title of Project :

INTEGRATION OF WATERTANK STORAGE, HOT WATER BOILER AND AUXILIARY HEATER

Objective and nature of the project

Objective
The basic development of an integrated storage-heater unit of cost-effective design.

Aspects to be studied
- The coinciding functions of the watertank storage, the hot water boiler and the auxiliary heater,
- The possible ways of combining the coinciding functions,
- The performance of the preferred combination(s),
- Such practical aspects as safety, control, corrosion, noise production, etc.

Short range goal (dec. 1978)
Establishment of the main features of the integrated design and definition of the problems requiring further investigations in order to optimise the unit.

Present status of knowledge
The separate incorporation of a thermally stratified watertank storage and an auxiliary heater in a solar heating system causes unnecessary investments, due both to the cost of the components and the mounting. Moreover the storing capacity of the watertank coincides with the main function of a conventional hot water boiler.
A simple combination of the three units mentioned above has been devised, and introductory experiments have shown the performance to be beyond expectations. Further investigations are being executed to confirm and refine the experimental results.

Period of the project
The project is scheduled for the years 1976-1979, with an average effort of 1,5 man, technical assistance included. The fundings proceed from the autonomous means of the EUT, and correspond to roughly $ 20,000 per year, overhead included.
An internal report is due to appear within a few months.

Country : THE NETHERLANDS

	Components :	Type of Research :
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation :
EINDHOVEN UNIVERSITY OF TECHNOLOGY
LAB. HEAT TECHNOLOGY

Name of Principal Researcher :
L.S. Fischer

Address :
P.O. Box 513
EINDHOVEN

tel. 040-472115

Title of Project :

SEASONAL STORAGE OF SOLAR HEAT IN THE GROUND

Objective and nature of the program

Objective

The development of economically viable and practicable methods for the seasonal storage of solar heat in the ground.

Aspects to be studied

- Fundamental: Heat transfer by conduction, natural convection and vapor transport in the ground; typically for instationary conditions.
- Technical : a) Lay-out, design and manufacture of heat exchanging surfaces and thermal insulation
  b) Control strategies for the loading and unloading of the storage.
- Economical : Cost optimization between heat demand, collector area and storage capacity.

Short range goal (Dec. 1978)

Exploratory calculations have proved the physical feasibility of seasonal storage in the ground for storage capacities beyond 10^5 kWh. As unsurmountable technical problems have not been detected and the economical prospects appear to be fair, the following short range goals (Dec. 1978) have been set:
- consolidation of the theoretical results,
- experimental verification of the calculations, particularly as regards any natural convection and vapor flow,
- checking the technical practicability by execution of an experiment on semi-technical scale.

Present status of knowledge

The required capacity of a seasonal ground storage for solar heat is typically 10^4 kWh for the average Dutch dwelling. The half-life of such a storage has been calculated to be about 2½ months. Consequently the half-life of a storage with a capacity of 10^5 kWh amounts to 8 months, which is sufficient for seasonal storage.
The volume of such a storage is about 5000 m^3, the maximum temperature of the ground being restricted to 80°C in order to avoid axcessive water vapor pressure.
Both economical and technical considerations plead for a slice-like lay-out of the storage, with a thickness of at least 5 meters, a very good thermal insulation on the top of the slice and a projected area according to the capacity. The loading and unloading of the storage may be effected by steel or plastic tubes at a mutual lateral distance of, say, about 1 m. The tubes may be horizontal, vertical or inclined. Heat at high temperatures should be stored in the upper layers of the slice and heat of moderate temperatures in the lower ones.

see continuation 1

continuation 1

SEASONAL STORAGE OF SOLAR HEAT IN THE GROUND (Eindhoven University of Technology)

Period of the project

The project is scheduled for the years 1976-1980, with an average effort of 1 senior research officer. The fundings proceed from the autonomous means of the EUT and correspond to roughly $ 50,000 per year, overhead included.
A paper on the most significant accomplishments will be presented at the ISES meeting 1977 in New Delhi.

Country :	THE NETHERLANDS

	Components :	Type of Research :
	☒ Solar Collector ☒ Heat Storage ☒ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation : N.V. PHILIPS GLOEILAMPEN FABRIEKEN	Address : Commercial Dept. Light - Solar Collectors Building EK-p EINDHOVEN tel. 040- 756716
Name of Principal Researcher : (Contact Person) Dr. Ir. S.H.A. Begemann	

Title of Project :

R&D ON SOLAR-THERMAL COMPONENTS

- Solar Collectors

Flat plate collectors (Eindhoven)

Improved top-insulation through application of layer of evecuated tubes.
. Absorber - steel (copper or aluminium optional)
. Cover - glass
. Insulation - polyisocyanurate
glasswool
evacuated glass tubes
. Maintenance free first 10 years
. Life time dependent on maintenance after 10 years
. Performance: $\alpha\tau = \pm 70\%$
$K = \pm 2.2\ W/m^2 {}^\circ C$ at $\Delta\tau = 40^\circ C$
. Other info proprietary.

Tubular collector (Achen-Germany)

Absorber & heat exchanger inside vacuum. Heat pipe configuration
. Material - glass
. Insulation - vacuum
. Maintenance free first 10 years
. Life time dependent on maintenance after 10 years
. Performance: $\alpha\tau = \pm 80\%$
$K = \pm 1.7\ W/m^2 {}^\circ C$ at $\Delta\tau = 80^\circ C$
. Other info proprietary.

Concentrating collectors (Eindhoven)

Line concentrating fresnell strip mirror with solar powered automatic tracking.
. Temperature max. 300°C
. Material - glass
. Life time - 10-20 years
. Other info proprietary

- Heat Storage (Aahen-Germany)

a. Reversible chemical reactions for long term energy storage (100-400°C)
b. Latent heat storage for low grade (roomtemp.) heat.
. Other info proprietary

see continuation 1

<u>- Air conditioning & Cooling</u> (Eindhoven)

a. Absorption - COP 1.5
b. Stirling cycle - COP 1.8 independent of temp. difference at $400^{o}C$ source temperature.

Capacity - < 20 kW
Other info proprietary.

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☐ Solar Collector ☒ Heat Storage , Heat pump ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☐ Component Development ☒ Computer simulation

Name of Organisation : CENTRAL TECHNICAL INSTITUTE TNO	Address : Laan van Westenenk 501, P.O. Box 342 APELDOORN-ZUID tel. 055-773344
Name of Principal Researcher : Ir. H. van der Ree	

Title of Project : COMPUTER SIMULATION OF A HEATING SYSTEM CONSISTING OF A HEAT PUMP IN COMBINATION WITH SOLAR COLLECTORS

- Objective and nature of the program

One of the possible heat sources for the heat pump is direct solar radiation. The "cold side" of the heat pump is then connected to the solar collector. This has an important advantage: the temperature of the solar collector is lowered artificially which results in an increase in its heat gain. For this gain in heat a price has to be paid, namely the energy consumption of the heat pump. The ratio of these two amounts of energy largely determines whether there is sense in application of a heat pump or not. In this study a computer simulation is made of a heating system consisting of a house with solar collectors, heat pump, heat storage on both sides of the heat pump, and auxiliary heating.

Conclusions.
If the energy consumption of the electrical heat pump and auxiliary heating is expressed in terms of primary energy and this system is compared with a solar heating systemwithout heat pump, then no saving of fossil fuel is achieved. The energy cost of solar heating systems with heat pump are higher than those of the same systems without heat pump. These conclusions are valid only for the system described. To allow more general conclusions to be made it is necessary to optimise the solar heating systems before a comparison can be made.

- Period of the project

- Fund in $ US: - Total for the period 1975-1976 $US. 20,000.--

- Important publications

H. van der Ree
De warmtepomp in verwarmingsinstallaties met zonne-energie;
Tekst van een voordracht gehouden voor de TNO/TVVL-dag nr. 5, oktober 1975.

H. van der Ree
De mogelijkheden voor de toepassing van de warmtepomp in combinatie met zonnecollectoren.
Tekst van een voordracht gehouden voor de Stichting Post Doctoraal Onderwijs in het bouwen op 31-3-1976.
Intern verslag ref.no. 76-01605 d.d. 9-2-1976, dossier nr. 02-5-50370

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation : CENTRAL TECHNICAL INSTITUTE TNO	**Address :** Laan van Westenenk 501, P.O. Box 342 APELDOORN-ZUID tel. 055-773344
Name of Principal Researcher : Ir. P.G.M. Nievergeld	

Title of Project :

INVESTIGATION ABOUT USING THE SOIL AS A NATURAL HEAT SOURCE FOR HEAT PUMPS

- Objective and nature of the program

The aim of the project is evaluating the soil as a natural heat source for heat pumps for the heating of houses. Among the points to be investigated are how much heat can be stored in and extracted from the soil during an average summer and winter.
The program will be executed as follows:

1. Study of literature of simultaneous heat and moisture transfer in the soil caused by temperature gradients of the moisture content. Collecting basic data with respect to thermal properties of Dutch soil, the level and stream of ground water, the meteorological conditions and the temperature of the undisturbed soil.

2. Developing a mathematical model for the heat transfer in the soil to and from the buried heat exchanger. The possibility of using a computer program developed by this institute for calculating heat transfer by means of the finite element method will be investigated.

3. Optimising the heat exchanger buried in the soil. In case this is made up of tubes the problem is to ascertain the required tube diameter, the distance between adjacent tubes and the depth at which the tubes have to be buried. It will also be gone into whether preference has to be given to a vertically or horizontally buried heat exchanger.

4. Calculating heat transfer in the soil to and from the buried heat exchanger and with the aid of this ascertaining the amount of heat which can be withdrawn from and stored in the soil for heating purposes.

5. Calculating the thermal behaviours of a heat pump system using heat from the soil, serving the purpose of heating a normal, well-insulated house over an average Dutch winter season.

6. Technical and economical evaluation of the merits of the heat pump system considered. Recommendations for further research.

- Period of the project

Final reporting about half 1978

- Fund: $US 60,000.--

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation : Institute of Applied Physiscs TNO-TH	Address : P.O. Box 155, Delft The Netherlands (tel. 015-569300)
Name of Principal Researcher : Ir. C. den Ouden	

Title of Project : Development of a thermal storage system based on encapsulated p.c.m.-materials

Objective and Nature of the Program

Development of a short term storage system, based on a phase change material encapsulated in a polymer, capable of storing a few days surplus of solar heat 200 kWh ≈ 700 MJ) at a temperature tevel of 35-60^{0}C.

Present Status or Summary of Significant Accomplishment

A few promising p.c.m.-materials are encapsulated, that show little supercooling and promising thermal properties;
Durability tests of several encapsulated samples show that the thermal properties after more than 100 cycles do not change.
A first prototype is made, and will be tested in the beginning of 1978.

Period of the project: 1977 - 1979.

Fund in $ US: - Current Year 110 000 $ *
- Total for the Period 350 000 $

This research is carried out in cooperation with Mayhall Chemical AG, CH;
50% of the expenditure for 1977 is made available by the Commission of the European Communities.

Portant Reports of Publications: -------------

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation : Institute of Applied Physics TNO	Address : P.O. Box 155, Delft The Netherlands (tel. 015-569300)
Name of Principal Researcher : ir. C. den Ouden	

Title of Project : Development of a reaction vessel of a thermal storage system using the heat of adhesion.

Objective and Nature of the Program

- To design a reaction vessel or reaction room, for short term or long term heat storage systems, using the heat of adhesion.
- A broadening of the knowledge on the heat production by the absorption of water in different poreous products.

Present Status

- The project will start in januari 1978.

Period of the Project: 1.1.1978 - 1.7.1979.

Fund in $ US: Total for the period $ 200.000*

*55% of the expenditure is made available by the Dutch Solar Energy Program, and 45% by the Commission of the European Communities.

Country : THE NETHERLANDS

Components :

☐ Solar Collector
☒ Heat Storage
☐ Air Conditioning and Cooling Unit
☐ Other Substantial Components

Type of Research :

☒ Material Research
☐ Component Development

Name of Organisation : INSTITUTE FOR ORGANIC CHEMISTRY TNO (TNO = Organization for Applied Scientific Research in the Neth.)

Address :
P.O. Box 5009
3502 JA - UTRECHT

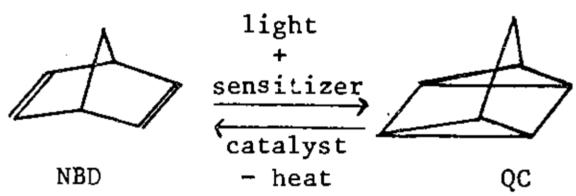
Tel. 030 - 882721

Name of Principal Researcher :
Dr. A. Mackor

Title of Project :
PHOTOCHEMICAL STORAGE OF SOLAR ENERGY FOR HEATING OF HOUSES AND BUILDINGS

- Objective and Nature of the Program

As discussed at the First International Conference on the Photochemical Conversion and Storage of Solar Energy (London, Ontario, August 1976), the state of the art in various disciplines now allow a successful approach to the problem of photochemical storage of solar energy in an organic model system. We have chosen for the reversible norbornadiene/quadricyclane system in which solar energy can be stored at room temperature for indefinite periods and regained as low-caloric heat.



Energy storage
110 kJ/mol C_7H_8

Our research mainly consists of three phases, overlapping in the time-scale, each lasting about two years.

1. Development of new and more effective photosensitizers for the forward reaction and furthermore immobilization of these sensitizers chemically onto organic polymers.
2. Optimalization of a transition metal catalyst (e.g. rhodium complexes), in collaboration with Prof. H. Hogeveen (State University of Groningen) and Prof. W. Drenth (State University of Utrecht), using phosphine or otherwise substituted organic polymers for binding the metal catalyst.
3. Building a working and cyclic model system in glass apparatus and testing its long-term performance. From this point the technological development may be started. In principle such a photochemical solar heating (or cooling) system is feasible as shown by a Battelle study [Solar Energy, 17 (1975) 367]. See attached drawing. This program will be carried out in collaboration with the Institute for Physical Chemistry TNO and the Institute of Applied Physics TNO/TH.

- Present Status

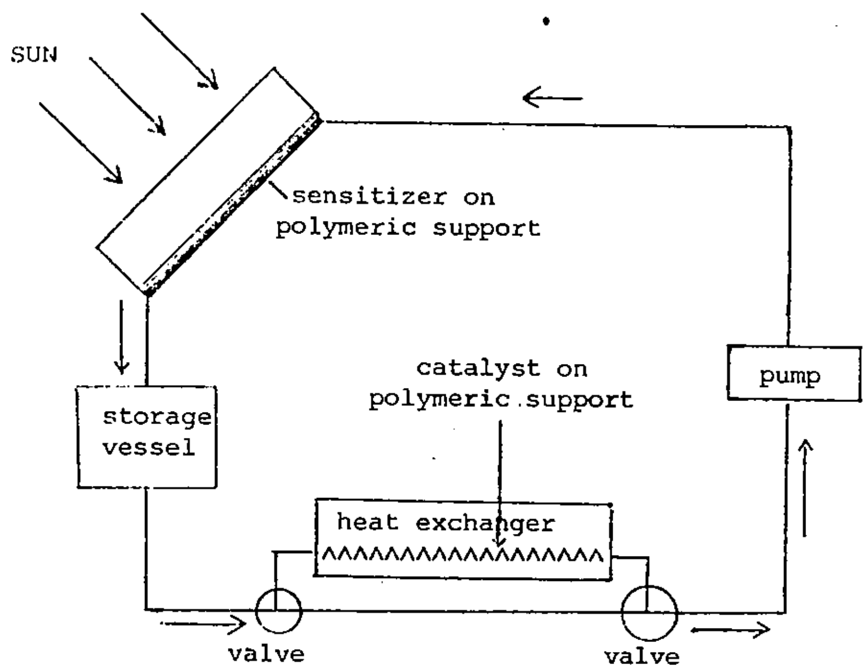
We have progressed in phase 1 to the point that we have synthetized acridone-type sensitizers, which absorb visible light (λ_{max} ∿400 nm) and which can store this energy by effective rearrangement of NBD and derivatives to give QC. This research is considered to be a "bottleneck" in the progress of our work and of other groups working in this field (e.g. Drs. C. Kutal and R.R. Hautala at the University of Georgia and Dr. W.H.F. Sasse of CSIRO-Australia).

See continuation 1

Continuation 1: INSTITUTE FOR ORGANIC CHEMISTRY TNO

Title: Photochemical storage of solar energy for heating of houses and buildings

- Period of the Project	1977 - 1980		
Level of funding in	1977	US$	100.000,-
	1978	US$	110.000,-
	1979	US$	120.000,-
	1980	US$	130.000,-



Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation :
VEG-GASINSTITUUT n.v.

Name of Principal Researcher :
ir. A.C. Koelewijn.

Address : VEG-GASINSTITUUT n.v.,
Wilmersdorf 50, P.O.Box 137,
APELDOORN.

tel. 055-230808.

Title of Project :
Solar Energy as a Complementary Source of Energy for Domestic Heating and Hot Water Supply

Objective and Nature of the Program:

The object of this test project is to determine:
1. the contribution of these installations to the total energy consumption of dwellings
2. the general applicability in dwellings as regards:
   a. the technical feasibility;
   b. the economy of the tested systems;
3. the optimal design of gas appliances as a source of heat to complement the greatly variable supply of solar energy.

Present Status or Summary of Significant Accomplishment:

Technical characteristics of the solar energy installation in the test project Apeldoorn.

Purpose	: space heating and hot water supply
Primary cooling	: water/glycol with pump circulation
Summer protection	: discharge of heat through convectors on the roof (control), through pressure and temperature operated cut-off switches on storage vessel.
Winter protection	: water/glycol mixture
Separation primary/secundary	: through separating heat exchanges
Tap water system	: auxiliary heat supply in combined water heater
Secundary heating system	: indirect air heating installation
Further energy conserving provisions	: insulation according to current standard + double panes
Integration	: complete integration of the three components: 1. accumulator in the floor construction of the dwelling; 2. DRU-collectors and 3. convectors in the roof construction

- Period of the Project: System analysis during 3 years.
- Fund in $ US: - Current Year $ 100,000
  - Total for the Period $ 150,000
- Important Reports or Publications:
  1. Report "Zonne-energie in Apeldoorn", VEG-GASINSTITUUT n.v., november 1977.
  2. "Experimentele zonne-energiewoningen in Apeldoorn", J.H.M. Heimeriks, P.Th.J. Overman, A.A.J. Thomassen (GAS, december 1977).
  3. "De accumulatie van zonnewarmte in de vloeren van een woning" A.A.J.Thomassen (GAS, januari 1978).

see attached sheet

Attached Sheet (VEG-GASINSTITUUT n.v.)

Solar Collector

These collectors are fabricated by DRU- ULFT according to the design of the Institute of Applied Physics TNO - TH - DELFT.

a. type flat plate. Dimensions 1650x800x94mm.
b. $\alpha\tau \approx 0.78$.
c. overall heat loss coefficient U_1 [$W/m^2.K$] (temp. range θ [^oC]) 4-5 (30-70^{o}C).
d. heat capacity (fluid included) $C \simeq 3.8$ $Wh/m^2.K$.
e. heat transfer medium (water/glycol).
f. material
    i) absorber: two 0.8 mm steel sheets, seam welded, and pressure, expanded covered with a coating of black glass enamel with a doped tinoxide layer. $\alpha \simeq 0.92$; $\varepsilon < 0.2$.
    ii) cover plate: glass, single 4 mm $\tau = 0.85$.
    iii) insulation: glasswool, 5 cm.
g. expected life time 20y.
h. estimated cost ($ US/m^2) $ 100/m^2.

Heat storage

a. type	: in floor mass of ground floor and first storey.
b. heat capacity	: 90 x 0,2 = 18 m^3 of concrete (total)
c. latent heat	: not applicable
d. heat exchanger	: spiralling pipes in floors
e. heat rate	:
f. insulation	: below ground floor
g. expected life time	: 50 years

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: NEW ZEALAND

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [X] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION PEL, DSIR	ADDRESS PEL
NAME OF PRINCIPAL RESEARCHER R.F. Benseman	

TITLE OF PROJECT

Develop packaged solar water heater

OBJECTIVE AND NATURE OF THE PROGRAMME:

To produce a packaged ground-mounted solar collector/tank that will temper water for hand washing. Unit to be constructed of steel, yet compatible with copper plumbing systems. Intended for use in schools.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Six units constructed and now on field test. One unit to Fiji for evaluation.

PERIOD OF PROJECT: 1976-77

FUND IN $ NZ N.A.

IMPORTANT REPORTS OR PUBLICATIONS:

Patents being applied for.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: NEW ZEALAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
School of Architecture,
University of Auckland

ADDRESS
University of Auckland,
Private Bag, Auckland, N.Z.

NAME OF PRINCIPAL RESEARCHER
Prof. H. Marshall

TITLE OF PROJECT
Solar space heating of houses in New Zealand.

OBJECTIVE AND NATURE OF THE PROGRAMME:
In this project, a low technology house was designed using fairly conventional architecture and building methods. The design team of students attempted to minimise space heating requirements by using solar energy stored in the floor and walls.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Design is complete

PERIOD OF PROJECT: 1976

FUND IN $ NZ 3500

IMPORTANT REPORTS OR PUBLICATIONS:
Draft report in hands of New Zealand Energy Research and Development Committee Contract No. 3081

Country: Sweden		
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** ☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☒ Materials Research ☒ Component Development

Name of Organization: AB Atomenergi	Address: Studsvik Fack S - 611 01 Nyköping Sweden
Name of Principal researcher: H Hedman	

Title of Project:

Energy Storage by Modified Use of Salt Hydrates.

Objective

The principal aim was to study the possibility of overcoming the well-known phase separation effects experienced particularly with Glauber's salt (sodium sulphate 10-hydrate) when used as a latent heat energy storage material. Glauber's salt is attractive as a solar heat storage medium on account of its high heat of fusion, ca 250 kJ/kg (approx. 100 kWh/m^3) and rather low melting point (32.5°C)*).

Firstly, this was performed by thermal balance studies using simulated micro-capsules of salt hydrate. Simulation was accomplished by use of a wide range of porous materials, e.g. epoxy and polyester foam plastics, which were impregnated with salt hydrate. Simulated microencapsulation was necessary since no supplier of suitable microcaps was available on schedule for the research program.**)

Secondly, model studies or simulations of microcaps were also realized through the use of spheres of molten Glauber's salt which covered a wide size range. These were suspended in an immiscible and hot heavy liquid which was agitated. Parallel with the above work some basic studies of the phase separation mechanism were carried out. Glauber's salt was introduced into glass tubes of different diameters down to capillary size and observed during thermal cycling.

Other salt hydrates suffering from similar separation effects were also planned to be included in the program if the encapsulation studies would prove successful.

Limited investigations were also made of the possibilities of influencing phase separation by ordinary mechanical agitation, ultrasound, and magnetic fields.

*) Total storage capability between 30°-60°C: approx. 350 kJ/kg or 140 kWh/m^3 (inclusive of sensible heat).

**) The thermal storage capability of packed beds of microcaps filled with Glauber's salt is estimated at 175 - 200 kJ/kg or 70 - 80 kWh/m^3 as latent heat, and 250 - 300 kJ/kg or 100 - 120 kWh/m^3 as latent and sensible heat for the temperature range 30°-60°C.

Results summary and present status

The experiments with simulated microcaps of Glauber's salt in carrier materials showed that storage capability declined rather quickly upon thermal cycling above and below the melting point (15^{o}-50^{o}C). This is in accordance to the actions of the material when thermally cycled in bulk. The loss was as much as ca 70 % after 10 cycles and about 40 % already after the first cycle as compared with the theoretical value. Different pore sizes corresponding to varying diameters of microcaps or changes of cycling mode (temperature and time) did not alter this situation appreciably.

Observations of the melting and freezing process verified that separation occurs independently of particle size. This was shown excellently clearly in the model simulation experiments with suspended spheres, since the process was visually observable in detail.

The quantities of the three phases formed upon melting of Glauber's salt were also determined. The precipitated anhydrous phase (Na_2SO_4), for instance, increased by ca 40 % after 10 complete cycles.

Other means for influencing the sedimentation process, e.i. mechanical agitation or use of magnetic or ultrasonic fields with the aim to preventing precipitation of hard solid phase, were studied tentatively, but proved unsuccessful. In any case, the specific energy demand for any of these alternatives would be intolerably large in comparison with the stored thermal energy per unit volume of salt hydrate, e.g. from a solar collector system.

The conclusion is that Glauber's salt has a very limited technical and economical life time as a heat storage material, irrespective of its treatment, whether encapsulated or agitated by different means. No further work is therefore motivated with Glauber's salt.

The present program is chiefly directed towards the construction of a so-called combined heat storage, comprising the use of macro-encapsulated salt hydrates, e.g. calcium chloride.

Project period

1976-04-01 -- 1977-09-30. Further work pending new funding.

Funding

Current year: $ US 22.000
Total   : $ US 48.000

Publication

No official reports or publications are available as yet.

Country: Sweden		
Check the mark X in the head of line, corresponding to the respective components and type of research:	Components ☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	Type of Research ☐ Materials Research ☒ Component Development

Division of Physical Chemistry ROYAL INSTITUTE OF TECHNOLOGY Bo Carlsson Hans Stymne Gunnar Wettermark	Address: Fack S-100 44 Stockholm 40 Sweden

Title of Project: "Solar Energy and Buildings"

Storage of Low Temperature Heat in Salt Hydrate Melts

Objective of the program:

- Experimental investigation of salt hydrates for use as latent heat storage material.
  Construction of prototype storage units for short term storage of solar energy for heating of buildings.
- The main candidate $CaCl_2 \cdot 6H_2O$ has been investigated in detail (see the attached sheet).

  Fund in $ US 74 444 current year
  $ US 208 888 1974-78
- Reports: Storage of low temperature heat in salt hydrate melts: Report of work carried out on the system $CaCl_2 \cdot 6H_2O$.
  (Swedish Council for Building Research, Dec. 1977).

STORAGE OF LOW TEMPERATURE HEAT IN SALT HYDRATE MELTS

Storage of heat in salt hydrate melts provides a basis for constructing solar heating system differing from those now generally used. They may give the advantage of low temperature of the solar collector in combination with high energy storage capacity in a small temperature interval closely above room temperature.

Low cost salt hydrates have been evaluated as phase change materials for thermal storage. The most promising candidate so far has shown to be calciumchloride hexahydrate. It has a melting point of 30°C and a heat of crystallisation of 170 J/g (71 kWh/m^3 melt). Particular attention has been paid to problems concerning:

1. Phase separation
2. Supercooling
3. Heat transfer of melting and solidification
4. Encapsulation
5. Integration with the building structure.

According to the phase diagram a tetrahydrate appears between 29.5°C and 32°C in $CaCl_2$-water mixture with the composition of the hexahydrate. The appearance of the tetrahydrate phase brings about a continuously diminishing storage capacity on repeated cycling. Methods are worked out for the prevention or elimination of this formation of a tetrahydrate phase.

The kinetics of the melting process is limited by the heat transfer through the melt. Thus, the melting rate can be raised appreciable by proper design of the geometry of the storage unit thereby maximizing the heat exchange through convection.

The kinetics of the crystallisation process is primarily limited by the heat transfer through the solid ($\sim$ 1 W, m^{-1}, K^{-1}). As the temperature difference between the salt hydrate and the heat transfer medium (*e.g.* air) necessarily has to be low, the heat transfer surfaces must be extremely large.

Encapsulation of the salt in plastic tubes - with outside heat exchange to air is preferred.

A 200 kg heat storage and air convector prototype has been built and is now to be tested. The prototype consists of standing polyethylene tubes ø 0.1 m. The tubes are arranged in a hexagonal array. Plastic pipes (ø 0.01 m) inside the tubes provide for heat transfer into the salt hydrate. Heat is extracted from the salt by forced air convection on the outside of the tubes.

Prototype data:

Capacity:	18 kWh (200 kg $CaCl_2 \cdot 6H_2O$)
Heat output:	200 - 400 W (28-23^{o}C)
Heat input:	2 kW (45^{o}C)
Expected life time:	unlimited
Air flow:	0-100 l/sec.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : SWITERLAND

COMPONENTS	TYPE OF RESEARCH
[ ] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [ ] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Ecole Polytechnique Fédérale de Lausanne	ADDRESS : 14, Av. de l'Eglise Anglaise 1001 LAUSANNE
NAME OF PRINCIPAL RESEARCHER A. FAIST	

TITLE OF PROJECT :
Hybrid fluid heat storage unit.

OBJECTIVE AND NATURE OF THE PROGRAM :
Evaluation of the performances of an hybrid heat storage using air as heat charging fluid and water as heat discharging fluid. Determination of the most promising spatial configurations and choice of the heat storage medium. Computer modeling of the system and experimental verification on a small sized unit.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

PERIOD OF PROJECT : 6 months (starting date : oct. 1977)

FUND IN SFR. : CURRENT YEAR : 12'500.-- (material)
TOTAL FOR THE PERIOD

IMPORTANT REPORTS OR PUBLICATIONS :

Format of Survey on Components for Solar Heating, Cooling and Hot water Supply Systems

Country: Switzerland		
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** ☐ Solar Collector ☒ Heat Storage ☐ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☐ Materials Research ☒ Component Development

Name of Organization: Ecole Polytechnique Fédérale Name of Principal researcher: Prof. Ph. Javet	Address: Institut de Génie chimique 140, rue du Centre CH 1025 St-Sulpice

Title of Project: Thermal energy storage by latent heat of fusion

- Objective and Nature of the Program:

Development of energy storage units using the latent heat of fusion in temperature ranges allowing hot water preparation. Realization of these units and measurements in a solar circuit. Obtention of reliable data for the dimensioning and realization of such units and for comparison purposes between latent and sensible heat storage.

Present status:

Pilot runs done, and evaluation of these in progress (PCM: paraffin).
First unit in starting-on phase
Evaluation of other PCM, in progress
Period of the project: 2 years, starting 1.1.1977
(possibly 3 more years)
Fund in $ US - current year : ∿ 56000 $
- total for the period: ∿ 110000 $

Important Reports or publication:

Keller-Javet: "Comment aborder le problème du stockage de l'énergie solaire" Bulletin technique de la Suisse Romande, 15, 255-262 (22.7.76)

Keller-Javet: "Etude comparative et critique des différentes possiblités de stockage de l'énergie solaire et thermique"
for: Office Fédéral de l'Economie Energétique, Berne

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION The Univ. of Alabama in Huntsville	**ADDRESS:** P. O. Box 1247 Huntsville, AL 35807
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT

Experimental and Computer Studies of Thermal Stratification in Water Storage Tank

OBJECTIVE AND NATURE OF THE PROGRAM:

To understand thermal stratification inside liquid storage tank on the total solar energy system performance. To develop mathematical models for liquid storage tank and verification of math models by extensive experimentation.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Importance of stratification has been studied. A one-dimensional viscous-entrainment storage tank model is developed. Two-dimensional (quasi-3D) tank temperature measurement is being developed.

PERIOD OF PROJECT:

September 1, 1977 - August 1978

FUND IN $ U.S.

FY - 1977 $65,035.00
FY - 1978 $

IMPORTANT REPORTS OR PUBLICATIONS:

S. M. Han and S.T. Wu, "The Effects of Thermal Stratification in Water Storage Tank for the Performance of a Solar Hot Water System," to appear in Proceedings of 14th Southeastern Seminar on Thermal Science, Apr. 6-7, 1978, N.C. State Univ., Raleigh, N.C.

S. M. Han and S. T. Wu, "Computer Simulation of a Solar Energy System with a Viscous-Entrainment Liquid Storage Tank Model," to appear in Application of Solar Energy - 1978 (Eds. S. T. Wu, D. Christensen, M. Nash and R. Humphries), UAH Press, Huntsville, Alabama.

Heat Storage

a) type (storage medium, phase change etc.) and configuration

Concrete rectangular tank with removable cover
Medium is water

b) heat capacity C (Wh/m^3) (temp. range θ (^{o}C))
1200 gal/water, 70°C - 90°C

c) latent heat h (Wh/m^3) (temp. θ (^{o}C))

d) heat exchanger YES/NO (heat transfer fluid)

No
Water

e) heat rate

Not available

f) insulation

3" outside, 1" inside polyurethane foam

g) expected life time t

10-15 years

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION ALTAS CORPORATION	**ADDRESS:** 500 Chestnut Street Santa Cruz, CA 95060
NAME OF PRINCIPAL RESEARCHER F. de Winter	

TITLE OF PROJECT

Investigation of Methods to Transfer Heat from Solar Liquid Heating Collectors to Heat Storage Tanks

OBJECTIVE AND NATURE OF THE PROGRAM:

This project is aimed at the identification and development of the most cost-effective methods of transferring heat from the solar collector to a water storage system, methods in which the problems of freezing and corrosion are either minimized or eliminated. The program will develop optimized criteria for components and identify suitable and unsuitable fluids.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Choice of components for draining system has been completed. A compendium of fluid properties has been prepared. Criteria for optimization of single loop antifreeze circuits have been developed.

PERIOD OF PROJECT:

15 months, (starting date: 3/15/76)

FUND IN $ U.S. Current Year $64,314

Total for the Period

IMPORTANT REPORTS OR PUBLICATIONS:

Completed Contract - The final report is in preparation. Papers will be submitted shortly to the Solar Energy Journal.

Altas Corporation (Data Sheet)

Heat Storage

a) type (storage medium, phase change etc.) and configuration

Water tank storage systems often used to be heated by an antifreeze solar collection loop. The tank must be heated by a coil or by an external heat exchanger with a pumped water loop. System optimization criteria were developed, and fluid properties were organized in a compendium. Different concepts for automatic draining systems were presented. A new design concept has been developed for a "buffered" heat exchanger, in which leakage from a poisonous antifreeze loop to a potable water loop is impossible. The development of hardware prototypes of these exchangers is planned in the near future.

b) heat capacity C (Wh/m^3) (temp. range θ (^oC))

c) latent heat h (Wh/m^3) (temp. θ (^oC))

d) heat exchanger YES/NO (heat transfer fluid)

e) heat rate

f) insulation

g) expected life time t

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Computer Code Development

NAME OF ORGANIZATION
Atomics International Division of Rockwell International

ADDRESS: Atomics International
8900 De Soto Avenue
Canoga Park, Calif. 91304

NAME OF PRINCIPAL RESEARCHER
Michael P. Moriarty

TITLE OF PROJECT
Hybrid Thermal Storage with Water (Contract EG-77-C-02-4480)

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this study is to evaluate the potential benefits and to provide engineering and cost data to allow effective design of hybrid thermal storage systems.

Successful solar heating systems require some form of heat storage for night time or cloudy weather heating. Sensible heat stored in tanks of water is generally considered both practical and relatively inexpensive. However, tank cost is a significant cost item, particularly as storage volume increases. Cost reductions may be possible for a hybrid system--by combining a water storage tank with an inexpensive material such as a rock--that would increase the thermal storage capacity of the system and at the same time effectively insulate the water tank.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Computer codes have been written to simulate hybrid storage and to simulate solar heating systems.

PERIOD OF PROJECT:

September 1, 1977 through August 31, 1978

FUND IN $ U.S.

FY 1977 $3,200
FY 1978 $105,627 (includes $67,327 expected to be authorized)

IMPORTANT REPORTS OR PUBLICATIONS:

Atomics International Internal Report "N001TI320005, Thermal Analyzer Program (TAP) Subroutine Package." January 12, 1978.

Heat Storage

a) type (storage medium, phase change etc.) and configuration

Hybrid Thermal Storage with Water

Sensible heat using water and solids (i.e., rocks, concrete tanks, etc.).

Conceptual study only, remaining questions do not apply (DNA).

b) heat capacity C (Wh/m^3) (temp. range θ (^oC))

DNA

c) latent heat h (Wh/m^3) (temp. θ (^oC))

DNA

d) heat exchanger YES/NO (heat transfer fluid)

DNA

e) heat rate

DNA

f) insulation

DNA

g) expected life time t

DNA

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Boeing Computer Services Company **NAME OF PRINCIPAL RESEARCHER** R. T. Haelsig	**ADDRESS:** Boeing Computer Services Company P. O. Box 24346, Mail Stop 9C-02 Seattle, Washington 98124

TITLE OF PROJECT
Developing and Upgrading of Solar System Thermal Energy Storage Simulation Models

OBJECTIVE AND NATURE OF THE PROGRAM: Collect, standardize, upgrade and link existing thermal energy storage (TES) models to permit simulation of a wide variety of solar heating and cooling system configurations. Validate and correlate these models with available operating system test data. Develop and validate streamlined versions of these models for overall system simulation purposes. An extensive set of TES models and solar system simulation techniques have been developed, in part, under AEC, NSF and ERDA sponsorship. The level of detail, mathematical formulation, experimental validation status, and solution methodology of these models differ widely. A consistent level of detail and solution technique will be achieved by standardization and upgrade actions, then linked via an existing general-purpose simulation program (SIMWEST) developed specifically for energy storage modeling. Validation and the development of computationally efficient streamlined models will be conducted within the environment of the SIMWEST simulation technique.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
The more important TES models have been acquired and are in detail evaluation. Validation sources are being identified.

PERIOD OF PROJECT:

September 1977 to August 1980

FUND IN $ U.S.
$476,973

IMPORTANT REPORTS OR PUBLICATIONS:
None, as of this date

Heat Storage

a) type (storage medium, phase change etc.) and configuration

Study contract pertains to all forms of thermal energy storage applicable to solar energy utilization. (The result will be validated mathematical models, not hardware end items; consequently, most of the items listed below are not applicable.)

b) heat capacity C (Wh/m^3) (temp. range θ (^oC))

N/A

c) latent heat h (Wh/m^3) (temp. θ (^oC))

N/A

d) heat exchanger YES/NO (heat transfer fluid)

Will include heat exchanger models

e) heat rate

N/A

f) insulation

N/A

g) expected life time t

N/A

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION EIC Corporation **NAME OF PRINCIPAL RESEARCHER** Peter O'D. Offenhartz	**ADDRESS:** 55 Chapel Street Newton, Massachusetts 02158

TITLE OF PROJECT

Solid Phase Absorbent Air Conditioning Studies

OBJECTIVE AND NATURE OF THE PROGRAM:

To design, construct, and test a solar air conditioner using a solid phase inorganic salt as the absorbent, and water as the refrigerant. Dehydrated inorganic salts can provide energy storage as well as refrigeration; hence, a system based on such salts will not require separate cold-side and hot-side energy storage.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

New Project

PERIOD OF PROJECT: September 20, 1977-September 30, 1978 (Phase I)

FUND IN $ U.S. $160,000

IMPORTANT REPORTS OR PUBLICATIONS: None to date.

EIC Corporation (Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar air conditioner, with integrated storage, using a solid-phase absorbent.

b) type of refrigerator (absorption, ...; working medium, ...)

Solid-phase absorption.

c) capacity of refrigerator (tons)

Ca. 3 tons.

d) temp. range 0 ($^{\circ}$C)

Not yet accurately known.

e) C.O.P.

0.6 (projected)

f) heat exchanger

Not yet designed.

g) auxiliary heat source

Any source of forced hot air.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Franklin Institute Research Laboratories

ADDRESS:
20th and Race Streets
Philadelphia, PA 19103

NAME OF PRINCIPAL RESEARCHER
Kenneth W. Kauffman

TITLE OF PROJECT

Thermal Energy Storage by Means of Saturated Aqueous Solutions

OBJECTIVE AND NATURE OF THE PROGRAM:

The project combines the heat transfer and installation cost advantages of sensible heat storage systems using pumped fluids and the small volumes and small operating temperature swings characteristic of latent heat storage devices. The method uses saturated aqueous solutions of solutes which dissolve endothermically and have large coefficients of solubility with temperature. The design of engineering prototpyes for application to off-peak air conditioning and solar space heating or cooling are the final objectives.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Final report has been issued; engineering prototype design was completed for off-peak air conditioning. Substantial energy savings is achieveable (up to 40%) compared to the use of ice, and 1/5 the volume requirement compared to the use of chilled water. Mechanical complexity indicates its use for large commercial as opposed to residential application.

PERIOD OF PROJECT:

July 1976-November 1977

FUND IN $ U.S.

107,061

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report:

1. Kauffman, K.W., and Lorsch, H.G., "Thermal Energy Storage with Saturated Aqueous Solutions," Task A Technical Report, QP-C4463-Franklin Institute Research Laboratories
2. Kauffman, K.L., Kyllonen, D.M., and Lorsch, H.G., "Thermal Energy Storage by Means of Saturated Aqueous Solutions," Final Report COO-5158-2, November 1977.

(Coolness)
Heat Storage

a) type (storage medium, phase change etc.) and configuration

We use the melting change in trimethylamine decahydrate over a range of temperature 4.4°C to 15.6°C), .and 10% extra water to prevent complete freezing. Aobut 80% of the phase change occurs between 4.4°C and 6.1°C. For configuration please see attachment.

b) heat capacity C (Wh/m^3) (temp. range θ (^{o}C))

11.1 kWh/m^3 over the temperature range 4.4°C to 15.6°C

c) latent heat h (Wh/m^3) (temp. θ (^{o}C))

62.8 kWh/m^3 over the temperature range 4.4°C to 15.6°C

d) heat exchanger YES/~~NO~~X (heat transfer fluid)

The fluid is Dowtherm J (paraffinic oil), 20 gallons for a device to store 58.6 kWh . The heat exchanger requires an oil pump with 1/4 h.p. motor, a mechanical separator, and oil sparger. Effectiveness estimated to be 90%.

e) heat rate

10.25 kW

f) insulation

71 ft^2 of 5-1/4" fiberglass batt for a device to store 200,00 Btu diurnally (58.6 kWh)

g) expected life time t

20 years

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Franklin Institute Research Laboratories	ADDRESS: 20th and Race Streets Philadelphia, PA 19103
NAME OF PRINCIPAL RESEARCHER George Peter Wachtell	

TITLE OF PROJECT

Self-Controlling, Self-Pumping Heat Circulation System Study

OBJECTIVE AND NATURE OF THE PROGRAM:

Schemes will be evaluated for expected performance and practicality. Inefficient self-pumping devices lead to a substantial performance penalty even though all pumping energy is ultimately delivered to the useful heat load or storage, because the δT between solar collector and load is proportional to the rate of entropy production. Schemes and underlying principles will be collected by a computerized literature search and by personal contacts with workers in the field. Air, liquid, or multi-phase systems using a thermodynamic cycle to drive a circulator, capillary or osmotic pumping, percolators, heat pipes, and thermosyphoning in which density effectively increases with temperature are examples of self-pumping schemes. Thermal diodes are examples of self-controlling devices. Selected schemes will be recommended for development.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Preliminary evaluations have been made of several schemes for moving liquid or air, or for condensate return in latent heat transport schemes.

PERIOD OF PROJECT:

August 1, 1977 to July 31, 1978

FUND IN $ U.S. 103,155

IMPORTANT REPORTS OR PUBLICATIONS:

Wachtell, G.P., "Self Pumping by Means of Power Cycles," Second National Passive Solar Conference, Philadelphia, PA, March 15-19, 1978

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS*	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION General Electric Company **NAME OF PRINCIPAL RESEARCHER** A. T. Tweedie/E. M. Mehalick	**ADDRESS:** Advanced Energy Programs PO Box 8555 Philadelphia, PA 19101

TITLE OF PROJECT

Two-Component Thermal Storage Material Study - Phase II

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of the current program is the development of a storage medium consisting of microencapsulated phase change material in a packed bed with a water heat transfer medium. The long-term reliability of the capsules to sustain the volume change effects of the phase change material and the packed bed environment will be verified. The study will also include an economic evaluation of the storage concept.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Identified capsules with long-term wall durability. Laboratory scale tests of a packed bed system are continuing.

PERIOD OF PROJECT:

6/76 - 2/78

FUND IN $ U.S.

$105 K

IMPORTANT REPORTS OR PUBLICATIONS:

NSF/RANN/SE/AER 74-09186 Nov., 1975
Final report of the Two-Component Thermal Energy Storage Material Program - Phase I

General Electric Company (Data Sheet)

Heat Storage

a) type (storage medium, phase change etc.) and configuration

Combined phase change/sensible heat storage. Microencapsulated Sunoco P116 wax and water in a packed bed.

b) heat capacity C (Wh/m^3) (temp. range θ (^oC))

Heat capacity C = 40,000 Wh/m^3 (Combined latent and sensible heat assuming 30% water by volume)

Temperature range $\theta_3 = 11^oC$

c) latent heat h (Wh/m^3) (temp. θ (^oC))

(Included in b)

d) heat exchanger YES/NO (heat transfer fluid)

Water heat transfer fluid with no internal heat exchanger.

e) heat rate

Not specified.

f) insulation

Not specified.

g) expected life time t

To be determined at the end of the current program.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION National Bureau of Standards **NAME OF PRINCIPAL RESEARCHER** J. E. Hill	**ADDRESS:** Gaithersburg, Maryland

TITLE OF PROJECT

Development of Methods of Evaluation and Test Procedures for Solar Collectors and Thermal Storage Devices

OBJECTIVE AND NATURE OF THE PROGRAM:

The objectives of this program are to develop standard test methods for determining thermal performance of solar collectors and thermal storage devices that are used in systems for heating and cooling of buildings. Also to experimentally verify the proposed test procedure utilizing test facilities at NBS as well as at other selected locations.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

- Adoption of ASHRAE Standard 94-77, Storage Test Procedure
- Experimental Verification of the Standard for a Water Tank and Pebble Bed, Both Sized for Typical Residential Applications

PERIOD OF PROJECT:

FUND IN $ U.S.	CURRENT YEAR	$100,000
	TOTAL FOR THE PERIOD	$795,000

IMPORTANT REPORTS OR PUBLICATIONS:

"Development of Proposed Standards for Testing Solar Collectors and Thermal Storage Devices", NBS Technical Note 899, February, 1976.

"A Method of Testing for Rating Thermal Storage Devices Based on Thermal Performance", Solar Energy, accepted for publication, 1977.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

North Carolina University

NAME OF PRINCIPAL RESEARCHER

J.A. Bailey & J.C. Mulligan

ADDRESS:

Department of Mech. & Aero. Engr.
North Carolina University
Raleigh, NC 27607

TITLE OF PROJECT

Research on Solar Energy Storage subsystem utilizing the Latent Heat of Phase change of certain organic materials.

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this one year continuation study is the further development of a heat storage subsystem (thermal Capacitor) which utilizes the latent heat of melting and solidification of organic waxes, i.e., mixtures of paraffins of varying molecular weights. A second objective is to ascertain the relative merits of alternative, commercially available encapsulating structures. The primary goal will be to determine both analytically and experimentally the effect of the finite melting temperature range (due to the mixture of hydrocarbons with different melting temperatures) on thermal storage performance.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Contract terminated 31 August, 1977. See attachment for significant accomplishments.

PERIOD OF PROJECT:

12 months (starting date: 3/18/76)

FUND IN $ U.S.

Current year: $94,408

Total for the Period

IMPORTANT REPORTS OR PUBLICATIONS: Research on Solar Energy Storage Subsystems Utilizing the Latent Heat of Phase Change of Paraffin Hydrocarbons for the Heating and Cooling of Buildings, Final Report No: NSF/RANN/GI44381/75. Research on Solar Energy Storage Subsystems Utilizing the Latent Heat of Phase Change of Certain Organic Materials Semi-Annual Report ERDA Contract E(40-1)-5101.

Significant Accomplishments

1. Selected thermal property data has been generated for ten inexpensive waxes of potential value for phase change thermal storage units.

2. Laboratory size phase change thermal storage units have been designed using three novel intra-structure configurations.

3. The two dimensional transient heat conduction problem with a change of phase and with sensible heating in the premelting and post melting regimes has been solved numerically, using an enthalpy method. The analysis has been used to predict the performance of the storage units. Performance was interpreted in terms of the effects of inlet temperature and mass flow rate of the thermal fluid on exit temperature, rate of heat stored and cummulative heat stored as a function of time.

4. Experimental data has been generated for each storage unit showing the effects of inlet temperature and mass flow rate of the thermal fluid on exit temperature, rate of heat stored and cummulative heat stored as a function of time. Sunoco wax 3420 and Eicosane were used as the phase change materials.

5. Comparisons were made between analytical and experimental data and good agreement was found.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION University of Virginia **NAME OF PRINCIPAL RESEARCHER** Dr. J. Taylor Beard	**ADDRESS:** School of Engineering and Applied Sciences Charlottesville, VA 22901

TITLE OF PROJECT

Annual Collection and Storage of Solar-Heated Water for the Heating of Buildings

OBJECTIVE AND NATURE OF THE PROGRAM:

The overall objective of this two-year study is to evaluate a particular system for the annual (yearround) collection, storage, and utilization of solar heated water for the heating of buildings. The research involves the design, construction and testing of the system, with simulation studies to determine the influence of design modifications. The system will be operated in both the collection mode and the heating mode, with energy being delivered to a simulated building heat load through a direct and a solar assisted heat pump mode of operation.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Construction and testing during a collection mode have been completed. Operation in a heating mode is to begin in the near future. Model simulation studies are fairly well developed.

PERIOD OF PROJECT

May 1976- June 1978.

FUND IN $ U.S.

first year: $78,181
second year: $ 87,485

IMPORTANT REPORTS OR PUBLICATIONS:

"Annual Collection and Storage of Solar Energy for the Heating of Buildings, Report No. 2", ORO/5136-77/2, Division of Solar Energy, ERDA (July 1977)

Heat Storage

a) type (storage medium, phase change etc.) and configuration

sensible heat stored below grade in water tank, with solar collector as cover

b) heat capacity C (Wh/m^3) (temp. range θ (^oC))

60,000 wh/m^3

c) latent heat h (Wh/m^3) (temp. θ (^oC))

not applicable

d) heat exchanger YES/NO (heat transfer fluid)

yes; water to air

e) heat rate

variable to simulate building heat load (with direct heating or heat pump augmentation)

f) insulation

earth at the base of pool (also acts as heat sink), earth berm with some styrafoam insulation at edges, solar collector with 0.3 m styrafoam bead insulation on top of water surface

g) expected life time t

unknown

AIR CONDITIONING

COUNTRY: DENMARK	
COMPONENTS	**TYPE OF RESEARCH**
[ ] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [x] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIAL RESEARCH [x] COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Refrigeration Laboratory The Technical Univ. of Denmark	ADDRESS: Bldg. 402 DK-2800 Lyngby, Denmark
NAME OF PRINCIPAL RESEARCHER P. Worsøe-Schmidt	

TITLE OF PROJECT Solar-powered refrigeration by a solid-absorption system

OBJECTIVE AND NATURE OF THE PROGRAM

Development of a solar-powered, solid-absorption system to be used where solar radiation is abundant, but other energy sources are either not available or too expensive. Primary applications are: production of block ice, cold storage, and air conditioning.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT

An experimental investigation of the processes of absorption and generation of ammonia in calcium chloride and strontium chloride is completed. A small demonstration plant has been built and tested.

PERIOD OF PROJECT

September 1975 -

FUND IN $ U.S. TOTAL FOR THE PERIOD 25.000

IMPORTANT REPORTS OR PUBLICATIONS:

P. Bechtoft Nielsen & P. Worsøe-Schmidt, Development of a solar-powered solid-absorption refrigeration system. Part I: Experimental investigation of the generation and absorption processes. Rept. F30-77.01, Refign. Lab. The Technical University of Denmark, August 1977.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☒ Heat Storage	☒ Component Development
☒ Air Conditioning and Cooling Unit	☒ Systems Development
☐	☐
☐	

Name of Organisation:	Address:
Messerschmitt-Bölkow-Blohm GmbH	Postfach 801169 8000 München 80
Name of Principal Researcher Dipl.Ing. H. Grallert	

Title of the Project: Modular solar house heating system - Phase I

Objective and Nature of the Project, Present Status

1. Aim

Theoretical and experimental investigations on the development of a modular solar house system which can be marketed in collaboration with other companies and in particular is suitable for use in temperate zones. A variant of the system is to be applied in combination with refrigeration systems for air conditioning.

2. Schedule

a) Investigation, development and design work on collectors, storage media, storage containers, heat exchangers as well as measurement and control units.

b) System layout from technical and economic points of view.

Continuation overleaf /

Period of the Project: 15.11.74 - 30.12.76

Fund in $ US: 478,500,- Government Contribution: 80%

Important Reports or Publications:

Title of the Project: Modular solar house heating system - Phase I

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Progress

In the first development phase the emphasis was on carrying out thorough technical and economic system analyses which were the starting point for the necessary component development. These analyses include estimation of the weather effects, a design study, investigation of all collector design parameters, the regulation system, heat requirement and consumption characterization, system cost estimation and optimization, complete simulation of the solar thermal and of the conventional heating system as well as thermal and mechanical computation of all components. As essential result it was established inter alia that the use of selective absorber coatings and that of IR effective cover glass coatings is at present still uneconomical in comparison with simple two-plate collectors (flat construction) and that only the small heat accumulator adapted to the heat requirement over approximately 1 week is suitable as cubic hot water tank for use in 1 and 2 family houses. Taking into account the cost increase which is expected to rise still further in the case of the fossil fuels it was possible with the aid of static meteorological data to demonstrate profitable use of the solar thermal heating system, in particular for hot service water preparation even in central European latitudes.
From the investigations of construction for the critical individual components two collector generators with 3 or 7 test modules of two-plate flat construction were derived and satisfactorily tried out as regards heat transfer and longterm durability on the openair test rig constructed for the purpose. For the version accepted in Autumn 1975 as regards performance production investigations were carried out with plastic and metal frames from the point

Title of the Project:
Modular solar house heating system - Phase I

Objective and Nature of the Project, Present Status:
- Continuation ....

of view of series production. Here it was found that production costs were considerably lower for the metal frame construction particularly in comparison with PU rigid foam frames. In addition, when using load supporting plastic components additional thermal expansion processes occur. Both constructions were followed through as far as the prototype and used in complete tests.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☒ Heat Storage	☐ Component Development
☒ Air Conditioning and Cooling Unit	☒ Systems Analysis
☐	☐
☐	

Name of Organisation:	Address:
Messerschmitt-Bölkow-Blohm GmbH	Postfach 801169 D-8000 München 80

Name of Principal Researcher

Dipl.-Ing. Grallert

Title of the Project:

Modular solar domestic heating system - Phase 2

Objective and Nature of the Project, Present Status

1. Aim

Continuation of the work commenced in Project ET 4066 A (first development phase) with the aim of applicational execution and optimization of solar heating systems for preferred use in the domestic field. Aim otherwise as in Phase 1.

2. Schedule

a) Further development of collector for higher operating temperatures.

b) Optimization of system layout.

c) Preparation of two complete research installations for demonstration of subsequent equipment and original

Continuation overleaf /

Period of the Project: 1.1.76 - 30.6.77

Fund in $ US: 562,300,- Government Contribution: 50%

Important Reports or Publications:

Objective and Nature of the Project, Present Status:
- Continuation ....

equipment with a solar domestic heating system.

d) Investigation of the installation parameters and of the standardization of solar heating systems.

e) Basic operations for going over to series production.

3. Progress

The emphasis of the second development phase is the installation and operation of systemwise balanced solar heating systems in two typical applications.
In an existing inhabited single family terraced house in Höhenkirchen near Munich a combined solar heating system was installed for room heating and water heating with 35 m^2 effective collector area and 4 m^3 water accumulator. With the installation commissioned in June 1976 important results were collected for simplification of the system technology and the installation outlay.
The use of solar energy resulted by the end of the year in a saving of more than 900 litres of fuel oil.
On the basis of the practical experience already gathered the development trend is towards pre-installed system sections, reduced equipment outlay and carefully insulated housing sections.

Although strict economy with combined systems is not yet attainable today, the monovalent solar heating system with electrical emergency heating seems to be an interesting solution for the future.
To examine selectively effective coatings 8 additional test collectors were tried out. Production problems in the reproduction of SnO_2 or black chromium coatings in some cases produced worse results than expected. Attention should be paid to condensate corrosion in the case of black chromium

Title of the Project:

Modular solar domestic heating system - Phase 2

Objective and Nature of the Project, Present Status:

- Continuation ....

coatings on aluminium. With selective coatings of this type no-load temperatures over 200°C are reached. If the cost of the coating can be reduced by more than half, use in one and two plate collectors appears attractive.

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☒ Heat Storage	☒ Component Development
☒ Air Conditioning and Cooling Unit	☐
☒ Heat Pump	☐
☐	

Name of Organisation:	Address:
Philips GmbH Forschungslaboratorium Aachen	Postfach 1980 D-5100 Aachen
Name of Principal Researcher Dr. H. Hörster	

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status

1. Aim

Analysis and evaluation of a wide variety of methods of rational use of energy and utilization of solar energy in buildings as regards economical use. Theoretical and experimental investigations in integrated energy systems in a test house with considerably modified building structure. Development of analysis method based on hourly meteorological data. Development of solar collectors of high efficiency.

Continuation overleaf /

Period of the Project: 18.6.74 - 31.12.77

Fund in $ US: 3935,882,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status:

- Continuation ....

2. Schedule

a) System analysis: investigation of various methods for optimization of solar and energy systems. Collation and investigation of meteorological data.

b) Development of high efficiency collectors. Investigation on selectively reflecting and absorbing coatings.

c) Designing an energy experimental house with considerably reduced energy requirement.

d) Designing the technical equipment of the experimental house consisting inter alia of heat pump system (for heat recovery, energy utilization from the ground, air conditioning), solar system (for hot water preparation, heating), controlled ventilation with heat recovery and a complete data collection system.

e) Test procedure and evaluation.

3. Relationship with other projects

Programme execution will take place in conjunction with RWE Essen and will make a contribution to the system study on industrial utilization of solar energy under reference ET 4045.

4. Progress

Hourly meteorological data from various meteorological stations were recorded on tape and evaluated. Solar data such as diffused, direct radiation for various orientation, intensity energy dependence on monthly and annual average were determined. The method of thermal analysis for optimization of energy systems was investigated. Several methods which describe the thermal behaviour of solar systems over the year were compared with one another. A

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status:

- Continuation ....

method of data compression was developed. Investigation of solar collectors was continued. Several configurations of cylindrical evacuated collectors were analysed and measured. Selectively absorbing coatings were investigated. Development and test of a specially effective selective absorber with alpha greater than equal 0.95 and epsilon less than equal 0.1 were commenced.

The energy experimental house was measured by means of automatic data collection. The specific energy requirement of the 75/76 heating season as well as the performance data of the individual energy systems of ventilation, heat pump and solar collector were established.

Country: JAPAN		March 1978
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** ☐ Solar Collector ☐ Heat Storage ☒ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☐ Materials Research ☒ Component Development
Name of Organization Ishikawajima-Harima Heavy Industries Co., Ltd.	Address: 2-16, 3 Toyosu, Koto-Ku, Tokyo, JAPAN 135-91	
Name of Principal researcher: Shinya Kameda		
Title of Project: R & D of solar heat actuated airconditioner for solar heating, cooling and hot water supply system in multi-family residence.		

Objective

The primary objective is to explore an energy conservative solar heat actuated airconditioner which is economically competitive with a conventional fossil fuel fired or electrically driven airconditioner.

Summary

a) Type:

Solar heat actuated Rankine Cycle Airconditioner

b) Type of refrigerator:

Vapour compressing type driven by a solar heat fired Rankine Cycle Engine

c) Capacity of refrigerator:

20 tons of refrigerator

d) Temp. range:

Rankine Cycle input temp.	70°C to 105°C
Condensing temp.	35°C to 45°C
Evaporating temp.	2.5°C to 8°C

e) C.O.P.:

The target coefficient of performance (COP) of the Rankine Cycle airconditioner, defined as the ratio of the actual cooling output to solar heat input to the power loop, is approximately 0.6.

f) Heat exchanger:

i) Freon boiler;

The heat exchanger to transfer the heat from the water to the Freon R-11 working fluid for the expander consists of 6-pass, shell and U-tubes having 20 m^2 of heat transfer area insulated with 50 mm insulation materials.

ii) Condenser;

The heat exchanger for cooling loop to transfer the heat from the Freon working fluid to the cooling water consists of 4-pass, shell and tubes having 42 m^2 of heat transfer area.

g) Auxiliary heat source:

Electricity

Period of the project: 1974-1980

Fund in US$: Current year (1978): 31,200 $.
Up to date total : 248,000 $.

Country: Japan		
Check the mar x in the head of line, corresponding to the respective components and type of research:	**Components** ☐ Solar Collector ☐ Heat Storage ☒ Air conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☐ Materials Research ☒ Component Development

Name of Organization:	Address:
KAWASAKI HEAVY INDUSTRIES, LTD	Osaka Works of Kawasaki Heavy Industries, Ltd. 1-35, 4-chome-Shimaya, Konohana-ku Osaka
Name of Principal Researcher:	
Dr. Toshiro Ozono, Mr. Kenji Ooka	

Title of Project: Development of large scale absorption machine which is operated in single effect by solar energy and in double effect by auxiliary heat source.

Objective and Nature of the Program:

We have investigated various types of refrigeration cycle along with the temperature of hot water from solar energy as a parameter, and then found out that the coefficiency of performance (COP) of H_2O - LiBr absorption chiller is most suitable for the solar cooling system.

The single effect type absorption chiller currently used for large buildings requires high temperature hot water or steam of 120°C - 130°C enough to regenerate the refrigerant. However, the efficiency of collection of solar heat decreases when it is operated at such a high temperature.

When the solar heat is practically collected at 85°C to 90°C and the conventional absorption chiller is used, the size of the ciller must be much larger and the temperature of the chilled water for cooling must be increased. For resolving the problem mentioned above, the regenerator, which will be able to separate the absorption liquid without any crystalization and also has a higher heat transfer efficiency at the considerably small temperature difference between hot water and liquid must be developed.

In 1974, a proto-type of regenerator itself with liquid film heat transfer (LFHT) system was manufactured and high performance was obtained in the testing. According to the testing result, we manufactured a 2.5 USRT experimental model using LFHT and tested it in 1975. The test results appeared to be good for solar cooling.

The double effect type absorption chillers having high COP are widely used for air-conditioning in Japan. In this case, high temperature steam or hot water at 180°C to 190°C are usually supplied to the chiller. The single effect type can be used for harnessing the solar energy and other auxiliary heat sources, but when the solar energy is dilute or on a rainy day the energy consumption of the single effect type will increase more than the double effect type.

On the other hand, if the double effect type is adopted, a high performance solar collector will be required for getting the high temperature heat source of 180°C to 190°C. To resolve this problem we developed the new system machine combined with the single effect operation by the solar energy and the double effect operation by the auxiliary heat source.

This system can harness the solar energy and the auxiliary heat separately and simultaneously. Relatively low temperature hot water heated by solar energy during poor solar radiation period can be used in the preheating system of double effect absorption machine.

When the solar collector by which the hot water of about 130°C is supplied with high efficiency, the double effect type absorption chiller could be operated by harnessing the solar energy.

Present Status of Summary of Significant Accomplishment:

a) type: Solar cooling

b) type of refrigerator:

We have investigated the COP of various kind of refrigerating cycle such as H_2O - LiBr absorption chiller, NH_3 - H_2O absorption chiller, Rankine cycle, steam-ejector system, IGT (Institute of Gas Technology) system, dehydration system and so on at the temperature range 70°C to 120°C, we found out that the COP of H_2O - LiBr absorption chiller is best among those units.

c) capacity:

A 2.5 USRT single effect absorption chiller tested at KHI's laboratory

A 2.5 USRT single effect and double effect combined type unit tested at KHI's laboratory

A 30 USRT single effect and double effect combined type unit being designed.

d) temp. range:

	Single effect	single - double effect combination	doube effect
chilled water	13 - 8	13 - 8	14 - 9
cooling water	31 - 38	single 31 - 38 double 31 - 36.5	31 - 36
heat source	85 - 77.5	single 85 - 77.5 double 2.0 kg/cm^2 (steam)	130 - 123

e) C.O.P.: single effect type unit ---------------------- 0.65

double effect type unit ---------------------- 1.00

single effect double effect type unit --------- 0.65 - 1.00

(The operation conditions of each unit are refered to d)

f) heat exchanger:

When the solar energy is collected by water as heat transfer medium, there are no heat exchangers. When the other types of heat transfer medium are used for collecting the solar energy, heat exchangers are required.

g) auxiliary heat source:

low pressure steam boiler (2 - 3 kg/cm^2)

- Period of the Project: for 7 years (1974 - 1980)

- Fund in $US: Current yeat (1976) - $60,000

- Important Reports or Publications: none

Format of Survey on Components for Solar Heating, Cooling and Hot water Supply Systems

Country: JAPAN		
Check the mark X in the head of line, corresponding to the respective components and type of research:	**Components** ☐ Solar Collector ☐ Heat Storage ☒ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research** ☐ Materials Research ☒ Component Development
Name of Organization: Mitsubishi Electric Corporation Name of Principal researcher: [illegible]	Address: 2-12, Marunouchi, Chiyoda-ku Tokyo	

Title of Project:

Development of the air conditioning unit driven by a solar powered Rankine-cycle engine.

- **Objective and Nature of the Program:**

Objective of the program is to develop a air conditioning unit driven by a solar powered Rankine cycle engine which has following features.

a) COP : 0.5 - 0.6

b) Cooling capacity : 1 - 5 ton

c) Boiler temperature : 90 - 100 °C

d) Condenser temperature: 35 - 40 °C

e) Chiller temperature : 5 - 10 °C

- **Present Status or Summary of Significant Accomplishment**

a) Type : Solar heating/cooling

b) Type of refrigerator : Vapour compression refrigerator driven by a solar powered Rankine cycle engine.

c) Capacity of refrigeration: 1 ton

d) Temp range

boiler temp : 90 °C

condenser temp : 38 °C

evaporator temp : 5°C

e) COP : 0.38

f) Heat exchanger

boiler	:	shell and coil type
condenser (for Rankine cycle)	:	shell and tube type
condenser (for chiller)	:	double tube type
evaporator (for chiller)	:	double tube type

g) Auxiliary heat source

- oil for heating
- electricity (motor) for cooling

Type of components and working fluid under development

a) Expander	:	sliding vane type
b) Compressor	:	rolling piston type
c) Feed pump	:	rotary type
d) Condenser	:	shell and tube type
e) Working fluid:		R114 (for Rankine cycle)
	:	R22 (for refrigeration cycle)

- Period of the Project

This project is a 7-year Solar Energy Research Program supported by MITI, from 1974 to 1980.

- Fund in \$ US: Current Year

\$30,000 (FY 1977)

- Important Reports or Publications:

None

Country :	THE NETHERLANDS	
	Components : ☐ Solar Collector ☐ Heat Storage ☒ Air Conditioning and Cooling Unit ☐ Other Substantial Components	**Type of Research :** ☐ Material Research ☒ Component Development

Name of Organisation :
DELFT UNIVERSITY OF TECHNOLOGY
Laboratory for Refrigerating Engineering

Address :
Mekelweg 2,
DELFT

Tel. 015 - 785040 or 786667

Name of Principal Researcher :
Ir. C. Keizer

Title of Project :

SOLAR POWERED ABSORPTION REFRIGERATING SYSTEMS

- Objective and Nature of the Program:

The research of the Delft University of Technology in the field of solar powered absorption cooling systems can be divided according to the following criteria:

1. evaporator temperature
2. place, where the refrigerator will be used.

ad 1: evaporator temperature.

a) an evaporating temperature > 5^{o}C.
   In this range refrigeration is mainly used for cooling purposes in air conditioning systems;
b) an evaporating temperature between -5^{o}C and -10^{o}C.
   In this range refrigeration is meant for short term storage of e.g. food;
c) an evaporating temperature of -25^{o}C.
   At this temperature freezing and thus long term storage of food is possible.

ad 2: place, where the refrigerator will be used.

Except the research which is done by checking the possibilities for solar cooling in The Netherlands, research has been done on the possibilities for solar cooling in countries with more sun, in particular in developing countries. In the last mentioned countries the requirements to the cooling system will be totally different. Production and operation of these systems should be very simple. Above all, these systems should be very reliable.
For countries with a lack of conventional energy, but with abundant solar energy (as in most developing countries), the absorption systems have an advantage, because they can operate with very few, or even without mechanical energy.

On behalf of these two criteria the research program is built and now exists of research for solar cooling for:

I. air conditioning in The Netherlands
II. air conditioning in developing countries
III. short term storage of food etc. in developing countries
IV. long term storage of food etc. in developing countries

Later on this program might be extended to research on solar cooling for:

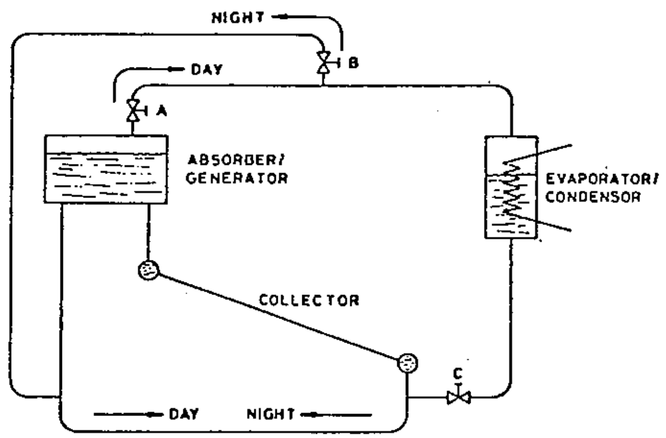
V. short term storage of food in The Netherlands
VI. long term storage of food in The Netherlands.

ad I; An experiment has been started to check the possibilities under the ruling circumstances of solar cooling of an office building.

see continuation 1

ad II: A design has been made for a periodically working LiBr-H_2O system with a cooling capacity, large enough to compensate the cooling load generated by the sun. It will be a window unit which can be placed in the wall of a house.

ad III: A pilot unit has been built which is working satisfactory now. It is a periodically working H_2O-NH_3 absorption refrigerating system, which can make ice.
At this moment it is possible to produce some 4 or 5 kg ice a day under tropical conditions. The area of the collector is 2 m^2. However, further research and development has to be done on the following issues:



SOLAR ICE MAKER

- condensor cooling at day time
Up till now the condensor is cooled by streaming water. In most cases there will be no cooling water available.
The condensor could either be air cooled or cooled by means of a cooling tower.

- returning the water which is transported from the generator to the evaporator during day time.

- automation of operating the system.
In the existing pilot unit valves have to be opened and to be closed for changing day and night phase, in which generation of refrigerant (NH_3) and evaporation (thus refrigeration) takeplace, respectively.
Experiments with non-return valves and with liquid shots have been carried out, but were not succesful yet.

- in general: increasing the efficiency of the whole system. A comparison will be made of 2 systems: a system with an integrated collector (the NH_3-H_2O mixture is the working fluid of the collector) will be compared with a non-integrated system (the collector has its own circuit with a different working medium, e.g. water under atmospheric conditions or under pressure).

ad IV: The activities on this subject are still in a theoretical phase.
It is not possible to realize an evaporator temperature of -25°C with flat plate collector and a periodically working or a continuously working one staged absorption system.
Research is done on multistaged systems.

ad V: In future the possibilities of solar cooling for domestic use in The Netherlandswill be checked.

see continuation 2

- Period of the project: The project has been started in 1976 and will be continued until 1981.

Continuation after this period will depend on the results, but should not be eliminated.

- Fund in $ US: For each year about $ 25,000.-.

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☒ Solar Collector ☒ Heat Storage ☒ Air Conditioning and Cooling Unit ☐ Other Substantial Components	☒ Material Research ☒ Component Development

Name of Organisation : N.V. PHILIPS GLOEILAMPEN FABRIEKEN	**Address :** Commercial Dept. Light - Solar Collectors Building EK-p EINDHOVEN tel. 040- 756716
Name of Principal Researcher : (Contact Person) Dr. Ir. S.H.A. Begemann	

Title of Project :

R&D ON SOLAR-THERMAL COMPONENTS

- Solar Collectors

Flat plate collectors (Eindhoven)

Improved top-insulation through application of layer of evecuated tubes.
. Absorber - steel (copper or aluminium optional)
. Cover - glass
. Insulation - polyisocyanurate
glasswool
evacuated glass tubes
. Maintenance free first 10 years
. Life time dependent on maintenance after 10 years
. Performance: $\alpha\tau = \pm 70\%$
$K = \pm 2.2\ W/m^2\,^oC$ at $\Delta\tau = 40^oC$
. Other info proprietary.

Tubular collector (Achen-Germany)

Absorber & heat exchanger inside vacuum. Heat pipe configuration
. Material - glass
. Insulation - vacuum
. Maintenance free first 10 years
. Life time dependent on maintenance after 10 years
. Performance: $\alpha\tau = \pm 80\%$
$K = \pm 1.7\ W/m^2\,^oC$ at $\Delta\tau = 80^oC$
. Other info proprietary.

Concentrating collectors (Eindhoven)

Line concentrating fresnell strip mirror with solar powered automatic tracking.
. Temperature max. 300^oC
. Material - glass
. Life time - 10-20 years
. Other info proprietary

- Heat Storage (Aahen-Germany)

a. Reversible chemical reactions for long term energy storage ($100-400^oC$)
b. Latent heat storage for low grade (roomtemp.) heat.
. Other info proprietary

see continuation 1

Continuation 1 R&D ON SOLAR-THERMAL COMPONENTS
(N.V. PHILIPS GLOEILAMPEN FABRIEKEN)

- Air conditioning & Cooling (Eindhoven)

a. Absorption - COP 1.5
b. Stirling cycle - COP 1.8 independent of temp. difference at $400^{\circ}C$ source temperature.

Capacity - < 20 kW
Other info proprietary.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION AirResearch Manufacturing Co. of Calif.	**ADDRESS:** 2525 W. 190th Street Torrance, CA 90509
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT

Development of a Solar Desiccant Dehumidifier

OBJECTIVE AND NATURE OF THE PROGRAM:

The program is aimed at the development of a solar desiccant dehumidifier featuring a rotary bed of granular silica gel and a rotary regenerator. This dehumidifier can be used for air conditioning through adialsatic saturation of the process air stream.

The program comprises three phases. Phase I covers the conceptual design of the system. Detailed design of the system will be performed in Phase II. Fabrication testing and evaluation in a simulated solar system is planned for Phase III.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

First semi-annual technical progress report in preparation. This report summarizes the preliminary design of the dehumidifier package.

PERIOD OF PROJECT: September 30, 1977 through September 29, 1980

FUND IN $ U.S. $681,694

IMPORTANT REPORTS OR PUBLICATIONS:

Air Conditioning and Cooling

a. type (heat pump, solar heating/cooling, ...)

solar cooling

b. type of refrigerator (absorption, ...; working medium,...)

desiccant

c. capacity of refrigerator (tons)

3 tons

d. temp. range 0 ($^{\circ}$C)

100°C - 12°C

e. C.O.P.

0.52

f. heat exchanger

Rotary regenerator for energy recovery

Fixed boundary finned tube heat exchanger for solar energy transfer

g. auxiliary heat source

fossil fuel (gas or fueld oil)

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION AiResearch Manufacturing Corp. of Cal. **NAME OF PRINCIPAL RESEARCHER** Mr. James Clark, NASA-MSFC, Tech. Mgr.	**ADDRESS:** 2525 West 190th Street Torrance, California 90509

TITLE OF PROJECT

Contract NAS8-32091

Solar Heating and Cooling Systems Design and Development

OBJECTIVE AND NATURE OF THE PROGRAM:

The objectives of this program are to design, develop and delivery prototype solar heating and hot water, and heating, hot water and cooling systems for single family, multi-family, light commercial, and commercial applications. Cooling subsystems to be developed are discrete 3, 25 and 75 ton Rankine cycle turbocompressor augmented by variable speed auxiliary motors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: Designs on the single family and light commercial heating and hot water systems have been completed and are being prepared for installation into their respective OTS. 3 and 25 ton chillers breadboards in test to confirm expected thermal performance.

PERIOD OF PROJECT:

July 1976 through September 1979

FUND IN $ U.S. $4.800 K

IMPORTANT REPORTS OR PUBLICATIONS:

None

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Rankine cycle turbo compressor heat pump solar heating and cooling system augmented with a variable speed motor drive.

b) type of refrigerator (absorption, ...; working medium, ...)

Turbo compressor using R-11 working fluid.

c) capacity of refrigerator (tons)

3 tons (single family)
25 tons (light commercial)
75 tons (commercial)

d) temp. range 0 ($^{\circ}$C)

150°F (65.5°C) to 195°F (90.6°C)

e) C.O.P. Rankine cycle

3 ton system: 0.55 to 0.80
25 ton system: 0.63 to 0.98
75 ton system: 0.63 to 0.98

f) heat exchanger

Hydronic to air

g) auxiliary heat source

Gas or oil (heating)
Electric (cooling)

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT ☒ SYSTEM DEVELOPMENT
NAME OF ORGANIZATION ARKLA INDUSTRIES INC.	**ADDRESS:** 819 East Franklin Street P. O. Box 534 Evansville, Indiana 47704
NAME OF PRINCIPAL RESEARCHER Richard H. Merrick	

TITLE OF PROJECT

Unitary Solar Heating/Cooling System Package Development

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Develop residential 3 ton unitary solar heating/cooling (absorption) system package.
2. Develop related application and installation software.
3. Develop commercial 25 ton system approach involving Arkla 25 ton WFB300 absorption chiller.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

A 3 ton system has been developed and commercialized using the Arkla WF36 absorption chiller.

PERIOD OF PROJECT:

June 1, 1977 to October 1, 1978

FUND IN $ U.S.

$924,988

IMPORTANT REPORTS OR PUBLICATIONS:

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar Heating/Cooling Unitary System

b) type of refrigerator (absorption, ...; working medium, ...)

Absorption

c) capacity of refrigerator (tons)

Residential - 3 Tons

Commercial - 25 Tons

d) temp. range 0 (°C)

Rated Cooling Capacity at 90.5°C Hot Water, 25.5°C Ambient WB and 7.2°C Chilled Water

e) C.O.P.

.72 at Rated Cooling Capacity.

f) heat exchanger

Fired by Hot Water.
Heating and Cooling delivered by hot or chilled water.

g) auxiliary heat source

Gas or oil fired boiler

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
ARKLA Industries, Inc.

NAME OF PRINCIPAL RESEARCHER
Richard H. Merrick

ADDRESS:
819 East Franklin Street
P.O. Box 534
Evansville, Indiana 47704

TITLE OF PROJECT
Engineering, Design, Construction and Testing of Salt Water Absorption Cooling Unit for use with a Solar Collector Heat Source.

OBJECTIVE AND NATURE OF THE PROGRAM:
The objective of this effort is to develop a 3 ton evaporatively cooled absorption chiller which would fire on 195°F hot water and produce 45°F chilled water. Three, 3-ton chiller units will be field tested. After field test experience, the design of the chiller will be refined with a view to production by ARKLA for availability for demonstration activity during the summer of 1979.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Field test units under construction. A lab unit has demonstrated target performance.

PERIOD OF PROJECT: 20 months (starting date: 7/1/76)

FUND IN $ U.S. 244,720

IMPORTANT REPORTS OR PUBLICATIONS:

ARKLA Industries, Inc. (Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Evaporatively Cooled Chiller

b) type of refrigerator (absorption, ...; working medium, ...)

Absorption

c) capacity of refrigerator (tons)

Three (3)

d) temp. range 0 (°C)

Rated capacity at 90.5°C hot water,
25.5°C ambient WB and 7.2°C chilled water

e) C.O.P.

.72 at Rated Capacity

f) heat exchanger

Fired from hot fluid
Cooling delivered via chilled water

g) auxiliary heat source

Any type boiler

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Energy Systems Division Carrier Corporation	ADDRESS: P. O. Box 4800 Syracuse, NY 13221
NAME OF PRINCIPAL RESEARCHER Wendell J. Biermann	

TITLE OF PROJECT

Single Family Absorption Chiller

OBJECTIVE AND NATURE OF THE PROGRAM:

To select best chemical system for air cooled, single family absorption chiller, collect necessary design data and prepare design. Construct Prototype chiller and operate under specified laboratory conditions simulating a range of anticipated conditions.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
Chemical system selected, design data being accumulated and design in progress

PERIOD OF PROJECT:

Oct. '78 to April'81

FUND IN $ U.S.

approx. $900,000

IMPORTANT REPORTS OR PUBLICATIONS:

Reviewed at Solar Cooling Workship, San Francisco, Feb. 1978

Air Conditioning and Cooling

a) **type (heat pump, solar heating/cooling, ...)**

Solar cooling

b) **type of refrigerator (absorption, ...; working medium, ...)**

absorption, air cooled. Lithium bromide and anti-crystallization additive.

c) **capacity of refrigerator (tons)**

10 KW

d) **temp. range 0 (°C)**

110°C solar fluid, 35°C ambient, 7°C chilled water is design goal.

e) **C.O.P.**

estimated about 0.68

f) **heat exchanger**

Plane fin absorber and condenser

g) **auxiliary heat source**

hot water

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Energy Systems Division Carrier Corporation	ADDRESS: P. O. Box 4800 Syracuse, NY 13221
NAME OF PRINCIPAL RESEARCHER Wendell J. Biermann	

TITLE OF PROJECT

Prototype Energy Recovery and Solar System

OBJECTIVE AND NATURE OF THE PROGRAM:

To design and construct an absorption chiller with a 15-ton rating and .74 COP at 180° firing water, 85° cooling water and 45-55°F chilled water. Useful cooling should be available to 165°F firing water or lower at above conditions. Lab test and install at Ross Control House, Bonneville Power Administration, Vancouver, Washington and operate for one cooling season with instrumentation.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Prototype lab tested and installed, awaiting cooling season.

PERIOD OF PROJECT:

to November 1978.

FUND IN $ U.S.

approx. $900,0000

IMPORTANT REPORTS OR PUBLICATIONS:

Reported at Solar Cooling Workshop, San Francisco February 1978

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

solar cooling

b) type of refrigerator (absorption, ...; working medium, ...)

lithium bromide absorption

c) capacity of refrigerator (tons)

15 tons, at 180°F design temperature

d) temp. range 0 (°C)

70 - 110°C

e) C.O.P.

.74 at design pt.

f) heat exchanger

Tube in shell, all heat exchangers

g) auxiliary heat source

hot water

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

CARRIER CORPORATION

ADDRESS:

CARRIER TOWER
P.O. BOX 4800
SYRACUSE, NEW YORK 13221

NAME OF PRINCIPAL RESEARCHER

RICHARD A. ENGLISH

TITLE OF PROJECT

HIGH TEMPERATURE SOLAR POWERED WATER CHILLER DEVELOPMENT

OBJECTIVE AND NATURE OF THE PROGRAM:

This is a program to develop a high temperature solar powered air cooled water chiller for commercial or multi-family air conditioning applications. It includes a conceptual design phase, a prototype design phase and a build and test phase. The objective is to develop a machine which will be cost effective in a selected solar system. The heat engine concept is a high speed Rankine turbine driving a centrifugal vapor compressor in a dual loop, single refrigerant, common condenser system.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Phase I, Conceptual Design, is approximately 2/3 completed.

PERIOD OF PROJECT:

October 1977–October 1980

FUND IN $ U.S.

$1,398,239

IMPORTANT REPORTS OR PUBLICATIONS:

None

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Air conditioner.

b) type of refrigerator (absorption, ...; working medium, ...)

Rankine driven vapor compression, dual loop, halocarbon refrigerant as working fluid.

c) capacity of refrigerator (tons)

25 tons at 300°F solar water

d) temp. range 0 (°C)

250°F-300°F

e) C.O.P.

$>$ 0.70

f) heat exchanger

Air cooled finned tube condenser.
Shell and tube boiler and cooler.
Finned tube regenerator and precooler.

g) auxiliary heat source

Electric Power.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Center for the Environment and Man, Inc.

ADDRESS:
275 Windsor Street
Hartford, CT 06120

NAME OF PRINCIPAL RESEARCHER
P. Lunde

TITLE OF PROJECT

Solar Desiccant Air Conditioning with Silica Gel.

OBJECTIVE AND NATURE OF THE PROGRAM:
The objective of this program is to design a realistic desiccant air conditioning system for use with low temperature solar collectors. Phase I goal is the construction and test of 1/4 capacity in realistic configuration. Phase II will demonstrate feasibility of a full size residential desiccant cooling system used with conventional flat plate collectors. Phase I tasks will include computer modeling, component design, 1/4 capacity bed design and test installation. Phase II tasks, includes full size A/C demonstration, dehumidifier demonstration, and heat exchange and desiccant research.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
1/4 capacity bed test has been initiated and full scale system preliminary design completed.

PERIOD OF PROJECT: 08-01-76 to 11-30-77

FUND IN $ U.S. CURRENT YEAR $103,000 FY77

TOTAL FOR THE PERIOD $143,155

IMPORTANT REPORTS OR PUBLICATIONS:
Solar Powered Desiccant Air Conditioning System, Final Report, Report No: NSF/RANN/SE/GI 44062/FR/75/1. Preliminary Design of a Solar-Powered Desiccant Air Conditioning System using Silica Gel: Report No. 4186-555

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Desiccant

b) type of refrigerator (absorption, ...; working medium, ...)

adsorption (silica gel)

c) capacity of refrigerator (tons)

two

d) temp. range 0 (^{o}C)

21-38

3) C.O.P.

1.6 (thermal)

f) heat exchanger

N.A.

g) auxiliary heat source

thermal, as desired

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

EIC Corporation

ADDRESS:

55 Chapel Street
Newton, Massachusetts 02158

NAME OF PRINCIPAL RESEARCHER

Peter O'D. Offenhartz

TITLE OF PROJECT

Solid Phase Absorbent Air Conditioning Studies

OBJECTIVE AND NATURE OF THE PROGRAM:

To design, construct, and test a solar air conditioner using a solid phase inorganic salt as the absorbent, and water as the refrigerant. Dehydrated inorganic salts can provide energy storage as well as refrigeration; hence, a system based on such salts will not require separate cold-side and hot-side energy storage.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

New Project

PERIOD OF PROJECT: September 20, 1977-September 30, 1978 (Phase I)

FUND IN $ U.S. $160,000

IMPORTANT REPORTS OR PUBLICATIONS: None to date.

EIC Corporation (Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar air conditioner, with integrated storage, using a solid-phase absorbent.

b) type of refrigerator (absorption, ...; working medium, ...)

Solid-phase absorption.

c) capacity of refrigerator (tons)

Ca. 3 tons.

d) temp. range 0 ($^{\circ}$C)

Not yet accurately known.

e) C.O.P.

0.6 (projected)

f) heat exchanger

Not yet designed.

g) auxiliary heat source

Any source of forced hot air.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Energy Technology Incorporated	**ADDRESS:** 4914 East 154th Street Cleveland, Ohio 44128
NAME OF PRINCIPAL RESEARCHER Cecil G. Martin	

TITLE OF PROJECT

Demonstration of a Solar Steam Engine for Heating and Cooling

OBJECTIVE AND NATURE OF THE PROGRAM:

The turbine technology to be developed under this contract, in conjunction with a hybrid Rankine cycle, will make possible the construction of a solar-Rankine air-conditioner with a heat rate of 8000 BTU/HR-TON. This is accomplished by superheating the output of a 300°F solar collector field either through the combustion of fossil fuel or with the output of a small parabolic dish collector (U.S. Patent 3,950,949).

The system can be operated such that the annual energy required to superheat the collector field output is less than 5 percent of the total annual energy consumption.

ETI's turbine also delivers good part load performance, which is important in a heating and cooling system since most of the operating hours are spent at off-design conditions.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Commencing design work on solar steam engine

PERIOD OF PROJECT:

September, 1977 To January, 1979

FUND IN $ U.S.

$279,552

IMPORTANT REPORTS OR PUBLICATIONS:

None to date

Energy Technology Incorporated , 4914 East 154 St. , Cleveland,Ohio
(Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar Steam Rankine Driven Air-Conditioner

b) type of refrigerator (absorption, ...; working medium, ...)

Vapor compression refrigeration unit

c) capacity of refrigerator (tons)

20 tons (demonstration unit)

d) temp. range 0 ($^{\circ}$C)

300°F (149°C) and up

e) C.O.P.

0.86 w/ 300°F solar collectors
1.20 w/ 400°F solar collectors

f) heat exchanger

Refrigerant-to-air

g) auxiliary heat source

Electricity or fossil fuel

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

General Electric Co.

ADDRESS:

Space Systems Division
Valley Forge, Pennsylvania

NAME OF PRINCIPAL RESEARCHER

William L. Moore, NASA-MSFC Tech. Mgr.

TITLE OF PROJECT

Contract NAS8-32092
Solar Heating and Cooling Systems Design and Development

OBJECTIVE AND NATURE OF THE PROGRAM:

This project is for the development of solar heating and combined solar heating and cooling systems and involves the complete design and development of marketable systems for single family and commercial applications and the delivery, installation, and monitoring of the prototype systems. The development of the two types of systems is proceeding in parallel with maximum commonality of system elements. The present project approach is to develop a solar driven Rankine engine to operate a vapor compression heat pump, utilizing a single working fluid at a maximum fluid temperature of 300°F (148.8°C). The program is to deliver 8 prototype heating and hot water, and heating, hot water and cooling systems to Operational Test Sites for data, analysis, and verification of systems performance and reliability. Chiller development is for both 3 and 10 ton cooling capacities.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Heating systems are presently being prepared for installation into Operational Test Sites. Cooling systems are presently being redesigned for improved manufacturability and commercialization.

PERIOD OF PROJECT:

July 1976 thru September 1979

FUND IN $ U.S.

$5.628M

IMPORTANT REPORTS OR PUBLICATIONS:

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Heating and cooling heat pump system employing a hermetically sealed expander-compressor-motor unit

b) type of refrigerator (absorption, ...; working medium, ...)

R-114 working fluid
Hermetically sealed expander-compressor

c) capacity of refrigerator (tons)

3 and 10 ton units

d) temp. range 0 (^{o}C)

Just under 300°F. (148.8°C)

e) C.O.P.

$>$ 1.0 predicted

f) heat exchanger

Hydronic to Air

g) auxiliary heat source

Gas or Electric

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Hittman Associates, Inc.	ADDRESS: 9190 Red Branch Road Columbia, Maryland 21045
NAME OF PRINCIPAL RESEARCHER Dr. H. M. Curran	

TITLE OF PROJECT

Assessment of Solar Powered Cooling of Buildings

OBJECTIVE AND NATURE OF THE PROGRAM:

The objectives of this continuation project are: (1) to provide technical and economic review and evaluation of solar cooling projects supported by the Energy Research and Development Administration and the Department of Energy, and (2) to develop a National Program Plan for Solar Cooling of Buildings. The Program Plan objective is to provide assistance to industry for the development and early commercialization of economically competitive solar cooling systems, in order eventually to meet a significant fraction of the national energy resource requirements for cooling.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Completed tasks include assessments of solar Rankine, solar/fossil Rankine, and solar absorption cooling; assessment of effects of reduced cooling loads by structural modification; review and evaluation of 20 R&D projects; development of draft of National Program Plan for Solar Cooling of Buildings.

PERIOD OF PROJECT:

33 months (starting date: 15 June 1975)

FUND IN $ U.S.

Current year: $108,124

IMPORTANT REPORTS OR PUBLICATIONS:

Assessment of Solar Powered Cooling of Buildings, Final Report, Report No. NSF-RANN-75-012, 1975.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Honeywell, Incorporated **NAME OF PRINCIPAL RESEARCHER**	**ADDRESS:** Energy Resources Center 2600 Ridgeway Parkway Minneapolis, Minnesota

TITLE OF PROJECT Contract NAS8-32093

Solar Heating and Cooling Systems Design and Development

OBJECTIVE AND NATURE OF THE PROGRAM: The objective of this program is to develop and deliver 2 prototype heating and domestic hot water systems for single family residences and 6 prototype heating, cooling and hot water systems for single family, multi-family, light commercial and commercial buildings. Cooling capacities shall be 3 tons for single family residences, 25 ton for multi-family or light commercial applications, and 75 ton (25 ton multiples) for commercial buildings. The above instrumented systems will be installed in OTS to provide test data for analyses and verification of system performance, reliability, and operational economics. Cooling units are solar driven Rankine cycle turbines coupled to either rotary vane or piston A/C compressors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: The two heating systems are being prepared for OTS installation. Installation is expected to be completed by December 1977. Component testing is underway on the 25 ton cooling systems. The 3 ton system is undergoing redesign for manufacturing.

PERIOD OF PROJECT:

July 1976 through September 1980

FUND IN \$ U.S.

\$3.9360 K

IMPORTANT REPORTS OR PUBLICATIONS:

None to date

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar heating and cooling systems employing a low temperature Rankine cycle turbine gear coupled to a rotary vane compressor via a motor-generator auxiliary unit.

b) type of refrigerator (absorption, ...; working medium, ...)

Rankine turbine fluid: R-113
Compressor (rotorary vane) fluid: R-22
Direct drive from turbine to compressor

c) capacity of refrigerator (tons)

3 ton

d) temp. range 0 (°C)

Design potential: 195°F (90.6°C)
Minimum design point: 155°F (68.3°C)

e) C.O.P.

0.6 to 0.8 (Rankine cycle)
5.82 (refrigeration)

f) heat exchanger

Freon to air

g) auxiliary heat source

Gas, oil or electric (heating)
Electric (Cooling)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar assisted heating and cooling, and hot water system for multi-family, light commercial, and commercial applications utilizing a hydronic to warm-air heating system, a Rankine cycle driving a 25 ton or 75 ton water chiller which operates at a constant speed, and a domestic hot water system.

b) type of refrigerator (absorption, ...; working medium, ...)

Rankine cycle fluid: R-113
Compressor fluid: R-12
Drive between turbine and compressor via over-running clutch

c) capacity of refrigerator (tons)

25 tons or 3 each 25 ton multiples

d) temp. range 0 ($^{\circ}C$) Control Range: $-65.6^{\circ}C$ to $93.3^{\circ}C$
Design point: $-190^{\circ}F$ ($87.8^{\circ}C$)

e) C.O.P.

0.6 to 0.8 (Rankine cycle)
6.0 (refrigeration)

f) heat exchanger

Freon to air

g) auxiliary heat source

Gas, oil or electric (heating)
Electric (Cooling)

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Illinois Institute of Technology

ADDRESS:
Illinois Institute of Technology
3110 South State Street
Chicago, Illinois 60616

NAME OF PRINCIPAL RESEARCHER (s)
Zalman Lavan and Dimitri Gidaspow

TITLE OF PROJECT

DEVELOPMENT OF A SOLAR DESICCANT DEHUMIDIFIER

OBJECTIVE AND NATURE OF THE PROGRAM:

The program is both analytical and experimental. The objective is to design, build, and test a desiccant air conditioning system that could be operated with flat plate solar collectors.

A sheet-like material made of micron size silica gel bound by a Teflon grid serves as the desiccant. This material is incorporated into a cross flow heat exchanger. The process stream flows in channels made of the desiccant material and a cooling stream of air flows in perpendicular channels. Adsorption will then take place at near iso-thermal conditions, maximizing the performance. Also the pressure drop, hence pumping power, will be low. A prototype of the cross flow desiccant heat exchanger will be incorporated into a complete solar cooling system that will be tested.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

PERIOD OF PROJECT:

(3 years) September 1977 thru September 1980

FUND IN $ U.S.

$590,350.00

IMPORTANT REPORTS OR PUBLICATIONS:

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling,....)

Air-conditioner

b) type of refrigerator (absorption, ...; working medium, ...)

Adsorption, air

c) capacity of refrigerator (tons)

2- 3 tons

d) temp. range 0 (^{O}C)

e) C.O.P.

2.0

f) heat exchanger

Cross flow desiccant dehumidifier

g) auxiliary heat source

Gas or electricity

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Institute of Gas Technology	**ADDRESS:** 3424 South State Street Chicago, Illinois 60616
NAME OF PRINCIPAL RESEARCHER Robert A. Macriss	

TITLE OF PROJECT

Solar Desiccant Air-Conditioner (Solar-MEC™) Development

OBJECTIVE AND NATURE OF THE PROGRAM:

This is an experimental and analytical project with emphasis on process modeling for design optimization (for which little previous data exists), and on hardware performance improvements (identified as necessary during an earlier phase of development). The test and evaluation program encompasses the desiccant and heat exchanger wheel, the desiccant support matrix material, air-seals, and the process as a whole.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Desiccant wheel performance measurements have been completed and process modeling for optimization is underway. Air-leakage tests and necessary improvements have been implemented. Heat exchanger testing is underway.

PERIOD OF PROJECT:

September 1977 - September 1978 (and continuing)

FUND IN $ U.S.

$254,000

IMPORTANT REPORTS OR PUBLICATIONS:

Institute of Gas Technology Report: NSF-8969 Final

Institute of Gas Technology (Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar heating/cooling

b) type of refrigerator (absorption, ...; working medium, ...)

Open-cycle desiccant system

c) capacity of refrigerator (tons)

2.5 - 75 tons

d) temp. range 0 (°C)

Collector delivered temperatures from 160° - 270°F (70° - 130°C)

e) C.O.P.

0.8

f) heat exchanger

Rotary regenerative

g) auxiliary heat source

Natural gas burner

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Institute of Gas Technology	**ADDRESS:** 3424 South State Street Chicago, Illinois 60616
NAME OF PRINCIPAL RESEARCHER Robert A. Macriss	

TITLE OF PROJECT

Development of New Fluids for Solar Absorption Cooling

OBJECTIVE AND NATURE OF THE PROGRAM:

This is primarily an experimental and analytical project, dealing with the identification, basic data developmental, and evaluation of new candidate fluid systems for solar absorption cooling. The emphasis is placed on systems that would result in increased COP when operating with air-cooled condenser and absrober and suitable solar input temperatures. The effort to date has focused on refrigerant-absorbent solutions that deviate positively from Raoult's law ideal behavior.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

The identification of many potential systems has been completed and the data development and evaluation of candidate pairs is under way.

PERIOD OF PROJECT:

September 1977 — September 1978

FUND IN $ U.S.

$96,500

IMPORTANT REPORTS OR PUBLICATIONS:

"Selecting Refrigerant-Absorbent Fluid Systems for Solar Energy Utilization," R.A. Macriss. Paper presented at the ASHRAE Semiannual Meeting, Dallas, February 1—5, 1976.

Institute of Gas Technology (Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar cooling

b) type of refrigerator (absorption, ...; working medium, ...)

Absorption

c) capacity of refrigerator (tons)

2.5 — 5 tons

d) temp. range 0 (°C)

75 — 150°C

e) C.O.P.

0.6 (minimum)

f) heat exchanger

Air-cooled finned tube for condenser and absorber

g) auxiliary heat source

Natural gas burner

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Lawrence Berkeley Laboratory	ADDRESS: University of California Berkeley, California 94720
NAME OF PRINCIPAL RESEARCHER Kim Dao	

TITLE OF PROJECT

Development of Solar-Driven Absorption Air-Conditioners and Heat-Pumps

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this project is the development of absorption air conditioners for solar cooling applications. The approaches being investigated are those that avoid the necessity for water cooling towers (and instead use air-cooled condensers and absorbers) and those leading to COP's (Coefficient of Performance) that increase as the input temperature increases. This is primarily an experimental project, with the emphasis on designing, fabricating and testing absorption chillers in operating regimes that are particularly suited for solar energy applications, and for which no previous experimental data exist. All of the effort to date has involved the use of ammonia-water absorption cycles. Commercialization opportunities are being explored with the assistance of industrial firms.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

First experimental chiller was fabricated and tested, and the results were published. Second prototype of single-effect chiller has been designed and all components have now been fabricated. Assembly and testing will follow.

PERIOD OF PROJECT:

Oct. 1977 - Sept. 1978 (and continuing)

FUND IN $ U.S.

$180,000

IMPORTANT REPORTS OR PUBLICATIONS:

Lawrence Berkeley Laboratory Reports: LBL-3293, LBL-5224, LBL-5911, and LBL-5982.

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Air-conditioner

b) type of refrigerator (absorption, ...; working medium, ...)

Absorption, single-effect, ammonia-water

c) capacity of refrigerator (tons)

3 tons at 100°C
5 tons at 125°C

d) temp. range 0 (°C)

Generator: 77-150°C
Condenser-Absorber: 35-53°C
Evaporator: 1-10°C

e) C.O.P.

.65

f) heat exchanger

Air-cooled finned tubes for condenser and absorber
Tube-in-tube, coaxial and triaxial for other components

g) auxiliary heat source

Gas

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Lawrence Berkeley Laboratory	ADDRESS: University of California Berkeley, CA. 94720
NAME OF PRINCIPAL RESEARCHER Michael Wahlig - Ridgway Banks	

TITLE OF PROJECT

Nitinol Engine Project

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of this project is to determine the feasibility of applying the shape-memory effect in certain intermetallic compounds (particularly "55-Nitinol") to the conversion of heat energy to work by means of solid-state heat engines. A primary milestone is the development of a prototype Nitinol engine on a scale suitable for powering a moderate-sized residential air conditioner with solar heated hot water. Other promising applications include the use of these engines for irrigation pumping, ocean thermal energy conversion, and utilization of waste heat.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

An experimental cycle simulator that will be used to determine work output and conversion efficiency of single Nitinol wires has been designed and fabricated. Rigorous theoretical and empirical materials studies are continuing.

PERIOD OF PROJECT:

Oct. 1977 - Sept. 1978 (and continuing)

FUND IN $ U.S.

$190,000

IMPORTANT REPORTS OR PUBLICATIONS: Banks, R., "Nitinol Heat Engines," from Shape Memory Effects in Alloys, J. Perkins, ed.; Plenum Publishing Corp., 1976.
Mohamed, H.A., Washburn, J., "Deformation Behavior and Shape Memory Effect of Near Equi-Atomic NiTi Alloy," Journal of Materials Science 12, 1977, 469-480.
Banks, R., Wahlig, M. "Nitinol Engine Development," LBL Report LBL-5293, 1976.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Los Alamos Scientific Lab.

ADDRESS:
Los Alamos, NM 87545

NAME OF PRINCIPAL RESEARCHER
J. Balcomb

TITLE OF PROJECT
Design of a Solar Rankine Cooling Unit

OBJECTIVE AND NATURE OF THE PROGRAM:

The principal objectives of this work are to design, procure and test a 77-ton solar powered Rankine-cycle/vapor-compression cycle cooler. The design will be compatible with flat plate collector performance. The Unit will be installed in the National Security and Resources Study Center at LASL. Its performance will be recorded and evaluated in a side-by-side comparison with a solar-powered lithium bromide absorption chiller under various design and off-design conditions. The reliability and maintenance costs of both coolers will be compared.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Design report has been released and detailed drawings and specifications issued.

PERIOD OF PROJECT: 24 months, (starting date: 1/4/75)

FUND IN $ U.S. Current Year $207,000

Total for the Period

IMPORTANT REPORTS OR PUBLICATIONS:

Design of A 77 Ton Solar Rankine Cycle Air Conditioning Unit for the National Security and Resources Study Center at Los Alamos, New Mexico., July 1975

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT x COMPUTER MODELING OF COMPONENTS AND SYSTEMS
NAME OF ORGANIZATION University of Maryland	**ADDRESS:** Mechanical Engineering Department University of Maryland College Park, MD 20742
NAME OF PRINCIPAL RESEARCHER Dr. R.W. Allen and Dr. D.K. Anand	

TITLE OF PROJECT

Solar Cooling Component Modeling and Optimization

OBJECTIVE AND NATURE OF THE PROGRAM:

Objectives of the research are:

1. Development of detailed cooling component models
2. Validation of cooling component models via manufacturers' performance data.
3. Development of a simplified program for cooling component model performance.
4. Optimization studies of complete solar cooling systems.
5. Study of control strategies.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Simplified program for absorption cooling machine performance has been completed.

PERIOD OF PROJECT:

7/1/77 - 6/30/79

FUND IN $ U.S.

1st year - $111,000
2nd year - $118,000

IMPORTANT REPORTS OR PUBLICATIONS:

"Simulation of a Lithium Bromide-Water Absorption Refrigeration System," Jan. 1978.
"Solar Powered Rankine Cycle/Vapor Compression Cycle Modeling and Performance Prediction," November 1977.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS

- [x] SOLAR COLLECTOR
- [ ] THERMAL ENERGY STORAGE
- [x] AIR CONDITIONING UNIT
- [ ] OTHER SUBSTANTIAL COMPONENTS

TYPE OF RESEARCH

- [x] MATERIAL RESEARCH
- [x] COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

M.I.T. Lincoln Laboratory

ADDRESS:

P. O. Box 73
Lexington, MA 02173

NAME OF PRINCIPAL RESEARCHER

Dr. D. I. Tchernev

TITLE OF PROJECT

INTEGRATED ZEOLITE COLLECTORS

OBJECTIVE AND NATURE OF THE PROGRAM: The objective of the program is to develop an integrated collector for solar heating and cooling systems utilizing the adsorption and desorption of water from molecular sieve zeolites. The specific tasks are to design, construct, and test a prototype of such a collector, capable of providing hot water during the day and chilled water at night, which will act as one-for-one replacement for existing hot water solar collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: Non-integrated zeolite collectors for solar heating and cooling have been developed under a previous project. Integration of the evaporator and condenser with the collector will be the goal of the present project.

PERIOD OF PROJECT:

(Proposed) November 1977 - October 1978

FUND IN $ U.S.

(Proposed) $150,000

IMPORTANT REPORTS OR PUBLICATIONS: Proceedings of "Zeolite 76" Conference (to be published).

Final Report NSF/RA-770017.

M.I.T. Lincoln Laboratory (Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Solar heating and cooling

b) type of refrigerator (absorption, ...; working medium, ...)

adsorption; zeolite and water vapor

c) capacity of refrigerator (tons)

~ 0.05 per collector (15-20 sq. feet)

d) temp. range 0 ($^{\circ}$C)

cooling, 5-10°C; heating, 40-50°C

e) C.O.P.

0.4 (total including collector)

f) heat exchanger

liquid to vapor

g) auxiliary heat source

none

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION RCA Corp., Gov't. & Comm. Systems	ADDRESS: Delaware & Cooper Streets Camden, N. J. 08102
NAME OF PRINCIPAL RESEARCHER M. S. Crouthamel	

TITLE OF PROJECT
Air Conditioning using a Regenerative Gas Cycle

OBJECTIVE AND NATURE OF THE PROGRAM: The objective of this program was to demonstrate the applicability of a regenerative gas expansion cycle (Vuilleumier cycle) to provide air conditioning. The key elements required for practicability of this cycle are high performance thermal regenerators and working fluid/water heat exchangers. These components are required to have low flow friction, low void volume and highly uniform gas flow spaces to be effective. Prototype versions of these components were fabricated and integrated into a 1/16 ton unit but funding limitations stopped the program.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Prototype 1/4 ton unit fabricated but not debugged or thermodynamically tested. Work terminated due to lack of funds.

PERIOD OF PROJECT:

Terminated.

FUND IN $ U.S. Total for the program - $260,000

IMPORTANT REPORTS OR PUBLICATIONS: Solar Driven Air Conditioning System, Semiannual Status Report, Report No. COO/2938-77/1

RCA Corp., Gov't & Comm. Systems (Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Heat pump/air conditioner

b) type of refrigerator (absorption, ...; working medium, ...)

Regenerative gas cycle using hydrogen or helium.

c) capacity of refrigerator (tons)

1/4 ton

d) temp. range 0 ($^{\circ}C$)

Hot water in = 225°F, Ambient water in = 100°F, Cold water in = 40°F.

e) C.O.P.

C.O.P. = .3 (cooling at 40°F/heat at 225°F)

f) heat exchanger

Conventional water to air heat exchangers.

g) auxiliary heat source

Not used.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION United Technologies Research Center	**ADDRESS:** 400 Main Street East Hartford, CT 06108
NAME OF PRINCIPAL RESEARCHER F. Biancardi	

TITLE OF PROJECT

Test and Evaluation of Solar Powered Turbocompressor Rankine Cycle for Building Air Conditioning

OBJECTIVE AND NATURE OF THE PROGRAM: The objective of this program is to demonstrate laboratory operation and performance of Rankine cycle turbocompressor air conditioning system at flat plate solar collector temperatures. The effort will include: (1) characterization tests at water-cooled and air-cooled condenser temperature levels over a selected range at turbine inlet conditions; (2) turbine design for high capacity operation at temperature levels below those achievable with present day absorption equipment; and (3) evaluation and further modification of turbocompressor to permit operation at turbine inlet temperatures consistent with medium concentrating collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: Feasibility demonstration test has been conducted with all system performance goals met. System performance was verified and low (160F) and high (240F) temperature operation demonstrated. Substantial improvements in system performance were demonstrated with minor component modifications. More than 700 hr of operation achieved.

PERIOD OF PROJECT:

13 months, (starting date: 1 /15/76)

FUND IN $ U.S.

CURRENT YEAR $219,388
TOTAL FOR THE PERIOD

IMPORTANT REPORTS OR PUBLICATIONS: Feasibility Demonstration of Solar-Powered Turbocompressor Air Conditioning and Heating System, Final Report, Report No: C0054-C903/75/1 Test and Evaluation of Solar Powered Turbocompressor Rankine Cycle for Building Air Conditioning. March 1977, C00-2824-1

United Technologies Research Center (Data Sheet)

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

Air conditioning, heat pump potential identified

b) type of refrigerator (absorption, ...; working medium, ...)

Rankine cycle double loop system - R11 working fluid in both loops

c) capacity of refrigerator (tons)

Three-to-five tons, depending upon operating temperatures of vapor generator, and condenser

d) temp. range 0 (^{o}C)

160 to 240 F in vapor generator, 90 F to 120 F in condenser

e) C.O.P.

Varies from 0.35 to 0.55

f) heat exchanger in Rankine cycle (power and cooling loop) vapor generator condenser(s) and evaporator, none envisioned for storage/collector interface.

g) auxiliary heat source, used steam to simulate solar thermal input in fully developed system could use oil- or gas-fired furnace, or electric motor/generator system.

OTHER SUBSTANTIAL UNITS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☐ COMPONENT DEVELOPMENT x SYSTEM ANALYSIS

NAME OF ORGANIZATION
Institut für Physikalische Chemie
University of Vienna

ADDRESS:
Währingerstrasse 42
A-1090 Vienna
Austria

NAME OF PRINCIPAL RESEARCHER
Prof. Dr. Roland Stickler

TITLE OF PROJECT
Development of a Measurement and Control System for Solar Energy Systems

OBJECTIVE AND NATURE OF THE PROGRAM:

The technical and economic parameters influencing the operation of solar systems for the production of low temperature heat were studied and analysed. On the basis of this study guidelines were worked out for the installation of solar systems in new buildings as well as for retrofitting in old buildings. Moreover, the importance of solar energy for the energy situation in Austria was studied.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
The results of this study, which are being evaluated, are of importance for the installation of solar systems, in particular for the integration of solar systems in conventional heating systems.

PERIOD OF PROJECT:

23.9.1975 - 1.10.1977

FUND IN $ U.S. CURRENT YEAR

TOTAL FOR THE PERIOD 18.000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☒ Systems Development
☒ Heat Pump	☒ Production Research
☐	

Name of Organisation:	Address:
Brown, Boveri + Cie. AG	Postfach 351 D-6800 Mannheim
Name of Principal Researcher Dr. F. Weil	

Title of the Project: Production of a solar collector installation for heating an openair swimming pool

Objective and Nature of the Project, Present Status

1. Aim

Planning, design and erection of a solar collector installation for heating an openair swimming pool.

2. Schedule

a) Erection of a solar collector installation for endurance tests and demonstration purposes, consisting of 1100 collectors.

b) Development of production methods for solar collectors in mass production.

Continuation overleaf /

Period of the Project: 19.12.74 - 31.12.76

Fund in $ US: 716,000,- Government Contribution: 100%

Important Reports or Publications:

Title of the Project: Production of a solar collector installation for heating an openair swimming pool

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Relationship with other projects

The project is based on initial test series of ET 4025. Tests on the solar collector installation will be carried out within the framework of project ET 4124 A.

4. Progress

Planning, erection and commissioning of the solar collector battery have been completed.

Country : Federal Republic of Germany

Components	Type of Research
☐ Solar Collector	☒ Materials Research
☐ Heat Storage	☒ Component Development
☐ Air Conditioning and Cooling Unit	☐
☒ Control Systems	☐
☒ Heat Carrier	

Name of Organisation:	Address:
Klöckner + Co., Abt. Wärmetechnik Werk Heckingen	Klöckner + Co. Postfach 1oo1o5, D-41oo Duisburg
Name of Principal Researcher: Ing. (grad.) Meyer	

Title of the Project: Development of control systems for solar heating systems in service water and heating installations. Selection of a heat carrier. Trial.

Objective and Nature of the Project, Present Status

1. Aim

Development of control systems for extraction of heat from solar collectors and use of the heat for service water preparation, building heating, swimming pool water heating. Selection of a heat carrier. Development of prefabricated assemblies for solar heating systems.

2. Schedule

a) Summary of common service water and heating systems.
b) Selection of suitable systems for solar auxiliary heating.

Continuation overleaf /

Period of the Project: 1.4.76 - 31.12.79

Fund in $ US: 380,280,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Development of control systems for solar heating systems in service water and heating installations. Selection of a heat carrier. Trial

Objective and Nature of the Project, Present Status:

- Continuation ....

c) Preparation of installation diagrams for b).

d) Selection and trial of suitable materials for pipes, valves, pumps, heat exchangers and insulation materials when using synthetic heat carriers.

e) Selection, trial and development of regulation and control equipment.

f) Structural preparation of assemblies ready for connection, trial and co-ordination with construction authority regulations.

3. Relationship with other projects

Development is taking place in collaboration with Metallgesellschaft AG for the rollbond process solar collectors to be developed (ET 4051/4).

4. Progress

The standardized service water preparation systems in accordance with DIN 1988 with the service water preparation units in accordance with DIN 4800 to 4804, the building heating systems which are only standardized as regards calculation (DIN 4701) and components and the swimming pool heating systems have been combined and from this suitable layouts have been provisionally selected for the solar heating systems. For this purpose installation diagrams have been prepared concentrating initially on service water heating, including the temperature control system. Commercially available instruments, fittings, pumps, heat carriers etc. have been checked for their use as regards stability (thermal, chemical) and selected for tests. A test installation has been erected in which the behaviour of the materials, of the heat carrier, of the control gear at various temperatures and rates of flow is being determined. These investigations with three aluminium collectors pro-

Title of the Project: Development of control systems for solar heating systems in service water and heating installations. Selection of a heat carrier. Trial.

Objective and Nature of the Project, Present Status:

- Continuation ....

duced by the rollbond method commenced at the end of August 1976 and will also be continued in 1977.
The tests with mixed materials in the test installation, such as iron hot galvanised, cold galvanised, aluminium, brass, gunmetal, malleable cast iron and plastics when using a synthetic heat carrier will provide information on corrosion behaviour in 1977. Initial findings on the switching behaviour of the temperature control system have led to modification of the equipment which is being carried out at present. One control unit for service water preparation unit is now in the design stage and should be tested in 1977. A suitable accumulator designed for bivalent heating has been selected and is being examined

Country : Federal Republic of Germany

Components	Type of Research
☒ Solar Collector	☐ Materials Research
☒ Heat Storage	☒ Component Development
☒ Air Conditioning and Cooling Unit	☐
☒ Heat Pump	☐
☐	

Name of Organisation:	Address:
Philips GmbH Forschungslaboratorium Aachen	Postfach 1980 D-5100 Aachen
Name of Principal Researcher Dr. H. Hörster	

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status

1. Aim

Analysis and evaluation of a wide variety of methods of rational use of energy and utilization of solar energy in buildings as regards economical use. Theoretical and experimental investigations in integrated energy systems in a test house with considerably modified building structure. Development of analysis method based on hourly meteorological data. Development of solar collectors of high efficiency.

Continuation overleaf /

Period of the Project: 18.6.74 - 31.12.77

Fund in $ US: 3935,882,- Government Contribution: 50%

Important Reports or Publications:

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status:

- Continuation ....

2. Schedule

a) System analysis: investigation of various methods for optimization of solar and energy systems. Collation and investigation of meteorological data.

b) Development of high efficiency collectors. Investigation on selectively reflecting and absorbing coatings.

c) Designing an energy experimental house with considerably reduced energy requirement.

d) Designing the technical equipment of the experimental house consisting inter alia of heat pump system (for heat recovery, energy utilization from the ground, air conditioning), solar system (for hot water preparation, heating), controlled ventilation with heat recovery and a complete data collection system.

e) Test procedure and evaluation.

3. Relationship with other projects

Programme execution will take place in conjunction with RWE Essen and will make a contribution to the system study on industrial utilization of solar energy under reference ET 4045.

4. Progress

Hourly meteorological data from various meteorological stations were recorded on tape and evaluated. Solar data such as diffused, direct radiation for various orientation, intensity energy dependence on monthly and annual average were determined. The method of thermal analysis for optimization of energy systems was investigated. Several methods which describe the thermal behaviour of solar systems over the year were compared with one another. A

Title of the Project: Rational use of energy and utilization of solar energy in buildings

Objective and Nature of the Project, Present Status:

- Continuation ....

method of data compression was developed. Investigation of solar collectors was continued. Several configurations of cylindrical evacuated collectors were analysed and measured. Selectively absorbing coatings were investigated. Development and test of a specially effective selective absorber with alpha greater than equal 0.95 and epsilon less than equal 0.1 were commenced.
The energy experimental house was measured by means of automatic data collection. The specific energy requirement of the 75/76 heating season as well as the performance data of the individual energy systems of ventilation, heat pump and solar collector were established.

Country :	THE NETHERLANDS	
	Components :	**Type of Research :**
	☐ Solar Collector ☐ Heat Storage ☐ Air Conditioning and Cooling Unit ☒ Other Substantial Components	☐ Material Research ☒ Component Development

Name of Organisation : Raadgevend Technies Buro VAN HEUGTEN B.V.	**Address :** St. Annastraat 145, P.O. Box 305 NIJMEGEN tel. 080-228317
Name of Principal Researcher : Mr. G. Brouwer	

Title of Project :

R&D ON OTHER SUBSTANTIAL SOLAR ENERGY COMPONENTS

- Objective and nature of the program

* Research on the system control, reliability and safety
* Research on the performance and the optimalisation of the capacity of solar system components.

- Present status or summary of significant accomplishments

Several solar energy systems of different applications are worked out and realised.

- Publications

1. "Het gebruik van zonnewarmte voor verwarmingsdoeleinden"
   G. Brouwer (Verwarming en Ventilatie, november 1975).
2. "Warmwatervoorziening in woningen en andere projekten door middel van zonnewarmte kollektoren".
   P.H.H. Leijendeckers (Postakademiale kursus "De zon als verwarmingsbron", T.H. Delft, maart/april 1975).
3. Nota "Doelmatig energieverbruik"
   P.H.H. Leijendeckers, E.H. Lysen, a.o. (Vereniging Milieudefensie, november 1976)
4. "Zonnewarmte installaties"
   G. Brouwer (Verwarming en Ventilatie, juni 1977).

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: NEW ZEALAND

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Zip Holdings Ltd. NAME OF PRINCIPAL RESEARCHER O.M. Kendon	ADDRESS Box 30-669 Lower Hutt, N.Z.

TITLE OF PROJECT

Develop economic domestic solar water heater

OBJECTIVE AND NATURE OF THE PROGRAMME:

Object was to reduce overall cost of solar auxillary equipment, including installation costs. Specifically
(a) to develop a solar operated pump
(b) simplify design and manufacture of collectors
(c) produce a control system to optimise savings.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
(a) Temporarily shalved
(b) and (c) units produced and tested in prototype - factory production planned.

PERIOD OF PROJECT:

FUND IN $ NZ 13,000

IMPORTANT REPORTS OR PUBLICATIONS:

<table>
<tr><td colspan="3">Country: Sweden</td></tr>
<tr><td>Check the mark x in the head of line, corresponding to the respective components and type of research:</td><td>Components
☒ Solar Collector
☐ Heat Storage
☐ Air Conditioning and Cooling Unit
☒ Other Substantial Components</td><td>Type of Research
☐ Materials Research
☒ Component Development</td></tr>
<tr><td>Name of Organization:

Name of Principal researcher:
Gösta Jansson</td><td colspan="2">Address:
AB Svenska Fläktfabriken
Equipment Division
Fack
551 84 JÖNKÖPING SWEDEN</td></tr>
<tr><td colspan="3">Title of Project:
AMPLITERM</td></tr>
</table>

AMPLITERM is an energy saving system, based on a combination of solar collectors and heat pump. It is mainly intended for heating of private houses.

Liquid is used as an absorbing medium. It circulates through collectors of a special type, absorbing heat from direct and indirect solar radiation and/or from outdoor air, which is made to flow across the panel. Three different ways of operating can be separated:

1. High solar intensity. The air flow through the collectors is shut off, and the liquid absorbs solar energy. The temperature of the liquid after the collectors is high enough for use, and the liquid is pumped directly to the storage tank.

2. Low solar intensity. Outdoor air is streaming through the collectors. The liquid is absorbing energy from both solar radiation and air. The temperature of the liquid after the collectors is higher than it should have been without support from solar energy, but not high enough to be used for heating. Therefor, the liquid is pumped to the heat pump, where the temperature level is increased with a good COP. In another liquid circuit the high temperature energy is transfered to the storage tank.

3. No solar radiation. Outdoor air is streaming through the collectors. The liquid is absorbing low temperature energy from the air, and the temperature level is increased by means of the heat pump.

Country: Sweden

Check the mark X in the head of line, corresponding to the respective components and type of research:	Components	Type of Research
	☐ Solar Collector	☐ Materials Research
	☐ Heat Storage	☒ Component Development
	☐ Air Conditioning and Cooling Unit	
	☒ Other Substantial Components	

Name of Organization:
AB Atomenergi

Name of Principal researcher:
A Johansson

Address:
Fack
S-611 01 NYKÖPING
Sweden

Title of Project:

Plastic Convectors

In low temperature solar heating systems the heat flux is low in the heating components, for example in heat convectors. Consequently, the thermal properties of the heat conducting materials are less important and cheaper materials can be used. Plastic pipes can be used for temperatures below 80°C.

Design

The convectors consist of plastic pipes with different lengths (30 - 60 metres) and with a front plate made of steel or reinforced polyester.

Program of the project

Prototypes of plastic convectors have been made and simple tests have been done in a standardized room of measurements. Experiences from different applications are evalued and efforts are made for getting the plastic convectors accepted with respect to fire characteristics.

Test results

Heat transfer coefficients of 6 - 11 W/m^2K have been measured. The coefficients depend strongly on the length of the chimney.

Publication

No publication is available.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION

Battelle's Columbus Laboratories

ADDRESS:

505 King Avenue
Columbus, Ohio 43201

NAME OF PRINCIPAL RESEARCHERS

R. D. Fischer/J. A. Eibling

TITLE OF PROJECT

Development of Solar Powered Heat Pump Utilizing Pivoting-Tip-Vane Rotating Equipment

OBJECTIVE AND NATURE OF THE PROGRAM:

Develop pivoting-tip-vane rotary compressor/expander for use in an advanced concept of a novel Rankine-cycle-powered heat-pump system for solar heating and cooling of buildings. Layout design drawings and sketches have been prepared for the experimental compressor and hardware to be fabricated in the next-phase program. Results from a one-year performance simulation of the solar heat pump in a residential application in Columbus, Ohio, were encouraging. Stable operation of the pivoting-tip gas bearings has been predicted for dynamic conditions expected in the rotary-vane compressor and expander application.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Phase 0, feasibility study has been completed (report dated September 29, 1975).

Phase 1, hardware design study has been completed (report dated July 29, 1977).

PERIOD OF PROJECT:

Phase 0: 14 months (starting date: July 1, 1974).

Phase 1: 10 months (starting date: August 14, 1976).

FUND IN $ U.S.

Current year - $-0-
Total for Phase 0 - $81,000
Total for Phase 1 - $64,000

IMPORTANT REPORTS OR PUBLICATIONS:

"A Solar-Powered Heat Pump Utilizing Pivoting-Tip Rotating Equipment -- Phase 1", by Robert D. Fischer, Christopher P. Crall, John H. Beck, and James A. Eibling, July 29, 1977.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Colorado State University	**ADDRESS:** Solar Energy Applications Laboratory Fort Collins, Colorado 80523
NAME OF PRINCIPAL RESEARCHER John C. Ward	

TITLE OF PROJECT Direct Contact Liquid-Liquid Heat Exchangers for Solar Heated and Cooled Buildings

OBJECTIVE AND NATURE OF THE PROGRAM:
By using a liquid in the solar collector loop that is immiscible with water, it is possible to transfer the collected heat directly in the hot water storage tank, provided that the liquid has a density either greater than or less than water. The principal objectives of this project are: (1) to develop a device which will make this form of heat transfer possible; (2) demonstrate the device on a full-scale basis with existing solar heating and cooling systems; and (3) evaluate and report the results of the full scale operation.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT: Full scale direct contact liquid-liquid heat exchanger under test.

PERIOD OF PROJECT: 27 months, (starting date: 2-1-76)

FUND IN $ U.S. Current year $85,819
Total for the Period $173,285

IMPORTANT REPORTS OR PUBLICATIONS: (1) Toxicological Evaluation of Liquids Proposed for Use in Direct Contact Liquid-Liquid Heat Exchangers for Solar Heated and Cooled Buildings. (2) Direct Contact Liquid-Liquid Heat Exchanger for Solar Heated and Cooled Buildings: Pilot Plant Results 9-26-77

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Lawrence Berkeley Laboratory	**ADDRESS:** University of California Berkeley, California 94720
NAME OF PRINCIPAL RESEARCHER Michael Wahlig	

TITLE OF PROJECT

Development of Electronic Controller and Evaluation of Control Algorithms for Solar Heating and Cooling Systems

OBJECTIVE AND NATURE OF THE PROGRAM:

A relatively-inexpensive electronic controller has been developed that will be capable of operating a solar heating and cooling system in a near-optimized manner. An experimental solar heating and cooling system has been constructed and will be used as a test facility to compare experimentally the value of alternative control algorithms, first using the LBL-developed controller, and then using other controllers that are commercially available. To achieve reproducible experimental running conditions necessary for accurate comparisons of alternative control algorithms, the test facility will include an input solar simulator and an output load simulator.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Prototype controller and experimental solar heating and cooling system, including input solar simulator, have been fabricated, instrumented, and tested. The output load simulator is being synthesized. Computer modeling is underway.

PERIOD OF PROJECT:

October 1977 - September 1978 (and continuing)

FUND IN $ U.S.

$130,000

IMPORTANT REPORTS OR PUBLICATIONS:

Lawrence Berkeley Laboratory Reports: LBL-4436, LBL-5982

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT

NAME OF ORGANIZATION
Los Alamos Scientific Laboratory (LASL)

NAME OF PRINCIPAL RESEARCHER
Donald R. Farris

ADDRESS: Group E-4, MS-429
P. O. Box 1663
Los Alamos, NM 87545

TITLE OF PROJECT
Adaptive Control for Energy Conservation

OBJECTIVE AND NATURE OF THE PROGRAM:
The objective of this program is to investigate the use of adaptive optimal control techniques in the control of heating, ventilating, and air-conditioning (HVAC) systems in large solar heated and cooled buildings in order to minimize auxiliary energy consumption while maintaining a comfortable environment in the building. A computer simulation model of a large solar heated and cooled building is used to test adaptive optimal control approaches and compare simulation results of auxiliary energy consumption with corresponding simulation results from the use of conventional control strategies. The computer simulation model of the building is largely taken from the National Security and Resources Study Center at LASL. Briefly, the adaptive optimal control approach identifies a linear mathematical model of the building; and that model is used to compute a control based on the linear regulator theory. The model is updated periodically and the control is recomputed to provide the optimal control for the new model.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:
For the heating model study, the adaptive controller has demonstrated a savings over the conventional controller of 28.8% in the use of auxiliary energy. For the cooling model, preliminary results indicate an auxiliary energy savings of 18.3%.

PERIOD OF PROJECT:
July 1976 - present continuing

FUND IN $ U.S.
$75,000 for FY 78

IMPORTANT REPORTS OR PUBLICATIONS: "Adaptive Control for Energy Conservation," August 1, 1976-February 15, 1977, D. R. Farris, H. S. Murray, T. E. Springer, T. E. McDonald, J. L. Melsa, R. V. Monopoli, Report LA-6753-SR, Los Alamos Scientific Laboratory, Mar. 1977. "Energy Conservation by Adaptive Control for a Solar Heated Building," D. R. Farris, J. L. Melsa, H. S. Murray, T. E. McDonald, T. E. Springer, Proceedings, 1977 International Conference on Cybernetics and Society, Sept. 1977. pp. 329-335.

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Scientific-Atlanta, Inc.	ADDRESS: 3845 Pleasantdale Road Atlanta, Georgia 30340
NAME OF PRINCIPAL RESEARCHER Dr. Sam V. Shelton	

TITLE OF PROJECT

Development of Solar Driven Heat Piston Dual Loop Heat Pump

OBJECTIVE AND NATURE OF THE PROGRAM:

Design, development, modeling, and testing of components for a free piston expander-compressor suited for Rankine cycle driven vapor compression cycles in solar heating/cooling systems driven by low temperature flat plate collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Analytical modeling of device has been completed with operating limits, friction effects, and valve losses evaluated.

PERIOD OF PROJECT:

Sept. 1, 1977 - Aug. 30, 1978

FUND IN $ U.S.

$169,000

IMPORTANT REPORTS OR PUBLICATIONS:

None

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: USA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIAL RESEARCH ☒ COMPONENT DEVELOPMENT
NAME OF ORGANIZATION Syracuse University	**ADDRESS:** Syracuse, NY 13210
NAME OF PRINCIPAL RESEARCHER E. E. Drucker	

TITLE OF PROJECT

Commercial Building Unitary Heat Pump System with Solar Heating

OBJECTIVE AND NATURE OF THE PROGRAM:

Parametric studies have been made for 2 building types in each of 13 geographic areas.

This program will extend the parametric studies to another building type and prepare the resulting information in convenient form for architects, engineers and contractors to use. Improvements and refinements in the simulation will be made. These will include a more realistic temperature control deadband, use of desiccant systems with solar regeneration, and the effects of internal load variations.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT:

Development of weather and insolation data for new cities has been completed.

PERIOD OF PROJECT: 12 months (starting date: 6/15/76 with no cost time extention to 10/31/77).

FUND IN $ U.S.

Current Year $66,184

Total for the Period $132,368

IMPORTANT REPORTS OR PUBLICATIONS: Commercial Building Unitary Heat Pump System with solar Heating, Final Report, Report #NSF/RANN/SE/GI-43895/FR/75/3. Solar Building Energy Use Analysis, American Section ISES Mtg, June 1977. Efficient Use of Energy in a Solar Bldg, Int. Conf. on Energy Use Mgmt., Oct 24-28, 1977.

(continued)

Important Reports or PUblications: (continued)

Generalized Weather Functions for Computer Analysis of Solar-Assisted HVAC Systems, ASME publication 76-WA/Sol-20. Thermal Simulation of a Building with Solar Assisted Closed Loop Unitary Heat Pumps, ASME publication 76/WA/Sol-23.

APPENDIX

APPENDIX

NATIONAL REPRESENTATIVES
TASK II: COORDINATION OF R & D ON SOLAR HEATING AND COOLING COMPONENTS

Country	Institution	Responsible Person
AUSTRIA	Austrian Solar and Space Agency Garnisongasse 7 A-1090 Vienna	Prof. Gerhard Faninger
BELGIUM	Faculte Polytechnique de Mons 31, Boulevard Dolez 7000 Mons	Prof. Andre Pilatte
DENMARK	Thermal Insulation Laboratory Building 118 Technical University of Denmark DK-2800 Lyngby	Mr. Ove Jorgensen
GERMANY	Kernforschungsanlage Julich GmbH Programmgruppe Systemforschung und Technologische Entwicklung Postfach 1913 D-5170 Julich	Dipl. Ing. Michael Meliss
ITALY	Instituto di Fisica Tecnica Piazzale Tecchio Universita di Napoli Napoli	Prof. Raffaele Vanoli
JAPAN	Sunshine Project Headquarters Agency of Industrial Science and Technology MITI 1-3 Kasumigaseki, Chiyoda-Ku Tokyo	Mr. Taira Sunami
NETHERLANDS	Netherlands Energy Research Foundation Westerduinweg 3 Petten N.H.	ir. W.F. Heshuysen
NEW ZEALAND	Physics and Engineering Laboratory Dept. of Scientific & Ind. Research Private Bag Lower Hutt	Dr. R.F. Benseman
SPAIN	Instituto Nacional de Tecnica Aerospacial Torrejon de Ardoz Madrid	Dr. Ing. Luis Nadal

Country	Institution	Responsible Person
SWEDEN	AB Svenska Flaktfabriken S-551 84 Jonkoping	Mr. Ove Strindehag
SWITZERLAND	Ecole Polytechnique Federale de Lausanne Dept. de Physique 33 Av. de Cour CH-1007 Lausanne	Dr. Andre Faist
U.S.A.	U.S. Department of Energy Division of Conservation and Solar Applications Washington, D.C. 20545	Dr. Frederick H. Morse