IEA

SOLAR R&D

INTERNATIONAL ENERGY AGENCY

programme
to develop and test
solar heating
and cooling systems

task II
coordination of R&D on solar heating and cooling components

survey of solar energy R&D projects for solar heating and cooling components

december 1980

SURVEY OF SOLAR ENERGY R & D PROJECTS FOR SOLAR HEATING AND COOLING COMPONENTS

Tetsuo Noguchi
Solar Research Laboratory, GIRI Nagoya
Japan

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Task II: Coordination of R & D on Solar Heating and Cooling Components
Subtask A: Summary of Component R & D Projects

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ABSTRACT

This document provides informations on R & D projects and significant achievements on components for solar heating, cooling and hot water supply systems. The document has resulted from the survey and review of reports submitted by representatives of countries participating in Task II, IEA. The matrix coding of solar heating and cooling components and also matrix coding on major technical problems as well as Comprehensive List of Solar Energy R & D Projects Reports for Solar Heating and Cooling Components have been included as Appendix 1, 2 and 3 respectively. The contact persons for each country participating in Task II are listed in Appendix 4.

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PREFACE

INTERNATIONAL ENERGY AGENCY

In order to strengthen cooperation in the vital area of energy policy, an Agreement on an International Energy Programme was formulated among a number of industrialized countries in November 1974. The International Energy Agency (IEA) was established as an autonomous body within the Organization for Economic Cooperation and Development (OECD) to administer that agreement. Twenty countries are currently members of the IEA, with the Commission of the European Communities participating under a special arrangement.

As one element of the International Energy Programme, the Participants undertake cooperative activities in energy research, development, and demonstration. A number of new and improved energy technologies which have the potential of making significant contributions to our energy needs were identified for collaborative efforts. The IEA Committee on Energy Research and Development (CRD), assisted by a small Secretariat, coordinates the energy research, development, and demonstration programme.

SOLAR HEATING AND COOLING PROGRAMME

Solar Heating and Cooling was one of the technologies selected by the IEA for a collaborative effort. The objective was to undertake cooperative research, development, demonstrations and exchanges of information in order to advance the activities of all Participants in the field of solar heating and cooling systems. Several tasks were developed in key areas of solar heating and cooling. A formal Implementing Agreement for this Programme, covering the contributions, obligations and rights of the Participants, as well as the scope of each task, was prepared and signed by 15 countries and the Commission of the European Communities. The overall programme is managed by an Executive Committee, while the management of the tasks is the responsibility of Operating Agents who act on behalf of the other Participants.

The tasks of the IEA Solar Heating and Cooling Programme and their respective Operating Agents are:

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

II. Coordination of R & D on Solar Heating and Cooling Components - Agency of Industrial Science and Technology, Japan

III. Performance Testing of Solar Collectors - Kernforschungsanlage Julich, Federal Republic of Germany

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

V. Use of Existing Meteorological Information for Solar Energy Application - Swedish Meteorological and Hydrological Institute

VI. Performance of Solar Heating, Cooling and Hot Water Systems Using Evacuated Collectors - United States Department of Energy

VII. Central Solar Heating with Seasonal Heat Storage - Swedish Council for Building Research

Collaboration in additional areas is likely to be considered as projects are completed or fruitful topics for cooperation identified.

TASK II - COORDINATION OF RESEARCH AND DEVELOPMENT ON SOLAR HEATING AND COOLING COMPONENTS

The development of effective components is crucial to the successful performance of solar systems. The objective of Task II is to coordinate the Participants' component R & D programs by exchanging information on activities involving major system components (e.g., collectors, heat storage units, air conditioning units, controls). The exchange of researchers between Participating Countries is another aspect of this task. By the sharing of information and expertise it is hoped that duplication of effort can be avoided and component development accelerated.

The subtasks included in this project are:

A. Survey of Component R & D Projects

B. Exchange of Solar Energy Research Personnel, especially in the area of component R & D

C. Survey and Review of National R & D Plans for Solar Heating and Cooling Components

The Participants in this Task are Austria, Belgium, Denmark, Germany, Greece, Italy, Japan, the Netherlands, New Zealand, Spain, Sweden, Switzerland, and the USA.

OVERVIEW OF SOLAR HEATING AND COOLING R & D PROJECT SUMMARIES

Introduction

The objective of Task II of the IEA Solar Heating and Cooling Programme is to increase the effectiveness of national R & D programmes related to the development of components for solar heating, cooling and hot water supply systems. These solar heating and cooling components consist of solar collectors, solar thermal energy storage, solar air conditioning and cooling, and other substantial components.

Task II Participants have been exchanging information including results of R & D on key solar heating and cooling system components, since 1977 as an activity of Subtask A. The aim is to discuss the possible key areas of development for these components and to exchange information and advice among the Participants. Furthermore it is to exchange information on solutions to the critical problems being pursued in current R & D projects as well as to avoid redundancy of efforts by the Participants. These R & D projects are funded in whole or in part by the Participant or the government of the Participant.

Reports compiling the above information, based on material submitted by the Participants using a special format, are prepared by the Operating Agent. Since the inauguration of Task II activities, the following four compilations have been distributed to the Participants:

Survey and Review of Components for Solar Heating, Cooling and Hot Water Supply Systems

(Compilation Part I	Oct. 1977)
(Compilation Part II	Mar. 1978)
(Compilation Part III	Nov. 1978)
(Compilation Part IV	Mar. 1980)

This technical report is the summary of these four compilations. It deals primarily with Compilation IV, but includes as Appendix 3 the comprehensive list of R & D Projects which were contained in Compilations I - IV. Other appendices are composed of matrix coding of Solar Heating and Cooling Components as well as matrix coding of major technical problems. Both matrices serve to provide an overview of the world research community's perception of where the major emphasis in research is needed to make solar energy a viable energy source.

Table 1 lists Component Project Summaries prepared by the Participants and R & D Projects included in the Summaries which appeared in Compilation IV. These project numbers have been increasing very rapidly since the first project reports were compiled. (See Table 2 for comparison.) Because R & D projects sometimes cover more than one component, the project figures are higher than the number of reports shown in the table as received. This should become clear when the format of the table is examined. The table shows that the figure for solar collector R & D projects is almost 43% of the total project nembers, while those of thermal energy storage, air conditioning units and other substantial components indicate approximately 26%, 11%, and 29% each.

It might be emphasized that a rapid increase of R & D projects on solar heating and cooling components has recently been observed among the Task II participating countries. Such a trend may accelerate the rise of the solar energy industry within this decade.

Solar Collector R & D Projects

The solar collector, by which absorbed solar radiation is transformed into an available heat source and transferred to the working fluid, is a key component of solar heating and cooling systems.

Through the compilation of solar collector R & D projects, solar collectors might be classified into the following categories based upon their design configurations and respective functions. Table 3 describes the classifications.

In earlier stages of the Task II activities (Compilation Part I), most of the R & D efforts on solar collectors in the reported projects were generally concerned with:

1) Feasibility studies and economic analysis of solar collectors
2) Heat transfer analysis and suppression of natural convection by the use of honeycomb structures, etc.

Table 1

REPORTS AND CLASSIFIED PROJECTS
ON SOLAR HEATING AND COOLING COMPONENTS

Compilation IV

Country	Numbers of reports received	Numbers of projects included	Numbers of projects on respective components			
			Solar Collector	Heat Storage	Air Cond. Unit	Other Subst. Unit
AUSTRIA	24	43	20	14	1	8
BELGIUM	----	----	----	----	----	----
DENMARK	5	7	2	4	----	1
F.R.G.	32	40	27	8	2	3
GREECE	1	1	1	----	----	----
ITALY	6	6	3	3	----	----
JAPAN	16	16	7	5	3	1
NETHERLANDS	8	10	5	3	1	1
NEW ZEALAND	----	----	----	----	----	----
SPAIN	----	----	----	----	----	----
SWEDEN	9	11	4	6	----	1
SWITZERLAND	52	64	17	14	5	28
U.S.A.	128	156	68	34	28	29
Total	281	354	154	91	40	72

Table 2

REPORTS AND CLASSIFIED PROJECTS

ON SOLAR HEATING AND COOLING COMPONENTS

CONTAINED IN THE COMPILATION PARTS I -III *

Country	Numbers of reports received	Numbers of projects included	Numbers of projects on respective components			
			Solar Collector	Heat Storage	Air Cond.	Other Subst.
AUSTRIA	21	39	17	12	1	9
BELGIUM	2	2	1	1	----	----
DENMARK	5	5	2	2	----	1
F.R.G.	22	28	20	4	3	1
ITALY	5	5	5	----	----	----
JAPAN	16	16	8	4	4	----
NETHERLANDS	22	32	13	10	3	6
NEW ZEALAND	7	8	6	2	----	----
SPAIN	1	1	----	----	1	----
SWEDEN	9	12	5	5	----	2
SWITZERLAND	5	5	3	2	----	----
U.S.A.	81	89	44	13	21	11
Total	196	242	124	55	33	30

* As of November 1978

Table 3

CLASSIFICATION OF SOLAR COLLECTORS FOR

SOLAR HEATING AND COOLING

Flat Plate Collectors (both for air and liquid heating)

- One pane black paint
- Two pane black paint
- One pane selective
- Two pane selective
- Honeycomb collector
- Evacuated flat plate collector

Tubulat Collectors

Evacuated Tubular Collectors

Heat Pipe Collectors

Concentrating Collectors

- With sun tracking mechanism
- Without sun tracking mechanism

Others

- Esthetic Collectors

3) Selective coating materials study
4) Mass production technology of solar collectors
5) Testing and evaluation of performance, durability and reliability of solar collectors.

By improving the performance characteristics of solar collectors as well as by efforts toward cost reduction, solar collectors for low cost domestic hot water supply systems have been developed in many countries.

Meanwhile, various advanced high performance collectors have also been developed for heating and especially for solar cooling applications. Evacuated tubular collectors, honeycomb collectors, and selective absorber surface collectors are typical of the types developed along these lines. Another approach is the development of concentrating collectors with and without sun tracking mechanisms. The economics of these collectors is less certain than for flat plate collectors, however.

Since the solar heating and cooling industry began initiating market activities, further R & D efforts in the following areas were emphasized, along with demonstration and information dissemination (Compilation Part III):

1) Improvement of solar collector performance, especially durability and reliability
2) Development of testing and evaluation procedures for solar collectors
3) Development of mass production procedures and related cost reduction efforts
4) Improved cost-effectiveness of solar collectors
5) Simplified construction, installation and maintenance for solar collectors as well as mounting, piping, etc.
6) Increased adaptability of solar collectors for diversified purposes such as industrial process heat.

Recently much attention has been paid to the testing and evaluation of collectors, corrosion protection of absorbers, and the effects of wind, besides the interest focused on durability and reliability. These trends might further be accelerated in accordance with the demonstration and commercialization of solar heating and cooling systems.

Thermal Energy Storage R & D Projects

Because the heat source of solar energy is by nature intermittent, storage components are indispensable for utilization of this resource. Storage systems are classified roughly into sensible heat storage, latent heat storage, and chemical reactions. These classifications are indicated in Table 4.

Among the sensible techniques, water heat storage has long survived, while optimisation studies and long term low cost seasonal storage techniques have recently attracted much attention by researchers with the increase of such projects. Nevertheless, latent heat storage through phase change materials has been investigated for years, problems of heat transfer as well as supercooling, phase separation and decomposition of the storage material, and corrosion problems have impeded the commercial application of this technique. A possible breakthrough might be a technique for encapsulating the storage materials, both by single and multi-component composition. R & D is proceeding along these lines.

Application of chemical reaction to solar heat storage is still in the early stages, but R & D projects on both chemical heat storage and chemical heat pumps are increasing in number.

R & D activities on analytical modelling, heat transfer problems and testing procedures on thermal energy storage have also increased recently.

Air Conditioning Unit and Solar Cooling R & D Projects

In the field of solar air conditioning, major early efforts have been concentrated on the development of water-salt absorption machines and Rankine cycle machines. Cost reduction and improved COPs have been the important targets for development of these machines.

In addition, R & D in desiccant systems and solar powered heat pumps was accelerated in 1978 in an attempt to find an economic and simple mechanism for solar cooling. Attention has

Table 4

THERMAL ENERGY STORAGE IN SOLAR HEATING AND COOLING

Sensible Heat Storage:	
	Water
	Liquid
	Liquid-solid mixture
	Solid
	Underground
	Others (Seasonal Storage)
Latent Heat Storage:	
	Organic compound
	Inorganic hydrate
	Fused salt
	PCM (Phase Change Materials)
	Others
Chemical Reaction:	
Others:	
	Dilution
	Absorption
	Photochemical process

also been given to passive systems and other techniques.

Other Substantial Components R & D Projects

R & D Projects of a wide variety have been reported in the category of other substantial components for solar heating and cooling, such as control subsystems, heat exchanger heat pumps and others. The economic potential of these components cannot be neglected in market penetration by solar heating and cooling systems, and R & D efforts are progressing steadily. Many projects are concerned with design, testing and assessment of control subsystems in solar heating and cooling. Mathematical modelling and validation, data processing, and heat transfer analysis are also included in this category.

LIST OF SOLAR ENERGY R & D PROJECTS

FOR SOLAR HEATING AND COOLING COMPONENTS

part IV

SOLAR COLLECTORS

AUSTRIA

A-1 MULTI-COMPONENT SYSTEM FOR DOMESTIC WATER HEATING AND SPACE HEATING AT THE "INST. F. MOLEKULARBIOLOGIE" OF THE "ÖSTERR. AKADEMIE D. WISSENSCHAFTER" SALZBURG
Prof. Dr. F. Viehböck, Allegemeine Physik, Univ. of Technology, Karlzplatz 13, A-1040 Vienna

A-2 SOLAR ENERGY TEST STATIONS IN AUSTRIA
Austrian Solar Space Agency, Garnisongasse 7 A-1090 Wien

A-3 INSTALLATION OF A SOLAR ENERGY STATION IN MALTA
Dr. Georg Turnheim, Vereinigte Metallwerke Ranshofen-Berndorf, Postfach 35, A-2560 Berndorf

A-4 SOLAR ENERGY TEST STATION AT BLUDENZ, VORARLBERG
Dipl.-Ing. Rünzler, ARGE Sonnenhaus Bludenz A-6800 Feldkirch

A-5 SYSTEM FOR DOMESTIC WATER HEATING WITHOUT AUXILIARY HEATING AT THE "BIOLOGISCHE VERSUCHSANSTALT" AT ILLMITY/NEUSIEDLERSEE
Dr. Georg Turnheim, Vereinigte Metallwerke Ranshofen-Berndorf, Leobersdorfer Strasze 26, A-2560 Berndorf

A-6 SOLAR ENERGY TEST STATION IN SISTRANS
Dipl.-Ing. Kiraly, A-6073 Sistrans

A-7 DEVELOPMENT OF SELECTIVE ALUMINIUM ABSORBERS
Dipl.-Ing. Dr. H. Meissner, Vereinigte Metallwerke Ranshofen-Berndorf, Leobersdorfer Strasze 26, A-2560 Berndorf

A-8 CONSTRUCTION AND OPERATION OF SOLAR COLLECTOR TEST STATION
Ing. J. Kriha, Bundesversuchs-und Forschungsanstalt, Arsenal 1030 Wien

A-9 CONSTRUCTION OF A DOMESTIC WATER HEATING SYSTEM IN OUAGADOUGOU
Dipl.-Ing. E. Podesser, Institute for Environmental Research, Elisabethstrasze 11 A-8010 Graz

A-10 OUTDOOR COLLECTOR TESTING
Dr. Georg Turnheim, Vereinigte Metallwerke Ranshofen-Berndorf, Leobersdorfer Strasze 26 A-2560 Berndorf

A-11 SOLAR HOUSE VIENNA-FLÖTZERSTEIG (AUSTRIAN SOLAR HOUSE)
Dr. Michael Wachberger/Ing. G. Spielmann, Austrian Institute for Building Research, Dr. Karl Lueger-Ring 10 A-1010 Wien

A-12 SOLAR-POWERED ABSORPTION COOLING SYSTEM
Dipl.-Ing. Erich Podesser, Institute for Environmental Research, Elizabethstrasze 11 8010 Graz

A-13 DEVELOPMENT AND TEST OF A PHOTOVOLTAIC THERMAL HYBRID-COLLECTOR
Prof. Dr. F. Viehböck, Allegemeine Physik, Univ. of Technology, Karlsplatz 13, A-1040 Wien

A-14 DEVELOPMENT OF A LOW TEMPERATURE SOLAR COLLECTOR
Prof. Dr. F. Viehböck, Institut f. Allegemeine Physik, Univ. of Technology, Karlsplatz 13 A-1040 Vienna

A-15 DEVELOPMENT OF A MEASUREMENT AND CONTROL SYSTEM FOR SOLAR ENERGY SYSTEMS
Prof. Dr. Roland Stickler, Institut für Physikalische Chemie, University of Vienna, Währinger Strasze 42, A-1090 Vienna

A-16 DOMESTIC WATER HEATING AND SPACE HEATING WITH SOLAR ENERGY
Prof. Dipl.-Ing. Dr. P.V.Gilli, Arbeitsgemeinschaft Sonnenenergie, Obere Techstrasze 21/1 A-8010 Graz

A-17 DEVELOPMENT OF A PROTOTYPE OF A SEMI-CONCENTRATING COLLECTOR
Ing. Walter Jäger, Fa. Ing. W. Jäger, Villacher Strasze 32, A-9300 St. Veit/Glan

A-18 COMPACT SOLAR SYSTEM FOR DOMESTIC WATER HEATING
Dr. Georg Turnheim, Vereinigte Metallwerke Ranshofen-Berndorf, Postfach 35 A-2560 Berndorf

A-22 DEVELOPMENT AND TESTING OF COMPONENTS FOR SOLAR HEATING SYSTEM
Ing. Bango and Dr. Bräunlich, Vogel & Noot AG and Institute for Environmental Research, A-8661 Wartberg/Mürztal

A-23 DWELLING WITH ALL ELECTRICAL ENERGY SUPPLY AND EXTREMELY LOW SPECIFIC ENERGY DEMEND
Dr. Peter Schaup, Gemeinnützige Wohnungs- und Siedlungsges. der Elin Union AG, Penzinger Strasze 76, A-1141 Vienna

DENMARK

D-1 FLOATING SOLAR COLLECTORS
Preben Hansen, The Technical University of Denmark, Thermal Insulation Laboratory, Building 118, 100 Lundtoftevej DK-2800 Lyngby

D-4 LOFT COLLECTOR WITH SLAB ON GRADE-HEAT STORAGE
Kurt Keilsgard Hansen, The Thermal Insulation Laboratory, The Technical University of Denmark, Building 118, 100 Lundtofvej DK-2800 Lyngby

FEDERAL REPUBLIC OF GERMANY

FRG-1 FLAT PLATE SOLAR ENERGY COLLECTORS
Dr. E. Hussmann, Jenaer Glaswerk Schott & Gen., Hattenbergstrasze 10, 6500 Mainz

FRG-2 DEVELOPMENT OF INDUSTRIAL SCALE MANUFACTURING PROCESS FOR SOLAR HEATING SYSTEM COMPONENTS, ESPECIALLY SOLAR COLLECTORS -PROJECT MANAGEMENT
Dr.-Ing. M. Möller, Metallgesellschaft AG, Reuterweg 14, D-6000, Frankfurt am Main 1

FRG-4 DEVELOPMENT OF LARGE SCALE PRODUCTION METHODS FOR COMPONENTS OF SOLAR ENERGY COLLECTION -3. SUBPROGRAM OF METALLGESELLSCHAFT
Dr. Eckart Hussmann, Jenaer Glaswerk Schott & Gen., Hattenbergerstr. 10, D-6500 Mainz

FRG-5 DEVELOPMENT OF SOLAR SELECTIVE ABSORBER COATINGS FOR ALUMINIUM ROLL BOND HEAT EXCHANGERS
Dipl.-Phys. W. Scherber, Dornier System GmbH, Postfach 1360 D-7990 Friedrichshafen

FRG-6 DEVELOPMENT OF ECONOMIC SOLAR HEATING SYSTEMS USING ENEXPENSIVE COLLECTORS
J. Lorenz, M.A.N. Technologie Maschienenfabrik Augsburg, Nürnberg AG

FRG-7 TESTING A MEASURING STATION FOR THE EVALUATION OF SOLAR COLLECTORS
Prof. Dr. A. Boettcher, KFA Jülich
Postfach 1913, 5170 Jülich 1

FRG-8 SOLAR COLLECTORS FOR FLAT ROOF
G. Feierabend, Klaus Esser GmbH & Co.KG
Postfach 29 09, 4000, Düsseldorf 1

FRG-9 IMPROVEMENT OF THERMAL EFFICIENCY OF FLAT PLATE SOLAR COLLECTORS
Dr. R. Sizmann, Universität München,
Amalienstr. 54, D-8000 München 40

FRG-10 BBC-CONTRIBUTION TO THE SOLAR COLLECTOR TEST PROGRAM, IEA-SUBPROJECT III
Dipl.-Phys. H. Birnbreier, Brown, Boveri & Cie AG, Zentrales Forschungslabor,
Eppelheimer Str. 82 D-6900 Heidelberg

FRG-11 ROLL-BONDED HEAT PIPE PANELS
Dr.-Ing. M. Möller, Metallgesellschaft AG, 6000 Frankfurt/Main

FRG-12 FLAT PLATE HEAT PIPE COLLECTORS MADE BY ROLL BONDING
Dr. Ing. W. Tanner, Dornier System GmbH,
Postfach 1360, 7990 Friedrichshafen

FRG-13 DEVELOPMENT AND OPTIMIZATION OF HERMETICALLY SEALED FLAT PLATE COLLECTORS WITH GAS FILLING/SELECTIVE ABSORBING THIN FILM
Dr. Wolfgang Zernial, Flachglas Aktiengeselischaft, Auf der Reiche 2,
4650 Gelsenkirchen

FRG-15 DEVELOPMENT OF DIRECT EVAPORATING COLLECTORS FOR SMALL SOLAR POWERED PLANTS AND SMALL SOLAR COOLING FACILITIES
Dipl.-Ing. K. Speidel, Dornier System GmbH, Postfach 13 60, 7900 Friedrichshafen 1

FRG-16 INVESTIGATION OF LOSS OF LIGHT TRANSMISSION OF SOLAR COLLECTORS DUE TO DIRT
Dr. O. K. Wack, Dr. O.K.Wack Chemie GmbH,
bunsenstr. 6, 8079 Ingolstadt

FRG-17 DEVELOPMENT OF A FLAT SOLAR ENERGY COLLECTOR FOR LOW TEMPERATURE HEATING USING STAINLESS STEEL PLATE-BARS AND POLYURETHANE
Ing. Manfred Schelzig, Georg Bucher GmbH,
D-8901 Meitingen-Ostendorf

FRG-18 DEVELOPMENT OF HIGH TEMPERATURE RESISTANT SOLAR ABSORBER COATING
Dipl.-Phys. W. Scherber, Dornier System GmbH, Postfach 1360, 7990 Friedrichshafen

FRG-19 ENERGY CONSERVATION AND THE USE OF SOLAR ENERGY IN BUILDINGS

Dr. H. Hörster, Philips GmbH, Forschungs-Laboratorium Aachen, D-5100 Aachen

FRG-21 DOMESTIC WATER HEATING BY SOLAR ENERGY

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

FRG-22 TECHNICAL AND SCIENTIFIC INVESTIGATIONS CARRIED OUT AT THE SOLAR ENERGY EXPERIMENTAL FACILITY IN WIEHL/FRG

K. Biasin, Energietechnik GmbH, 4300 Essen-Kettwig

FRG-24 MEASURING PROGRAM FOR HOT WATER SUPPLY IN PRE-FABRICATED HOUSES USING SOLAR ENERGY

Ing. grad. U. Heidtmann, Süddeutsche Metallwerke GmbH, Impexstrasze 5, D-6909, Walldorf

FRG-25 SOLAR ENERGY PLANT TO SUPPLEMENT A CONVENTIONAL HEATING SYSTEM

Prof. Doering, Fachhochschule für Technik, Fachbereich Versorgungstechnik Kanalstrasze 33, 7300 Esslingen

FRG-26 SOLAR EQUIPMENT SYSTEM-PACKAGE FOR OLD AND NEW BUILDINGS TO PROVIDE WARM WATER AND PARTIAL HEATING

Dr. F. Müller, Rütgerswerke AG, Mainzer Landstrasze 217, 6000 Frankfurt/ Main 1

FRG-27 CREATION OF AN ECONOMICAL SOLAR HEATING SYSTEM FOR A NEW AND AN EXISTING RESIDENTIAL HOME COMPLEX CONSTRUCTION-HEGBACHER INSTALLATIONS

Gerd Bakic Engineering Office, Domestic Service Systems, Planning, Electr.-Heating-Sanitary-Ventil.,8016 Heimstetten/ München

FRG-28 HEAT-PIPE SOLAR ABSORBER

Dipl.-Ing. K. Speidel, Dornier System GmbH, Postfach 1360, 7990 Friedrichshafen

FRG-29 FLAT PLATE COLLECTORS AS FACADE ELEMENTS FOR WATER PREHEATING AND HEAT INSULATION

Prof. Dr.-Ing. M. Mäisz, Technische Fachhochschule, Berlin, Luxemburger str. 10, 1000 Berlin 65

FRG-30 SOLAR HOUSE FREIBURG

Dr. K. R. Schreitmüller, DFVLR

FRG-32 TECHNICAL USE OF SOLAR ENERGY

Prof. G. Lehner, Institutsgemeinschaft für die Technologie-Nutzung Solarer Energie Universität Stuttgart, Breidscheidstrasse 3/7000 Stuttgart 1

GREECE

G-1 HEAT PIPE
Dr. Argyrios V. Spyrindonos, N.R.C. Democritos, Applied Thermodynamics Lab. Technical Application Division, Agia Paraskevi-Attikis

ITALY

I-4 SOLAR PLASTIC PLATE COLLECTOR
Montedison DIRS, Centro Ricerche Napoli, Via Nuova delle Brecce 150, 80147 Napoli:Barra

I-5 RUBBER PLATE SOLAR COLLECTOR
Ing. Edoardo Robecchi, Industrie Pirelli spa Piazza Duca d'Aosta, Milano

I-6 LONG TERM PERFORMANCES OF SOLAR SYSTEMS
Prof. V. Silvestrini, Istituto di Fisica, Facolta di Ingegenria, Piazzale Tecchio 80125 Napoli

JAPAN

J-1 DEVELOPMENT OF TUBULAR EVACUATED SOLAR COLLECTOR
K. Hinotani, Sanyo Electric Co., Ltd., 1-18-13 Hashiridani, Hirakata, Osaka 573

J-3 SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM FOR LARGE BUILDING
Masao Yoshiwa, Kawasaki Heavy Industries, Ltd., 2-14, Higashi Kawasaki-cho, Ikuta-ku Kobe

J-6 RESEARCH AND DEVELOPMENT OF SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM (R & D OF METALLIC MATERIALS)
Yuichiro Asano, Showa Aluminium K.K. 480 Inuzuka, Oyama, Tochigi 323

J-7 R/D OF COLLECTOR OF GLASS BASE
T. Yamada, Nippon Sheet Glass Co., Ltd., 8, 4-chome, Doshomachi, Higashi-ku, Osaka

J-8 DEVELOPMENT OF SOLAR COLLECTORS AND THEIR COMPONENTS MAINLY CONSISTING OF PLASTIC MATERIALS
M. Itoga, Toray Industries, Inc., 2-2 Nihonbachi-muromachi, Chuo-ku, Tokyo

J-9 RESEARCH ON SOLAR COLLECTOR MATERIALS
S. Tanemura, Solar Research Lab., GIRIN 1 Hirate-machi, Kita-ku, Nagoya 462

J-13 R & D OF SOLAR COLLECTOR FOR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM IN A MULTI-FAMILY RESIDENCE
Dr. Shoichi Tsuji, Ishikawajima-Harima Heavy Industries, 2-16, 3 Toyosu, Koto-ku Tokyo 135-91

NETHERLANDS

NL-1 NATIONAL PROGRAMME ON SOLAR ENERGY RESEARCH
K. Joon, Project office for Energy Research
BEOP c/o ECN P.O.Box 1 1755 zg Petten

NL-2 APPLICATION OF SOLAR ENERGY FOR CLIMATE CONTROL, IF NECESSARY COMBINED WITH HEAT PUMP AND/OR HEAT RECOVERY SYSTEM
J. van der Kooi, Laboratory for refrigerating Engineering, Delft University of Technology, Mekelweg 2, Delft

NL-6 SUPPRESSION OF NATURAL CONVECTION IN THERMAL SOLAR COLLECTOR
S. Linthorst, Heat Transfer Group, Applied Physics, Delft University of Technology, Lorentzweg 1, P.O.Box 5046 2600 GA Delft

NL-7 HEAT PIPE COLLECTOR FOR LOW TEMPERATURES AND INVESTIGATION OF THE PHYSICAL PROPERTIES OF SPECTRAL SELECTIVE LAYERS
J.C.Franken, Technical Physics Laboratory, Univeristy of Groningen, Zernikelaan, Nijenborgh 18 9747 AG Groningen

NL-8 SPECTRAL SELECTIVE LAYERS FOR PHOTOTHERMAL CONVERSION OF SOLAR ENERGY
M. van der Leij, Heat Transfer Group, Applied Physics, Delft University of Technology, Lorentzweg 1, P.O.Box 5046 2600 GA Delft

SWEDEN

SWED-1 RESEARCH AND DEVELOPMENT ON SEMI CONCENTRATING COLLECTORS FOR APPLICATIONS IN EXISTING BUILDING
R. Roseen, H. Zinko and B. Perers, Studsvik Energiteknik AB, S-611 82 Nyköping

SWED-2 SUNTERM
Gösta Jansson, Fläkt Evaporator AB, S-551 84 JönKöping

SWED-7 CENTRAL SOLAR HEAT STATION. DEMONSTRATION PLANT IN STUDSVIK
Rutger Toseen, Studsvik Energiteknik AB, S-611 82 Nyköping

SWED-9 THE INGELSTAD PROJECT - SOLAR HEAT PLANT
Rejlers Ingenjörsbyrå AB, V. Esplanaden 18, 352 32 Växjö

SWITZERLAND

SWIT-4 INDUSTRIAL FLAT PLATE COLLECTOR
Star Unity AG, Abt. Sonnenenergie CH 8804
Au-Zurich

SWIT-7 INDUSTRIAL FLAT PLATE COLLECTOR
Energie solaire S.A. p/a Granit S.A.
Avant Poste 4, 1000 Lausanne

SWIT-10 COMMERCIALIZATION OF LOW COST SELECTIVE ABSORBER COATINGS
Dr. Trevor P. Woodman, Coralur Laboratories,
Mittelbergsteig 15 CH-8044 Zürich

SWIT-12 UNDERGROUND HEAT STORAGE
B. Saugy and J.C.Hadorn, IPEN-EPF Lausanne
Département de Génie Civil, Ecublens 1015
Lausanne

SWIT-16 BLACK SURFACE RESEARCH
E. Thurnauer, Sulzer Bros. Ltd., 8401
Winterthur

SWIT -17 ALMERIA RECEIVER
H.W. Fricker, Sulzer Bros. Ltd., 8401
Winterthur

SWIT-22 PERFORMANCE OF REAL ACTIVE SOLAR HEATING SYSTEM
C.Calatayud and M. Nilsson, Institut de
Thermique Appliquée, EPF-Lausanne,
Halle de Mécanique Ecublens, CH-1015
Lausanne

SWIT-23 ACTIVE SOLAR HEATING SYSTEM
J.R. Muller and P.Suter, Institut de
Thermique appliquée EPF-L, Halles de
Mécanique Ecblens, 1015 Lausanne

SWIT-24 INTERACTION OF SOLAR COLLECTOR AND HEAT PUMP
J.R. muller and P. Matthry, Unité de
Thermique de l'EPF-L, Halles de Mécanique
Ecblens 1015 Lausanne

SWIT-25 EVACUATED FLAT PLATE COLLECTOR
P. Sonderegger, EPF-L Mécanique-ITA
1015 Lausanne

SWIT-29 DIRECT SOLAR GAINS THROUGH WINDOWS
J-B. Gay and A. Faist, Labo. de Phys. Th.
14 av. Eglise Anglaise 1006 Lausanne

SWIT-30 MODELISATION OF A TROMBE WALL
J-B. Gay and Y. Rey, Labo. de Phys. Th.
14 av. Eglise Anglais 1006 Lausanne

SWIT-34 MOBIL TEST EQUIPMENT FOR SOLAR COLLECTOR
B. Seiler, ETH-Z, Professur für Apparatebau
der Elektrotechnik, Pestalozzistr. 24
8032 Zürich

SWIT-35 EVACUATED FLAT-PLATE SOLAR COLLECTOR (HIGH-VACUUM)
H. Freyholdt, AMI SA, 120, Avenue d'Echallens
1004 Lausanne

SWIT-44 THE LAYOUT OF SOLAR HOT WATER SYSTEMS, USING STATISTICAL METEO-AND HEAT DEMAND DATA
P. Kesselring and A. Duppenthaler, Swiss Federal Institute for Reactor Research (EIR)
5303 Würenlingen

SWIT-45 MEASUREMENTS OF PERFORMANCE AND EFFICIENCY OF SOLAR ENERGY SYSTEMS
J.M.Sutter and P. Kesselring, Swiss Federal Institute for Reactor Research (EIR)
5303 Würenlingen

SWIT-47 PERFORMANCE TEST OF SOLAR COLLECTORS ON OUTDOOR AND INDOOR TEST FACILITIES
J.M.Sutter and P. Kesselring, Swiss Federal Institute for Reactor Research (EIR)
5303 Würenlingen

U.S.A.

US-1 FURTHER DEVELOPMENT OF A LOW COST SOLAR PANEL
E.V.Nelson and Tim Muller, Aurex Corporation, Alternate Energy Division, 485 Clyde Avenue
Mountain View CA 94042

US-2 DEVELOPMENT OF COST-EFFECTIVE HAIL PROTECTION DEVICES FOR SOLAR FLAT PLATE COLLECTORS
Francis de Winter, Altas Corporation,
500 Chestnut Street, Santa Cruz, CA 95060

US-3 DEVELOPMENT OF SOLAR WALL ASSEMBLY
Robert B. Whitesides, Aluminum Co. of America
ALCOA Technical Center, Alcoa Center, PA
15069

US-4 DEVELOPMENT AND DEMONSTRATION OF CPC COLLECTORS FOR SOLAR HEATING AND COOLING APPLICATIONS
Kent A. Reed, Argonne National Laboratory, Chemical Engineering Division, 9700 South Cass Ave., Bldg. 362 Argonne, IL 60439

US-5 DEVELOPMENT OF A LOW-COST BLACK-LIQUID SOLAR COLLECTOR
D. Karl Landstrom, Battelle-Columbus Laboratories
505 King Avenue, Columbus, Ohio 43201

US-6 CORROSION PROBLEMS WITH AQUEOUS COOLANTS
Ronald B. Diegle, Battelle-Columbus Laboratories
505 King Avenue, Columbus, Ohio 43201

US-7 DEVELOPMENT OF FLAT PLATE COLLECTOR WITH FLEXIBLE ELASTOMERIC ABSORBER
Calvin D. MacCracken, CALMAC Manufacturing Corporation, 150 South Van Brunt Street
Englewood, N.J. 07631

US-8 DEVELOPMENT OF IMPROVED INSULATION MATERIALS
James A. Rabe, Dow Corning Corporation, P.O.Box 1592 3901 S. Saginaw Road, Midland MI 48640

US-9 DOUBLE-EXPOSURE COLLECTOR SYSTEM
D.C.Larson and C.W.Savery, Drexel University Dept. of Physics and Atmos. Science, Philadelphia, PA 19104

US-10 UPPOWERED, FROST RESISTANT, INEXPENSIVE SOLAR HOT WATER HEATER
John L. Loth, Dynamic Flow Inc., P.O.Box 4094 Morgantown WV 26505

US-11 COMPUTER SIMULATION OF THE PERFORMANCE OF CHEMICAL HEAT PUMPS BASED ON THE H_2SO_4/H_2O, $CaCl_2/CH_3OH$ and NH_4NO_3/NH_3 REACTIONS
Peter O'D. Offenhartz, EIC Corporation, 55 Chapel Street, Newton, Massachusetts 02158

US-12 CORROSION PROTECTION OF SOLAR-COLLECTOR HEAT EXCHANGERS WITH ELECTROCHEMICALLY DEPOSITED FILMS
Dr. Victor R. Koch, EIC Corporation, 55 Chapel Street, Newton, Massachusetts 02158

US-13 GROUND COUPLED SOLAR ASSISTED HEAT PUMP FIELD PERFORMANCE EVALUATIONS
Sam V. Shelton, E-Tech, Inc., 3570 American Drive, Atlanta, GA 30341

US-14 A COAXIAL EXTRUSION CONVERSION CONCEPT FOR POLYMERIC FLAT PLATE SOLAR COLLECTORS
Nicholas J. Chapman, FAFCO Inc., 235 Constitution Drive, Menlo Park, CA 94025

US-15 RESIDENTIAL SOLAR HEATING DEVELOPMENT & DEMONSTRATION
Philip Levine, Fern Engineering Co., 536 MacArthur Blvd, Bourne, MA 02532

US-16 SYSTEM DESIGN AND DEVELOPMENT OF SOLAR HEATING & COOLING SYSTEMS
James C. Graf, General Electric, Advanced Energy Department, P.O.Box 8661, Philadelphia, PA 19101

US-17 MEDIUM TEMPERATURE AIR HEATER DEVELOPMENT PROGRAM
K.K.Hanson, General Electric Company, Valley Forge Space Center, P.O.Box 8661 Philadelphia, PA 19101

US-18 STUDY OF CORROSION AND ITS CONTROL IN ALUMINUM SOLAR COLLECTOR
Jose Giner, Giner, Inc., 14 Spring Street Waltham, MA 02154

US-19 SOLAR THERMAL ENHANCED OIL RECOVERY
P.D.Mitchell, Honeywell, Inc.

US-20 TEXTILE DRYING USING SOLAR PROCESS STEAM
P.D.Mitchell, Honeywell, Inc.

US-21 SURVEY MIRRORS AND LENSES AND THEIR REQUIRED SURFACE ACCURACY
Gary Smith, Honeywell, Inc., 2600 Ridgeway Parkway, Minneapolis, MN 55413

US-22 DUAL CURVATURE ACOUSTICALLY DAMPED CONCENTRATING COLLECTOR
Gary A. Smith, Honeywell, Inc., 2600 Ridgeway Parkway, Minneapolis, MN 55413

US-23 DEVELOPMENT OF NON GLASS GLAZING AND SURFACE COATINGS
Dr. Norman Bilow, Hughes Aircraft Company, Centinela & Teale Avenue, Culver City, CA 90230

US-24 PHOENIX/CITY OF COLORADO SPRINGS SOLAR ASSISTED HEAT PUMP PROJECT
Douglas M. Jardine, P.E., Kaman Sciences Corporation, P.O.Box 7463 1500 Garden of the God Road, Colorado Springs, Colorado 80933

US-25 FIXED TILT SOLAR COLLECTOR EMPLOYING REVERSIBLE VEE-TROUGH AND VACUUM TUBE RECEIVERS
M.K.Selcuk, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Bldg. 507 Room 228 Pasadena, CA 91103

US-26 AN INFLATED CYLINDRICAL CONCENTRATOR FOR INDUSTRIAL PROCESS HEAT
Jerry W. Gerich, Lawrence Livermore Laboratory, P.O.Box 808, Livermore CA 94550

US-27 A SURVEY OF TRACKING MECHANISM AND ROTARY JOINTS FOR COOLANT PIPING
Michael E. Gruchalla, EG & G Washington Analytical Services Center, Inc., 9733 Coors Road, NW, Albuquerque, NM 87114

US-28 COLLECTOR AND MATERIALS RESEARCH
Donald A. Neeper, Los Alamos Scientific Lab. M.S. 571, Los Alamos, NM 87545

US-29 SOLAR GRADIENT STABILIZED SOLAR PONDS
Donald A. Neeper, Los Alamos Scientific Lab. M.S. 571 Los Alamos, NM 87545

US-30 SOLAR COLLECTOR PROGRAM SUPPORT
Charles A. Bankston, Los Alamos Scientific Lab. M.S. 571, Los Alamos, NM 87545

US-31 NATIONAL SECURITY AND RESOURCES STUDY CENTER
James Hedstrom, Los Alamos Scientific Lab. M.S. 571, Los Alamos, NM 87545

US-32 LARGE AREA ROOFTOP COLLECTOR
William C. Dickinson and Richard L. Wood, Lawrence Livermore Laboratory, P.O.Box 808 L-046, Livermore, CA 94550

US-33 MICROPROCESSOR CONTROLLED SOLAR COLLECTOR SYSTEM
Richard L.T.Wolfson, Middlebury College
Middlebury, Vermont 05753

US-34 ADDITION OF INEXPENSIVE SOLAR AIR HEATERS TO A PRE-ENGINEERED METAL BUILDING
Dr. Richard Forbesm Mississippi State Univ. Mechanical Engineering, Drawer ME Mississippi State, MS 39762

US-35 SUPERIOR HEAT TRANSFER FLUIDS FOR SOLAR HEATING AND COOLING APPLICATIONS
Leo Parts, Monsanto Research Corp., Dayton Laboratory, 1515 Nicholas Road, Dayton, OH 45407

US-36 LOW-COST MIRROR CONCENTRATOR BASED ON DOUBLE-WALLED METALLIZED, TUBULAR FILMS
George L. Ball, III, Monsanto Research Corp., Dayton Laboratory, Station B. Box 8
Dayton, Ohio 45407

US-37 MEDIUM TEMPERATURE AIR HEATERS BASED ON DURABLE TRANSPARENT FILMS
George L. Ball, III, Monsanto Research Corp., Dayton Laboratory, Station B, Box 8,
Dayton, Ohio 45407

US-38 EVALUATION OF THE MIAMISBURG SALT-GRADIENT SOLAR POND
Layton J. Wittenberg, Monsanto Research Corp., Mound Facility, P.O.Box, 32, Miamisburg, Ohio 45342

US-39 DEVELOPMENT OF METHODS OF EVALUATION AND TEST PROCEDURES FOR SOLAR COLLECTORS AND THERMAL STORAGE DEVICES
James E. Hill, National Bureau of Standards, Center for Building Technology, Washington, D.C. 20234

US-40 IMPROVED COLLECTOR EFFICIENCY THROUGH THE USE OF ANTI-REFLECTIVE COATINGS AND IMPROVEMENT IN SOLAR SELECTIVE COATING STABILITY
Louis Spanoudis, Owens-Illinois, Inc., P.O.Box 1035 Toledo, OH 43666

US-41 BLACK GERMANIUM SELECTIVE ABSORBER SURFACES
R. Messier and K. Vedam, The Pennsylvania State University, Materials Research Laboratory
University Park, PA 16802

US-42 FORCED AND NATURAL CONVECTION STUDIES ON SOLAR COLLECTORS FOR HEATING AND COOLING APPLICATIONS
Joseph T. Pearson, Purdue University, Heat Transfer Laboratory, School of Mechanical Engineering, West Lafayette, Indiana 47907

US-43 DEVELOPMENT OF A 10 X LENS CONCENTRATOR
David Holdridge, Swedlow, Inc., 12122 Western Ave., Garden Grove, CA 92645

US-44 DEVELOPEMNT OF A FOCUSING SOLAR COLLECTOR ENERGY CONVERSION SYSTEM
William Roger and David Borton, Rensselaer Polytechnic Institute, Dept. of Mechanical, Aeronautical Engineering & Mechanics
Jonsson Engineering Center, Rm. 5007
Troy, N.Y. 12181

US-45 ANALYTICAL SELECTION OF MARKETABLE SAHP SYSTEM
William Kahan, The Singer Company, 286 Eldridge Road, Fairfield, NJ 07006

US-46 TESTING OF SOLAR COLLECTORS THERMAL PERFORMANCE AND RELIABILITY AND DESIGN VERIFICATION
H.A.Ingley, Solar Energy and Energy Conversion Lab., Rm. 325 MEB, University of Florida, Gainsville, FL 32611

US-47 COLORADO STATE UNIVERSITY SOLAR HOUSE III
Dan S. Ward, Solar Energy Applications Laboratory, Colorado State University, Fort Collins, Colorado 80523

US-48 DEVELOPMENT AND EVALUATION OF A RESIDENTIAL SOLAR HEATING AND COOLING SYSTEM WITH HIGH PERFORMANCE EVACUATED TUBE COLLECTORS --CSU SOLAR HOUSE I
William S. Duff and George O.G.Löf, Solar Energy Applications Laboratory, Colorado State University, Fort Collins, Co 80523

US-49 IMAGE COLLAPSING CONCENTRATORS
Carlyle J. Sletten, Solar Energy Technology Inc., Civil Terminal Building,L.G.Hanscom Field, Bedford, MA 01730

US-50 DEVELOPMENT OF POLYIMIDE MATERIALS FOR USE IN SOLAR ENERGY SYSTEM
John Gagliani, Solar Turbines International, 2200 Pacific Highway, P.O.Box 80966
San Diego, CA 92138

US-51 SOLAR COLLECTOR STUDIES FOR SOLAR HEATING AND COOLING APPLICATIONS
S.O.Jensen, Sperry Univac, P.O.Box 3525
St. Paul, Minnesota 55165 MS. UOS23

US-52 DEVELOPMENT OF SELECTIVE SURFACES
John A. Thornton, Telic Corporation, 1631 Colorado Avenue, Santa Monica, CA 90404

US-53 THE EFFECT OF WIND ON COLLECTORS
Hudy C. Hewitt, Jr., Tennessee Technological University, Box 5161, TTU Cookeville, TN 38501

US-54 WIND LOADS ON SOLAR COLLECTOR PANELS AND SUPPORT STRUCTURES

H.L.Chevalier, Texas A&M University, Aerospace Engineering Department, College Station, Texas 77843

US-55 STRUCTURAL INTEGRITY OF SOLAR COLLECTORS

H.L.Chevalier and R.A.Wilke, Texas A&M University, College Station, Texas 77843

US-56 DEVELOPMENT OF SITE FABRICATED, BUILDING-INTEGRATED AIR SOLAR SYSTEM

Peter L. Temple, Total Environmental Action Inc., Church Hill, Harrisville, NH 03450

US-57 GILROY FOODS SOLAR PROJECT

Payson D. Sierer, Jr.,Trident Engineering Associates, Inc., 48 Maryland Avenue, Annapolis, Maryland 21401

US-58 STUDIES FOR PREDICTABLY MODIFYING THE OPTICAL CONSTANTS OF DOPED INDIUM OXIDE FILMS

Prof. Ronald B. Goldner, Tufts University, Department of Electrical Engineering, Medford, MA 02155

US-59 DESIGN, DEVELOPMENT AND TEST OF A PROTOTYPE SOLAR POWERED TURBOCOMPRESSOR HEAT PUMP

Frank R. Biancardi and James W. Sitler, Division of United Technologies Corp., and Research Center and Hamilton Standard, Silver Lane, East Hartford, CT 06108

US-60 SOLAR POND STUDIES: PHASE III

Howard C. Bryant, Physics & Astronomy, Univ. of New Mexico, 800 Yale Blvd. N.E. Albuquerque, NM 87131

US-61 INSTRUMENTATION OF A SOLAR HEATED AND COOLED APARTMENT BUILDING FOR MONITORING AND EVALUATION

Gary C. Vliet, The University of Texas at Austin, Center for Energy Studies, ENS 143 Austin, Texas 78712

US-62 ANNUAL COLLECTION AND STORAGE OF SOLAR ENERGY FOR THE HEATING OF BUILDINGS

Dr. J. Taylor Beard, University of Virginia, Department of Mechanical and Aerospace Engg. Charlottesville, Virginia 22901

US-63 METHODS OF REDUCING HEAT LOSSES FROM SOLAR COLLECTORS -PHASE III

K.G.T.Hollands, University of Waterloo, Department of Mechanical Engineering, Waterloo Ontario, Canada

US-64 GROOVED FOAMGLAS SOLAR AIR HEATER
John L. Loth, West Virginia University, Aerospace Engineering, Morgantown, WV 26506

US-65 LOW COST EVACUATED TUBE SOLAR COLLECTOR
D.T.Beecher, Westinghouse Electric Corporation Westinghouse Research & Development Center, 1310 Beulah Road, Churchill Boro, Pittsburgh PA 15235

US-66 EVALUATION OF HEAT TRANSFER ENHANCEMENT IN AIR HEATING COLLECTORS
Donald L. Mattox, Northrop Services, Inc., P.O.Box 1484 Huntsville, Alabama

US-67 COLLECTOR SEALANTS AND BREATHING
M.A.Mendelsohn, Westinghouse Research & Development Center, 1310 Beulah Road, Pittsburgh, PA 15235

US-68 INTEGRATED SOLAR ZEOLITE COLLECTOR
Dr. Dimiter Tchernev, The Zeopower Company, 75 Middlesex Avenue, Natick, MA 01760

AUSTRIA

A-1 MULTI-COMPONENT SYSTEM FOR DOMESTIC WATER HEATING AND SPACE HEATING AT THE "INST. F. MOLEKULARBIOLOGIE" OF THE "ÖSTERR. AKADEMIE D. WISSENSCHAFTER" SALZBURG
Prof. Dr. F. Viehböck, Allegemeine Physik, Univ. of Technology, Karlsplatz 13 A-1040 Vienna

A-2 SOLAR ENERGY TEST STATIONS IN AUSTRIA
Austrian Solar and Space Agency, Garnisongasse 7, A-1090 Wien

A-4 SOLAR ENERGY TEST STATION AT BLUDENZ, VORARLBERG
Dipl.-Ing.Rünzler, ARGE Sonnenhaus Bludenz A-6800 Feldkirch

A-5 SYSTEM FOR DOMESTIC WATER HEATING WITHOUT AUXILIARY HEATING AT THE "BIOLOGISCHE VERSUCHSANSTALT" AT ILLMITZ/NEUSIEDLERSEE
Dr. Georg Turnheim, Vereinigt Metallwerke Ranshofen-Berndorf, Leobersdorfer Str. 26 A-2560 Berndorf

A-6 SOLAR ENERGY TEST STATION IN SISTRANS
Dipl.-Ing. Kiraly, A-6073 Sistrans

A-9 CONSTRUCTION OF A DOMESTIC WATER HEATING SYSTEM IN OUAGADOUGOU
Dipl.-Ing.E. Podesser, Institute for Environmental Research, Elisabethstrasze 11 A-8010 Graz

A-11 SOLAR HOUSE VIENNA-FLÖTZERSTEIG (AUSTRIAN SOLAR HOUSE)
Dr. Michael Wachberger/Ing. G. Spielmann, Austrian Institute for Building Research, Dr. Karl Leuger-Ring 10, A-1010 Wien

A-15 DEVELOPMENT OF A MEASUREMENT AND CONTROL SYSTEM FOR SOLAR ENERGY SYSTEM
Prof. Dr. Roland Stickler, Institut für Physikalische Chemie, University of Vienna, Währinger strasze 42, A-1090 Vienna

A-16 DOMESTIC WATER HEATING AND SPACE HEATING WITH SOLAR ENERGY
Prof. Dipl.-Ing. Dr. P.V.Gilli, Arbeitsgemeinschaft Sonnenenergie, Obere Techstrasze 21/1. A-8010 Graz

A-18 COMPACT SOLAR SYSTEM FOR DOMESTIC WATER HEATING
Dr. Georg Turnheim, Vereinigte Metallwerke Ranshofen-Berndorf, Postfach 35 A-2560 Berndorf

A-19 DEVELOPMENT OF A PROTOTYPE OF AN INEXPENSIVE PLASTIC STORAGE SYSTEM
Prof. Dr. E. Panzhauser, Inst. f. Hochbau und Entwerfen 1, University of Technology Karlsplatz 13, A-1040 Wien

A-22 DEVELOPMENT AND TESTING OF COMPONENTS FOR SOLAR HEATING SYSTEMS
Ing. Bango and Dr. Braülich, Inst. f. Environmental Research, Graz, A-8661 Wartberg/Mürztal

A-23 DWELLING WITH ALL ELECTRICAL ENERGY SUPPLY AND EXTREMELY LOW SPECIFIC ENERGY DEMAND
Dr. Peter Schaup, Gemeinnützige Wohnungs- und Siedlungsges. der Elin Union AG Penxinger Strasze 76 A-1141 Vienna

A-24 REDUCTION OF HEATING COSTS IN GREENHOUSES BY HEAT STORAGE
Dipl.-Ing. Konrad Frey, Institut für Umweltforschung, Elisabethstrasze 11 A-8010 Graz

DENMARK

D-2 CHEMICAL HEAT STORAGE
Peter Christensen, Thermal Insulation Laboratory, The Technical University of Denmark, Building 118, 100 Lundtoftevej DK-2800 Lyngby

D-3 HEAT OF FUSION STORAGE UNITS
Simon Furbo, Thermal Insulation Laboratory, The Technical University of Denmark, Building 118, 100 Lundtoftevej DK-2800 Lyngby

D-4 LOFT COLLECTOR WITH SLAB ON GRADE -HEAT STORAGE
Kurt Kielsgård, Thermal Insulation Laboratory, The Technical University of Denmark, Building 118, 100 Lundtoftevej DK-2800 Lyngby

D-5 SEASONAL HEAT STORAGE IN UNDERGROUND HOT WATER STORES
Preben Hansen, Thermal Insulation Laboratory, The Technical University of Denmark, Building 118, Lundtoftevej, DK-2800 Lyngby

FEDERAL REPUBLIC
OF GERMANY

FRG-19 ENERGY CONSERVATION AND THE USE OF SOLAR ENERGY IN BUILDINGS
Dr. H. Hörster, Philips GmbH, Forschungs-Laboratorium Aachen, D-5100 Aachen

FRG-20 LONG-TERM ENERGY STORAGE TANKS FOR RESIDENTIAL BUILDINGS AND THE ARCHITECTURAL DESIGN OF SOLAR HOUSES
Dr.-Ing. B. Dietrich, Energietechnik GmbH Freihofstrasse 31, 4307 Kettwig

FRG-23 DEVELOPMENT OF A MODULAR EXCHANGER WITH INTEGRATED LATENT-THERMAL ENERGY STORAGE
Dr. A. Abhat, Dr. G. Neuer, Kerntechnik und Energiewandlung eV, Holderbuschweg 52 7000 Stuttgart 80

FRG-24 MEASURING PROGRAM FOR HOT WATER SUPPLY IN PRE-FABRICATED HOUSES USING SOLAR ENERGY
Ing. grad. U. Heidmann, Süddeitsche Metallwerke GmbH, Impexstrasse 5, D-6909 Walldorf

FRG-25 SOLAR ENERGY PLANT TO SUPPLEMENT A CONVENTIONAL HEATING SYSTEM
Prof. Doering, Fachhochschule für Technik, Fachbereich Versorgungstechnik, Kanalstrasze 33, 7300 Esslingen

FRG-29 FLAT PLATE COLLECTORS AS FACADE ELEMENTS FOR WATER PREHEATING AND HEAT INSULATION
Prof. Dr.-Ing. M. Mäisz, Technische Fachhochschule, Berlin, Luxemburger str., 10, 1000 Berlin 65

FRG-30 SOLAR HOUSE FREIBURG
Dr. K.R.Schreitmüller, DFVLR

FRG-32 TECHNICAL USE OF SOLAR ENERGY
Prof. G. Lehner, Institutsgemeinschaft für die Technologie-Nutzung Solarer Energie Universität Stuttgart, Breidscheidstrasse 3/7000 Stuttgart 1

ITALY

I-1 HEAT STORAGE BY SOLID-SOLID PHASE TRANSITION
Prof. Fabio Fittipaldi, Istituto di Fisica Facoltà di Ingegnerio, Piazzale Tecchio 80125 Napoli

I-2 SOLID-SOLID PHASE TRANSITION SUBSTANCES IN POLYMERIC MATRICES
A. Addeo and L.Nicolais, Istituto G. Donegani, Montedison, Barra Napoli

I-3 HEAT STORAGE BY REVERSIBLE CATALYTIC REACTIONS
Prof. Nicola Giordano, Istituto Chimica Industriale, Università di Messina, Via Ghibellina 64 Nessina

JAPAN

J-4 SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM FOR LARGE BUILDING
Yasuo Tanaka, Toyo Netsu Kogyo Kaisha, Ltd., 5-12 Kyobachi 2-chome, Chuo-ku Tokyo

J-10 MATERIALS AND SYSTEM COMPONENT FOR THERMAL ENERGY STORAGE
M. Kosaka, Solar Research Laboratory, GIRIN 1 Hirate-machi, Kita-ku, Nagoya 462

J-11 FUNDAMENTAL STUDY OF UNDERGROUND STORAGE OF HEAT IN SOLAR HEATING AND COOLING SYSTEM
Dr. Tatsuaki Tanaka, Ohbayashi-Gumi Research Institute, 4-640, Shimokiyoto, Kiyose-shi, Tokyo

J-14 R & D OF HEAT STORAGE FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM IN A MULTIFAMILY RESIDENCE
Dr. Manabu Kurita, Ishikawajima-Harima Heavy Industries, 2-16, 3 Toyosu, Koto-ku Tokyo 135-91

J-15 SOLAR HEAT STORAGE
Junjiro Kai, Mitsubishi Electric Corporation, 2-3 Marunouchi 2-chome, Chiyoda-ku, Tokyo

NETHERLANDS

NL-1 NATIONAL PROGRAMME ON SOLAR ENERGY RESEARCH
K. Joon, Project Office for Energy Research BEOP, c/o ECN P.O.Box 1 1755 ZG Petten (N.-H)

NL-4 HEAT STORAGE IN PHASE CHANGE MATERIALS
A.G.de Jong, Heat Transfer Group, Applied Physics, Delft University of Technology, Lorentzweg 1 P.O.Box 5046, 2600 GA Delft

NL-5 SEASONAL STORAGE OF SOLAR HEAT IN THE GROUND
C.W.J.van Koppen and L.S.Fischer, Eindhoven University of Technology, Lab. Heat Technology, P.O.Box 513 Eindhoven

SWEDEN

SWED-3 SALT HYDRATE STORAGE FOR STORING HEAT IN AIR-BASED SOLAR ENERGY HEATING SYSTEM
Henry Hedman, Studsvik Energiteknik AB S-611 82 Nyköping

SWED-4 SOLAR ENERGY AND BUILDINGS
Bo Carlsson, Hans Stymne, & Gunnar Wettermark, Phys. Chem., Royal Inst., of Technology, FACK S-1-0 44 Stockholm 40

SWED-5 THERMOCHEMICAL STORAGE OF ENERGY
Bo Carlsson, Wiktor Raldow, Hans Stymne and Gunnar Wettermark, Dept. of Phys. Chem. Royal Inst.of Technology, FACK 100 44 Stockholm 70.

SWED-7 CENTRAL SOLAR HEAT STATION. DEMONSTRATION PLANT IN STUDSVIK
Rutger Roseen, Studsvik Energiteknik AB, S-611 82 Nyköping

SWED-8 THE LAMBOHOV PROJECT - SOLAR ENERGY HOUSES IN LINKÖPING
Jan Svensson, AB Östgöta-Byggen, Box 9001 580 09 Linköping

SWED-9 THE INGELSTAD PROJECT - SOLAR HEAT PLANT
Rejlers Ingenjörsbyrå AB, Community of Växjö, V. Esplanaden 18, 352 32 Växjö

SWITZERLAND

SWIT-1 EARTH HEAT PUMP
Heinz H. Sulzer, Sans G. Sulzer, Lohnstrasse 1 8200 Schaffhausen

SWIT-3 INTERSEASONAL HEAT ACCUMULATOR IN THE GROUND FOR SOLAR ENERGY FOR FAMILY HOUSES
Bernard Mathey, B.Mathey/Geologue Conseil, CH-2205 Montezillon

SWIT-9 SOLAR TRAP - PASSIVE UND AKTIVE SONNENENERGIENUTZUNG BEI GEBÄUDEN
Arbeitsgruppe "Solar Trap", Basler & Hofmann, Consulting Engineers, Forchstrasse 395 CH-8029 Zürich

SWIT-11 GENERATION AND STORAGE OF CHEMICAL ENERGY
PD Dr. Gion Calzaferri, University of Berne, Inorganic and Physical Chemistry, Freiestrasse 3, CH-3000 Bern 9

SWIT-12 UNDERGROUND HEAT STORAGE
B. Saugy and J.C.Hadorn, IPEN - EPF Lausanne Département de Génie Civil, Ecublens 1015 Lausanne

SWIT-13 UNDERGROUND HEAT STORAGE
B.Saugy and B. Mathey, IPEN-Lausanne & CHY-Neuchatel, IPEN-EPF Lausanne, Département de Génie Civil, Ecublens 1015 Lausanne

SWIT-14 COMPARISON BETWEEN LATENT HEAT STORAGE AND SENSIBLE HEAT STORAGE IN A SOLAR WATER HEATING SYSTEM
L. Keller, Bureau d'Etudes Keller-Burnier CH-1171 Lavigny

SWIT-15 STEAM POWER STATION WITH HEAT STORAGE
J. Zabelka, Sulzer Bros. Ltd., 8401 Winterthur

SWIT-26 SENSIBLE HEAT STORAGE TANKS WITH FORCED STRATIFICATION
M. Balawi & P. Suter, EPF-Lausanne, Institut de Thermique appliquée, Halles de Mécanique Ecublens 1015 Lausanne

SWIT-33 THERMOSYPHON MODEL
N. Morel, Solar Group - EPFL, Lab. de Physique Théorique, 14 Av. de L'Eglise Anglaise 1006 Lausanne

SWIT-44 THE LAYOUT OF SOLAR HOT WATER SYSTEMS, USING STATISTICAL METEO- AND HEAT DEMAND DATA
P.Kesselring and A. Duppenthaler,EIR Würenlingen, Swiss Federal Institute for Reactor Research (EIR), 5303 Würenlingen

SWIT-45 MEASUREMENT OF PERFORMANCE AND EFFICIENCY OF SOLAR ENERGY SYSTEMS
J.M.Suter and P. Kesselring, EIR Würenlingen Swiss Federal Institute for Reactor Research (EIR), 5303 Würenlingen

SWIT-46 OASE, THE SOLAR ENERGY HOT WATER SUPPLY SYSTEM OF THE INSTITUTE'S RESTAURANT
J.M.Suter and Th. Nordmann, EIR Würenlingen Swiss Federal Institute of Reactor Research (EIR) 5303 Würenlingen

SWIT-51 CHEMICAL THERMAL STORAGE
Atlantis Energy Ltd., Thunstrasse 8, CH-3000 Bern 6

U. S. A.

US-11 COMPUTER SIMULATION OF THE PERFORMANCE OF CHEMICAL HEAT PUMPS BASED ON THE H_2SO_4/H_2O, $CaCl_2/CH_3OH$, AND NH_4NO_3/NH_3 REACTIONS
PeterO'D Offenhartz, EIC Corporation, 55 Chapel Street, Newton MA 02158

US-13 GROUND COUPLED SOLAR ASSISTED HEAT PUMP FIELD PERFORMANCE EVALUATIONS
Sam V. Shelton, E-Tech, Inc., 3570 American Drive, Atlanta, GA 30341

US-15 RESIDENTIAL SOLAR HEATING DEVELOPMENT & DEMONSTRATION
Philip Levine, Fern Engineering Co., 536 Mac Arthur Blvd., Bourne, MA 02532

US-24 PHOENIX/CITY OF COLORADO SPRINGS SOLAR ASSISTED HEAT PUMP PROJECT
Douglas M. Jardine, P.E., Kaman Sciences Corporation, P.O.Box 7463, 1500 Garden of the God Road, Colorado Springs, Colorado 80933

US-31 NATIONAL SECURITY AND RESOURCES STUDY CENTER
James Hedstrom, Los Alamos Scientific Laboratory, Box 1663 M.S. 571 Los Alamos NM 87545

US-33 MICROPROCESSOR CONTROLLED SOLAR COLLECTOR SYSTEM
Richard L.T.Wolfson, Middlebury College, Middlebury, Vermont 05753

US-35 SUPERIOR HEAT TRANSFER FLUIDS FOR SOLAR HEATING AND COOLING APPLICATIONS
Leo Parts, Monsanto Research Corp, Dayton Laboratory, 1515 Nicholas Road, Dayton OH 45407

US-38 EVALUATION OF THE MIAMISBURG SALT-GRADIENT SOLAR POND
Layton J. Wittenberg, Monsanto Research Corp., Mound Facility, P.O.Box. 32, Miamisburg, OH 45342

US-45 ANALYTICAL SELECTION OF MARKETABLE SAHP SYSTEM
William Kahan, The Singer Company, 286 Eldridge Road, Fairfield, NJ 07006

US-47 COLORADO STATE UNIVERSITY SOLAR HOUSE III
Dan S. Ward, Solar Energy Application Laboratory, Colorado State University, Fort Collins, Colorado 80523

US-48 DEVELOPMENT AND EVALUATION OF A RESIDENTIAL SOLAR HEATING AND COOLING SYSTEM WITH HIGH PERFORMANCE EVACUATED TUBE COLLECTORS --CSU SOLAR HOUSE I
William S. Duff and George O.G.Löf, Solar Energy Applications Laboratory, Colorado State University, Fort Collins CO 80523

US-56 DEVELOPMENT OF SITE FABRICATED, BUILDING-INTEGRATED AIR SOLAR SYSTEM
Peter L. Temple, Total Environmental Action, Inc., Church Hill, Harrisville, NH 03450

US-59 DESIGN, DEVELOPMENT AND TEST OF A PROTOTYPE SOLAR-POWERED TURBOCOMPRESSOR HEAT PUMP
Frank R. Biancardi and James W. Sitler, Division of United Technologies Corp., and Research Center and Hamilton Standard, United Technologies Research Center, Silver Lane, East Hartford, CT 06108

US-60 SOLAR POND STUDIES: PHASE III
Howard C. Bryant, Physics & Astronomy, University of New Mexico, 800 Yale Blvd. N.E. Albuqueque, NM 87131

US-61 INSTRUMENTATION OF A SOLAR HEATED AND COOLED APARTMENT BUILDING FOR MONITORING AND EVALUATION
Gary C. Vliet, The University of Texas at Austin, Center for Energy Studies, ENS 143 Austin, Texas 78712

US-62 ANNUAL COLLECTION AND STORAGE OF SOLAR ENERGY FOR THE HEATING OF BUILDINGS
Dr. J. Taylor Beard, University of Virginia Department of Mechanical and Aerospace Engineering, Charlottesville, VA 22901

US-69 SOLAR HEATING AND COOLING SYSTEM DESIGN AND DEVELOPMENT
Robert Gunner, AiResearch Manufacturing Co., of California, 2525 West 190th St. Torrance, CA 90509

US-70 DESIGN AND INSTALLATION MANUAL FOR THERMAL ENERGY STORAGE
Roger L. Cole, Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439

US-71 ANALYTICAL MODELLING OF THERMOCLINE AND HALOTHERMOCLINE STORAGE SYSTEMS
E.I.H.Lin and W.T.Sha, Argonne National Laboratory, 9700 South Cass Avenue, Argonne IL 60439

US-72 THERMAL ENERGY STORAGE SUBSYSTEM
Dr. Fred Ordway, Artech Corp., 2901 Telestar Court, Falls Church, Virginia 22042

US-73 SALT HYDRATE THERMAL ENERGY STORAGE SYSTEMS FOR SOLAR HEATING AND AIR CONDITIONING
Calvin D. MacCracken, Calmac Manufacturing Corporation, 150 South Van Brunt Street, Englewood, NJ 07631

US-74 CHEMICAL HEAT PUMPS BASED ON THE REACTION OF $CaCl_2$ WITH H_2O AND CH_3OH
Peter O'D. Offenhartz, EIC Corporation, 55 Chapel Street, Newton, MA 02158

US-75 TWO-COMPONENT THERMAL STORAGE MATERIAL STUDY-PHASE II
A.T.Tweedie and E.M.Mehalick, General Electric Company, Advanced Energy Programs P.O.Box 8661, Philadelphia PA 19101

US-76 PROTOTYPE DESIGN AND TESTING OF THE ROLLING CYLINDER THERMAL STORAGE SYSTEM
C.S. Herrick, General Electric Corporate R&D P.O.Box 8, Schenectady, NY 12301

US-78 SOLAR APPLICATIONS OF THERMAL ENERGY STORAGE
Dr. Charles Lee, Hittman Associates, Inc., 9190 Red Branch Road, Columbia, MD 21045

US-79 ACTIVE HEAT EXCHANGE SYSTEM DEV. FOR HEAT OF FUSION TES
R.T.LeFrois, Honeywell, Inc., Technology Strategy Center, 2600 Ridgeway Parkway, Minneapolis, MN 55413

US-81 DEVELOPMENT OF AN IMPROVED WATER TANK FOR THERMAL STORAGE

William T. Hudson and William M. Jones, Independent Living, Inc., 5965 Peachtree Corners East Unit A-4, Norcross, Georgia 30071

US-82 THERMAL STORAGE FOR SOLAR COOLING USING AMMONIATED SALTS

Martin Marietta Aerospace, P.O.Box 179 Denver CO 80201

US-83 DEVELOPMENT OF METHODS FOR EVALUATION AND TEST PROCEDURES FOR SOLAR COLLECTORS AND THERMAL STORAGE DEVICES

James E. Hill, National Bureau of Standards, Center for Building Technology, Washington, D.C. 20234

US-84 DESIGN AND FIELD TESTING OF SOLAR ASSISTED EARTH COILS

James E. Bose, Oklahoma State University, School of Technology, 101 Industrial Building Stillwater, OK 74074

US-85 SOLAR ENERGY STORAGE IN SLAT GRADIENT PONDS

Dr. Carl E. Nielsen, The Ohio State Univ. Physics, OSU Research Foundation, 1314 Kinnear Road, Columbus, OH 43210

US-86 HYBRID THERMAL STORAGE WITH WATER

Michael P. Moriarty, Rockwell International 8900 DeSoto Avenue, Canoga Park, CA 91304

US-87 MEMBRANE-LINE THERMAL STORAGE SYSTEMS

Richard Bourne, University of Nebraska-Lincoln, Engineering Research Center. Lincoln, NE 68588

US-88 LIGHTWEIGHT CONCRETE MATERIALS AND STRUCTURAL SYSTEMS FOR WATER TANKS FOR THERMAL STORAGE

R.W. Buckman, Jr, Westinghouse Advanced Energy Systems Division, P.O.Box 10864 Pittsburgh, PA 15236

AIR CONDITIONING UNITS

AUSTRIA

A-12 SOLAR-POWERED ABSORPTION COOLING SYSTEM
Dipl.-Ing.. Erich Podesser, Institute for Environmental Research, Elisabethstrasse 11, 8010 Graz

FEDERAL REPUBLIC OF GERMANY

FRG-31 SOLAR AIR CONDITIONING AND COOLING - PHASE 1
Dipl.-Ing. H. Grallert, Messerschmitt-Bölkow-Blohm GmbH, Postfach 801169 8000 München 80

FRG-32 TECHNICAL USE OF SOLAR ENERGY
Prof. G. Lehner, Institutsgemeinschaft für die Technologie-Nutzung Solarer Energie, Universität Stuttgart, Breidscheidstrasse 3/7000 Stuttgart 1

JAPAN

J-2 DEVELOPMENT OF LARGE SCALE ABSORPTION MACHINE WHICH IS OPERATED IN SINGLE EFFECT BY SOLAR AND IN DOUBLE EFFECT BY AUXILIARY HEAT SOURCES
Kenji Ooka, Kawasaki Heavy Industries, Ltd., Osaka Works of Kawasaki Heavy Industries, Ltd., 1-35, 4-chome-shimaya, Konohana-ku Osaka

J-12 R & D SOLAR RANKINE CYCLE AIRCONDITIONER FOR SOLAR HEATING AND COOLING IN A MULTI-FAMILY RESIDENCE
Akira Uchihara, Ishikawajima-Harima Heavy Industries, 2-16, 3 Toyosu, Koto-ku, Tokyo 135-91

J-16 DEVELOPMENT OF THE AIR-CONDITIONING UNIT DRIVEN BY A SOLAR POWERED RANKINE CYCLE ENGINE
Mitsubishi Electric Corporation, 2-3 Marunouchi, 2-chome, Chiyoda-ku, Tokyo 100

NETHERLANDS

NL-3 SOLAR POWERED ABSORPTION REFRIGERATING SYSTEMS
C.Keizer, Laboratory of Refrigerating Engineering, Delft University of Technology, Mekelweg 2, Delft

SWITZERLAND

SWIT-2 LOW TEMPERATURE SOLAR SYSTEM
B.G.Kunz Ing HTL, Synchroplan AG Bremgarten, Haldenstrasse 10, 8967 Widen

SWIT-8 AEROCAL - HEAT PUMP
R. Spalinger and F. Michels, Störi & Co., AG, CH 8820 Wädenswil

SWIT-23 ACTIVE SOLAR HEATING SYSTEM
J.R.Muller and P.Suter, EPF-Lausanne, Institute de Thermique appliquée, Halles de Mécanique Ecublens, 1015 Lausanne

SWIT-24 INTERACTION OF SOLAR COLLECTOR AND HEAT PUMP
J.R.Muller and P. Matthey, EPF-Lausanne Unité de Thermique de l'EPF-L, Halles de Mécanique Ecublens, 1015 Lausanne

SWIT-48 INTERMITTENT SOLAR ABSORPTION COOLING UNIT
H.J. Leibundgut and R. Favre, Laboratory for Dairy Research, Labor für Milchwissenschaft ETH-Z Eisgasse 8, 8004 Zürich

U. S. A.

US-11 COMPUTER SIMULATION OF THE PERFORMANCE OF CHEMICAL HEAT PUMPS BASED ON THE H_2SO_4/H_2O, $CaCl_2/CH_3OH$, and NH_4NO_3/NH_3 REACTIONS
Peter O'D. Offenhartz, EIC Corporation, 55 Chapel Street, Newton MA 02158

US-16 SYSTEM DESIGN ADN DEVELOPMENT OF SOLAR HEATING AND COOLING SYSTEMS
James C.Graf, General Electric, Advanced Energy Department, P.O.Box 8661, Philadelphia PA 19101

US-24 PHONIX/CITY OF COLORADO SPRINGS SOLAR ASSISTED HEAT PUMP PROJECT
Douglas M. Jardine, P.E., Kaman Sciences Corporation, P.O.Box 7436, 1500 Garden of the God Road, Corolado Springs, CO 80933

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James Hedstrom, Los Alamos Scientific Laboratory, Box 1663, M.S. 571 Los Alamos, N.M. 87545

US-47 COLORADO STATE UNIVERSITY SOLAR HOUSE III
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William S. Duff and George O.G.Löf, Solar Energy Applications Laboratory, Colorado State University, Fort Collins CO 80523

US-59 DESIGN, DEVELOPMENT AND TEST OF A PROTOTYPE SOLAR POWERED TURBOCOMPRESSOR HEAT PUMP

Frank R. Biancardi and James W. Sitler, Division of United Technologies Corp., and Research Center and Hamilton Standard, United Technologies Research Center, Silver Lane, East Hartford, CT 06108

US-61 INSTRUMENTATION OF A SOLAR HEATED AND COOLED APARTMENT BUILDING FOR MONITORING AND EVALUATION

Gary C. Vliet, The University of Texas at Austin, Center for Energy Studies, ENS 143, Austin, Texas 78712

US-68 INTEGRATED SOLAR ZEOLITE COLLECTOR

Dr. Dimiter Tchernev, The Zeolite Company, 75 Middlesex Avenue, Natick, MA 01760

US-69 SOLAR HEATING AND COOLING SYSTEMS DESIGN AND DEVELOPMENT

Robert Gunner, AiResearch Manufacturing Co. of California, 2525 West 190th St. Torrance, CA 90509

US-74 CHEMICAL HEAT PUMPS BASED ON THE REACTIONS OF $CaCl_2$ WITH H_2O AND CH_3OH

Peter O'D. Offenhartz, EIC Corporation, 55 Chapel Street, Newton MA 02158

US-82 THERMAL STORAGE FOR SOLAR COOLING USING AMMONIATED SALTS

Martin Marietta Aerospace, P.O.Box 179 Denver CO 80201

US-89 DEVELOPMENT OF A SOLAR DESICCANT DEHUMIDIFIER

J. Rousseau, AiResearch Manufacturing Co., of California, 2525 W. 190th St., Torrance CA 90509

US-90 LONG-TERM ICE STORAGE FOR COOLING APPLICATIONS USING PASSIVE FREEZING TECHNIQUES

Anthony J. Gorski, Argonne National Laboratory, 9700 South Cass Ave., Bldg. 362, Argonne, IL 60439

US-91 UNITARY SOLAR HEATING/COOLING SYSTEM PACKAGE DEVELOPMENT

Richard H. Herrick, Arkla Industries Inc.,

US-92 DEVELOPMENT OF HARDWARE SIMULATIONS FOR TESTS OF SOLAR COOLING/HEATING SUBSYSTEMS AND SYSTEMS

Paul Chungmoo Auh, Brookhaven National Laboratory, Solar Technology Group, Bldg. 701 Upton, N.Y. 11973

US-93 PROTOTYPE MODULAR ABSORPTION AIR CONDITIONING SYSTEM

Dr. Wendell and J. Biermann, Energy Systems Division, Carrier Corp., P.O.Box 4895, Summit Landing, Syracuse NY 13221

US-94 DEVELOPMENT OF A HIGH TEMPERATURE SOLAR POWERED WATER CHILLER FOR USE IN A SOLAR HEATING AND COOLING SYSTEM

Richard A. English, Energy Systems Division, Carrier Corp., P.O.Box 4895 Summit Landing Syracuse, NY 13221

US-95 SINGLE FAMILY ABSORPTION CHILLER FOR SOLAR USE

Dr. Wendell and J. Biermann, Energy Systems Division, Carrier Corp., P.O.Box 4895 Summit Landing, Syracuse, NY 13221

US-96 DEVELOPMENT OF A SOLAR DESSICANT DEHUMIDIFIER

Z. Lavan and D. Gidaspow, Illinois Institute of Technology, 3110 South State Street, Chicago, IL 60616

US-97 ANALYSIS OF ADVANCED CONCEPTUAL DESIGNS FOR SINGLE-FAMILY-SIZE ABSORPTION CHILLERS

Robert A. Macriss and Thomas S. Zawacki, Institute of Gas Technology, 3425, S. State Street, Chicago, IL 60616

US-98 SOLAR DESICCANT AIR-CONDITIONER (SOLAR-MEC) DEVELOPMENT

Robert A. Macriss and Jaroslav Wurm, Institute of Gas Technology, 3424, S. State Street, Chicago, IL 60616

US-99 DEVELOPMENT OF SOLAR-DRIVEN ABSORPTION AIR-CONDITIONERS AND HEAT PUMPS

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

US-100 COMPONENT AND SYSTEMS EVALUATIONS STUDY OF SOLAR DESICCANT COOLING

J.W.Mitchell and J.A.Duffie, Solar Energy Laboratory, University of Wisconsin, 1500 Johnson Drive, Madison, WI 53706

US-101 OPTIMIZATION OF SOLAR COOLING SYSTEMS

D.K.Anand and R.W.Allen, University of Maryland, Mechanical Engineering Dept., College Park, MD 20742

US-124 SOLAR COOLING SYSTEM EVALUATION

Dr. H.M. Curran, Hittman Associates, Inc. 9190 Red Branch Road, Columbia, MD 21045

US-128 ADVANCE SOLAR SYSTEM ANALYSES

Jeffrey H. Morehouse, Science Applications Inc., 1764, Old Meadow Lane, McLean Virginia 22180

OTHER SUBSTANTIAL COMPONENTS

AUSTRIA

A-2 SOLAR ENERGY TEST STATIONS IN AUSTRIA
Austrian Solar and Space Agency, Garnisongasse 7, A-1090 Wien

A-6 SOLAR ENERGY TEST STATION IN SISTRANS
Dipl. -Ing. Kiraly, A-6073 Sistrans

A-8 CONSTRUCTION AND OPERATION OF SOLAR COLLECTOR TEST STATION
Ing. J. Kriha, Bundesversuchs - und Forschungsanstalt, Arsenal 1030 Wien

A-9 CONSTRUCTION OF A DOMESTIC WATER HEATING SYSTEM IN OUAGADOUGOU
Dipl. - Ing. E. Podesser, Institute for Environmental Research, Elisabethstrasse 11 A-8010 Graz

A-11 SOLAR HOUSE VIENNA-FLÖTZERSTEIG (AUSTRIAN SOLAR HOUSE)
Dr. Michael Wachberger/Ing. G. Spielmann, Austrial Institute for Building Research Dr. Karl Lueger-Ring 10, A-1010 Wien

A-16 DOMESTIC WATER HEATING AND SPACE HEATING WITH SOLAR ENERGY
Prof. Dipl.-Ing. Dr. P.V.Gilii, Arbeitsgemeinschaft Sonnenenergie, Obere Techstrasze 21/1 A-8010

A-20 DEVELOPMENT OF A DATA LOGGER FOR AUTOMATICAL RECORDING AND PROCESSING OF RELEVANT DATA FOR THE DETERMINATION OF THE ENERGY FLUX IN MULTI COMPONENT SOLAR SYSTEMS
Dr. M. Bruck & Prof. F. Viehböck, Austrian Solar and Space Agency, Garnisongasse 7, A-1090 Vienna

A-21 GAS DRIVEN HEAT PUMPS AND THEIR USE IN HEATING SYSTEMS
Jenbacher Werke, A-6200 Jenback

DENMARK

D-4 LOFT COLLECTOR WITH SLAB ON GRADE-HEAT STORAGE
Kurt Kielsgård Hansen, Thermal Insulation Laboratory, Thermal Insulation Laboratory, The Technical University of Denmark, Building 118, 100 Lundtoftevej, DK-2800 Lyngby

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OF GERMANY

FRG-3 DEVELOPMENT OF SOLAR HEATING CONTROLS FOR WATER-HEATING AND BUILDING-HEATING SYSTEMS. CHOICE OF FLUIDS, TEST

Klöchner & Co., Wärmetechnik, Werk Herchingen, Haigerlocherstrasse 42
Postbox 1109, D-7450 Hechingen 1

FRG-6 DEVELOPMENT OF ECONOMIC SOLAR HEATING SYSTEMS USING INEXPENSIVE COLLECTORS

J. Lorenz, M.A.N. Technologie Maschinenfabrik Augsburg - Nürnberg AG

FRG-22 TECHNICAL AND SCIENTIFIC INVESTIGATIONS CARRIED OUT AT THE SOLAR ENERGY EXPERIMENTAL FACILITY IN WIEHL/FRG

K. Biasin, Energietechnik GmbH,
4300 Essen-Kettwig

JAPAN

J-5 SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM FOR LARGE BUILDING

Yasuo Tanaka, Toyo Netsu Kogyo Kaisha, Ltd.
5-12 Kyobashi 2-chome, Chuo-ku, Tokyo

NETHERLANDS

NL-1 NATIONAL PROGRAMME ON SOLAR ENERGY RESEARCH

K. Joon, Project Office for Energy Research
BEOP c/o ECN P.O.Box 1, 1755 ZG Petten (N.-H)

SWEDEN

SWED-6 PLASTIC CONVECTORS

Allan Johansson, Studsvik Energiteknik AB
S-611 82 Nyköping

SWITZERLAND

SWIT-1 EARTH HEAT PUMP

Hans G. Sulzer, Lohnstrasse 1, 8200 Schaffhausen

SWIT-2 LOW TEMPERATURE SOLAR SYSTEM

B. G. Kunz Ing HTL, Synchroplan AG Bremgarten
Synchroplan AG, Haldenstrasse 10, 8967 Widen

SWIT-5 HELIOSTAT TEST FACILITY

H. Tannenberger & J. Sekler, Laboratoire Suisse de Recherches Horlogere, Rue A-L Breguet 2, Case postale 42, 2000 Neuchâtel 7

SWIT-6 SMALL SOLAR POWER PLANT WITH SOLAR CELLS

M. Camani, Dipartimento Ambiente, 6500 Bellinzona

SWIT-9 SOLAR TRAP - PASSIVE UND AKTIVE SONNENENERGIENUTZUNG BEI GEBÄUDEN
Arbeitsgruppe "Solar Trap", Basler & Hofmann Consulting Engineers, Forchstrasse 395
CH-8029 Zürich

SWIT-15 STEAM POWER STATION WITH HEAT STORAGE
J. Zabelka, Sulzer Bros. Ltd., 8401 Winterthur

SWIT-18 ALMERIA STEAM GENERATOR
H. W. Fricker, Sulzer Bros. Ltd., 8401 Winterthur

SWIT-19 RADIATION LOSSES AND ENERGY CONSUMPTION OF BUILDINGS
Prof. Kneubühl/Sagelsdorff, ETHZ/EMPA, ETHZ CH-8093 Zürich Infrared Physics, EMPA CH-8600 Dübendorf

SWIT-20 SOLAR RADIATION MEASUREMENT
Dr. P. Valko, Swiss Meteorological Institute Krähbühlstrasse 58, CA-8044 Zürich

SWIT-21 SOLAR MULTISTAGE WATER DESALINATION
R. Kriesi, Ing. Dipl., Institut de Thermique Appliquèe de l'EPF-LAUSANNE, Halles de Mècanique Ecublens, 1015 Lausanne

SWIT-27 PHOTOGALVANIC CELLS
A. von Zelewsky & O. Haas, University of Fribourg, Institute of Inorganic Chemistry, University Pèrolles, CH-1700 Fribourg

SWIT-28 CHARACTERIZATION OF AMORPHOUS SILICON DEPOSITED BY LOW PRESSURE CHEMICAL VAPOR DEPOSITION (LPCVD)
A. E. Widmer & G. Harbeke, Laboratories RCA Ltd., Badenerstrasse 569, 8048 Zürich

SWIT-31 TEST AND DEVELOPMENT OF HEAT FLOW METERS
A. Razafindraibe, Solar Group-EPFL, EPFL Lab. de Physique Thèorique, 14, Av. de L'Eglise Anglaise, 1006 Lausanne

SWIT-32 MATHEMATICAL MODEL FOR COMPUTING TILTED SURFACE SOLAR IRRADIATION
Perrin & Ferraris, Solar Groupe-EPFL, EPFL Lab. de Physique Thèorique 14, Av. de L'Eglise Anglaise 1006 Lausanne

SWIT-33 THERMOSYPHON MODEL
N. Morel, Solar Groupe-EPFL, EPFL Lab. de Physique Thèorique 14, Av. de L'Eglise Anglaise 1006 Lausanne

SWIT-36 LIGHT-OPERATED VACUUM-PUMP
H. Freyholdt, AMI SA, 120, Avenue d'Echallens 1004 Lausanne

SWIT-37 EVACUATED WINDOW, $\kappa = 0.3\ W/m^2\kappa$
H. Freyholdt, AMI SA, 120, Avenue d'Ech-llens 1004 Lausanne

SWIT-38 TEST STAND FOR HIGH-TEMPERATURE (300°C) SOLAR COLLECTORS
H. Freyholdt, AMI SA, 120, Avenue d'Echallens
1004 Lausanne

SWIT-39 VACUUM-INSULATED PIPING SYSTEM FOR DISTANCE HEATING
H. Freyholdt, AMI SA, 120, Avenue d'Echallens
1004 Lausanne

SWIT-40 INSTRUMENTATION OF PASSIVE SOLAR HOUSES
G. R. Perrin/A. Razafindraibe, Solar Group
EPFL Laboratoire de Physique Théorique 14,
Av. de l'Eglise Anglaise, 1006 Lausanne

SWIT-41 GREENHOUSE
Ruedi Zai, Architekturbüro Zai,
Im Aesch, 8821 Schönenberg

SWIT-42 SMALL SOLAR POWER SYSTEM (INTERNATIONAL ENERGY AGENCY)
Dr. P. Kesselring & M. Real, Swiss Federal
Institut for Reactor Research, CH-5303
Würenlingen

SWIT-43 HELIOSTAT TEST FACILITY
Markus Real, Swiss Federal Institut for
Reactor Research, CH-5303 Würenlingen

SWIT-46 OASE, THE SOLAR ENERGY HOT WATER SUPPLY SYSTEM OF THE INSTITUTE'S RESTAURANT
J. M. Suter & Th. Nordmann, EIR Würenlingen
Swiss Federal Institute of Reactor Research
(EIR) 5303 Würenlingen

SWIT-48 INTERMITTENT SOLAR ABSORPTION COOLING UNIT
H. J. Leibundgut & R. Favre, Laboratory for
Dairy Research, Labor für Milchwissenschaft
ETH-Z Eisgasse 8, 8004 Zülich

SWIT-49 THERMOPHOTOVOLTAIC COLLECTOR
Atlantis Energy Ltd., Thunstrasse 8,
3006 Bern

SWIT-50 CALORIMETER FOR POWER TOWER SYSTEMS
Atlantis Energy Ltd., Thunstrasse 8,
CH-3000 Bern 6

SWIT-52 SOLAR SEAWATER DESALINATION UNIT
Atlantis Energy Ltd., Thunstrasse 8,
CH-3000 Bern 6

U. S. A.

US-11 COMPUTER SIMULATION OF THE PERFORMANCE OF CHEMICAL HEAT PUMPS BASED ON THE H_2SO_4/H_2O, $CaCl_2/CH_3OH$, AND NH_4NO_3/NH_3 REACTIONS
Peter O'D. Offenhartz, EIC Corporation,
55 Chapel Street, Newton, Massachusetts
02168

US-47 COLORADO STATE UNIVERSITY SOLAR HOUSE II
Dan S. Ward, Solar Energy Applications Lab. Colorado State University, Fort Collins, Colorado 80523

US-59 DESIGN, DEVELOPMENT AND TEST OF A PROTOTYPE SOLAR-POWERED TURBOCOMPRESSOR HEAT PUMP
Frank R. Biancardi(UTRC) & James W. Sitler (HSD), Research Center and Hamilton Standard Division of United Technologies Corp., United Technologies Research Center Silver Lane, East Hartford, CT 06108

US-69 SOLAR HEATING AND COOLING SYSTEMS DESIGN AND DEVELOPMENT
Mr. Robert Gunner, AiResearch Manufacturing Co. of Calif., 2525 West 190th Street, Torrance, California 90509

US-102 "DEVELOPMENT OF A GAS BACKUP WATER HEATER PROPERLY INTEGRETED WITH SOLAR HEATED DOMESTIC HOT WATER STORAGE TANKS"
Francis de Winter, Altas Corporation, 500 Chestnut Street, Santa Cruz, CA 95060

US-103 EVALUATION OF COLLECTORS FOR HEAT PUMP APPLICATIONS
G. Gary Skartvedt, American Heliothermal Corporation, 2625 South Santa Fe Drive, Denver, Colorado 80223

US-104 DEVELOPMENT OF SELECTIVE SURFACES
John L. Cotsworth, The Berry Group, Woodbridge at Main, P.O. Box 327, Edison, NJ 08817

US-105 SERIES-PARALLEL SOLAR AUGMENTED ROCK-BED HEAT PUMP
E. F. Sowell, Calif. State University, Fullerton, Div. of Engineering, E-100, California State University, Fullerton

US-106 DEVELOPMENT OF A SOLAR-POWERED THERMOPUMP
Calvin D. MacCracken, 150 South Van Brunt St. Englewood, NJ 07631

US-107 SUPERIOR COOLANT LIQUID
D. B. Haines, Dow Corning Corporation, 2200 Salzburg Rd. Box 1767, Midland, MI 48640

US-108 DOMESTIC WATER HEATING SYSTEM DEVELOPMENT
Terence C. Honikman, Elcam Inc., 5330 Debbie Lane, Santa Barbara CA 93111

US-109 ROF STEAM TURBINE FOR SOLAR COOLING
Terry Kolenc, Energy Technology Incorporated 4914 East 154th Street, Cleveland OH 44128

US-110 NOVEL CONTROL STRATEGIES THAT REDUCE ELECTRIC UTILITY PEAKS
Harold G. Lorsch, Franklin Research Center Benjamin Franklin Parkway, Philadelphia PA 19103

US-111 SELF CONTROLLING, SELF PUMPING HEAT CIRCULATION SYSTEM STUDY

G. P. Wachtell, Franklin Research Center
20th St. and Parkway, Philadelphia PA
19103

US-112 CONTINUED EXPOSURE TEST AND EVALUATION OF REFLECTIVE MATERIALS FOR SOLAR APPLICATIONS

Roger A. Rausch, Honeywell, Technology
Strategy Center, 2600 Ridgway Parkway,
Minneapolis MN 55413

US-113 DESIGN AND DEVELOPMENT OF SINGLE FAMILY, MULTI-FAMILY, LIGHT COMMERCIAL SIZE SOLAR HEATING, COOLING AND HOT WATER SYSTEMS

Steve Scarborough, Honeywell, Inc.,
Technology Strategy Center, 2600 Ridgway
Parkway, Minneapolis MN 55413

US-114 MEASUREMENT OF CIRCUMSLOAR RADIATION

Donald Grether, Lawrence Berkeley Laboratory
University of California, Barkeley CA
94720

US-115 PASSIVE COOLING

Marlo Martin, Lawrence Berkeley Laboratory
University of California, Berkeley CA
94720

US-116 EXPERIMENTAL AND THEORETICAL EVALUATION OF CONTROL STRATEGIES FOR SOLAR HEATING AND COOLING

Michael Wahlig, Lawrence Berkeley Laboratory
University of California, Berkeley CA
94720

US-117 EVALUATION OF ADVANCED CONTROLS FOR BUILDING ENERGY CONSERVATION

Donald R. Farris, Los Alamos Scientific
Laboratory(LASL), Group E-4, MS 429
P.O. Box 1663, Los Alamos NM 87545

US-118 PROGRAMMABLE SOLAR CONTROLLER

Edward S. Peltzman, Rho Sigma, Inc.,
11922 Valerio Street, North Hollywood CA
91605

US-119 MODEL VALIDATION STUDIES OF SOLAR SYSTEMS

Dr. C. Byron Winn, Solar Environmental
Engineering Co., Inc., 2524 E. Vine Drive
Fort Collins, Colorado 80524

US-120 RESEARCH IN ACTIVE FILMS FOR ENERGY MODULATION IN BUILDINGS AND DEVELOPMENT OF PASSIVE COMPONENTS USING ADVANCED MATERIALS

Day Chahroudi, Suntek Research Associates
506 Tamal Plaza, Corte Madera CA 94925

US-121 HIGH PERFORMANCE APERTURES FOR PASSIVE SOLAR HEATING

Charles Tilford, Suntek Research Associates
506 Tamal Plaza, Corte Madera CA 94925

US-122 COST EFFECTIVE SOLAR COLLECTORS USING HEAT PIPES
Donald M. Ernst, Thermacore, Inc., 780
Eden Road, Lancaster, Pa. 17601

US-123 SURVEY AND EVALUATION OF AVAILABLE THERMAL INSULATION MATERIALS FOR USE ON SOLAR HEATING AND COOLING SYSTEMS
Ralph D. Gift, Versar, Inc., 6621 Electronic Dr.
Springfield, Va. 22151

US-124 SOLAR COOLING SYSTEMS EVALUATION
H.M.Curran, Hittman Associates, Inc., 9190
Red Branch Road, Columbia, MD 21045

US-125 OPTIMAL CONTROL STUDIES
C. Byron Winn, Colorado State Univ., Dept.
Mechanical Engineering, Colorado State Univ.
Fort Collins, CO 80523

US-126 PASSIVE SOLAR ANALYSIS AND DESIGN
Ron Kammerud/Wayne Place, Lawrence Berkeley
Laboratory, 1 Cyclotron Road, Berkeley, CA 94720

US-127 ASSESSMENT OF THE NEED FOR NEW SOLAR CONTROLLERS
Andrew Davis, Rho Sigma, Inc., 11922 Valerio St.
No. Hollywood, CA 91605

US-128 ADVANCE SOLAR SYSTEM ANALYSES
Jeffrey H. Morehouse, Science Applications, Inc.
1764 Old Meadow Lane, McLean, Virginia 22180

Code No.: A-1

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☒ SYSTEM ANALYSIS
NAME OF ORGANIZATION Institut f. Allgemeine Physik, Univ. 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 "Inst. f. Molekularbiologie" of the "Österr. Akademie d. Wissenschaften" 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 demonstration 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 futher evaluation of solar heating and eventual cooling of buildings in Austria.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

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

PERIOD OF PROJECT: 1975 - 1979

FUNDING IN $ U.S.: 46.950,--

IMPORTANT REPORTS OR PUBLICATIONS:

Anual Status Report (from 1975 to 1979)

Code No.: A-1

ORGANIZATION: Institut für Allgemeine Physik, University of Technology, Vienna

PROJECT TITLE: Multi-Compnonent System for Domestic Water Heating and Space Heating at the "Institut für Molekularbiologie" of tne "Österreichische Akademie der Wissenschaften", Salzburg

DATA SHEET

Component :

Solar Collectors

a) flat plate

b) 0,8

c) 5,5

e) water/glycol

f) i) aluminium platines copper tubes
ii) GFK, no. 1, 0,9
iii) glass fibre - 50 mm

g) more than 10 years

h) S U.S. 150,-- /m^2

Heat Storage

a) water storage tank

b) 23 kWh/m^2

d) heat exchanger - yes

f) 15 cm

g) more than 10 years

Code No.: A-2

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [x] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION Austrian Solar and Space Agency	ADDRESS: Garnisongasse 7 A-1090 Wien
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 stations, 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 SIGINIFICANT ACCOMPLISHMENTS:

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

PERIOD OF PROJECT: 1976 (open)

FUNDING IN $ U.S.: 375,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

M. Bruck, G. Faninger, P. Varga "Sonnenenergie-Meßstationen in Österreich", ASSA-Fachbericht "Solar-Heizungssysteme 1979", (Austrian Solar and Space Agency)

Code No.: A-3

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

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

NAME OF ORGANIZATION
Vereinigte Metallwerke Ranshofen-Berndorf

ADDRESS:
Postfach 35
A-2560 Berndorf

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 SIGINIFICANT ACCOMPLISHMENTS:

The Analysis of the data gained in an observation period beginning in summer 1977 till august 1978 show that the total useful heat supplied from the collector amounts to 1941,7 kWh, the efficiency to 82,1 % and the system efficiency to 34,5 %. The system supplies useful knowledge for the erection and operation of solar plants, installed in the climatic condition of the mediterrenean zone. Experiences made can be used for other regions with similar climatic conditions.

PERIOD OF PROJECT: 1977 - 1979

FUNDING IN $ U.S.: 22,690.--

IMPORTANT REPORTS OR PUBLICATIONS:

Status Report

ORGANIZATION: Vereinigte Metallwerke Ranshofen-Berndorf

PROJECT TITLE: Installation of a Solar Energy Station in Malta

DATA SHEET

Component :

Solar Collectors

a) flat plate

b) 0,8

c) 7,0

e) water

f) i) aluminium paneel (0,9, 0,9)
ii) glass (no. 1, 0,9)
iii) PU-foam 30 mm

g) about ten years

Heat Storage

a) water

b) 14 kWh

c) 20-40 °C

d) heat exchanger - yes

f) 12 cm glass fibre wool

g) about 10 years

Code No.: A-4

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION ARGE Sonnenhaus Bludenz NAME OF PRINCIPAL RESEARCHER Dipl.-Ing. Rünzler	ADDRESS: A-6800 Feldkirch

TITLE OF PROJECT
Solar Energy Test Station at Bludenz, Vorarlberg

OBJECTIVE AND NATURE OF THE PROGRAM:

One family house, altitude 620 m, surface area 198 m^2 ($U = 0,38\ W/m^2K$).
The house has been equipped with a flat plate collector plant (8 m2 collector area) for domestic water heating and an asphalt collector (useful collector area 150 m^2) to meet the need of heating energy - in combination with a heat pump as well as a ground storage system (storage area 400 m^2). The storage is divided in 2 separated registers, one of them is installed 1,50 m the other 3m below ground level (material: copper tubes with a diameter of 15/17 mm). The distance between parallel tubes is approximately 60 cm. The tube-register in the asphalt collector consists of copper tubes with a diameter of 15/17 mm, distance between parallel tubes is 30 cm. This systems provides a direct use of the asphalt collector respectively ground collector with the help of the heat pump as well as the charge of the ground storage using the asphalt collector during summermonths.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Operating experiences have been gained since summer 1978.

PERIOD OF PROJECT: 1978/1979 FUNDING IN \$ U.S.: 130,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

H. Rünzler "Das Solarhaus in Bludenz", ASSA-Fachbericht "Solar-Heizungssysteme 1979", (Austrian Solar and Space Agency)

Code No.: A-5

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [x] System Analysis
NAME OF ORGANIZATION Vereinigt Metallwerke Ranshofen-Berndorf NAME OF PRINCIPAL RESEARCHER Dr. Georg Turnheim	ADDRESS: Leobersdorfer Straße 26 A-2560 Berndorf

TITLE OF PROJECT System for Domestic Water Heating Without Auxiliary Heating at the "Biologische Versuchsanstalt" at Illmitz / Neusiedlersee

OBJECTIVE AND NATURE OF THE PROGRAM:

A simple solar energy system without auxiliary heating was designed for the Biological Experimental Station at Illmitz in order to study the thermal behaviour throughout the year. This system is an experiment for determining the usefulness of solar energy systems under specific climatic conditions:

The main purposes of this system are:
- long-term testing of solar collector materials;
- extensive data collection and evalutation.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The system has been in operation since April 1976; data are being evaluated.

PERIOD OF PROJECT: 1976- 1979

FUNDING IN $ U.S.: 37,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Status Reports

Code No.: A-5

ORGANIZATION: Vereinigte Metallwerke Ranshofen-Berndorf AG

PROJECT TITLE: System for Domestic Water Heating Without Auxiliary Heating at the "Biologische Versuchsanstalt" at Illmitz/Neusiedlersee

DATA SHEET

Component :

Solar Collectors

a) flat plate
b) 0.8
c) 7,0
e) water
f) i) aluminium paneel (o,9, 0,9)
ii) glass (no. 1, 0,9)
iii) PU-foam 30 mm
g) about ten years

Heat Storage

a) water
b) 14 kWh
c) 20-40 °C
d) heat exchanger - yes
f) 12 cm glass fibre wool
g) about 10 years

Code No.: A-6

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [x] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [x] System Development
NAME OF ORGANIZATION	ADDRESS: A-6073 Sistrans
NAME OF PRINCIPAL RESEARCHER Dipl.- Ing. Kiraly	

TITLE OF PROJECT

Solar Energy Test Station in Sistrans

OBJECTIVE AND NATURE OF THE PROGRAM:

A low-temperature heating system, consisting of solar-collectors, soil storage, heat pumps and conventional heating systems was installed in a one-family house with optimal insulation (U = 0,4 W/m2K). Within the framework of this project, the helio-data logger is used to ensure an optimal system control. The plant consists of solar-collectors with a total area of 28,4 m^2 and a ground storage with a collector area of 350 m^2. The tube register of the ground storage is installed 2 m below surface. The distance between parallel tubes is 30 cm; in the whole 10 parallel PE-plastic tubes - 100 m each have been laid. The mean heating power removed from ground during the heating season is about 25 W/m^2. The heat supply for a domestic water heating system with a mean daily need of 500 l of 45 °C and a 1 m^3 storage tank for the low temperature heating system and a swimming pool of 33 m^3 is provided directly with the solar cycle or indirectly with the ground collector coupled to a heat-pump (electrical input 4,85 kW)

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Operating experiences have been made since August 1978.

PERIOD OF PROJECT: 1978/1979

FUNDING IN $ U.S.: 25,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

J. Kiraly "Das Solarhaus in Sistrans", ASSA-Fachbericht Solar-Heizungssysteme 1979" (Austrian Solar and Space Agency)

Code No.: A- 7

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Vereinigte Metallwerke Ranshofen-Berndorf	ADDRESS: Leobersdorfer Straße 26 A-2560 Berndorf
NAME OF PRINCIPAL RESEARCHER Dipl.- Ing. Dr. H. Meissner	

TITLE OF PROJECT

Development of Selective Aluminium Absorbers

OBJECTIVE AND NATURE OF THE PROGRAM:

A chemical process has been developed for the coating of MgO on aluminium surfaces. With this porcess it was made possible to produce selective surfaces, (Selection: α = 0,88, ε = 0,21, α/ε = 0,42) with long durability and low prices

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The project was initiated in July 1976.

PERIOD OF PROJECT: 2 years

FUNDING IN $ U.S.: 120,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Status Report

Code No.: A-8

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Bundesversuchs- und Forschungsanstalt	ADDRESS: Arsenal 1030 Wien Austria
NAME OF PRINCIPAL RESEARCHER Ing. J. Kriha.	

TITLE OF PROJECT

Construction and Operation of Solar Collector Test Station.

OBJECTIVE AND NATURE OF THE PROGRAM:

A collector test station for the determination of the thermal properties, durability and life time of flat-plate collectors was installed at the Bundesversuchs- und Forschungsanstalt (Federal Institute for Experiments and Research) Arsenal

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1978/1979

FUNDING IN $ U.S.: 60,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

"Collector Test Methods - Analysis of Test Methods for the Determination of the Thermal Efficiency of Flat-Plate Collectors", ASSA-Fachbericht, (Austrian Solar and Space Agency)

ORGANIZATION: Bundesversuchs- und Forschungsanstalt, Arsenal

PROJECT TITLE: Construction and Operation of Solar Collector Test Station

DATA SHEET

Component :

The collector test stand is equipped for efficiency measurements at flat-plate collectors in accordance with the BSE-standard: The test procedure is outlined in the following figure.

1 Flat-plate collector to be tested
2 Preparation of the transfer fluid - In a container the transfer fluid is either cooled or heated to obtain the temperature required.
2a Heat exchanger to cool the transfer fluid
2b Heater
3 Pump for circulating the transfer fluid
4 Control valve for the transfer fluid
5 Filter
6 Open expansion vessel
7 Cooling engine
8 Energy supply and control instrument for the temperature of the transfer fluid
9 Fan to produce an air flow across the collector cover
10 Temperature sensor for the collector inlet temperature
the collector outlet temperature
the temperature difference of the transfer fluid
11 Measurement of the volume of the transfer fluid
12 Measurement of the pressure drop across the collector
13 Measurement of solar radiation incident upon the collector aperture
14 Measurement of ambient temperature
15 Throttle valve

Components: Page 2

Mechanical set-up

The collector test stand is movable so that indoor and outdoor tests can be conducted. It is designed for the testing of flat-plate collectors with an area of more than about 4 m2. The movable test rack contains the instruments required for the preparation and circulation of the transfer fluid, as well as the control and measurement instruments.The collector to be tested is mounted on a swinging frame on the test rack.

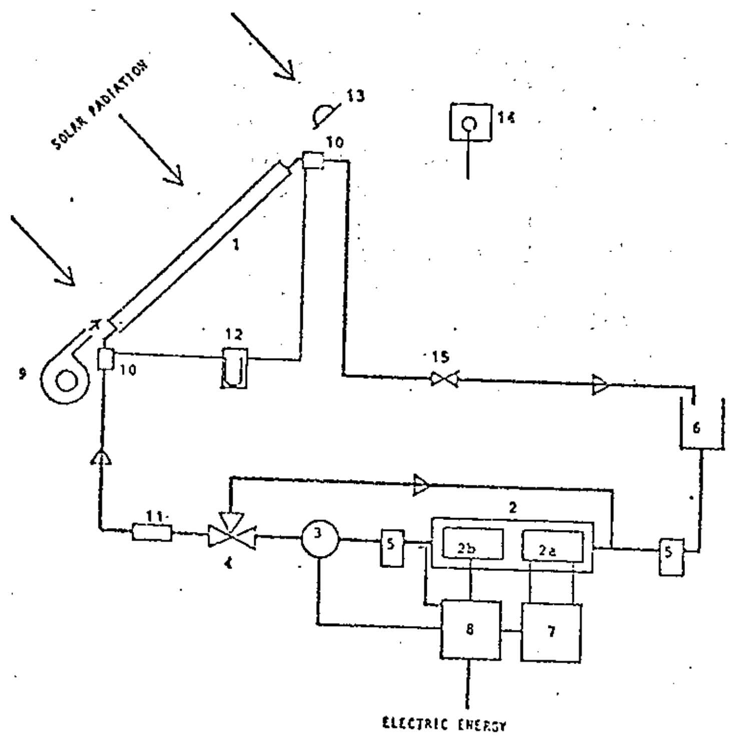
The construction of the test stand provides for the adjustment of the collector to the direction of incident radiation. A movable locker is equipped with the instruments necessary for the recording of data.

Testing apparatus

At present, the following methods are used:

- Temperature measurement: Platinum wire thermometer and recording with an electronic compensograph.
- Measurement of the volume of the transfer fluid: Measurement shield with pressure recorder and electronic transformer. Recording with an electronic compensograph and an integrator with numerical print.
- Irrediation intensity: Pyranometer together with a multiple-integrator. Instantaneous values are recorded with an electronic compensograph.

It is planned to establish an automatic data logger to enable computer evaluation.



Test stand for flat-plate collectors; testing procedure

Code No.: A-9

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [x] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [x] System Development
NAME OF ORGANIZATION Institute for Environmental Research	ADDRESS: Elisabethstraße 11 A-8010 Graz
NAME OF PRINCIPAL RESEARCHER Dipl-Ing. E. Podesser	

TITLE OF PROJECT

Construction of a Domestic Water Heating System in Ouagadougou

OBJECTIVE AND NATURE OF THE PROGRAM:

Within the framework of technology transfer from Austria to Third World countries this project was initiated in order to establish and test a solar energy system for domestic water heating in a technical school in Ouagadougou, Obervolta. The plant consists of a total collector area of 12 m^2, 3 domestic water storage tanks, 300 l each and the necessary control equipment.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Operating experiences have been gained from spring 1978 up to now.

PERIOD OF PROJECT: 1978/1979 FUNDING IN $ U.S.: 23,070.--

IMPORTANT REPORTS OR PUBLICATIONS:

Status Report

ORGANIZATION: Institute for Environmental Research

PROJECT TITLE: Construction of a Domestic Water Heating System in Ouagadougou

DATA SHEET

Component :

Solar Collectors

a) flat plate

b) 0,8

c) 7,0

e) water

f) i) aluminium paneel (0,9, 0,9)
ii) glass (no. 1, 0,9)
iii) PU-foam 30 mm

g) about ten years

Heat Storage

a) water

b) 14 kWh

c) 20-40 °C

d) heat exchanger - yes

f) 12 cm glass fibre wool

g) about 10 years

Code No.: A-10

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☑ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ System Analysis, Collector Performance
NAME OF ORGANIZATION Vereinigte Metallwerke Ranshofen-Berndorf NAME OF PRINCIPAL RESEARCHER Dr. Georg Turnheim	ADDRESS: Leobersdorfer Straße 26 A-2560 Berndorf

TITLE OF PROJECT

Outdoor Solar Collector Testing

OBJECTIVE AND NATURE OF THE PROGRAM:

In order to study the thermal performance of various types of collectors under identical weather conditions an outdoor testing station was designed and constructed by the Vereinigte Metallwerke Ranshofen Berndorf. The main purposes of this test station are:

- Simultaneous measurements of the thermal performance of three solar collectors;
- Simulation of various solar systems (swimming-pool, space and domestic water heating) by means of a temperature-controlled storage tank at different working conditions.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The system has been operating since March 1978.

PERIOD OF PROJECT: 2 years

FUNDING IN $ U.S.: 60,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: A-11

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [x] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [x] System Analysis

NAME OF ORGANIZATION

Austrian Institute for Building Research

NAME OF PRINCIPAL RESEARCHER

Dr. Michael Wachberger/Ing. G. Spielmann

ADDRESS:

Dr. karl Lueger-Ring 10
A-1010 Wien

TITLE OF PROJECT

Solar House Vienna-Flötzersteig (Austrian Solar House)

OBJECTIVE AND NATURE OF THE PROGRAM:

Investigation of the possibilities of the use of solar systems for domestic water heating and room heating in housing subsidized by public funds. Implementation of simulated calculations based on meteorological data collected every hour (air temperature, solar radiation both direct and diffuse, solar reflexion, clouding factors).

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

A report on the project will appear in the publishing house of the Austrian Institute for Building Research.

PERIOD OF PROJECT: 1979

FUNDING IN $ U.S.: 150,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

M. Wachberger, "Darstellung des Planungsablaufs bei der ib-Sonnenhausanlage", ASSA-Fachbericht "Solar-Heizungssysteme 1979" (Austrian Solar and Space Agency)

Code No. :A-12

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Institute for Environmental Research	ADDRESS: Elisabethstraße 11 8010 Graz Austria
NAME OF PRINCIPAL RESEARCHER Dipl.-Ing. Erich Podesser	

TITLE OF PROJECT
Solar-powered Absorption Cooling System

OBJECTIVE AND NATURE OF THE PROGRAM:

The aim of this project is to develop an air-conditioning unit equipped with flat-plate collectors. This is done in two steps:

1) Construction of a small-scale model (cooling power 800 W); typical system and operating parameters: heating temperatures 80-83 ^{o}C, efficiency of flat-plate collectors: 40 %; cooling water temperature: 20-35 ^{o}C. COP: 0,6-0,7

2) Construction of a one-stage continously working absorption circle with a cooling power of 12 kW.

This project is carried out in close co-operation with the Austrian firm Vereinigte Metallwerke Ranshofen-Berndorf.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

From 1976 to 1978 the system was tested in a laboratory.
In 1979 the plant was tested in Split under operating conditions.

PERIOD OF PROJECT: 1976 - 1979 FUNDING IN $ U.S.: 71.920,--

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report: Solar Powered Water Chiller K 7720
Institut für Umweltforschung, Graz

ORGANIZATION: Institute for Environmental Research

PROJECT TITLE: Solar powered Absorption Cooling System

DATA SHEET

Component :

Solar Collectors

a) flat plate

b) 0,81

c) 6

e) water/glycol

f) aluminium platines 0,9, 0,3
GFK 0,9
glass fibre wool - 50 mm
g) mor
g) more than 10 years

Air Conditioning and Cooling

a) heat pump, solar cooling

b) absorption, amoniac-water

c) cooling power - 800 W

d) heating temperature 80 - 83 ^{o}C, cooling water 20 - 35 ^{o}C

e) 0,6 - 0,7

Code No.: A-13

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION Institut f. Allgemeine Physik, Univ. of Technology	ADDRESS: Karlsplatz 13 A-1040 Wien
NAME OF PRINCIPAL RESEARCHER Prof. Dr. F. Viehböck	

TITLE OF PROJECT
Development and Test of a Photovoltaic Thermal Hybrid-Collector

OBJECTIVE AND NATURE OF THE PROGRAM:

Aim of this project is the simulation and construction of a combined photovoltaic and thermal solar collector for a simultaneous generation of electrical power and useful heat for domestic use. The simulation includes the establishment of a mathematical model for the hybrid-collector and the use of this model in a complex multicomponent-simulation program. Aim of the simulation is to examine the influence of the electrical working conditions on the thermal output. The experimental works include the working drawing and the erection of 3 prototypes of collectors as well as the examination of appropriate function at a collector test stand. The data gained will be recorded with the help of a HELIODATA.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1979/1980

FUNDING IN $ U.S.: 57.000,--

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: A-14

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Institut f. Allgemeine Physik, Univ. of Technology	ADDRESS: Karlsplatz 13 A-1040 Vienna
NAME OF PRINCIPAL RESEARCHER Prof. Dr. F. Viehböck	

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 SIGINIFICANT ACCOMPLISHMENTS:

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   FUNDING IN $ U.S.: 20,000.--

IMPORTANT REPORTS OR PUBLICATIONS:
Final Report

Code No.: A-15

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ SYSTEM ANALYSIS
NAME OF ORGANIZATION Institut für Physikalische Chemie ~~University of Vienna~~ NAME OF PRINCIPAL RESEARCHER Prof. Dr. Roland Stickler	ADDRESS: Währinger Straße 42 A-1090 Vienna

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 SIGINIFICANT ACCOMPLISHMENTS:

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 FUNDING IN $ U.S.: 18,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report

Code No.: A-16

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [x] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION Arbeitsgemeinschaft Sonnenenergie	ADDRESS: Obere Techstraße 21/1 A-8010 Graz
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 SIGINIFICANT ACCOMPLISHMENTS:

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) FUNDING IN $ U.S.: 52.000,--

IMPORTANT REPORTS OR PUBLICATIONS:

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

CODE NO.: A-17

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______________
NAME OF ORGANIZATION Fa. Ing. W. Jäger	ADDRESS: Villacher Straße 32. A-9300 St. Veit/Glan
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 SIGINIFICANT ACCOMPLISHMENTS:

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: 1976 - one year **FUNDING IN \$ U.S.:** 10,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report

Code No.: A-18

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [x] SYSTEM DEVELOPMENT
NAME OF ORGANIZATION Vereinigte Metallwerke Ranshofen-Berndf.	ADDRESS: Postfach 35 A-2560 Berndorf
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 a 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 SIGINIFICANT ACCOMPLISHMENTS:

With this plant 70 - 90 % (in summer) and 10 - 20 % (in winter) of the total 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 FUNDING IN $ U.S.: 15,500.--

IMPORTANT REPORTS OR PUBLICATIONS:

ASSA-Information Service 4/1977.

Code No.: A-19

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Inst. f. Hochbau u. Entwerfen 1, Univeristy of Technology	ADDRESS: Karlsplatz 13 A-1040 Wien
NAME OF PRINCIPAL RESEARCHER Prof. Dr. E. 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 insulation. Moreover the storage system was to be easily integrated in already existing solar systems.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1977 - 1978

FUNDING IN $ U.S.: 2.000,--

IMPORTANT REPORTS OR PUBLICATIONS:

Final report

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☒ SYSTEM ANALYSIS

NAME OF ORGANIZATION Austrian Solar and Space Agency NAME OF PRINCIPAL RESEARCHER Dr. M. Bruck, Prof. F. Viehböck	ADDRESS: Garnisongasse 7 A-1090 Vienna

TITLE OF PROJECT Development of a Data Logger for Automatical Recording and Processing of Relevant Data for the Determination of the Energy Flux in Multi Component Solar Systems.

OBJECTIVE AND NATURE OF THE PROGRAM:

A data logger was developed by which all parameters determining the energy balance of multi-component systems for the production of low temperature heat can be recorded and evaluated automatically.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1978

FUNDING IN $ U.S.: 35,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

M. Bruck, F. Viehböck, E. Benes. P. Blum, W. Husinsky, L. Wimmer, K. Harms: "Entwicklung und Bau eines standardisierten Meßgeräte-Paketes zur Bestimmung der Energie-Bilanzen von Niedertemperatur-Solar-Anlagen"; ASSA FA-11, Dezember 1978.
M. Bruck, E. Benes: "Die experimentelle Bestimmung der Energiebilanzen von multivalenten Heizsystemen"; in ASSA-Fachbericht "Solarheizungssysteme 1979".

Code No.: A-21

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA.

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Jenbacher Werke	ADDRESS: A-6200 Jenbach
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT

Gas driven Heat Pumps and their use in Heating Systems

OBJECTIVE AND NATURE OF THE PROGRAM:

This project examines the technological properties as well as the economic conditions for utilization of gas-driven heat pumps in relatively small space-heating systems.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1 year - 1978 FUNDING IN $ U.S.: 215,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Vogel & Noot AG NAME OF PRINCIPAL RESEARCHER Ing. Bango; Dr. Bräunlich (Inst. f. Environmental Research, Graz)	ADDRESS: A-8661 Wartberg/Mürztal

TITLE OF PROJECT
Development and testing of components for solar heating systems

OBJECTIVE AND NATURE OF THE PROGRAM:

- Development of system components for solar heating systems
- Development of solar-heat-exchanger tanks
- Testing and improvement of solar collectors
- Installation of solar pilot plants (for an open air swimming pool in Eggersdorf/Graz with 600 m^2 of collectors)

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Second generation of solar collectors and solar boilers in production, pilot plants more than three years in operation.

PERIOD OF PROJECT: 1974 - 1977 FUNDING IN $ U.S.: 2 700 000,--

IMPORTANT REPORTS OR PUBLICATIONS: Manual for solar collector application (available at Vogel & Noot AG) "Nutzung der Sonnenenergie zur Wärmeerzeugung"; Ing. H. Bango, Vogel & Noot AG; published in "Ergebnisse geförderter Projekte im Prioritätsbereich Energieforschung", Wien 1977, Forschungsförderungsfonds der gewerblichen Wirtschaft.

Code No.: A-23

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [x] HEAT PUMP

NAME OF ORGANIZATION
Gemeinnützige Wohnungs- und Siedlungsges. der Elin Union AG

NAME OF PRINCIPAL RESEARCHER
Dr. Peter Schaup, resp. f. "Solar Project"

ADDRESS:
Penzinger Straße 76
A-1141 Vienna

TITLE OF PROJECT
Dwelling With all Electrical Energy Supply and Extremly low Specific Energy Demand

OBJECTIVE AND NATURE OF THE PROGRAM:

Aim of this project is to realize a certain number of energy saving measurements to reduce the specific electrical input as well as the energy need. These measurements referred to the thermal quality of the building, which is provided with triple windows and very good insulation of walls and ceilings, and to the heating system for which an electrical floor heating had been chosen. As further possibility for energy savings an auxiliary system for the solar domestic hot water preparation consisting of a heat recovering system, connected with a vaste water heat pump was chosen.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1977 - 1980

FUNDING IN $ U.S.: 856,000.--
(costs for the construction of the house included)

IMPORTANT REPORTS OR PUBLICATIONS:

P. Schaup, Zentrale Warmwasserbereitung mit Sonnenenergie und Abwasserwärmepumpe; ASSA-Fachbericht "Sonnenenergie 1979", Wien 1979

Code No.: A-24

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: AUSTRIA

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Institut für Umweltforschung	ADDRESS: Elisabethstraße 11 A-8010 Graz
NAME OF PRINCIPAL RESEARCHER Dipl.-Ing. Konrad Frey	

TITLE OF PROJECT

Reduction of Heating Costs in Greenhouses by Heat Storage

OBJECTIVE AND NATURE OF THE PROGRAM:

Heating bills in commercial greenhouses account for up to 50 % of operational costs. Conventional greenhouses generate considerable amounts of heat during sunny days, often in excess of optimal temperatures for plant growth. This excess energy is commonly vented away and thus lost.

The present project aims at recovering this heat and storing it for use at night.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Pilot storage unit developed.

Tests underway.

PERIOD OF PROJECT:

Completion July 1980

FUNDING IN $ U.S.:

300,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

–

Code No.: A-24

ORGANIZATION: Institut für Umweltforschung
Elisbethstraße 11, A-8010 Graz

PROJECT TITLE: Reduction of Heating Costs in Greenhouses by Heat Storage

DATA SHEET

Component :

Heat Storage

a) storage medium water

b) heat capacity 7000 Wh/m^3

c) -

d) heat exchanger yes

e) -

f) insulation none

g) 20 years

Code No.: D-1

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:	
COMPONENTS	**TYPE OF RESEARCH**
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ________
NAME OF ORGANIZATION The Technical University of Denmark	ADDRESS: Thermal Insulation Laboratoy The Technical University of Denmark Building 118, 100 Lundtoftevej DK-2800 Lyngby
NAME OF PRINCIPAL RESEARCHER Preben Hansen	
TITLE OF PROJECT Floating solar collectors	

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of 2 or 3 prototypes of floating collectors and testing thermal efficiency and durability when the collectors are built as top cover on small water tanks. (Each collector type having a surface area of 30 - 50 m^2).

The floating collector will be a cheap collector type when used to charge seasonal hot water stores as the necessary top insulation of the store can be an integrated part of the collector.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: D-1

ORGANIZATION: The Technical University of Denmark

PROJECT TITLE: Floating Solar Collectors

DATA SHEET

Component : The collectors will be constructed mainly using plastic materials.

Code No.: D-2

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Denmark

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Thermal Insulation Laboratory	ADDRESS: Thermal Insulation Laboratory The Technical University of Denmark Building 118, 100 Lundtoftevej DK-2800 Lyngby
NAME OF PRINCIPAL RESEARCHER Peter Christensen	

TITLE OF PROJECT
Chemical Heat Storage

OBJECTIVE AND NATURE OF THE PROGRAM:

The aim of the project is to construct a unit for long-term storage of low temperature heat.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

ORGANIZATION:

PROJECT TITLE:

Chemical Heat Storage

DATA SHEET

Component :

Chemical heat pump (CHP) with water as the vapour phase.
It is planned to build a CHP with a capacity of 200-300 kWh/m^3 and a temperature difference of 40-100 °C between the cold and the hot side.

Code No.: D-3

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Denmark

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Thermal Insulation Laboratory NAME OF PRINCIPAL RESEARCHER Simon Furbo	ADDRESS: Thermal Insulation Laboratory The Technical University of Denmark Building 118, 100 Lundtoftevej DK-2800 Lyngby

TITLE OF PROJECT
Heat of fusion storage units

OBJECTIVE AND NATURE OF THE PROGRAM:

The aim is to develope and investigate salt hydrate storage units for domestic hot water supply. The heat storage material is a salt hydrate making use of the extra water principle.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

A heat storage method making use of an incongruently melting salt hydrate as storage material has been developed. A heat storage unit for domestic hot water supply has been constructed and tested with one salt water mixture as storage material.

PERIOD OF PROJECT: 1/8 79 - 31/7 80 FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

"Heat storage in a solar heating system using salt hydrates", S. Furbo, S. Svendsen, July 1977.

"Investigation of heat storages with salt hydrate as storage medium based on the extra water principle", S. Furbo, December 1979.

ORGANIZATION: Thermal Insulation Laboratory

PROJECT TITLE: Heat of fusion storage units

DATA SHEET

Component :

a) A 250 l phase change heat storage unit with a 80 l hot water tank situated inside the 170 l storage tank. The heat storage material investigated is a sodium carbonate water mixture.

b) c) Total heat content in the temperature interval 10 °C to 60 °C: 26000 Wh

d) Yes. Heat exchanger spiral situated in the heat storage tank.

e)

f) 10 cm mineral wool

g) 25 years

Code No.: D-4

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Denmark

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Thermal Insulation Laboratoy	ADDRESS: Thermal Insulation Laboratory The Technical University of Denmark Building 118, 100 Lundtoftevej DK-2800 Lyngby
NAME OF PRINCIPAL RESEARCHER Kurt Kielsgård Hansen, M.Sc.,Civ. Eng.	

TITLE OF PROJECT

Loft collector with slab on grade - heat storage.

OBJECTIVE AND NATURE OF THE PROGRAM:

Storage:
The aim of the project is to test variaous lay-outs of heat transfer systems giving heat input to the ground, respectively the heating system of the house. In addition measuring of relevant parameters to determine the storage characteristic and efficiency.

Collector:
Full scale experiments to examine different designs of loft collectors integrated in the attic.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

A 60 m^2 experimental house with a four layered slab construction has been built. Now we install a water/water heat pump to lower the temperature in the storage (i.e. the soil) to 0 ^oC. The evaporator of the heat pump is connected to the polyethylene pipes and the condenser is connected to the pipes in the floor heating system of the house.

PERIOD OF PROJECT:

1979, 1980, 1981

FUNDING IN $ U.S.:

50,000 $

IMPORTANT REPORTS OR PUBLICATIONS:

Hansen, Kurt Kielsgård: TAGRUMSSOLFANGER. Projektering og udførelse af tagrum, målerum og gulvkonstruktion i prøvestanden. Rapport 79-16 sept. 1979, Laboratoriet for Varmeisolering, Danmarks tekniske Højskole.

ORGANIZATION: Thermal Insulation Laboratory

PROJECT TITLE: Loft Collector with slab on grade - heat storage

DATA SHEET

Component :

Solar Collector:
a) Loft collector integrated in the attic
b) $\tau\alpha = 0.85$
c) $U_L = 7\ W/m^2\ K$
e) Heat transfer medium: air, 36 $m^3/m^2 \cdot h$
f) absorber $\alpha = \varepsilon = 0.95$
cover plate: 1 cover, $\tau = 0.9$
insulation: 150 mm
g) 20 years, expected lifetime
h) 20 \$ US/m^2, estimated cost

Heat storage:
a) storage medium: pebbles and soil
b) heat capacity $C = 1.6\ MJ/m^3\ {}^{o}C$. $0\ {}^{o}C \leq t \leq 30\ {}^{o}C$
d) heat exchanger: YES. Heat transfer fluid: air
f) no insulation
g) 20 years expected lifetime

Code No.: D-5

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Denmark

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________

NAME OF ORGANIZATION The Technical University of Denmark	ADDRESS: Thermal Insulation Laboratory The Technical University of Denmark Building 118, 100 Lundtoftevej DK-2800 Lyngby
NAME OF PRINCIPAL RESEARCHER Preben Hansen	

TITLE OF PROJECT

Seasonal heat storage in underground hot water stores

OBJECTIVE AND NATURE OF THE PROGRAM:

Projection and building of a 6000 m^3 seasonal warm water store followed by testing the efficiency. The store is partly excavated into the ground placing the diggings around as embankments ending up with a pyramidal geometry. The ground surface is made waterproof by the use of a plastic liner. No insulation materials are used on this surface.

The top is heat insulated and protected against evaporation and against the weather by the use of a plastic cover.

The main objective of the project is to investigate the efficiency of this type of heat storage and gain experience both regarding construction and durability.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Most of the preliminary studies have been done. Projection and building of the store are planned to be carried out in 1980.

PERIOD OF PROJECT: 1/7-78 - ?

FUNDING IN $ U.S.: min 100,000
max ?

IMPORTANT REPORTS OR PUBLICATIONS:

Hansen, P.N., Seasonal Heat Storage in Hot Water Stores, Paper presented at the International Conference on Numerical Methods in Thermal Problems, July 2nd - 6th 1979, Swansea.

Dipco Engineering, Preliminary study of the construction principles to be used building seasonal hot water stores in the ground (in Danish), Dec. 1979. Thermal Insulation Laboratory, Technical University of Denmark.

ORGANIZATION: The Technical University of Denmark

PROJECT TITLE: Seasonal heat storage in underground hot water stores.

DATA SHEET

Component : The Store.

Type: Seasonal hot water store.
Heat capacity: 35 kWh/m^3, temperature range 30-60 °C.
Storage efficiency ~ 70%.
Insulation: Only top insulated. No insulation versus the ground.
Expected life time: Min. 12 years.

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: FRG 3.2.1.1.1

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Jenaer Glaswerk Schott & Gen. NAME OF PRINCIPAL RESEARCHER Dr. E. Hussmann	ADDRESS: Hattenbergstraße 10 6500 Mainz

TITLE OF PROJECT
Flat Plate Solar Energy Collectors

OBJECTIVE AND NATURE OF THE PROGRAM: Different flat plate solar energy collectors with high efficiency are to be developed, in order to make better use of the high degree of diffuse radiation in our climate.

Work Program

a) Development of IR-reflecting glass coverings as well as anti-reflecting layers.
b) Development of α/ε-layer systems.
c) Development of a special connection between transparent cover system and absorber which prohibits water vapour diffusion and results in a collector which can withstand the maximum "No Flow" temperature.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf/

PERIOD OF PROJECT:
15.11.1975 - 30.06.1979

FUNDING IN $ U.S.: 723,700.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Flat Plate Solar Energy Collectors

Objective and Nature of the Project, Present Status:

- Continuation ....

d) Development of an evacuated all-glass flat plate collector on the basis of hollow glass-fiber absorber plates.

Status

After completion of the preliminary work (test-facility, simulation computer programs, construction of several highly efficient collectors) the most promising types were selected and improved.
Flat plate collectors with honeycomb structures between cover plate and absorber showed some disadvantages. They are highly efficient collectors, but it seems to be extremely difficult to prevent water vapour diffusion into the gap between absorber and the cover plate and to make them capable of withstanding high temperatures under "no-flow" conditions. Work on these "honeycomb" collectors was stopped.
The main emphasis was therefore directed towards a collector with two cover plates, the inner one coated on both sides with a layer highly transparent for solar radiation and simultaneously capable of reflecting long wave infrared radiation. Using a special connection between absorber and cover plate it was possible to prevent water vapour diffusion into the space between absorber and cover plate. Simultaneously it was arranged that this collector withstands high temperatures under "no-flow" conditions.
The heat flow to the frame of the collectors is small, the organic adhesive stays relatively cool and the pressure-rise in the space between absorber and cover plate is reduced. Prototypes were built and tested in cooperation with other companies.
The results provide evidence that flat plate collectors of this type can be manufactured on a large industrial scale.

Code No.: FRG- 2

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.1.2-3.2.1.1.5

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Metallgesellschaft AG	ADDRESS: Reuterweg 14 D-6000 Frankfurt am Main 1
NAME OF PRINCIPAL RESEARCHER Dr.-Ing. M. Möller	

TITLE OF PROJECT Development of Industrial Scale Manufacturing Processes for Solar Heating System Components, Especially Solar Collectors - Project Management

OBJECTIVE AND NATURE OF THE PROGRAM: Formation of a working group for the development of manufacturing processes for solar heating systems components, especially highly efficient solar collectors for the medium temperature range up to 100°C, in collaboration with contractors from trade and industry, and craft as well as with university institutes. Coordination of the whole project.

Work Program

a) Development of selective solar absorbers on the basis of aluminium Rollbond heat exchangers.
b) Development of solar collector casings.
c) Development of components for the solar heating circuits.
d) System and component testing.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf /

PERIOD OF PROJECT: 15.11.1975 -30.06.1979

FUNDING IN \$ U.S.: 300,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: FRG-2

PROJECT TITLE: Development of Industrial Scale Manufacturing Processes for Heating System Components, Especially Solar Collectors - Project Management

Objective and Nature of the Project, Present Status:

- Continuation ....

e) Preparation for the manufacture of chosen prototypes.
f) Tentative manufacture of the developed system.

Relation to other Projects

The developments are carried out in collaboration with Dornier System GmbH., Jenaer Schott & Gen., Mainz, and Klöckner & Co., Abt. Wärmetechnik, Hechingen as well as the various sections of Metallgesellschaft AG indicated in the individual projects.

Status

The development of a selective coating for Al-Rollbond absorbers has been completed, The coating may be used in hermetically sealed collectors. The α and ε values amount to $\alpha \geq 94$ % and $\varepsilon \leq 14$ %. The requirements for a small-scale production are fulfilled. The means allocated for this project have been increased with a view to developing a coating that is also suited for open collectors.
The developmental work relating to a fixing-in system of zinc for mounting collectors on saddle roofs as well as to collector frames and compounds for a hermetic collector sealing has also been completed. In addition, a process for manufacturing AlMn-Rollbond with an improved heat resistance has been developed and tested. The investigation of materials was mainly concentrated on the chemical and mechanical properties of the metal components that are mostly used in combination in the collector systems.

Project includes the following subprojects:

4-ET 4051 A	3.2.1.1.2
4-ET 4051/2	3.2.1.1.3
4-ET 4051 C	3.2.1.1.4
4-ET 4051/D	3.2.1.1.5

ORGANIZATION: Metallgesellschaft AG

PROJECT TITLE: Development of Industrial Scale Manufacturing Processes for Solar Heating System Components, Especially Solar Collectors - Project Management

DATA SHEET

Solar Collector

a) Type flat plate

b) $\alpha\tau$ = 0.82

c)

d)

e) heat transfer medium: Alcylbenzol

f) material: Al
   i) absorber α = 94%; ε = 14%
   ii) cover plate: one τ = 87%
   iii) insulation 60 mm glass wool

g) expected life time: 20 years

h) estimated cost: $150

Code No.: FRG-3

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.3.1.1.6

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Klöckner & Co., Wärmetechnik, Werk Herchingen	ADDRESS: Haigerlocherstrasse 42 Postbox 1109 D-7450 Hechingen 1
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT Development of Solar Heating Controls for Water-Heating and Building-Heating Systems. Choice of Fluids. Test

OBJECTIVE AND NATURE OF THE PROGRAM: Development of controls for heat extraction from solar collectors and usage of heat for water heating, heating of buildings, swimming pool heating. Choice of heat carriers. Development of prefabricated assemblies for solar heating installations.

Work Program

a) Statement on the usual water heater and heating systems.
b) Choice of suitable systems for application to solar heating.
c) Preparation of installation diagrams for b).
d) Choice and testing of suitable material for pipes, valves, pumps, heat exchangers and insulating materials using synthetic fluid.
e) Choice, testing and development of regulating and control assemblies.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf/

PERIOD OF PROJECT: 01.04.1976 - 31.12.1979

FUNDING IN $ U.S.: 475,350.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Development of Solar Heating Controls for Water-Heating and Building-Heating Systems. Choice of Fluids. Test.

Objective and Nature of the Project, Present Status:

- Continuation ....

f) Structural preparation of assemblies, ready for installation testing. Adjustment within the limits of the building authorities.

Relation to other Projects

Development in co-operation with "Metallgesellschaft AG" concerning solar collectors developed by the rollbond system (ET 4051/4).

Status

The collector- tests with selective and non-selective absorber coatings and different glass covers were continued. Optimum flowrates for the synthetic heat transfer fluid have been tested with success. A controlling device for guiding collectors has been tested as well and the mechanical parts are under construction.

The cascade arrangement of the hot water tanks has given good results. The low temperature of the heat transfer fluid entering the spiral collector allows higher energy gains to be achieved.

Prefabricated components are being improved to reduce the mounting times.

With a 4 sq. m. collector (spiral absorber with selective coating and synthetic heat transfer fluid) it has been possible to heat 200 l of water from room temperature to 45°C even in November.

Locality: Schwäbische Alb

Installations for customers were delivered within the EEC and overseas.

ORGANIZATION: Klöckner & Co., Wärmetechnik, Werk Herchingen

PROJECT TITLE: Development of Solar Heating Controls for Water-Heating and Building-Heating Systems. Choice of Fluids. Test.

DATA SHEET

Solar Collector

a) type: flat plate, spiral-absorber, selective surface aluminium frame.
1.07 m^2

b) $\alpha\tau$: 0.82

c)

d) heat capacity (fluid included) C (Wh/m^2K) 1.7

e) heat transfer medium: thermo-oil

f) material
i) absorber: (α, ε) Aluminium, α=0.94, ε=0.14
ii) cover plate: glass, one, τ= 0.87
iii) insulation: glasswool, 60mm

g) expected life time: t=20 years

h) estimated cost ($ US/m^2) : 200

Code No.: FRG-4

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.1.7

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ________
NAME OF ORGANIZATION Jenaer Glaswerk Schott & Gen.	ADDRESS: Hattenbergstr. 10 D-6500 Mainz
NAME OF PRINCIPAL RESEARCHER Dr. Eckart Hussmann	

TITLE OF PROJECT Development of Large Scale Production Methods for Components of Solar Energy Collection - 3. Subprogram of Metallgesellsch.

OBJECTIVE AND NATURE OF THE PROGRAM: Transparent glass cover systems for large scale production of solar energy flat plate collectors with optimized mechanical, thermal, corrosion resistant properties and their connection to the collector system.

Work Programm

a) Defining the field of characteristic loads.
b) Computing the thermal and mechanical loads.
c) Experimental investigation of characteristic loads.
d) Optimization of the cover system and its connection to the rest of the collector.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf/

PERIOD OF PROJECT:

01.01.1976 - 30.06.1979

FUNDING IN $ U.S.: 132.800.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Development of Large Scale Production Methods for Components of Solar Energy Collection - 3. Subprogram of Metallgesellschaft

Objective and Nature of the Project, Present Status:

- Continuation ....

Status

An analysis of the stresses in a collector cover plate indicated that the most critical mechanical and thermal stresses showed up at high temperatures under no-load conditions.
If the space between absorber and cover plate is completely air tight, then a rise in temperature is followed by a pressure rise.
The deformation of the cover plate was calculated and measured; the accompanying stresses were also calculated.
The mechanical stresses are superimposed by thermal stresses resulting from uneven temperature distribution in the cover plate.
A method was developed to calculate the temperature distribution of any collector, especially in the critical edge zone.
The calculations were confirmed by experiment.
A reliable assessment of stresses which occur under certain conditions in the cover plate is now possible.
In order to get a complete survey on the effects of different external and structural influences, extensive calculations were performed.
Insulation, outside temperature and the structural details were varied both for different working temperatures and for "no-load conditions."

Code No.: FRG-5

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.1.8

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Dornier System GmbH	ADDRESS: Postfach 1360 D-7990 Friedrichshafen West Germany
NAME OF PRINCIPAL RESEARCHER Dipl.-Phys. W. Scherber	

TITLE OF PROJECT Development of Solar Selective Absorber Coatings for Aluminium Roll Bond Heat Exchangers.

OBJECTIVE AND NATURE OF THE PROGRAM: Development of a stable selective coating for aluminium solar panels, which can be deposited on a large scale by low cost production methods.

a. Work Program

a) Preparation of well-known and new absorber coatings.
b) Uniform life-time tests under simulated and real environmental conditions.
c) Analysis of degradation effects and optimization of film properties.
d) Development of low cost deposition methods.
e) Prototype production and comparative out-door tests.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf/

PERIOD OF PROJECT:
15.11.1975 - 30.06.1979

FUNDING IN $ U.S.: 555,290.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Development of Solar Selective Absorber Coatings for Aluminium Roll Bond Heat Exchangers

Objective and Nature of the Project, Present Status:

- Continuation ....

Relation to other projects

This project represents the 2nd part of the main project of the Metallgesellschaft AG: "Development of large scale production methods for components of solar heating systems, especially for solar collectors".

Status

The development of the new solar selective absorber coating (SOLAROX) for application on aluminium rollbond panels in "moisture free" collectors was completed. The pilot production started early this year. The beneficial properties of the Solarox-process, such as sheet homogeneity, reproducibility, process reliability and costs, have been fully confirmed also under series production conditions.

In a second part of the project the Solarex coating shall be improved in order to meet the requirements of the ordinary type of collector in the normal atmosphere. A coating resistant to humidity (DIN 50017) with a thermal emittance of ε = 22% is now available. Work is being done in order to obtain a further reduction in the ε-value and to transfer the Solarex procedure onto standard anodized aluminium.

Code No.: FRG-6

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.1.9

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION M.A.N. Technologie Maschinenfabrik Augsburg -	ADDRESS: Nürnberg AG
NAME OF PRINCIPAL RESEARCHER J. Lorenz	

TITLE OF PROJECT Development of Economic Solar Heating Systems using Inexpensive Collectors

1. OBJECTIVE AND NATURE OF THE PROGRAM: Development and construction of simple solar collectors consisting only of a few mass-produced components. Testing of collectors in an optimized circuit with respect to efficiency, operating response and operating reliability.

2. Work Program

a) Design and construction of prototype collectors adapted for mass production.
b) Testing of prototype collectors with respect to efficiency, operating response and operation reliability in an optimized circuit.
c) Mass production tests with selected collector models.
d) Construction of collectors suitable as roofing materials.

3. PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Work has concentrated on expanded plastic collectors. Indoor and outdoor tests taking into consideration different concepts have been carried out.
First collectors with load-bearing expanded structures (rigid expanded PUR with compact layer of PUR) were examined for mechanical behavior and form stability at idling temperatures. These tests disclosed deformation and irreversible changes in length, so various components, such as the basic material and the specific weight, were changed. Glass rovings were inserted, a sandwich structure built up and the tests repeated. The results of these tests were also negative

continuation overleaf/

PERIOD OF PROJECT:
01.01.1977 -31.12.1978

FUNDING IN $ U.S.: 277,077

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Development of economic solar heating systems using inexpensive collectors

Objective and Nature of the Project, Present Status:

- Continuation ....

so development work on PUR expanded dishes had to be stopped.

Conclusion: rigid expanded PUR systems do not yet exhibit the characteristics demanded by the purposes discussed here. Consequently work is being intensified on the manufacture and testing of collectors having load-bearing and insulating elements consisting of a rigid expanded body (PUR, PIR, expanded glass) surrounded by a thin, deep-drawn metal casing. The casing protects the insulating material against environmental influences and against shocks during transport and assembly. It also facilitates the attachment of a variety of mountings. During the manufacturing development phase, in addition to the questions of favourable production costs and increased service life, particular attention was given to the "leakproof" collector. Various ways of compensating internal and external pressures were examined, samples were made and tested. Parallel to this,development work was carried out on leakproof connections between metal dish and glass cover, such as adhesives, solder and pressed compounds.
A number of these collectors were subjected to indoor tests to determine idling stability and thermal efficiency. They were then installed at an outdoor test facility to investigate long-term behaviour. These collectors are still working perfectly today.

Code No.: FRG-7

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G

3.2.1.1.10

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________

NAME OF ORGANIZATION

KFA Jülich

ADDRESS:

Postfach 1913
5170 Jülich1

NAME OF PRINCIPAL RESEARCHER

Prof. Dr. A. Boettcher

TITLE OF PROJECT Testing a measuring station for the evaluation of solar collectors

OBJECTIVE AND NATURE OF THE PROGRAM: (BMFT)

1. Objective

Erection and testing of a simple measuring station to compare the useful efficiency rates of different collectors with a standard collector.

2. Work Program

a) Design of the measuring station
b) Erection and assembly
c) Putting into operation and functional test
d) Elaboration of test specifications
e) Examination of different collector models

continuation overleaf/

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:

1.1.1977 - 31.12.1978

FUNDING IN $ U.S.: 13,400

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Testing a measuring station for the evaluation of solar collectors

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Relation to Other Projects

The activities specified under 2d) and 2e) are intended to be carried out in collaboration with the Nuclear Research Center "Demokritos" in Greece under the leadership of Prof. Dr. A. Deliyannis. The fundamental work carried out here is the basis for the research projects ET 4172 A and ET 4172 B.

4. Status

The collector test-facility has meanwhile been built and tested. The Jülich prototype has altogether proved satisfactory, minor modifications are still necessary.
A description of the facility and initial measurements have been published.
As part of collaborative work with Greece, four identical collectors were tested for their suitability as standard collectors in the "Demokritos" Nuclear Research Center. Although three of the collectors failed due to corrosion after only a few weeks, the fourth one has so far been working faultlessly.
The three damaged units were taken back by the supplier and replaced by new ones.

Code No.: FRG-8

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: FRG 3.2.1.1.11

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Klaus Esser GmbH & Co. KG	ADDRESS: Postfach 29 09 4000 Düsseldorf 1
NAME OF PRINCIPAL RESEARCHER G. Feierabend	

TITLE OF PROJECT Solar Collectors for Flat Roofs

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Development and construction of solar collectors for flat roofs ready to go into production; testing their ability for continuous operation in practice. Furthermore, the prcblematic nature of installation techniques, which meet technical requirements and guarantee good operation, as well as the optimization of the collector parts, considering the choice of material and manufacturing technique, shall be investigated.

2. Work Program

a) Experimental and theoretical investigations for collector optimization.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
01.10.1977 - 31.12.1978

FUNDING IN $ U.S.: 219,550.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Solar Collectors for Flat Roofs

Objective and Nature of the Project, Present Status:

- Continuation ....

b) Field trials and power measurements of collector constructions in the open air and in the laboratory.
c) Development of a computing model for the handling of collectors being equipped with flat mirrors.
d) Establishing a computing program for calculation of the thermal characteristics of flat-roof collectors compared with the customary components of flat-roof collectors.
e) Investigations on the suitability of collector components for permanent use via accelerated tests.
f) Determination of the material most suitable for use in practice as well as manufacturing techniques for series production.
g) Development and construction ready for production.

3. Relation to Other Projects

This project represents the logical continuation of the work performed in ET 4017 A.

4. Status

Material endurance has been studied with the improved collector type using thermo-oil at a temperature of 453 K (180°C.)

The choice of this temperature made it possible to thoroughly examine the behaviour of each of the collector components under maximum load using an accelerated testing method.

The results obtained have become part of an improved design which is ready for series production and will generally meet all requirements considered in the previous test runs.

A comparison of the improved collector type with customary flat roof collectors, regarding their thermal properties, has been accomplished using a mathematical model and computer program (SOKOL) developed by the Institut für Wärmeübertragung und Klimatechnik, TH Aachen. The very positive results in favour of the improved design on the whole comfirmed the outcome of earlier comparisons (ET 4017 A).

Code No.: FRG-9

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: FRG 3.2.1.1.12

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Universität München	ADDRESS: University of Munich Amalienstr. 54 D-8000 München 40
NAME OF PRINCIPAL RESEARCHER Dr. R. Sizmann	

TITLE OF PROJECT Improvement of thermal efficiency of flat plate solar collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Fundamental research on thermal efficiency and improvement of solar flat plate collectors.

2. Work Program

a) Investigation in α/ε -parameters of selective absorbers: solid layers of semiconductor materials or liquid films of heat transport media with selective dyes.

b) Investigation of the convective heat loss rates between absorber plate and covers; reduction of such heat losses.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:

01.05.1977-31.3.1979

FUNDING IN $ U.S.: 120,550

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Improvement of thermal efficiency of flat plate solar collectors

Objective and Nature of the Project, Present Status:

- Continuation ....

c) Investigation of various profiles on the transparent external cover plate to improve transmission under oblique solar radiation.

d) Tests with flat plate collectors: empirical stage to ascertain validity of test parameters.

3. Status

a) The investigation of the α/ε-behaviour of absorber surfaces covered with various structures of silicon grains was completed. Coarse grains exhibit a reduced α because of reflectivity; fine Si-powder lost the ε-selectivity of bulk material.

b) Heat transfer by internal convection in flat plate collectors decreases markedly with increasing angle of inclination. The convection losses can already be reduced by 30% with simple fixtures.

c) Unfavourable angles of inclination of flat plate collectors (caused, for instance, by a given inclination of the roof) can be corrected by profile structures in the cover plate. In this way high insolation loads in summer months can be reduced simultaneously. East-west misalignments can be corrected by utilizing interference layers.

d) Various methods for the analysis of the behaviour of flat plate collectors with relation to time were experimentally investigated. A first comparative test of 12 commercial flat plate collectors has been completed.

Code No.: FRG-10

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.1.13

COMPONENTS	TYPE OF RESEARCH
☑ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION Brown, Boveri & Cie AG	ADDRESS: Brown, Boveri & Cie AG Zentrales Forschungslabor Eppelheimer Str. 82 D-6900 Heidelberg
NAME OF PRINCIPAL RESEARCHER Dipl.-Phys. H. Birnbreier	

TITLE OF PROJECT BBC-contribution to the solar collector test program, IEA-Subproject III

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

As part of a project of the International Energy Agency (IEA) methods for the measurement of the efficiency of solar collectors will be rated. Two different collectors will be tested in several laboratories.

2. Work Program

Collector tests

- -using the method of the US National Bureau of Standards,
- -using the method of the German Bundesverband Solarenergie
- -evaluation of all test results.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT: 1.6.1977-31.12.1979

FUNDING IN $ U.S.: 12,000

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: BBC-contribution to the solar collector test program, IEA-Subproject III

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Status

-Test of a solar collector according to the methods of the US National Bureau of Standards and the German Bundesverband Solarenergie;

-Cooperation in the IEA-Expert group "Collector test";

-Report on collector test-instrumentation and test results.

Code No.: FRG-11

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: FRG   3.2.1.1.14

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION Metallgesellschaft AG	ADDRESS: 6000 Frankfurt/Main
NAME OF PRINCIPAL RESEARCHER Dr.-Ing. M. Möller	

TITLE OF PROJECT

Roll-bonded heat pipe panels

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Development of roll-bonded heat pipe panels, especially by using Al-alloy roll-bond.

2. Work Program

2.1 Fabrication of Al-alloy roll-bond (see ET 4051/4)
2.2 Internal tube pressure tests
2.3 Corrosion tests
2.4 Planning of fabrication for lengths of about 3 m
2.5 Mechanical, technological test of heat pipe specimens

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
1.11.1977-12.12.1980

FUNDING IN $ U.S.: 136,500

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Roll-bonded heat pipe panels

Objective and Nature of the Project, Present Status:

- Continuation ....

2.6 Integration of heat exchanger with billet
2.7 Selective coating of roll-bonded heat pipe panels
2.8 Development of test methods

3. Relation to other Projects

The development work is done in collaboration with Dornier System GmbH and is supported by the programs ET 4051/2 and ET 4051/4.

4. Status

The preliminary thermodynamic investigations have been terminated and the rolling and cladding technique has been agreed upon. A small number of triple-sandwich absorbers has already been fabricated.

Code No.: FRG-12

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.1.15

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Dornier System GmbH.	ADDRESS: Postfach 1360, 7990 Friedrichshafen
NAME OF PRINCIPAL RESEARCHER Dr. Ing. W. Tanner	

TITLE OF PROJECT Flat Plate Heat Pipe Collectors Made By Rollbonding

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

In this project the method of rollbonding metals which is specially suited for mass production shall be adapted for heat-pipes. In this a combination of the physical advantages of heat pipe collectors with the manufacturing and economic qualities of the rollbonding technique is to be expected.

2. Work Program

- thermodynamic investigations and calculations
- cptimization of the capillary geometry and selection of heat transfer media

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
01.11.1977 - 12.12.1980

FUNDING IN $ U.S.: 259,562.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Flat Plate Heat Pipe Collectors Made By Rollbonding

Objective and Nature of the Project, Present Status:

- Continuation ....

- manufacturing of laboratory samples and performing laboratory tests
- development of an integrated heat exchanger
- adaption of heat pipe and heat exchanger to peripheral components
- outdoor test
- integration of the collectors into the overall system

3. Relation to other Projects

The R&D- program will be performed in cooperation with Metallgesellschaft, Frankfurt, within the project "Hot water preparation with aluminium collectors".

4. Status

The aim of the preliminary thermodynamic investigations was to find a covenient channel system for heat pipes. The thermal operation and the technical realization of several concepts were investigated. For the fabrication of the first flat plate heat pipes a channel system exchanger at the lower end was selected. An integrated heat exchanger (parallel flow direction) was designed.

A first solution for limiting the high vapour pressure, resulting from the high temperatures at no-load conditions was found. The fluid is withdrawn from the heat pipe at a certain maximum temperature and collected in a container of variable volume.

Code No.: FRG-1[illegible]

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.1.16	
COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Flachglas Aktiengesellschaft	ADDRESS: Auf der Reihe 2 4650 Gelsenkirchen
NAME OF PRINCIPAL RESEARCHER Dr. Wolfgang Zernial	

TITLE OF PROJECT Development and Optimization of Hermetically Sealed Flat Plate Collectors with Gas Filling/Selective Absorbing Thin Films

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Development and production of selective absorbing thin films and hermetically sealed flat plate collectors with gas filling.

2. Work Program

Selective films

a) Development in laboratory and pilot scale
b) Construction and test of a continuous pilot-plant for selective absorbing thin films on a small scale
c) Development and completion of an industrial prototype coating plant
d) Production and test measurements of large surface selective films

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
01.11.1977

FUNDING IN $ U.S.: 743,450.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Development and Optimization of Hermetically Sealed Flat Plate Collectors with Gas Filling/Selective Absorbing Thin Films

Objective and Nature of the Project, Present Status:

- Continuation ....

Hermetically sealed flat plate collectors
a) Optimization
b) Development of gas filled collectors
c) Test measurements and analysis

3. Status

Selective films by vacuum process

Work on laboratory scale with substrate dimensions of about 12 x 12 cm was finished successfully. On aluminium, copper, steel and stainless steel we found absorption values α for solar light with Moon mass m = 2 up to 95% and emissivity values ε of 5% to 10%, depending on the substrate, at a temperature of about 315 K. During work on pilot scale with substrate dimensions up to 1 x 1 m, α = 80% and ε = 16% on aluminium was found. The high partial pressures of water and oxygen are responsible for this deterioration. This difficulty shall be avoided by the installation of a high vacuum pump.

From examination of the selective films, high corrosion stability of films on stainless steel and copper was found, medium corrosion stability on aluminium whereas it was poor on steel. For aluminium, copper and steel the temperature stability is up to 250^{o} C, for stainless steel up to 300^{o} C.

Hermetically sealed flat plate collectors

Theoretical and experimental studies on the behaviour of insulating windows during pressure and temperature change resulted in the determination of dimensions for the hermetically sealed modules. Modules consisted of absorber plates and double glass plates. Sizes were 150 x 100 cm with copper absorber plates, and 6 mm spacing between the glass plates each 4 mm thick.

First results were obtained with air, argon and SF_6-filling of the modules; an interpretation of the measured data has not yet been finished.

Diverse silicon adhesives for high temperatures were tested with regard to adhesion. Measurements of gas impermeability during forced aging have started.

Code No.: FRG-15

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: FRG 3.2.1.1.18

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Dornier System GmbH	ADDRESS: Postfach 13 60 7990 Friedrichshafen 1
NAME OF PRINCIPAL RESEARCHER Dipl.-Ing. K. Speidel	

TITLE OF PROJECT Development of Direct Evaporating Collectors for Small Solar Powered Plants and Small Solar Cooling Facilities

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

The objective of this program is to develop direct evaporators for small solar-powered systems. If the working fluid is evaporated in the collector field itself, higher system efficiency can be expected.

2. Work Program

- System design for the use of direct evaporators
- Experiments for different evaporator designs such as: partially filled evaporator, film evaporator and heat-pipe evaporator in the temperature range of 130 - 180° C
- Adaptation of existing concentrating collectors or development of evacuated collectors for direct evaporation

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT: 20.06.1978 - 30.06.1979

FUNDING IN $ U.S.: 218,508.--

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: FRG-15

PROJECT TITLE: Development of Direct Evaporating Collectors for Small Solar Powered Plants and Small Solar ~~Cooling Facilities~~

Objective and Nature of the Project, Present Status:

- Continuation ....

-Construction of an operating model
-Design and production of a prototype.

3. Status

Different experiments have been performed for the evaporator design. The system designs have been optimized according to the direct evaporators. Calculations have been performed for concentrating systems and evacuated flat plate collectors. Operating models will now be constructed.

Code No.: FRG-16

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G   3.2.1.1.19

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Dr. O. K. Wack Chemie GmbH	ADDRESS: Bunsenstr. 6 8070 Ingolstadt
NAME OF PRINCIPAL RESEARCHER Dr. O. K. Wack	

TITLE OF PROJECT Investigation of loss of light transmission of solar collectors due to dirt.

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

The increasing importance of solar energy collectors leads to the question of whether or not the natural soiling of these collectors will lead to a loss in transmission of solar energy. The soiling is caused by dust and industrial dirt which are only partly removed by rain.

The second objective was to get some idea of the possible loss in light transmission in relation to the total light radiation under operating conditions.

Continuation overleaf/

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:
01.04.1978 - 30.07.1978

FUNDING IN $ U.S.: 11,808.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Investigation of loss of light transmission of solar collectors due to dirt.

Objective and Nature of the Project, Present Status:

- Continuation ....

2. Work Program

Glass slides were soiled with different types of standard dirt. The light transmission of these dirty slides was compared with clean standard slides.

3. Status

The results of these tests showed that under laboratory conditions the loss in light transmission due to soiling, which varied between 0.4 and 0.9 g/m^2, was between 9 and 20%. As a next step it should be checked to find whether there is a correlation between these results and reality.

Code No.: FRG-17

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: FRG

3.2.1.1.20

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION Georg Bucher GmbH	ADDRESS: D-8901 Meitingen-Ostendorf
NAME OF PRINCIPAL RESEARCHER Ing. Manfred Schelzig	

TITLE OF PROJECT Development of a flat solar energy collector for low temperature heating using stainless steel plate-bars and polyurethane shells

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Experimental studies for determination of the processing technique to be employed for the manufacture of flat solar energy collectors. Usability tests under natural and simulated conditions of the flat solar energy collectors manufactured in accordance with the processing technique determined.

2. Work Program

- Design and construction of moulds suitable for the manufacture of the collector troughs and the stainless-steel plate-bars.

Continuation overleaf

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:
1.5.1978-31.12.1978

FUNDING IN $ U.S.: 208,642.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Development of a flat solar energy collector for low temperature heating using stainless steel plate-bars and polyurethane shells.

Objective and Nature of the Project, Present Status:

- Continuation ....

- Development and construction of a pilot plant for the manufacture of the collector troughs and the stainless-steel plate-bars.

- Investigation of the chemical engineering technique at the large-scale unit.

- Usability testing:

  a) stainless steel plate-bars, in particular testing of the materials employed with regard to operating pressures, absorbing capacity and emissive power;

  b) collector trough, in particular testing for insulating power, mechanical strength, and also for dimensional stability under heat, stability to light and weather conditions.

  c) float glass covering, in particular testing of the air-tight sealing and stability under the various weather conditions.

3. Status

Studies and experiments carried out as mentioned above permitted a successful completion of the work program.

Production of a pilot lot will be started in the near future.

Code No.: FRG-17

ORGANIZATION: Georg Bucher GmbH

PROJECT TITLE: Development of Flat Solar Energy Collector for Low Temperature Heating Using Stainless Steel Plate-Bars and Polyurethane

DATA SHEET

Solar Collector

a) flat plate

b) $\alpha\tau$ = 80%

c) overall heat loss coefficient: 4,5 W/m^2K

d)

e) heat transfer medium: water

f) material i) absorber: $\alpha = 0.91$, $\varepsilon = 0.156$

ii) cover plate

iii) insulation: PUR 50 mm

g)

Code No.: FRG-18

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: FRG

3.2.1.1.21

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Dornier System GmbH	ADDRESS: Postfach 1360 7990 Friedrichshafen W. Germany
NAME OF PRINCIPAL RESEARCHER Dipl.-Phys. W. Scherber	

TITLE OF PROJECT Development of high temperature resistant solar absorber coatings

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Development of low cost production methods for durable selective absorber coatings for high temperature collector application up to 400° and 600° C.

2. Work Program

a) Further improvement of the electroplated structure type coating suitable for medium absorber temperatures up to 400° C.

b) Development of the high temperature region up to 600° C by means of new preparation techniques (thermoconversion).

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf/

PERIOD OF PROJECT:
01.07.1978 - 30.6.1981

FUNDING IN $ U.S.: 650,182.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Development of high temperature resistant solar absorber coatings

Objective and Nature of the Project, Present Status:

- Continuation ....

c) Transfer of the deposition process to original sized absorber tubes and production of prototypes.

d) Investigation of the long-time stability of the coatings by outdoor exposure tests.

3. Status

The work on item b) has been started.

Code No.: FRG-19

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G   3.2.1.2.1

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☒ Monitoring of a Solar System
NAME OF ORGANIZATION Philips GmbH	ADDRESS: Forschungslaboratorium Aachen D-5100 Aachen
NAME OF PRINCIPAL RESEARCHER Dr. H. Hörster	

TITLE OF PROJECT Energy conservation and the use of solar energy in buildings

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

a) Evaluation and analysis of the economically justifiable use of energy conservation measures and solar energy in buildings.

b) Theoretical and experimental investigation into integrated energy systems in a test house constructed differently from the normal.

c) Development of analytical methods for calculating building and system performance based on hourly weather data.

d) Development of highly efficient solar collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf/

PERIOD OF PROJECT:

18.06.1974 - 30.6.1978

FUNDING IN $ U.S.: 6,560,000

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: FRG-19

PROJECT TITLE: Energy conservation and the use of solar energy in buildings

Objective and Nature of the Project, Present Status:

- Continuation ....

2. Work Program

a) Systems analysis: Investigation of various methods for the optimization of solar and alternative energy systems. Computation of solar domestic hot water and heating installations. Optimization calculations, sensitivity analysis. Computational evaluation of active and passive system components. Cataloguing and analysis of weather data.

b) Development of highly efficient collectors. Investigation of selective reflecting and absorbing layers.

c) Conceptional design of a protctype minimum energy house.

d) Planning and carrying out of various detailed investigations in the experimental energy house.

e) Continuation of long-term experiments in the experimental energy house (solar heating and domestic hot water production, controlled ventilation, heat recovery, application of heat pumps.)

f) Evaluation and interpretation of experimental results.

3. Relation to Other Projects

This project is being carried out in collaboration with RWE Essen and is a contribution of the system study ET 4045 on the use of solar energy. Extended system analysis using climatic data from various locations forms a part of the IEA Solar Energy Program Task I: "Investigation of the performance of solar heating and cooling systems."

4. Status

-Computer programs for the simulation and optimization of solar and alternative energy systems were developed, tested and compared with known methods with respect to reliability and computional velocity. Comparison of theoretical with experimental results obtained from detailed measurements in the experimental house.

-Heat pump-assisted solar systems for heating, cooling and domestic hot water production were calculated (yearly coefficient of performance, percentage covered by the solar part.)

-Investigation of window structures with low heat losses.

-Sensitivity analysis computations were made for several solar heating and hot water systems, i.e., system parameters were quantitatively evaluated.

Continuation/

Code No.: FRG-19

PROJECT TITLE: Energy conservation and the use of solar energy in buildings

Objective and Nature of the Project, Present Status:

- Continuation ....

-Consideration of the profitability of solar domestic hot water systems.

-Further development of evacuated tubular collectors with selective absorption layers with the aim of simplifying and improving the collector arrangement.

-Measurement and analysis of insolation data (direct and diffuse radiation, anisotropy of the diffuse fraction.)

-Long-term investigations in the experimental energy house were continued:
dynamic determination of the energy fluxes inside the house and in the solar heat pump, heat recovery and ventilation systems as well as the determination of meteorological data by means of electronic data acquisition.

-Results of the 3rd heating season were evaluated.

-Summary of all the results in a final report.

Code No.: FRG-19

ORGANIZATION: Philips GmbH

PROJECT TITLE: Energy Conservation and the Use of Solar Energy in Buildings

DATA SHEET

Solar Collector

a) type: tubular, evacuated
b) $\alpha\tau$: 0.7 (including one cover glass)
c) overall heat loss coefficient U_1: 1.9 W/m^2K
d)
e) heat transfer medium: water
f) material i) absorber: α =0.95
ii) selective: τ =0.85, ρ =0.90
iii)
g)
h)

Heat Storage (long term storage unit)

a) type: water
b) heat capacity C: 1.16 kWh/m^3K; 5^oC--95^oC
c)
d) heat exchanger: yes
e)
f) insulation: 50cm rock wool, bottom: 25cm rock wool
g)

Code No.: FRG-20

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: FRG 3.2.1.2.2

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION Energietechnik GmbH NAME OF PRINCIPAL RESEARCHER Dr.-Ing. B. Dietrich	ADDRESS: Freihofstrasse 31 4307 Kettwig

TITLE OF PROJECT Long-term energy storage tanks for residential buildings and the architectural design of solar houses

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Development and testing of suitable long-term water storage tanks for low temperature heat. Optimization of technological applications and economic factors. Investigations of the architectural design of future solar residences considering the requirements of a solar energy system.

2. Work Program

a) Development of various storage concepts;
b) Construction of various storage systems;
c) Construction of a facility to conduct tests on loading and unload-

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf/

PERIOD OF PROJECT: 1.6.1975 - 30.6.1978

FUNDING IN $ U.S.: 202,500

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Long-term energy storage tanks for residential buildings and the architectural design of solar houses

Objective and Nature of the Project, Present Status:

- Continuation ....

ing the tank;
d) Actual testing of the storage tanks;
e) Optimization of loading and unloading systems;
f) Evaluation of the experience gained with respect to the cost optimization of storage tanks.

3. Relation to Other Projects

The investigations for 2e) are being carried out jointly with the Kernforschunganlage Jülich (Nuclear Research Facility at Jülich) in conjunction with the project "Large heat storage unit" (ET 5200 A.)

4. Status

Long-term storage tank
Loading and unloading tests have been concluded on a 40 m^3 storage tank, in collaboration with KFA Jülich, for measuring the temperature layers and for optimizing the loading and unloading equipment (Project ET 5200 A.)

The experience acquired in the manufacture and operation of different test tanks led to the development of a modern large warm water compact storage tank having the following characteristics:

- cuboidal, dismountable storage tank, the manufactured parts of which can easily be transported into cellars where they can be assembled quite simply.

- the tank wall consists of statically load-bearing rigid expanded polyurethane insulating plates with diffusion-tight coating.

- outer wall strutting of steel trapeze structure holding the insulating plates together against the pressure of the static water head of the tank.

- sealing of the tank by means of a prefabricated, warm water-resistant plastic lining made of a reasonably-priced special foil.

Solar house architecture

The elaboration of different solar house designs and the studies on the possibilities of integrating these designs into a concrete development plan were already completed in 1977.

Code No.: FRG-21

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G

3.2.1.2.4

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ System Development
NAME OF ORGANIZATION Kraftanlagen AG	ADDRESS: Im Breitspiel 7 6900 Heidelberg
NAME OF PRINCIPAL RESEARCHER Dipl.-Ing. F. Reinmuth	

TITLE OF PROJECT Domestic water heating by solar energy

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

A solar plant is being installed in an extension to a house. The effect of the installation on the year's oil consumption for the whole house should be discovered through a program of measurements.

2. Work Program

Meters to measure heat quantity will be installed in various positions in the plant. Hot water usage and the central heating system are to be controlled. The energy radiated from the sun and the outside temperature will be recorded. A comparison with data from the German

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf/

PERIOD OF PROJECT:

26.7.1976 - 30.6.1978

FUNDING IN $ U.S.: 17,325

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Domestic water heating by solar energy

Objective and Nature of the Project, Present Status:

- Continuation ....

meteorological office will be made. In this way, the results of the year's measurements can be compared with the average values from the meteorological office. By this method, a significant prediction of the effect of the solar plant on heating oil consumption is possible.

3. Status

The measuring program was finished in September, 1978, and then the evaluation was carried out.

The most striking results are:

a) The average collector efficiency during the one year of operation was 15.9%.

b) The total collector area of 30 m^2 (23 m^2 facing southwest and 7 m^2 facing southeast) has produced useful heat of 3.9 MWh during an operating period of 12 months.

c) The climatic data of the test year (sun radiation and outside temperatures) were found to be well in agreement with the average data of the German weather bureau as worked out over many years.

d) The collector area of 30 m^2 could only satisfy about 16% of the annual heat requirement of the newly built dwelling. The aim of the customer to be independent of oil was not reached with the solar plant that he had installed himself.

The final report was finished at the end of 1978. Advantages and disadvantages of the solar plant and possible improvements were discussed.

Code No.: FRG-22

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G

3.2.1.2.6

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [x] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [x] ~~System Development~~ x System Analysis
NAME OF ORGANIZATION Energietechnik GmbH	ADDRESS: 4300 Essen-Kettwig
NAME OF PRINCIPAL RESEARCHER K. Biasin	

TITLE OF PROJECT Technical and scientific investigations carried out at the solar energy experimental facility in Wiehl/FRG

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Investigation of the capacity, the reliability, and the aging characteristics of

a) a solar collector system consisting of a collector surface of 1500 m^2 for heating the pool water of an outdoor swimming pool with a surface area of water of 1500 m^2;

b) a solar collector system consisting of a collector surface of approx. 80 m^2 for heating the shower water;

c) a heat pump system, the heat sources of which are the ice-skating

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Continuation overleaf/

PERIOD OF PROJECT:
15.7.1976 - 31.12.1980

FUNDING IN $ U.S.: 1,833,374

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Technical and Scientific Investigations Carried out at the Solar Energy Experimental Facility in Wiehl/FRG

Objective and Nature of the Project, Present Status:

- Continuation ....

rink of a multi-purpose hall and the ground.

Investigation of the reduction in heat requirement and the primary energy requirements of

a) the outdoor swimming pool by means of the installed covering system and the heat recovery system from filter rinse water and shower water;

b) the multi-purpose hall by using waste heat.

2. Work Program

a) Planning, installation and operation of a measuring device as well as a process computer for recording and evaluating the experimental data.

b) Experimental investigation into:

-the solar collector system for heating the pool water;
-the solar collector system for heating the shower water;
-the heat pump including the ground heat exchanger;
-the system for heat recovery from filter rinse water;
-the system for heat recovery from shower waste water;
-the covering systems for the outdoor swimming pool.

3. Status

-During the bathing seasons 1977 and 1978, the capacity of the solar collector system was determined and then described on the basis of the most important operational and meteorological data. In addition, different types of losses of the collector system were measured.

-Since July, 1978, the thermal capacity of the different solar collector types used for heating shower water has been determined.

-During the bathing season 1978, the efficiency of the system for heat recovery from shower waste water was measured.

-In 1978, extensive investigations were carried out on the heat pump system and the ground heat exchangers. The temperature flow in the ground during heat absorption and heat supply to the ground was measured and the possibility of using the ground as heat reservoir was examined. In addition, the heat consumption of the multi-purpose hall was measured and the performance coefficient of the heat pump determined.

Code No.: FRG-22

ORGANIZATION: Energietechnik GmbH

PROJECT TITLE: Technical and Scientific Investigations Carried out at the Solar Energy Experimental Facility in Wiehl/FRG

DATA SHEET

Solar Collector

a) Flat plate type: size 1.5 m x 1.0 m (single glass cover, non-evacuated, non-selective)

b) $\alpha\tau = 0.84$

c) Overall heat loss coefficient:
$U_L = 8.5$ W/m^{2}K (working temperature $\sim 35^\circ$C)

d) Heat capacity: 6.3 Wh/m^{2}K (fluid included)

e) Heat transfer medium: swimming pool water

f) Materials:

Absorber: stainless steel, black painted ($\alpha = 0.97$)
Coverplate: single glass ($\tau \sim 0.85$, thickness 4 mm)
Insulation: rock wool (thickness 3 cm)

Heat Storage

a) Swimming pool itself is the storage

b) Medium: water, volume: 2600 m^3

c) Heat capacity C: 1.16 kWh/Km^3

d) No heat exchanger

e) No insulation

Code No.: FRG-23

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G

3.2.1.2.9

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Institut für Kerntechnik und Energiewandlung eV	ADDRESS: Holderbuschweg 52 7000 Stuttgart 80
NAME OF PRINCIPAL RESEARCHER Dr. A. Abhat, Dr. G.Neuer	

TITLE OF PROJECT Development of a modular exchanger with integrated latent-thermal energy storage

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Development of a heat exchanger/thermal storage unit which shall be employed in combination with solar heating/cooling systems using the latent heat of a suitable phase change material. Either liquid or air can be used as the heat transfer medium.

The important characteristics are: modular construction - ease in manufacture - ease in integration with the solar energy system - economical and low maintenance - long life.

Continuation overleaf/

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:

1.1.1977-30.6.1979

FUNDING IN $ U.S.: 312,764

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: FRG-23

PROJECT TITLE: Development of a modular exchanger with integrated latent-thermal energy storage

Objective and Nature of the Project, Present Status:

- Continuation ....

2. Work Program

a) Investigation and selection of phase change materials
b) Theoretical analysis and design of the storage unit
c) Construction of a test model and experimental investigation of its thermal performance
d) Analysis of the theoretical and experimental data. Recommendations for the design and construction of a prototype heat exchanger.

3. Status

- A second test model of the finned pipe heat exchanger concept with optimized fin dimensions has been constructed. The performance of the test model was determined experimentally with 3 different organic and inorganic heat storage materials and compared with results from the numerical analysis.

- A prototype heat storage module with a total storage volume of 100 l was designed, constructed and fitted out with instruments. Work on an on-line data processing system for storage and evaluation of data gained from the prototype has been completed.

- Investigation of long-term melting/freezing behaviour of several selected organic and inorganic heat storage materials has been started. The investigation of chemical properties, i.e., corrosion behaviour, is concluded.

ORGANIZATION: Institut für Kerntechnik und Energiewandlung eV

PROJECT TITLE: Development of a modular exchanger with integrated latent-thermal energy storage

DATA SHEET

Heat Storage

a) phase change; finned heat pipe heat exchanger; diverse storage media
b) heat capacity 5-8 kWH/m^3 (= 10K)
c) latent heat 35-120 kWH/m^3 (20-80°C)
d) heat exchanger: YES integral to thermal storage (water or air)
e) heat rate: ca. 1000 watts
f) insulation: Armflex
g) expected life time: 20 years

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.2.10

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION Süddeutsche Metallwerke GmbH	ADDRESS: Impexstraße 5 D-6909 Walldorf
NAME OF PRINCIPAL RESEARCHER Ing. grad. U. Heidtmann	

TITLE OF PROJECT Measuring Program for Hot Water Supply in Prefabricated Houses Using Solar Energy

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Six tap water heating systems of identical construction, using solar energy, were installed in prefabricated houses in 1976. These systems are operated according to similar sumulated consumption cycles. Measurements of meteorological data and energy gain are performed in order to yield information on the amount of solar energy gained under different climatic conditions.

2. Work Program

a) Acquisition of meteorological data: total radiation, ambient temperature

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:

01.06.1977 - 31.05.1979

FUNDING IN $ U.S.: 201,600.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Measuring Program for Hot Water Supply in Prefabricated Houses Using Solar Energy

Objective and Nature of the Project, Present Status:

- Continuation ....

b) Determination of the energy gain for simulated consumption cycles and the auxiliary energy for pumps and additional electrical heating
c) Calculation of the amount of solar energy obtained and the system's efficiency
d) Comparison of meteorological data and energy gain by means of statistical methods; search for a significant correlation
e) Control and maintenance of the system (measuring devices)
f) Gain of long term test experience

3. Relation to other Projects

This project makes use of experience resulting from project ET 4025 "Tap water heating by solar energy".

4. Status

A comparison of total radiation data (mean values) shows that station 1 (Wahlstedt near Hamburg) receives significantly less radiation than stations 2 - 6. For all stations a yearly average energy gain of 50 - 60% of the simulated warm water consumption is recorded.

All stations have been checked regularly at the beginning and end of each year. Correlation analysis confirms stable long-term performance of the systems.

Code No.: FRG-24

ORGANIZATION: Süddeutsche Metallwerke GmbH

PROJECT TITLE: Measuring Program for Hot Water Supply in Prefabricated Houses Using Solar Energy

DATA SHEET

Solar Collector

a) type : flat plate
b) $\alpha\tau$: 0,83
c) overall heat loss coefficient : 6,0 (W/m^2K) 45°C
d) heat capacity : ca. 6,0 (Wh/m^2K)
e) heat transfer medium : special fluid
f) material
  i) absorber α = 0,95 ε = 0,93
  ii) cover plate 1/0,87
  iii) insulation 50 mm
g) expected life time : 20 years
h) estimated cost : -.-

Heat Storage

a) type : water / cylinder
b) heat capacity : 12563 (Wh/m^3 (10°C → 85°C)
c) latent heat : -.-
d) heat exchanger : YES
e) heat rate : -.-
f) insulation : 80 mm mineral wool
g) expected life time : 20 years

Air Conditioning and Cooling

a) type : -.-
b) type of refrigerator : -.-
c) capacity of refrigerator : -.-
d) temp. range : -.-
e) C.O.P. : -.-
f) heat exchanger : -.-
g) auxiliary heat source : -.-

Code No.: FRG-25

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.2.11

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Measuring on a solar energy plant
NAME OF ORGANIZATION Fachhochschule für Technik	ADDRESS: Fachbereich Versorgungstechnik Kanalstraße 33 7300 Esslingen
NAME OF PRINCIPAL RESEARCHER Prof. Doering	

TITLE OF PROJECT Solar Energy Plant to Supplement a Conventional Heating System

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Measurement of the storage and consumption of solar energy in a one-family house.

2. Work Program

a) Planning of the solar energy plant to be installed and combination with existing heating system, performed by the firm Schmid, heating engineers.
b) Planning of measuring arrangements and fixing of the measuring points, executed by the Laboratory for Ventilation and Climate Engineering in co-operation with the firm Schmid.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:

1.6.1977 - 30.6.1978

FUNDING IN $ U.S.: 14,000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: FRG-25

PROJECT TITLE: Solar Energy Plant to Supplement a Conventional Heating System

Objective and Nature of the Project, Present Status:

- Continuation ....

c) Construction of the solar energy plant and fitting of the connecting pieces for the measuring feelers, performed by the firm Schmid.
d) Installation of the measuring assembly with ensuing pilot tests.
e) Measuring the storage and consumption of solar energy.
f) Preparation of an analysis of economic factors concerning the installation of solar energy plants as a supplement to a conventional heating system.

3. Status

The work specified under a) to d) has been completed. Indications for the improvement of the wiring diagram and for the planning of future solar plants resulted from the pilot tests. The measuring arrangement could be improved to such an extent, that a perfect registration of all data required has become possible. In particular it appeared that insulating losses at the conduit pipes and storage devices had been underestimated. At present the insulation of the conduit pipes, that branch off from the collectors, are being reinforced and we hope for an increase in the heat measured in the solar circuit additional to the heat radiated. Measurements at the solar energy plant were carried out from October 1st, 1977 to September 30th, 1978. The final report is at present being prepared.

ORGANIZATION: Fachhochschule für Technik, Fachbereich Versorgungstechnik

PROJECT TITLE: Solar Plant to Supplement a Conventional Heating System

DATA SHEET

Solar Collector

The collector area is assembled from 8 flat plate collector elements (dimension 3.0 x 1.5 m^2 per element) with an absorber of aluminium. In a crimp (groove, notch) from the sheet of aluminium are put 8 tubes of steel with and inside diameter of 12 mm connected in parallel. The sheet aluminium is painted with special colour for selective transmission. The rear insulation (PU) has a thickness of 40 mm. For cover plates a foil and a plastic plate (GFK) are used. The working fluid is a mixture of water and antifrogen - N. Other facts are not known.

Heat Storage

The solar energy is stored in a heat storage with a volume of 1.568 m^3. The tank is made of sheet steel and has two spiral shape copper tube heat exchangers connected in parallel for the solar side and two for the consumption side. It is filled with unpressurised water. The tank insulation has an U-value of 0,3 W/m^2K.

Code No.: FRG-26

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: FRG 3.2.1.2.12

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Rütgerswerke AG.	ADDRESS: Mainzer Landstraße 217 6000 Frankfurt/Main 1
NAME OF PRINCIPAL RESEARCHER Dr. F. Müller	

TITLE OF PROJECT Solar Equipment System-packages for Old and New Buildings to Provide Warm Water and Partial Heating

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Development of system-packages for using solar energy. The systems are to be optimum, technically and economically fully developed for the market. They are to used for heating domestic water and space heating in old and new buildings.

2. Work Program

2.1 Testing and selection of solar collectors

According to ASE-standards by laboratory procedures to test longterm behaviour of collectors and collector materials.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
01.11.1977 - 31.12.1980

FUNDING IN $ U.S.: 641,655.--

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: FRG-26

PROJECT TITLE: Solar Equipment System-packages for Old and New Buildings to Provide Warm Water and Partial Heating

Objective and Nature of the Project, Present Status:

- Continuation ....

2.2 Integration of solar collectors into roof and wall surfaces with the objective of minimizing assembly and installation labour and preparation of the corresponding manuals.

2.3 System development, layout and specifications for solar equipment system-packages

2.4 Development of plastic solar collectors including selection of materials, processing of moulding powders, construction of test patterns and fabrication of prototypes.

3. Status

Testing and selection of solar collectors:

The reconstruction of the test unit has been finished. Outdoor tests for a double glass covered collector give a conversion factor (maximum collector efficiency) of 75 %.

Integration of solar collectors into roof and wall surfaces:

The design work has been finished. Constructive solutions are being prepared.

System development, layout and specifications for solar equipment system- packages:

A first draft for this system has been prepared. A simulating program has already been started to select the system and to recheck the layout and to consider the compatibility of system components.

Development of plastic solar collectors

A plastic orientated concept for an absorber consisting of a highly heat resistant duroplastic base-plate and a tranparent cover is under consideration. Practical tests show that there are no problems involved in the formulation of the developed moulding powder and the processing of the duroplastic-plate. At present, the most difficult problem is the connection of the two absorber parts. The development of a collector made up of glass-fibre reinforced modified polyester has been started.

Code No.: FRG-27

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.2.15

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Gerd Bakic Engineering Office, Domestic Service Systems	ADDRESS: Planning, Electr.-Heating-Sanitary-Ventil. 8016 Heimstetten / München
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT Creation of an Economical Solar Heating System for a New and an Existing Residential Home Complex. Construction - Hegbacher Installations -

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

Creation of an economical solar heating system for space heating, regenerative ventilation systems and hot water production for a new residential home complex. These are to be run bivalently in the low temperature range.
Supply of the surplus energy for hot water production and for space heating to the existing residential home complexes and commercial units.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
01.05.1977 - 31.12.1978

FUNDING IN $ U.S.: 430,398.--

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.:FRG-27

PROJECT TITLE: Creation of an Economical Solar Heating System for a New and an Existing Residential Home Complex. Construction - Heggbacher Installations -

Objective and Nature of the Project, Present Status:

- Continuation ....

2. Work Program

a) Creation of the energy engineering prerequisites for the most economical use of the solar energy system by means of heat engineering system checks on house frontages and window types. As a result, low-temperature floor-heating systems and regenerative ventilation systems are used.

b) Planning of the solar heating systems as a flat-roof collector system, taking into consideration the collectors currently being offered for sale.

c) Planning of the control components and system connections for economical use of the solar energy which is fed directly to the low-temperature consumption points without the interconnection of system-separating heat exchangers in the solar heating circuit.

d) Planning of an automatically operating storage system with fully automatic surplus-heat transfer to the existing construction.

e) The use of conventional materials of generally accepted quality which have been sold on the heating market for years.

f) Integration of the flat collectors into the partial roof surfaces of the residential homes.

g) Provision of the system components such as pipes, storage units and control systems along with all peripheral installations.

3. Status

The tasks listed in a - g have been completed. The measuring program will start in 1979. 884 m^2 of flat-roof collectors (made by the Esser Co.) were installed on the 8 partial roof surfaces of the new residential homes and integrated into the roof superstructure.
The collector insulation is also used as roof insulation.
Due to the direct heating of the consumption points from the solar heating circuit, the full supply of the floor heating and regenerative ventilation systems is guaranteed to be approximately 298 - 308°K, depending on the outside temperature.

PROJECT TITLE: Creation of an Economical Solar Heating System for a New and an Existing Residential Home Complex. Construction - Heggbacher Installations -

Objective and Nature of the Project, Present Status:

- Continuation ....

Independently of this, the solar energy serves to pre-heat hot water to approximately 293°K. If 308°K are reached, the storage units are loaded, 5 m^3 per residential home in round tanks. If the storage temperature rises above 318°K, the solar energy is transferred as surplus energy to the existing residential homes and commercial units via a distributor line.

Here, the solar energy is used for cold water pre-heating and warm water production via 2 doublesided warm water boilers holding 2.5 m^3 each. Total untilization of the solar energy provided was established. The general system was conceived in line with the mean irradiation values.
In the case of maximum solar irradiation values occurring consecutively for several days maximum temperatures of approximately 360°K were measured. The system has been in operation since 30.04.1978 in one residential home. The second residential home was put into operation in September. Apart from "teething troubles", the systems work without fault.

Exact data on the energy savings made in 1978 cannot be provided yet. However, the annual heating fuel consumption figures for 1976 -1978 have provided an approximate constant. Tangible energy savings can be expected for the residential homes' interior space of approximately 27,000 m^3.

Code No.: FRG-28

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.2.16

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Dornier System GmbH	ADDRESS: Postfach 1360 7990 Friedrichshafen
NAME OF PRINCIPAL RESEARCHER Dipl.-Ing. K. Speidel	

TITLE OF PROJECT Heat-pipe Solar Absorber

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

The aim of the continuation of the project ET 4148 A is to determine a wide technical data base for the development and optimization of solar collectors and components for the solar heating system.

2. Work Program

- Control and maintenance of the solar house heating system
- Detailed measurements of the house heating facilities
- Evaluation of the measured data

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
1.6.1977 - 31.5.1979

FUNDING IN $ U.S.: 118,862.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Heat-pipe Solar Absorber

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Status

The solar house heating system has been in operation since the beginning of 1976 and is still working satisfactorily. The installed data acquisition system enables all components of the house heating facility to be investigated especially over a long period of time.

It could be shown that about 50 % of the yearly total energy needed for hot water production, space heating and heating of the swimming pool could be provided by the installed solar house heating facility.

Code No.: FRG-29

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.1.18

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☒ Control System
NAME OF ORGANIZATION Technische Fachhochschule, Berlin NAME OF PRINCIPAL RESEARCHER Prof. Dr.-Ing. M. Mäiß	ADDRESS: Luxemburger Str. 10 1000 Berlin 65

TITLE OF PROJECT Flat Plate Collectors as Facade Elements for Water Preheating and Heat Insulation

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

The long-term operating and profitability behaviour of a facade installation with flat collectors and storage column shall be investigated on a real example - the Institute for Inorganic Chemistry at the Free University Berlin. The collectors are installed as integrated building components for pre-heating domestic water for the Institute and as heat insulation according to EnEG 7/77 against transmission losses and as part of the building structure.
The long-term characteristics for various operating conditions and the constructional behaviour shall lead to basic data for future designs.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
1.3.1978 - 31.12.1981

FUNDING IN $ U.S.: 302,621.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Flat Plate Collectors as Facade Elements for Water Preheating and Heat Insulation

Objective and Nature of the Project, Present Status:

- Continuation ....

This is a collaborative effort of TFH Berlin between the departments FB 4 (Architecture/Construction Technique), FB 6 (Heating and Air Conditioning) and FB 9 (Mechanical Engineering) for the development and technical evaluation and the "Senator für Bau- und Wohnungswesen" of Berlin for the technical constructional part of the project.

2. Status

Length of facade ca. 28 m, height of facade ca. 31 m. 5 rows of collectors between the rows of windows, each ca. 1.7 m high, each row with 4 groups of 4 collectors.
2 closed solar circuits each with 40 collectors for series or parallel operation, piping according to the Tichelmann-System.
Pressureless storage column consisting of 0.65, 1.5 and 2 x 3.0 cbm which are filled according to an order of priority.
Electronic regulation to control the heat supply. This can be influenced by externally or internally operating conditions.
Central registration and processing of data from external, operating and demand conditions.
Passive heat transmission factor of the collector part of the facade is 0.45 W/m^2K.
Integrated facade structure in the collector area is based on Al-glass.
The total costs mentioned do not include the building and auxiliary costs for the rest of the facade or the collector costs to a value of DM 1,570,000.-- ($ US 785,000.--)

Code No.: FRG-29

ORGANIZATION: Technische Fachhochschule Berlin

PROJECT TITLE: Flat Plate Collectors as Facade Elements for Water Preheating and Heat Insulation

DATA SHEET

Solar Collector

a) collector type:
flat plate, 1 cover plate, nonevacuated, frame AlMgSi 0.5

c) over all heat loss coefficient :
max. 0.45 W/m^2K ; temp. range - 30/ + 120° C

d) heat capacity : 1.6 Wh/m^2K incl. medium

e) heat transfer medium : 70% water, 30% glycoleum, 350 cm^3/m^2

f) absorber unit :

1. absorber plate AlMg 1, boarded
surface selective coated, black

degree of vertical absorption 90%
IR - emission less than 20%

with pipes installed underneath the absorber plate, 10 x 1 mm,
X5CrNi 18 9 = 1.4301

2. cover plate : crystal glass, safety, 6 mm.

3. insulation :
foamglass board, type T2, 50 mm, = 0.05 W/mK
c = 0.23 Wh/kg K
unburnable, formresistant up to 50 N/cm^2
coated with Al-foil, = 0.1

4. working dates : working temperature - 30/ + 110 °C
working pressure 10/ 16 bar
test pressure 20 bar
according to the german specifications for closed heating systems

g) expected life time : MTBF 10 years
MTTF 25 years

h) estimated cost : 200.- USD/m^2 = 380.- DM/m^2

Code No.: FRG-30

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.2.21

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☑ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Monitering a Solar System
NAME OF ORGANIZATION (under Objective and Nature)	ADDRESS:
NAME OF PRINCIPAL RESEARCHER German Part: Dr. K.R. Schreitmüller	, DFVLR

TITLE OF PROJECT Solar House Freiburg

OBJECTIVE AND NATURE OF THE PROGRAM:

NAME OF ORGANIZATION:

German Part:

Part A.: Philips Forschungslabor Aachen; IST, 7859 Eimeldingen

Part B.: DFVLR Stuttgart/Köln; Part C: Siedlungsgesellschaft Freiburg

American Part: (promoting agency: ERDA; Project leader : Prof.W.S.Duff CSU) Colorado State University, Fort Collins, Col.; Corning Glass Works, Corning, N.Y., USA

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:

01.09.1976 - 30.06.1979

FUNDING IN $ U.S.: 1,994,500.-

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: FRG-30

PROJECT TITLE: Solar House Freiburg

Objective and Nature of the Project, Present Status:

- Continuation ....

1. Concise description of the project

A 12-apartment house, constructed by the Siedlungsgesellschaft Freiburg, will be equipped with two high-effiency collector units for hot water preparation and (partial) heating. During the first phase of the experiment (1.5 to 2 years) the two units will be operated separately (unit A for the hot water system, B for the heating system and vice versa). Afterwards, both units will furnish the combined energy system.
The house is equipped with an improved thermal insulation and with energy saving and recovery installations.
A similar experiment is carried out in Fort Collins, Col., where the collectors are used for hot water preparation, for heating and for cooling purposes.

2. Objective

Tests of high-efficiency collectors under different climatic conditions (Colorado and Freiburg) and realistic operating situations.
The detailed registration of all relevant data as the basis for computer simulation of solar energy systems.
The test of various calculation models by the experiment.
The quantitative determination of the effects of the variables on the gross energy consumption. These variables include the various energy saving and recovery installations and methods, several operational modes and an improved thermal insulation.
The quantitative determination of the effects of various energy economizing arrangements on the convenience of the inhabitants. The proof of the acceptability of various energy economizing installations and methods to the users.

3. Work Program

Part A: Philips Forschungslabor
a) Design and tests of components for high-efficiency collectors.
b) Construction of large collector modules for the experimental determination of the collector characteristics (indoor and outdoor tests).
c) Development of inexpensive manufacturing processes for high-efficiency collectors.
d) Construction and provision of one of the two collector units, assistance at the installation and the start-up of the solar system.

Part B: DFVLR (advisory function: Philips Forschungslabor)
a) Selection of the measuring instruments: type and quantity, specification of the characteristics, development of calibration methods.

continuation overleaf/

Code No.: FRG-30

PROJECT TITLE: Solar House Freiburg

Objective and Nature of the Project, Present Status:

- Continuation ....

b) Specification and selection of the data recording and processing system, software generation.
c) Design of the solar hot water preparation and heating system
d) Design of the control system (conventional and solar part).
e) Selection and dimensioning of the energy economizing devices
f) Design and installation of the measuring system.
g) Control of the installation and the start-up of the solar system.
h) Execution and evaluation of the experiments.

Part C: Siedlungsgesellschaft Freiburg (advisory function: DFVLR and Philips Forschungslabor)

a) Design of the blueprints with particular regard to thermal insulation arrangements.
b) Construction and operation of the house.

4. Status

Part A

Design and tests of the collectors have been completed. The large collector modules have been installed on the roof of the solar house.

Part B

The solar and the auxiliary (heating, ventilation) systems have been set in operation and the conventional control system has been adjusted. The microprocessor for the more sophisticated controls has been integrated and is now being tested. The sensors of the solar house have been individually calibrated whereby an accuracy of ±.03 K for the temperature sensors and and of ±.5 % for the flow meters has been accomplished. The various instruments have been installed within the solar system and have been connected to the data acquisition system. The software has been completed and the data acquisition system set in operation and tested. As the preliminary work is now finished, the essential part of the experiment will start on 1st January 1979.

Part C

The house was completed and occupied in September 1978. The preliminary results (up to now) confirm the design data.

Code No.: FRG-31

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.1.3.1

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Messerchmitt-Bölkow-Blohm GmbH	ADDRESS: Postfach 801169 8000 München 80
NAME OF PRINCIPAL RESEARCHER Dipl.-Ing. H. Grallert	

TITLE OF PROJECT Solar Air Conditioning and Cooling - Phase 1

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

In the development phase 1 the suitable application of absorption cooling machines in connection with solar cycles will be proved. A demonstration plant will be constructed out of readily available components. This system will be tested.

2. Work Program

a) Fabrication of double glass collectors with selective absorber plates
b) Reconstruction of an air freight container to accommodate a cooling chamber and measurement devices.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
1.6.1977 - 31.5.1978

FUNDING IN $ U.S.: 290,875.--

IMPORTANT REPORTS OR PUBLICATIONS:

PROJECT TITLE: Solar Air Conditioning and Cooling - Phase 1

Objective and Nature of the Project, Present Status:

- Continuation ....

c) Erection and tubing of the collector area
d) Installation of an absorption cooling system, the solar buffer heat storage tank and all necessary peripheral devices
e) Setting the cooling cycle in operation
f) Setting the collector cycles in operation
g) Complete testing of the solar heated absorption cooling system
h) Calculation of the measurement results

3. Status

On a wooden support similar to a roof construction 40 m^2 double glass collectors with selective absorbers were installed. The 30° tilted collector area is located on land belonging to the MMB. The collector integration and all interfaces to the conventional roof structure were realistically performed for demonstration purposes. An Arkla absorption cooling machine with 10 kW cooling power (type WF 501) was installed in a reconstructed air freight container. This work was done with the co-operation of the company Ruckelshausen. Furthermore the recooling cycle and a device for the simulation of an increased ambient heat input into the container were installed. The insulated pressurized heat storage tank of the collector loop was also fitted out with an auxiliary electric heater to be independent of weather conditions when testing the cooling cycle only. The tubing of the collector area and of all system cycles was finished in December. The cooling system alone was set in operation for the first time at the end of November 1977. The cooling cycle control has been improved compared with the more recent utilization of the machine type WF 501.

The collector loop is operated with a synthetic working fluid, which has an evaporation point at more than 200°C. In the pressurized heat storage tank hot water is used. The cooling machine operates with the two component fluid mixture LiBr/water.
The complete test program carried out in May and June 1978 demonstrated that it is possible to operate a normal absorption cooling machine using solar energy. The investigated system concept proved to be suitable. By further improvements with respect to collectors, heat exchangers and adaptation of the cooling machine generator to the solar heating conditions, the investigated type of cooling plant can be technically and economically optimized. In particular, these measures would lead to a considerable reduction in the electrical energy demand of the auxiliary devices.

ORGANIZATION: Messerschmitt-Bölkow-Blohm GmbH

PROJECT TITLE: Solar Air Conditioning and Cooling - Phase 1

DATA SHEET

Solar Collector

a) Flat plate type with steel framing
b) $\alpha\tau \approx 0.7$
c) $U_1 = 3\ W/m^2K$ (temp. range $\theta \leqq 160^oC$
d) $c = 4{,}6\ Wh/m^2K$
e) heat transfer medium is thermo oil
f) Absorber material : aluminium-roll-bond
   Absorber coating : black chrome ($\alpha \approx 0{,}95$; $\varepsilon \approx 0{,}25$)
   Cover plates : 2 glass covers, total transmission 0,73
   Insulation : 5 cm PU-foam + air gap
g) test collector, no life time prediction
h) test collector, no serial fabrication cost calculation

Heat Storage

a) Hot water storage, pressurized steel tank
b) $c = 1{,}17\ kWh/m^3K$ (temp. range $\theta \leqq 110^oC$)
c)
d) closed loop system (heat input transfer fluid s.a., heat output transfer fluid pressurized water)
e) (unknown)
f) up to 30 cm PU-foam insulation
g) test tank, no life time prediction

continuation overleaf/

ORGANIZATION: Messerschmitt-Bölkow-Blohm GmbH

PROJECT TITLE: Solar Air Conditioning and Cooling - Phase 1

DATA SHEET

Air Conditioning and Cooling

a) solar air conditioning unit
b) absorption cooling machine working with LiBr/Water-Solution, Arkla WF 501
c) 2,83 tons capacity of refrigerator
d) heating temp. range 80 -110 ^{o}C
e) C.O.P. $\approx$ 0,63
f) (unknown)
g) electric heater integrated in the heat storage tank

Code No.: FRG-32

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: F R G 3.2.4.12

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [x] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [x] System Analysis

NAME OF ORGANIZATION
Institutsgemeinschaft für die Technologie - Nutzung Solarer Energie,

ADDRESS:
Universität Stuttgart
Breidscheidstrasse
3/7000 Stuttgart 1

NAME OF PRINCIPAL RESEARCHER
Prof. G. Lehner

TITLE OF PROJECT Technical Use of Solar Energy

OBJECTIVE AND NATURE OF THE PROGRAM:

1. Objective

The experimental and theoretical investigations hitherto performed by the Institutsgemeinschaft in the field of the technical use of solar energy are to continued.
For the gain of low temperature heat from solar energy, the components necessary (collectors, storage systems) are to be investigated for improvement. The development and testing of selective coatings is considered in this respect; the systems and their optimization will play an important part of this. Absorption-cooling systems are to be considered theoretically and experimentally.
In particular solar-cells will be used for the production of electrical energy. The main effort is devoted to the investigation of production technologies of CdS-cells.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

continuation overleaf/

PERIOD OF PROJECT:
01.03.1978 -28.02.1982

FUNDING IN $ U.S.: 3,779,750.--

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: FRG-32

PROJECT TITLE: Technical Use of Solar Energy

Objective and Nature of the Project, Present Status:

- Continuation ....

Procedures already developed will be improved and new ones worked out. Long term investigations of the existing, and the still to be extended 1 kW silicon-cell generator are to be continued. Silicon-cells are also to be tested with light concentration. These investigations are part of the system studies on solar-cells. Hybrid collectors for the simultaneous production of heat and electricity have to be further developed and improved. Accompanying tasks are: the acquisition and collection of meteorological data, especially radiation which will be provided for both national and international programs.

2. Work Program

a) Low temperature heat

- Comparative investigations and long-term tests on flat plate solar collectors with water and air as heat carriers
- Application of ASHARE and NBS test specifications to Central European conditions
- Optimization of collector specific parameters with respect to various working procedures and variable weather conditions
- Comparison of laboratory and open air tests
- Experimental and theoretical investigations on the transient and intransient behaviour of collectors and storage devices and their interaction
- Optimization of various collector-storage devices
- Investigation on the stability of thermal stratification in warm water storages and effects of charging and discharging
- Development and construction of a solar absorption cooling unit and a model cold store
- Further development of selective coatings

b) Electrical Energy

- Tests on spraying and sputtering for thin-film solar cells
- Production and investigation of several CdS-solar-cell generators (1 m area each)
- Installation of outdoor test stations for thin-film solar cells at various locations
- Correlation of spectrum measurements and efficiency of thin-film solar cells
- Physical investigation of structure and properties of CU_2S and CdS
- Continuation of measurements on a 1 kW solar-cell-generator and experiments with concentrators
- Improvement and continuation of experiments on the thermoelectric conversion
- Experiments with flat and concentrating hybrid collectors

c) Meteorological data - Collection of data

- Co-operation in a program for collection of meteorological data

continuation overleaf/

PROJECT TITLE: Technical Use of Solar Energy

Objective and Nature of the Project, Present Status:

- Continuation ....

3. Status

The influence of various parameters on the transient behaviour of flat plate collectors has been investigated and the transient response of a solar heating system has been simulated. Longtime experiments with water-cooled flat plate collectors and usual tests according to NBS and BSE test procedures were performed in order to prove these procedures. The suitability of an indoor test-loop for collector efficiency measurements could be shown. At the air-cooled collector test-facility some commercial collectors were investigated. The temperature profiles in a hot water storage tank were measured under transient conditions. The heat of fusion of paraffins, which are suitable materials for the storage of latent heat in the range of melting temperatures between -5° C and +40° C, has been determined experimentally. The work on the improvement of selective absorber coatings has been continued. The diagnostic equipment for the measurement of their radiative properties has been further improved. The experiments on the thermoelectric conversion of solar energy have been terminated within the present project. The photovoltaic test generator, which was built in co-operation with AEG, has meanwhile been equipped with polycrystalline silicon solar-cells. Tests with recently developed flat plate hybrid (thermal and photovoltaic) solar collectors have been started. Initial measurements were mainly concerned with the output of electric power under various conditions. The experiments with solar cells in concentrators have been continued. A part of the experiments was done with a special Fresnel lens, adapted for use with 2 x 2 cm^2 solar cells. For direct conversion of solar energy to electrical energy, Cu_2S-CdS thin film solar cells have been developed. Using inexpensive materials such as ordinary window-glass as substrate and and cover material, encapsulated solar cells were fabricated, and these are already connected to subpanels. The back contact and the n-type CdS-layer are produced by evaporation. The p-type Cu_2S-layer is fabricated topotaxially. The transparent front contact and encapsulation is carried out in a vacuum. Efficiencies of 6.5% have been achieved for solar cells with an area of 7 x 7 cm^2.

ORGANIZATION: Institutsgemeinschaft für die Technologie - Nutzung Solarer Energie, Universität Stuttgart

PROJECT TITLE: Technical Use of Solar Energy

DATA SHEET

Solar Collector

a) type:
flat plate
tubular
concentrated
non-evacuated
configuration:
commercial and prototype collectors: cover material, absorber, isolation

b) $\alpha\tau$:

water collectors	38 - 85 %
air collectors:	67 - 89 % (extrapol ated)
concentrated collectors:	60 - 75 %

c) overall heat loss coefficient:

water collectors:	4 - 7,6 W/m^2K (10^0C - 90^0C)
air collectors:	8 - 15 W/m^2K (20^0C - 80^0C)
concentrated collectors:	2,5 - 3 W/m^2K (10^0C - 150^0C)

d) heat capacity: no specification

e) heat transfer medium:
water, water-glykol, thermo-oil

f) material:
i) absorber
water collectors: aluminium, copper, steel
$\alpha = 0,85 - 0,94$
$\varepsilon = 0,12 - 0,8$

air collectors: aluminium, steel
$\alpha = 0,95 - 0,968$
$\varepsilon = 0,67 - 0,89$

concentrated collectors: aluminium
$\alpha = 0,8 - 0,96$
$\varepsilon = 0,8$

ORGANIZATION: Institutsgemeinschaft für die Technologie - Nutzung Solarer Energie, Universität Stuttgart

PROJECT TITLE: Technical Use of Solar Energy

DATA SHEET

ii) cover plate

water collectors:	glass, plastic foil, glasfibre number: 1 - 2; τ = 0,8 - 0,9
air collectors:	glass number 1 - 2 ; τ = 0,8 - 0,9
concentrated collectors:	glass tube number 1 ; τ = 0,9

iii) insulation

water collectors:	PU-Foam, rockwool thickness: 12,5 mm - 50 mm
air collectors:	PU-Foam, fibreglass, styropor thickness: 30 mm - 90 mm
concentrated collectors:	none

g) expected life time:

water collectors:	1 - 10 years
air collectors:	-
concentrated collectors:	-

h) estimated cost:

water collectors:	50 - 175 US $\$/m^2$
air collectors:	50 - 150 US $\$/m^2$
concentrated collectors:	500 US $\$/m^2$

Heat Storage

a) type: water and latent storage
storage medium: water, lauric acid
configuration: water: tank
latent: tube bundle

b) heat capacity:
water: c_p = 4,187 kJ/kgK (20°C - 60°C)
latent: $c_{p_{liquid}}$ = 2,156 kJ/kgK (57°C)

ORGANIZATION: Institutsgemeinschaft für die Technologie - Nutzung Solarer Energie, Universität Stuttgart

PROJECT TITLE: Technical Use of Solar Energy

DATA SHEET

c) latent heat: water: no phase change
latent: 182,7 kJ/kg (158,6 kJ/cm^3) (43-46^{0}C)

d) heat exchanger: water: yes (water)
latent: yes (water)

e) heat rate: -

f) insulation: water: rockwool
latent: air gap

g) expected life time:
water: 10 years
latent: unknown

Air Conditioning and Cooling

a) type: solar cooling

b) type of refrigerator: absorption
working medium: ammonia

c) capacity of refrigerator: -

d) temperature range: - 5^{0}C

e) C.O.P.: -

f) heat exchanger: yes

g) auxiliary heat source: yes

Code No.: G-/

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION N.R.C.DEMOCRITOS	ADDRESS: APPLIED THERMODYNAMICS LAB. TECHN.APPLICATIONS DIVISION N.R.C.DEMOCRITOS AGIA PARASKEVI - ATTIKIS GREECE
NAME OF PRINCIPAL RESEARCHER Dr.Argyrios V. Spyridonos	

TITLE OF PROJECT Heat-pipe

OBJECTIVE AND NATURE OF THE PROGRAM:

Construction of a solar collector, flat-plate or concentrator composed of heat pipes

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Maximum evaporator temperature reached 150°C

Studies on the reversibility of the porous material.

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Heat-pipe filled with glycol-water solution 2and Miami International Conference on Alteative sources of Energy 10-15 Dec.1979.Secsion 4A,paper 7

Code No.: G-1

8 **ORGANIZATION:** N.R.C. DEMOCRITOS

9 **PROJECT TITLE:** Heat pipe

DATA SHEET

10 **Component :** A single Heat-pipe of 600 mm length is studied, a longer heat pipe is under construction

Overall heat loss coefficient	U_L (W/m^2K)	3,2
temperature range	°C	20 - 150°C
Heat capacity		- - - - -
Heat transfer medium		glycol-water solution
Material		
absorber		copper tube

Code No.: I-1

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Italy

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Istituto di Fisica	ADDRESS: Istituto di Fisica Facoltà di Ingegneria Piazzale Tecchio 80125 NAPOLI
NAME OF PRINCIPAL RESEARCHER Prof.fabio Fittipaldi	

TITLE OF PROJECT Heat storage by solid-solid phase transition

OBJECTIVE AND NATURE OF THE PROGRAM: To found new substances able to store thermal energy by solid-solid phase transitions.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:
Synthetised families of substances $(n-C_nH_{2n+1}NH_3)_2MCl_4$ with high transition hentalpy and with temperature transition between 280 °K and 480° K

PERIOD OF PROJECT:
1977-80

FUNDING IN $ U.S.:
150,000 by C.N.R. National Research Council

IMPORTANT REPORTS OR PUBLICATIONS:
Italian Solar Energy Reports -C.N.R. 1978 and 1979
Solar Energy (in press)

Code No.: I-1

ORGANIZATION: Istituto di Fisica Facoltà di Ingegneria Napoli

PROJECT TITLE: Heat storage by solid-solid phase transition

DATA SHEET

1) Solid-solid phase transitions

Component :

Code No.: I-2

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Italy

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Istituto G.Donegani	ADDRESS: Istituto G.Donegani Montedison BARRA(Napoli)
NAME OF PRINCIPAL RESEARCHER A.Addeo L.Nicolais	

TITLE OF PROJECT Solid-solid phase transition substances in polymeric matrices.

OBJECTIVE AND NATURE OF THE PROGRAM:

To develop solid-solid pase transitions substances in polimeric matrix

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

It is found the convenience to use polistirene as matrix container off solid-solid phase transition substances

PERIOD OF PROJECT:
1979-80

FUNDING IN $ U.S.:
50,000

IMPORTANT REPORTS OR PUBLICATIONS:

Italian solar energy reports C.N.R. 1979

Code No.: I-3

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Italy

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Istituto Chimica Industriale	ADDRESS: Istituto di Chimica Industriale Università di Messina Via Ghibellina 64 MESSINA
NAME OF PRINCIPAL RESEARCHER Prof.Nicolò Giordano	

TITLE OF PROJECT

Heat storage by reversible cathalytic reactions

OBJECTIVE AND NATURE OF THE PROGRAM:

To study the reaction H_2+benzene === ciclohexane

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Reaction study by catalitic reactor are done,with very good results

PERIOD OF PROJECT:
1978-80

FUNDING IN $ U.S.:
100,000 by C.N.R.

IMPORTANT REPORTS OR PUBLICATIONS:

Italian solar energy reports C.N.R. 1979

Code No.: I-4

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Italy

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION MONTEDISON DIRS	ADDRESS: Montedison DIRS Centro Ricerche Napoli Via Nuova delle Brecce 150 80147 Napoli:Barra
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT Solar plastic plate collector

OBJECTIVE AND NATURE OF THE PROGRAM: To Buid new plastic collectors with very good efficiency and with cheap material.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Three types of collectors are made each of one with very good characteristic;one of thode ism completely folding

PERIOD OF PROJECT: 1978-79

FUNDING IN $ U.S.: 40,000 in part by CNR

IMPORTANT REPORTS OR PUBLICATIONS:

Italian solar energy reports CNR 1979

Code No.: I-5

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: ITALY

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______________
NAME OF ORGANIZATION Industrie Pirelli spa	ADDRESS: Piazza Duca d'Aosta MILANO
NAME OF PRINCIPAL RESEARCHER Ing. Edoardo ROBECCHI	

TITLE OF PROJECT

Rubber plate solar collector

OBJECTIVE AND NATURE OF THE PROGRAM:

To develop and to build a new rubber plate collector

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

It is completely developped the new solar rubber plate collector

PERIOD OF PROJECT: 1977-80

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Italian solar energy reports CNR 1978/79

Code No.: I-6

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: ITALY

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Istituto di Fisica	ADDRESS: Istituto di Fisica Facoltà di Ingegenria Piazzale Tecchio 80125 NAPOLI
NAME OF PRINCIPAL RESEARCHER Prof.V.Silvestrini	

TITLE OF PROJECT Long therm performances of solar systems

OBJECTIVE AND NATURE OF THE PROGRAM:
To study long therm performances of cylindric-parabolic collectors

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:
Have been developped two computers programs:VERTAR and TARIQ; one needs climatic hourly data,the other daily data.

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:
Solar energy italian program CNR 1979

Code No.: J-1

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Japan

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION Sanyo Electric Co. Ltd. NAME OF PRINCIPAL RESEARCHER K. Hinotani	ADDRESS: 1-18-13, Hashiridani, Hirakata Osaka 573

TITLE OF PROJECT

Development of Tubular Evacuated Solar Collector

OBJECTIVE AND NATURE OF THE PROGRAM: The objective of this program is to develop a solar collector for solar cooling, heating and hot water supply systems. The specific works are to design, construct and test an evacuated glass tube collector capable of operating at 90°C at greater than 65% efficiency. Also works are made in terms of its durability, reliability and cost effectiveness.

The project includes the testing of a solar cooling, heating and hot water supply system for a single family house.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Development of the solar collector was completed.
The solar system design and construction were completed and the measurement of the system is under way.

PERIOD OF PROJECT: 1974-1980

FUNDING IN $ U.S.: $440,000(about)

IMPORTANT REPORTS OR PUBLICATIONS: Annual Reports to the MITI(in Japanese)

Code No.: J-1

ORGANIZATION: Sanyo Electric Co. Ltd.

PROJECT TITLE: Development of Tubular Evacuated Solar Collector

DATA SHEET

Component : Solar Collectors

a) type and configuration:
   Tubular and evacuated, unit size is 100 mm dia. and 2000 mm long.

b) $\alpha\tau$: 0.79

c) overall heat loss coefficient U : 3.1 ($w/m^2{}^\circ K$)

d) heat capacity (fluid included) : 7.1 ($wh/m^2{}^\circ K$)

e) heat transfer medium : water

f) material i) absorber: α = 0.9 ε = 0.1
   ii) cover plate: one pane(glass tube) τ = 0.88
   iii) insulation: evacuated

g) expected life time: 15 years

h) estimated cost : \$240/m^2

Code No.: J-2

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Japan

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________

NAME OF ORGANIZATION
KAWASAKI HEAVY INDUSTRIES, LTD.

NAME OF PRINCIPAL RESEARCHER
Mr. Kenji Ooka

ADDRESS:
Osaka Works of Kawasaki Heavy Industries, Ltd.
1-35, 4 Chome-Shimaya, Konohana-ku, Osaka

TITLE OF PROJECT Development of Large scale absorption machine which is operated in single effect by solar and in double effect by auxiliary heat source.

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of following technology for the purpose of realizing an energy saving and economical solar cooling for large building.

1) Application of the low-temperature hot water by solar to absorption liquid chiller.
2) Combined system of single effect by solar and double effect by auxiliary heat source which is capable of using auxiliary energy effectively.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

A 30 USRT combined single/double effect absorption chiller was manufactured by KHI and tested at Oita Uni. in 1978 and 1979 cooling seasons.
The average COP by solar and auxiliary heat source was about 0.6 and 1.0 respectively, and that of the combined system was certified to be between 0.6 and 1.0.

PERIOD OF PROJECT:

1974 ~ 1981

FUNDING IN $ U.S.: about 43,000. (1978)

IMPORTANT REPORTS OR PUBLICATIONS:

NONE

ORGANIZATION: Kawasaki Heavy Industries Ltd.

PROJECT TITLE: Development of large scale absorption machine which is operated in single effect by solar and in double effect by auxiliary heat source.

DATA SHEET

Component :

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 from 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.
30 ∿ 100 USRT single effect and double effect combined type units manufactured by KHI.
d) temp. range:

	single effect	single - double effect combination	double effect
Chilled water	14 - 9	14 - 9	14 - 9
cooling water	30 - 38.2	single 30 - 38.2 double 30 - 36.6	30 - 36.6
heat source	85 - 77.5	single 85 - 77.5 double 3.0 kg/cm^2 (steam)	3.0 kg/cm^2 (Steam)

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 (3 - 4 kg/cm^2)

Code No.: J-3

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: JAPAN

COMPONENTS	TYPE OF RESEARCH
☑ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________

NAME OF ORGANIZATION
Kawasaki Heavy Industries, Ltd.

NAME OF PRINCIPAL RESEARCHER
Masao Yoshiwa

ADDRESS:
2-14, Higashi Kawasaki-cho, Ikuta-ku
Kobe, Japan

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 innovativative but economical solar collector for heating, cooling and domestic hot water supply system for large building.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Fourty large flat-plate solar collectors have been installed on the experimental building(three stories, installed area of about 500m^2) of Department of Energy Engineering, Ohita University in 1977.

The experiment and the evaluation will be made from April, 1978 to March, 1981.

PERIOD OF PROJECT:

July, 1974 - March, 1981

FUNDING IN $ U.S.:

Current Year: $60,000
Total for the Period: not available

IMPORTANT REPORTS OR PUBLICATIONS:

none

Code No.: J-3

ORGANIZATION: KAWASAKI HEAVY INDUSTRIES, LTD.

PROJECT TITLE: Solar Heating, Cooling and Hot Water Supply System for Large Building

DATA SHEET

Component : Solar Collector

a) type: Flat plate (2m in width x 7.5m in length x 0.2m in hight)

b) $\alpha\tau$: 0.80

c) over all heat loss coefficient u: 3.8 w/m^{2}K
Temperature Range: 55°C to 85°C

d) heat capacity (fluid included) c: 1.94wh/m^{2}K

e) heat transfer medium: water

f) material:

i) absorber α =0.96 ε =0.92 (pipe on sheet copper black paint)

ii) cover plate 2 pane τ =0.83

iii) insulation glass wool (50mm) + polyethylene foam (25mm)

g) expected life time: 20 years

h) estimated cost: 125 $US/m^2

Code No.: J-4

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: JAPAN

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Toyo Netsu Kogyo Kaisha, Ltd.	ADDRESS: 5-12 Kyobashi 2-Chome Chuo-ku Tokyo
NAME OF PRINCIPAL RESEARCHER Yasuo Tanaka	

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 was 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 SIGINIFICANT ACCOMPLISHMENTS:

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.

One of the experimental results in 1978 was as follows: the ratio of piston flow zone in these tanks was 0.85 and the ratio of mixed flow zone in these tanks was 0.08 and the rest was considered as dead zone.

PERIOD OF PROJECT:

This project started in July 1974 and will end in March 1980.

FUNDING IN $ U.S.: $185,000
(Estimated total research fund only for heat storage)

IMPORTANT REPORTS OR PUBLICATIONS:

1. H. Matsudaira, Y. Tanaka, "Dynamic Characteristics of a Heat Storage Water Tank —— Part I", ASHRAE Transactions 1979, Vol.85, Part 1.
2. H. Matsudaira, Y. Tanaka, "Dynamic Characteristics of a Heat Storage Water Tank —— Part II", ASHRAE Transactions 1979, Vol.85, Part 1.

Code No.: J-4

ORGANIZATION:

Toyo Netsu Kogyo Kaisha, Ltd.

PROJECT TITLE:

Solar Heating, Cooling and Hot Water Supply System for Large Buildings.

DATA SHEET

Component : Thermal Energy Storage.

Characteristics of the heat storage water tanks used in the system for the experimental building in the compound of Oita University 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 4.5m in length, 2.5m in width and 4.8m 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
Max. input rate is 105 kW on design condition.
Max. output rate is 88 kW on design condition.

f) Insulation
Insulation around these tanks consists of 100 mm rigid urethane foam.

g) Expected life time
Expected life time is about 20 years.

Code No.: J-5

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: JAPAN

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ SYSTEM DEVELOPMENT
NAME OF ORGANIZATION Toyo Netsu Kogyo Kaisha, Ltd.	ADDRESS: 5-12 Kyobashi 2-Chome Chuo-ku Tokyo
NAME OF PRINCIPAL RESEARCHER Yasuo Tanaka	

TITLE OF PROJECT
Solar Heating, Cooling and Hot Water Supply System for Large Building.

OBJECTIVE AND NATURE OF THE PROGRAM:

This program calls for the development of a solar collecting system having the following features:

(1) eliminating the possibility of damage by freezing in the winter season even where no control of the solar heat collecting system is effected
(2) reducing the power cost of the circulation pump of the heat collecting system
(3) minimizing the possibility of the corrosion, caused by dissolved oxygen, of the heat collecting system

The features of experimental appatatus of the solar heat collecting system are as follows:

The closed system is made vacuum to create a condition facilitating the evaporation of the working fluid(water:H_2O). The working fluid stored in the receiver tank is pumped up to the solar heat collectors, where it is heated by solar heat and evaporates. The steam flows into the heat exchanger, gives heat to the hot water ,condensing the steam.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

In fiscal 1977 and fiscal 1978, small sized experimental apparatuses of solar heat collecting system were manufactured and set up, and basic experiments were conducted.

In fiscal 1979 actual-size experimental apparatuses of the solar heat collecting system were manufactured and instituted. Presently data are being collected by conducting experiments and are being analyzed.

PERIOD OF PROJECT:
This project started in July 1974 and will end in March 1980.

FUNDING IN $ U.S.: 84,000
(Estimated total research fund only for this system development)

IMPORTANT REPORTS OR PUBLICATIONS:
Any reports or publications are not open to the public.

Code No.: J-5

ORGANIZATION: Toyo Netsu Kogyo Kaisha, Ltd.

PROJECT TITLE: Solar Heating, Cooling and Hot Water Supply System for Large Buildings.

DATA SHEET

Component : Solar Heat Collecting System with Phase Change of Working Fluid.

The main components of the solar heat collecting system with phase change of working fluid are as follows,

(a) Solar Heat Collector	Size: width 1990mm length 4069mm height 160mm Numbers of Units: 5 units Type of Collector: Double Pane, Black Paint Absorber: Tube on Sheet, Copper
(b) Working Fluid	Water (H_2O)
(c) Collecting Pump	Plunger Type 0.2 kW 0.961 l/hr 20 mAq
(d) Receiver Tank	0.052 m^3
(e) Vacuum Pump	Oilles Vacuum Pump 0.25 kW Oil-sealled Vacuum Pump 0.25 kW
(f) Electric Heater	1 kW 4 units
(g) Heat Storage Tank	0.6 m^3
(h) Radiator	Fan Coil Unit 0.178 kW 34CMM 10,830 kcal/hr 1 unit

Code No.: J-6

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Japan

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION SHOWA ALUMINIUM K.K.	ADDRESS: 480 Inuzuka, Oyama Tochigi 323 JAPAN
NAME OF PRINCIPAL RESEARCHER Yuichiro Asano	

TITLE OF PROJECT Research and development of solar heating, cooling and hot water supply system.(R&D of metallic materials)

OBJECTIVE AND NATURE OF THE PROGRAM:

Research and development of technologies, solar collectors and materials listed below necessary to supply of such solar collectors made of aluminum or other metals and used in the solar 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 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 collectors and collector materials mentioned above.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

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.

PERIOD OF PROJECT:
1980

FUNDING IN $ U.S.:
Current Year (FY 1979) 80,000

IMPORTANT REPORTS OR PUBLICATIONS:

none

ORGANIZATION: SHOWA ALUMINIUM K.K.

PROJECT TITLE:

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

DATA SHEET

Component : Solar Collector

a) type
flat plate, extruded aluminum flame

b) $\alpha\tau$
$F_R\alpha\tau=0.808$

c) overall heat loss coefficient U_L (W/m^{2}K)
$F_R U_1=5.22$

d) heat capacity C (Wh/m^{2}K)
not measured

e) heat transfer medium
water

f) material
i) absorber
copper tube + aluminum fin
selective coating, $\alpha \geqq 0.91$, $\varepsilon \leqq 0.12$

ii) cover plate
1 pane tempered glass, 3mmt, $\tau=0.876$

iii) insulation
50mmt fiber glass

g) expected life time
20 years

h) estimated cost (\$ US/m^2)
130

Code No.: J-7

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Japan

COMPONENTS	TYPE OF RESEARCH
☑ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☑ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______

NAME OF ORGANIZATION
Nippon Sheet Glass Co. Ltd.,

ADDRESS:
8, 4-Chome, Doshomachi,
Higashi-Ku, Osaka, Japan

NAME OF PRINCIPAL RESEARCHER
T. Yamada

TITLE OF PROJECT
R/D of collector of glass base

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of collector component materials of glass base and high performance flat plate collector using above meterials.

a. Reseach on selective transparent glass by high rate sputtering process.
b. Development of the anti-reflective glass by chemical etching process.
c. Reseach on the high weather resistant selectivecoating of glass enamel.
d. Development of the high performance collector, using glass honeycomb etc.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

A large number of collectors with anti-reflective glass are being practically tested in apartment solar model house.

PERIOD OF PROJECT:

1974～1979 FY

FUNDING IN $ U.S.:

Current Year : 49,000 $
in 1979 FY

IMPORTANT REPORTS OR PUBLICATIONS:

none

ORGANIZATION:

Nippon Sheet Glass Co. Ltd.,

PROJECT TITLE:

R/D of collectors of glass base

DATA SHEET

Component :

a. Selective transparent glass
In order to effective optical performance to use for the cover glass of collectors, various coating methods are studied.
The high rate sputtering method is most excellent for the optical performance and productivity of selective transparent glass.
Construction : $\lambda/4$ SiO_2 — Glass — $\lambda/2$ In_2O_3-SnO_2 — $\lambda/4$ SiO_2
Transmittance of solar incident : 0.83 (at 3mm sheet glass)
Reflectance of infra-red light : 0.80 (at 8μm)

b. Anti-reflective glass
It is proved that the anti-reflective glass treated chemically has about 2% reflectance for solar incident, and is very effective for collector efficency.
By using facilities with which 1x2m sheet glass can be tested, the optimum conditions to get high performance and uniformity of A.R film were decided, and the cost-performance of A.R glass was evaluated.

c. Selective coating of glass enamel type
It is proved that black glass enamel film coated with SnO_2 on steel plate has a good selective performance as follows.
Solar absorptance = 0.92 ~ 0.94
Infra-red emittance = 0.22 ~ 0.27
Collector plate using above glass enamel is being designed and evaluated.

d. High performance collector
2 types of high performance flat plate collector were studied.
One is cilindrical glass honeycomb (HG type), the other is A.R glass pipe glazing type (PG type).
Collector efficiency : HG type 0.59 ~ 0.62
PG type 0.53 ~ 0.54
Solar incident : 700 Kcal/m² hr, Collector Temp. : 90 °C
Ambient Temp. : 30 °C
In order to reduce the cost of glass honeycomb, making process of sine wave honeycomb structure with corrugated glass is being studied.

Code No.: J-8

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: JAPAN

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Toray Industries, Inc.	ADDRESS: 2-2 Nihonbashi-Muromachi, Chuo-ku, Tokyo
NAME OF PRINCIPAL RESEARCHER M. Itoga	

TITLE OF PROJECT Development of solar collectors and their components mainly consisting of plastic materials

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective of our program is to develop high-efficiency, long-life and low-cost solar collectors and their components mainly consisting of plastic materials for heating, cooling and hot water supply system.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Collector efficiency of flat plate type constituted by single plastic film cover and selective absorber (paint) is 48 % at the following condition.

Solar incident : 814 W/m^2, Ambient temp. : 30 ^{o}C,

Absorber temp. : 90 ^{o}C

Use of plastic materials can reduce about 40 % of weight of ordinary collector.

PERIOD OF PROJECT:

1974 - 1980

FUNDING IN $ U.S.:

$ 60,000 (in 1979)

IMPORTANT REPORTS OR PUBLICATIONS:

None.

ORGANIZATION: Toray Industries, Inc.

PROJECT TITLE: Development of solar collectors and their components mainly consisting of plastic materials

DATA SHEET

Component : Solar Collectors

a) type : flat plate

b) $\alpha\tau$: 0.81

c) overall heat loss coefficients : $F'U_L = 4.9\ W/m^2K$
(temp. range 30 - 90 ^{o}C)

d) heat capacity : not measured

e) heat transfer medium : water

f) material :

i) absorber, $\alpha = 0.92$, $\varepsilon = 0.20$
ii) cover plate, single plastic film, $\tau = 0.88$
iii) insulation, plastic foam (50 mm)

g) expected life time : about 10 years

h) extimated cost : 100 $US/m^2

Code No.: J-9

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Solar Res. Lab., G. I. R. I. Nagoya	ADDRESS: 1 Hirate-machi, Kita-ku, Nagoya 462
NAME OF PRINCIPAL RESEARCHER S. Tanemura	

TITLE OF PROJECT

Research on Solar Collector Materials

OBJECTIVE AND NATURE OF THE PROGRAM:

Survey and researches on properties of materials for the wide (350K - 1200K) application of solar collectors, and studies on testing procedures as well as evaluation methods for components and materials in solar energy technologies.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Materials Research: The experimental apparatuses which enable us to measure both the normal spectral emittance and reflectance of the specimen at elevated temperatures between (350K - 1000K) in situ alternately, and the directional hemispherical spectral reflectance of the specimen between 0.5 μm 15.0 μm in wave length have been constructed. The device for obtaining the ratio between total solar absorptance and total emittance of the specimen by means of calorimetry has also been designed. The material testing for a solar collector and the studies of the multi-stack of high temperature materials such as HfC, SiC, Al_2O_3, W_2O_5 etc. fabricated by R - F sputtering technique have been carried out.

PERIOD OF PROJECT:

1974 - 1980

FUNDING IN $ U.S.:

350,000$

IMPORTANT REPORTS OR PUBLICATIONS:

1) The spectroscopic properties of SiC at high temperature; ISES 1975 Congress Extended Abstract pp 159 - 160 (1975)
2) On the optical properties and the composition of black copper and black chrome coating; ISES 1978 New Delhi Congress, Extended Abstract Vol. 2 859 - 865 (1978)
3) Solar collector materials and collector testing procedure; J. of Japan Soc. of Prec. Engineering Vol. 44, pp 39 - 46 (1978) (in Japanese)

Code No.: J-10

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Solar Res. Lab., G. I. R. I. Nagoya	ADDRESS: 1 Hirate-machi, Kita-ku, Nagoya 462
NAME OF PRINCIPAL RESEARCHER M. Kosaka	

TITLE OF PROJECT

Materials and system component for thermal energy storage

OBJECTIVE AND NATURE OF THE PROGRAM:

To develop energy storage subsystems for use with solar energy; selection of strage materials (including PCM and CCM) and numerical modelling of the thermal storage devices.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

A numerical model for the sensible heat of a packed bed of alumina spheres was developed. The model has been extended to the model of latent heat storage with macro-encapsulated phase change materials, which were selected by some laboratory testing.

PERIOD OF PROJECT:

1974 - 1980

FUNDING IN $ U.S.:

332,000 $

IMPORTANT REPORTS OR PUBLICATIONS:

"A thermal storage analysis on packed bed of alumina spheres"
T. Asahina and M. Kosaka, Proc. Int. Solar Energy Soc. Conf. (New Delhi) January, 1978, Vol. 1, pp. 573.

Code No.: J-10

ORGANIZATION:

PROJECT TITLE:

DATA SHEET

Component : Heat strage unit.

a) Macro-encapsulated PCM, about 5,000 aluminium capsules (2.0 cm ϕ X 2.0 cm h) were packed in an insulated box (30 X 30 X 50 cm). Waxes, wood's metal, $Mg(NO_3)_2 \cdot 6H_2O$, $NH_4Al(SO_4)_2 \cdot 12H_2O$, etc. are used as PCM.

b) $\sim$ 26 Kwh/m_3 for wax (60 $\sim$ 90°C)

c) $\sim$ 13.5 Kwh/m_3 for wax (60 $\sim$ 90°C)

d) aluminium capsule it self. (air as heat transfer fluid)

e) under testing

f) about 20 cm thichness of glass wool

g) under testing

Code No.: J-11

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: JAPAN

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Ohbayashi-Gumi Research Institute	ADDRESS: 4-640, Shimokiyoto, Kiyose-shi Tokio/JAPAN
NAME OF PRINCIPAL RESEARCHER Dr. Tatsuaki Tanaka	

TITLE OF PROJECT

Foundamental Study of Underground Storage of Heat in Solar Heating and Cooling System

OBJECTIVE AND NATURE OF THE PROGRAM:

The purpose of the present investigation is to solve the more specific problem of determing the optimal demensions of an earth heat storage volume in the shape of a right circular cylinder having vertical axis.

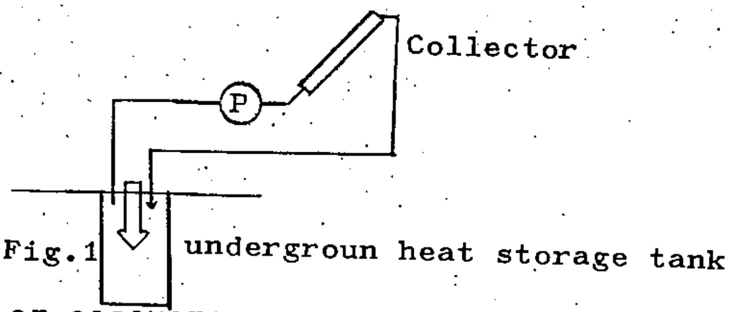


Fig.1

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

An earth heat storage tank (Fig. 1) was installed in the field of Ohbayashi-Gumi Research Institute (Kiyose-shi, Tokio) and thermal storage rates
and heat loss rates
are measured.

PERIOD OF PROJECT:

April 1978- March 1980

FUNDING IN $ U.S.:

about US $ 30,000.-

IMPORTANT REPORTS OR PUBLICATIONS:

Report on cooling and heating system of new residences by Solar Energy (Sun Shine Project 1979) (March 1979)
(in JAPANESE)

IHI

Code No.: J-12

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Japan — Dec. 1979

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ 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 Akira Uchihira	

TITLE OF PROJECT. R & D Solar Rankine Cycle Airccnditioner for solar heating and cooling in a multi-family residence.

OBJECTIVE AND NATURE OF THE PROGRAM:

The primary objective is to develop an energy conservative Solar Rankine Cycle Airconditioner which is economically competitive with a conventional fossil fuel fired or electrically driven airconditioner.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

A 20 tons Rankine cycle airconditioner has been installed in the Goverment experimental demonstration house which is the first solar heated and cooled a multi-family residence in Tokyo, Japan.
Field test and evaluation of it have started.

PERIOD OF PROJECT: 1974 — 1980

FUNDING IN $ U.S.: Current year $69,600 (FY 1979)

IMPORTANT REPORTS OR PUBLICATIONS:

(1) Paper submitted to the interregional simposium on solar energy for development, Feb. 1979, "R & D of Organic Rankine Cycle Engine for solar energy utilization, Series No. C-1-2."

(2) Outline of Solar Rankine Cycle airconditioner, Refrigeration Vol. 54, No. 626.

ORGANIZATION: Ishikawajima-Harima Heavy Industries Co., Ltd.

PROJECT TITLE: R & D of Solar Rankine Cycle Airconditioner for solar heating and cooling in a multi-family residence.

DATA SHEET

Component :

(a) Type: Solar cooling/heating

In summer, the airconditioner is driven by the Rankine cycle engine using the solar energy collected by the collector. In winter, the solar energy collected by the collector heat directly. When the solar energy is short, heating is done by operating the heat pump using water in solar collectors or outside air as a heat source automatically according to the temperature conditions.

(b) Type of refrigerator:

A vapor compression type refrigerator directly coupled to the Rankine cycle engine using Freon 11 (R-11) as a working medium.

(c) Capacity of refrigerator: 20 tons

(d) Temp. range:

Rankine cycle engine input temp.	80 — 105[°C]	(hot water)
Condensing temp.	35 — 45[°C]	
Evaporating temp.	-5 — 8[°C]	

(e) C.O.P:

0.45 for cooling, solar assisted.
4.0 for cooling, motor back up.
3.0 for heating, air source heat pump.
4.0 for heating, solar heat source heat pump.

(f) Heat exchanger for Rankine cycle engine:

(1) 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.

(2) 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 31 m^2 of heat transfer area

(g) Auxiliary heat source: Electricity

Code No.: J-13

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Japan Dec. 1979

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ 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 Dr. Shoichi Tsuji	

TITLE OF PROJECT R & D of solar collector for heating, cooling and hot water supply system in a multi-family residence.

OBJECTIVE AND NATURE OF THE PROGRAM:

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

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

122 sets of flat plate collectors (area 413 m^2) and 60 tubes of evacuated collectors (area 30 m^2) have been installed on the Goverment experimental demonstration house which is the first solar heated and cooled a multi-family residence in Japan. And field test and evaluation of them have started. Non-tracking concentrating collectors composed by evacuated tubes are going to install on the experimental house.

PERIOD OF PROJECT: 1974 — 1980

FUNDING IN $ U.S.: Current year $65,200 (1979 FY)

IMPORTANT REPORTS OR PUBLICATIONS: None

Code No.: J-13

ORGANIZATION: Ishikawajima-Harima Heavy Industries Co., Ltd.

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

DATA SHEET

Component : Solar Collectors

Item \ No.	1	2	3
a) type	flat plate, double glasing	evacuated tubular type	non-tracking concentrating type
b)	0.77	0.83	0.65
c) overall heat loss coefficient U_L [W/m²K]	4.2	3.3	1.8
d) heat capacity (fluid included) [Wh/m²K]	8.6	6.7	3.9
e) heat transfer medium	water		
f) materials 1) absorber	Copper tube in the extruded aluminum fin, selective coating $\alpha = 0.9$, $\varepsilon = 0.1$		
2) cover plate	2-pane, anti reflective coating, $\tau = 0.91$	glass tube, $\tau = 0.90$ 150 mm in the diameter	
3) insulation	100 mm fiber glass	evacuated	
g) expected life time	20 years		

Code No.: J-14

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Japan Dec. 1979

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ 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
Dr. Manabu Kurita

TITLE OF PROJECT R & D of heat storage for solar heating, cooling and hot water supply system in a multi-family residence.

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective is to develop components of the heat storage utilizing latent heat of fusion, for heating, cooling and hot water supply system, which store the heat from the collector and supply it to the Rankine Cycle airconditioner.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Thermophysical properties such as specific heat, heat of fusion and thermal conductivity, were measured, for several candidate materials, e.g. inorganic hydrates, paraffin wax, polyethylene wax.
Heat exchange test with small components of encapsulation and fin-tube were performed and thermal design parameters were obtained.

PERIOD OF PROJECT: from 1974 to 1980

FUNDING IN $ U.S.: Current year $43,500 (FY 1979)

IMPORTANT REPORTS OR PUBLICATIONS: None

Code No.: J-14

ORGANIZATION:

Ishikawajima-Harima Heavy Industries Co., Ltd.

PROJECT TITLE:

R & D of heat storage for solar heating, cooling and hot water supply system in a multi-family residence.

DATA SHEET

Component : Thermal Energy Storage:

(a) Type : Latent heat storage

(b) Storage material: (1) Paraffin wax (2) Polyethylene wax
(3) Potassium alum

(c) Average latent heat (measured)

(1) Paraffin wax : 36 cal/g (60 — 98°C)
(2) P-E wax : 40 cal/g (60 — 88°C)
(3) K-alum : 42 cal/g (90 — 100°C)

(d) Heat Exchanger : Capsule Type

(e) Heat Capacity : 23 KWH/0.16 m^3 (80 — 90°C)
(P.E. Wax)

(f) Heat Rate : Input 3.5 KW
Output 2.3 KW

(g) Insulation : Rockwool 50 m/m

(h) Life time : Under estimation

Code No.: J-15

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Mitsubishi Electric Corporation	ADDRESS: 2-3 Marunouchi 2-chome Chiyoda-ku, Tokyo
NAME OF PRINCIPAL RESEARCHER Junjiro Kai	

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 Rankine-Cycle engine.

The research program consists of two items
1) heat storage materials and their application technology
2) structure of heat storage with high thermal efficiency

Final goal of this program is the development of the heat storage which satisfies required thermal parameters.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

1) Several salt hydrates were examined and ammonium alum was selected as the phase change material. Corrosion tests for several materials to construct heat storage were done.

2) Nucleating system and plate fin tube type heat exchanger were tested.

3) Latent heat storage was developed and operated in two summer seasons in our experimental solar house successfully.

PERIOD OF PROJECT: 1974 - 1979 FUNDING IN $ U.S.: 114,500

IMPORTANT REPORTS OR PUBLICATIONS:

E. Nishiyama, M. Sugihara, J. Kai, K. Kashiwamura, M. Ohtsubo,

"Test Results of the Solar Powered Rankine Cycle Refrigerator Installed in the Experimental House", presented at the ISES Silver Jubilee, Altlanta, Georgia, May 1979

Code No.: J-15

ORGANIZATION: Mitsubishi Electric Corporation

PROJECT TITLE: Solar Heat Storage

DATA SHEET

Component : Heat Storage

a) Type: latent heat storage with storage medium of ammonium alum, 240Kg

b) Heat capacity c: 4.0kWh/m3 (94 - 80°C) (2.4kWh overall*)

c) Latent heat h: 20.4kWh/m3 (94°C) (12.2kWh overall)

d) Heat exchanger: YES, plate fin tube type
heat transfer fluid: water and refrigerant R114

e) Heat rate: input: 9.3kW
output: 11.6kW

f) Insulation: rock wool, 100mm thick

g) Expected life time: under inspection

* outer dimension of the storage: 1040mm-845mm-680mm (high), 0.593m3

total wight: 650Kg

Code No.: J-16

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Japan

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION Mitsubishi Electric Corporation	ADDRESS: 2-3, Marunouchi, 2-chome, Chiyoda-ku, Tokyo, 100 Japan
NAME OF PRINCIPAL RESEARCHER	

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 solar powered Rankine Cycle engine which has following features.

COP	:	0.5 - 0.6
Cooling capacity	:	1 - 5 tons
Boiler temperature	:	90° - 100°C
Condenser temperature	:	35° - 40°C
Chiller temperature	:	5° - 10°C

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

We have developed a Rankine Cycle engine driven Refrigerator which has following performance.

a) capacity of refrigeration : 1 RT

b) expander output : 750 watt

c) expander adiabatic efficiency: 77%

d) COP: 0.47
(boiler temp 90°C, condenser temp 38°C, evaporator temp 5°C)

PERIOD OF PROJECT:

1974 - 1979

FUNDING IN $ U.S.:

19890 (FY 1979)

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: J-16

ORGANIZATION:

Mitsubishi Electric Corporation

PROJECT TITLE:

Development of the air-conditioning unit driven by a solar powered Rankine cycle engine.

DATA SHEET

Component : Air Conditioning and Cooling

a) type: Solar-heating/cooling

b) type of refrigerator

power cycle : Rankine Cycle (WM R114)
refrigeration cycle: Vapor Compression (WM R22)

c) capacity of refrigeration: 1 ton

d) temp range

boiler: 90°C, condenser 38°C,
evaporator 5°C

e) COP: 0.47

f) heat exchanger

boiler : shell and tube type
condenser : shell and tube type
evaporator: double pipe type

g) auxiliary heat source

oil for heating
electricity (motor) for cooling

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. NL-1

COUNTRY: the Netherlands

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [X] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [X] DEMONSTRATION
NAME OF ORGANIZATION Project Office for Energy Research	ADDRESS: Project Office for Energy Research BEOP c/o ECN P.O. Box 1 1755 ZG PETTEN (N.-H)
NAME OF PRINCIPAL RESEARCHER K. Joon	

TITLE OF PROJECT National Programme on Solar Energy Research

OBJECTIVE AND NATURE OF THE PROJECT:

The total programme has as general objectives:

- justifiable introduction
- expansion of application
- sound industry/market
- low cost

It has been agreed to carry out a first phase with objectives:

- demonstrate solar boiler
- recommandations for decision making
- prepare demonstration space heating
- explore seasonal storage and cooling
- study social consequences

PRESENT STATUS AS PER 010480 OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

At present 60 projects are either under way or have been completed. The number of projects will probably increase at short term. A summing up of the current projects is given in additional sheets together with information about the participating research organisations or industries. A description of the funding is given below:

Part A SOLAR BOILER PROGRAMME

Activity	Nr. of projects	Funding
R and D	6	$ 0,25 m
field experiments	5	- 0,35 m
demonstrations	25	- 1,42 m
theoretical studies	4	- 0,26 m
social-economic	10	- 0,20 m.

Part B SPACE HEATING PROGRAMME

Activity	Nr. of projects	Funding
R and D	up to 20	$ 1,02 m
theoretical studies	5	- 0,65 m
field experiments	up to 20	- 2,50 m
social-economic	10	- 0,73 m
passive	5	- 0,30 m.

Part C SEASONAL STORAGE AND COOLING

Activity	Nr. of projects	Funding
research	2	$ 0,31 m
development	1	- 0,12 m
field experiments	3	- 0,40 m
cooling studies	1	- 0,12 m.

Part C PROJECTS OF GENERAL INTEREST

Activity	Funding
climatological model	$ 0,21 m
Pilot Test Facility	- 0,38 m
corrosion	- 0,20 m.

The total funding for phase 1 which covers a four year period (1978-1981) is $ 15 million, of which $ 10 million is government funding and $ 5 million private funding.

FUNDING 1st PHASE

solar boiler	$ 2,5 m
space heating	- 5,2 m
seasonal storage	- 0,8 m
cooling	- 0,1 m
general	- 0,6 m
unforseen	- 0,8 m.

PERIOD OF PROJECT: phase 1 1979-1982

IMPORTANT REPORTS OR PUBLICATIONS: cf. page 14-15

NATIONAL PROGRAMME ON SOLAR ENERGY RESEARCH Pace 2

Part A solar boiler

NL-1-1 : The development of an aircollector solar boiler system
organisation : Bouwcentrum
status : running + demo proposed
type : component + system development

NL-1-3 : Computer model for solar boilers
organisation : TPD
status : verification of model
type : modelling + system analysis

NL-1-8 : Solar boiler demo at Veldhoven
organisation : Philips
status : running
type : demonstration + performance monitoring

NL-1-10a : Solar heating swimmingpool Noordwijk
organisation : Sportfondsen Nederland N.V.
status : completed
type : demo + performance monitoring

NL-1-10b : Solar heating swimmingpool Alphen/Rijn
organisation : Openbare Werken
status : under construction
type : demo + performance monitoring

NL-1-10c : Solar heating swimmingpool Nieuwegein
organisation : Sportfondsen Nederland N.V.
status : proposal
type : demo + monitoring

NL-1-11 : Solar boilers in 84 dwellings in Amsterdam (Gaasperdam)
organisation : Gemeente Woningdienst - Amsterdam
status : running
type : demo + evaluation

NL-1-12b : Solar boilers in 2 appartment buildings in Amsterdam (Indische buurt)
organisation : Gemeente Woningbedrijf - Amsterdam
status : running
type : demo + performance monitoring

NL-1-14a : Hot water in service centre for old age people
organisation : Michaels Hoeve Brunssum
status : proposal
type : demo + performance monitoring

NL-1-15 : Industrial applications of solar boilers
organisation : ENKA-AKZO
status : proposal
type : demo + evaluation

NL-1-16 : Application of solar boilers in agriculture: hot water for food preparation of fatting-calfs
organisation : IMAG
status : running
type : demo + evaluation

NL-1-18 : Instruction for design and installation of solar boiler systems
organsiation : Bouwcentrum + TVVL
status : running
type : info

NL-1-21 : Market allocation study
organisation : ESC-ECN
status : runnning
type : systems analysis/scenario study

Part B space heating

NL-1-23 : Development of spectral selective layers
organisation : Rijksuniversiteit Groningen
status : running
type : materials research

NL-1-24 : Development of heat pipe collectors
organisation : Rijksuniversiteit Groningen
status : running
type : component development

NL-1-25 : Development of flat plate aircollector
organisation : Ubbink Plastics
status : proposal
type : component development

NL-1-26 : Development of high performance spectral selective flat plate vacuum collector
organisation : TPD
status : finished 1st phase, running 2nd phase
type : component development

NL-1-27 : Collector testing
organisation : TPD
status : starting
type : component testing

NL-1-28 : Development of durable absorber plate with spectral selective layer
organisation : TPD/Calcol
status : completed
type : component development

NL-1-29 : Parametric study of heat storage systems for solar space heating
organisation : TPD
status : ready
type : study, system analysis

NL-1-30 : Development and demonstration of a concrete heat storage system combined with aircollector

organisation	: Bouwcentrum
status	: running, design made for 10 dwellings in Cappelle/IJssel
type	: component development + demonstration

NL-1-32 : Computer model for performance analysis

organisation	: TPD
status	: verification of model
type	: modelling + systems analysis

NL-1-33 : Application of solar space heating in utility buildings

organisation	: TPD
status	: proposal
type	: desk study

NL-1-34 : Computer model for solar space heat system

organisation	: Technical University Eindhoven (THE)
status	: running
type	: systems analysis

NL-1-36 : Development of industrial processes for making spectral selective layers based on cobalt oxide

organisation	: Metaal Instituut TNO
status	: proposal
type	: fabrication techniques

NL-1-39 : Demonstration of solar dwellings in Zoetermeer

organisation	: Bredero/TPD/Bouwcentrum
status	: to be concluded
type	: demo + performance monitoring

NL-1-40 : Performance monitoring in 32 dwellings in Veldhoven

organisation	: Philips
status	: running
type	: demo + performance monitoring

NL-1-41 : Demo of concrete collector/storage system in 17 dwellings at Haarlem
organisation : Bouwcentrum
status : running
type : demo + component development + perf.monitoring

NL-1-42 : Combined solar heating/heat pump system in dwelling in Slijk Ewijk
organisation : Technical University Delft
status : completed
type : demo + model verification

NL-1-43 : Solar energy + heat recovery systems in 4 appartment buildings in Amsterdam
organisation : WILMA
status : running
type : demo + performance monitoring

NL-1-44a : Concrete aircollector/storage system in solar home at Zundert
organisation : Bouwcentrum
status : running
type : testing + performance monitoring

NL-1-46b : Solar driven airheating system in combination with heatpump and storage system at Staphorst
organisation : Brink Luchtverwarming
status : running
type : demo + perfomance monitoring

NL-1-45 : Solar installation in food and commodity inspection building
organisation : municipality of Enschede
status : completed
type : demo + performance monitoring

NL-1-47	: Application of solar energy in utility buildings
a	organisation : TPD/Scheldebouw
b	Bouwcentrum/DHV
	status : proposal
	type : demo

NL-1-47c	: Application of solar energy in an office building
	organisation : Bakker en Boots - Schagen
	status : running
	type : demo + monitoring

NL-1-49	: Solar energy powered biogas production from dung
	organisation : IMAG
	status : running
	type : demo + performance monitoring

NL-1-50a	: Solar assisted drying of flower bulbs and tubers
	organisation : IMAG
	status : proposal
	type : demo + evaluation

NL-1-50b	: Solar powered drying of wet dung
	organisation : IMAG
	status : proposal
	type : demo + evaluation

NL-1-55/56	: Introduction secnario's for solar heating
	organisation : ESC-ECN
	status : to be started
	type : systems analysis + scenario's

NL-1-57	: Instructions for design and application of passive use of solar energy
	organisation : Bouwcentrum + Techn. Universitity Eindhoven
	status : running
	type : desk-study

NL-1-58a	: Construction of 10 passive solar houses at Capelle a.d. IJssel		
	organisation	:	Bouwcentrum
	status	:	construction phase
	type	:	demo + performance monitoring
NL-1-58b	: Design and construction of houses with combined passive use of solar energy and other conservation techniques at Gouda		
	organisation	:	Techn. University Eindhoven
	status	:	proposal
	type	:	design + demo + performance monitoring

Part C Seasonal storage of energy

NL-1-59 : Energy storage in hygroscopic materials
organisation : TPD
status : running
type : materials research + component + development

NL-1-60 : Energy storage in soil
organisation : Laboratorium van Grondmechanica
TPD
Philips
status : running
proposal for test site
type : experiment + demo + performance monitoring

NL-1-62 : Integration of heat storage and solar heating system
organisation : TPD
status : proposal
type : desk study

Part D	General Projects
NL-1-65	: Climatology of solar irradiation on inclined planes organisation : KNMI/TPD status : phase 1 concluded phase 2 running type : data collection + model development
NL-1-66	: Pilot Test Facility for component testing and model verification/comparison status : running (under EEC contract) type : component testing
NL-1-67	: Audiovisual presentation organisation : TPD status : running type : information
NL-1-68	: Participation in IEA solar energy program cf. IEA
NL-1-69	: Inventory of corrosion problems organisation : Metaalinstituut TNO status : proposal type : desk study
NL-1-70	: Photo (electro-)chemical production of hydrogen and reduction of carbondioxide organisation : Organisch Chemisch Instituut TNO status : running type : basic research

LIST OF PARTICIPATING ORGANISATIONS

Bouwcentrum
Weena 700
Postbus 299
3000 AG ROTTERDAM

Brink Luchtverwarming B.V.
Industrieterrein 5
Postbus 24
7950 AA STAPHORST

Calcol B.V.
Westerlaan 1
Postbus 567
3016 CK ROTTERDAM

ENKA-AKZO
Velperweg 76
Postbus 60
6800 AB ARNHEM

Ing. Bureau Dwars, Heederik en Verhey (DHV)
Laan 1914 35
Postbus 85
3800 AB AMERSFOORT

Energie Studie Centrum - Energieonderzoek Centrum Nederland (ESC-ECN)
Westerduinweg 3
Postbus 1
1755 ZG PETTEN (N.-H)

Sportfondsen Nederland N.V.
Postbus 10510
1001 EM AMSTERDAM

Gemeente Woningbedrijf Amsterdam
Wibautstraat 83
1091 GH AMSTERDAM

Instituut voor Mechanisatie, Arbeid en Gebouwen (IMAG)
Mansholtlaan 10
6708 PA WAGENINGEN

Laboratorium voor Grondmechanica
Postbus 69 AB DELFT
Stieltjesweg 2

Metaalinstituut
Laan van Westenenk 501
7500 AJ APELDOORN

Stichting St. Michaelshoeve
Zutphensestraat
BRUMMEN

Gemeente Enschede
Langestraat 24
7511 HC ENSCHEDE

Koninklijk Nederlands Meteorologisch Instituut (KNMI)
Wilhelminalaan 10
Postbus 201
3730 AE DE BILT

Organisch Chemisch Laboratorium TNO
Croesestraat 79
Postbus 5009
3502 JA UTRECHT

N.V. Philips Gloeilampen fabrieken
5600 MD EINDHOVEN

Rijks Universiteit Groningen
Nijenborgh 18
Universiteitscomplex Paddepoel
9747 AG GRONINGEN

Technisch Physische Dienst TPD/TNO/TH
Stieltjesweg 1
Postbus 155
2600 AD DELFT

Ubbink Nederland B.V.
Verheuellweg 9
6984 AA DOESBURG

Technische Hogeschool Eindhoven (THE)
Den Dolech 2
5612 AZ EINDHOVEN

Technische Hogeschool Delft (THD)
Lorentzweg 1
2628 CJ DELFT -

Verenigde Bedrijven WILMA
Kasteelsingel 10
6001 EZ WEERT

Installatie Techniek Bredero B.V.
Postbus 2419
3500 GK UTRECHT

Kon. Mij. de Schelde B.V.
Glacisstr. 165
4381 SE VLISSINGEN

Openbare Werken
Postbus 99
ALPHEN a/d RIJN

PUBLICATIONS

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3. M. Sikkens; Radiation Heat Losses in Solar Collectors with Plastic Covers, Applied Energy, vol. 4, no. 2 (1978).

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5. M. v.d. Leij, M. Sikkens; Eigenschappen van spectraal-selective materialen, Nederlands Tijdschrift voor Natuurkunde A 44 (1) p. 19-27, (1978).

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IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. NL-2

COUNTRY: THE NETHERLANDS

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION Laboratory for refrigerating engineering DELFT UNIVERSITY OF TECHNOLOGY	ADDRESS: Mekelweg 2 Delft tel. 015-786912 or 786667
NAME OF PRINCIPAL RESEARCHER dr.ir. J. van der Kooi	

TITLE OF PROJECT APPLICATION OF SOLAR ENERGY FOR CLIMATE CONTROL, IF NECESSARY COMBINED WITH HEAT PUMP AND/OR HEAT RECOVERY SYSTEM.

OBJECTIVE AND NATURE OF THE PROJECT:

The aim of the project is an investigation of energy conservation by means of solar energy/heat pump systems. Both computational and measurement techniques are applied. A standard dwelling has been equipped with a unit. Comparisons are made of freon and water filled collectors. The application of a solar powered absorption unit is investigated.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1974-1981

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. NL-3

COUNTRY: THE NETHERLANDS

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION Laboratory of Refregerating Engineering DELFT UNIVERSITY OF TECHNOLOGY	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 PROJECT:

Objectives (aims)

Aim of the total project is an investigation of the possibilities of cooling at - 25 °C by a solar driven absorption unit. Application of a multistage absorption refrigeration machine has the advantage that it can reach the proposed low evaporator temperature by using the low level heat of standard flat plate collectors. The possibilities (system performances) for refrigeration of multistage systems coupled to standard collectors for use in EEC countries, especially in The Netherlands, will be investigated by means of a computer simulation.

The work under contract is part of a project and will exist of forming a simulation model of absorption cycles in which weather data and collector properties can be implicated.

Work programme

1. Theoretical and experimental work on subprocesses in absorption refrigeration machines. In particular the heat- and mass transfer problems related to the absorption and generation processes will be investigated.
2. The forming of a methematical model of absorption refrigeration cycles in which data on collectors and the weather all over the year can be implicated. With this model it will be possible:
   - to compare different cycles,
   - to examine the influence of various modifications,
   - to eximine the influence of process variables
3. Excercising with the mathematical model in which the results of the theoretical and experimental work will be involved. System performances will be judged and economic possibilities will be assessed of the various systems.

STATUS

At the moment the basis of the computer model is being made. Fundamental equations of the NH_3-H_2O mixture are available. All thermodynamic properties can be derived form the equations. A testing for experiments on the absorption process itself will be finished by September.

PERIOD OF PROJECT: 1.1.78 - 30.6.79

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. NL-4

COUNTRY: THE NETHERLANDS

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Heat Transfer Group, Applied Physics DELFT UNIVERSITY OF TECHNOLOGY	ADDRESS: Lorentzweg 1 P.O. Box 5046 2600 GA DELFT tel. 015-786037
NAME OF PRINCIPAL RESEARCHER Ir. A.G. de Jong	

TITLE OF PROJECT HEAT STORAGE IN PHASE CHANGE MATERIALS

OBJECTIVE AND NATURE OF THE PROJECT:

The objective is to improve storage of solar heat.
The heat transfer and the heat capacity of solid/liquid c.q. cristallising systems are investigated both theoretically and experimentally. Special attention is given to ~~the~~ solidifying behaviour and the improvement of heat transfer in solidifying layers.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1978-1981

IMPORTANT REPORTS OR PUBLICATIONS:

COUNTRY: THE NETHERLANDS

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION EINDHOVEN UNIVERSITY OF TECHNOLOGY LAB. HEAT TECHNOLOGY	ADDRESS: P.O. Box 513 EINDHOVEN tel. 040-472115
NAME OF PRINCIPAL RESEARCHER Prof.ir. C.W.J. van Koppen, ir. L.S.Fischer	

TITLE OF PROJECT SEASONAL STORAGE OF SOLAR HEAT IN THE GROUND

OBJECTIVE AND NATURE OF THE PROJECT:

Objective

The development of economically viable and practicable methods for the seasonal storage of solar heat in the ground.

Aspects to be studied

- Fundamenytal: Heat tranfer 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 unlaoding of the sorage.
- Economical : Cost optimization between heat demand, collector area and storage capacity.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1984

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. NL-6

COUNTRY: THE NETHERLANDS

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ________

NAME OF ORGANIZATION Heat Transfer Group, Applied Physics DELFT UNIVERSITY OF TECHNOLOGY	ADDRESS: Lorentzweg 1 P.O. Box 5046 2600 GA DELFT tel. 015-783222
NAME OF PRINCIPAL RESEARCHER ir. S. Linthorst	

TITLE OF PROJECT Suppression of natural convection in thermal solar collectors

OBJECTIVE AND NATURE OF THE PROJECT:

The objective is to decrease the convection losses in solar collectors by application of honeycomb structures. Heat flow and heat transfer will be investigated. theoretically and experimentally. Wanted are those geometries that combine low convection with good radiation properties.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 19771983

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. NL-7

COUNTRY: THE NETHERLANDS

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION Technical Physics Laboratory UNIVERSITY OF GRONINGEN	ADDRESS: Zernikelaan Nijenborgh 18 9747 AG GRONINGEN tel. 050-115950
NAME OF PRINCIPAL RESEARCHER Prof.ir. J.C. Franken	

TITLE OF PROJECT HEAT PIPE COLLECTOR FOR LOW TEMPERATURES AND INVESTIGATION OF THE PHYSICAL PROPERTIES OF SPECTRAL SELECTIVE LAYERS

OBJECTIVE AND NATURE OF THE PROJECT:

a) investigation of optical properties, especially absorption and emission of nickel carbides on nickel prepared by reactive
b) investigation of the metioned parameters as function of temperature (up to 200°C) and of stability during overheating (up to 400°)
c) preparation of suitable layers on nickel foil that can be fixed on several types of collectors.
d) extension of points a thru c on nitrides of nickel and eventually other transition metals
e) investigation of the properties of a planar collector base on the heat pipe principle for low temperatures (up to 100°C)
f) investigation of high performance collector of a specially developed heat pipe equiped with vacuum shroud tube and internal concentrating mirror.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1977-1983

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. NL -8

COUNTRY: THE NETHERLANDS

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [ ] ____________

NAME OF ORGANIZATION
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 PROJECT:

The aim of the project is the improvement of the radiation efficiency of the absorber plate of a solar collector. A study is made of spectral selective surfaces such as cobalt oxide on nickel and tin oxide on black enamel. Extensive optical measurements in the visible and infrared region serve for physical characterization of the selective layers.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1974-1984

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWED-1

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______________
NAME OF ORGANIZATION STUDSVIK ENERGITEKNIK AB	ADDRESS: STUDSVIK ENERGITEKNIK AB S-611 82 NYKÖPING Sweden
NAME OF PRINCIPAL RESEARCHER R Roseen, H Zinko, B Perers	

TITLE OF PROJECT Research and development on semi concentrating collectors for applications in existing buildings.

OBJECTIVE AND NATURE OF THE PROGRAM:

The aim of the project is to develop a solar collector of low weight. The collector is of the concentrating type with CPC reflector. Concentration factor 2 for fixed application and concentration 4 for one dimensional tracking. The structural element is foamed plastic.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The first prototypes are tested, and the collector is expected to be introduced on the market within a couple of years. The manufacturer is AB Bofors Plast, Trelleborg.

PERIOD OF PROJECT:

1977-07-01--1979-02-14

FUNDING IN $ U.S.: 94 000 $

IMPORTANT REPORTS OR PUBLICATIONS: STU Report 77-3929 (in Swedish)

Code No.: SWED-1

ORGANIZATION: STUDSVIK ENERGITEKNIK AB

PROJECT TITLE: Research and development on simiconcentrating collectors for applications in existing buildings.

DATA SHEET

Component :

Type: Concentrating, CPC reflector

$F'\alpha\tau \approx 0,7$ Concentration factor 2
$F'U_L \approx 3$ [W/m^2K]

$F'\alpha\tau \approx 0,65$ Concentration factor 4
$F'U_L \approx 2,5$

Heat capacity ≈ 5000 [J/Km^2]

Heat transfer medium: Water

Material absorber: Copper
cover plate: Acrylic or glass
insulation: Polyurethane foam

Code No.: SWED-2

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Sweden

COMPONENTS

- [X] SOLAR COLLECTOR
- [ ] THERMAL ENERGY STORAGE
- [ ] AIR CONDITIONING UNIT
- [ ] OTHER SUBSTANTIAL COMPONENTS

TYPE OF RESEARCH

- [ ] MATERIALS RESEARCH
- [X] COMPONENT DEVELOPMENT
- [X] SYSTEM DEVELOPMENT

NAME OF ORGANIZATION

NAME OF PRINCIPAL RESEARCHER
Gösta Jansson

ADDRESS:
FLÄKT EVAPORATOR AB
S-551 84 JÖNKÖPING
SWEDEN

TITLE OF PROJECT SUNTERM

OBJECTIVE AND NATURE OF THE PROGRAM:

SUNTERM is a complete system for domestic hot water heating by means of solar energy. The absorber panel of the collector is made entirely of copper. The upper surface is treated to provide selective characteristics.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

SUNTERM is commercially introduced in several countries, for instance Sweden, Denmark, France and Belgium.

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

ORGANIZATION: FLÄKT EVAPORATOR AB

PROJECT TITLE: SUNTERM

DATA SHEET

Component : Solar Collectors

a) flate plate

e) water with an anti-freeze agent

f) i) Copper. The tube is soldered to the plate for metallic contact.

ii) One pane of glass fibre reinforced polyester.

iii) 50 mm mineral wool.

h) 150 US$/$m^2$

Heat Storage

a-c) The storage tank is made of steel and is lined with copper.

d) Yes. A flanged tubular coil of copper.

e) The volume is 300 l.

f) 30 mm urethane foam.

Code No.: SWED-3

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION STUDSVIK ENERGITEKNIK AB	ADDRESS: S-611 82 NYKÖPING Sweden
NAME OF PRINCIPAL RESEARCHER Henry Hedman	

TITLE OF PROJECT SALT HYDRATE STORAGE FOR STORING HEAT IN AIR-BASED SOLAR ENERGY HEATING SYSTEMS

OBJECTIVE AND NATURE OF THE PROGRAM:

Short-term storage is accomplished by using the latent fusion heat of some salt hydrates for applications in air-based solar space heating systems. This type of storage is interesting in comparison with more conventional technique using sensible heat, e.g. rock bins, mainly because of less volume requirements and reduced heat storage costs. Furthermore, the storage and use of energy at low and constant temp-ratures will have a positive effect on the efficiency of the solar collectors and consequently also on the total economy of the system.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Capsules suitable for salt hydrates were studied as well as the storage material. Thermal measurements and tests have been carried out with an air-heated model storage. On this basis a small prototype storage of about 300 l is being constructed which will be tested first in the laboratory in respect of certain performance parameters, e.g. the movement of the melting/ solidification-zone at charging/ discharging of the storage, supercooling effects, and heat transfer capacity. Field testing will follow under varying service conditions which are simulating the heating characteristics of a solar heated house.

PERIOD OF PROJECT:

1978-07-01 -- 1980-06-30

FUNDING IN $ U.S.:

65.000

IMPORTANT REPORTS OR PUBLICATIONS:

Final report of previous work connected to present project:

STUDSVIK/E3-79/12 (in Swedish)
Performance study of three different types of storage (theoretical study and practical comparison of existing experimental houses in Sweden): STUDSVIK/E3-79/6 (in Swedish).
The latter work will be published in the English edition of "Energy Newsletter" by The Swedish National Board for Technical Development.

ORGANIZATION: STUDSVIK ENERGITEKNIK AB, SWEDEN

PROJECT TITLE: SALT HYDRATE STORAGE FOR STORING HEAT IN AIR-BASED SOLAR ENERGY HEATING SYSTEMS.

DATA SHEET

Component : a) Latent heat storage using the phase change (fusion heat) of calcium chloride hexa hydrate (stabilized type). Storage constructed as a wooden box with the following outside dimensions: 700 × 700 × 1200 mm. Storage volume: abt. 400 l. Storage medium encapsulated in corrosion protected metal cans (≈ 300 l or ≈ 450 kg salt is used).

b) Heat capacity: 16.5 kWh/m^3 over a temperature range of 20°-40°C.

c) Latent heat of fusion: approx. 70 kWh/m^3

d) Heat exchanger: No (cans containing the storage medium act as heat exchangers themselves).

e) Heat rate: 4 kW

f) Insulation: 10 cm styrofoam.

g) Expected life time: Depends on cycling stability of salt charge. Minimum: the project period, but calculated life time of 8-20 years.

Code No.: SWED-4

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Dept. of Phys.Chem., Royal Inst. of Techn.	ADDRESS: FACK S-1-0 44 STOCKHOLM 40 Sweden
NAME OF PRINCIPAL RESEARCHER Bo Carlsson, Hans Stymne, Gunnar Wettermark	

TITLE OF PROJECT "SOLAR ENERGY AND BUILDINGS"

OBJECTIVE AND NATURE OF THE PROGRAM:

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.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

- The main candidate $CaCl_2 \cdot 6H_2O$ has been investigated in detail (see the attached sheet).

PERIOD OF PROJECT:

1974 and on-going

FUNDING IN $ U.S.:

$US: 283,300 1974-1979
77,800 1979/80 F.Y.

IMPORTANT REPORTS OR PUBLICATIONS:

- Reports: - Storage of low temperature heat in salt hydrate melts - Calcium chloride hexahydrate
  (Swedish Council for Building Research, Document D12: 1978)
  - An incongruent heat-of-fusion system - $CaCl_2 \cdot 6H_2O$ - made congruent through modification of the chemical composition of the system.
  Solar Energy 23, 343/350 (1979).

Code No.: SWED-5

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Dept.of Phys. Chem.,Royal Inst. of Technology	ADDRESS: Fack 100 44 STOCKHOLM 70 Sweden
NAME OF PRINCIPAL RESEARCHER Bo CARLSSON,WIKTOR RALDOW,Hans STYMNE, Gunnar WETTERMARK	

TITLE OF PROJECT "THERMOCHEMICAL STORAGE OF ENERGY"

OBJECTIVE AND NATURE OF THE PROGRAM:

- Assesment of chemical reactions and chemical processes for heat-storage and energy conversion
- Experimental investigation of selected systems for use as seasonal heat-storage materials
- Construction of prototype units

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Absorption of water vapour or ammonia by various salts and adsorbents are now being studied experimentally.

PERIOD OF PROJECT:
1976 and ongoing

FUNDING IN $ U.S.:
$US 200,800,1976-1979,
138,700, 1979/80 F.Y.

IMPORTANT REPORTS OR PUBLICATIONS: B. Carlsson and G. Wettermark: The photochemical heat pipe, Solar Energy 21, 87/92 (1978).
G. Wettermark, B. Carlsson, H. Stymne: Storage of Heat - A Survey of Efforts and Possibilities (Swedish Council for Building Research, Document D2:1979).
W.M. Raldow and W.E. Wentworth: Chemical Heat Pumps - a Basic Thermodynamic Analysis, Solar Energy 23, 75/79 (1979).

Code No.: SWED-6

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Studsvik Energiteknik AB	ADDRESS:
NAME OF PRINCIPAL RESEARCHER Allan Johansson	S-611 82 NYKÖPING Sweden

TITLE OF PROJECT

Plastic convectors

OBJECTIVE AND NATURE OF THE PROGRAM:

No further work has been done since last report.
Components are in use in several buildings.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWED- 7

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONOITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ __________
NAME OF ORGANIZATION STUDSVIK ENERGITEKNIK AB NAME OF PRINCIPAL RESEARCHER Rutger Roseen	ADDRESS: STUDSVIK ENERGITEKNIK AB S-611 82 NYKÖPING Sweden

TITLE OF PROJECT Central solar heat station. Demonstration plant in Studsvik.

OBJECTIVE AND NATURE OF THE PROGRAM:

The objective is to design, construct and test a system for seasonal storage of solar energy. The principle is based on an excavated pit for hot water storage, with the solar collectors placed on the floating lid. The lid rotates and subsequently the solar collectors track the sun. The plant is designed to supply a 500 m^2 low temperature heated office building. The total heat demand will be supplied by solar energy.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The system has been in operation since February 1979.

PERIOD OF PROJECT: 1978 - 1980 FUNDING IN $ U.S.: 300 000 $

IMPORTANT REPORTS OR PUBLICATIONS:

ORGANIZATION: STUDSVIK ENERGITEKNIK AB

PROJECT TITLE: Central solar heat station.
Demonstration plant in Studsvik.

DATA SHEET

Component :

Solar collectors

a Concentrating CPC profile concentrating factor 4

b $\alpha\tau$ = 0,65

c U_L = 2,5 W/m^{2}K

d Heat capacity 5000 J/m^{2}K

e Water

f i cupper
ii single glass
iii 5 cm polyurethane

g 5 years

h 100 $/m^2

Heat storage

a Water in an insulated pit

b Heat capacity 46600 $\frac{Wh}{m^3}$ 25-65°C

d Water/air in the building

f 40 cm mineral wool/40 cm polyurethane foam

g 20 years

Code No.: SWED-8

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION AB ÖSTGÖTA-BYGGEN	ADDRESS: Box 9001 580 09 LINKÖPING Sweden
NAME OF PRINCIPAL RESEARCHER Jan Svensson	

TITLE OF PROJECT
The Lambohov project - solar energy houses in Linköping.

OBJECTIVE AND NATURE OF THE PROGRAM:

Solar energy will be used for the whole production of heat and hot water for 55 terrace houses. For seasonal storage of solar energy a heat store of 10 000 m^3 water is used. The store is in the form of a cylindrical excavation in the ground.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The plant should be completed i January 1980.

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Report R117:1979, Swedish Council for Building Research, Stockholm.

ORGANIZATION: AB ÖSTGÖTA-BYGGEN

PROJECT TITLE: The Lambohov project - solar houses in Linköping.

DATA SHEET

Component : Solar Collectors

a) flate plate collector, 0.9 x 6 m

c) 3.5 - 5.5 W /m^2K (0-100 °C)

e) water

f) i) $\alpha = 0.95$, $\varepsilon = 0.15$

ii) single glass

iii) 5 cm mineral wool

g) 15 years

h) 260 US$/$m^2$

Heat Storage

a) Water in a cylindrical pit (Ø 32 m, 12 deep)

b) 20 - 70 °C

f) 0.7 - 1.5 m LECA concrete

g) 20 years

Code No.: SWED-9

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

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

NAME OF ORGANIZATION
Community of Växjö

NAME OF PRINCIPAL RESEARCHER
Rejlers Ingenjörsbyrå AB

ADDRESS:
V.Esplanaden 18, 352 32 VÄXJÖ

P O Box 3104, 350 03 VÄXJÖ

TITLE OF PROJECT
The Ingelstad project - solar heat plant

OBJECTIVE AND NATURE OF THE PROGRAM:

This solar heating plant is connected to a residential area, consisting of 52 single-family houses. 50% of the energy needed for space heating and domestic hot water is covered by 1.320 m^2 parabolic solar collectors and supplementary heating is coming from an oil-fired boiler. For seasonal storage of solar energy is used a heat store with a volume of abt. 5.000 m^3. This store has been designed as an above-ground circular concrete tank.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The parabolic solar collectors has been used from May - October 1979 with temporary breaks for adjustment. The energy collected is abt. 200 MWh. The rise of temperature in store amounts to abt. 35°C from abt. 5 to 40°C.

In order to enable studying the heat store already during winter season 79/80 at full temperature, i.e. 95°C, a rise of temperature by feeding energy into the store from the oil-heated boiler is now being made.

PERIOD OF PROJECT:
Building phase Nov 1978 - Aug 1979
Evaluation program July 1979 - Sept 1981

FUNDING IN $ U.S.:
$ 1.915.000

IMPORTANT REPORTS OR PUBLICATIONS:

D14:1979 The Ingelstad project, design and construction stage
ISBN 91-540-3119-2
Swedish Council for Building Research, Stockholm/Sweden.

ORGANIZATION: *Community of Växjö*

PROJECT TITLE: *The Ingelstad project - solar heat plant*

DATA SHEET

Component :

Solar collectors:

a) *Parabolic glass reflecting collectors*

e) *Water + 25% (by weight) propylene glycol*

f) *Copper tube collector with selective coating enclosed within a glass tube*

h) 470 US$/m^2

Heat storage

a) *Cylindrical concrete tank for water*

b) *95 - 40^{o}C*

d) *Heat exchanger water/water*

f) *1,0 m mineral wool*

Code No.: SWIT-1

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Hans G. Sulzer	ADDRESS: Lohnstrasse 1 8200 Schaffhausen Switzerland
NAME OF PRINCIPAL RESEARCHER Heinz H. Sulzer, Ing.	

TITLE OF PROJECT Earth Heat Pump

OBJECTIVE AND NATURE OF THE PROGRAM:

Field test program of earth heat storage for use with heat pump driven by a Ford 1,6 l, Industrial Otto Combustion Engine

Loading during summer time, Temp. Range + 18.... – 5 °C

Heat Transfer Fluid: Aetylen Glycol Mixture: ESKASOL, Scheller Comp.Zuric

Insulation: none

Expected life time: 70 years

Storage size: 2'500 m^3 of soil, 12'000 m of earth coil

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Plant will go into operation in January 1980

PERIOD OF PROJECT:

3 years

FUNDING IN $ U.S.:

10'000.--

IMPORTANT REPORTS OR PUBLICATIONS:

to be made

Code No.: SWIT-2

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION SYNCHROPLAN AG Bremgarten	ADDRESS: Synchroplan AG Haldenstrasse 10 8967 Widen
NAME OF PRINCIPAL RESEARCHER B.G.Kunz Ing HTL	

TITLE OF PROJECT LowTemperature Solar System

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a solar system with low temperature storage and a heatpump.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The first installation is complete

PERIOD OF PROJECT: 1977-1981

FUNDING IN $ U.S.: 50.000 $

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-3

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION B. MATHEY / GEOLOGUE CONSEIL NAME OF PRINCIPAL RESEARCHER Bernard MATHEY	ADDRESS: CH- 2205 MONTEZILLON SWITZERLAND

TITLE OF PROJECT Interseasonal Heat Accumulator in the Ground for Solar Energy for family houses

OBJECTIVE AND NATURE OF THE PROGRAM:

Study of different geometries of accumulators for optimisation of costs, efficiency, and technical problems. Simulation of such accumulators with finite elementsmodels.

A practical realisation must be made during the spring of 1980

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The numerical study carried out has shown that it is possible to construct a ground heat accumulator coupled with solar installation, and to only partially insulate it. For a volume of 5000 m^3, (10 family houses), it possible to avoid the use of an heat pump.

PERIOD OF PROJECT: FUNDING IN \$ U.S.: 15'000

The governemental supported part of the project is no finished. The experimental part of the project must be paid by the owners of the houses !

IMPORTANT REPORTS OR PUBLICATIONS:

Mathey B., 1979: Interseasonal Heat Accumulators in the Ground for Solar Energy Results of Numerical Simulations. Nordic Symposium on Earth Heat Pump Systems.

Code No.: SWIT-

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION Star Unity AG	ADDRESS: Abt.Sonnenenergie CH 8804 Au-ZURICH
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT Industrial Flat Plate Collector

OBJECTIVE AND NATURE OF THE PROGRAM:

Build a Flat Plate Collector :
- -Low Price
- -Easy to Intergrate
- -Variety of Applications

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The Collector has been sold for 5 Years

PERIOD OF PROJECT: not fixed

FUNDING IN $ U.S.: -

IMPORTANT REPORTS OR PUBLICATIONS: -

Code No.: SWIT-5

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION LABORATOIRE SUISSE DE RECHERCHES HORLOGERE	ADDRESS: Rue A-L Breguet 2 Case postale 42 2000 Neuchâtel 7
NAME OF PRINCIPAL RESEARCHER H Tannenberger J Sekler	

TITLE OF PROJECT Heliostat test facility

OBJECTIVE AND NATURE OF THE PROGRAM:

Participation in the programme of: the Swiss federal Institute for React Research

- demonstrating the feasability of solar power station in Swiss mountains

with special attention to the intensity measurement of the solar energy produced by the Heliostat

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Building the testing facility for intensity measurement in high mountain environment

PERIOD OF PROJECT: May 79 - May 80 FUNDING IN $ U.S.: ~25'000.--

IMPORTANT REPORTS OR PUBLICATIONS:

____

Code No.: SWIT-6

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL ~~COMPONENTS~~ Systems	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Dipartimento Ambiente	ADDRESS: 6500 Bellinzona
NAME OF PRINCIPAL RESEARCHER M. Camani	

TITLE OF PROJECT
Small solar power plant with solar cells

OBJECTIVE AND NATURE OF THE PROGRAM:

to build a small solar power plant with solar cells, 2-5 kW_p
optimalization of the components
tests of performance
DC- 220 AC conversion - grid

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Beginning : January 1980

PERIOD OF PROJECT:
January-March 1980 optimalizazion of the components

FUNDING IN $ U.S.: 10.000
15.000 Fr.

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-7

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION ENERGIE SOLAIRE S.A. NAME OF PRINCIPAL RESEARCHER	ADDRESS: p/a Granit S.A. Avant Poste 4 1000 LAUSANNE

TITLE OF PROJECT INDUSTRIAL FLAT PLATE COLLECTOR

OBJECTIVE AND NATURE OF THE PROGRAM:

Manufacturing of flat plate collectors having the following properties

- -high efficiency, using a selective black coating
- -high dirability
- -low cost by industrial production
- -custom format, minimizing installation costs
- -easy to mount in a roof, a wall, ore elsewhere

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The necessary machines are achieved dec. 79.
Large galvanic installation for black chrome is in operation.
1980 production rate should be 1000 sq. meter a month.
Some more investments are necessary to enhance the production rate.

PERIOD OF PROJECT:

Jan. 1973- dec 1978

FUNDING IN $ U.S.:

Total 440'000.- $

IMPORTANT REPORTS OR PUBLICATIONS:

C. Roulet: Une façade rideau solaire (SSES Symposium, Lausanne, 1975)
C. Roulet: La fabriacation industrielle d'un absorbeur solaire (EPFL symposium on R & D in solar energy in Switzerland, Lausanne 1979)

Code No : SWIT-7

ENERGIE
SOLAIRE

DATA SHEET FOR FLAT PLATE SOLAR COLLECTOR

a) TYPE

Water film flat plate absorber, made of two pressed stainless steel sheets, seam and spot welded. Black chrome selective coating.
Installation on field with fiberglass insulation, aluminium profiles for the frame, and one special white tempered glass covering.
The absorbers can be produced industrially in any format with maximum dimensions 1.5 x 3 meter.

b) OPTICAL EFFICIENCY

82 % at normal incidence

c) OVERALL HEAT LOSS COEFFICIENT

Less than 4 W/m^2K from 20 to 100 ^oC

d) HEAT CAPACITY

Less than 10 kJ/m^2K, when filled with pure water (Less than 2.8 Wh/m^2K)

e) HEAT TRANSFER MEDIUM

Water and passivated ethylene or propylene glycol. No chlorine ion admitted.
Maximum pressure: 0,3 MPa.
Nominal fluid flow: 17 - 33 g/s
Pressure losses at nominal fluid flow: less than 200 Pa for water.

f) MATERIAL

- absorber: Stainless steel AISI 304 or 409 or 430
- black: Black chrome. Absorbtivity 0,93, emissivity: less than 0,2
- cover plate: 1 white tempered glass, 6 mm thick
- insulation: 6 to 8 cm glass wool
- frame: Aluminium profiles, neoprene seals.

g) ESTIMATED LIFE TIME

More than ten years

h) PRICES

Depends on series. Between 150 and 300 US $ / m^2 (dec. 1979)

DOMAINE DU BOCHET CH-1025 ST-SULPICE TÉL. (021) 24 24 94 TELEX 25 695 GRANI CH

Code No.: SWIT-8

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Störi &Co. AG	ADDRESS: Störi & Co. AG CH 8820 Wädenswil
NAME OF PRINCIPAL RESEARCHER R.Spalinger, F.Michels	

TITLE OF PROJECT AEROCAL - Heatpump

OBJECTIVE AND NATURE OF THE PROGRAM:

Air and Water Heat Pump for Air Heating of Appartments in a range between 14 and 31 KW. Temperature range : Outdoor Temperature -11 ^{o} C and Air Heating Temperature Max 65 ^{o} C.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Development untill it is ready for marketing and Mass Production.

PERIOD OF PROJECT: 1973 - 1980

FUNDING IN $ U.S.: 2'000'000.--

IMPORTANT REPORTS OR PUBLICATIONS:

Code No: SWIT-8

INSTRUCTIONS FOR DATA SHEET

Please retype items under relevant component category on blank DATA SHEET and provide answers. If your project involves more than one type of component, please complete a DATA SHEET for each. The data items for respective components are shown as follows:

Solar Collectors

a) type (flat plate, tubular, concentrating, ..., evacuated, non-evacuated, ...) and configuration

b) $\alpha\tau$

c) overall heat loss coefficient U_L [W/m²K] (temp. range θ [°C])

d) heat capacity (fluid included) C [Wh/m²K]

e) heat transfer medium (water, air, ...)

f) material
   i) absorber (α, ε)
   ii) cover plate (number, τ, ...)
   iii) insulation (thickness, ...)

g) expected life time

h) estimated cost ($ US/m²)

Heat Storage

a) type (storage medium, phase change, etc.) and configuration

b) heat capacity C [Wh/m³] (temp. range θ [°C])

c) latent heat h [Wh/m³] (temp. θ [°C])

d) heat exchanger YES/NO (heat transfer fluid)

e) heat rate

f) insulation

g) expected life time

Air Conditioning and Cooling

a) type (heat pump, solar ~~heating/cooling~~, ...) Compressor

b) type of refrigerator (~~absorption~~, ...; working medium, ...) R12

c) capacity of refrigerator [tons] 2,0 -6,5

d) temp. range θ [°C] -20 - +15 / +30 - +65

e) C.O.P.

f) heat exchanger No

g) auxiliary heat source No

Code No.: SWIT-9

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:	
COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Arbeitsgruppe "Solar Trap"	ADDRESS: BASLER & HOFMANN Consulting Engineers Forchstrasse 395 CH - 8029 Zürich
NAME OF PRINCIPAL RESEARCHER ________	

TITLE OF PROJECT
Solar Trap - Passive und aktive Sonnenenergienutzung bei Gebäuden

OBJECTIVE AND NATURE OF THE PROGRAM:

The research project aims to establish rules for the application of passive heating elements in building design.

The program includes:
- Pilot-House (roughly 25 m3)
- Simulation of system behaviour
- Comparision of predictions with real data

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Program will be startet in December 1979

Solar Trap project has been awarded the first price in the 6th international prefabricated housing design competition (1978)
Misawa Homes Institute of Research and Development, Tokyo, Japan

PERIOD OF PROJECT: ______ FUNDING IN $ U.S.: ______

IMPORTANT REPORTS OR PUBLICATIONS:

Code No: SWIT-9

INSTRUCTIONS FOR DATA SHEET

Please retype items under relevant component category on blank DATA SHEET and provide answers. If your project involves more than one type of component, please complete a DATA SHEET for each. The data items for respective components are shown as follows:

Solar Collectors

a) type (flat plate, tubular, concentrating, ..., evacuated, non-evacuated, ...) and configuration

b) $\alpha\tau$

c) overall heat loss coefficient U_L [W/m²K] (temp. range θ [°C])

d) heat capacity (fluid included) C [Wh/m²K]

e) heat transfer medium (water, air, ...)

f) material
   i) absorber (α, ε)
   ii) cover plate (number, τ, ...)
   iii) insulation (thickness, ...)

g) expected life time

h) estimated cost ($ US/m²)

Heat Storage

a) type (storage medium, phase change, etc.) and configuration

b) heat capacity C [Wh/m³] (temp. range θ [°C])

c) latent heat h [Wh/m³] (temp. θ [°C]) Several options

d) heat exchanger YES/NO (heat transfer fluid) are investigated

e) heat rate

f) insulation

g) expected life time

Air Conditioning and Cooling

a) type (heat pump, solar heating/cooling, ...)

b) type of refrigerator (absorption, ...; working medium, ...)

c) capacity of refrigerator [tons]

d) temp. range θ [°C]

e) C.O.P.

f) heat exchanger

g) auxiliary heat source

Code No.: SWIT-10

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:	
COMPONENTS	**TYPE OF RESEARCH**
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Coralur Laboratories NAME OF PRINCIPAL RESEARCHER Dr. Trevor P. Woodman	ADDRESS: Mittelbergsteig 15 CH-8044 Zürich

TITLE OF PROJECT Commercialization of low cost selective absorber coatings

OBJECTIVE AND NATURE OF THE PROGRAM:

A first aim is to achieve routine spray coating of commercial solar collectors.

Secondly, to commercialize other techniques, such as the continuous coating of metal foil and band.

Thirdly, to commercialize a very low cost coating for service below 100°C, e.g. for passive heating systems.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The first aim has been accomplished, with optical values $\alpha_s = 0.93$ and $\epsilon = 0.25-0.30$. Singly glazed collectors fabricated with the coating have higher performance than standard collectors with double glazing. The coating performs at least as well as more expensive electrochemical coatings.

Aims 2 and 3 are being pursued; the technology is available.

PERIOD OF PROJECT: Continuing

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

T.P.Woodman: "Selektive Absorberbeschichtungen ...", Sonnenenergie/Energie Solaire (CH) 1 (1979) 18-20.

Code No.: SWIT-11

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ PHOTOCHEMICAL ENERGY STORAGE
NAME OF ORGANIZATION University of Berne, Inorganic and Physical Chemistry	ADDRESS: Institute for Inorganic & Physical Chemistry Freiestrasse 3 CH-3000 Bern 9
NAME OF PRINCIPAL RESEARCHER PD Dr. Gion Calzaferri	

TITLE OF PROJECT Generation and Storage of Chemical Energy

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of photocatalytic systems for cyclic photochemical cleavage of water.

Investigation on photogalvanic and photovoltaic cells.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

A number of interesting systems are under investigation.

PERIOD OF PROJECT: (1.1.1977-1.1.1978) FUNDING IN $ U.S.:
1.1.1980-1.1.1982

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-12

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
[*] SOLAR COLLECTOR [*] THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT [*] ~~Modelisation of solar~~ systems
NAME OF ORGANIZATION IPEN - EPF Lausanne NAME OF PRINCIPAL RESEARCHER B. Saugy J.C. Hadorn	ADDRESS: IPEN - EPF Lausanne Département de Génie Civil Ecublens 1015 Lausanne

TITLE OF PROJECT
Underground Heat Storage

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a computer program (predicting performances of an active solar system using meteorological datas over a 10 years period,with a time step of 1 hour) for the optimisation of the seasonal underground heat storage and the prediction of performances of an energetic line including solar system and underground heat storage

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-1[illegible]

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR [*] THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION IPEN - Lausanne & CHY - Neuchatel	ADDRESS: IPEN - EPF Lausanne Dêpartement de Gênie Civil Ecublens 1015 Lausanne
NAME OF PRINCIPAL RESEARCHER B. Saugy B.mathey	

TITLE OF PROJECT Underground Heat Storage

OBJECTIVE AND NATURE OF THE PROGRAM:

.Selection of sites in Switzerland

.Prediction by simulation using models developped in the IPEN of the efficiency of an underground heat storage

.Design of a long term underground heat storage (injection of hot water in a porous media)

.Construction of the accumulator (boreholes,well...)

.Chemical and biological effects of temperature increase on a porous media

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

-Site selection in Switzerland

-Hydrogeological survey of the choosen site

PERIOD OF PROJECT: 1979-1981

FUNDING IN $ U.S.:

Total estimated:1 000 000.-
supported by NEFF

IMPORTANT REPORTS OR PUBLICATIONS:

"Stockage thermique souterrain" in Symposium Energie Solaire
2 juillet 1979 - Lausanne

Code No : SWIT-13

UNDERGROUND HEAT STORAGE
****

DATA SHEET

a) Type: heat storage in a porous medium
injection of water in radiant drains

b) Heat capacity: C=1000 à 5000 Wh/m^3
T=20 à 90 oC

c) Latent heat: -

d) Heat exchanger: Yes (type depends on extracted water quality)

e) Heat rate: 1 à 5 l/s during 6 months

f) Insulation: not required

g) Expected life time: 20 à 30 years

Code No.: SWIT-14

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☒ ~~feasibility~~
NAME OF ORGANIZATION Bureau d'Etudes Keller-Burnier	ADDRESS: CH-1171 Lavigny Switzerland
NAME OF PRINCIPAL RESEARCHER L. Keller	

TITLE OF PROJECT Comparison between latent heat storage and sensible heat storage in a solar water heating system

OBJECTIVE AND NATURE OF THE PROGRAM:

Theoretical and experimental comparison between latent and sensible heat storage in a solar water heating system, taking into account the cost and the energy produced

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The theoretical study has been done; it is shown that the latent heat store is at best equivalent to the sensible heat store, and probably dearer. The experimental systems are under construction.

PERIOD OF PROJECT: 1978 - 1981 FUNDING IN $ U.S.: 75'000

IMPORTANT REPORTS OR PUBLICATIONS:

L. Keller, Comparaison entre un stock latent et un stock sensible dans une installation solaire (NEFF, 1979)

L. Keller, Sizing the heat exchangers in a latent heat storage device, submitted for publication

Code No: SWIT-14

Heat storage

	latent	sensible
a)	phase change	water
b)	132 Wh/m^3	depends on the incoming solar energy
c)	132 Wh/m^3 (64 °C)	
d)	yes (30% propylene glycol)	yes (30% propylene glycol)
e)	≥ 550 W/K [1)]	550 W/K
f)	U_L = 0,4 W/m^2K	U_L = 0,4 W/m^2K

1) a small sensible heat store (medium: water) is included in the latent system to allow the great heat rate needed for tapping (~50 kW)

Code No.: SWIT-15

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION SULZER BROS. LTD.	ADDRESS: SULZER BROS. LTD. 8401 Winterthur
NAME OF PRINCIPAL RESEARCHER J. Zabelka	

TITLE OF PROJECT
STEAM POWER STATION WITH HEAT STORAGE

OBJECTIVE AND NATURE OF THE PROGRAM:

Steam power station law power range (1 - 10 MW) with Tower-receiver and Heliostats for production of electricity and heat.

Solar-receiver is designed to generate superheated steam. Twofold heatstorage, comprised of saturated steam and HITEC, to allow better adaptibility to user conditions.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Feasibility study is prepared.

PERIOD OF PROJECT:

FUNDING IN $ U.S.:
none

IMPORTANT REPORTS OR PUBLICATIONS:

no external reports yet

Code No.: SWIT-16

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [ ] ______________
NAME OF ORGANIZATION SULZER BROS. LTD.	ADDRESS: SULZER BROS. LTD, 8401 Winterthur
NAME OF PRINCIPAL RESEARCHER E. Thurnauer	

TITLE OF PROJECT

BLACK SURFACE RESEARCH

OBJECTIVE AND NATURE OF THE PROGRAM:

Determine absorptivity of various "black" and "white" surfaces or coatings.

Develop coatings with optimum characteristics.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Aquired fair knowledge on commercial coatings. Some promising results on proprietary coating.

PERIOD OF PROJECT:
1978/1980

FUNDING IN $ U.S.:
none

IMPORTANT REPORTS OR PUBLICATIONS:

no external reports yet.

Code No.: SWIT-17

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________

NAME OF ORGANIZATION
SULZER BROS. LTD.

NAME OF PRINCIPAL RESEARCHER
H.W. Fricker

ADDRESS:
SULZER BROS. LTD,
8401 Winterthur

TITLE OF PROJECT
ALMERIA RECEIVER

OBJECTIVE AND NATURE OF THE PROGRAM:

Design and manufacture (in 1980) of the 2.8 MW sodium cooled receiver for the CRS plant Almeria. Tubular, concentrating.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Basic design completed.
Detailed design in progress.

PERIOD OF PROJECT:
1979/1980

FUNDING IN $ U.S.:
none (commercial contract)

IMPORTANT REPORTS OR PUBLICATIONS:
none

Code No.: SWIT-18

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION SULZER BROS. LTD. NAME OF PRINCIPAL RESEARCHER H.W. Fricker	ADDRESS: SULZER BROS. LTD, 8401 Winterthur

TITLE OF PROJECT ALMERIA STEAM GENERATOR

OBJECTIVE AND NATURE OF THE PROGRAM:

Design and manufacture of sodium heated steam generator for the CRS plant Almeria. Helical tube type.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Basic and detail design completed.
Manufacture to start early 1980.

PERIOD OF PROJECT:

1978/1980

FUNDING IN $ U.S.:

none (commercial contract)

IMPORTANT REPORTS OR PUBLICATIONS:

none so far

Code No.: SWIT-19

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION ETHZ/EMPA	ADDRESS: ETHZ CH-8093 Zürich Infrared Physics
NAME OF PRINCIPAL RESEARCHER Prof.Kneubühl/Sagelsdorff	EMPA CH-8600 Dübendorf

TITLE OF PROJECT
Radiation losses and Energy Consumption of Buildings

OBJECTIVE AND NATURE OF THE PROGRAM:

- Longtime Measurements of the atmospheric infrared Radiation
- Determination of spectral Characteristics of Building Materials (Shortwave and lonwave Radiation o,2 - 40 μm)
- Selective Coatings and Retrofittings
- Energy Balance of the Building Envelope
- Simulation of the thermal behaviour of buildings (Computer programs)
- Measurements of heat consumption in test buildings with different selective surface properties under real meteorological conditions
- Calculation of the infrared properties of the atmosphere (Lowtran IV Program)

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

- Mobile meteorological data station (Temperatures,Humidity,solar radiation direct and diffuse,angular dependent IR-counterradiation of the atmosphere,wind speed and direction,cloudness number)
- Measurements on two test buildings with variable selective surface properties:Determination of Energy consumption as function of the spectral surface properties and the real meteorological conditions.
- Calculation of the energy consumption of buildings and verification by the measurements of the test building.

PERIOD OF PROJECT: 1978-1982 FUNDING IN $ U.S.: 800'000 .-$

IMPORTANT REPORTS OR PUBLICATIONS:

See list on next page:

Code No: SWIT-19

PUBLIKATIONEN

[1] G.Finger,F.K.Kneubühl,F.Thiébaud,Ch.Zürcher,Th.Frank
"Verbesserung des Energiehaushaltes von Gebäuden durch Verminderung der Wärmeabstrahlung von Fenstern und Fassaden".
Schweizer Ingenieur und Architekt 17,(1979),287-294

[2] G.Finger,F.K.Kneubühl,F.Thiébaud,Ch.Zürcher
Th.Frank,J.Gass,P.Hartmann,R.Sagelsdorff
"Ueber den Energieverbrauch von Gebäuden durch Wärmestrahlung".
Helv.Phys.Acta 52,(1979),75-78

[3] Ch.Zürcher,F.K.Kneubühl,G.Finger,F.Thiébaud
Th.Frank,R.Sagelsdorff
"Thermal Radiation and Building Envelopes"
Proc.2nd Int.CIB Symposium on Energy Conservation in the Built Environment,Copenhagen 1979

[4] Ch.Zürcher
"Infrarotspiegel an Gebäudeoberflächen helfen Wärme bewahren".
Weltwoche 2o,(1979),57

[5] Th.Frank
"Rechenprogramme zur Ermittlung des Energiebedarfes von Gebäuden"
Schweizer Ingenieur und Architekt 32/33,(1979),594-595

Code No.: SWIT-20

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Solar Radiation Data
NAME OF ORGANIZATION Swiss Meteorological Institute NAME OF PRINCIPAL RESEARCHER Dr. P. VALKO	ADDRESS: Krähbühlstr. 58 CH-8044 Zürich

TITLE OF PROJECT

OBJECTIVE AND NATURE OF THE PROGRAM:

The Swiss Meteorological Institute measures various components of radiation as well as other meteorological parameters. In addition we produce many kinds of statistical information (tables, graphs, geographic maps of radiation distribution) for solar energy users. A dense network of radiation measuring stations and a mobile system with special devices for solar radiation research are in operation. We also participate in the IEA-Projects IV and V.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

See enclosures and publication mentioned below.

PERIOD OF PROJECT:
1978 - 1980 (should continue)

FUNDING IN $ U.S.:
$ 250'000 p.a.

IMPORTANT REPORTS OR PUBLICATIONS:

Some empirical properties of solar radiation and related parameters. Chapter 8 International Energy Agency, Solar Heating and Cooling Program, Task IV Handbook "An introduction to meteorological measurements and data handling for solar energy applications"(in press,publication expected early 1980).

Code No: SWIT-21

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING
COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR	☐ MATERIAL RESEARCH
☐ THERMAL ENERGY STORAGE	☒ COMPONENT DEVELOPMENT
☐ AIR CONDITIONING UNIT	
☒ OTHER SUBSTANTIAL COMPONENTS	

NAME OF ORGANIZATION
Institut de Thermique appliquée de l'EPF-LAUSANNE

ADDRESS :
Halles de Mécanique Ecublens
1015 LAUSANNE

NAME OF PRINCIPAL RESEARCHER
R. KRIESI, ing. dipl.

TITLE OF PROJECT :
Solar multistage water desalination

OBJECTIVE AND NATURE OF THE PROGRAM :

Modify existing multistage water distillation components in order to adapt it to solar energy : Possibility for part load performance without mechanical control devices ; very low pumping power.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

First pilot plant tested ; second modified version under study.

PERIOD OF PROJECT : April 1977 - July 1980

FUND IN SFR. : CURRENT YEAR 200 000.- SFR
TOTAL FOR THE PERIOD 430 000.- SFR

IMPORTANT REPORTS OR PUBLICATIONS :

Code No: SWIT-22

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR	☐ MATERIAL RESEARCH
☐ THERMAL ENERGY STORAGE	☐ COMPONENT DEVELOPMENT
☐ AIR CONDITIONING UNIT	
☐ OTHER SUBSTANTIAL COMPONENTS	

NAME OF ORGANIZATION
EPF-LAUSANNE
Institut de Thermique Appliquée

NAME OF PRINCIPAL RESEARCHER
C. Calatayud/M. Nilsson

ADDRESS :
Institut de Thermique Appliquée
EPF-L
Halle de Mécanique Ecublens
CH-1015 LAUSANNE

TITLE OF PROJECT :

Performance of real active solar heating systems

OBJECTIVE AND NATURE OF THE PROGRAM :

Instrumentation of 2 active solar heating systems

Comparison between calculated and real data

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

Instrumentation of the Systems

PERIOD OF PROJECT : 1978-1981

FUND IN SFR. : CURRENT YEAR 150 000.- SFR
TOTAL FOR THE PERIOD 470 000.- SFR

IMPORTANT REPORTS OR PUBLICATIONS :

Code No: SWIT-23

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

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

NAME OF ORGANIZATION
EPF-LAUSANNE Institut Thermique appliquée

ADDRESS :
Institut de Thermique appliquée EPF-L
Halles de Mécanique Ecublens
1015 LAUSANNE

NAME OF PRINCIPAL RESEARCHER
J.R. Muller & P. Suter

TITLE OF PROJECT :
Active solar heating systems.

OBJECTIVE AND NATURE OF THE PROGRAM :
Simulation of transient system behaviour on the basis of tests concerning components and systems, in order to work out the relations between meteorological and system parameters and to define optimisation criteria.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :
Long and short time tests on 3 installations. Detailed simulation of water heat storage tank dynamic performance. New model for transient behaviour of collectors. General computer program for system performance including regulation. New method verified by tests to compose typical meteorological sets and to evaluate collector performances.

PERIOD OF PROJECT :
1975 - 1980

FUND IN SFR. : CURRENT YEAR : 90 000.- SFR
TOTAL FOR THE PERIOD : 500 000.- SFR

IMPORTANT REPORTS OR PUBLICATIONS :

Code No: SWIT-24

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

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

NAME OF ORGANIZATION
EPF-LAUSANNE Unité de Thermique

ADDRESS :
Unité de Thermique de l'EPF-L
Halles de Mécanique Ecublens
1015 LAUSANNE

NAME OF PRINCIPAL RESEARCHER
J.R. Muller & P. Matthey

TITLE OF PROJECT :
Interaction of solar collector and heat pump.

OBJECTIVE AND NATURE OF THE PROGRAM :
Testing of different modes of operation in an installation comprising flat and concentrating collectors, heat pump, heat storage on three levels. Continuous recording simulation and optimisation.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

Continuous recording available for 39 months. Analysis must make use of exergy concept. Important heat gain possible by air-to-water heat exchanger-function of the solar collectors.

PERIOD OF PROJECT :
1975 - 1979

FUND IN SFR. : CURRENT YEAR : 30 000.- SFR
TOTAL FOR THE PERIOD : 150 000.- SFR

IMPORTANT REPORTS OR PUBLICATIONS :

Code No: SWIT-25

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR	☐ MATERIAL RESEARCH
☐ THERMAL ENERGY STORAGE	☒ COMPONENT DEVELOPMENT
☐ AIR CONDITIONING UNIT	
☐ OTHER SUBSTANTIAL COMPONENTS	

NAME OF ORGANIZATION :
EPF-LAUSANNE Institut de Thermique Appliquée.

ADDRESS :
EPFL -Mecanique-ITA
1015 LAUSANNE

NAME OF PRINCIPAL RESEARCHER
P.Sonderegger

TITLE OF PROJECT :
Evacuated Flat-Plate Collectors

OBJECTIVE AND NATURE OF THE PROGRAM :

Research and Testing of 15 Evacuated Flat-Plate Collectors

Characteristics : High Vacuum (10^{-4} torr) and Selective Coating

Evaluation of Performance for Incorporation in a Cooling System.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :
First Prototypes are being Built

PERIOD OF PROJECT : 1 Nov 1978 - 1980

FUND IN SFR. : CURRENT YEAR 90 000.- SFR
TOTAL FOR THE PERIOD 140 000.- SFR

IMPORTANT REPORTS OR PUBLICATIONS :

Code No: SWIT-26

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR	☐ MATERIAL RESEARCH
☒ THERMAL ENERGY STORAGE	☒ COMPONENT DEVELOPMENT
☐ AIR CONDITIONING UNIT	
☐ OTHER SUBSTANTIAL COMPONENTS	

NAME OF ORGANIZATION
EPF-LAUSANNE, Institut de Thermique appl.

NAME OF PRINCIPAL RESEARCHER
M. Balawi & P. Suter

ADDRESS :
Institut de Thermique appliquée EPF-L
Halles de Mécanique Ecublens
1015 LAUSANNE

TITLE OF PROJECT :
Sensible heat storage tanks with forced stratification.

OBJECTIVE AND NATURE OF THE PROGRAM :

Experimental and theoretical investigation of new devices intended to assure stratification in heat storage tanks (water) ; technologies must be suitable for developping countries.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

Primary test confirms chosen principle. Pilot plant in erection.

PERIOD OF PROJECT :
3 1/2 years, starting October 1, 1977.

FUND IN SFR. : CURRENT YEAR : 50000.- SFR
TOTAL FOR THE PERIOD : 150000.- SFR

IMPORTANT REPORTS OR PUBLICATIONS :

Code No.: SWIT-27

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION University of Fribourg	ADDRESS: Institute of inorganic Chemistry, University Pérolles CH - 1700 Fribourg (Switzerland)
NAME OF PRINCIPAL RESEARCHER A. von Zelewsky, O. Haas	

TITLE OF PROJECT Photogalvanic Cells

OBJECTIVE AND NATURE OF THE PROGRAM: Performance of photogalvanic cells, their mechanism and dynamic processes are studied using $Ru(bipy)_3^{2+}$ and various other Ru(II)-complexes as photoactive species with different quenchers like Fe^{3+}, Cu^{2+}, paraquat and phenazin. Surface attached redox couple are used on metal and semi-conductor electrodes to investigate charge separation at phase boundaries.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

- The fundamental processes in photogalvanic cells are elaborated theoretically and experimentally.
- An a.c. cell is tested using a rotating mirror system.
- Electrode attached systems like ferrocene derivatives, Poly (4-Vinylpyridine) Ru-Complexes and Phenazin are under investigation.

PERIOD OF PROJECT: 1977-1981

FUNDING IN $ U.S.: sFr. 120'000.- per year

IMPORTANT REPORTS OR PUBLICATIONS:

1. Claude Daul, Otto Haas and Alex von Zelewsky; Transient Processes in Photogalvanic cells, I: Fundamentals; accepted for publication, Sept. 1979, J. Electroanal. Chem.
2. Claude Daul, Otto Haas, Alois Lottaz, Alex von Zelewsky and H.R. Zumbrunnen; Transient Processes in Photogalvanic Cells, II: Cells containing Ruthenium Complexes as Photoactive Species; Submitted for publication, Oct. 1979, J. Electro-anal. Chem.

Code No.: SWIT-2[illegible]

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Laboratories RCA Ltd.	ADDRESS: Badenerstrasse 569 8048 Zürich
NAME OF PRINCIPAL RESEARCHER A.E. Widmer, G. Harbeke	

TITLE OF PROJECT Characterization of amorphous silicon deposited by Low Pressure Chemical Vapor Deposition (LPCVD)

OBJECTIVE AND NATURE OF THE PROGRAM:

Evaluation of hydrogenated amorphous silicon produced by Low Pressure Chemical Vapor Deposition (LPCVD) for solar cell applications. The material is characterized in terms of electrical resistivity, photoconductivity, photoluminescence, optical absorption and hydrogen content. Device parameters are measured on Pt-Schottky barrier cells.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

No publication at this time.

Code No.: SWIT-29

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION EPFL - Solar Group	ADDRESS: Labo. de Phys. Th. 14 av.Eglise Anglaise 1006 Lausanne
NAME OF PRINCIPAL RESEARCHER J-B.Gay + A.Faist	

TITLE OF PROJECT Direct Solar Gains Through Windows

OBJECTIVE AND NATURE OF THE PROGRAM:

-Measuring the Performance of Different kinds of Windows (Including IR Coating)

-Evaluation of Passive Direct Gains using a Massive Measurment Cell

-Mathematical Modelisation of the System

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

-Measurments are already being taken

PERIOD OF PROJECT: Jan 1979-June 1981 FUNDING IN $ U.S.: 100.000 $

IMPORTANT REPORTS OR PUBLICATIONS:

Helvetica Physica Acta 52(1979) 67 Influence de Vitrages et des murs dans le bilan thermique saisonnier d'une construction

Code No.: SWIT-30

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] MODELISATION
NAME OF ORGANIZATION EPFL -Solar Group	ADDRESS: Labo de Phys Th. 14 av.Eglise Anglais 1006 Lausanne
NAME OF PRINCIPAL RESEARCHER J-B.Gay + Y.Rey	

TITLE OF PROJECT Modelisation of a Trombe Wall

OBJECTIVE AND NATURE OF THE PROGRAM:

-Measuring the peformance of a small size Trombe wall ($5m^2$)

-Mathematical modelisation of the system, comparison with the measurements, extrapolation to other types of wall.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

-Measurements are being taken over 3 months

-Simulation of the system is also under way

PERIOD OF PROJECT: 1979 - 1980

FUNDING IN $ U.S.: 10.000.$

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-31

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Solar Group- EPFL NAME OF PRINCIPAL RESEARCHER A.Razafindraibe	ADDRESS: EPFL Lab. de Physique Théorique 14,Av. de L'Eglise Anglaise 1006 Lausanne

TITLE OF PROJECT Test and Development of Heat Flow Meters

OBJECTIVE AND NATURE OF THE PROGRAM:

- Comparison between existing heat flow meters
- Development of analogical heat flow meters

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Different heat flow meters are mounted on test rig for evaluation.

PERIOD OF PROJECT: 6 Months - Dec 79 FUNDING IN $ U.S.: 8000 $

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-3?

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Weather data aquisition
NAME OF ORGANIZATION Solar Groupe- EPFL NAME OF PRINCIPAL RESEARCHER Perrin + Ferraris	ADDRESS: EPFL Lab. de Physique Théorique 14,Av. de L'Eglise Anglaise 1006 Lausanne

TITLE OF PROJECT
Mathematical model for computing tilted surface solar irradiation.

OBJECTIVE AND NATURE OF THE PROGRAM:

- Test of the different existing models under the local climate (lausanne)
- Development of specific models for the local climate to calculate the insulation on any tilted surface for hourly values,daily values and Monthly values.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

- Hourly models have been developed and tested for vertical surfaces - south ,east and west and for 45^0 tilt south.

PERIOD OF PROJECT: 6 months - Oct 1979 FUNDING IN $ U.S.: 5000 $

IMPORTANT REPORTS OR PUBLICATIONS:

- Intermediate report of the 3 first months of experience.

Code No.: SWIT-33

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Solar Groupe - EPFL	ADDRESS: EPFL Lab. de Physique Théorique 14,Av.de L'Eglise Anglaise 1006 Lausanne
NAME OF PRINCIPAL RESEARCHER N.Morel	

TITLE OF PROJECT
Thermosyphon Model

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a theoretical model of thermociculation of solar systems.

Implementation of this model in the modular simulation program TRNSYS.

Verification of the model by comparison with experimental data.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The first approximate model has been implemented in the TRNSYS program.

PERIOD OF PROJECT:
DEC 1979 - MAY 1980

FUNDING IN $ U.S.: 10 000.- $

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-34

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Performance Test
NAME OF ORGANIZATION ETH-Z NAME OF PRINCIPAL RESEARCHER B. Seiler	ADDRESS: Professur für Apparatebau der Elektrotechnik Pestalozzistr. 24 8032 Zürich

TITLE OF PROJECT
Mobil test equipment for solar collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

Examination of the methods for testing solar collectors by means of an easy adaptable mobile measuring equipment

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 1975-80 FUNDING IN $ U.S.: 19'500.-

IMPORTANT REPORTS OR PUBLICATIONS:

Ein mobiler Prüfstand für Sonnenkollektoren, 1979

Code No.: SWIT-35

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION AMI SA NAME OF PRINCIPAL RESEARCHER H. Freyholdt	ADDRESS: AMI SA 120, Avenue d'Echallens 1004 Lausanne

TITLE OF PROJECT
Evacuated Flat-Plate Solar Collector (high-vacuum).

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a steel absorber plate consisting of steel tubing with attached fins.

Development of the glass envelope for the absorber.

Development of the piping connections through the rear glass sheet of the envelope.

Development of selective coatings to be stable under vacuum and at high temperatures.

Short-range goal for 1980: Fabrication and testing of 15 prototypes.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

All components have been developed. Assembly of prototypes is under way.

PERIOD OF PROJECT: 1978 - 1980

FUNDING IN $ U.S.: 50'000.-

IMPORTANT REPORTS OR PUBLICATIONS:

None

Code No.: SWIT-36

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION AMI SA NAME OF PRINCIPAL RESEARCHER H. Freyholdt	ADDRESS: AMI SA 120, Avenue d'Echallens 1004 Lausanne

TITLE OF PROJECT
Light-operated Vacuum-pump

OBJECTIVE AND NATURE OF THE PROGRAM:

In order to maintain a vacuum of better than 10^{-4} torr for a duration of at least 20 years inside an evacuated flat-plate collector, an autonomous vacuum pump to be installed inside the collector has been developed.

The testing of the pump is being continued and an improved version is currently under study.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The development of the vacuum pump is completed. A second generation pump is under study.

PERIOD OF PROJECT:

1978 - 1980

FUNDING IN $ U.S.:

56'000.-

IMPORTANT REPORTS OR PUBLICATIONS:

None

Code No.: SWIT-37

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________

NAME OF ORGANIZATION
AMI SA

NAME OF PRINCIPAL RESEARCHER
H. Freyholdt

ADDRESS:
AMI SA
120, Avenue d'Echallens
1004 Lausanne

TITLE OF PROJECT
Evacuated Window, k = 0,3 W/m^2K

OBJECTIVE AND NATURE OF THE PROGRAM:

It is the objective of the program to develop a (high-vacuum) evacuated window with IR-coating, this window having a positive energy balance throughout the heating period even in the North orientation. The window can therefore be considered to be a passive solar energy component for the heating of buildings. A method for the industrial fabrication is being studied.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The testing of prototypes is being continued.

PERIOD OF PROJECT:

1977 - 1981

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

None

Code No.: SWIT-33

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION AMI SA NAME OF PRINCIPAL RESEARCHER H. Freyholdt	ADDRESS: AMI SA 120, Avenue d'Echallens 1004 Lausanne

TITLE OF PROJECT
Test Stand for High-Temperature (300°C) Solar Collectors

OBJECTIVE AND NATURE OF THE PROGRAM:

The purpose of the program is to complete an existing test stand at AMI SA and to make this test stand available to the Swiss Public for utilization.
More particularly, modified testing standards and testing procedures for high-temperature solar collectors are being proposed. Also, a thermal flow meter for high-temperature oil is being developed. The measurement of IR sky radiation is analysed.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The development of the thermal flow meter is completed. A data acquisition chain has been selected.

PERIOD OF PROJECT:

1978 - 1980

FUNDING IN $ U.S.:

87'500.-

IMPORTANT REPORTS OR PUBLICATIONS:

None

Code No.: SWIT-39

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY:

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION AMI SA NAME OF PRINCIPAL RESEARCHER H. Freyholdt	ADDRESS: AMI SA 120, Avenue d'Echallens 1004 Lausanne

TITLE OF PROJECT
Vacuum-insulated piping system for distance heating

OBJECTIVE AND NATURE OF THE PROGRAM:

A vacuum-insulated piping system (10^{-4} torr vacuum with a number of radiation shields) is being developed to permit the transport of heat with a minimum of heat loss. This piping system will be of importance in Distributed-Collector-Systems (DCS) and will result in considerable reduction of required collector area.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

A first prototype has been built. Tests over a period of more than 9 months show that the high vacuum can be maintained by means of an autonomous built-in vacuum pump and that heat transfer coefficients are two orders of magnitude lower than those of conventionally insulated piping.

PERIOD OF PROJECT:
1978 - 1981

FUNDING IN $ U.S.:
50'000.-

IMPORTANT REPORTS OR PUBLICATIONS:

None

Code No: SWIT-40

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : SWITZERLAND

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

NAME OF ORGANIZATION
Solar Group

NAME OF PRINCIPAL RESEARCHER
G.-R. PERRIN/ A. RAZAFINDRAIBE

ADDRESS : EPFL
Laboratoire de Physique Théorique
14, Av. de l'Eglise Anglaise
1006 LAUSANNE

TITLE OF PROJECT :
Instrumentation of passive solar houses

OBJECTIVE AND NATURE OF THE PROGRAM :
instrumentation of passive solar houses (3)

comparison between calculated and real data

collection of a weather data bank

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :
the instrumentation of the first two houses :

PERIOD OF PROJECT : Sept 1978 - Dec. 1981

FUND IN SFR. : CURRENT YEAR 200 000.- (120 000 $)
TOTAL FOR THE PERIOD

IMPORTANT REPORTS OR PUBLICATIONS :
Reporting Format (french Edition)

Contribution to the FirstSwiss Solar Sysmosium

Code No.: SWIT-41

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: SWITZERLAND

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Architekturbüro Zai NAME OF PRINCIPAL RESEARCHER Ruedi Zai	ADDRESS: Ruedi Zai Im Aesch 8821 Schönenberg

TITLE OF PROJECT Greenhouse

OBJECTIVE AND NATURE OF THE PROGRAM:

-Measurment of the conditions in the greenhouse

-Use of the greenhouse during the different seasons of the year

-Interaction between the greenhouse and the living areas.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

The house was built in 1979 and the greenhouse will be finished in spring 1979. Measurments from spring 1979

PERIOD OF PROJECT: 1980-1981 FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Gebäude. Habitation Space Volume 2, P.O. Box 3574, 1-20100 Milan, Projekt B 225.

Code No: SWIT-42

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR	☐ MATERIAL RESEARCH
☐ THERMAL ENERGY STORAGE	☐ COMPONENT DEVELOPMENT
☐ AIR CONDITIONING UNIT	
☐ OTHER SUBSTANTIAL SYSTEMS ~~COMPONENTS~~	

NAME OF ORGANIZATION	ADDRESS :
Swiss federal Institut for reactor research	CH-5303 Würenlingen

NAME OF PRINCIPAL RESEARCHER

Dr.P.Kesselring, M. Real

TITLE OF PROJECT : Small Solar Power System (International Energy Agency)

OBJECTIVE AND NATURE OF THE PROGRAM :

- Is to participate on the International Energy System Project which will built two 500 kW Solar Power Plants in Spain.
- Is to understand solar technolgy to realize an own Pilotplant in the Swiss mountains. Such a project is under Discussion in the Swiss Government.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

The final design of the two Power Plants are accomplished and signing the agreement by the participating countries (incl.Switzerland) is expected till end of April

PERIOD OF PROJECT :

Feb. 1977 - 1982

FUND IN SFR. : CURRENT YEAR 100'000 (NEFF)

TOTAL FOR THE PERIOD 4.5 Mil

IMPORTANT REPORTS OR PUBLICATIONS :

Final design of a) CRS by Interatom and Consortial Members
b) DCS by Amrex and Consortial Members

Code No: SWIT-43

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR	☐ MATERIAL RESEARCH
☐ THERMAL ENERGY STORAGE	☒ COMPONENT DEVELOPMENT
☐ AIR CONDITIONING UNIT	
☒ OTHER SUBSTANTIAL COMPONENTS	

NAME OF ORGANIZATION
Swiss federal Institut for reactor research

ADDRESS :
CH-5303 Würenlingen

NAME OF PRINCIPAL RESEARCHER
Markus Real

TITLE OF PROJECT :

Heliostat test facility

OBJECTIVE AND NATURE OF THE PROGRAM :

- Is to demonstrate the feasability of solar power stations in Swiss mountains.
- To reach that goal, a proven Heliostat design (CETHEL) was bought, and will be tested and evaluated under special conditions during winter 79 / 80. The test facility will be sophisticated enough to measure optical and mechanical performance of the Heliostat under all conditions.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :
Preliminary tests on the behaviour of Heliostat mirrors for the last two years. Built up a Heliostat test measurement technology

PERIOD OF PROJECT :
Final report for Heliostat-test: Mai 1980

FUND IN SFR. : CURRENT YEAR 680'000.- (EIR)
TOTAL FOR THE PERIOD 0.8 Mil

IMPORTANT REPORTS OR PUBLICATIONS :

"The behaviour of Heliostat mirrors in the Swiss mountains" (Mai 1978), M. Real and P. Kesselring, Intern. Symposium of Solar Power Stations, Cologne (Germany)

Code No: SWIT-41

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

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

NAME OF ORGANIZATION

EIR Würenlingen

NAME OF PRINCIPAL RESEARCHER

P. Kesselring, A. Duppenthaler

ADDRESS :

Swiss Federal Institute for
Reactor Research (EIR)
53o3 Würenlingen

TITLE OF PROJECT : The layout of Solar Hot Water Systems, Using Statistical Meteo- and Heat Demand Data

OBJECTIVE AND NATURE OF THE PROGRAM : In Switzerland hourly values of solar irradiation and ambient temperature are available for some places over at least lo years. To use them for an efficient layout of solar hot water systems we have proposed and developed a design procedure basing on statistical methods. It allows to survey quickly the performance and economics of different systems and to identify the critical subsystem parameters.
The task has been broken down into 3 subtasks with simple interfaces. These are the determination of average gross heat output of collector ("all day performance"), short term storage behaviour and average useful heat production.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

PERIOD OF PROJECT : 1976-...

FUND IN SFR. : CURRENT YEAR EIR : 30'000.--
TOTAL FOR THE PERIOD 1976-1978 : 100'000.--

IMPORTANT REPORTS OR PUBLICATIONS : Review article to be published in Proc. of ISES-Congres, Atlanta, May 79.
P. Kesselring: "Die Abschätzung von Wärmenettoerträgen solarer Brauchwasseranlagen im Schweizer Mittelland", Schweizerische Technische Zeitschrift, Zürich (in press)

Code JVO: SWIT-45

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

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

NAME OF ORGANIZATION
EIR Würenlingen

NAME OF PRINCIPAL RESEARCHER
J.M. Suter & P. Kesselring

ADDRESS :
Swiss Federal Institute for
Reactor Research (EIR)
53o3 Würenlingen

TITLE OF PROJECT : Measurements of performance and efficiency of solar energy systems

OBJECTIVE AND NATURE OF THE PROGRAM : The physical and economic efficiencies of a solar energy system depends not only on the performance of each component (collector, heat storage device, heat exchanger, etc), but also on the optimal layout of the whole system (control device, adaptation of all components with one another). In the present state of developement of solar technology, performance data for different system types and for the numerous Swiss microclimates are highly needed. In particular, it is important to clarify by on-site measurements the reason for actual overall system performance often lying far below the theoretical optimum. This requires simple measurements of limited accuracy on a large number of solar systems of different types (incl. heat pumps). They will provide an estimate of the actual potential of such systems for Switzerland.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT : A microprocessor controlled data acquisition system has been developed on a modular basis, incl. the servicing and calibrating equipments. The first 5 (of 25) selected solar energy systems have been equiped.

PERIOD OF PROJECT : 1976 - .....

FUND IN SFR. : CURRENT YEAR EIR : 3oo'ooo.--
NEFF : 51o'ooo.--

TOTAL FOR THE PERIOD 1976 - 1978: EIR : 71o'ooo.--
NEFF : 6o'ooo.--

IMPORTANT REPORTS OR PUBLICATIONS :
J.M. Suter, P. Kesselring and coworkers, "Measurements of performance and efficiency of solar energy systems", Proc. of the ISES Silver Jubilee Congress 1979, Atlanta (U.S.A.), to be published.

Code No: SWIT-46

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

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

NAME OF ORGANIZATION

EIR Würenlingen

NAME OF PRINCIPAL RESEARCHER

J.M. Suter & Th. Nordmann

ADDRESS :

Swiss Federal Institute of
Reactor Research (EIR)
53o3 Würenlingen

TITLE OF PROJECT : OASE, the solar energy hot water supply system of the institute's restaurant.

OBJECTIVE AND NATURE OF THE PROGRAM : The solar energy system provides the institute's restaurant with 5 m^3/day of 85°C hot water from Monday to Friday. loo m^2 of flat, double glased collectors and loo m^2 of concentrating parabolic trough collectors are connected to three 5 m^3 storage tanks. A 5o kW electric back-up system is turned on by night, if necessary. Research goals of the system are: optimization of a whole system to maximize overall efficiency, study of the water stratification in the storage tanks, testing new control philosophies and heat storage management, comparison of performance of the two collector types, study of long time properties (corrosion, etc.) and of economics. The system is also a public demonstration object.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

The system became operational in June 1978

PERIOD OF PROJECT : 1977 - ......

FUND IN SFR. : CURRENT YEAR EIR : 15o'ooo.--

TOTAL FOR THE PERIOD 1977 - 1978 : 1'o49'ooo.--

IMPORTANT REPORTS OR PUBLICATIONS :

Th. Nordmann, H.-J. Gübeli, J.M. Suter, "Die Sonnenenergieanlage zur Warmwasserbereitung der EIR-Kantine", SSES-Symposium VI, p. 99 and ff., Luzern, October 13, 1978.

Code No: SWIT-47

INTERNATIONAL ENERGY AGENCY
SURVEY OF COMPONENTS FOR SOLAR HEATING COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY : Switzerland

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

NAME OF ORGANIZATION

EIR Würenlingen

NAME OF PRINCIPAL RESEARCHER

J.M. Suter & P. Kesselring

ADDRESS :

Swiss Federal Institute of
Reactor Research (EIR)

53o3 Würenlingen

TITLE OF PROJECT : Performance test of solar collectors on outdoor and indoor test facilities.

OBJECTIVE AND NATURE OF THE PROGRAM : Two test facilities for measuring the performance of hot water solar collectors have been designed and constructed. On the outdoor test facility, up to lo collectors can be simultaneously tested. We measure the parameters (optical efficiency and thermal loss factor) of ~ 3o different, in Switzerland commercially available collectors per year. The tests are made under contract and all results are subsequently published. Care is taken to repeat the measurements on several days with similar meteorological situation so that the values of the parameters obtained are averages, which can be used for estimating overall monthly performance data in a given climate.
In designing the indoor test facility, emphasis has been laid on producing a parallel light beam. This allows a simple determination of incident angle modifiers as well as ordinary efficiency measurements. Indoor tests are not meant to replace outdoor experiments - at least in the near future - but rather to give complementary information.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENT :

37 collectors tested up-to-now on the outdoor test facility.
The indoor facility is now checked for measurement accuracy.

PERIOD OF PROJECT : 1975 - ....

FUND IN SFR. : CURRENT YEAR
EIR : 17o'ooo.-- Fr.S.
NEFF : 165'ooo.-- Fr.S.

TOTAL FOR THE PERIOD 1975 - 1978: EIR : 1'43o'ooo.--
NEFF : 65'ooo.--

IMPORTANT REPORTS OR PUBLICATIONS :

J.M. Suter, F. Widder, P. Kesselring: "Die Bestimmung von Kenngrössen für Sonnenkollektoren zur Warmwasseraufbereitung auf dem EIR-Freiluftprüfstand: Vereinfachte Prüfmethode zur schnellen Beurteilung eines Kollektors", SSES-Symposium VI, p. 123 and ff., Luzern, October 13, 1978.

Code No.: SWIT-48

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________

NAME OF ORGANIZATION
Laboratory for Dairy Research

NAME OF PRINCIPAL RESEARCHER
H.J.Leibundgut, R. Favre

ADDRESS:
Labor für Milchwissenschaft ETH-Z
Eisgasse 8
8004 Zürich

TITLE OF PROJECT
Intermittent Solar Absorption Cooling Unit

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a simple solar refrigeration unit working on the intermittent absorption principle using the combination ammonia/water. Cooling capacity: 40'000 kJ/day at -5°C. Water cooling of the resorber, radiation cooling of the absorber. Heat exchange in the generator part of the plant. Generation of the ammonia vapor in the tubes of the flat plate collector.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Prototype with 20 m2 collector area in test in Portugal. Modification planned in July 1980.

PERIOD OF PROJECT: 1976 - 1980

FUNDING IN $ U.S.: 220'000.--

IMPORTANT REPORTS OR PUBLICATIONS:

"Kälte und Klimaingenieur", Februar 1980: Periodische Solar-Absorptionskühlanlage

Code No.: SWIT-49

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION ATLANTIS ENERGY LTD	ADDRESS: Thunstrasse 8 3006 Bern
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT thermophotovoltaïc collector

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a concentrating roof integrated solar collector for the production of thermal and electrical energy simultaneously.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Phase I: The theory of the thermophotovoltaïc collector. Optimisation of a model-design and construction of two prototypes with 20x and 40x concentrating factors.

Phase II: Measurements of efficiency. Energy spectral analysis. Optimisation of components and system.

Phase III: Development of production prototypes.

PERIOD OF PROJECT:

1979-1980

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-50

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION ATLANTIS ENERGY LTD	ADDRESS: Thunstrasse 8 CH - 3000 Bern 6
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT Calorimeter for power tower systems

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a cavity calorimeter, specially designed for energy flux measurements on the receiver plane of power tower Heliostats.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:
1979-1980

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-51

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION ATLANTIS ENERGY LTD	ADDRESS: Thunstrasse 8 CH-3000 Bern 6
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT Chemical thermal storage

OBJECTIVE AND NATURE OF THE PROGRAM:

Development of a chemical and sensible heat storage system.

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:

1979-1980

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: SWIT-52

INTERNATIONAL ENERGY AGENCY

SURVEY OF COMPONETS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

COUNTRY: Switzerland

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION ATLANTIS ENERGY LTD	ADDRESS: Thunstrasse 8 CH - 3000 Bern 6
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT Solar seawater desalination unit

OBJECTIVE AND NATURE OF THE PROGRAM:

Conception and development of a multistage desalination unit specially adapted to solar energy supply (in cooperation with EPFL).

PRESENT STATUS OR SUMMARY OF SIGINIFICANT ACCOMPLISHMENTS:

Construction of a 10 ton/day prototype and start of industrial production.

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-1

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ______________
NAME OF ORGANIZATION Acurex Corporation, Alternate Energy Division	ADDRESS: Acurex Corporation Alternate Energy Division 485 Clyde Avenue Mountain View, CA 94042
NAME OF PRINCIPAL RESEARCHER E.V. Nelson and Tim Muller	

TITLE OF PROJECT
Further Development of a Low Cost Solar Panel

OBJECTIVE AND NATURE OF THE PROJECT:

The primary objective of the research is to fabricate and test a large panel section of the laminated plastic film.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

A prior contract demonstrated the feasibility of using high production rate machinery to produce a flat plate collector of laminated plastic flim. This contract is a follow-on to produce a collector and test its performance; the follow-on work has just commenced.

PERIOD OF PROJECT:
Sept. 79 - Sept. 80

FUNDING IN $ U.S.:
$146,850

IMPORTANT REPORTS OR PUBLICATIONS:

Prior contract draft final report 79-348 "Development of a Low-Cost Solar Panel Using Laminated Polymer Films." No publications on this contract.

Code No.: US-1

ORGANIZATION: Acurex Corporation, Alternate Energy Division

PROJECT TITLE: Further Development of a Low Cost Solar Panel

DATA SHEET

Component : Solar Collector

a) Type: Flat plate constructed of laminated plastic film

b) $\delta\tau$: Not available. Estimated at 0.81

c) Overall loss coefficient: Not available (Ambient to 77°C)

d) Heat Capacity: Not available

e) Heat Transfer Medium: Water

f) Material: Absorber - Hytrel, Pet, Polypropylene, High Density Polyethylene

Glazing - Single (Material not selected)

Insulation - Not selected

g) Expected Lifetime: 3-5 years

h) Estimated Cost: $20-30/M^2

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-2

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] Weather Modeling
NAME OF ORGANIZATION ALTAS CORPORATION	ADDRESS: 500 Chestnut Street Santa Cruz, CA 95060
NAME OF PRINCIPAL RESEARCHER Francis de Winter	

TITLE OF PROJECT "Development of Cost-Effective Hail Protection Devices for Solar Flat Plate Collectors."

OBJECTIVE AND NATURE OF THE PROJECT:

1. To define the probability of encountering large, potentially damaging hail on solar ground installations.
2. To evaluate the size of hail to which solar flat plate collector glazings are susceptible (by impacting test glazings with simulated hail).
3. To evaluate the design and cost-effectiveness of protection devices, such as cover screens. Also to evaluate penalties realized in their use, such as thermal performance lost due to shading effects.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

1. Above has essentially been completed at present, with a statistical model that can be used to assess the risk of encountering large, potentially damaging hail anywhere in the Central United States. Work on 2. and 3., continues with results to be available in the near future (11/03/79).

PERIOD OF PROJECT: June, 1978 - November, 1979

FUNDING IN $ U.S.: $59,890

IMPORTANT REPORTS OR PUBLICATIONS:

M. Cox and P.R. Armstrong, "A Statistical Model for Assessing the Risk of Hail Damage to Any Ground Installation," prepared by Altas Corporation for the U.S. Department of Energy, ALO/4291-1, September 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-3

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] COLLECTOR DEVELOPMENT

NAME OF ORGANIZATION

ALUMINUM COMPANY OF AMERICA

NAME OF PRINCIPAL RESEARCHER

ROBERT B. WHITESIDES

ADDRESS:

ALUMINUM COMPANY OF AMERICA
ALCOA TECHNICAL CENTER
ALCOA CENTER, PA 15069

TITLE OF PROJECT

DEVELOPMENT OF SOLAR WALL ASSEMBLY

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of the program is to develop a low temperature, non-concentrating solar air heater that can be installed as a integral part of a building structure primarily for comfort air heating. Key criterion is to develop a passive collector that will insure pay-back of less than 10 years as a result of energy savings.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The program was completed with the submission of the draft final report. The report indicates a low temperature passive collector can meet the objectives when compared with electrical energy. The passive collector concept operates at low temperatures resulting in high efficiency and low costs. With the integration of the collector into the structure, additional economies were obtained by eliminating redundant components common to the collector and structure.

PERIOD OF PROJECT:

76-September 27-79 February 28

FUNDING IN $ U.S.:

$135,890.00

IMPORTANT REPORTS OR PUBLICATIONS:

DEVELOPMENT OF SOLAR WALL ASSEMBLY - Final draft report. Dated 1979 March 20.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-4

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ________

NAME OF ORGANIZATION
Argonne National Laboratory

NAME OF PRINCIPAL RESEARCHER
Kent A. Reed

ADDRESS: Chemical Engineering Division
9700 South Cass Ave., Bldg. 362
Argonne, IL 60439
USA

TITLE OF PROJECT
Development & Demonstration of CPC Collectors for Solar Heating & Cooling Applications

OBJECTIVE AND NATURE OF THE PROJECT: The objective of this project is the development and demonstration of improved collector systems for heating and cooling buildings. The price and performance levels required for effective solar heating and cooling are being sought through the combining of optical concentration and evacuated absorbers in practical collector designs. Argonne National Laboratory has been a leader in developing the family of nonimaging optical concentrators known generically as compound parabolic concentrators. Solar collectors based on these concentrators possess very large angular fields of view, such that for moderate concentration levels they can be stationary or require only seasonal tilt adjustments. Their performance is extremely tolerant of mirror errors and surface imperfections, and they accept a large fraction of the diffuse sky radiation. To promote early commercialization, the work includes measurements of solar materials properties and evaluation of commercial and experimental components such as absorbers. Existing and proposed collector designs are analysed optically and thermally, and completed modules are evaluated experimentally at the Argonne Solar Energy Test Facility.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Stationary concentrating collector designs developed at Argonne have been successfully commercialized. Sunmaster Corporation, Corning, NY (USA) sells a 1.3m^2 aperture module with north-south oriented absorbers, designed for drainable operation at temperatures below about 115°C using water. Energy Design Corporation, Memphis, TN (USA), sells a 2.6m^2 aperture module with east-west oriented absorbers designed for operation at temperatures up to about 230°C using heat transfer oils.

PERIOD OF PROJECT: Continuing

FUNDING IN $ U.S.: 300,000

IMPORTANT REPORTS OR PUBLICATIONS:

W. R. McIntire, "Truncation of Nonimaging Cusp Concentrators," Solar Energy 23, 351 (1979).

M. Collares-Pereira, et al., "Applications of CPC's in Solar Energy - An Overview," Proceedings of 1979 International Congress, ISES, 1979.

Code No.: US-4

ORGANIZATION: ARGONNE NATIONAL LABORATORY

PROJECT TITLE: Development and Demonstration of CPC Collectors for Solar Heating and Cooling Applications

DATA SHEET

Component : a) Type: Stationary nonimaging concentrating collector (generic description)
Evacuated tubular absorber in CPC cusp-reflector troughs
Concentration ratio ca 1.5x

b) Optical efficiency (ordinate intercept): currently ca. 0.53 using presently available commercial absorbers.

c) Heat loss coefficient: 0.6 W/m^2-K-0.8 W/m^2-K for $20°C<\Theta<150°C$

d) Thermal time constant: 1.5 min-15 min depending upon manifolding and fluid channel configuration.

e) Heat transfer fluid: liquid - water, water and antifreeze.

f) Material:

i) Absorber - evacuated tubes (Owens Illinois, General Electric); typically α = 0.78-0.80, ε = 0.04-0.-06, τ = 0.92.

ii) Reflector - anodized electropolished aluminum sheet or plastic/aluminum film on aluminum; typically ρ = 0.85.

iii) Cover plate - low iron content glass, typically τ = 0.92.

g) Estimated life time: 20 years

h) Current sales price ca $250/$m^2$ (US)

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-5

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________

NAME OF ORGANIZATION
Battelle-Columbus Laboratories

ADDRESS:
505 King Avenue
Columbus, Ohio 43201

NAME OF PRINCIPAL RESEARCHER
D. Karl Landstrom

TITLE OF PROJECT
Development of a Low-Cost Black-Liquid Solar Collector

OBJECTIVE AND NATURE OF THE PROJECT:

(1) To evaluate several candidate plastic materials suitable for black-liquid solar collectors

(2) To plan and conduct long-term exposure evaluations of combinations of plastic collectors and improved black fluids

(3) To investigate overall system performance for variations in collector designs, materials, and applications, in order to obtain sufficient data to design a full-scale demonstration for a commercial application which will provide long life and good performance.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

(1) Two collector test facilities are being built for outdoor durability studies in Columbus, Ohio, and Phoenix, Arizona.

(2) Literature survey and materials aging studies have begun.

PERIOD OF PROJECT: 1/79 - 5/81

FUNDING IN $ U.S.: $150,000

IMPORTANT REPORTS OR PUBLICATIONS:

(1) Landstrom, D. K., Stickford, G. H. Jr., Talbert, S. G., and Hess, R. E., "Development of a Low-Temperature, Low-Cost Solar Collector Using a Black-Liquid Concept", Proceedings of the 1978 AS/ISES Meeting, Denver, Colorado, Vol. 2.1, pp 228-234 (August 1978).

Code No.: US-5

ORGANIZATION: Battelle-Columbus Laboratories

PROJECT TITLE: Development of a Low-Cost Black-Liquid Solar Collector

DATA SHEET

Component :

Solar Collectors

a) Flat plate

b) $\alpha\tau = 0.85$

c) $U_L = 15.45\ w/m^2K$

   Temperature range (less than 70 C)

d) Heat capacity = 12 wh/m^2K

e) Water/propylene glycol

f) Absorber - black fluid

   Cover plate - acrylic or polycarbonate

   Insulation - 25 mm Syrafoam

g) Expected life - 10 yrs

h) Cost $ US - 65/m^2

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-6

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______

NAME OF ORGANIZATION
BATTELLE-COLUMBUS LABORATORIES

NAME OF PRINCIPAL RESEARCHER
RONALD B. DIEGLE

ADDRESS: BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

TITLE OF PROJECT
Corrosion Problems with Aqueous Coolants

OBJECTIVE AND NATURE OF THE PROJECT:

The objectives of this program were to elucidate the corrosion problems likely to be encountered with nonconcentrating solar collectors and aqueous heat-transfer fluids, and to recommend procedures for minimizing corrosion damage. Specific objectives were to: (1) review the current state of the art of collector corrosion processes; (2) study corrosion in multi-metallic systems; and (3) characterize the degradation and changes in corrosivity of various chemical antifreeze additives.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The corrosion behavior of candidate metals of construction for solar collectors was evaluated under accelerated conditions simulating harsh collector operating conditions. Degradation of glycol-base coolants was characterized.

PERIOD OF PROJECT: 9/78 to 9/79

FUNDING IN $ U.S.: $206,000

IMPORTANT REPORTS OR PUBLICATIONS:

Diegle, R. B., Beavers, J. A. and Clifford, J. E., "Corrosion Problems With Aqueous Coolants", Final Report to United States Department of Energy, Office of Solar Applications, Contract No. DE-AC04-79CS10510, November, 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-7

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION CALMAC Manufacturing Corporation	ADDRESS: 150 South Van Brunt Street Englewood, N.J. 07631
NAME OF PRINCIPAL RESEARCHER Calvin D. MacCracken	

TITLE OF PROJECT
Development of Flat Plate Collector with Flexible Elastomeric Absorber

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of the project was to develop a single-glazed flat plate collector using a flexible elastomeric absorber that could be assembled in the field. The advantages of this approach are as follows: collectors can be dimensioned to fit the demands of the site, lighter weight, lower cost, easy repairs, fewer problems in shipping, freeze-tolerance.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The development was successful. The product is now commercially available under the tradename SunMat.

PERIOD OF PROJECT: Oct.'76 - April '77 FUNDING IN $ U.S.: $133,000

IMPORTANT REPORTS OR PUBLICATIONS:
Installation, Operation and Maintenance Manuals are available.

Code No.: US-7

ORGANIZATION: Calmac Manufacturing Corporation

PROJECT TITLE: Development of Flat Plate Collector with Flexible Elastomeric Absorber

DATA SHEET

Component : Solar Collector

a. Type: flat plate

b. at: .70

c. overall heat loss coefficient (U_L): .86

temperature range: 0-100°C

d. heat capacity:

e. heat transfer medium: water or antifreeze

f. materials:

absorber: EPDM, a = .95, e = .95

cover plate: single-glazed, polyester

insulation: 1" of isocyanurate

g. expected life time: 15 years

h. estimated cost: $\$85/m^2$

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-8

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [ ] ____________
NAME OF ORGANIZATION Dow Corning Corporation NAME OF PRINCIPAL RESEARCHER James A. Rabe	ADDRESS: P.O. Box 1592 3901 S. Saginaw Road Midland, MI 48640

TITLE OF PROJECT

Development of Improved Insulation Materials

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this study is to develop a thermally stable low density silicone elastomeric foam as principal insulation for flat plate solar collectors. The project includes:

1. Selection and optimization of a low density foam formulation.
2. Demonstration of the foam's performance in a solar collector environment.
3. Calculation of the foam's cost effectiveness.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

A 3 lb/ft^3 silicone foam has been produced which is stable at 200°C, possesses excellent weatherability, and is flame retardant. Flat plat solar collectors insulated with this foam or a composite of silicone foam and isocyanurate foam meet the HUD Cycle 4A requirements. Silicone foam has a higher initial cost than isocyanurate or fiber glass, but its superior performance may make it more cost effective over the life of a collector system.

PERIOD OF PROJECT:

Sept. 1, 1978 - Sept. 30, 1979

FUNDING IN $ U.S.:

$141,116

IMPORTANT REPORTS OR PUBLICATIONS:

"Development of Improved Insulation Materials" Final Report
Contract No. EM-78-C-04-4295, September, 1979

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-9

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________

NAME OF ORGANIZATION

Drexel University

NAME OF PRINCIPAL RESEARCHER

D.C. Larson & C.W. Savery

ADDRESS:

Dept. Physics and Atmos. Science
Drexel University
Philadelphia, PA 19104

TITLE OF PROJECT Double-Exposure Collector System

OBJECTIVE AND NATURE OF THE PROJECT:

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 ACCOMPLISHMENTS:

The DEC units have been found to provide from two (summer) to four (winter) times as much useful heat output per panel area than conventional collectors. Design modifications have also been made which would further enhance the DEC unit performance. The cost of the DEC units is estimated to be only 1.7 times more than conventional collectors per panel area and as a result a local company has begun to manufacture modified DEC units. The modified units are designed for at least biannual front and rear mirror adjustments and feature a modified rear-mirror enclosure and a completely redesigned panel and enclosure structure.

PERIOD OF PROJECT: 30 September 1977 to 30 September 1979

FUNDING IN $ U.S.: $75,536

IMPORTANT REPORTS OR PUBLICATIONS:

Proc. Int. Solar Energy Congress, New Delhi, India, Vol. 2, p. 1033, Jan. 1978
Proc. Am. Sec. Int. Solar Energy Soc., Vol. 2.1, p. 649, Aug. 1978.
Proc. Izmir Int. Symp. on Solar Energy, Izmir, Turkey, Aug. 1979
"Mirror Enclosures for Double-Exposure Solar Collectors," Solar Energy, to be publ.
"Optimization of Flat-Plate Collector-Flat Mirror Systems," " " "
"Solar Elevation Angle Probability Distribution," Solar Energy, to be published.

Code No.: US-9

ORGANIZATION: Drexel University

PROJECT TITLE: Double-Exposure Collector System

DATA SHEET

Component : Solar Collector

a) 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 = 6 W/m^2K at 60 to 90 ^oC.

d) Fluid heat capacity unknown.

e) Heat transfer medium is water-propylene glycol with additives.

f) Material
   i) absorber: α = 0.98, ε = 0.3
   ii) cover plate: one with τ = 0.9
   iii) insulation: none

g) Expected life time t = 20 years for collector, unknown for glass mirrors

h) Estimated cost $200/$m^2$

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-10

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______

NAME OF ORGANIZATION
Dynamic Flow Inc.

NAME OF PRINCIPAL RESEARCHER
John L.Loth

ADDRESS:
Dynamic Flow Inc.
P.O.Box 4094
Morgantown WV 26505

TITLE OF PROJECT Unpowered, Frost Resistant, Inexpensive Solar Hot Water Heater

OBJECTIVE AND NATURE OF THE PROJECT:

The object is to develop a freezing and thawing resistant flat plate domestic solar hot water heater. The unit is designed to operate under city water pressure and does not use heat exchangers, anti-freeze or special drain down systems. The collector is connected in line with the city cold water supply. When the collector freezes or the water inside the collector is too cold then the water supply automatically by passes the collector. Such a collector appears thermally efficient and inexpensive to construct.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

An experimental solar absorber is presently undergoing cyclic freezing and thawing tests to determine if the freeze protection is adequate.

PERIOD OF PROJECT: 9-29-'79 to 9-30-'80 FUNDING IN $ U.S.: $8336.-

Appropriate Technology Small Grant Program, Region 111 of U.S. Department of Energy

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-11

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [x] AIR CONDITIONING UNIT [x] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [x] SYSTEMS SIMULATION
NAME OF ORGANIZATION EIC Corporation	ADDRESS: 55 Chapel Street Newton, Massachusetts 02158 USA
NAME OF PRINCIPAL RESEARCHER Peter O'D. Offenhartz	

TITLE OF PROJECT: COMPUTER SIMULATION OF THE PERFORMANCE OF CHEMICAL HEAT PUMPS BASED ON THE H_2SO_4/H_2O, $CaCl_2/CH_3OH$, and NH_4NO_3/NH_3 REACTIONS

OBJECTIVE AND NATURE OF THE PROJECT:

To simulate and compare the projected performance of chemical heat pump based on the reactions above, both in the heating and cooling modes, and as storage devices.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

TRNSYS-compatible subroutines have been written for all three chemical heat pumps. Detailed comparisons of the systems are in progress.

PERIOD OF PROJECT: 19 Months

FUNDING IN $ U.S.: $104,000

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report (on subroutine development) available from Argonne National Laboratory.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-12

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION EIC Corporation	ADDRESS: 55 Chapel Street Newton, Massachusetts 02158
NAME OF PRINCIPAL RESEARCHER Dr. Victor R. Koch	

TITLE OF PROJECT CORROSION PROTECTION OF SOLAR-COLLECTOR HEAT EXCHANGERS WITH ELECTROCHEMICALLY DEPOSITED FILMS

OBJECTIVE AND NATURE OF THE PROJECT:

This program is concerned with the electropolymerization of films onto the interior of solar-collector heat exchangers. The in situ deposition of thin, coherent organic films on solar-collector metals (Al, Cu, mild steel) should prevent, or at least minimize, parasitic corrosion reactions. The work will focus on the anodic polymerization of substituted phenols to polyphenylene oxides and the cathodic polymerization of substituted styrenes to polystyrenes. These polymers are adherent, and are expected to have suitable chemical and thermal stability for solar-collector heat exchangers.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

We have demonstrated the feasibility of anodically filming Cu and mild steel tubing; Al tubing may be cathodically filmed. Although the films as such are adherent, they are not pinhole free. However, by heterogeneously cross linking these films in a subsequent chemical step the film may be "sealed." Filmed and cross linked Al tubing has been found to resist pitting in 50:50 ethylene glycol: H_2O at 125°C

PERIOD OF PROJECT: 18 Months

FUNDING IN $ U.S.: 203,000

IMPORTANT REPORTS OR PUBLICATIONS:

G. H. Schnaper, V. R. Koch and S. B. Brummer, Corrosion Protection of Solar-Collector Heat Exchangers and Geothermal Systems by Electrodeposited Organic Films, submitted to ASTM Symposium Proceedings.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-13

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] System Development

NAME OF ORGANIZATION E-Tech, Inc.	ADDRESS: 3570 American Drive Atlanta, GA 30341
NAME OF PRINCIPAL RESEARCHER Sam V. Shelton	

TITLE OF PROJECT Ground Coupled Solar Assisted Heat Pump Field Performance Evaluations

OBJECTIVE AND NATURE OF THE PROJECT:

This program is designed to collect field data on seven residential ground coupled solar assisted heat pump systems. Two system concepts will be evaluated using low temperature solar collectors, a water-to-air heat pump, and a ground coil. The first concept uses low temperature solar collectors storing heat in a water storage tank. House heating is accomplished by a heat pump using either the storage tank or a ground coil as a heat source.

The second system concept eliminates the water storage tank. The low temperature solar collectors store heat directly in the ground via the ground coil. House heating is supplied by the heat pump extracting this ground heat to heat the house. Air conditioning in both concepts is supplied by the heat pump rejecting heat to the ground. The systems are completely instrumented with solar radiation, Btu, kwhr, and temperature recorders to determine all system performance parameters.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

All ground coils have been installed and systems operating. Instrumentation on two installations are installed. Others are presently being instrumented.

PERIOD OF PROJECT: 79 Apr thru 79 Sept FUNDING IN $ U.S.: $177,520

IMPORTANT REPORTS OR PUBLICATIONS: None to date

Code No.: US-13

ORGANIZATION: E-Tech, Inc.

PROJECT TITLE: Ground Coupled Solar Assisted Heat Pump Field Performance Evaluations

DATA SHEET

Component : Solar Collectors - 7 systems

a) type - Flat Plate
b) $\tau\alpha$ = 0.7
c) Heat loss coefficient - 8 $w/m^2\ ^oK$
d) Heat capacity - .003 $wh/m^2\ K$
e) Heat transfer medium - silicone fluid
f) material - i) absorber - steel (α = 0.9, ϵ = 0.9)
ii) cover plate - fiberglass (1, 0.80)
iii) insulation - fiberglass (15 cm)
g) life time - 10 years
h) Estimated Installed Cost - $80/m^2$

Code No.: US-13

ORGANIZATION: E-Tech, Inc.

PROJECT TITLE: Ground Coupled Solar Assisted Heat Pump Field Performance Evaluations

DATA SHEET

Component : Heat Storage - 4 systems

a) type - water tank
b) heat capacity - 58 wh/m^3 ($50^{\circ}C$ range)
c) latent heat - (not applicable)
d) heat exchanger - Yes (water)
e) heat rate - 15 kw
f) insulation - 15 cm urethane
g) expected life - 20 years

Code No.: US-13

ORGANIZATION: E-Tech, Inc.

PROJECT TITLE: Ground Coupled Solar Assisted Heat Pump Field Performance Evaluations

DATA SHEET

Component : Heat Storage - 3 systems

a) type - ground soil
b) heat capacity - 0.85 wh/m^3 ^{o}K
c) latent heat - not applicable
d) heat exchanger - Yes (water)
e) heat rate - 15 kw
f) insulation - none
g) expected life time - 20 years

Code No.: US-13

ORGANIZATION: E-Tech, Inc.

PROJECT TITLE: Ground Coupled Solar Assisted Heat Pump Field Performance Evaluations

DATA SHEET

Component : Air Conditioning and Cooling - 7 systems

a) type - water-to-air heat pump

b) Type of refrigerator - electric vapor/compression

c) Capacity - 3-1/2 tons

d) Temperature range - not applicable

e) COP - 2.5

f) heat exchanger - water condensing loop to ground coil

g) auxiliary heat source - none

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-14

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION FAFCO, INC. NAME OF PRINCIPAL RESEARCHER Nicholas J. Chapman	ADDRESS: 235 Constitution Drive Menlo Park, CA 94025

TITLE OF PROJECT A COAXIAL EXTRUSION CONVERSION CONCEPT FOR POLYMERIC FLAT PLATE SOLAR COLLECTORS

OBJECTIVE AND NATURE OF THE PROJECT: TO RESEARCH MATERIALS AND PROCESSES FOR FUNDAMENTAL IMPROVEMENTS IN FLAT-PLATE SOLAR COLLECTOR COST AND PERFORMANCE. THE GOAL IS TO DEVELOP A PROCESS FOR DIRECT CONVERSION OF INEXPENSIVE RAW MATERIALS INTO FINISHED SOLAR COLLECTORS WITHOUT LABOR INTENSIVE ASSEMBLY OPERATIONS. USE OF MATERIAL CAREFULLY MATCHED TO THE PROCESS AND END USE ENVIRONMENT WILL SUBSTANTIALLY REDUCE COLLECTOR COSTS COMPARED TO CONVENTIONAL INDUSTRY PRACTICE.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
FINAL TECHNICAL REPORT WILL BE COMPLETED JANUARY 1980, INCLUDING SUMMARY OF ENTIRE PROJECT. POLYMERIC MATERIALS RESEARCH THROUGH PROCESSING EXPERIMENTS.

PERIOD OF PROJECT: 9/30/78 - 12/31/79

FUNDING IN $ U.S.: $120,852 Phase I

IMPORTANT REPORTS OR PUBLICATIONS:
TECHNICAL STATUS REPORTS SUBMITTED MONTHLY

Code No.: US-14

ORGANIZATION: FAFCO, INC.
235 CONSTITUTION DRIVE
MENLO PARK, CA 94025

PROJECT TITLE:

A COAXIAL EXTRUSION CONVERSION CONCEPT FOR POLYMERIC FLAT PLATE SOLAR COLLECTORS

DATA SHEET

Component :

SOLAR COLLECTORS

a. Type - Flat Plate, Tubular Profile

b. = .85

c. Overall heat loss coefficient U_L [W/m^2K] = 6.35 W/m^2K

d. Heat Capacity C [Wh/m^2K] = Not avavilable at this time.

e. Heat Transfer Medium = Water

f. Material
   i) absorber = Unknown at present =.90 avg.
   ii) Cover plate = Polycarbonate, 1 plate, =.90 avg.
   iii) Insulation - Polyurethane, Air, Thickness=2.45CM

g. Expected Life Time = $^+$10 yrs.

h. Estimated Cost = $125/$m^2$

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-15

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [X] SYSTEM DEVELOPMENT
NAME OF ORGANIZATION Fern Engineering Co. NAME OF PRINCIPAL RESEARCHER Philip Levine	ADDRESS: 536 MacArthur Blvd. Bourne, MA 02532

TITLE OF PROJECT
Residential Solar Heating Development & Demonstration

OBJECTIVE AND NATURE OF THE PROJECT:

The contract was issued to advance the development of air heating flat plate collectors and application to residential space heating/DHW systems in colder US climates. Collectors were designed and built. A test facility was built. Collectors were tested per ASHRAE 93. Systems were installed instrumented and tested at Lansing, Mich. and Tunkhannock, PA.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Accomplishments:

1) Collector optical, thermal, & mechanical design & test
2) System thermal & mechanical design & test
3) Performance design & evaluation & power consumption economics
4) Cost economics

PERIOD OF PROJECT:
October 1976 - September 1979

FUNDING IN $ U.S.: $198,000.

IMPORTANT REPORTS OR PUBLICATIONS:

Code No. US-15

Fern Engineering Co.

DATA SHEET

SOLAR COLLECTORS

a) Type - flat plate

b) $\alpha\tau$ = .61

c) Overall heat loss coefficient U_L = 4.2 W/m^{2}K

d) Time constant 2.5 min.

e) Heat transfer medium air

f) Material
   i) absorber α = .93 ϵ = .08
   ii) cover plate: Single glass τ =.91
   iii) insulation: 3" fiberglass, 1" isocyanurate

g) Expected life time: 20 years

h) Estimated cost: $220/m^2

HEAT STORAGE

a) Water

b) Heat capacity ———

c) Latent heat ———

d) Heat exchanger: air to water

e) Heat rate 45000 Btu/hr.

f) Insulation: 9" fiberglass

g) Expected life time: 20 years

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-16

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [x] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [ ] ________
NAME OF ORGANIZATION General Electric, Advanced Energy Department	ADDRESS: P. O. Box 8661 Philadelphia, PA 19101
NAME OF PRINCIPAL RESEARCHER James C. Graf	

TITLE OF PROJECT System Design and Development of Solar Heating & Cooling Systems

OBJECTIVE AND NATURE OF THE PROJECT:

Design, develop and field test prototype heating and heating and cooling systems for residential and commercial applications. Development included are evacuated tubular collector, energy management module, controls, 3 ton and 10 ton heat pumps

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Four heating only systems and one 3 ton residential heating and cooling system have been installed and are operating. The two ten ton heating and cooling systems have completed laboratory test and have been delivered to TVA for installation

PERIOD OF PROJECT: July '76 thru present FUNDING IN $ U.S.: 8,591,800

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report - Solar Heating & Cooling System Design and Development

Code No.: US-16

ORGANIZATION: General Electric Co.
Advanced Energy Department

PROJECT TITLE:

Solar Heating and Cooling System Design and Development

DATA SHEET

Component :

a. Type: Evacuated tubular solar collector with mildly concentrating cusp type reflector

b. $\alpha\tau$ = 0.574

c. Overall heat loss coefficient:

$U_L = (.009)\ (T_{Fi} - T_A) + (.306)$ at Insolation = 81.27 $\frac{CAL.}{hr\ CM^2}$

Temperature range - ambient: -29°C to 60°C (-20°F to 140°F)

fluid: 38°C to 150°C (100°F to 300°F)

T_{Fi} = Fluid Inlet Temp °C; T_A = Ambient Temp °C

d. Heat capacity: (1.1) $\frac{Wh}{M^2\,^oK}$ (Gross Area: $1.62M^2$)

e. Heat Transfer medium: water with 35% Prestone II

f. Material: i) absorber - selective multi layer coating α = .88, ϵ = .04

ii) cover plate - evacuated tube, optional acrylic or Lexan cover if desired

iii) insulation - evacuated tube
- fiberglass on headers

g. Expected life time: greater than 15 years

h. Cost ($215 U.S./$M^2$) - Manufacturer's List Price 1979

Code No.: US-16

ORGANIZATION: General Electric Co.
Advanced Energy Department

PROJECT TITLE: Solar Heating and Cooling System Design and Development

DATA SHEET

Component :

a. Type: Heat Pump

b. Rankine driver cycle (FC-88 working fluid)
Rankine direct expansion cooling cycle (R22 working fluid)

c. 3 ton capacity

d) Operating temperature range of working fluid: 115 to 150°C (240 - 300°F)

e) $C.O.P._{th} = .59^{(1)}$
EER = 20.5

f) Air condensing heat exchanger (110°F operation at 95°F standard ASHRAE conditions)

g) Auxiliary heat source - electric heat pump using the same direct expansion equipment

(1) Measured performance of initial prototype. Anticipated performance of future systems = .80

Code No.: US-16

ORGANIZATION: General Electric Co.
Advanced Energy Department

PROJECT TITLE: Solar Heating and Cooling System Design and Development

DATA SHEET

Component :

a. Type: Heat Pump

b. Rankine driver cycle (FC88 working fluid)
Rankine direct expansion cooling cycle (R22 working fluid)

c. 10 ton capacity

d. Operating temperature range of working fluid: 115 to 150°C+ (240 to 300°F+)

e. COP_{th} = .73 (1) (2)
EER = 20.65 (1)

f. Air condensing heat exchanger (110°F operation at 95°F standard ASHRAE conditions)

g. Auxiliary heat source - electric heat pump using the same direct expansion equipment

(1) Measured test result

(2) Anticipated performance of future system estimated to exceed COP_{th} = .8

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS — Code No. 17

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ______

NAME OF ORGANIZATION
General Electric Company

NAME OF PRINCIPAL RESEARCHER
K. L. Hanson

ADDRESS:
Valley Forge Space Center
P.O. Box 8661
Philadelphia, PA 19101

TITLE OF PROJECT
Medium Temperature Air Heater Development Program

OBJECTIVE AND NATURE OF THE PROJECT:
The overall objective of this project was to develop a superior Btu/$, non-concentrating, medium temperature air heater for space heating and domestic hot water applications. It was intended to utilize the vacuum tube solar absorber previously developed by General Electric for solar collectors. Cost effectiveness and producibility for volume production were key considerations. The design studies resulted in the conclusion that the domestic hot water applications provided the best near term commercialization opportunity so the design effort was directed at this application. The product concept included the use of 2, 3 or 4 solar collectors (nominally 16 ft.^{2} each), interconnecting ductwork, and the air to water heat exchanger, pump, blower, and controls unit. The product is connected to an on-site water tank to provide a hot water supply.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The project has been completed and the final report is in the review process. Two prototype units were built for evaluation purposes.

The design concept was the basis for further product development activity and it is anticipated that units will be sold commercially in selected regions to evaluate the market.

PERIOD OF PROJECT:
09/30/77 to 12/31/78

FUNDING IN $ U.S.:
$149,800

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report (in review).

"Medium Temperature Air Heater," Proceedings, Third Annual DOE Solar R&D Contractors' Meeting, September 1978.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-18

COUNTRY: UNITED STATES

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

NAME OF ORGANIZATION
GINER, INC.

ADDRESS:
14 Spring Street
Waltham, MA 02154

NAME OF PRINCIPAL RESEARCHER
Jose Giner

TITLE OF PROJECT
Study of Corrosion and Its Control in Aluminum Solar Collectors

OBJECTIVE AND NATURE OF THE PROJECT:

To obtain means whereby aluminum solar heat collectors and aqueous glycol heat transfer fluids can be used safely over extended periods of time.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

- Uninhibited glycol solutions are too corrosive to aluminum solar collector systems, especially when chloride and heavy metal ions are present.
- Conventional corrosion inhibitors used in automotive coolants provide adequate corrosion protection at operating temperatures below 100°C.
- A combination of zinc powder and conventional corrosion inhibitors can stop aluminum corrosion totally up to 160°C.

PERIOD OF PROJECT:
June 1, 1976 - July 31, 1978

FUNDING IN $ U.S.:
$190,000.00

IMPORTANT REPORTS OR PUBLICATIONS:

1 - D. Wong, L. Swette and F. H. Cocks, "Aluminum Corrosion in Uninhibited Ethylene Glycol-Water Solutions," J. Electrochem. Soc., 126, 11 (1979).
2 - J. Giner, F. H. Cocks and D. Wong, "Study of Corrosion and Its Control in Aluminum Solar Collectors," Annual Progress Report (COO-2934-4), 6/1/76-5/31/77.
3 - D. Wong, F. H. Cocks, J. Giner and P. S. Majahad, "Study of Corrosion and Its Control in Aluminum Solar Collectors," Annual Report (COO-2934-7), 6/1/77-7/31/78.

<table>
<tr><td colspan="2">COUNTRY: UNITED STATES</td></tr>
<tr><td>COMPONENTS</td><td>TYPE OF RESEARCH</td></tr>
<tr><td>[x] SOLAR COLLECTOR
[ ] THERMAL ENERGY STORAGE
[ ] AIR CONDITIONING UNIT
[ ] OTHER SUBSTANTIAL COMPONENTS</td><td>[ ] MATERIALS RESEARCH
[ ] COMPONENT DEVELOPMENT
[x] Feasibility Study</td></tr>
<tr><td>NAME OF ORGANIZATION
Honeywell, Inc.</td><td rowspan="2">ADDRESS:</td></tr>
<tr><td>NAME OF PRINCIPAL RESEARCHER
P. D. Mitchell</td></tr>
<tr><td colspan="2">TITLE OF PROJECT
SOLAR THERMAL ENHANCED OIL RECOVERY</td></tr>
</table>

OBJECTIVE AND NATURE OF THE PROJECT:

Investigate the feasibility of utilizing current parabolic trough tracking solar collectors to provide process steam for existing enhanced oil recovery techniques.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Study in Progress

PERIOD OF PROJECT:

1 October 1979 - 31 March 1980

FUNDING IN $ U.S.:

$130,000

IMPORTANT REPORTS OR PUBLICATIONS:

- None Published Yet

Code No.: US-19

ORGANIZATION:

Honeywell, Inc.

PROJECT TITLE:

SOLAR THERMAL ENHANCED OIL RECOVERY

DATA SHEET

Component : Solar Collector

a) Concentrating, tracking, parabolic trough

b)

c) Temperature Range -15°C to 300°C

d)

e) High Pressure Water or Oil

f) Steel absorber with selective coating
(black chrome, $\alpha = 0.94$, $\epsilon = 0.12$)
Glass Cover

g)

h) ~\$200/m^2

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-20

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Demo/Field Test

NAME OF ORGANIZATION
Honeywell, Inc.

ADDRESS:

NAME OF PRINCIPAL RESEARCHER
P.D. Mitchell

TITLE OF PROJECT
TEXTILE DRYING USING SOLAR PROCESS STEAM

OBJECTIVE AND NATURE OF THE PROJECT:

The overall objective of this DOE program is to design, test, and evaluate the application of solar energy to textile drying. During the second phase of the program, the solar process steam system, including a concentrating collector field, was installed at the West Point Pepperell Fairfax, Alabama, textile mill. This system will supply saturated steam to the cylindrical can dryers in a textile process line. The third phase is directed toward operation and evaluation of this process steam system.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

- Detailed Design Complete
- Installation Complete
- Operational Period Underway
- System Upgrade Proposed

PERIOD OF PROJECT:

March 1976 to Present

FUNDING IN $ U.S.:

$890,000

IMPORTANT REPORTS OR PUBLICATIONS:

- Phase I Final Report
- Phase II Final Report

Code No.: US-20

ORGANIZATION:

Honeywell, Inc.

PROJECT TITLE:

TEXTILE DRYING USING SOLAR PROCESS STEAM

DATA SHEET

Component : Solar Collectors

a) Concentrating, tracking, parabolic trough, aluminum honeycomb mirror structure, aluminized acrylic film mirror, A/C motor gear drive

b)

c) Temperature range -15°C to 210°C

d)

e) High Pressure Water

f) Steel absorber with selective coating
(black chrome $\alpha = .94$ $\epsilon = .12$)
Single etched glass window
Calcium Silicate Insulation - 1.5 inches

g)

h) $360/m^2

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-21

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [x] Concentrator Optical Performance Analysis
NAME OF ORGANIZATION Honeywell, Inc.	ADDRESS: 2600 Ridgway Parkway Minneapolis, MN 55413
NAME OF PRINCIPAL RESEARCHER Gary Smith	

TITLE OF PROJECT

SURVEY MIRRORS AND LENSES AND THEIR REQUIRED SURFACE ACCURACY

OBJECTIVE AND NATURE OF THE PROJECT:

This project is investigating and evaluating the potential performance of solar concentrators using plane or cylindrical mirror and lens surfaces of various types. It covers the full spectrum of configurations, from simple V-troughs to units with concentration ratios of 10 or more. The evaluation will include real surface effects, such as manufacturing irregularities, surface properties, aging of surfaces and deformation of surfaces due to applied loads or thermal stress. The effect of dirt and other environmental accumulations on the reflective surface or lenses will be evaluated. Requirements for maintaining the optical quality for concentrators will also be investigated.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The project mathematically modelled 11 different concentrating collectors. A Monte Carlo ray trace technique was used and computer software was developed for potential users to define optical performance of the concentrators. In addition, a study of reflective and lensing materials available was conducted to provide users with candidate components for concentrators.

PERIOD OF PROJECT:

September 15, 1979 to January 1, 1980

FUNDING IN $ U.S.:

$156, 429

IMPORTANT REPORTS OR PUBLICATIONS:

"Survey Mirrors and Lenses and Their Required Surface Accuracy" Semi-Annual Technical Progress Report, May 1979.

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ______________
NAME OF ORGANIZATION Honeywell, Inc.	ADDRESS: 2600 Ridgway Parkway Minneapolis, MN 55413
NAME OF PRINCIPAL RESEARCHER Gary A. Smith	

TITLE OF PROJECT
DUAL CURVATURE ACOUSTICALLY DAMPED CONCENTRATING COLLECTOR

OBJECTIVE AND NATURE OF THE PROJECT:

This project is the initial development phase for a Dual Curvature Collector Configuration. The configuration for reflecting sunlight uses an elastic film mounted under tension on a frame to form a near-hyperbolic paraboloid surface. The surface is capable of linear focusing, at a concentration ratio of 10x or greater, on a heat shielded tube-in-cavity receiver.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The project has concluded the analysis, design, build and test of a prototype Dual Curvature Collector. The reflector modules were successfully fabricated using a 2-mil aluminized polyester film heat shrunk onto .61 x 1.22 m frames. The aluminized surface was then coated with a 0.2 mil acrylic finish to provide protection from environmental effects.

PERIOD OF PROJECT:
July 1, 1978 - January 1, 1980

FUNDING IN $ U.S.:
$358,582

IMPORTANT REPORTS OR PUBLICATIONS:

"Dual Curvature Acoustically Damped Concentration Collector", Semi-Annual Progress Report 1, December 1978
"Dual Curvature Acoustically Damped Concentration Collector", Semi-Annual Progress Report 2, July 1979

Code No.: US-22

ORGANIZATION:

Honeywell

PROJECT TITLE:

DUAL CURVATURE ACOUSTICALLY DAMPED CONCENTRATING COLLECTOR

DATA SHEET

Component : Solar Collector

a) type - Linear Concentrator

b) $\alpha\tau$ - optical efficiency (max) = 0.58

c) overall heat loss coefficient U [W/m^2K] - approx. 0.4
(temp. range θ [°C], 100°C - 230°C

d) heat capacity (fluid included) C [Wh/m^2k] - not available

e) heat transfer medium - Therminol 44

f) material
i) absorber (α, ϵ) - black chrome
ii) reflector - coated aluminized polyester (φ = 0.82)
iii) receiver glazing - acrylic plate (τ_{AM1} = 0.87) AMO

g) expected life time - 5 years film, 30 years collector

h) estimated cost (\$ US/m^2) - \$130/m^2

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-23

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Hughes Aircraft Company	ADDRESS: Centinela & Teale Avenue Culver City, Calif. 90230
NAME OF PRINCIPAL RESEARCHER Dr. Norman Bilow	

TITLE OF PROJECT Development of Non Glass Glazings and Surface Coatings

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this research was to develop improved heat resistant, ultraviolet radiation stable, polycarbonates which are transparent and impact resistant. Such materials are to be useful glazings for solar collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Eight different types of polycarbonates were synthesized and evaluated under simulated solar radiation. One of the polymers showed no evidence of degradation. Very long term radiation stability tests of the latter are thus needed.

PERIOD OF PROJECT: 8/10/78 - 7/31/79 FUNDING IN $ U.S.: 162.2K

IMPORTANT REPORTS OR PUBLICATIONS:

"Development of Non Glass Glazings and Surface Coatings" Summary Report, Contract Em-78-C-04-5301, Dec. 1979, Hughes Aircraft Co. Report No. FR80-76-531, N. Bilow, R. I. Akawie, D. I. Basiulis, A. L. Landis

Code No.: US-23

ORGANIZATION: Hughes Aircraft Co.
Culver City, Calif.

PROJECT TITLE: Non Glass Glazings and Solar Collectors

DATA SHEET

COMPONENT: Polycarbonate derived from hexafluoroisopropylidenediphenol

- transparent glazing material
- engineering properties not yet available
- glass transition temperature 140-150°C.
- estimated cost $2/lb.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS Code No. US-24

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [x] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [x] SYSTEMS DEVELOPMENT
NAME OF ORGANIZATION KAMAN SCIENCES CORPORATION	ADDRESS: P.O. BOX 7463 1500 GARDEN OF THE GODS ROAD COLORADO SPRINGS, COLORADO 80933
NAME OF PRINCIPAL RESEARCHER DOUGLAS M. JARDINE, P.E.	

TITLE OF PROJECT
PHOENIX/CITY OF COLORADO SPRINGS SOLAR ASSISTED HEAT PUMP PROJECT

OBJECTIVE AND NATURE OF THE PROJECT:

The objectives of this project are to stimulate the development of preferred solar assisted heat pump (SAHP) systems, and to improve the data base for evaluation of SAHP systems.

This project is characterized as engineering field testing of preferred SAHP systems in different climates.

The performance of recent technological improvements in the form of new products which have been designed specifically to operate optimally within SAHP fluid heat sink and heat source requirements will be evaluated under controlled conditions.

Technical and economic information on the performance of SAHP systems operating with ground coupled storage subsystems (GCSS) in various climates will be evaluated.

Data will be gathered and the thermal performance of a GCSS will be evaluated based on empirical soil temperatures, densities, thermal conductivity, and moisture contents.

The output of this work will be the selection of the best marketable components and products for the SAHP and knowledge of and experience with the operation of the preferred SAHP for space heating and cooling and water heating in the various climatic regions of the United States.

There are three systems involved at three locations as follows:

- o Colorado Springs, Colorado, 5 ton residential system
- o Albuquerque, New Mexico, 15 ton office building system
- o Middletown, Ohio, 2-1/2 ton, industrial building system

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The systems in Colorado Springs, Colorado has been operational since October 1979. This system has instrumentation in the ground for evaluating GCSS performance capability. A thermal gradient has been established and measured in the ground around the GCSS and the charging of the ground with thermal energy has been documented. The basis for measuring moisture migration to and away from the GCSS unit is established and this migration will be measured as the annual storage temperature cycle.

The system in Albuquerque will become operational in early December 1979, while the Ohio system will become operational in late November 1979.

PERIOD OF PROJECT: 6/28/79 to 6/27/81 FUNDING IN $ U.S.: $465,639

IMPORTANT REPORTS OR PUBLICATIONS:

Jardine, D. M., Jones, D. W., "Phoenix/City of Colorado Springs Solar Assisted Heat Pump Project (Phase II) Final Report, April 1979.
Jardine, D. M., Jones, D. W., "Phoenix House," Final Report EPRI ER-712, March 1978

Code No.: US-24

ORGANIZATION: Kaman Sciences Corporation

PROJECT TITLE: Phoenix/City of Colorado Springs Solar Assisted Heat Pump Project

DATA SHEET

Component : Air Conditioning and Cooling

a) Type:

Fluid to air heat pump in series between GCSS and thermal load, and in series between thermal load and electric utility. Thermal load consists of space heating, space cooling, and water heating. GCCS is evaporator heat source and condenser heat sink.

b) Working Medium

R-22 with hermetic reciprocating compressor

c) Nominal Capacity - Tons

	Colorado Springs	Albuquerque	Middletown
	5	2 @ 7-1/2=15	2-1/2

d) Operating Temperature Range °C 4.4 to 43.3

e) COP Annual System $4.5 = \frac{\text{Annual Space Heating, Cooling, Water Heating Load}}{\text{Annual Heat Pump and Collector Pump Power Use}}$

f) Heat Exchangers

Air Side - Finned tube

Water Side - Linear concentric plastic tubes

Hot Water - Copper tube spiral wound on and soldered to compressor discharge pipe

g) Auxiliary Heat Source

Electric power is used to drive the heat pump compressor. Due to large GCCS capacity and its seasonal characteristic, there is no auxiliary heat source required for space heating. There is a 1 KW I^2R auxiliary water heater in the upper protion of the hot water storage tank for use on mild days when the heat pump operates infrequently.

Code No.: US-24

ORGANIZATION: Kaman Sciences Corporation

PROJECT TITLE: Phoenix/City of Colorado Springs Solar Assisted Heat Pump Project

DATA SHEET

Component : Solar Collector

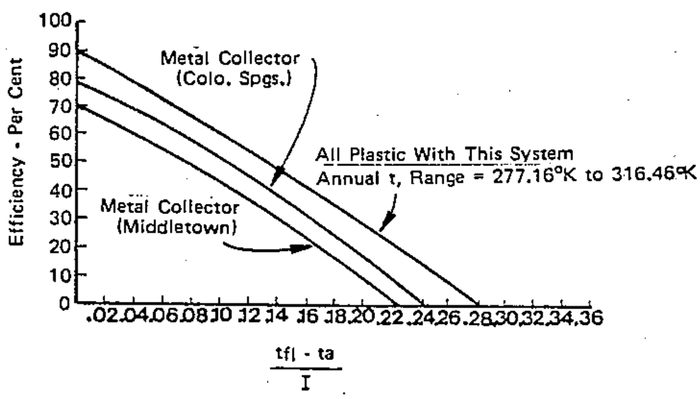
a) Types Flat Plate
b) $\alpha\tau$ - Integrated in Performance Curves
c) Overall Heat Loss Coefficient - See Performance Curve
d) Heat Capacity (Fluid Included)
- Double Glazed with Metal Absorber Plate - 18.6 Wh/m^2K
- All Plastic Collector - 7.6 Wh/m^2K

e) Heat Transfer Medium
- Colorado Springs, Metal Absorber Plate - Therminol 60
- Albuquerque, All Plastic Collector - Water/Ethylene Glycol 50/50
- Middletown, All Plastic Collector - Water/Ethylene Glycol 50/50
- Middletown, Metal Absorber Plate - Water/Ethylene Glycol 50/50

f)

Material	Colorado Springs	Albuquerque & Middletown	Middletown
Absorber Plate	Aluminum Roll Bond	Polyolefin	Aluminum Roll Bond
Cover Plate	2-3 mm Tempered Glass	1-Polyolefin- 3mm	2-3 mm Tempered Glass
Insulation Thickness	6.4 cm	3.81 cm	5.08 cm
Housing	Wood-Building Structure	Polyolefin	Sheet Metal
Expected Life	50 Years	25 Years	5 Years
Estimated Cost/ m^2	\$129	\$86	\$291

g) Performance Curve



Code No.: US-24

ORGANIZATION: Kaman Sciences Corporation

PROJECT TITLE: Phoenix/City of Colorado Springs Solar Assisted Heat Pump Project

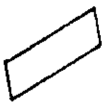
DATA SHEET

Component : Thermal Storage

a) Type: All Three Locations Have GCSS Configured as Follows:

Colorado Springs  Direct buried, uninsulated and nonstratifying cylindrical tank with serpentine copper heat exchanger for collector.

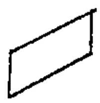
Albuquerque  Direct buried, uninsulated, 3 cylinder tanks interconnected with risers and downcomers with plastic collector absorber plate heat exchangers in bottom drums for collector.

 Direct buried, uninsulated plastic collector absorber plates.

Middletown  Direct buried, uninsulated and nonstratifying cylindrical tank with serpentine steel heat exchangers for collector and heat heat pump.

 Direct buried, uninsulated, 3 cylinder tank interconnected with risers and downcomers with serpentine steel heat exchangers for heat pump and collectors.

b) Performance Characteristics

			
• Heat capacity kWh/m^3 (seasonal) (Total tank and ground heat based on tank volume of 30 m^3)	587	643	410
• Temperature range θ °C	4.4 to 43.3	4.4 to 43.3	4.4 to 43.3
• Latent heat kWh/m^3 @ 4.4°C	15	16.5	10.5
• Heat rate W/m^2 ground contact area			
Tank temperature 4.4°C	276	302	193
43.3°C	417	456	292
• Expected lifetime	50 Years	50 Years	25 Years

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-25

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION Jet Propulsion Laboratory NAME OF PRINCIPAL RESEARCHER M. K. Selçuk	ADDRESS: 4800 Oak Grove Drive Bldg. 507 Room 228 Pasadena, California 91103

TITLE OF PROJECT - Fixed Tilt Solar Collector Employing Reversible Vee-Through and Vacuum Tube Receivers.

OBJECTIVE AND NATURE OF THE PROJECT:

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 were conducted on a test bed collector and an analytical thermal model was developed for optimization studies. A prototype was designed 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.

During the second phase of the project collect test data was collected for one year starting from October 1977 until October 1978 to verify the annual performance predictions.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Both phases of the project are completed. Test results and mathematical analyses including optimization studies are completed. Data collected for two years are processed. Information is disseminated and the test bed is disassembled since grants are not available any more.

PERIOD OF PROJECT:

First phase was 12 months plus 4 month extension.
Second phase was 12 months.

FUNDING IN $ U.S.:

First Phase	$183,000
Second Phase	$ 50,000

IMPORTANT REPORTS OR PUBLICATIONS:

Two final reports are published. Additional papers are presented at ASME 1975 Winter Annual Meeting, U. of Miami - ERDA Forum 1976, ERDA Concentrating Collector Conference 1977, ASME 1977 WAM and ISES Silver Jubilee, Atlanta 1979.

Code No.: US-25

ORGANIZATION:

Jet Propulsion Laboratory

PROJECT TITLE:

Fixed Tilt Solar Collector Employing Reversible Vee-Trough Reflectors and Vacuum Tube Receivers

DATA SHEET

Component : Solar Collector

a) type - evacuated tubular with asymmetric vee-trough concentrators

b) $\alpha\tau$ = 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
@ 52°C U_L = 1.48 W/m²°k
@ 126°C U_L = 2.15 W/m²°k
@ 232°C U_L = 2.73 W/m²°k

d) heat capacity - negligibly small

e) heat transfer medium - Therminol 44

f) material i) absorber (α,ε) α = 0.93; τ_{aver} = 0.89
ii) cover plate - single tube wall
iii) insulation - vacuum

g) expected life time + 20 years

h) estimated cost - US $100/m² aperture area basis

IEA SURVEY OF COMPONENTS FOR SOLAR HEAT:
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-26

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ________

NAME OF ORGANIZATION Lawrence Livermore Laboratory	ADDRESS: PO Box 808 Livermore CA 94550
NAME OF PRINCIPAL RESEARCHER Jerry W. Gerich	

TITLE OF PROJECT
An Inflated Cylindrical Concentrator for Industrial Process Heat

OBJECTIVE AND NATURE OF THE PROJECT:

The project objective is to develop a cost effective concentrating collector capable of producing industrial process steam up to 175 °C. This unique collector uses a non-tracking design and weatherable thin film plastics to achieve the extremely low cost per unit area.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Analytical models of the optical and thermal characteristics have been developed. The first generation collectors were tested, and they verified the analytical models. The second generation collectors are currently being tested.

PERIOD OF PROJECT:

October 1977 - September 1979

FUNDING IN $ U.S.:

$400,000.

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.
- An Inflated Cylindrical Solar Concentrator, Proc. of the 1978 Annual Meeting - American Section of ISES, Jerry W. Gerich, Denver, Col., Vol 2.1, 889-894, Aug.1978.
- A Non-tracking Inflated Cylindrical Solar Concentrator, Jerry W. Gerich, Lawrence Livermore Laboratory, UCRL-82721, May 22, 1979.

Code No.: US-26

ORGANIZATION:

Lawrence Livermore Laboratory

PROJECT TITLE:

An Inflated Cylindrical Concentrator for Industrial Process Heat

DATA SHEET

Component : Solar Collector

a) type and configuration
A non-imaging, seasonally adjusted, line concentrator 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 a thin film plastic jacket surrounding it for heat transfer suppression.

b) $\alpha\tau$
$\alpha\tau = 0.80$

c) overall heat loss coefficient U_l (W/m^2K) (temp. range θ °C)

$$U_l = 4.6 \frac{W}{m^2K} \qquad \text{(at 175 °C)}$$

d) heat capacity (fluid included) C (Whr/m^2K)

$$C = 1.5 \frac{W\text{-}hr}{m^2K}$$

e) heat transfer medium
Water

f) material
i) absorber $\alpha = 0.95$, $\epsilon = 0.25$
ii) cover plates $\tau_1 = 0.89$, $\tau_2 = 0.89$
iii) insulation None

g) expected life time
Three to five years for plastic cylinder (easily replaceable)
Twenty years for receiver tube and other components

h) estimated cost ($ US/m^2)
$75 per square meter

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. 27

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION EG&G Washington Analytical Services Center, Inc. NAME OF PRINCIPAL RESEARCHER Michael E. Gruchalla	ADDRESS: 9733 Coors Road, NW Albuquerque, NM 87114

TITLE OF PROJECT A Survey of Tracking Mechanisms and Rotary Joints for Coolant Piping

OBJECTIVE AND NATURE OF THE PROJECT:

The objectives of this project were to survey and evaluate problems with respect to solar tracking mechanisms and rotary joints for coolant piping. The final report includes an analytical development of celestial mechanics, one- and two-axis tracking configurations and the effect of tracking accuracy versus collector efficiency. Tracking system and control system performance specifications were determined. Alternative conceptual tracking approaches were defined and a cost and performance evaluation of a mechanical tracking concept was performed. Fluid coupling service specifications were determined.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Complete final report published:

EG&G AG-1407

PERIOD OF PROJECT:
15 August 1978 - 14 August 1979

FUNDING IN $ U.S.:
$93,391

IMPORTANT REPORTS OR PUBLICATIONS:

EG&G AG-1407

Contract # EM-78-C-04-5320

IEA SURVEY OF COMPONENTS FOR SOLAR HEAT COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-28

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] Engineering Research
NAME OF ORGANIZATION Los Alamos Scientific Laboratory	ADDRESS: M. S. 571 Los Alamos Scientific Laboratory Los Alamos, NM 87545
NAME OF PRINCIPAL RESEARCHER Donald A. Neeper	

TITLE OF PROJECT
Collector and Materials Research

OBJECTIVE AND NATURE OF THE PROJECT: LASL is conducting a continuing program of research into the design, development and application of solar collectors for all applications. Investigations have included a broad range of studies of collector materials, fluids, engineering and design techniques, concept evaluation, and development of test methods and techniques. The collector laboratory at Los Alamos is capable of testing and evaluating both air and liquid heating collectors on a two-axis tracker at temperatures up to 600°F. Facilities and instruments are also available for a wide range of physical and optical studies of materials and components.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Studies of heat transfer augmentation in air heating collectors of both the solid and matrix absorber type have been completed recently. Currently, research attention is focussed on evaluation of evacuated collectors for high temperature application and/or the production and utilization of photothermal/photovoltaic coatings in evacuated tube collectors.

PERIOD OF PROJECT: Continuing

FUNDING IN $ U.S.: 100K$ (FY-80)

IMPORTANT REPORTS OR PUBLICATIONS:

Bankston, Charles A. and Neeper, Donald A., Solar Energy Research at LASL, LA-7741-PR, Oct., 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEAT: COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-29

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] Technical Direction & Research
NAME OF ORGANIZATION Los Alamos Scientific Laboratory	ADDRESS: LASL M. S. 571 Los Alamos, NM 87545
NAME OF PRINCIPAL RESEARCHER Donald A. Neeper	

TITLE OF PROJECT

Salt Gradient Stabilized Solar Ponds

OBJECTIVE AND NATURE OF THE PROJECT: The objective of this work is to establish the technical feasibility of salt-gradient solar ponds for heating, cooling and process application in the U.S. LASL provides technical guidance and monitoring of the DOE contracts involving stationary solar collectors, which currently includes five pond projects. In addition, LASL conducts theoretical studies of the hydrodynamics of ponds. Of particular interest is the behavior of the interface between a stable salt gradient solution and an adjoining convective region and the influence of sloping walls.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Five solar pond projects are in progress. These range from monitoring the thermal performance of a large pond supplying heat to a recreational complex in Miamisburg, Ohio, to research projects involving studies of laboratory-scale ponds.

PERIOD OF PROJECT: Continuing

FUNDING IN $ U.S.: 80K$ (FY-80)

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATI...
COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-30

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] Technical Direction & Monitoring
NAME OF ORGANIZATION Los Alamos Scientific Laboratory	ADDRESS: M. S. 571 Los Alamos Scientific Laboratory Los Alamos, NM 87545
NAME OF PRINCIPAL RESEARCHER Charles A. Bankston	

TITLE OF PROJECT
Solar Collector Program Support

OBJECTIVE AND NATURE OF THE PROJECT: Los Alamos provides technical direction and project monitoring for the DOE program in solar collector and collector materials research and development. The DOE collector program, the objective of which is to provide the solar industry with the components, materials, and information it needs, includes development of stationary and tracking collectors of all types, research and development on materials used in solar collectors, and basic engineering and application studies related to the design, manufacture, and application of collectors. LASL's primary responsibilities involve the continuous and close monitoring and evaluation of technical activities of DOE contractors. This includes review of reports and publications, site visits, technical progress evaluation and redirection, contract modification, analysis of schedules and goals, and the coordination of these projects with the overall heating and cooling program.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS: The collector program, which was largely implemented in 1977, has involved as many as 96 and now includes 74 active projects. Many development projects have already been completed but many really important results from study and research projects are just beginning to surface. The nature of the support work is undergoing the transition from an emphasis on implementation to an emphasis on review and evaluation of accomplishments and utilization of results. This year, program support staff will begin to compile, evaluate and select information and engineering data generated by collector projects and prepare a collector design handbook. Program-generated information will be supplemented with information from the solar, engineering design, materials science, thermal sciences and manufacturing literature in order to provide solar collector designers and manufacturers with everything necessary for engineering of collectors in a single comprehensive and authoritative source. The handbook will represent the essence of the multi-year, 20 million dollar DOE collector research and development program.

PERIOD OF PROJECT: Continuing   FUNDING IN $ U.S.: 455,000 (FY-80)

IMPORTANT REPORTS OF PUBLICATIONS:

- C. A. Bankston and S. L. Sargent, "The National Program for Solar Collector Research, Development and Commercialization," 1978 Annual Meeting of Am. Section of ISES, Denver, CO, Aug. 28-31, 1978.
- Research and Development Summaries, DOE/CS-0010, U.S. Department of Energy, May, 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-31

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [X] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] System Development
NAME OF ORGANIZATION Los Alamos Scientific Laboratory NAME OF PRINCIPAL RESEARCHER James Hedstrom	ADDRESS: Box 1663 M. S. 571 Los Alamos, NM 87545

TITLE OF PROJECT
National Security and Resources Study Center

OBJECTIVE AND NATURE OF THE PROJECT:

To Obtain System Performance on a Large Solar Heated and Cooled Building

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Two Years of Performance Data Obtained

PERIOD OF PROJECT: 1976 - 1980

FUNDING IN $ U.S.: 400,000

IMPORTANT REPORTS OR PUBLICATIONS:

Solar Heating and Cooling Results for the Los Alamos Study Center

Code No.: US-31

ORGANIZATION:

Los Alamos Scientific Laboratory

PROJECT TITLE:

National Security and Resources Study Center

DATA SHEET

Component : Solar Collectors

a) Type - Flat Plate $716 m^2$ in one planar array tilted at 35^{o}

b) $\alpha\tau$ = .836

c) U_L = 5.12 w/m^2K

d) Heat Capacity 5.7 wh/m^2K

e) Heat Transfer Oil - Paraffinic Oil (Shell Thermia 33)

f) Material - Steel with Black Chrome Selective Surface

   i) Absorber α = .93, ε = .09
   ii) Cover Plate - 1 sheet glass τ = .91
   iii) Insulation - Urethane Foam - 5.1 cm thick

g) Lifetime - 40 years

h) Estimated Cost - $205/$m^2$

Code No.: US-31

ORGANIZATION:

Los Alamos Scientific Laboratory

PROJECT TITLE:

National Security and Resources Study Center

DATA SHEET

Component : Heat Storage

a) Type - Water Tank 2.44m dia x 7.9m high

b) Heat Capacity - 27000 wh/m^2, $\Delta T = 45^{o}C$

c) Latent Heat - None

d) Heat Exchanger - Yes (Paraffinic Oil to Water)

e) Heat Rate - 360kw

f) Insulation - 5.1cm figerglass

g) Expected Lifetime - 40 years

Code No.: US-31

ORGANIZATION:

Los Alamos Scientific Laboratory

PROJECT TITLE:

National Security and Resources Study Center

DATA SHEET

Component : Absorption Chiller

a) Type - Cooling

b) Type of Refrigerator - LiBr Absorption Unit

c) Capacity - 80 Tons

d) Temperature Range - 70 - 115°C

e) COP - 0.66 Seasonal

f) Heat Exchanger - Yes

g) Auxiliary - Waste Steam to Hot Water

Code No.: US-31

ORGANIZATION:

Los Alamos Scientific Laboratory

PROJECT TITLE:

National Security and Resources Study Center

DATA SHEET

Component : Rankine Chiller

a) Type Cooling - Rankine-powered Cooling System

b) Type of Refrigeration - Centrifugal Upper Compression R-11 Working Fluid

c) Capacity - 77 Tons

d) Temperature Range - 70 - 98^{0}C

e) COP - 0.70 Seasonal

f) Heat Exchanger - Tube in Shell

g) Auxiliary - Waste Steam to Hote Water

Code No. US-32

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ______

NAME OF ORGANIZATION Lawrence Livermore Laboratory	ADDRESS: P.O. Box 808 L-046 Livermore, Ca. 94550
NAME OF PRINCIPAL RESEARCHER William C. Dickinson/Richard L. Wood	

TITLE OF PROJECT
Large Area Rooftop Collector

OBJECTIVE AND NATURE OF THE PROJECT: to develop a practical rooftop mountable collector for use in very large industrial hot water systems (1500 sq. meters and up). To be attractive to an industrial investor, the collector must have a very low system first cost and acceptable thermal performance. Large module size brings simpler plumbing system and lower installation cost. An easily maintainable design allows use of less durable, but very inexpensive materials. A continuous flow of water is contained in flexible polymer membrane. Two schemes for maintaining uniform wetting are under consideration: 1) fill to a given depth, fluid outlet is overflow from weir or dam; 2) gravity flow with wicking action. Air supported thin film polymer cover sheet and fixtures are borrowed from standard greenhouse technology. Foam glass bottom insulation is borrowed from standard roofing technology.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Two generations of prototypes have been built in order to test design concepts, materials, and performance. A combination of polymeric materials/design which can withstand stagnation, are fairly weatherable, and reasonably inexpensive were identified. The 2nd model is a 3 meter by 15 meter module. With modifications, expected $\tau\alpha$ is 0.8 and U is about 8. W/m^2K. The installed collector cost, assuming the roof is comatible, will be under \$60 US per sq. meter, in large quantity (over 3000 m^2).

PERIOD OF PROJECT: 10/78 - 9/79

FUNDING IN $ U.S.: \$100,000

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: US-32

ORGANIZATION: Lawrence Livermore Laboratory
P.O.Box 808 L-046
Livermore, CA 94550

PROJECT TITLE: LARGE AREA ROOFTOP COLLECTOR

DATA SHEET

Component : a) Large module "flat plate" collector, similar to the shallow solar pond, but rooftop mountable.

b) $\tau\alpha = 0.79$

c) $U = 8.\ W/m^2K$

d) $C = 27.5\ Wh/m^2K$

e) for heating hot water.

f) i) Absorber is a 20 mil polyvinylchloride water bag. Bottom layer is black, upper is transparent. 5 - 10 year lifetime.

ii) Cover is a 3 mil, UV stabilized polyethylene sheet. Air supported @ .5 cm H_2O pressure. 1 - 2 year lifetime.

iii) Insulation is 4 cm foam glass under a polymer roof membrane. 50 year lifetime.

g) lifetime -- see f)

h) installed collector cost under 60 $US per sq. meter if bought in quantity (over 3000 m^2).

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS Code No. US-33

COUNTRY: UNITED STATES	
COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Control Strategies
NAME OF ORGANIZATION Middlebury College	ADDRESS: Middlebury, Vermont 05753
NAME OF PRINCIPAL RESEARCHER Richard L.T. Wolfson	

TITLE OF PROJECT
Microprocessor Controlled Solar Collector System

OBJECTIVE AND NATURE OF THE PROJECT:

Experimental comparisons of identical solar collector systems operating side-by-side under different control strategies.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Experiment with dual-temperature storage system currently underway.

PERIOD OF PROJECT: 1/4/78 - FUNDING IN $ U.S.: $9900

IMPORTANT REPORTS OR PUBLICATIONS:

Wolfson, R.L.T. and Harvey, H.S. "Control Strategies for Dual Tank Storage Systems: An Experimental Comparison", to be published in Proceedings of the Second Annual Systems Simulation and Economic Analysis Conference, January 1980.

Code No.: US-33

ORGANIZATION:

Middlebury College

PROJECT TITLE:

Microprocessor Controlled Solar Collector System

DATA SHEET

Component :

Solar Collectors:

Columbia Chase Corp. model 4394
Medium: water

Heat Storage

40 gallon and 15 gallon tank for each system.

No heat exchanger.

Insulation: 6" fiberglass.

Instrumentation

Eppley PSP pyranometer

Fenwal UUT 43J1 thermistors

Digital PDP 11 V03 computer

Pumps

Grundfos UPS20-42F

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-34

COUNTRY: UNITED STATES

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

NAME OF ORGANIZATION
Mississippi State University, Mechanical Engineering

ADDRESS: Drawer ME
Mississippi State, MS 39762

NAME OF PRINCIPAL RESEARCHER
Dr. Richard Forbes

TITLE OF PROJECT Addition of Inexpensive Solar Air Heaters to a Pre-Engineered Metal Building

OBJECTIVE AND NATURE OF THE PROJECT:

A pre-engineered metal building was modified to incorporate an air heater solar collector as an integral part of the south wall. A second layer of corrugated metal was "criss-crossed" with the skin of the building forming horizontal airflow channels in the south facing wall. The building used for these tests had two walls (north and south facing) which are inclined to an angle of 70 deg to the horizontal. The outer skin of the building served as the absorber surface for the collectors. The absorber surface was painted using flat black paint. The collector was completed by using 0.060-in.-thick KALWALL, supported by wooden strips, as the glazing. Air was drawn through the collectors by a variable speed induced draft fan. Total collector area was 45 sq m (48 sq ft). A horizontal rock bed was used for heat storage and auxiliary heat was provided by electrical resistance heaters. The system was capable of operating in four modes: 1) heating directly with collectors, 2) storing heat, 3) heating from storage, and 4) heating with auxiliary heat. The building was insulated to energy-conserving standards. Performance for the system is represented in the form of efficiency and total heat collection curves where these are plotted versus solar time.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:

25 Sept. 1977 - 25 March 1979

FUNDING IN $ U.S.:

$37,609.89

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report, May 1979; "Addition of Solar Air Heaters to a Pre-Engineered Metal Building", Paper 79-WA/SOL-33, to be presented at Winter Annual Meeting of ASME, December 2-7, 1979.

Code No.: US-34

ORGANIZATION:

Mississippi State University, Mechanical Engineering Department

PROJECT TITLE:

"Addition of Inexpensive Solar Air Heaters to a Pre-Engineered Metal Building"

DATA SHEET

Component :

Solar Collectors

a) type (site built)

b) $\alpha\tau \approx .80$

c) heat transfer medium (air....)

d) material
   i) absorber (α, ε) - 26 gage steel (.90, .90)
   ii) cover plate (number, τ, ...) - .060" KALWALL (1,.90)
   iii) insulation (thickness, ...) - 8 cm (urea-formaldehyde foam)

e) expected life time - 20 years

f) estimated cost (\$ US/m^2) - \$15.00

Heat Storage

a) type (horizontal rock bed)

b) heat exchanger - No

c) insulation - (2.5 cm polystyrene foam)

d) expected life time - (20 years)

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-35

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [x] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[x] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [ ] ________
NAME OF ORGANIZATION Monsanto Research Corp, Dayton Laboratory	ADDRESS: 1515 Nicholas Road Dayton, OH 45407
NAME OF PRINCIPAL RESEARCHER Leo Parts	

TITLE OF PROJECT   Superior Heat Transfer Fluids for Solar Heating and Cooling Applications

OBJECTIVE AND NATURE OF THE PROJECT:

Program Objectives:

- Establish physical performance, handling, and other requirements which the fluids, to be used for solar energy collection and storage, must meet.
- Conduct a state-of-the-art survey of current commercial developmental and candidate fluids; collect and compile pertinent physical properties, performance and cost data.
- Determine certain properties of fluids (ignitability and mutagenicity), if data are not available, that are pertinent for their safe use.
- Analyze the performance characteristics of fluids with reference to requirements and recommend superior fluids for specific applications.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Two broad surveys have been conducted. One encompassed the designers and manufacturers of solar collectors and collection systems to establish the data base for the required fluids properties. The second survey was addressed to the manufacturers of heat transfer fluids. A summary, containing the results of the surveys and their analysis, are being prepared. The preparation of a manual containing the physical and handling properties of organic heat transfer fluids, usable heating and cooling application, is contemplated. This manual would also contain a tutorial section to guide the users in the selection of superior fluids for their specific solar collectors.

PERIOD OF PROJECT: FUNDING IN $ U.S.: 155,960

20 August 1978 - 31 December 1979

IMPORTANT REPORTS OR PUBLICATIONS:

L. Parts, D. R. Miller and Q. E. Thompson, "Superior Heat Transfer Fluids for Solar Heating and Cooling Applications," Semiannual Report for 20 August 1978 - 20 February 1979, Report No. ALO/45356-1, September 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-36

COUNTRY: UNITED STATES

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

NAME OF ORGANIZATION
MONSANTO RESEARCH CORPORATION

NAME OF PRINCIPAL RESEARCHER
George L. Ball, III

ADDRESS:
Monsanto Research Corporation
Dayton Laboratory
Station B. Box 8
Dayton, Ohio 45407

TITLE OF PROJECT LOW-COST MIRROR CONCENTRATOR BASED ON DOUBLE-WALLED, METALLIZED, TUBULAR FILMS

OBJECTIVE AND NATURE OF THE PROJECT:

The objective is to develop an innovative air-inflatable nontracking cylindrical mirror concentrator of about 3X concentration ratio. There is to be an emphasis placed upon improving the design to maximize use of low cost materials and reduce the cost of mass-produced units.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

A tubular concentrator design was developed that employs two joined partial cylindrical sections which reduce both cover and mirror requirements by 40% and land area useage by approximately 20% relative to a conventional cylindrical tubular design. Aluminum foil/plastic laminates have been selected as an alternative to aluminized polyester films because of their low cost, ease of fabrication, good durability, high strength and acceptable reflectivity. A specially UV stabilized polyvinyl chloride film has been developed for use as the inflatable window. Testing of a prototype will be performed in the first quarter of 1980.

PERIOD OF PROJECT:
19 February 1978 to 18 March 1980

FUNDING IN $ U.S.: $220,330.00

IMPORTANT REPORTS OR PUBLICATIONS:
Interim progress reports only; none available.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-37

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ______

NAME OF ORGANIZATION

MONSANTO RESEARCH CORPORATION

ADDRESS: Monsanto Research Corporation
Dayton Laboratory
Station B, Box 8
Dayton, Ohio 45407

NAME OF PRINCIPAL RESEARCHER

George L. Ball, III

TITLE OF PROJECT MEDIUM TEMPERATURE AIR HEATERS BASED ON DURABLE TRANSPARENT FILMS

OBJECTIVE AND NATURE OF THE PROJECT:

The objective was to make available a low-cost, durable, medium temperature solar air heater. In accomplishing this objective, low-cost, specially stabilized and reinforced polyvinylchloride (PVC) film was to be optimized and used.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

A special UV-stabilized and scrim-reinforced flexible (PVC) film was developed, characterized, and tested on an air solar heater according to ASHRAE 93. Solar energy transmission of early pre-contract 20-mil thick film was determined to be about 83% after two months outdoor Florida exposure, dropping to 78% after two years. Outdoor exposure and artificial UV aging tests indicate that a 10-year lifetime could be possible.

PERIOD OF PROJECT:

30 September 1977 to 31 October 1978

FUNDING IN $ U.S.: $106,657.00

IMPORTANT REPORTS OR PUBLICATIONS:

NON-CONCENTRATING COLLECTORS FOR SOLAR HEATING APPLICATIONS (MEDIUM TEMPERATURE AIR HEATERS BASED ON DURABLE TRANSPARENT FILMS)

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-38

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] SYSTEM EVALUATION

NAME OF ORGANIZATION
Monsanto Research Corporation

NAME OF PRINCIPAL RESEARCHER
Layton J. Wittenberg

ADDRESS:
Monsanto Research Corporation
Mound Facility
P. O. Box 32
Miamisburg, Ohio 45342

TITLE OF PROJECT
Evaluation of the Miamisburg Salt-Gradient Solar Pond

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this project is to install instrumentation, collect data and evaluate the performance of the largest salt-gradient solar pond in the United States. This solar pond was constructed by the City of Miamisburg, Ohio, to provide heat at their Community Park facilities. The solar pond is conservatively estimated to provide approximately 234,000 kWh of heat for an outdoor swimming pool from May-September and 47,000 kWh of heat for an adjacent recreational building from October to December, without the use of a heat pump. The performance of this solar pond should be typical of proposed installations in the Northeastern United States with measured 1979 average ambient air temperatures of 10.8°C and average solar insolation of 144 W/m^2.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The pond was constructed during 1978 and the initial heat, 40,000 kWh, was utilized during the summer of 1979. The pond is expected to be nearly at thermal steady-state during 1980.

During the construction of the pond, numerous thermocouples were installed in the pond and in the ground below the pond. An underwater pyranometer is used to determine the solar radiation into the pond. In addition, the total solar radiation, air temperature, wind speed and direction, and the conductivity of the salt solution as a function of depth are measured. All of these instrument probes are automatically read and the data recorded by a small electronic computer.

PERIOD OF PROJECT:
May 1978 - September 1980

FUNDING IN $ U.S.:
FY-78 - $23,000; FY-79 - $50,000
FY-80 - -$50,000

IMPORTANT REPORTS OR PUBLICATIONS:

1. R. S. Bryant, R. P. Bowser and L. J. Wittenberg, "Construction and Initial Operation of the Miamisburg Salt-Gradient Solar Pond," Proceedings International Solar Energy Congress, Atlanta, May 28-June 1, 1979 (Pergamon Press).
2. L. J. Wittenberg and M. J. Harris, "Performance of a Large, Salt-Gradient Solar Pond," pp. 49-52, 14th Intersociety Energy Conversion Eng. Conf., Boston, August 5-10, 1979 (American Chemical Society Publication).

Code No.: US-38

ORGANIZATION: Monsanto Research Corporation
Mound Facility
Miamisburg, Ohio 45342

PROJECT TITLE: Evaluation of the Miamisburg Salt-Gradient Solar Pond

DATA SHEET
SALT-GRADIENT SOLAR POND

Component : Combined Solar Collector and Heat Storage System

Surface Area: 2020 m^2 Total Depth: 3 m

Depth Profile: Top Convective Layer: ~0.25 m, Gradient Zone: 1 m

Bottom Convective Zone: 1.75 m (18% NaCl solution)

Liner: 0.7 mm thick, chemically resistant polymer-coated polyester fabric, laid directly on the ground.

Cover: None

Salt Content: 1,000 metric tonne, sodium chloride

Heat Exchanger: 25.4 mm o.d. copper tubing; 138 m^2 surface area, located in the bottom convective zone of pond.

Heat Transfer Medium: water

Temperature Swing: 66°C summer - 28°C winter

Installed Cost: $35/$m^2$

Lifetime: 10-12 years for the plastic liner. A replacement liner can then be installed without disturbing the pond.

Heat Utilization: 281,000 kWh/yr (estimated)

Instrumentation

Static: 40 thermocouples in pond and ground
Pyranometer (total horizontal), anemometer and wind direction, air temperature.

Scanning Depth of Pond: Pyranometer (submersible), temperature sensor, salt conductivity probe.

Data Collection: automatic recording and storage with small on-line computer.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-39

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] STANDARDS DEVELOPMENT
NAME OF ORGANIZATION National Bureau of Standards	ADDRESS: National Bureau of Standards Center for Building Technology Washington, D.C. 20234
NAME OF PRINCIPAL RESEARCHER James 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 PROJECT:

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 ACCOMPLISHMENTS:

- o Adoption of ASHRAE 93-77, Collector Test Procedure
- o Experimental verification of ASHRAE 93 Standard for Selected Air and Water-Cooled Collectors at NBS
- o Completion of Round-Robin Collector Test Program
- o Experimental verification of indoor heat loss procedures for water-cooled collectors
- o Experimental evaluation of heat transfer fluid properties and flow rate on flat-plate collector efficiency

PERIOD OF PROJECT:

January 1974-September 1979

FUNDING IN $ U.S.:

current year $110,000

total for period $905,000 (includes storage work)

IMPORTANT REPORTS OR PUBLICATIONS:

- o "Development of Proposed Standards for Testing Solar Collectors and Thermal Storage Devices," NBS Technical Note 899, February 1976.
- o "A Method of Testing for Rating Solar Collectors Based on Thermal Performance," Solar Energy, Vol. 18, pp. 421-429, 1976.
- o "Results and Analysis of a Round-Robin Test Program for Liquid-Heating, Flat-Plate Solar Collectors," NBS Technical Note 975, August 1978.

(Continued on attached sheet)

IMPORTANT REPORTS OR PUBLICATIONS (Continued)

- "A Comparison of Flat-Plate Solar Collector Thermal Performance Data Obtained Indoors and Outdoors," Proceedings of 1978 Meeting of American Section, ISES, August 1978.
- "Experimental Verification of a Standard Test Procedure for Solar Collectors," NBS Building Science Series 117, January 1979.
- "A Comparison of Test Results for Flat-Plate, Water-Heating Solar Collectors Using the BSE and ASHRAE Procedures," Proceedings of the 1979 International Congress of ISES, May 28-June 1, 1979.
- "An Evaluation of the Influence of Heat Transfer Fluid Properties and Flow Rate on Flat-Plate Solar Collector Efficiency," Proceedings of the 1979 International Congress of ISES, May 28-June 1, 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-40

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [ ] ________

NAME OF ORGANIZATION
Owens-Illinois, Inc.

NAME OF PRINCIPAL RESEARCHER
Louis Spanoudis

ADDRESS:
P. O. Box 1035
Toledo, OH 43666

TITLE OF PROJECT Improved Collector Efficiency through the use of Anti-Reflective Coatings and Improvement in Solar Selective Coating Stability.

OBJECTIVE AND NATURE OF THE PROJECT: The objectives of this project are:

1. Increase cost effectiveness of evacuated tubular collectors through the use of anti-reflective coatings to improve the transmissivity of the cover tube and to decrease reflection losses from the absorber coating.

2. Increase the high temperature stability of the absorver coating to allow higher concentration ratios.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Using methods described in U. S. Patents samples were prepared where the transmissivity of the cover glass was increased from 0.92 to 0.98.

Absorptivities up to 0.94 have been obtained on coupons by application of thin dielectric films over the commercial chrome oxide-over-aluminum selective coating. Present activity centers on application techniques to apply these coatings onto prototype collector tubes.

The high temperature stability of the absorber coating was improved by increasing the aluminum thickness. Best results were obtained by substituting copper for aluminum.

PERIOD OF PROJECT:
9/01/78 through 5/31/80

FUNDING IN $ U.S.:
266,107

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: US-40

ORGANIZATION:

Owens-Illinois, Inc.

PROJECT TITLE:

Improved Collector Efficiency through the Use of Anti-Reflective Coatings and Improvement in Solar Selective Coating Stability

DATA SHEET

Component :

a) Type: Evacuated Tube

b) $\alpha\tau$ = 0.74

c) Overall loss coefficient:

Tube: 0.50 W/m^2k (10^oC - 120^oC)
Manifold: 0.50 W/m^2k (10^oC - 120^oC)
Total: 1.00 W/m^2k (10^oC - 120^oC)

d) Heat Capacity: MC = 15.8 $Wh/m^{2o}C$

e) Ht transfer medium: Water

f) Material (i) absorber: Borosilicate glass (α = 0.8, ε = 0.05)
(ii) cover plate: Borosilicate glass (τ = 0.92)
(iii) insulation: Vacuum (tubes), urethane foam (manifold)

g) expected life: 20 years

h) estimated cost: Confidential

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-41

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[XXX] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	X[XX] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [ ] ______

NAME OF ORGANIZATION
The Pennsylvania State University

ADDRESS:
Materials Research Laboratory
University Park, PA 16802

NAME OF PRINCIPAL RESEARCHER
R. Messier and K. Vedam

TITLE OF PROJECT Black Germanium Selective Absorber Surfaces

OBJECTIVE AND NATURE OF THE PROJECT:

The purpose of this research is to develop the basic and applied understanding of the preparation, characterization, and properties of black germanium films, so as to determine the feasibility and conditions for their use as optimized selective absorber surfaces in solar collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Project and final report are completed. We have prepared structurally anisotropic black Ge (and black Si) films by rf-sputtering and post-deposition etching. We have shown that we can alter the morphology of these films and hence their selective absorbing properties by proper choice of rf-power, substrate temperature and its nature and finish, etching time, etc. We can explain this etching behavior on the basis of oxidation through aligned voids. Further, correlation between etching behavior and microstructure of the film is established. While an α_s of greater than 99% is obtained, ε_{IR}, for films above 3 μm thick, is still being controlled by the film. Further work is needed in order to establish the thickness at which ε_{IR} is controlled by the substrate while maintaining a high α_s value.

PERIOD OF PROJECT:
September 1, 1978 to June 30, 1979

FUNDING IN $ U.S.:
$67,211.00

IMPORTANT REPORTS OR PUBLICATIONS:

P. Swab, S.V. Krishnaswamy and R. Messier. Characterization of Black Ge Selective Absorbers. J. Vac. Sci. Technol. (in press).

R. Messier, S.V. Krishnaswamy, L.R. Gilbert and P. Swab. Black a-Si Solar Selective Absorber Surfaces. J. Appl. Phys. (in press).

S.V. Krishnaswamy, R. Messier, Yee S. Ng, T.T. Tsong and S.B. McLane. Atom Probe FIM Investigation of Voids in a-Ge. Proc. 8th Int. Conf. on Amorphous and Liquid Semiconductors (in press).

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS Code No. US-42

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________

NAME OF ORGANIZATION
Purdue University

NAME OF PRINCIPAL RESEARCHER
Joseph T. Pearson

ADDRESS:
Heat Transfer Laboratory
School of Mechanical Engineering
Purdue University
West Lafayette, Indiana 47907

TITLE OF PROJECT Forced and Natural Convection Studies on Solar Collectors for Heating and Cooling Applications

OBJECTIVE AND NATURE OF THE PROJECT: The overall objective is to stimulate the advancement of commercial, industrial and professional capabilities for producing and distributing various air-heating solar energy systems. It is contemplated that the demand on fossil fuel supplies will be reduced through widespread use of air-heating solar energy systems (a) in the heating and possibly the cooling of residential and commercial buildings, (b) for heating service and process hot water, and (c) for the thermal needs of agricultural and industrial processes. Specific objectives of this work are to obtain information on forced and natural convection in air-heating solar collectors through theoretical, experimental and technological studies.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Convective heat transfer and fluid mechanics relationships applicable to (a) flat plate, (b) flat plate with plane fins, (c) flat plate with corrugations, (d) porous matrix, and (e) louvered absorber configuration collectors are being determined and documented.

PERIOD OF PROJECT:
Sept. 11, 1978 - Sept. 10, 1980

FUNDING IN $ U.S.:
$142,327

IMPORTANT REPORTS OR PUBLICATIONS:

Pearson, J.T., "Forced and Natural Convection Studies on Solar Collectors for Heating and Cooling Applications," Semiannual Report ALO/5366-1 to DOE, April, 1979.

Code No.: US-42

ORGANIZATION: Heat Transfer Laboratory
School of Mechanical Engineering
Purdue University
West Lafayette, Indiana 47907

PROJECT TITLE: Forced and Natural Convection Studies on Solar Collectors for Heating and Cooling Applications

DATA SHEET

Component : Solar Collectors

a) flat plate for air-heating with the following types of absorber configurations:

   i) Flat plate
   ii) Flat plate with fins
   iii) Flat plate with V-corrugations
   iv) Porous matrix
   v) Louvered surfaces

b) $\alpha\tau$ from 0.70 to 0.82

c) overall heat loss coefficient U_L from 2.5 to 8.0 W/m^2 K
inlet air temperature range: 20 to 40°C

d) heat capacity (fluid included) C from 1.0 to 2.5 Wh/m^2 K

e) heat transfer medium: air

f) material
   i) absorber painted aluminum or steel α from 0.90 to 0.98, ε from 0.2 to 0.90
   ii) cover plates
   number: 1 and 2
   τ from 0.80 to 0.91
   iii) insulation
   material: rigid fiberglass
   thickness 5 to 8 cm

g) expected lifetime is 20 years

h) estimated cost is from 75. to 300. $US/m^2

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. 43

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ________

NAME OF ORGANIZATION
SWEDLOW, INC.

NAME OF PRINCIPAL RESEARCHER
David Holdridge

ADDRESS:
12122 Western Ave.
Garden Grove, Ca. 92645

TITLE OF PROJECT
DEVELOPMENT OF A 10X LENS CONCENTRATOR

OBJECTIVE AND NATURE OF THE PROJECT:

Swedlow, Inc. has contracted to develop and test a low concentration (10X) linear Fresnel lens for solar heating and cooling applications. This program will include performance predictions for candidate designs under ideal conditions and with system tolerances imposed. An evaluation procedure will be developed to select a design which offers the best overall performance for a specific installation.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Performance analysis on three optically unique lens geometries have been completed. Tracking and collector system alternatives have been evaluated. Cost distinctions among candidate systems have been recognized. The final program report is nearing completion.

PERIOD OF PROJECT:

April 1, 1978 thru March 31, 1980

FUNDING IN $ U.S.:

$133,000

IMPORTANT REPORTS OR PUBLICATIONS:

Pending Final Report
Interim Monthly Progress Reports

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-44

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ________

NAME OF ORGANIZATION

Rensselaer Polytechnic Institute

NAME OF PRINCIPAL RESEARCHER

William Rogers & David Borton

ADDRESS:

Dept. of Mechanical, Aeronautical Engineering & Mechanics
Jonsson Engineering Center, Rm. 5007
Troy, N.Y. 12181

TITLE OF PROJECT

Development of a Focusing Solar Collector Energy Conversion System

OBJECTIVE AND NATURE OF THE PROJECT:

Development of a low cost system consisting of a concentrating reflector, cavity boiler receiver and a programmable controller which will deliver steam between 100 and 300C.

A complete collector system is under test and will soon be connected to an existing steam heating system replacing heating oil use of an RPI building in Troy, N.Y.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: 9/30/77-12/31/79 FUNDING IN $ U.S.: $222,035

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: US-44

ORGANIZATION: Rensselaer Polytechnic Institute

PROJECT TITLE: Development of a Focusing Solar Collector Energy Conversion System

DATA SHEET

Component : Concentrating Solar Collector

a) Type; Fresnel reflecting parabaloid, 80 sq.m. (864 sq.ft.), flat glass 2nd surface silvered mirrors, concentration ratio ~500

b) $\alpha\gamma$; α~.9, γN.A.

c) Heat loss coefficient; U_L~1 w/m^2K @200C

d) Heat capacity; C~0.2 wh/m^2K

e) Heat transfer medium; Steam

f) Material; i) Absorber; copper monotube boiler, α~.9, ε~.9
ii) Cover plate; being investigated
iii) Insulation; 6" ceramic fiber

g) Expected life; 25 yr.

h) Estimated cost; \$200/m^2 @ medium production

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-45

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Study of System Economics
NAME OF ORGANIZATION The Singer Company	ADDRESS: 286 Eldridge Road Fairfield, N.J. 07006
NAME OF PRINCIPAL RESEARCHER William Kahan	

TITLE OF PROJECT
Analytical Selection of Marketable SAHP Systems

OBJECTIVE AND NATURE OF THE PROJECT:

The project's objective is to determine the U.S. marketability of solar assisted heat pump (SAHP) systems as compared to the marketability of competing systems. The nature of the work is analytical assessment of the thermal and economic performance of series, parallel, and dual source SAHP systems as well as stand-alone heat pumps and solar energy systems in various U.S. climate regions.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Analytical models of competing systems have been developed. The models' accuracy has been verified by comparison with results obtained from detailed simulations (TRNSYS). In general, at low energy costs, air-to-air heat pumps have the lowest life cycle costs and are therefore considered most marketable. At higher energy costs (> $0.15/kWh), series SAHP systems have the lowest life cycle costs.

PERIOD OF PROJECT:
October 76 to February 80

FUNDING IN $ U.S.:
450,000

IMPORTANT REPORTS OR PUBLICATIONS:
Latest report: "Optimization and Comparison Strategies for Solar Energy Systems" by R.C. Estes and W. Kahan, Winter Annual Meeting of the American Society of Mechanical Engineers, New York, N.Y., 5 December 1979, 79-WA/Sol-26.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-46

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] TEST PROCEDURE VERIFICATION X EQUIPMENT EVALUATION
NAME OF ORGANIZATION Solar Energy and Energy Conversion Lab	ADDRESS: Rm. 325 MEB University of Florida Gainesville, Fl. 32611
NAME OF PRINCIPAL RESEARCHER H.A. Ingley, PhD, PE	

TITLE OF PROJECT Testing of Solar Collectors Thermal Performance And Reliability And Design Verification

OBJECTIVE AND NATURE OF THE PROJECT:

Evaluation of the thermal performance of solar collectors. The data is generated by several testing laboratories with comparability quality control administered by the government.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Testing completed

Individual reports submitted

PERIOD OF PROJECT: 1½ years FUNDING IN $ U.S.: $14,000

IMPORTANT REPORTS OR PUBLICATIONS:

Solar Collector Thermal Performance Test Reports

Code No. US-46

ORGANIZATION: UNIVERSITY OF FLORIDA
SOLAR ENERGY AND ENERGY CONVERSION LABORATORY

PROJECT TITLE: TESTING OF SOLAR COLLECTORS THERMAL PERFORMANCE AND RELIABILITY AND DESIGN VERIFICATION

DATA SHEET

Component: Solar Collectors

Designation 8(L)
1) Type - Flat Plate Solar Collector
2) $K\alpha\tau$ - 0.689 (Baseline)
3) KU_L - -6.463 (Baseline)
4) Heat Transfer Medium - Water

Designation 9(L)
1) Type - Flat Plate Collector
2) $K\alpha\tau$ - 0.680 (Baseline)
0.673 (Post Stagnation)
3) KU_L - -4.784 (Baseline)
-4.792 (Post Stagnation)
4) Heat Transfer Medium - Water

Designation 20(L)
1) Type - Flat Plate Solar Collector
2) $K\alpha\tau$ - 0.758 (Baseline)
0.730 (Post Stagnation)
3) KU_L - -8.173 (Baseline)
-7.413 (Post Stagnation)
4) Heat Transfer Medium - Water

Designation 45(L)
1) Type - Flat Plate Solar Collector
2) $K\alpha\tau$ - 0.524 (Baseline)
0.472 (Post Stagnation)
3) KU_L - -5.794 (Baseline)
-5.250 (Post Stagnation)

Designation 47(L)
1) Type - Flat Plate Solar Collector
2) $K\alpha\tau$ - 0.663 (Baseline)
0.654 (Post Stagnation)
3) KU_L - -7.354 (Baseline)
-6.909 (Post Stagnation)
4) Heat Transfer Medium - Water

Designation 73(L)
1) Type - Flat Plate Solar Collector
2) $K\alpha\tau$ - 0.686 (Baseline)
0.657 (Post Stagnation)
3) KU_L - -6.902 (Baseline)
-6.629 (Post Stagnation)

Designation 158(L)
1) Type - Flat Plate Solar Collector
2) $K\alpha\tau$ - 0.757 (Baseline)
0.762 (Post Stagnation)
3) KU_L - -3.704 (Baseline)
-3.541 (Post Stagnation)
4) Heat Transfer Medium - Water

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-47

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [X] AIR CONDITIONING UNIT [X] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] SYSTEMS RESEARCH AND DEVELOPMENT
NAME OF ORGANIZATION Solar Energy Applications Laboratory	ADDRESS: Colorado State University Fort Collins, Colorado 80523
NAME OF PRINCIPAL RESEARCHER Dan S. Ward	

TITLE OF PROJECT
Colorado State University Solar House III

OBJECTIVE AND NATURE OF THE PROJECT:

To evaluate the effective performance improvements in system design modifications on an integrated solar heating and cooling system using Chamberlain single glazed selective surface flat-plate solar collectors, hot water thermal storage, Yazaki lithium bromide absorption chiller, heat pump auxiliary, and an indirect Domestic Hot Water subsystem. A principal aim is to obtain quantitative performance values for major design variations between the 1978 and 1979 systems, and to utilize this information in developing more specific design procedures.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Analysis of the summer cooling data has been completed with comparative evaluation of the performance during the 1978 and 1979 summer cooling seasons now accomplished (published in the Proceedings of the Second Annual Solar Heating and Cooling Systems Operational Results Conference, Colorado Springs, November 1979). The 1979-1980 winter heating data are now being acquired and will be compared with the 1978-1979 winter heating performance.

PERIOD OF PROJECT:
1 May 1978 through 30 September 1979

FUNDING IN $ U.S.:
$259,920

IMPORTANT REPORTS OR PUBLICATIONS:

"Solar Cooling Performance in CSU Solar House III", Proceedings of the First Annual Solar Heating and Cooling Systems Operational Results Conference, Colorado Springs, November-December 1978.

"Residential Solar Heating and Cooling Using Evacuated Tube Solar Collectors - CSU Solar House III". Final report, COO-2858-24, March 1979.

"Improving Performance of Solar Cooling Systems", Second Operational Results Conf., November 1979.

Code No.: US-47

ORGANIZATION: Solar Energy Applications Laboratory
Colorado State University

PROJECT TITLE: Colorado State University Solar House III

DATA SHEET

Component: Solar Collectors
Chamberlain

(a) Type: Liquid flat-plate, single glazed, selective surface, non-evacuated
Configuration: Fifteen (15) columns of two collectors in series with reverse return manifolding

(b) $\tau\alpha$ = .846

(c) U_L = 5.1 $W/m^2 \cdot °C$
Temperature range = -7 to 32°C

(d) Heat capacity = 2.49 $Wh/°C \cdot m^2$

(e) Heat transfer fluid = water/ethylene glycol

(f) Material:
   (i) Absorber = copper (α = .94, ε = .12)
   (ii) Cover plate = 1/8" glass, low iron, tempered (τ = .9)
   (iii) Insulation = 3 inches, R-10

(g) Expected life time = 20 years

(h) Estimated cost = $153.61/$m^3$ (includes manifolding)

Code No.: US-47

ORGANIZATION: Solar Energy Applications Laboratory
Colorado State University

PROJECT TITLE: Colorado State University Solar House III

DATA SHEET

Component: Heat Storage

(a) Type: Horizontal water tank

(b) Heat capacity (i) Winter = 62.08 Wh/m^3
(ii) Summer = 28.05 Wh/m^3

(c) Latent heat = none

(d) Heat exchanger = yes (water-to-water glycol)

(e) Heat loss rate = .675 $Wh/hr \cdot m^2$

(f) Insulation = 4 inches urethane foam, R-28 (manufacturer's data)

(g) Expected life time = 20 years

Code No.: US-47

ORGANIZATION: Solar Energy Applications Laboratory
Colorado State University

PROJECT TITLE: Colorado State University Solar House III

DATA SHEET

Component: Cooling

(a) Type: Solar heating/cooling/domestic hot water

(b) Type of chiller: Lithium bromide absorption chiller

(c) Capacity: 2 tons

(d) Temperature range = 75 to 100°C

(e) C.O.P. = .5 to .65

(f) Heat exchanger = liquid-to-air finned tube

(g) Auxiliary heat source = heat pump

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-48

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ SYSTEMS RESEARCH

NAME OF ORGANIZATION
Solar Energy Applications Laboratory

NAME OF PRINCIPAL RESEARCHERS
William S. Duff and George O.G. Löf

ADDRESS:
Colorado State University
Fort Collins, CO 80523

TITLE OF PROJECT Development and Evaluation of a Residential Solar Heating and Cooling System with High Performance Evacuated Tube Collectors -- CSU Solar House I

OBJECTIVE AND NATURE OF THE PROJECT:

The primary objective of the project is the evaluation and improvement of systems for space heating, cooling, and hot water supply by use of solar energy collected in a liquid circulating through flat-plate and evacuated tubular collectors. Specific objectives of the project during the 1977-1978 year were:

(1) Evaluation of system performance for space heating and for space cooling with two types of evacuated tubular collectors
(2) Comparison of the evacuated tubular collector systems with a flat-plate system
(3) Evaluation and improvement of absorption cooling systems supplied with solar heated water from evacuated tubular collectors
(4) Participation in the planning and evaluation of a joint solar heating project in the Federal Republic of Germany

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Tested two evacuated tubular collector designs in operational house heating/cooling system. Use of absorption chiller resulting in improvement in chiller design and use of second generation chiller in system. Incorporation of modular design storage chamber to reduce storage heat losses. Long-term system comparative performance data (original project with flat-plate collector funded in 1974) for operating systems.

PERIOD OF PROJECT:
1 October 1977 to 30 September 1978

FUNDING IN $ U.S.:
196,438

IMPORTANT REPORTS OR PUBLICATIONS:

"Comparative Performance of Two Types of Evacuated Tubular Solar Collectors in a Residential Heating and Cooling System", Duff and Löf, Report COO-2577-19, Sept. 1979

"Operational Improvements in the CSU Solar House I System Supplied with Heat from Evacuated Collectors", Duff, Hancock and Löf. 2nd Oper. Results Conf. on Solar Heating and Cooling Systems, Colorado Springs, Nov. 1979

"Comparative Performance of Two Types of Evacuated Tube Solar Collectors in a Residential Heating and Cooling System - The Progress Report", Conway, et al, ISES Proc. Annual Meeting, Atlanta, June 1979.

Code No.: US-48

ORGANIZATION: Solar Energy Applications Laboratory
Colorado State University

PROJECT TITLE: Development and Evaluation of a Residential Solar Heating and Cooling System with High Performance Evacuated Tube Collectors -- CSU Solar House I

DATA SHEET

Component: Heat Storage

(a) Type: liquid (water), 1100 gallon modular storage tank

(b) Heat capacity: 1164 Wh/m^3

(c) Latent heat: Not applicable

(d) Heat exchanger: Yes (Young Radiator), heat transfer fluid is water

(e) Insulation: 4 inches of polyurethane foam

(f) Expected lifetime: Unknown

Code No.: US-48

ORGANIZATION: Solar Energy Applications Laboratory
Colorado State University

PROJECT TITLE: Development and Evaluation of a Residential Solar Heating and Cooling System with High Performance Evacuated Tube Collectors -- CSU Solar House I

DATA SHEET

Component: Solar Collectors

(a) Type: Two types of collectors investigated:
(1) Corning evacuated tubular
(2) Philips evacuated tubular

(b) $\alpha\tau$ (1) Corning: .63
(2) Philips: .71 based on aperture area

(c) Overall heat loss coefficient (temperature range 30°-100°C)
(1) Corning: U_L = 1.35
(2) Philips: U_L = 2.18 based on aperture area

(d) Heat transfer medium (both): water/ethylene glycol, 60%/40% mixture

(e) Material
(i) Absorber (1) Corning: α = .95, ε = .03
(2) Philips: α = .98 ε = .03
(ii) Cover plate (1) Corning: 2
(2) Philips: 2

(f) Expected lifetime (both): 20 years

(g) Estimated cost (1) Corning: prototype unit
(2) Philips: prototype unit

Code No.: US-48

ORGANIZATION: Solar Energy Applications Laboratory
Colorado State University

PROJECT TITLE: Development and Evaluation of a Residential Solar Heating and Cooling System with High Performance Evacuated Tube Collectors -- CSU Solar House I

DATA SHEET

Component: Air Conditioning and Cooling

(a) Type: solar heating/cooling

(b) Type of refrigerator: absorption
Working medium: lithium bromide

(c) Capacity of refrigerator: 3 tons

(d) C.O.P.: 0.5 - 0.6

(e) Heat exchanger: Liquid-to-air coil

(f) Auxiliary heat source: electric boiler

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-49

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR ~~COLLECTOR~~ Concentrator [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______________
NAME OF ORGANIZATION Solar Energy Technology, Inc.	ADDRESS: Civil Terminal Building L. G. Hanscom Field Bedford, Mass. 01730 USA
NAME OF PRINCIPAL RESEARCHER Carlyle J. Sletten	

TITLE OF PROJECT

IMAGE COLLAPSING CONCENTRATORS

OBJECTIVE AND NATURE OF THE PROJECT: Research, development and testing of a Stepped Prism Lens (Fresnel type) with and Image Collapsing Subreflector(SPLICS) which concentrates the solar energy in a 60° in elevation by 100° in azimuth acceptance ange sector with a concentration ratio of approximately 3. This non-tracking concentrator makes use of a novel two-point corrected Fresnel Lens and an especially shaped cylindrical mirror which bring all the direct and diffuse solar energy in the acceptance zone onto a narrow flat strip or "shelf". The lens constructed had the prism facets on the front surface of the acrylic lens and, under a continuation of the project, a new lens will be designed with prism steps on the inside surface of the lens. New work in progress includes experimental tests using evacuated absorbers and an economic study of life time costs of SPLICS collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

A 30½ cm by 30½ cm section of the Stepped Prism Lens and an Image Collapsing Subreflector based on the lens' focal properties has been constructed and tested using computer and laser ray tracing and solar measurement techniques. Thermal efficiency tests were conducted using water circulant through selectively coated copper tubes situated on the shelf of the concentrator. All the optical characteristics of the concentrator were verified successfully and the thermal tests indicated that excellent performance of full sized aperture collectors with evacuated absorbers can be expected.

PERIOD OF PROJECT: October 1977 to August 1980

FUNDING IN \$ U.S.: \$85,874

IMPORTANT REPORTS OR PUBLICATIONS:

Interim Scientific Report under Department of Energy Grant DE FG 04.77CS34163, Image Collapsing Concentrators, entitled "Wide-angle Lenses and Image Collapsing Subreflectors for Non-Tracking Solar Collectors" 31 May 1979

Code No.: US-49

ORGANIZATION: Solar Energy Technology, Inc.

PROJECT TITLE: Image Collapsing Concentrators

DATA SHEET

Component : Solar Concentrator

a) Type: Cylindrical Fresnel lens with subreflecting mirror of special shape. Lens aperture 30½ x30½ cms and nearly flat; Correction angles at ± 25° in the 60° elevation coverage sector; Index of refraction 1.49; Minimum lens thickness 1.27 cms; Lens has 40 prism steps each 0.762 cms high; Focal length on axis 32 cms, at correction points 29.3 cms. Subreflector mirror width 25 cms and length 22 cms. Absorber shelf width 7.94 cms. Concentration ratio approx. 3.8.

Thermal testing with evacuated absorbers will result in final collector performance data in 1980.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-50

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________

NAME OF ORGANIZATION
Solar Turbines International

NAME OF PRINCIPAL RESEARCHER
John Gagliani

ADDRESS:
2200 Pacific Highway
P.O. Box 80966
San Diego, CA 92138

TITLE OF PROJECT
Development of Polyimide Materials for Use in Solar Energy System

OBJECTIVE AND NATURE OF THE PROJECT:

The major objective of this project involves the characterization of fire resistant no smoke emitting polyimide foams with a wide spectrum of rigidity and density characteristics for use in insulation of solar energy systems and components. Other important objectives of the program are the optimization of the properties of these materials with special efforts directed toward improving outside exposure resistance, dimensional stability and the development of cost effective processes for their production.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The significant accomplishments of the program recently completed include selection and characterization of flexible polyimide foams and rigid polyimide foams possessing a wide range of density and mechanical characteristics. These materials are resistant to outside exposure and do not burn or emit smoke when subjected to open flames.

PERIOD OF PROJECT: 8/78 to 10/79

FUNDING IN $ U.S.: $132,000

IMPORTANT REPORTS OR PUBLICATIONS:

None

Code No.: US-50

ORGANIZATION: Solar Turbines International, An Operating Group of International Harvester

PROJECT TITLE: Development of Polyimide Materials for Use in Solar Energy System

DATA SHEET

Component : Solar Collectors

f) Material

iii) Insulation: Flexible and rigid polyimide foams

Density (minimum):	19.2 kg/m^3
Thickness (maximum):	25 cm
Resistance to Heat (continuous):	561 K
Burning rate:	non-burning
Smoke emission:	none
Thermal conductivity:	0.04 $Wm^{-1} K^{-1}$

IEA SURVEY OF COMPONENTS FOR SOLAR HEAT...,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-51

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________

NAME OF ORGANIZATION
Sperry Univac

NAME OF PRINCIPAL RESEARCHER
S. O. Jensen

ADDRESS:
P.O. Box 3525
St. Paul, Minnesota
55165 MS. UOS23

TITLE OF PROJECT
Solar Collector Studies for Solar Heating and Cooling Applications

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this work is to evaluate the potential of solar collectors in which the solar energy is deposited in the heat transfer fluid or deposited in particles carried by the fluid. The most promising fluids, absorbers, and collectors design shall be identified.

The objective also is to determine the corrosion effects of the liquid, the stability of the liquid and the cost implications of providing a transparent container for the liquid.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The project has been completed and the final technical report is being written.

PERIOD OF PROJECT: September 18, 1978 through January 31, 1980

FUNDING IN $ U.S.: 63,680.00

IMPORTANT REPORTS OR PUBLICATIONS: A six month technical report published March 1979

Code No.: US-51

ORGANIZATION: Sperry Univac

PROJECT TITLE: Solar Collector Studies for Solar Heating and Cooling Applications

DATA SHEET

Component :

Solar Collectors - 3 Tube Type

Collector #1 - 1½" X 10' corning industrial glass pipe spaced 1" apart in a 4' X 10' enclosure. It is provided with a reflective back consisting of foil backed fiberglass insulation. This collector has a mass of 90 pounds empty; 212 pounds full. This represents the unit with the most black liquid exposed relative to the total unit area, 18.75 ft.^{2} tube plane surface area/37.8125 ft.^{2} aperture area.

Collector #2 - 1" X 10' Brockway light weight soda lime glass tubes spaced 1" apart in a 4' X 10' enclosure. It is provided with a reflective back as with Collector #1. This collector weighs 58.6 pounds empty; 133 pounds full, and presents a tube plane surface area of 16.66 ft.^{2}/ 37.8125 ft.^{2} aperture area.

Collector #3 - Uses exactly the same tube system as Collector #2, but with the aluminum foil backed insulation painted black with Krylon flat black enamel.

The mass of these units did not require any alteration of the conventional roof structure of 2" X 6" studs on 24" centers with 5/8" plywood decking.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-52

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________

NAME OF ORGANIZATION

Telic Corporation

ADDRESS:

1631 Colorado Avenue
Santa Monica, CA 90404

NAME OF PRINCIPAL RESEARCHER

John A. Thornton

TITLE OF PROJECT

Development of Selective Surfaces

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of project is to examine the applicability of cylindrical magnetron sputtering for depositing solar selective coatings, primarily by reactive sputtering. Two representative absorber coatings were selected for development as vehicles for evaluating the sputtering technology in a four-phase program. One phase examines a sputter-deposited cermet type coating that might be a substitute for black chrome. A second phase examines all-sputter-deposited Al_2O_3-Mo-Al_2O_3 coatings. In two proof-of-concept phases a cermet type coating is continuously deposited onto aluminum foil, and hollow cathodes are used to deposit Al_2O_3-Mo-Al_2O_3 coatings onto the outside diameter of short tubular sections.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

First two phases have been completed. Proof-of-concept phases are in progress. Coatings of stainless steel sputtered in Ar and O_2 with Al_2O_3 reactively sputtered antireflection coatings have yielded absorptances (α) of 0.90 and room temperature emittances (ϵ) of 0.07. Coatings of stainless steel sputtered in Ar and CO have yielded $\alpha = 0.89$ and $\epsilon = 0.08$. Co-deposited Cr/Al_2O_3 cermets have yielded $\alpha = 0.92$ and $\epsilon = 0.07$. Optimum Al_2O_3-Mo-Al_2O_3 coatings are in agreement with theoretical predictions and yielded $\alpha = 0.94$ and $\epsilon = 0.07$.

PERIOD OF PROJECT: 11 September 1978 to 31 March 1980.

FUNDING IN $ U.S.: $77,215.00

IMPORTANT REPORTS OR PUBLICATIONS:

J.A. Thornton, "Sputter Deposited Selective Absorber Coatings," paper presented at Second American Electroplaters Society, Inc., Coatings for Solar Collectors Symposium, St. Louis, Missouri, Oct. 16-17, 1979.

J.A. Thornton, A.S. Penfold, and J.L. Lamb, "Sputter Deposited Al_2O_3-Mo-Al_2O_3 Selective Absorber Coatings," paper to be presented at International Coatings Conference, San Diego, CA, March 21-25, 1980.

IEA SURVEY OF COMPONENTS FOR SOLAR HEAT..
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-53

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] Design for Solar Systems
NAME OF ORGANIZATION Tennessee Technological University	ADDRESS: Box 5161, TTU Cookeville, TN 38501
NAME OF PRINCIPAL RESEARCHER Hudy C. Hewitt, Jr.	

TITLE OF PROJECT
The Effect of Wind on Collectors

OBJECTIVE AND NATURE OF THE PROJECT:

Three major efforts to evaluate the effect of wind on collector performance were to be addressed. A study of wind flow patterns around residential dwellings was to be correlated with wind velocity data collected by the weather stations. A sensor system was to be evaluated in an effort to measure the effect of wind on collector performance more accurately. The convective film heat transfer from an inclined surface was to be studied.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The final report of these studies was forwarded to DOE in November 1979 (Contract Number EM-78-C-04-5364). Positive results are reported on all three objectives.

PERIOD OF PROJECT:
10-1-78 to 10-1-79

FUNDING IN $ U.S.:
$71,642

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report: "Wind Effects on Collectors"
Contract Number EM-78-C-04-5364

IEA SURVEY OF COMPONENTS FOR SOLAR HEAT.
COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-54

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [x] LOADS ANALYSIS
NAME OF ORGANIZATION Texas A&M University	ADDRESS: Aerospace Engineering Department Texas A&M University College Station, Texas 77843
NAME OF PRINCIPAL RESEARCHER H. L. Chevalier	

TITLE OF PROJECT Wind Loads on Solar Collector Panels and Support Structures (EY-76-S-05-5130)

OBJECTIVE AND NATURE OF THE PROJECT:

The investigation consisted of wind tunnel tests to determine wind loads, full-scale tests of a collector to obtain comparison data, and a structural analysis of a typical collector. The objectives were to obtain force and moment coefficients, to determine the effects of changes in geometric variables, and to analyze the suitability of design techniques.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The investigation is complete and a final report has been submitted. The tests and theoretical analyses showed that the flow over solar collectors is more complex than initially realized, but that the effects of steady flow could be predicted.

PERIOD OF PROJECT: 1/1/77 to 6/15/79   FUNDING IN $ U.S.: $84,544

IMPORTANT REPORTS OR PUBLICATIONS:

1. Stricklin, J. A., Chevalier, H. L., Norton, D. J., and Hix, C. M., "Structural Integrity of Solar Collectors," Progress Report, Contract No. E-(40-1)-5130, Texas A&M University Research Foundation, 1978.
2. Chevalier, H. L. and Norton, D. J., "Wind Loads on Solar Collector Panels and Support Structures," Final Report, Contract No. EY-75-S-05-5130, Texas A&M University Research Foundation, 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEAT, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-55

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ LOADS ANALYSIS
NAME OF ORGANIZATION Texas A&M University	ADDRESS: Aerospace Engineering Department Texas A&M University College Station, Texas 77843
NAME OF PRINCIPAL RESEARCHER H. L. Chevalier and R. A. Wilke	

TITLE OF PROJECT
Structural Integrity of Solar Collectors (DE-AC04-79AL11774)

OBJECTIVE AND NATURE OF THE PROJECT:

The project will investigate the dynamic and unsteady loads on solar collectors and support structures. The effect of wind turbulence and gusts will be obtained from measurements of the unsteady force coefficients for various collector geometric variables. In addition, the nature of the pressure distributions about the surface of collectors will be determined. Although most of the testing will be conducted in the wind tunnel where changes in geometric shapes can be readily made, measurements will also be obtained from full-scale solar collector systems.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Instrumentation for the full-scale test has been designed and is 80% complete. Wind tunnel test plan is in progress.

PERIOD OF PROJECT: 9/1/79 to 9/30/80 FUNDING IN $ U.S.: $39,617

IMPORTANT REPORTS OR PUBLICATIONS: None

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ____________
NAME OF ORGANIZATION Total Environmental Action, Inc.	ADDRESS: Church Hill, Harrisville, NH 03450
NAME OF PRINCIPAL RESEARCHER Peter L. Temple	

TITLE OF PROJECT

Development of Site Fabricated, Building-Integrated Air Solar System

OBJECTIVE AND NATURE OF THE PROJECT:

The general goal of the project is the development of a cost-effective, building-integrated, flat-plate air collector, and the accompanying storage and control system. The specific objectives are:(1) Development of a site-fabricated, solar air system design with performance comparable or superior to presently available manufactured collectors. (2) Development of the air system design so that it can be cost-effectively integrated into building structures in the majority of potential building situations with a minimum of construction problems. (3) Development of sufficient technical and economic data, drawings, and other information to promote the application of the design and provide for its evaluation.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Significant accomplishments are: (1) Assessment of existing site-fabricated, solar air heaters, including nation-wide survey of installations. (2) Detailed analysis of materials available for use in site-fabricated air collectors. (3) Evaluation of seven alternative collector designs, including theoretical performance calculations, computer analysis of annual performance, and comparisons of costs, durability, construction simplicity, ease of building integration, and aesthetics. (4) Optimization of the best design and testing of five collector modules to ASHRAE 93-77 and HUD 30-day stagnation test, with measured performance comparable to that of standard manufactured collector. (5) Final collector design costs approximately one third as much as most manufactured collectors. Present Status: The remainder of the system design is nearing completion and the final product of the project, *

PERIOD OF PROJECT:

September 1977 to October 1978
September 1979 to March 1980

FUNDING IN $ U.S.:

$142,076.00

IMPORTANT REPORTS OR PUBLICATIONS:

"Development of a Site-Fabricated, Building Integrated Air Collector. Part I: Evaluation of Alternative Collector Designs," Proceedings of the First Annual New England Site-Built Collector Conference, December, 1978 (with J. Kohler, J. Coleman, and P. Sullivan).

"Evaluation of Six Designs for a Site-Fabricated, Building Integrated Air Heater. Part II: Cost, Seasonal Performance, Building Integration, Reliability and Aesthetics." Proceedings of the 1978 Annual Meeting of the American Secion of **

*See attached page **See attached page

*PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS: (continued)

a complete construction manual, should be released in early 1980.

**IMPORTANT REPORTS OR PBULICATIONS: (continued)

the International Solar Energy Society, Vol. 2.1 (September, 1978) (with J. Kohler, J. Coleman, and P. Sullivan).
"The MODEL-TEA Site-Fabricated, Building Integrated, Solar Collector," ASHRAE Transactions, presented June, 1979, at the annual meeting (with J. Kohler and P. Sullivan).
Progress reports submitted to the United States Department of Energy: April 28, 1978; July 31, 1978; January 3, 1979; January 20, 1980.

Code No.: US-56

ORGANIZATION: Total Environmental Action, Inc.
Harrisville, NH 03450

PROJECT TITLE: Development of a Site-Fabricated, Building-Integrated, Air Solar System.

DATA SHEET

Component : Solar Collector

a) flat plate, integrated into building roof, fabricated on site, single glazed

b) $\tau\alpha = 0.86$

c) $U_L = 6.2\ W/m^2K$ (30 to 60°C)

d) $c = 0.8\ Wh/m^2K$

e) air

f) i) absorber
flat black aluminum
$\alpha = 0.95$ $\varepsilon = 0.95$

ii) one cover plate
low-iron glass
$\tau = 0.90$

iii) collector integrated into building surface, insulation is full standard roof insulation, such as 6" of fiberglass

g) expected lifetime is 20 years

h) extimated cost is $\$75/m^2$

Code No.: US-56

ORGANIZATION: Total Environmental Action, Inc.
Harrisville, NH 03450

PROJECT TITLE: Development of a Site-Fabricated, Building-Integrated, Air Solar System.

DATA SHEET

Component : Heat Storage

a) rock bin

b) $C = 293\ Wh/m^3K$ (30 to 60^oC)

c) --

d) No

e) --

f) rock bin insulated with 6 inches of fiberglass

g) expected lifetime is 20 years

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-57

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Application to Industrial Process
NAME OF ORGANIZATION Trident Engineering Associates, Inc.	ADDRESS: 48 Maryland Avenue Annapolis, Maryland 21401
NAME OF PRINCIPAL RESEARCHER Payson D. Sierer, Jr.	

TITLE OF PROJECT Gilroy Foods Solar Project

OBJECTIVE AND NATURE OF THE PROJECT:

Application of solar industrial process heat to the continuous belt dehydration of onions

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

System became operational in July 1979 and is producing industrial process heat at the Gilroy Foods, Inc. onion and garlic dehydration plant in Gilroy, California

PERIOD OF PROJECT: 5/25/76 - 8/5/80 FUNDING IN $ U.S.: $1,021,562

IMPORTANT REPORTS OR PUBLICATIONS: "Application of Solar Energy to Continuous Belt Dehydration - Phase I - Final Report", April 25, 1977, Trident Engineering Associates, Inc.

"The Application of Solar Industrial Process Heat to the Continuous Belt Dehydration of Garlic and Onions", B. J. Graham, P. D. Sierer, Jr., Trident Engineering Associates, Inc., D. Powell, Gilroy Foods, Inc., Paper presented at the SERI Industrial Process Heat Symposium, Oakland, Ca., Oct. 30 - Nov. 1, 1979

Code No.: US-57

ORGANIZATION: Trident Engineering Associates, Inc.

PROJECT TITLE: GILROY FOODS SOLAR PROJECT

DATA SHEET

Component :

GILROY FOODS SOLAR ENERGY PROJECT
SYSTEM DESCRIPTION

System Purpose	Process Heat, for onion/garlic dehydration
Solar Collector	General Electric TC-100 Evacuated Tube Solar Collector Design Characteristics Normal Size: 4'-0" x 4'-0" Number of Vacuum Tubes: 8 Weight Filled: 59 Lbs. Frame: 18 Ga. Aluminized Steel Reflector: Polished Aluminum Fluid Lines: 1/4" Copper Tube Module Area: Total Frame 1.62 m² (17.4 ft²)-[active*] 1.38 m² (14.8 ft²) Flow Rate: 0.22 GPM Pressure Drop-Design: 7.0 psi @ 82°C (180°F) Operating Temperature: 38°C (100°F) to 149°C (300°F)
Number of Collectors	402 Modules
Slope Angle of Collectors	22°
Area of Collectors	553 m² (5950 ft²) [active*]
Heat Transport Fluid	Demineralized Water
System Flow Rate	88 Gallons per Minute
System Operating Pressure	65 psig pump discharge - 30 psig collector inlet
System Operating Temperature	90°C (194°F)
Maximum Heat Production Rate	1.16×10^9 J/hr (1.1 MBtu/hr)
Total Annual Heat Production Rate	2.47×10^{12} J/hr (2340 million Btu/yr)
Piping System	2-1/2" Diameter Copper Pipe
System Insulation	1-1/2" Fiberglass
System Control	Automatic Data Acquisition and Systems Control with Remote Command Capability
Module Cleaning	Automatic Washdown System

* *Heat producing area*

IEA SURVEY OF COMPONENTS FOR SOLAR HEA...,
COOLING AND HOT WATER SUPPLY SYSTEMS　　　Code No. US-58

COUNTRY: UNITED STATES

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

NAME OF ORGANIZATION
TUFTS UNIVERSITY

NAME OF PRINCIPAL RESEARCHER
PROF. RONALD B. GOLDNER

ADDRESS:
Department of Electrical Engineering
Tufts University
Medford, MA 02155

TITLE OF PROJECT STUDIES FOR PREDICTABLY MODIFYING THE OPTICAL CONSTANTS OF DOPED INDIUM OXIDE FILMS

OBJECTIVE AND NATURE OF THE PROJECT:

Correlate the dependence of the optical constants of polycrystalline films of doped indium oxide with structure, composition, and thermal history; and to arrive at a useful model of the electromagnetic behavior of doped indium oxide so that one could predictably modify its optical constants and those of related metal oxides.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Two measuring methods, the Brewster/Abelès and the Prism-Coupled Optical Waveguide techniques, have been developed to precisely measure the refractive index at 633 nm. wavelength. The measurements are being utilized to evaluate two refractive index models, which are currently yielding good predictability for Fe -, B -, Aℓ -, Sn -, Zr -, and combined (B- + Sn-) doped indium oxide films. Changes in refractive index associated with oxidation, reduction anneals are also being evaluated.

PERIOD OF PROJECT:
5 June 1978 - 31 May 1980

FUNDING IN $ U.S.:
$73,000

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. 59

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [X] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS [X] HEAT PUMP	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [ ] SYSTEM DEVELOPMENT

NAME OF ORGANIZATION
Research Center and Hamilton Standard Division of United Technologies Corp.

NAME OF PRINCIPAL RESEARCHER
Frank R. Biancardi (UTRC)
James W. Sitler (HSD)

ADDRESS:
United Technologies Research Center
Silver Lane
East Hartford, CT 06108

TITLE OF PROJECT Design, Development and Test of a Prototype Solar-Powered Turbocompressor Heat Pump - DE-AC03-77CS34510

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of the extended testing to be conducted under the above contract is to evaluate and demonstrate the component and overall performance, reliability and endurance characteristics of the prototype solar-powered turbocompressor heat pump and identify areas requiring further development. The results will provide the data essential to initiate tests of a totally integrated solar system utilizing the UTC heat pump.

This program is an immediate continuation of a previous DOE funded solar-powered heat pump contract whose objective was to design, fabricate and conduct preliminary tests of a prototype heat pump nominally sized (18-ton capacity) for multi-family residential applications. The heat pump incorporates a new turbocompressor specifically designed to operate at temperatures consistent with air cooling and medium-concentration collectors presently under development for solar heating and cooling applications.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The heat pump has been built and tested successfully over a wide range of conditions. Design point heating and cooling goals have been demonstrated (i.e., 18 tons of cooling at COP = 0.6 to 0.8 and heating of 450,000 Btu/hr with COP = 1.7). Endurance testing is being conducted to identify further improvements. System will be field tested within next year under separate contract.

PERIOD OF PROJECT:

1 September 1977 - 31 May 1980

FUNDING IN $ U.S.:

$1,318,000

IMPORTANT REPORTS OR PUBLICATIONS:

See Attached

IMPORTANT REPORTS OR PUBLICATIONS

1. Biancardi, F. R., et al: "Design, Development and Testing of a Solar Powered Multi-Family Residential Prototype Turbocompressor Heat Pump Final Report": Draft Report R79-953050-1, prepared under DOE Contract AC03-777-CS34510, September 1979.

2. Biancardi, F. R. and G. Melikian: "Analysis and Design of an 18-ton Solar-Powered Heating and Cooling System," Paper 789524 presented at 13th IECEC, San Diego, CA, August 1978.

3. Melikian, G., B. W. Rhodes and T. N. Obee: "Results of Systems Simulation and Economic Analysis of a Solar-Powered Turbocompressor Heat Pump" Paper presented at DOE/SERI Symposium on Systems Analysis, January 23-25, 1980.

4. Young, P., and F. R. Biancardi: "Design and Development of a Prototype Solar-Powered Turbocompressor Cooling and Heating System" Paper presented at Third DOE Workshop on Use of Solar Energy for Building Cooling, San Francisco, CA, February 15-17, 1978.

Code No.: 59

ORGANIZATION:

Research Center and Hamilton Standard
Division of United Technologies Corporation

PROJECT TITLE:

Design, Development and Test of a Prototype Solar-Powered Turbocompressor Heat Pump - DE-AC03-77CS34510

DATA SHEET

Components - Air Conditioning and Cooling

a) Type - solar heat pump

b) Refrigerator - Vapor compression cooling cycle - driven by
Rankine cycle power loop - single stage turbine direct driving
a single stage compressor
R11 working fluid in both loops

c) 18 tons cooling (range 3 to 20 tons)
500,000 Btu/hr in heat pump mode (range 250,000 to 600,000 Btu/hr)

d) Output-Cooling Mode - chilled water at 45 F
" -Heat Pump Mode - hot water at 135 F

e) Cooling-COP range - 0.6 to 0.9
Heat Pump - 1.3 to 3.5 (heat out/heat supplied)

f) Heat exchangers - various types - flooded and direct exchange
- separate fan coil

g) Furnace (gas or oil-fired) in both cooling or heat pump mode

Code No.: 59

ORGANIZATION:

Research Center and Hamilton Standard
Division of United Technologies Corporation

PROJECT TITLE:

Design, Development and Test of a Prototype Solar-Powered Turbocompressor Heat Pump - DE-AC03-77CS34510

DATA SHEET

Components - Solar Collectors

All types of collectors can be used. Preference for Northeast is concentrating evacuated tube (CPC) type, parabolic trough for Southwest U.S. Combinations of various types for selected U. S. geographical area. Collectors would be purchased from current manufacturers of each type.

Code No.: 59

ORGANIZATION:

Research Center and Hamilton Standard
Division of United Technologies Corporation

PROJECT TITLE:

Design, Development and Test of a Prototype Solar-Powered Turbocompressor Heat Pump - DE-AC03-77CS34510

DATA SHEET

Components - Heat Storage

Various types of hot water or water/other fluid systems possible. Maximum storage water temperature levels would be 300-325 F. Components (Tanks, valves, controls) would be purchased from current manufacturers.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS. Code No. US-60

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ____________

NAME OF ORGANIZATION
Physics & Astronomy, Univ. of New Mexico

ADDRESS:
800 Yale Blvd. N.E.
Albuquerque, NM 87131

NAME OF PRINCIPAL RESEARCHER
Howard C. Bryant

TITLE OF PROJECT
Solar Pond Studies: Phase III

OBJECTIVE AND NATURE OF THE PROJECT:
A mature, salt-gradient (NaCl), full-scale solar pond continues to be maintained and monitored daily. Data on the pond is being acquired using a computer-based system (MIK 11), and is being compared with the results of a computerized mathematical model of the pond currently under development. The objective of this year's research is to prepare a model, reflecting the UNM experiences, that can be used in the design of future ponds.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Salt-gradient solar pond research at UNM is now in its fourth year, based on a full-scale NaCl pond. Techniques for filling such ponds and extracting heat have been developed. The effects of the pond's sloping walls on salt transport and thermal efficiency are being studied. A model saturated-salt gradient pond using KNO_3 has been successfully operated. The conditions of stability for both unsaturated and saturated ponds have been studied and put into a practical form.

PERIOD OF PROJECT: April 1, 1977- August 30, 1980

FUNDING IN $ U.S.: $155,952

IMPORTANT REPORTS OR PUBLICATIONS:

Bryant, H. C., Colbeck, I. (1977). A Solar Pond for London? Solar Energy 19, 321.

Zangrando, F., Bryant, H. C. (1977). Heat extraction from a salt gradient solar pond. Proc. of the Internatl. Conf. on Alternative Energy Sources, Miami Beach, FL. Also available as NMEI 45, New Mexico Energy Institute, Las Cruces.

Zangrando, F, Bryant, H. C. (1978). Solar Ponds. Solar Age 3, 21.

Zangrando, F (1979). Observation and Analysis of a Full-Scale Salt Gradient Solar Pond. Ph.D. Dissertation, The University of New Mexico, May, 1979.

Rothmeyer, M. (1979). Saturated Solar Ponds--Modified Equations and Results of a Laboratory Experiment. M.S. thesis, The University of New Mexico, December, 1979.

Code No.: US-60

ORGANIZATION: Department of Physics and Astronomy
University of New Mexico

PROJECT TITLE: Solar Pond Studies: Phase III

DATA SHEET

Component : Salt-gradient solar pond. This object is both a collector and a long-term storage element. Our full-scale pond is embedded in the dry, sandy soil on the University of New Mexico campus. The pond is in the form of a frustum of a cone with a bank angle of 34° from horizontal. Its top diameter is 15 m; depth, 2.5 m. Average collecting area is 105 m^2. The capacity of the pond is 230 m^3, with a storage volume in the bottom convecting layer of 130 m^3. There is no insulation in the walls of the pond, which is lined with 45-mil, 3-ply Hypalon, guaranteed for 20 years against normal weathering. The other constitutents are water from the municipal supply and NaCl. The bottom layer (storage) is approximately 20% NaCl by weight, with the concentration falling monotonically to 1 or 2% by weight on the surface. The measured efficiency of the pond is approximately 9% averaged over one year with heat being withdrawn as needed by a 185 m^2 Albuquerque residence. The estimated cost of the pond (not including land) is \$54/m^2 (1975 dollars). A laboratory saturated pond, using KNO_3 has also been studied, with encouraging results.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-61

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [X] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] Systems Performance Monitoring
NAME OF ORGANIZATION The University of Texas at Austin NAME OF PRINCIPAL RESEARCHER Gary C. Vliet	ADDRESS: Center for Energy Studies ENS 143 The University of Texas at Austin Austin, Texas 78712

TITLE OF PROJECT Instrumentation of a Solar Heated and Cooled Apartment Building for Monitoring and Evaluation

OBJECTIVE AND NATURE OF THE PROJECT:

To instrument, monitor and evaluate the performance of an apartment building which was retrofitted for solar heating, cooling and domestic hot water.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The sensing instrumentation has been installed and a borrowed data acquisition system used to do some monitoring for a few months during the summer '79. Subsequently the new data acquisition system has been installed and we are about ready to do serious monitoring.

PERIOD OF PROJECT:
Sept. 15, 1978 - Sept. 15, 1979*
(*to be extended for at least one year)

FUNDING IN $ U.S.:
$56,000

IMPORTANT REPORTS OR PUBLICATIONS:

(1) G. C. Vliet, "Retrofitting of an Apartment Building for Solar Heating, Cooling and Hot Water", presented at DOE Regional Solar Update, Orlando, Florida, July 15-17, 1979.

(2) R. L. Srubar, "Performance Monitoring of a Solar Heated and Air Conditioned Multiple Family Dwelling," M.S. Thesis, Univ. of Texas, December, 1979.

Code No.: US-61

ORGANIZATION:

Center for Energy Studies
The University of Texas at Austin
Austin, Texas 78712

PROJECT TITLE:

Instrumentation of a Solar Heated and Cooled Apartment Building for Monitoring and Evaluation

DATA SHEET

Component :

(1) Solar Collectors
- a) type - concentrating-linear Fresnel
- b) $\alpha\tau$ - (not readily known)
- c) U_L - (not readily known)
- d) C - (not readily known)
- e) heat transfer medium - water
- f) material -
  - i) nickel oxide coated, flattened copper tube
  - ii) acrylic Fresnel lens
  - iii) 2.5 cm. fiberglass insulation
- g) expected life - unknown
- h) cost - $\$310/m^2$ (not installed)

(2) Heat Storage
- a) type - water in pressurized steel tanks
  5000 gallon hot water tank
  500 gallon chilled water tank
- b) heat capacity: 3.5×10^4 Wh/m^3 each for 30^oC range
- c) N/A
- d) heat exchangers: Water/water for domestic heater in hot tank
- e) "heat rate": 5.4 m^2 surface area (immersed u-tube exchanger)
- f) insulation: 5 cm. polyurethane foam
- g) expected life: 25 years

(3) Air Conditioning and Cooling
- a) type - solar heating/cooling
- b) type of ref: absorption - water/lithium bromide
- c) capacity: 25 ton Arkla (derated to 15 tons)
- d) temp. range: unit operates at 75^oC and above
- e) C.O.P. - 0.6
- f) heat exchanger - none (direct)
- g) auxiliary heat source - electric resistance heat, electric vapor compression air conditioning and electric water heaters retained for auxiliary and backup.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-62

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [ ] COMPONENT DEVELOPMENT [X] System Evaluation

NAME OF ORGANIZATION
University of Virginia

NAME OF PRINCIPAL RESEARCHER
Dr. J. Taylor Beard

ADDRESS:
Department of Mechanical and Aerospace Engineering
University of Virginia
Charlottesville, Virginia 22901

TITLE OF PROJECT Annual Collection and Storage of Solar Energy for the Heating of Buildings

OBJECTIVE AND NATURE OF THE PROJECT:

The research objectives included the design, construction, testing, and evaluation of an experimental system for year-round collection and storage of solar energy for the heating of buildings.

The storage resembles a swimming pool with 103 m^3 (27,400 gal.) of water. The collector was 53.5 m^2 (576 ft. ^{2}) near horizontal open water-channel solar collector having two glasings. The solar collector seals the top of the pool and reduces losses from the energy storage pool. An evaluation of potential design modifications for improved thermal performance was an important part of the research objectives.

The testing and evaluation program has included the use of standard instrumentation and measuring techniques. Analytical simulation was used to determine system performance under varying ambient and design conditions.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

An experimental system was operated on for an annyal cycle from February 1977 through January 1978, and the project has been completed. The overall conclusion of the reseach is that the system, as constructed and tested, is inadequate for the annual collection and storage of solar energy for the heating of buildings. The storage system experiences excessive heat losses during cool and cold weather which may be considerably reduced by providing appropriate insulation. Computer simulation has shown that the system performance is greatly improved by using a water-source heat pump rather than by depending on direct solar heating alone. In addition, system improvement occurs when the collector is reoriented to a customary sloping near south-facing orientation.

PERIOD OF PROJECT: 5/1/76 to 7/31/78 FUNDING IN \$ U.S.: 165,666

IMPORTANT REPORTS OR PUBLICATIONS:

Beard, J. T., et. al, "Analysis and Experimental Evaluation of a System for the Annual Collection and Storage of Solar Energy," ASHRAE Transactions, Vol. 85, Part 1 (1979).

Beard, J. T., et. Al, "Heat Transfer Analysis of a System for Annual Collection and Storage of Solar Energy," Heat Transfer in Solar Energy Systems, ASME Publication No. H00104 (1977), pp. 113-19.

Code No.: US-62

ORGANIZATION: Department of Mechanical and Aerospace Engineering
University of Virginia
Charlottesville, Virginia 22901

PROJECT TITLE: Annual Collection and Storage of Solar Energy for the Heating of Building

DATA SHEET

Component : Solar Collector

a) Open water-channel solar collector

b) $\tau\alpha = 0.78$

c) $U_L = 12.8\ W/m^2K$

d) Heat capacity not measured

e) Heat transfer medium is water

f) i) Absorber material is Corrugated aluminum metal painted black.
ii) Glazing material is 6-mil thick flexible polyethylene copolymer, Monsanto 602, with τ=0.88, 2 glazings with inner glazing touching the upper corrugation surface the absorber plate.
iii) Insulation is styrafoam beads, 0.1 m (1 ft.) thick.

g) Experimental system, glazing lifetime may be around 2 years.

h) Estimated cost of materials for collector alone is $5.00/m^2. (Note that the collector is integrated into system and was field fabricated.)

Code No.: US-62

ORGANIZATION: University of Virginia
Department of Mechanical and Aerospace Engineering
Charlottesville, Virginia 22901

PROJECT TITLE: Annual Collection and Storage of Solar Energy for the Heating of Buildings

DATA SHEET

Component : Heat Storage

a) Sensible heat storage using water in below grade pool (103 m^3) having solar collector to seal the top of the pool.

b) Heat capacity of water is 1,144 Wh/m^3; with the range designed from 30 to 95 C; Heat capacity of earth surrounding pool is 1,050 Wh/m^3.

c) Did not use latent heat

d) Heat exchanger not used within storage system

e) Insulation was on the bottom and sides of the pool was originally expected to be provided by the earth which would also act as energy storage. This concept was unsuccessful, and 0.3 m (1 ft.) of equivalent foam insulation would be reccomended.

f) System was an experimental concept investigation, and the expected life of the unit constructed would be one year.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-63

COUNTRY: UNITED STATES

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

NAME OF ORGANIZATION
University of Waterloo

NAME OF PRINCIPAL RESEARCHER
K. G. T. Hollands

ADDRESS:
Department of Mechanical Engineering
University of Waterloo
Waterloo, Ontario, Canada

TITLE OF PROJECT
Methods of Reducing Heat Losses from Solar Collectors - Phase III

OBJECTIVE AND NATURE OF THE PROJECT:

To develop a predictive technique for the combined conductive and radiative heat transfer across honeycombs in solar flat plate collectors; to test this theory against measurements. To examine the effect of plate and glass emissivity on the convection suppression capabilities of honeycombs. To assess the viability of the combination of honeycomb and selective surface.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The work is completed and fully described in the report described below. Predictive techniques were developed which were within 20% of measurements. The combination of a selective surface and honeycomb was found to be not as satisfactory as earlier, simpler, theories had indicated.

PERIOD OF PROJECT:

May 1, 1977 to January 31, 1979

FUNDING IN $ U.S.: 48,900

IMPORTANT REPORTS OR PUBLICATIONS:

Methods of Reducing Heat Losses from Flat Plate Solar Collectors, Phase III, K. G. T. Hollands, G. D. Raithby, F. B. Russell, R. G. Wilkinson. Available from University of Waterloo in limited Edition. Also available from NTIS, state number COO/2597-5.

Code No.: US-63

ORGANIZATION: University of Waterloo

PROJECT TITLE: Methods of Reducing Heat Losses from Flat Plate Solar Collectors, Phase III

DATA SHEET

Component : Solar collector, flat plate, honeycomb type

--other information not relevant because this was not a component development contract and a basic research contract

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-64

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION West Virginia University	ADDRESS: West Virginia University Aero Space Engineering Morgantown, WV 26506
NAME OF PRINCIPAL RESEARCHER John L. Loth	

TITLE OF PROJECT   GROOVED FOAMGLAS SOLAR AIR HEATER

OBJECTIVE AND NATURE OF THE PROJECT:

To construct and test various configurations of grooved foam solar air heaters. The air is blown along the grooves in the rough black radiation absorber surface. The material cost of the six configurations tested ranges from $20 to $45 per square meter and is mainly a function of the cover material used and the type selected. Both galvanized sheet metal and wood frames have been used. At West Virginia University a 30 meter square collector array has been tested in conjunction with air to water heat exchangers. On Pittsburgh Police station number 2 an area of 53 square meters is used in conjunction with heat pumps.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The performance tests indicate that these inexpensive air heaters perform equally well to the metal absorber types. A problem with surface dust from the Foamglas absorber has been experienced and different absorber surfaces are currently undergoing tests to try and eliminate this problem.

PERIOD OF PROJECT: 10/30/77 - 12/30/78 FUNDING IN $ U.S.: $106,578

IMPORTANT REPORTS OR PUBLICATIONS:

Loth, J. L., Palmer, G. Michael, Srivatsan, R., "Grooved Foamglas Solar Air Heater; Final Contract Report", TR-65, Department of Aerospace, West Virginia University, Morgantown, WV, February 1979.

Loth, J. L., "Hybrid Air to Water Solar Collector Design", Department of Aerospace Engineering, West Virginia University, Morgantown, WV, presented at Thirteenth Intersociety Energy Conversion Engineering Conference, Aug. 20-25, 1978, (W/ Palmer)

Loth, J. L., "Domestic Hot Water Heating Using Hot Air Solar Collectors", AIAA Paper No. 79-0973, presented at the June 1979 Terrestial Energy Systems Conference, Orlando Florida.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-65

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[x] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [x] COMPONENT DEVELOPMENT [ ] ______
NAME OF ORGANIZATION WESTINGHOUSE ELECTRIC CORPORATION NAME OF PRINCIPAL RESEARCHER D. T. BEECHER	ADDRESS: Westinghouse Research & Development Center 1310 Beulah Road, Churchill Boro Pittsburgh, PA 15235

TITLE OF PROJECT
LOW COST EVACUATED TUBE SOLAR COLLECTOR

OBJECTIVE AND NATURE OF THE PROJECT:

The price of liquid cooled evacuated tube solar collectors now marketed is $20 per square foot. The objectives of this study are: to design an air cooled evacuated tube solar collector module that can be manufactured for substantially less than $10 per square foot; to specify the equipment necessary to produce this collector at a rate of one million square feet per year; to define a production line layout; and to formulate specifications for vacuum deposition of a black chromium oxide selective coating (information which is now not available in the general literature).

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The interim report describes the work accomplished to date with two exceptions. The production line layout and manufactured cost estimates have recently been completed and evaluation of the expected deterioration of the black chromium oxide selective coating at stagnation temperatures in a gettered vacuum flask is the subject of on going tests.

PERIOD OF PROJECT: Oct. 1978-May 1980 FUNDING IN $ U.S.: $306,664

IMPORTANT REPORTS OR PUBLICATIONS:

Interim Report

 Code No. 66

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☑ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☑ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION	ADDRESS: Northrop Services, Inc. P. O. Box 1484 Huntsville, Alabama 35807
NAME OF PRINCIPAL RESEARCHER Mr. Donald L. Mattox	

TITLE OF PROJECT
Evaluation of Heat Transfer Enhancement in Air Heating Collectors

OBJECTIVE AND NATURE OF THE PROJECT:
The recent effort was to identify techniques for enhancing the heat transfer between the absorber and the air stream, develop methods of performance comparison for widely diverse designs, determine optimum Reynolds number flow regime for solar collector operation, develop theoretical prediction relationships for scaling state-of-the-art designs, and to make recommendations for further research. The objectives have been accomplished.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The recent effort has been completed in the form of a final report submitted to DOE. Some of the more significant accomplishments were: (1) A solar collector systems analysis was performed to evaluate the impact of various techniques for enhancing the heat transfer between the absorber and air stream on overall thermal performance of the entire solar collector.(2) On basis of this systems analysis one solar collector design providing ducted cooling air on the absorber shaded side was selected for detailed study.(3) A transient heat transfer analysis of a complete solar air heating collector was used to demonstrate that an optimum absorber-to-air heat exchanger design could be provided with several "interrupted" fin configurations.(4) Analyses were performed to establish that the maximum solar collector thermal performance to required pumping power was realized for a Reynolds number range of 1000 to 2000.(5) This Reynolds number range was used to establish a theoretical design limit curve for maximum thermal performance versus required pumping power for all "interrupted" fin designs as published in the open literature. (6) Heat and momentum transfer empirical relationships were defined for scaling the state-the-art high conductance fin designs identified from a "compact" configuration to the less compact designs needed for solar collectors.(7) A proposal was submitted to conduct a research program including the design and fabrication of a miniature wind tunnel plus the design, test and evaluation of twelve air-heating solar absorber matrices.

PERIOD OF PROJECT: 9/5/78 to 6/1/79 FUNDING IN $ U.S.: $40,425.

IMPORTANT REPORTS OR PUBLICATIONS:

1. Mattox, D. L., "Evaluation of Heat Transfer Enhancement in Air-Heating Collectors", 3rd Annual Solar Heating and Cooling R&D Contractor's Meeting, September 1978.
2. Mattox, D. L., "Evaluation of Heat Transfer Enhancement Air-Heating Collectors - Final Report", Northrop Services, Inc., Huntsville, Alabama Technical Report 230-1968, June 1979.

Code No.: 66

ORGANIZATION: Northrop Services, Inc.

PROJECT TITLE: Evaluation of Heat Transfer Enhancement in Air Heating Collectors.

DATA SHEET

Component : Solar Collector

Analysis was performed for following:

a) Flat plate air heating solar collector
b) Black acrylic paint (α=.967) outer Lucite (τ=.815) AR glazing and an inner glass (τ=.88) resulting in a $\alpha\tau$=.694.
c) An overall conductance value was not calculated since a time dependent finite difference analysis was performed for the complete collector.
d) Heat capacity of air absorber plate and heat exchanger were variables evaluated in the study.
e) Heat transfer medium (air)
f) Material
    i) absorber (α=.967, ε=.967)
    ii) cover plate (2. covers, outer 1.25 cm Lucite AR, τ=.815, inner .475 cm glass, τ = .88)
    iii) 6.1 cm of 701 Fiberglass
g) Expected life of collector was not evaluated as part of study.
h) Estimated cost was not evaluated as part of study.

Code No.: US-66

ORGANIZATION: WESTINGHOUSE ELECTRIC CORPORATION

PROJECT TITLE: LOW COST EVACUATED TUBE SOLAR COLLECTOR

DATA SHEET

Component : a) Evacuated

b) $\alpha\tau$ = .88

e) air

f) black chromium oxide (0.85, 0.07)
1, .92
none

g) 20 yr.?

h) cost $75.50/m^2
price ?

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-67

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☒ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Westinghouse Research & Development Ctr.	ADDRESS: 1310 Beulah Road Pittsburgh, PA 15235
NAME OF PRINCIPAL RESEARCHER M. A. Mendelsohn	

TITLE OF PROJECT

Collector Sealants and Breathing

OBJECTIVE AND NATURE OF THE PROJECT:

The objectives are to investigate pertinent properties of a variety of sealants for solar collectors for the purpose of identifying the most promising candidates and to study the effects and control of breathing in solar collector units.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

A large variety of sealants comprising caulk and gasket types are being evaluated for use in flat plate solar collectors. Sealants are tested for thermal stability in presence of air, hydrolytic stability, ozone resistance, weathering resistance and resistance to fungus. Properties monitored during the above tests include compression set, tensile strength, elongation, tensile modulus, hardness, weight loss, and outgassing characteristics. This will lead to the selection of the more durable materials. Efficiencies of several adsorbents and desiccants for removing moisture and organic vapors from the collector are being evaluated.

PERIOD OF PROJECT:

Sept. 25, 1978 - Dec. 31, 1979

FUNDING IN $ U.S.:

$186,425

IMPORTANT REPORTS OR PUBLICATIONS:

Results of this investigation will be published during 1980.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-68

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [X] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ______________
NAME OF ORGANIZATION THE ZEOPOWER COMPANY	ADDRESS: 75 Middlesex Avenue Natick, MA 01760
NAME OF PRINCIPAL RESEARCHER Dr. Dimiter Tchernev	

TITLE OF PROJECT

INTEGRATED SOLAR ZEOLITE COLLECTOR

OBJECTIVE AND NATURE OF THE PROJECT:

To design, construct, test and evaluate the performance of an Integrated Solar Zeolite Collector capable of providing hot water during the day and chilled water at night. Such collector, by supplying both the heating and airconditioning needs of a building, will almost double the utilization time of the collector field and drastically reduce the repayment period of the solar system.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Integrated Solar Zeolite Collectors were constructed and preliminary tests indicate overall total daily efficiencies of over 25% for cooling and even higher for heating. A number of the collectors will be tested under different climatic conditions and their total preformance will be evaluated.

PERIOD OF PROJECT:

Sept. 25, 1978 to Sept. 24, 1980

FUNDING IN $ U.S.:

$379,075.00

IMPORTANT REPORTS OR PUBLICATIONS:

Not available.

Code No.: US-68

ORGANIZATION: THE ZEOPOWER COMPANY

PROJECT TITLE: INTEGRATED SOLAR ZEOLITE COLLECTOR

DATA SHEET

Component :
a) Type - flat plate integrated collector
b) $\alpha\tau$ = 0.77
c) Not applicable
d) Not applicable
e) Heat transfer medium - water
f) Material - i) absorber - copper
ii) cover plate - 2 low iron glass
iii) insulation - 5 cm. polyurethane
g) Lifetime - 20 years
h) Estimated cost - \$260.00/m^2

COOLING PERFORMANCE

a) Type - solar heating/cooling
b) Type of refrigerator - adsorption, working medium - water vapor
c) Capacity of refrigerator - 500 BTU/ft^2 day = 0.02 $\frac{\text{ton}}{\text{m}^2\ \text{day}}$
d) Temp. range - θ = 50°C
e) C.O.P. = 0.78
f) Heat exchanger - copper
g) Not applicable

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS Code No. US-69

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION AiResearch Manufacturing Co. of Calif.	ADDRESS: 2525 West 190th Street Torrance, California 90509
NAME OF PRINCIPAL RESEARCHER Mr. Robert Gunner, NASA-MSFC, Tech. Mgr.	

TITLE OF PROJECT
Contract NAS8-32091 Solar Heating and Cooling Systems Design and Development

OBJECTIVE AND NATURE OF THE PROJECT:

The objectives of this program are to design, develop and fabricate prototype solar heating and cooling systems for single family, multi-family, light commercial, and commercial applications. Cooling subsystems to be developed are 3, 25 and 75 ton Rankine cycle turbocompressor augmented by electric motors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

1. Development tests to be completed
2. Endurance testing confirms design points.
3. Two 75-ton machines to be installed at test sites for monitor operation.

PERIOD OF PROJECT:
July 1976 through May 1980

FUNDING IN $ U.S.:
$4,800,000

IMPORTANT REPORTS OR PUBLICATIONS:

Rousseau, J., "Solar-Powered Rankine Heat Pump for Heating and Cooling", AiResearch Mfg. Co. of California, 1978

Code No.: US-69

ORGANIZATION: AIRESEARCH MANUFACTURING COMPANY OF CALIFORNIA

PROJECT TITLE: Solar Heating and Cooling Systems Design and Development

DATA SHEET

Component : Air Conditioning and Cooling

a. type (heat pump, solar heating/cooling, ...)

Solar-Powered Rankine heat pump augmented with a electric motor.

b. type of refrigerator (absorption, ...; working medium, ...)

Turbocompressor 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 (°C)

150°F (66°C) to 200°F (93°C)

e. C.O.P.

3 ton system: 0.56
25 ton system: 0.71
75 ton system: 0.75

f. heat exchanger

Evaporator/Boiler - Water-to-R-11 inner finned tubes.
Condenser - Shell-and-tube with low profile finned tubes.
Air Handler - Hydronic-to-air fin coils.

g. auxiliary heat source

Gas or Electric (heating)
Electric (cooling)

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-70

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Information Dissemination
NAME OF ORGANIZATION Argonne National Laboratory	ADDRESS: 9700 South Cass Avenue Argonne, Illinois 60439
NAME OF PRINCIPAL RESEARCHER Roger L. Cole	

TITLE OF PROJECT

Design and Installation Manual for Thermal Energy Storage

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this project is to write a manual on thermal energy storage. The manual is intended for contractors, installers, solar system designers, engineers, architects, and manufacturers.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The second edition of the "Design and Installation Manual for Thermal Energy Storage", Argonne National Laboratory report number ANL 79-15 is in printing and will be available soon. In addition to the manual, four seminars on thermal energy storage have been presented.

PERIOD OF PROJECT:

October '78 to November '79

FUNDING IN $ U.S.:

$100,000

IMPORTANT REPORTS OR PUBLICATIONS:

"Design and Installation Manual for Thermal Energy Storage", ANL 79-15 (Available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161. Price: $11.00 per printed copy.)

Code No.: US-70

ORGANIZATION:

Argonne National Laboratory

PROJECT TITLE:

Design and Installation Manual for Thermal Energy Storage

DATA SHEET

Component :

Heat Storage

a) type: Sensible and latent heat storage for air- and liquid-based systems in domestic water heating, space heating, and space cooling applications.

b) heat capacity: Methods for sizing sensible heat storage are provided.

c) latent heat: Methods for sizing latent heat storage are provided.

d) heat exchanger: Methods for analyzing and sizing heat exchangers are provided. Data on heat transfer-fluids is included.

e) heat rate: See items b), c), and d).

f) insulation: Methods for determining the required amount of insulation are provided.

g) expected life time: Information on material properties and corrosion is included.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-71

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Analytical Modeling
NAME OF ORGANIZATION Argonne National Laboratory	ADDRESS: 9700 South Cass Avenue Argonne, Illinois 60439 U.S.A.
NAME OF PRINCIPAL RESEARCHER E. I. H. Lin and W. T. Sha	

TITLE OF PROJECT
ANALYTICAL MODELING OF THERMOCLINE AND HALOTHERMOCLINE STORAGE SYSTEMS

OBJECTIVE AND NATURE OF THE PROJECT:

(1) Develop and validate a 3-D thermohydrodynamic computer code COMMIX-SA including a porous-media model and a double-diffusive convection model to investigate heat, mass and momentum transport phenomena in, and stability characteristics of, thermocline and halothermocline storage systems; (2) Utilize the computer code to perform parametric studies on stratified water tanks, rock beds, and salt-gradient solar ponds so as to optimize design and improve performance of these solar thermal storage components; (3) Interface with ongoing experimental programs and/or provide input to forthcoming ones concerning the aforementioned components to facilitate attainment of useful and practical information.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
The 3-D code COMMIX-SA was developed, documented and released. The code was used to determine effects of geometry, flow rate, jetting and baffles on heat-discharge and heat-charge responses of storage tanks. Design features promoting stratification and high performance were identified. A cylindrical tank with height-to-diameter ratio equal to 4, equipped with VCCB (i.e., vertical concentric cylindrical baffles) and inlet ring distributor, was shown to achieve discharge and charge efficiencies upwards of 90%. The COMMIX-SA porous-media model for rock beds and double-diffusive-convection model for salt-gradient solar ponds are currently under development. These are intended to address the flow-channeling problem in rock beds and the stability question in solar ponds.

PERIOD OF PROJECT:
Oct. 1978 - present (ongoing)

FUNDING IN $ U.S.: $430,000 (FY1980)

IMPORTANT REPORTS OR PUBLICATIONS:

- E.Lin & W.Sha, "Effects of Baffles on Therm. Strat. in Thermocline Storage Tanks" Proc. Int. Cong. ISES (1979).
- E.Lin, W.Sha & S.Soo, "Stability Considerations and a Double-Diffusive Convection Model for Solar Ponds," ANL-CT-79-34 (1979).
- E.Lin, W.Sha & A.Michaels, "On Therm. Energy Stor. Efficiency & Use of COMMIX-SA for its Evaluation and Enhancement," Solar Energy Stor. Options Wksp., Tx (1979)
- W.Sha & E.Lin, "3-D Math. Model of Flow Strat. in Thermocline Stor. Tanks," Application of Solar Energy 1978, UAH Press (1978).

Code No.: US-71

ORGANIZATION: Argonne National Laboratory

PROJECT TITLE: Analytical Modeling of Thermocline and Halothermocline Storage Systems

DATA SHEET

Component : Heat Storage

(a) Water tanks, rock beds, and salt-gradient solar ponds

(b) Temperature range:
Water tanks: usually 15°-60° C, but the computer code can handle larger temperature ranges (e.g. 0°-100° C).
Rock beds: usually 15°-60° C.
Salt-gradient solar ponds: 20°-100° C in the storage zone

(c) Latent heat: not applicable

(d) Heat exchanger: with or without

(e) Heat rate: variable, depending on applications

(f) Insulation: with or without

(g) Expected life time: 10 years or more, depending on construction

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-72

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION ARTECH CORP. NAME OF PRINCIPAL RESEARCHER Dr. Fred Ordway	ADDRESS: 2901 Telestar Court Falls Church, Virginia 22042

TITLE OF PROJECT
Thermal Energy Storage Subsystem

OBJECTIVE AND NATURE OF THE PROJECT:

To develop a thermal energy storage unit for use with air-circulating solar heating systems, utilizing the latent heat of fusion of salt hydrate mixtures. The work comprises designing a heat storage unit for efficient production, installation, and operation; fabricating a prototype; and determining its performance by the procedure developed by the National Bureau of Standards.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

A heat storage module, the TESmod$^{(TM)}$, has been designed for installation as a unit in any desired heat storage chamber or duct, but may be disassembled and installed by one person without lifting equipment if necessary. Each module, 2x2 ft (60x60 cm) in floor area and 2, 4, or 6 ft (0.6, 1.2, or 1.8 m) high, designed for horizontal air flow, is an assembly of sealed containers supported by a frame. Production of the molded containers is under way.

PERIOD OF PROJECT:
Sept. 30, 1976 - July 15, 1980

FUNDING IN $ U.S.:
$151,306.

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: US-72

ORGANIZATION:

ARTECH CORP.

PROJECT TITLE:

Thermal Energy Storage Subsystem

DATA SHEET

Component :

Heat storage module (TESmod™)

(a) Type and configuration

Phase change; module, 2x2 ft (60x60 cm) in floor area and 2, 4, or 6 ft (0.6, 1.2, or 1.8 m) high, for installation in horizontal air flow; arrangement of modules in series/parallel to be dictated by system design.

(b)* Heat capacity C; temperature range Θ_1-Θ_2

475 Btu/ft^3 (4.9 kW·h/m^3); 70-145 F (21-63 C)

(c)* Latent heat h; temperature Θ

5 300 Btu/ft^3 (55 kW·h/m^3); 120 F (49 C), 90 F (32 C), or 55 F (13 C)

(d) Heat exchanger; heat transfer fluid

Sealed containers of phase change material provide heat exchange surface; designed for air, but can be used in water.

(e)* Heat rate

330 Btu/hr·ft^3 (3.9 kW/m^3)

(f) Insulation

Provided by user according to system design

(g)* Expected lifetime

>20 years

* Design estimate

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS — Code No. US-73

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Calmac Manufacturing Corporation	ADDRESS: 150 South Van Brunt Street Englewood, N.J. 07631
NAME OF PRINCIPAL RESEARCHER Calvin D. MacCracken	

TITLE OF PROJECT

Salt Hydrate Thermal Energy Storage Systems for Solar Space Heating & Air Conditioning

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of the project is to develop three bulk storage phase change thermal energy storage systems using a plastic mat-type heat exchanger immersed in a tank of salt hydrates. The desired temperature ranges are 40°-50°F (4°-10°C), 100°-120°F (38°-49°C), and 220°-240°F (104°-115°C).

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

All three systems are in the final stages of development and testing. Units are expected to be commercially available in 1980.

PERIOD OF PROJECT: Dec.'77 - June '80 FUNDING IN $ U.S.: $455,000

IMPORTANT REPORTS OR PUBLICATIONS:

Semi-annual progress reports to Argonne National Laboratory.

Code No.: US-73

ORGANIZATION: Calmac Manufacturing Corporation

PROJECT TITLE: Development of Salt Hydrate Thermal Energy Storage Systems for Solar Space Heating and Air Conditioning.

DATA SHEET

Component : Thermal Energy Storage

		4°-10°C	38°-49°C	104°-115°C
a.	Type:	Phase Change	Phase Change	Phase Change
b.	Heat Capacity:	68,600 Wh/m^3	84,800 Wh/m^3	67,800 Wh/m^3
c.	Latent Heat:	56,300 Wh/m^3	75,000 Wh/m^3	60,000 Wh/m^3
d.	Heat Exchanger:	yes water/anti-freeze	yes water/anti-freeze	yes glycol
e.	Heat Rate:	2,600 Wh/hr	3,000 Wh/hr	2,600 Wh/hr
f.	Insulation:	Expanded polystyrene	Expanded polystyrene	"Isofoam"
g.	Life Time:	20 years	20 years	20 years

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-74

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION EIC Corporation	ADDRESS: EIC Corporation 55 Chapel Street, Newton, MA 02158
NAME OF PRINCIPAL RESEARCHER Peter O'D. Offenhartz	

TITLE OF PROJECT CHEMICAL HEAT PUMPS BASED ON THE REACTIONS OF $CaCl_2$ with H_2O and CH_3OH

OBJECTIVE AND NATURE OF THE PROJECT:

To design, construct and test chemical heat pumps based on either of the reactions

$$CaCl_2 + CH_3OH \rightarrow CaCl_2 \cdot 2CH_3OH$$

or

$$CaCl_2 \cdot H_2O + H_2O \rightarrow CaCl_2 \cdot 2H_2O$$

for solar energy storage, air conditioning, and heating (at COP > 1).

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

An engineering development system with 100,000 BTU storage capacity, based on the $CaCl_2/CH_3OH$ reaction, has been constructed. Pertinent parameters include cooling COP of 0.6, heating COP of 1.6, 120-140°C required solar collector temperature (for CH_3OH condensation at 40°C), and -5°C minimum evaporator temperature (for heat exchange fluid to $CaCl_2$ bed at 40°C).

PERIOD OF PROJECT: 40 Months   FUNDING IN $ U.S.: ca. $200,000/yr

IMPORTANT REPORTS OR PUBLICATIONS:

P. Offenhartz, F. C. Brown, R. W. Mar and R. W. Carling, "A Heat Pump and Thermal Storage System for Solar Heating and Cooling Based on the Reaction of Calcium Chloride and Methanol Vapor," J. Solar Energy Engineering (ASME), Vol. 1 (in press).

Code No.: US-74

ORGANIZATION: EIC Corporation

PROJECT TITLE: CHEMICAL HEAT PUMPS BASED ON THE REACTIONS OF $CaCl_2$ with H_2O and CH_3OH

DATA SHEET

Component : Chemical heat pump for solar storage, air conditioning and heating.

a) Type: Thermally activated heat pump with intrinsic (chemical) energy storage.

b) Type of refrigerator: Absorption cycle based on reaction of $CaCl_2$ and CH_3OH vapor to form solid-phase $CaCl_2 \cdot 2CH_3OH$.

c) Capacity: 1-3 tons

d) Temperature Range: 45°C difference between evaporator and absorber; 90°C difference between generator and condenser.

e) COP = 1.6 for heating, 0.6 for cooling.

f) Inherent energy storage equivalent to 8-10 hours operation at rated output.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-75

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION General Electric Company NAME OF PRINCIPAL RESEARCHER A. T. Tweedie/E. M. Mehalick	ADDRESS: Advanced Energy Programs P.O. Box 8661 Philadelphia, PA 19101

TITLE OF PROJECT
Two-Component Thermal Storage Material Study - Phase II

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of the 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 were to be verified. The study also included an economic evaluation of the storage concept.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The capsules demonstrated long-term reliability under volume change effects of the phase change material, but they did not survive the packed bed environment. Costs also appeared higher than acceptable for a commercial product. The program is complete and the final report issued.

PERIOD OF PROJECT: 6/76 - 2/78   FUNDING IN $ U.S.: $105 K

IMPORTANT REPORTS OR PUBLICATIONS:

NSF/RANN/SE/AER 74-09156 Nov., 1975
Final report "Two-Component Thermal Energy Storage Material Project - Phase I"
COO/2845 - 78/2 Final report, "Two-Component Thermal Storage Material Study, Phase II", May 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-76

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION General Electric Corporate R&D	ADDRESS: P. O. Box 8 Schenectady, NY 12301
NAME OF PRINCIPAL RESEARCHER C. S. Herrick	

TITLE OF PROJECT Prototype Design and Testing of the Rolling Cylinder Thermal Storage System

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this project has been to develop the technology and the engineering data required to implement the rolling cylinder latent heat store in solar energy systems.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The rolling cylinder with Glauber's Salt appears to be a satisfactory functional latent heat store based on laboratory scale behavior.

PERIOD OF PROJECT:
August 1978 to March 1979

FUNDING IN $ U.S.:
$175,000

IMPORTANT REPORTS OR PUBLICATIONS:

"Rolling Cylinder Thermal Storage - Interim Report" on contract DE-AC05-78ORO5759, prepared for the Department of Energy by General Electric Co. (June 1979).

"Heat Storage Capability of a Rolling Cylinder Using Glauber's Salt", C. S. Herrick and K. P. Zarnoch, Ambient Energy, (in press).

Code No.: US-76

ORGANIZATION:

General Electric Corporate Research and Development

PROJECT TITLE:

Prototype Design and Testing of the Rolling Cylinder Thermal Storage System

DATA SHEET

Component : Heat Storage

a) Type and configuration:

Phase change in a closed cylindrical vessel rotating about the cylindrical axis.

b)

c) Latent Heat h:

Latent heat 9840 Btu/cuft at 90.3°F

d) Heat Exchanger:

The cylinder is the heat exchanger. Exchange fluid is air or water.

e) Heat Rate:

Heat rates up to 200 Btu/hr/sqft have been measured

f)

g) Expected life time:

25 years

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. 77

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[X] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ________
NAME OF ORGANIZATION OWEN & MAYES, INC.	ADDRESS: 1106 Laxton Road Lynchburg, Virginia 24502
NAME OF PRINCIPAL RESEARCHER J. M. Owen, P.E., R. Akers (Assoc.)	

TITLE OF PROJECT Optimization of a Compound Parabolic Concentrator of a C.R. of 1.5 to 3:1 with/without evaporated absorbers

OBJECTIVE AND NATURE OF THE PROJECT:

Reduction of cost to manufacture and install C.P.C. type collector unit, but with high degree of reliability, good life span (20 yrs.), maintainable (in place), and good efficiency unaffected by handling, weathering, and production variables.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Basic physical dimension of ideal concentrator defined. Test circuit being set up to test same and variations of said module, i.e., reflective surface(s) to enhance receptor (absorber) efficiency.

PERIOD OF PROJECT: 11 Nov. 78 to 10 Mar. 1980

FUNDING IN $ U.S.: 112,000

IMPORTANT REPORTS OR PUBLICATIONS: Monthly reports available at expense of requestor

Code No.: 77

ORGANIZATION: OWEN & MAYES, INC.

PROJECT TITLE: Optimization of a Compound Parabolic Concentrator of a 1.5 to 3:1 concentration ratio with/without evacuated absorbers

DATA SHEET

Component :

a) Type - Concentrating with evacuated (10^{-5} TORR) absorbers
   Configuration: Parallel absorbers, north-south orientation series flow for heat transfer medium

b) α, τ: Trying to achieve $\alpha \geq .96$ $\tau \geq .93$ for single glazing if required at point of use
   $\varepsilon = .04$

c) U_L [W/M^2-°K] = .20 $\frac{BTU}{Hr.-ft.^2-°F}$ (At absorber temp. of 573°R or 300°C maximum, 90% of temp. at stagnation).
   or 2144×10^{-6} $W/M^2°K$

d) Heat Capacity $C_p \doteq 17.4 \times 10^{-4}$ $KWh/M^2°K$ (at ambient of 0°C and 6778.9 watts/M^2 daily insolation, clear and sunny, 45% collection efficienc
   NOTE: C usually refers to concentration ratio

e) Medium: Polypropolene glycol and tap water, 50% concentration

f) i. Absorber: $\alpha = .95$, $\varepsilon = .05$ (Borosillicate glass w/polycarbonate tube cup
   ii. Cover Plate: One, Teflon 1 mil 96% (τ) or Tedlar 4 mil 90% (τ)
   iii. Insulation: Thickness, 1/2" isocyanurate foam (170°C working ambient)

g) Life: approximately 20 years

h) Estimated Cost (U.S.) 387.20/M^2 1/80

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-78

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ EQUIPMENT SURVEY

NAME OF ORGANIZATION
Hittman Associates, Inc.

ADDRESS: 9190 Red Branch Road
Columbia, MD 21045

NAME OF PRINCIPAL RESEARCHER
Dr. Charles Lee

TITLE OF PROJECT
Solar Applications of Thermal Energy Storage

OBJECTIVE AND NATURE OF THE PROJECT:

The purpose of this project is to identify the characteristics of the major available thermal energy storage units for solar applications. The storage units were classified into four major types: Liquid-sensible, solid-sensible, phase-change, and thermochemical.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Project is complete. Twenty-six storage units were identified and data on their characteristics were published in the report.

PERIOD OF PROJECT:
July 78 - January 1979

FUNDING IN $ U.S.:
$52,000

IMPORTANT REPORTS OR PUBLICATIONS:
Lee, Charles, Lawrence Taylor, John DeVries, and Stephen Heibein. "Solar Applications of Thermal Energy Storage," January 1979, Hittman Associates, Inc.

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[ ] SOLAR COLLECTOR [X] THERMAL ENERGY STORAGE [ ] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[X] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ________
NAME OF ORGANIZATION Honeywell, Inc.	ADDRESS: Technology Strategy Center 2600 Ridgway Parkway Minneapolis, MN 55413
NAME OF PRINCIPAL RESEARCHER R. T. LeFrois	

TITLE OF PROJECT
ACTIVE HEAT EXCHANGE SYSTEM DEV. FOR HEAT OF FUSION TES

OBJECTIVE AND NATURE OF THE PROJECT:
Alternative mechanizations of active heat exchange concepts were analyzed for use with heat of fusion Phase Change Materials (PCM's) in the temperature range of 250° to 350°C for solar and conventional power plant applications. Over 24 heat exchange concepts were reviewed, and eight were selected for detailed assessment. Two candidates were chosen for small-scale experimentation: a coated tube and shell heat exchanger and a direct contact reflux boiler.

A dilute eutectic mixture of sodium nitrate and sodium hydroxide was selected as the PCM from over fifty inorganic salt mixtures investigated.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Preliminary experiments with various tube coatings indicated that a nickel or chrome plating or Teflon or Ryton coating had promise of being successful. An electroless nickel plating was selected for further testing. A series of tests with nickel-plated heat transfer tubes showed that the solidifying sodium nitrate adhered to the tubes and the experiment failed to meet the required discharge heat transfer rate of 10 kW(t).

Testing of the reflux boiler is under way. Direct injection of cool high-pressure water as a spray into the ullage was accomplished and steam was generated.

PERIOD OF PROJECT: May 1978 - December 1979

FUNDING IN $ U.S.: $328, 701

IMPORTANT REPORTS OR PUBLICATIONS:
NASA CR 159727
NASA CR 159479

Code No. US-79

ORGANIZATION:

Honeywell, Inc

PROJECT TITLE: ACTIVE HEAT EXCHANGE SYSTEM DEV. FOR LATENT HEAT OF FUSION TES

[illegible]

Component : Reflux Boiler

The experimental apparatus used to model the reflux boiler system for a 10-kWh(t) capacity and 10-kW(t) rate must resolve the technical issues yet circumvent the development of expensive, specialized equipment. This can be done by operating the model in a batch mode and using compressed gas to transfer the molten salt into the system. This eliminates the need for a high-pressure salt pump. In addition, the low-head, high-temperature pump necessary for feedwater refluxing is replaced by a low-temperature, high-pressure pump and water preheater.

The experimental apparatus, consists of a reflux boiler nearly filled with molten salt into which hot water is injected under high pressure. The molten salt gives up heat to boil the water. The steam bubbles to the surface of the salt and passes to the condenser, where it condenses on the cool condenser coils heating the secondary heat transfer fluid. For the experiment, the secondary fluid will be heat transfer oil Mobiltherm 603 to provide close temperature control and high heat transfer rates without using a high-pressure recirculating water loop.

The water-steam cycle will not be operated in a refluxing mode, but will be operated open-loop to provide an accurate means of measuring and controlling the water injection rate. This is achieved by measuring the rate of water uptake at the pump suction port. The condensate receiver provides a means of collecting and storing a nominal 15-minute flow of water, which can later be cooled and analyzed for salt content to estimate salt carryover. Further analysis of salt carryover can be made by disassembly of the shell and tube condenser at the end of a test run.

The advantages of this mechanization from a modeling standpoint are:

- No high-pressure pumping of salt is required.
- No throttling of a high-pressure salt or salt plus water is required.
- No valves in the saltlines must be opened or closed while high-pressure differentials exist across them.

Performance:

- Heat of fusion 80 Wh/m^3
- Fusion temperature 600°F (306°C)
- 1 year lifetime
- Active heat exchanger
- 10 KW heat rate
- 4" mineral wool

Code No. US-79

ORGANIZATION:

Honeywell Inc.

PROJECT TITLE: ACTIVE HEAT EXCHANGE SYSTEM DEV. FOR LATENT HEAT TES

DATA SHEET

Component: Coated Tube and Shell Flowby Module

This experiment, consists of an insulated mild steel tank that is heated externally with controllable guard heaters. A sump-type pump is mounted in the main storage tank such that the pump is always immersed in molten salt. A discharge line connects the salt pump to the flowby module. The module consists of a rectangular chamber with a tubular cross-flow heat exchanger which extends across the test chamber.

The solid tubes are inactive; i.e., they do not transfer heat but are flow patterns. Fifteen tubes, 19 millimeters in diameter, are arranged to transmit heat (plain tubes). These tubes are blanked off at the outboard ends and fed with cooling oil from a manifold through concentric internal tubes. Heated oil flows out through the outlet oil manifold.

The tube bundle is arranged with separator plates and, together with the oil manifolding, may be removed as a unit for servicing and changing of coated tube elements. When the unit is inserted into the test chamber, salt flow passes through the tube bundle three times. Turning vanes maintain a proper flow pattern to simulate a large tube bundle.

A discharge duct located above and at the outlet of the tube bundle and the salt stream channels the flow back to the tank. A butterfly valve regulates the back pressure and flow level in the channel. A force guage attached to a contoured pintle measures changes in momentum of the salt slurry. By measuring the liquid height and by knowing the force, the salt slurry flow can be calculated. An electrical contact probe was planned to determine liquid levels in the flow meter. A small quantity of salt will be continually drained off the channel through a tube. This salt will flow into the main settling tank.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-81

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______

NAME OF ORGANIZATION
Independent Living, Inc.

ADDRESS:
5965 Peachtree Corners East
Unit A-4
Norcross, Georgia 30071

NAME OF PRINCIPAL RESEARCHERS
William T. Hudson and William M. Jones

TITLE OF PROJECT
Development of an Improved Water Tank for Thermal Storage

OBJECTIVE AND NATURE OF THE PROJECT:

To design and develop a modular, transportable, pre-insulated solar thermal storage tank which can be plant manufactured and shipped to distant locations. Concept is to use two fiberglass shells with foam insulation between them to create a sandwich effect. The tank is to be designed with an upper and lower hat so that one hat can easily be handled by two or three persons. The two hat concept will allow the total volume to be reduced by placing one hat inside the other hat during shipping. The objective is to identify, analyze, and implement materials which can be used for such a tank, to fabricate and test the tank, and provide a volume product for the solar market.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Material testing for inner shell of fiberglass tank is progressing. Test program includes determination of water permeation rate and tensile creep properties of certain polyester and vinly ester resin systems while immersed in 200°F water for extended periods of time. A prototype tank is to be built in the near future with tank design testing to follow. Preliminary testing and analysis of the tank design on a prototype model reinforced the concept. Determination of sealing the two hats together is virtually completed.

PERIOD OF PROJECT:
July, 1978 - April 1980

FUNDING IN $ U.S.:
≈ $130,000

IMPORTANT REPORTS OR PUBLICATIONS:
Monthly Project Status Reports to DOE in Chicago.

Code No.: US-81

ORGANIZATION:

Independent Living, Inc.

PROJECT TITLE:

Development of an Improved Water Tank for Thermal Storage

DATA SHEET

Component :

The tank being developed is 1000 gallons in capacity and designed for a continuous service temperature of 200^{o}F. The heat transfer and storage fluid is water. The tank design is described as follows:

1) Cylindrical in shape, with a flat top and bottom, tank is positioned vertically.
2) Modular design - two halves, top hat and bottom hat with a two hat flanged joint at mid section for sealing.
3) 3" or 4" of rigid foam insulation, thickness depending on tank's site location and use.
4) Outer protective coating of sprayed-on chopped fiberglass.

The tank concept is to develop a light weight, easily installed, preinsulated, highly efficient tank with an expected longevity of service between 20 and 30 years. The tank is modular so that any one half can be handled easily and can fit through the rough opening of a three foot door.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-82

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Martin Marietta Aerospace	ADDRESS: P. O. Box 179 Denver CO 80201
NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT

Thermal Storage for Solar Cooling Using Ammoniated Salts

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of the program is to develop a system capable of both heating and cooling with the capability of storing energy for both functions. The unit is to be capable of using a solar heat source

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

A residential system using a liquid ammonia absorber has been designed. Subscale (600 in^3) test reactors have cycled to demonstrate concept feasibility. A full scale test unit (500,000 Btu capacity) has been designed and is being fabricated. Testing will be conducted in early 1980.

PERIOD OF PROJECT: 7/1978 - 9/1980

FUNDING IN $ U.S.: $412,000

IMPORTANT REPORTS OR PUBLICATIONS:

Jaeger, F. A., Interium Report for the Period July 1978 - June 1979 C00/4700-1

Code No.: US-82

ORGANIZATION: Martin Marietta Aerospace

PROJECT TITLE: Thermal Storage for Solar Cooling Using Ammoniated Salts

DATA SHEET

Component :

a. Type - heat pump/thermal storage unit.

b. Type of refrigerator - absorption, ammonia

c. Capacity 3T refrigeration
500,000 Btu Storage

d. Temperature Range 0 - 55°C

e. C.O.P. Cooling 0.56
heating 1.2

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-83

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ STANDARDS DEVELOPMENT

NAME OF ORGANIZATION

National Bureau of Standards

NAME OF PRINCIPAL RESEARCHER

James E. Hill

ADDRESS:

National Bureau of Standards
Center for Building Technology
Washington, D.C. 20234

TITLE OF PROJECT Development of Methods for Evaluation and Test Procedures for Solar Collectors and Thermal Storage Devices

OBJECTIVE AND NATURE OF THE PROJECT:

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 ACCOMPLISHMENTS:

- o Adoption of ASHRAE 94-77, Storage Test Procedure
- o Experimental verification of the ASHRAE 94 Standard for a water tank, pebble bed and phase-change storage device

PERIOD OF PROJECT:

January 1974-September 1978

FUNDING IN $ U.S.:

Work on thermal storage devices completed

IMPORTANT REPORTS OR PUBLICATIONS:

- o "Development of Proposed Standards for Testing Solar Collectors and Thermal Storage Devices," NBS Technical Note 899, February 1976.
- o "A Method of Testing for Rating Thermal Storage Devices Based on Thermal Performance," Solar Energy, Vol. 19, No. 6, 1977.
- o "An Evaluation of ASHRAE Standard 94-77 for Testing Water Tanks for Thermal Storage," NBS Report NBSIR 78-1548, October 1978.
- o "Testing of Pebble-Bed and Phase-Change Thermal Energy Storage Devices According to ASHRAE Standard 94-77," NBS Report NBSIR 79-1737, May 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-84

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______

NAME OF ORGANIZATION
Oklahoma State University

NAME OF PRINCIPAL RESEARCHER
James E. Bose, PhD, PE

ADDRESS:
School of Technology
101 Industrial Building
Oklahoma State University
Stillwater, OK 74074

TITLE OF PROJECT
Design and Field Testing of Solar Assisted Earth Coils

OBJECTIVE AND NATURE OF THE PROJECT:

The project objective is to design and operate a set of field instrumented experiments to determine engineering data for ground coupled devices for use in solar heat pump systems. Experiments include horizontal pipes in trenches and vertical coils or wells. The project includes the comparison of the experimental results with simple models of soil thermodynamics and other published results. Promising ground coupling configurations are to be identified.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Test data are presently being recorded on both horizontal and vertical earth coils. Data from two heating and one cooling seasons have been obtained and overall heat transfer values have been obtained for one soil type. Commercialization of heat pump systems to operate on earth coil systems has been initiated with several local HVAC contractors.

PERIOD OF PROJECT:
8/01/78 - 7/31/80

FUNDING IN $ U.S.:
$ 159,510.

IMPORTANT REPORTS OR PUBLICATIONS:

1) Presented paper at the Nordic Symposium on Earth Heat Pump Systems, Goteborg, Sweden, October 15 & 16, 1979; paper entitled "Field Test Results of Solar-Assisted Heat Pumps Using Earth Coil Coupling and Storage."
2) Presented paper at the Heat Pump Technology Conference, Oklahoma State University, April, 1979; paper entitled "Experimental Results of a Low-Cost Solar-Assisted Heat Pump System Using Earth Coil and Geo-Thermal Well Storage."

IMPORTANT REPORTS OR PUBLICATIONS: (Continued)

3) Annual Report, 1 August 1978 - 31 July 1979, "Design and Field Testing of Solar Assisted Earth Coils," under DOE Contract No. EM-78-S-01-4257.

Code No.: US-84

ORGANIZATION: OKLAHOMA STATE UNIVERSITY
School of Technology
Stillwater, OK 74074

PROJECT TITLE: Design and Field Testing of Solar Assisted Earth Coils

DATA SHEET

Component :

Heat Storage

a) Type - Unprepared earth including both horizontal and vertical earth coils.

b) Heat capacity - C
SI 465.8 Wh/m^3
English 45 Btu/ft^3
Temp. range: 0 to 43° C.

c) Latent heat h
None - Non-freezing

d) Heat exchanger - PVC pipe

e) Heat rate -
Steady-state
Vertical pipe 3.5 Btu/(hr- ℓft - °F)
Horizontal pipe 2.0 Btu/(hr- ℓft - °F)

f) Insulation - None

g) Expected life time - 30 to 50 years

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS Code No. 85

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ R&D-Salt Gradient Solar Pond
NAME OF ORGANIZATION THE OHIO STATE UNIVERSITY-PHYSICS	ADDRESS: OSU Research Foundation 1314 Kinnear Road Columbus, OH 43210
NAME OF PRINCIPAL RESEARCHER DR. CARL E. NIELSEN	

TITLE OF PROJECT
SOLAR ENERGY STORAGE IN SALT GRADIENT PONDS

OBJECTIVE AND NATURE OF THE PROJECT:

To study the application and practicality of use of salt gradient ponds for energy collection and storage. Multiple projects utilizing techniques such as a new and simple injection procedure for controlling the thickness of the gradient zone are progressing.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Results to date on a pond used to supply heat for grain drying in September and October, and to preheat water for dairy operations throughout the year indicate: a pond of 100 m^2 (0.25 acre) area and 3 m (10 ft) deep can provide 220,000 kW-hr of energy annually, approximately equally divided between grain drying and water preheating. Operating costs (including 10% of construction/year) is $4120. For this, the pond returns 220,000 kW-hr of energy per year, which is equivalent to 12,000 gallons of propane burned at 70% efficiency and costing $6240 at 52¢ per gallon.

PERIOD OF PROJECT: Continuing FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

C. E. Nielsen, "Control of Gradient Zone Boundaries," Proceedings, I.E.A. Solar Energy Society, Atlanta, GA, May 1979.

C. E. Nielsen, Solar Pond Applications. Leaflet prepared for distribution at the Farm Science Review, The Ohio State University, 1978.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-86

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ SYSTEM ANALYSIS

NAME OF ORGANIZATION
ROCKWELL INTERNATIONAL

NAME OF PRINCIPAL RESEARCHER
MICHAEL P. MORIARTY

ADDRESS:
8900 DeSoto Avenue
Canoga Park, CA 91304

TITLE OF PROJECT
HYBRID THERMAL STORAGE WITH WATER

OBJECTIVE AND NATURE OF THE PROJECT:

The primary objective of this effort was to develop parametric engineering data to aid in the evaluation of hybrid storage systems. Several computer codes were developed to estimate the behavior of hybrid storage systems. A simplified system model was developed and yielded results in good agreement with the TRNSYS Code, but required only 5% of the computer time.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The results indicated that there was a distinct performance advantage in the use of an annular tank in a rock bed when compared to an insulated water tank. However, experimental verification is required before the results can be recommended for widespread use. The project has been completed and a final report will be available through NTIS.

PERIOD OF PROJECT:
Sept. 1, 1977 - November 10, 1978

FUNDING IN $ U.S.:
$107,000

IMPORTANT REPORTS OR PUBLICATIONS:

1) ESG-DOE-13259, "Hybrid Thermal Storage With Water, Final Report, Rockwell International, Canoga Park, CA 1979

2) French, E.P., "Hybrid Thermal Storage Subroutine for Transient Simulation," Paper No. 79910S, Proc. 14th IECEC, Boston, 1979

3) Moriarty, M. P., "A Simplified Algorithm for the Evaluation of Hybrid Thermal Storage with Water Systems," Paper No. 799106, Proc. 14th IECEC, Boston 1979

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-87

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION University of Nebraska-Lincoln NAME OF PRINCIPAL RESEARCHER Richard Bourne	ADDRESS: Engineering Research Center University of Nebraska Lincoln, NE 68588

TITLE OF PROJECT
Membrane-line Thermal Storage Systems

OBJECTIVE AND NATURE OF THE PROJECT: To develop improved liquid thermal storage containers for solar heating systems. The project was designed to evaluate the cost-effectiveness, versatility, and performance of membrane-lined storage concepts.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Surveys of existing projects and potential liner materials have been completed. Alternate structural enclosure designs for basement, crawl space, and slab-on-grade foundation types, and optimal-cost designs have been identified. Also, imporved heat transfer mathods were investigated. Design and laboratory testing results have been compiled for several forced air jacketed concepts. In addition, results were compiled for four domestic water preheaters immersed in the storage container.

PERIOD OF PROJECT: 20 months FUNDING IN $ U.S.: 110,239

IMPORTANT REPORTS OR PUBLICATIONS:

Bourne, Richard C., "Membrane-Lined Foundation Systems for Liquid Thermal Storage," Proceedings of 3rd Annual Solar Heating and Cooling Research and Development Branch Contractors Meeting, Washington, D.C., September, 1978, pp. 208-211.

Bourne, Richard C.,"Membrane-Lined Foundations for Liquid Thermal Storage, Annual Report (Draft) Aug. 1979," available from author, to be published by NTIS.

Bourne, Richard C., "Direct Air Heating from Membrane-Lined Water Storage," Proceedings of Solar Energy Storage Options, San Antonio, March, 1979, pp. 417-427.

Bourne, Richard C., "Membrane-Lined Thermal Storage Systems," Paper presented at 2nd Miami International Conference on Alternative Energy Sources, December, 1979.

Code No.: US-87

ORGANIZATION: University of Nebraska

PROJECT TITLE: Membrane-Lined Thermal Storage Systems

DATA SHEET

Component : Heat Storage

a) type: water, with membrane liners, various configurations

b) heat capacity: 4.6×10^6 Wh for 35-95 C range

c) latent heat: none

d) heat exchanger: YES for domestic water preheat

e) heat rate: dependent on collector

f) insulation: fiberglass blanket and rigid polystyrene

g) expected liner lifetime: 20 years target: liner aging uncertain

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-88

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☒ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Westinghouse Advanced Energy Systems Div. NAME OF PRINCIPAL RESEARCHER R. W. Buckman, Jr.	ADDRESS: P. O. Box 10864 Pittsburgh, PA. 15236

TITLE OF PROJECT Lightweight Concrete Materials and Structural Systems for Water Tanks for Thermal Storage

OBJECTIVE AND NATURE OF THE PROJECT:

Development of a water storage system made with precast or cast on-site lightweight (structural and insulating) elements possessing the necessary properties and capable of being easily assembled or fabricated especially for retrofitting into and integration with existing residential and other structures.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Have completed design and fabrication of two subscale 500 gallon size tanks. Thermal testing completed on initial tank. With water at 150° - 160°F, heat loss on order of 800 BTU/hour. Second tank calculated to have heat loss on order of 400 BTU/hour. A third modular tank has been designed and is in process of being fabricated.

PERIOD OF PROJECT:
March 1978 - February 1980

FUNDING IN $ U.S.:
$290,000

IMPORTANT REPORTS OR PUBLICATIONS:

Lightweight Concrete Materials and Structural Systems for Water Tanks for Thermal Storage, R. W. Buckman, Jr., Presented at 3rd Annual Solar Heating and Cooling R&D Contractors' Meeting, September 1978.

Lightweight Concrete Materials for Water Tanks for Thermal Storage, R. W. Buckman, Jr., and Y. Ichikawa, Westinghouse Electric Corporation, Pittsburgh, PA.

Code No.: US-88

ORGANIZATION:

Westinghouse Advanced Energy Systems Division

PROJECT TITLE:

Lightweight Concrete Materials and Structural Systems for Water Tanks for Thermal Storage

DATA SHEET

Component : Lightweight Concrete Hot Water Storage Tank

Still under development. Final performance data not available.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-89

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________

NAME OF ORGANIZATION
AiResearch Manufacturing Co. of Calif.

ADDRESS:
2525 W. 190th Street
Torrance, Ca 90509

NAME OF PRINCIPAL RESEARCHER
J. Rousseau

TITLE OF PROJECT
Development of a Solar Desiccant Dehumidifier

OBJECTIVE AND NATURE OF THE PROJECT:

The program is aimed at the development of a solar dessiccant 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 1: Conceptual Design of the System
- Phase 11: Detail Design
- Phase 111: Fabrication and Performance Evaluation

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

1. Phases 1 and 11 have been completed.
2. Preliminary testing confirms design point selection.
3. Performance characterization to be completed.

PERIOD OF PROJECT:
September 1977 through May 1980

FUNDING IN $ U.S.:
$681,694

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: US-89

ORGANIZATION: AIRESEARCH MANUFACTURING COMPANY OF CALIFORNIA

PROJECT TITLE: Development of a Solar Desiccant Dehumidifier

DATA SHEET

Component : 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)

1.5 tons

d. Temp. range (°C)

100°C - 12°C

e. C.O.P.

0.5

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 fuel oil)

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-90

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION Argonne National Laboratory	ADDRESS: 9700 South Cass Ave., Bldg.362 Argonne, IL 60439
NAME OF PRINCIPAL RESEARCHER Anthony J. Gorski	

TITLE OF PROJECT
Long-Term Ice Storage for Cooling Applications Using Passive Freezing Techniques

OBJECTIVE AND NATURE OF THE PROJECT:

The object of this project is to develop a passive method of solar cooling that uses ice produced and stored during the winter for summer cooling needs. A major design constraint imposed on this project is that the ice shall be grown and stored in the same container without any external energy input or manual intervention by the user. The major components of this system consist of a large insulated tank of water buried under the ground and modified heat pipes which act as passive refrigeration units. These heat pipes are specially designed units that extend from the bottom of the tank through the top of the tank and up into the air. During the winter when temperatures are below freezing, these pipes will form and release ice in the tank. This stored volume of ice and water can then be used to satisfy summer cooling needs.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Using an indoor experimental ice growing apparatus, we have been growing and releasing ice automatically for approximately three months. In addition to these experimental efforts, we have developed computer codes to determine ice production rates for various ambient conditions, and have designed a new heat pipe configuration that will automatically go through a freeze-defrost mode independently of variations in outdoor temperature conditions. Construction has also started on a full-scale outdoor test tank. This tank will be used to test the formation, release, and storage of ice produced during the winter conditions. A concrete tank of dimensions 16' x 16' x 16' will be buried underground at the Argonne Solar Testing Facility.

PERIOD OF PROJECT:

FY 79 - FY 80

FUNDING IN $ U.S.:

FY 79 - $50K Operating FY-80 $60K
$85K Equipment

IMPORTANT REPORTS OR PUBLICATIONS:

"Long-Term Ice Storage for Cooling Applications Using Passive Freezing Techniques," by A. Gorski, et al. 4th National Passive Solar Conference, Oct. 3-4-5, 1979, Kansas City, MO.

Code No.: US-90

ORGANIZATION:

Argonne National Laboratory

PROJECT TITLE:

Long-Term Ice Storage for Cooling Applications Using Passive Freezing Techniques

DATA SHEET

Component :

Air Conditioning and Cooling

a) Type (Passive Solar Cooling)

b) Type of refrigerator (Modified heat pipes)

c) Capacity of refrigerator (Theoretical stored energy after 6 months storage at 70°F ambient is 62.2 ton-days)

d) Temperature range (0°C to 10°C)

e) C.O.P.

f) Heat exchanger (to be determined)

g) Auxiliary heat source (none)

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-91

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ System Development
NAME OF ORGANIZATION Arkla Industries Inc.	ADDRESS:
NAME OF PRINCIPAL RESEARCHER Richard H. Merrick	

TITLE OF PROJECT
Unitary Solar Heating/Cooling System Package Development

OBJECTIVE AND NATURE OF THE PROJECT:

1. Develop and field test a residential 3 ton solar heating/cooling (absorption) system package.

2. Develop and field test a direct evaporatively cooled 3 ton LiBr absorption chiller.

3. Develop a commercial 25 ton unitary system and skid mounted hardware package including the Arkla WFB300 absorption chiller.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

1. Commercialized residential system package has logged 2 years on Arkla Oak Meadow solar house and 1 year on retrofit house.

2. Summer of 1979 field and life tests successful on evaporatively cooled 3-ton LiBr absorption chiller. Experimental manufacturing is scheduled.

3. Commercial 25 ton package ready for laboratory tests. System design studies continuing.

PERIOD OF PROJECT:
June 1, 1977 through May 31, 1980

FUNDING IN $ U.S.:
$1,087,000

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: US-91

ORGANIZATION: Arkla Industries Inc.

PROJECT TITLE: Unitary Solar Heating/Cooling System Package Development

DATA SHEET

(Ref to Objective #1)

Component : Solar Heating/Cooling System Package - Residential

(a) Type: A complete packaged system, exclusive of field installed components, for providing cooling, heating, and DHW loads for a residential sized load. This product has been field tested and commercialized as Arkla's 36P, employing a successful draindown collection system.

(b1) Type of Refrigerator: LiBr absorption using solar heated hot water. Chilled water is supplied at 7.2°C (45°F) to a fan coil.

(b2) Type of Heating: In the heating mode, the solar heated water is pumped to the fan coil.

(b3) Other: The packaged system also includes the collector pump, DHW-preheat pump, back-up gas fired hot water generator with pump, and the system tank (field connected to a storage tank)aand collectors.

(c) Capacity of Refrigerator: 3 tons - Model WF36, W/C.

(c2) Capacity of Heating: (60,000 Btu/hr - 17,600W)

(d) Temp. Range: Gen. Hot Water In 79.4°C(175°F) thru 93°C(200°F) Capacity of 3 tons is at 91°C (195°F)

(e) COP = 0.72 for steady state conditions. For typical cycling duty, a new control system feature yields a cummulative COP of 0.65 when matched to a 3 ton load.

(f) Heat Exchanger: None used when collectors are flat plate.

(g) Auxiliary Heat Source: Gas heated hot water.

Code No.: US-91

ORGANIZATION: Arkla Industries Inc.

PROJECT TITLE: Unitary Solar Heating/Cooling System Package Development

DATA SHEET

(Refer to Objective #2)

Component : Direct evaporatively cooled 3 ton chiller (3rd generation).

(a) Type: Solar Hot Water Fired Air Conditioner.

(b) Type of Refrigerator: Absorption, LiBr.

(c) Capacity of Refrigerator: 3 tons at design conditions.

(d) Temp. Range: Supply Hot Water 93°C(200°F) to 79.4°C(175°F)

Design Conditions:
25.6°C(78°F) Wet Bulb Heat Rejection Air
7.2°C(45°F) Leaving Chilled Water
91°C(193°F) Supply Hot Water

(e) COP: 1) Steady State Instantaneous 0.72
2) Cycling Cummulative - Typical 0.65

(f) Heat Exchanger: Standard 3 Ton Fan Coil Unit with Duct Work

(g) Auxiliary Heat Source: Gas Heated Hot Water Recommended.

Note: This chiller was field tested on a 36P (packaged solar HVAC system) in place of the commercially available WF-36 water cooled unit). The unit operated reliably during the entire summer of 1979 at the Arkla retrofit solar home. Other units are being laboratory tested.

Code No.: US-91

ORGANIZATION: Arkla Industries Inc.

PROJECT TITLE: Unitary Solar Heating/Cooling System Package Development

DATA SHEET

(Refer to Objective #3)

Component : 25 Ton Solar Packaged Unit for Commercial HVAC Systems (Based on the successful 3 ton package development, this 25 ton system uses the same design philosophy).

(a) Type: A packaged system, using the WFB-300 commercialized 25 ton chiller, includes all pumps, controls, heat energy auxiliary, and system tank for use with draindown collectors with storage and air handling components selected to match the individual job requirements.

(b1) Type of Refrigerator: LiBr absorption chiller, hot water fired.

(b2) Type of Heating: Solar heated water pumped directly into air handling system coils.

(c1) Capacity of Refrigerator: 25 ton at design conditions

(c2) Capacity of Heating: 132,000 W (450,000 Btu/hr)

(d) Temp. Range: Gen. Hot Water In 93°C (200°F) to 71.1°C (160°F)
25 tons capacity at 91°C (195°F)

(e) COP is 0.68 for steady state conditions

(f) Heat Exchanger: None used or needed with flat plate collectors.

(g) Auxiliary Heat Source: Gas heated hot water

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS Code No. US-92

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Hardware Simulation of Component
NAME OF ORGANIZATION Brookhaven National Laboratory NAME OF PRINCIPAL RESEARCHER Paul Chungmoo Auh	ADDRESS: Solar Technology Group Bldg. 701 Upton, New York 11973

TITLE OF PROJECT Development of Hardware Simulations for Tests of Solar Cooling/Heating Subsystems and Systems

OBJECTIVE AND NATURE OF THE PROJECT:

The overall objectives of the project are to: (1) develop a hardware simulator, which can be used to simulate any advanced solar cooling/heating subsystem and/or system of residential size, (2) determine steady state & unsteady state performance characteristics and parasitic power requirements of advanced solar cooling/heating subsystems and/or systems, (3) provide base performance data for the validation of computer simulation models for subsystems and/or systems, and (4) optimize system performance based on system configurations, subsystem options, control strategy, and parasitic power requirements.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

1) Subsystem hardware simulation of residential size has been successfully designed, built, and operated. 2) Steady state simulation of the advanced chiller was performed. The results were analyzed and the discussions were made about the performance differences between units and on the performance degradations due to unseen problems. 3) Unsteady state or transient simulation of the same cooling device was performed under both the conventional and the new proposed control modes. Analysis of the results indicated that, under the simple modified control mode of the chiller, significant improvements (especially during short cycling conditions) in both the capacity and the COP result. It may be suggested that the need of a large, expensive cold-side storage may no longer be required.

PERIOD OF PROJECT:
10/1/77 ∿ 9/30/79

FUNDING IN $ U.S.: ∿200 K

IMPORTANT REPORTS OR PUBLICATIONS:

SEE ATTACHED SHEET

Code No.: US-92

ORGANIZATION: Brookhaven National Laboratory

PROJECT TITLE: Development of Hardware Simulators for Tests of Solar Cooling/Heating Subsystems and Systems

DATA SHEET

Component : Second generation Arkla Absorption Chiller (WF36) was used for the Simulation study.

a)	Type	--	Solar Cooling
b)	Type of refrigerator	--	Absorption Chiller
c)	Capacity of refrigerator	--	3 tons
d)	Temperature range	--	170°F ~ 205°F
e)	COP	--	0.7
f)	Heat exchangers	--	Fluid-to-fluid
g)	Auxiliary heat source	--	N/A

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-93

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ UNITARY PACKAGE DEVELOPMENT

NAME OF ORGANIZATION

ENERGY SYSTEMS DIVISION, CARRIER CORP.

ADDRESS:

P.O. BOX 4895
SUMMIT LANDING
SYRACUSE, NEW YORK 13221

NAME OF PRINCIPAL RESEARCHER

DR. WENDELL J. BIERMANN

TITLE OF PROJECT PROTOTYPE MODULAR ABSORPTION AIR CONDITIONING SYSTEM
BPA CONTRACT DE-AC79-79BP 10467

OBJECTIVE AND NATURE OF THE PROJECT:

TO INTEGRATE THE 15 TON SOLAR ABSORPTION CHILLER DEVELOPED ON A PREVIOUS BONNEVILLE POWER ADMINISTRATION CONTRACT INTO A FACTORY ASSEMBLED HEATING/COOLING PACKAGE COMPRISING PUMPS, CONTROLS, ETC, REQUIRED FOR SOLAR HEATING/COOLING SYSTEM. TO INSTALL PACKAGES ON SITES IN TYLER, TEXAS AND THE DALLES, OREGON AND MONITOR FOR ONE YEAR

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

· PACKAGES INSTALLED AND OPERATIONAL

PERIOD OF PROJECT:

3/79 TO 10/80

FUNDING IN $ U.S.: $750,000

IMPORTANT REPORTS OR PUBLICATIONS:

NONE

Code No.: US-93

ORGANIZATION:

ENERGY SYSTEMS DIVISION OF CARRIER CORPORATION

PROJECT TITLE:

PROTOTYPE MODULAR ABSORPTION AIR CONDITIONING SYSTEM
BPA CONTRACT DE-AC79-79BP 01467

DATA SHEET

Component : HEATING/COOLING SOLAR MACHINERY PACKAGE

A. TYPE: CHILLER, WATER COOLED.
SOLAR HEATING

B. TYPE OF REFRIGERATOR: WATER COOLED, LITHIUM BROMIDE ABSORPTION CHILLER DESIGNED FOR LOW TEMPERATURE HOT WATER APPLICATION

C. CAPACITY: 15 TONS AT 82.2°C HOT WATER, 29.4°C TOWER WATER, 7.2°C CHILLED WATER

D. TEMPERATURE RANGE: AT 29.4° HOT WATER, 65°C TO 100°C

E. COP: 0.72 AT DESIGN POINT

F. AUXILIARY HEAT SOURCE:

TYLER: STEAM
THE DALLES: ELECTRIC HEAT PUMP USED AS SUPPLEMENTAL COOLING.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-94

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________
NAME OF ORGANIZATION ENERGY SYSTEMS DIVISION, CARRIER CORP. NAME OF PRINCIPAL RESEARCHER RICHARD A. ENGLISH	ADDRESS: P.O. BOX 4895 SUMMIT LANDING SYRACUSE, NEW YORK 13221

TITLE OF PROJECT: DEVELOPMENT OF A HIGH TEMPERATURE SOLAR POWERED WATER CHILLER FOR USE IN A SOLAR HEATING AND COOLING SYSTEM

OBJECTIVE AND NATURE OF THE PROJECT:

THIS PROJECT WILL DESIGN, CONSTRUCT, AND TEST A 25 TON AIR COOLED WATER CHILLER FOR MULTI-FAMILY AND COMMERCIAL APPLICATIONS.

THE DESIGN UTILIZES A DUAL LOOP RANKINE POWER CYCLE DRIVING A RANKINE VAPOR COMPRESSION CYCLE. THE PRIME MOVER WILL BE A HIGH SPEED TURBINE DIRECTLY DRIVING A CENTRIFUGAL COMPRESSOR ON THE SAME SHAFT IN A HERMETIC ENCLOSURE. A VARIABLE SPEED ELECTRIC MOTOR AUXILIARY ENERGY SOURCE MOUNTED ON THE SHAFT BETWEEN WILL DRIVE THE COMPRESSOR UNDER CERTAIN OPERATING CONDITIONS.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

THE PROJECT HAS COMPLETED PHASE I, CONCEPTUAL DESIGN; PHASE II, THE DETAILED DESIGN; AND IS IN THE CONSTRUCTION STAGE OF PHASE III.

PERIOD OF PROJECT:
36 MONTHS

FUNDING IN $ U.S.:
$1,308,509

IMPORTANT REPORTS OR PUBLICATIONS:

DEVELOPMENT OF A HIGH TEMPERATURE SOLAR POWERED WATER CHILLER, PHASE I TECHNICAL PROGRESS REPORT FOR PERIOD 10/26/77 - 6/1/79 (4 VOLUMES)

Code No.: US-94

ORGANIZATION: ENERGY SYSTEMS DIVISION, CARRIER CORPORATION

PROJECT TITLE: DEVELOPMENT OF A HIGH TEMPERATURE SOLAR POWERED WATER CHILLER FOR USE IN A SOLAR HEATING AND COOLING SYSTEM

DATA SHEET

Component :

Type: SOLAR COOLING UNIT

Type of Refrigeration: RANKINE/RANKINE; R-113

Capacity: 25 TONS

Temperature Range: 120-160^{o}C

COP: 0.74

Auxiliary Heat Source: ELECTRIC POWER

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-95

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION ENERGY SYSTEMS DIVISION, CARRIER CORP.	ADDRESS: P.O. BOX 4895 SUMMIT LANDING SYRACUSE, NEW YORK 13221
NAME OF PRINCIPAL RESEARCHER DR. WENDELL J. BIERMANN	

TITLE OF PROJECT SINGLE FAMILY ABSORPTION CHILLER FOR SOLAR USE

OBJECTIVE AND NATURE OF THE PROJECT:

TO DEVELOP A SUITABLE CHEMICAL SYSTEM FOR SUSTAINING AN AIR COOLED ABSORPTION CYCLE AND TO CONSTRUCT AND TEST A 10 KW (3 TON) PROTOTYPE AIR COOLED ABSORPTION CHILLER

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

BREADBOARD VERSION HAS BEEN SUCCESSFULLY OPERATED, HEAT TRANSFER BEHAVIOR CHARACTERIZED AND DESIGN OF PROTOTYPE IS ESSENTIALLY COMPLETE.

PERIOD OF PROJECT:

9/26/77 - 6/30/80

FUNDING IN $ U.S.: $835,000

DOE CONTRACT EG-77-C-03-1587

IMPORTANT REPORTS OR PUBLICATIONS:

CANDIDATE CHEMICAL SYSTEMS FOR AIR COOLED, SOLAR POWERED, ABSORPTION AIR CONDITIONER DESIGN
PART I - ORGANIC ABSORBENT SYSTEMS
PART II - SOLID ABSORBENTS, HIGH LATENT HEAT REFRIGERANTS
PART III - LITHIUM SALTS WITH ANTIFREEZE ADDITIVES (AVAILABLE NTIS)

Code No.: US-95

ORGANIZATION:

ENERGY SYSTEMS DIVISION OF CARRIER CORPORATION

PROJECT TITLE:

SINGLE FAMILY ABSORPTION CHILLER FOR USE IN SOLAR HEATING/COOLING SYSTEMS

DATA SHEET

Component :

AIR CONDITIONING CHILLER

A. TYPE: SOLAR COOLING

B. TYPE OF REFRIGERATOR: ABSORPTION CHILLER AIR COOLED. WORKING MEDIUM IS LITHIUM BROMIDE-WATER WITH ANTI-CRYSTALLIZATION AND HEAT TRANSFER ADDITIVES

C. CAPACITY: 10 kW (3 TONS)

D. TEMPERATURE RANGE: HOT WATER 110°C, 35°C AIR AND 7.2°C CHILLED WATER

E. COP: 0.74

F. AUXILIARY HEAT SOURCE: AS AVAILABLE

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-96

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ DESICCANT COOLING
NAME OF ORGANIZATION ILLINOIS INSTITUTE OF TECHNOLOGY	ADDRESS: 3110 South State Street Chicago, IL 60616
NAME OF PRINCIPAL RESEARCHER Z. LAVAN AND D. GIDASPOW	

TITLE OF PROJECT
Development of a Solar Desiccant Dehumidifier

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this contract is to develop a fixed bed desiccant cooling system that uses silica gel. The dehumidifiers are cross-cooled with air and are to be regenerated with hot air from flat plate solar collectors. The configuration is designed for very low pressure drop. A prototype of the complete cooling system will be built and tested.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Silica gel sheets were fabricated.
A small dehumidifier model was built and tested.
A 3/4 ton prototype is presently being tested.
A computer simulation model was developed.

PERIOD OF PROJECT:
September 1979 to September 30, 1980

FUNDING IN $ U.S.:
$590,000.00

IMPORTANT REPORTS OR PUBLICATIONS:

"Development of a Solar Desiccant Dehumidifier" Solar Heating & Cooling R&D Contractors' Meeting, September 1978.
"Development of A Solar Desiccant Dehumidifier" IECEC, October 1978.
"Solar Operated Crossflow Desiccant Cooling System" ISES, June 1979.
"Performance Predictions for Adiabatic Desiccant Dehumidifiers Using Linear Solutions" Solar Energy Journal, ASME, February 1980.

Code No.: US-96

ORGANIZATION: Illinois Institute of Technology

PROJECT TITLE: Development of a Solar Desiccant Dehumidifier

DATA SHEET

Component : Air conditioning and Cooling

a) Desiccant Dehumidifier
b) Sorption of water vapor by silica gel sheets
   working medium is air
c) Prototype is 0.7 tons
d) Cooling of air to about 13°C
   Regeneration temperature is about 65°C
e) COP is about 0.6
f) Heat exchanger's effectiveness is 0.9

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-97

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Institute of Gas Technology	ADDRESS: 3424 S. State Street Chicago, Illinois 60616
NAME OF PRINCIPAL RESEARCHER Robert A. Macriss and Thomas S. Zawacki	

TITLE OF PROJECT
Analysis of Advanced Conceptual Designs for Single-Family-Size Absorption Chillers

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this program is the development of radically new absorption fluid systems, tailored to the requirements of solar cooling applications. The approaches taken to achieve the program objective comprised the identification, and analytical and laboratory evaluation, of binary absorption fluid systems that exhibit positive deviations from Raoult's law; also, of other more complex systems, such as ternary fluid systems for air-cooled, residential, solar cooling applications.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Based on the criteria established for this program and on realistic computer cycle computations, several binary and ternary systems have been identified as potentially superior to conventional systems for solar-absorption cooling. Prominent among these are binary solutions using methanol as the refrigerant with projected maximum COP's of 1.2 at generator temperature of 82°C and condenser/absorber temperature of 32°C, or maximum COP's of 0.7 at 120°C and 50°C, respectively; also, ternary methanol solutions which, when utilized in a two stage regenerator mode, can approach maximum COP's of 1.5 at generator temperature of 120°C and condenser/absorber temperatures of 35°C.

PERIOD OF PROJECT:
September 1977 - September 1978

FUNDING IN $ U.S.:
$96,500

IMPORTANT REPORTS OR PUBLICATIONS:

"Analysis of Advanced Conceptual Designs for Single-Family-Size Absorption Chillers", Final Report No. ROO-1439-14, February 1979.

Code No.: US-97

ORGANIZATION: Institute of Gas Technology

PROJECT TITLE: Analysis of Advanced Conceptual Designs for Single-Family-Size Absorption Chillers

DATA SHEET

a) type (heat pump, solar heat/cooling...)

Cooling

b) type of refrigerator (absorption,...; working medium,...)

Absorption

c) capacity of refrigerator [tons]

2.5 - 5 tons

d) temp. range Θ [°C]

75° - 150°C

e) C.O.P.

0.7 (minimum)

f) heat exchanger

Air-cooled finned-tube condenser/absorber

g) auxiliary heat source

Natural gas

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS — Code No. US-98

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
[ ] SOLAR COLLECTOR [ ] THERMAL ENERGY STORAGE [X] AIR CONDITIONING UNIT [ ] OTHER SUBSTANTIAL COMPONENTS	[ ] MATERIALS RESEARCH [X] COMPONENT DEVELOPMENT [ ] ________
NAME OF ORGANIZATION Institute of Gas Technology	ADDRESS: 3424 S. State Street Chicago, Illinois 60616
NAME OF PRINCIPAL RESEARCHER Robert A. Macriss and Jaroslav Wurm	

TITLE OF PROJECT
Solar Desiccant Air-Conditioner (SOLAR-MEC®) Development

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this program is to develop an advanced version of the SOLAR-MEC® solid-desiccant heating/cooling system for solar cooling applications. The approaches taken to achieve the program objective are analytical and experimental and comprise the design, fabrication and laboratory evaluation of two "advanced" versions of a residential-size solar powered heating/cooling unit, the incorporation of a non-asbestos desiccant wheel as part of the advanced unit, and the development of a seasonal model for design optimization and seasonal heating/cooling performance simulation.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Since September 1977, two "advanced" versions of a residential-size SOLAR-MEC® heating-cooling unit have been conceived, designed, fabricated and evaluated in the laboratory. Preliminary results from these evaluations show that improvements in the cooling seasonal performance factor (SPF) of 15 to 20 percent are possible with the most advanced unit (compared to early designs) coupled with a 20 percent improvement in cooling capacity, with a concommittant decrease in parasitic power of the order of 30 percent.

PERIOD OF PROJECT:
September 1977 - December 1979

FUNDING IN $ U.S.:
$539,480

IMPORTANT REPORTS OR PUBLICATIONS:

"SOLAR-MEC® Development Program," Annual Report (FY 1977) No. COO-4495-15, 1979.

Code No.: US-98

ORGANIZATION: Institute of Gas Technology

PROJECT TITLE: SOLAR-MEC® Development Program

DATA SHEET

a) type (heat pump, solar heat/cooling...)

Heating/Cooling

b) type of refrigerator (absorption,...; working medium,...)

Open-cycle desiccant system

c) capacity of refrigerator [tons]

2.5 @ ARI Design Conditions

d) temp. range Θ [°C]

70° - 130°C

e) C.O.P.

Cooling: 0.7 @ ARI Design Conditions

f) heat exchanger

Rotary Regenerative

g) auxiliary heat source

Natural Gas

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS Code No. US-99

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______

NAME OF ORGANIZATION
Lawrence Berkeley Laboratory

NAME OF PRINCIPAL RESEARCHER
Kim Dao

ADDRESS:
University of California
Berkeley, California 94720

TITLE OF PROJECT
Development of Solar-Driven Absorption Air-Conditioners and Heat-Pumps.

OBJECTIVE AND NATURE OF THE PROJECT:

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 ACCOMPLISHMENTS:

First experimental chiller was fabricated and tested, and the results were published. Second prototype of single-effect chiller was fabricated. Testing is underway. Design of the components of the advanced-cycle absorption chiller (double-effect regenerative absorption chiller) has been started.

PERIOD OF PROJECT:
October 1978 - September 1979

FUNDING IN $ U.S.:
$200,000

IMPORTANT REPORTS OR PUBLICATIONS:
Lawrence Berkeley Laboratory Reports:

LBL 3293, LBL 5224, LBL 5911, LBL 5982, LBL 6879, LBL 8405

Code No.: US-99

ORGANIZATION:

Lawrence Berkeley Laboratory

PROJECT TITLE:

Development of Solar-Driven Absorption Air-Conditioners and Heat-Pumps.

DATA SHEET

Component :

a) Air Conditioning Unit

b) Type: Double-effect Regenerative Absorption

c) Capacity: Nominal 3 Tons at 135°C heat source
1 Ton at 77°C
3.5 Tons at 160°C

d) Temperature Range:
Heat Source: 77°C - 160°C
Cooling Air: 35°C
Chilled Water: 7.5°C

e) C.O.P.: 0.36 at 77°C
0.70 at 110°C
0.90 at 135°C
0.93 at 160°C

f) Heat Exchanger:
Air-cooled formed tubes for condenser and absorber.
Tube-in-tube, coaxial and triaxial for other components.

g) Auxiliary heat source:
Gas.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-100

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ System Evaluation
NAME OF ORGANIZATION Solar Energy Lab, Univ. of Wisconsin NAME OF PRINCIPAL RESEARCHER J.W. Mitchell/J.A. Duffie	ADDRESS: 1500 Johnson Drive University of Wisconsin Madison, WI 53706, USA

TITLE OF PROJECT
Component and Systems Evaluations Study of Solar Desiccant Cooling

OBJECTIVE AND NATURE OF THE PROJECT:

Open cycle cooling methods which use solid or liquid desiccants have potential use for solar applications. This project (which is cooperative with Division of Mech. Engr., CSIRO, Australia) is to develop mathematical models for the components used in these systems, check these models experimentally, using them develop simulation methods for evaluating solar desiccant systems, and use the simulation models to explore and evaluate systems.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The contract was received in October 1979. Preliminary work prior to the contract has led to a first set of simulations of a particular system. (See Nelson et.al., Solar Energy, 21, 273 (1978).)

PERIOD OF PROJECT:
Funded 8/1/79 to 6/30/80
1 additional year planned

FUNDING IN $ U.S.:
$147,000

IMPORTANT REPORTS OR PUBLICATIONS:

Code No.: US-100

ORGANIZATION: Solar Energy Laboratory
University of Wisconsin-Madison

PROJECT TITLE:

Component and Systems Evaluation Study of Solar Desiccant Cooling

DATA SHEET

Component : Air Conditioning and Cooling

a) Type: Open-Cycle, Desiccant Air Conditioning System

b) Type of Refrigerator: Open cycle absorption system, with water working medium

c) Capacity: Not restricted

d) Temperature Range: Normal evaporator temperatures (2-10 C) with flat plate collectors

e) CDP: unknown, but probably in 0.5-0.75 range

f) Heat Exchanger: - - -

g) Auxiliary Heat Source: Not restricted

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-101

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Solar Cooling Systems Simulation and Technical Monitoring
NAME OF ORGANIZATION University of Maryland	ADDRESS: Mechanical Engineering Department University of Maryland College Park, MD 20742
NAME OF PRINCIPAL RESEARCHER D. K. Anand and R. W. Allen	

TITLE OF PROJECT
OPTIMIZATION OF SOLAR COOLING SYSTEMS

OBJECTIVE AND NATURE OF THE PROJECT:

To model solar cooling subsystems consisting of absorption cooling units and Rankine cycle cooling units.

To review the status of U.S. Government-sponsored absorption cooling fluid research.

To optimize solar cooling systems via the University of Maryland computer program "SHASP."

To develop solar cooling system design techniques.

To provide U.S. Department of Energy with technical evaluations of solar absorption cooling contract projects.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Site visits to cooling contractors: University of Texas, Carrier Corporation, and Arkla Industries.

Development of a heat-transfer transient start-up model of absorption cooling unit.

PERIOD OF PROJECT: July 1, 1979 to June 30, 1980

FUNDING IN $ U.S.: $95,000

IMPORTANT REPORTS OR PUBLICATIONS:

Site visit reports (internal distribution only)

"Review of the State-of-the-Art of Absorption Cooling Fluid Research," Mechanical Engineering Department, University of Maryland, College Park, 1979.

"Optimization of a Photovoltaic Powered Solar Cooling System," Mechanical Engineering Department, University of Maryland, College Park, 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-102

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION ALTAS CORPORATION	ADDRESS: 500 Chestnut Street Santa Cruz, CA 95060
NAME OF PRINCIPAL RESEARCHER Francis de Winter	

TITLE OF PROJECT "Development of a Gas Backup Water Heater Properly Integrated with Solar Heated Domestic Hot Water Storage Tanks"

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this program is to design, construct and test a prototype of a novel gas fired heater for use with solar DHW systems. The backup tank is located above the solar storage tank and the two are coupled by a "split-tube" connector which promotes the convection of solar heat upward whenever the bottom tank is warmer than the top. Auxiliary energy is input to the backup tank via a one-way copper-water heat pipe. The advantage of this design is a high firing efficiency, negligible standby losses, and the maximum utilization of the solar source.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Detailed system and component modules have been written and numerous thermal experiments have been performed for the various heater components. A final system design has now been selected and a prototype is under construction.

PERIOD OF PROJECT: April 1978-April 1980

FUNDING IN $ U.S.: $195,000

IMPORTANT REPORTS OR PUBLICATIONS:

"Development of a Gas Backup Water Heater Properly Integrated with Solar Heated Domestic Hot Water Storage Tanks" Annual Progress Report July 78 - June 79

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-103

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION American Heliothermal Corporation	ADDRESS: 2625 South Santa Fe Drive Denver, CO 80223
NAME OF PRINCIPAL RESEARCHER G. Gary Skartvedt	

TITLE OF PROJECT
Evaluation of Collectors for Heat Pump Applications

OBJECTIVE AND NATURE OF THE PROJECT:

1. Weather and load data will be compiled hour-by-hour for a number of locations in the U.S. which span a broad and representative range of climatic conditions.
2. Candidate collector designs will be selected from representative liquid and air flat plate collector configurations currently on the market.
3. Annual cost effectiveness of selected candidate designs will be evaluated by computer simulation of each design in a geographic location, operating hour-by-hour against the appropriate building load profile. The final step will be preparation of a performance/cost matrix of each design in each climatic area, and specific recommendations for further analyses, studies and development activities.
4. Experimental task added to determine effective night sky temperature and convective heat transfer coefficients for surface with large characteristics dimensions.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT: Through 4/17/80

FUNDING IN $ U.S.: 97,797

IMPORTANT REPORTS OR PUBLICATIONS:
No report available

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-104

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☑ OTHER SUBSTANTIAL COMPONENTS	☑ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION THE BERRY GROUP	ADDRESS: Woodbridge at Main P.O. Box 327 Edison, NJ 08817
NAME OF PRINCIPAL RESEARCHER John L. Cotsworth	

TITLE OF PROJECT
Development of Selective Surfaces DE-AS04-78CS34293

OBJECTIVE AND NATURE OF THE PROJECT:
Investigation and Development of Selective Surfaces for Solar Absorbers on Copper, Aluminum and Stainless Steel Substrates.

Hundreds of inorganic coatings deposited by electroplating and a number of semi-selective organic coatings have been collected, measured for optical properties and exposed to accelerated durability testing to 450°F. Quality controls for Black Chrome have been intensively studied.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Approximately 50% completed. Optical properties are Absorptivity .93 minimum, Emissivity .10 maximum or Absorptivity .95 minimum, Emissivity .15 maximum Black Chrome on Nickel Plated Copper. Cost of application $.80 per s/f in volume. Surface protected during fabrication, such as by welding of copper tube, by strippable plastic film or paper.

PERIOD OF PROJECT: October 1978 to August 1980

FUNDING IN $ U.S.: 148,049

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS Code No. US-105

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS ☒ SYSTEM	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ SYSTEM ANALYSIS
NAME OF ORGANIZATION Calif. State University, Fullerton	ADDRESS: Div. of Engineering, E-100 California State University, Fullerton
NAME OF PRINCIPAL RESEARCHER E.F. SOWELL	

TITLE OF PROJECT

SERIES-PARALLEL SOLAR AUGMENTED ROCK-BED HEAT PUMP

OBJECTIVE AND NATURE OF THE PROJECT:

Computer simulation, design, life-cycle cost analysis of a unique arrangement of solar collector (air type), rock bed and air-to-air heat pump for heating & cooling of single-family residence. Limited investigation of appropriate heat pump.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Project completed. System has seasonal performance of heating and cooling of about 3 in Albuquerque with 56m^2 of commercial air-type collector. Has capability for load-shifting for electrical power from utility, either heating or cooling. Predictive control algorithm was developed. Cost-effectiveness is lower than conventional heat pump due to collector costs.

PERIOD OF PROJECT: 1 Feb. 1978 to 31 Aug. 1979

FUNDING IN $ U.S.: $95,000

IMPORTANT REPORTS OR PUBLICATIONS:

1. Series-Parallel Solar-Augmented Rock Bed Heat Pump, Tech. Progress Report, COO-4697-1, 31 July 1978.

2. Series-Parallel Solar-Augmented Rock Bed Heat Pump, Final Report, COO-4697-2, 31 Dec. 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-106

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
CALMAC Manufacturing Corporation NAME OF ORGANIZATION	ADDRESS: 150 South Van Brunt St. Englewood, N J 07631
Calvin D. MacCracken NAME OF PRINCIPAL RESEARCHER	

TITLE OF PROJECT

Development of a Solar-Powered Thermopump

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of the project was to develop a pump to be powered by steam from a concentrating solar collector. In the thermopump cycle entering steam empties out a chamber of fluid, then condenses and sucks new fluid in.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Pumps were built and tested to specifications, but because of the cost of the concentrating collectors required to drive the pump commercial production has not been undertaken.

PERIOD OF PROJECT: October '76 - April'77 FUNDING IN $ U.S.: $43,000

IMPORTANT REPORTS OR PUBLICATIONS:

Pump Manual - Technical Guide SE-1325

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-107

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS (Thermal Fluids)	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Systems Performance Assessments
NAME OF ORGANIZATION Dow Corning Corporation	ADDRESS: Dow Corning Corporation 2200 Salzburg Rd. Box 1767 Midland, MI 48640
NAME OF PRINCIPAL RESEARCHER D. B. Haines	

TITLE OF PROJECT

Superior Coolant Liquid

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this project is to establish the most cost effective solar heat transfer fluid of the currently available choices.

The bases for determination are:

1. Solar Collector Stagnation Studies
2. Fire Hazard Testing
3. Physical Property Profiles
4. Toxicological Studies
5. Corrosion Analysis

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

1. Glycol/water mixtures tested have demonstrated relatively poor stability and unanticipated flash points.
2. Polyalpholefin fluid tested has a relatively low flash point profile and restrictively high viscosities at low use temperatures.
3. Silicone fluid, although the highest priced fluid initially, has demonstrated the lowest life cylce cost to the user.

PERIOD OF PROJECT:
Sept. 1, 1978 - Dec. 31, 1979

FUNDING IN $ U.S.: $120M

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-108

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION ELCAM INC.	ADDRESS: 5330 DEBBIE LN. SANTA BARBARA CA 93111
NAME OF PRINCIPAL RESEARCHER TERENCE C. HONIKMAN	

TITLE OF PROJECT DOMESTIC WATER HEATING SYSTEM DEVELOPMENT

OBJECTIVE AND NATURE OF THE PROJECT:

TO TAKE A NOVEL WATER HEATING SOLAR CONTROL CONCEPT AND DEVELOP IT INTO A MARKETABLE PRODUCT. THE IMPORTANT ELEMENT OF THIS PROJECT WAS THE DEVELOPMENT OF AN ENERGY MANAGEMENT SOLAR CONTROL SYSTEM.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

CONTRACT COMPLETE. UNDERWRITERS LABORATORIES LISTING OBTAINED. SYSTEM IN SMALL SCALE PRODUCTION. OVER 500 SUNSPOT CONSOL UNITS INSTALLED PRIMARILY IN SOUTHWEST U.S. TWO DEMONSTRATION SYSTEMS INSTALLED UNDER CONTRACT TO NASA, INDEPENDENTLY MONITORED BY IBM SITE DATA AQUISITION SUBSYSTEM (SDAS).

PERIOD OF PROJECT:

OCTOBER 76 THRU SEPTEMBER 79

FUNDING IN $ U.S.:

~$130,000

IMPORTANT REPORTS OR PUBLICATIONS:

ESC -7d AUTOCONTROL LOGIC
ESC -34 SUNSPOT CASCADE OPERATING ADVANTAGES

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-109

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Energy Technology Incorporated	ADDRESS: 4914 East 154th Street Cleveland, OH 44128
NAME OF PRINCIPAL RESEARCHER Terry Kolenc	

TITLE OF PROJECT
ROF Steam Turbine for Solar Cooling

OBJECTIVE AND NATURE OF THE PROJECT:

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% 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 *

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Shakedown testing of the rotating package has been completed. Performance testing of the ROF steam turbine will commence in the near future, pending on-going contract negotiations.

* hours are spent at off-design conditions.

PERIOD OF PROJECT:
September 19, 1977 to June 1, 1980

FUNDING IN $ U.S.:
$392,397 (to date)

IMPORTANT REPORTS OR PUBLICATIONS:
None to date.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-110

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______________

NAME OF ORGANIZATION	ADDRESS:
Franklin Research Center	Benjamin Franklin Parkway Philadelphia, PA 19103
NAME OF PRINCIPAL RESEARCHER Harold G. Lorsch	

TITLE OF PROJECT
Novel Control Strategies that Reduce Electric Utility Peaks

OBJECTIVE AND NATURE OF THE PROJECT:

The purpose of this contract is to develop novel control strategies for solar heating and cooling systems that decrease electric utility peaks from auxiliary energy demands. The use of offpeak electrical energy and thermal storage is the key to these control strategies.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Twelve space heating, four water heating, and five space cooling systems have been evaluated. On-peak electrical backup demands can be avoided for solar space heating systems by using offpeak backup energy and storing it every night; the energy penalty is 15% to 25%. These results were found for Philadelphia, PA. Calculations for other locations and other electric utility systems are underway.

PERIOD OF PROJECT:
June 1977 - December 1979

FUNDING IN $ U.S.:
$125,000

IMPORTANT REPORTS OR PUBLICATIONS:

IMPORTANT REPORTS OR PUBLICATIONS:

Lorsch, H.G., "Novel Control Strategies for Solar Assisted Heating and Cooling Systems," Proceedings, Workshop on the Use of Solar Energy for the Cooling of Buildings, San Francisco, California, February 1978.

Lorsch, H.G., Oswald, R.L. and Crane, R.E., "Control Strategies for Electrical Peak Shaving," Proceedings, Workshop on the Control of Solar Energy Systems for Heating and Cooling, Hyannis, MA, May 1978.

Lorsch, H.G., Oswald, R.L. and Crane, R.E., "Control Strategies for Solar Heating/Cooling Systems that Reduce Electric Utility Peak Loads," Conference Proceedings, American Section, International Solar Energy Society, Denver, CO, August 1978.

Lorsch, H.G., Oswald, R.L. and Crane, R.E., "Thermal Storage of Off-Peak Electrical Energy in Solar Heating and Cooling Systems," Proceedings, IEEE Meeting on Decision and Control, San Diego, CA, January 1979.

"Novel Control Strategies for Solar Assisted Systems," Annual Progress Report No. I-C4827, October, 1978.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-111

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION Franklin Research Center	ADDRESS: 20th St. and Parkway Philadelphia, Pennsylvania 19103
NAME OF PRINCIPAL RESEARCHER G. P. Wachtell	

TITLE OF PROJECT Self Controlling, Self Pumping Heat Circulation System Study

OBJECTIVE AND NATURE OF THE PROJECT:

The purpose of self pumping is to transport heat from solar collectors to the thermal energy storage or point of use without using utility power. The project objective was to define and evaluate self pumping schemes. The principal application considered was one in which flat plate collectors are used for space heating for a single-family dwelling. The work included literature search, contact with workers in the field, and conception of schemes by members of the project staff.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Status: Completed, final report to be issued.

Accomplishments: A number of schemes were evaluated. Schemes found to be feasible included power cycles, vapor bubble lift, condensate entrainment by vapor, and others.

PERIOD OF PROJECT:
August 1, 1977-July 31, 1978

FUNDING IN $ U.S.:
$102,600

IMPORTANT REPORTS OR PUBLICATIONS:

Code No. US-111

Franklin Research Center

Self Controlling, Self Pumping Heat Circulation System Study.

Reports and Publications

1. Wachtell, G.P., "Self Pumping By Means of Power Cycles," Second National Passive Solar Conference, Philadelphia, PA., March 15-19, 1978, Vol. 3, page 514. DOE Report No. COO-4484-01.

2. Wachtell, G.P., "Self Controlling, Self Pumping Heat Circulation System Study," Progress Report, June 1978. DOE Report No. COO-4484-02.

3. Wachtell, G.P., "Self Pumping Self Controlling Circulation Systems," Department of Energy Workshop on The Control of Solar Energy Systems for Heating and Cooling, Hyannis, MA., May 23-25, 1978. DOE Report No. COO-4484-03.

4. Oswald, R.L., and Wachtell, G.P., "The Feasibility of a Concentrating Optical Duct System for Collecting and Transporting Solar Energy to Storage," Annual Meeting, American Section, International Solar Energy Society, Denver, CO., August 28-31, 1978. DOE Report No. COO-4484-04.

5. Wachtell, G.P., "Self Pumping Downward Heat Transport," Annual Meeting, American Section, International Solar Energy Society, Denver, CO., August 28-31, 1978. DOE Report No. COO-4484-05.

6. Wachtell, G.P., "Solar Self Pumping," Solar Energy Storage Options, Workshop, March 19-20, 1979, San Antonio, TX. DOE Report No. COO-4484-06.

7. Wachtell, G.P., "Self Controlling, Self Pumping Heat Circulation System Study," Final Report, July 31, 1978. DOE Report No. COO-4484-07.

 Code No. US-112

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Honeywell	ADDRESS: Technology Strategy Center 2600 Ridgway Parkway Minneapolis, MN 55413
NAME OF PRINCIPAL RESEARCHER Roger A. Rausch	

TITLE OF PROJECT CONTINUED EXPOSURE TEST AND EVALUATION OF REFLECTIVE MATERIALS FOR SOLAR APPLICATIONS

OBJECTIVE AND NATURE OF THE PROJECT:

Obtain performance histories of various reflective materials which have been subjected to accelerated and unaccelerated exposure test conditions.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Program concluded. Final report is being processed. Material samples were exposed at an Arizona test site and reflectance measurements were obtained.

PERIOD OF PROJECT:
September 1, 1978 - August 31, 1979

FUNDING IN $ U.S.:
$25,230

IMPORTANT REPORTS OR PUBLICATIONS:

Raush, R.A. and B. P. Gupta "Exposure Test Results For Reflective Materials", Proceedings Of The IES Seminar On Testing Solar Energy Materials and Systems, May 22-24, 1978, Pages 184-7.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-113

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ System Design & Development
NAME OF ORGANIZATION Honeywell, Inc. NAME OF PRINCIPAL RESEARCHER Steve Scarborough	ADDRESS: Honeywell, Inc. Technology Strategy Center 2600 Ridgway Parkway Minneapolis, MN 55413

TITLE OF PROJECT - Design and Development of Single Family, Multi-family, light commercial size solar heating, cooling and hot water systems.

OBJECTIVE AND NATURE OF THE PROJECT:

Design, develop and deliver hardware for solar heating, cooling and domestic hot water systems to be used by Marshall Space Flight Center (NASA) for performance monitoring and demonstration purposes. The following tasks are included:

- Design and deliver a total of (7)-25 Ton Rankine Assisted Chillers
- Design and deliver a total of (4)- 3 Ton Rankine Assisted Air Conditioners
- Design and deliver other solar hardware for each site/system
- Develop the complete system design for each site application
- Provide the results of a computer performance simulation for each site/system
- Design and deliver a 25 Ton Rankine Assisted Chiller for high temperature application
- Perform system cost reduction studies including installation cost analysis, system design trade-offs and high cycle cost analysis to aid in commercialization of these systems
- Design and develop and deliver a 16 KWe (nominal) Rankine Power Generation Unit

The intent of this program is to bring these systems and hardware through the prototype product development stage leading toward products that are commercially available and cost effective.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Sites which are currently operable:

- Stillwater, MN-single family heating & hot water
- New Castle, PA-single family heating and hot water
- Duffield, VA-single family heating, cooling & hot water
- Carrollton, TX-50 Ton commercial heating, cooling & hot water
- Lawrence, KS-25 Ton multi-family heating, cooling & hot water
- Macon, GA-25 Ton commercial heating, cooling & hot water
- Lawrenceburg, TENN-3 Ton single family heating, cooling, & hot water.

PERIOD OF PROJECT: 07/09/76-Mid 1982 FUNDING IN $ U.S.: 6299608

IMPORTANT REPORTS OR PUBLICATIONS:

None

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-114

COUNTRY: UNITED STATES	
COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ RESOURCE ASSESSMENT
NAME OF ORGANIZATION Lawrence Berkeley Laboratory	ADDRESS: University of California Berkeley, CA 94720
NAME OF PRINCIPAL RESEARCHER Donald Grether	

TITLE OF PROJECT
Measurement of Circumsolar Radiation

OBJECTIVE AND NATURE OF THE PROJECT: The objective is to provide measurements of the solar and circumsolar radiation for input to performance evaluations of systems employing concentrating collectors. Circumsolar radiation results from the scattering of direct sunlight from atmospheric aerosols such as dust, or ice crystals in thin clouds. Concentrating systems typically collect the direct solar radiation plus some fraction of the circumsolar, the exact fraction depending upon the details of collector design.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Instruments developed at LBL provide measurements at several locations. The data are processed into forms suitable for application to concentrating systems. Anaylses are carried out at LBL and other institutions of the effect of circumsolar radiation on a variety of types of focusing systems.

PERIOD OF PROJECT: Oct. 79 to Sept. 80 (and continuing)

FUNDING IN $ U.S.: $178K

IMPORTANT REPORTS OR PUBLICATIONS: Lawrence Berkeley Laboratory Reports: LBL 9214, 9412, 10243

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-115

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________

NAME OF ORGANIZATION Lawrence Berkeley Laboratory NAME OF PRINCIPAL RESEARCHER Marlo Martin	ADDRESS: University of California Berkeley, California 94720

TITLE OF PROJECT
Passive Cooling

OBJECTIVE AND NATURE OF THE PROJECT:

The feasibility of using radiative and passive cooling systems to displace conventional air conditioning is being investigated. Selectively emitting infrared radiators are receiving special emphasis. Present efforts center around computer analysis of infrared radiative transfer in the atmosphere, and the design and construction of radiometers to measure infrared sky radiance in several wavelength bands. A radiator assembly test facility has been completed and tests are being performed on a number of radiator/windscreen combinations. The performance of candidate systems utilizing radiative, convective, and/or evaporative cooling will be predicted.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Four filter spectrometers are now taking infrared sky radiation data. Computer program to calculate infrared sky radiance has been developed, and employed to determine the sensitivity of sky radiance to water vapor, cloud cover, temperature and other meteorological variables. A radiator assembly test facility is now operational for measuring the emissive properties of various infrared emitters and windscreens.

PERIOD OF PROJECT:
October 1977 - September 1978
(and continuing)

FUNDING IN $ U.S.:
$294,000

IMPORTANT REPORTS OR PUBLICATIONS:

P.Berdahl, M.Martin: Spectral Measurements of Infrared Sky Radiance. Proc. of Third National Passive Solar Conference, San Jose, CA. (Jan. 1979)

P.Berdahl, M.Martin: Infrared Radiative Cooling. Proceedings of the International Congress of the International Solar Energy Society, Atlanta, GA. (June 1979).

F.Sakkal, M.Martin & P.Berdahl: Experimental Test Facility for Selective Radiative Cooling Surfaces. Proc. of 4th Annual Passive Solar Conf., Kansas City, MO (Oct.1979)

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-116

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS 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: Experimental and Theoretical Evaluation of Control Strategies for Solar Heating and Cooling

OBJECTIVE AND NATURE OF THE PROJECT: A test facility has been constructed to evaluate experimentally the relative performance of different solar heating and cooling controllers and control strategies. The facility includes a solar input simulator (pseudo-collector) and a building load simulator that allows testing for a variety of meteorological conditions and building load demands. Theoretical studies of collector and load loop performance are carried out in support of the experimental work. Technical support activities are performed for the controls part of the DOE solar R & D program.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS: Solar input and building load simulators are operational. System to be simulated is sized for typical residence with 50% annual solar contribution. Theoretical studies of on/off vs proportional control for representative weater conditions are complete. The experimental program is underway.

PERIOD OF PROJECT: October 79 to September 80 (and continuing).

FUNDING IN $ U.S.: $250 K$

IMPORTANT REPORTS OR PUBLICATIONS: Lawrence Berkeley Laboratory Reports: LBL-4436, LBL-5982, LBL-8308, LBL-8381.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-117

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ CONTROLS RESEARCH
NAME OF ORGANIZATION Los Alamos Scientific Laboratory (LASL)	ADDRESS: Group E-4, MS 429 P. O. Box 1663 Los Alamos, NM 87545
NAME OF PRINCIPAL RESEARCHER DONALD R. FARRIS	

TITLE OF PROJECT

EVALUATION OF ADVANCED CONTROLS FOR BUILDING ENERGY CONSERVATION

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this program is to investigate the use of adaptive and 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. Computer simulation has been used in the study and comparisons have been made between conventional control strategies and a technique termed Adaptive Optimal Control (AOC). The AOC technique uses linear regulator theory from optimal control theory and a least-squares system identification technique to accomplish the control. Installation and operation of AOC in a large building is planned.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Simulation results have been very encouraging, demonstrating auxiliary energy savings in excess of 50% for the heating case. The AOC technique is under development to facilitate installation of an AOC system in a large building at LASL. This installation will provide testing of AOC as well as other advanced control approaches.

PERIOD OF PROJECT:

July 1976 - Present, continuing

FUNDING IN $ U.S.:

$150,000 for FY 1980
Joint funding with Johnson Controls, Inc.

IMPORTANT REPORTS OR PUBLICATIONS:

"Adaptive Optimal Control - An Algorithm for Direct Digital Control," ASHRAE Transactions, Vol 86, Part 1.

"On the Use of Adaptive Optimal Control to Provide Energy Conservation in Large Buildings," 18th IEEE CDC, December 1979.

"Energy Savings for a Solar Heated and Cooled Building Through Adaptive Optimal Control," 17th IEEE CDC, January 1979.

"Adaptive Control for Energy Conservation August 1, 1976 - February 15, 1977," LASL Status Report LA-6753-SR, March 1977

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-118

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Rho Sigma, Inc.	ADDRESS: 11922 Valerio Street North Hollywood, CA 91605
NAME OF PRINCIPAL RESEARCHER Edward S. Peltzman	

TITLE OF PROJECT

Programmable Solar Controller

OBJECTIVE AND NATURE OF THE PROJECT:

Develop a programmable microprocessor based controller for complex solar systems.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The program was completedwith delivery of 3 RS 600 programmable controls to the U.S. Department of Energy, D.O.E.

PERIOD OF PROJECT: 12/76 - 7/79 FUNDING IN $ U.S.: $45,196

IMPORTANT REPORTS OR PUBLICATIONS:

Final documentation delivered with the controls.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-119

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Computer code validation
NAME OF ORGANIZATION Solar Environmental Engineering Co., Inc. NAME OF PRINCIPAL RESEARCHER Dr. C. Byron Winn	ADDRESS: 2524 E. Vine Drive Fort Collins, CO 80524

TITLE OF PROJECT
Model Validation Studies of Solar Systems

OBJECTIVE AND NATURE OF THE PROJECT: To validate computer codes used for solar system design; e.g., TRNSYS, SIMSHAC, FCHART and SOLCOST; also, to validate codes used to estimate insolation levels.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Comparisons between the design codes as well as comparisons to real data are presented in the final report.

PERIOD OF PROJECT: March '77-March '78 FUNDING IN $ U.S.: $98,838.00

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report: Lantz, L.J. and Winn, C.B., "Model Validation Studies of Solar Systems, Phase III", December 1, 1978. Contract #EG-77-C-4229.A001.

Lantz, L.J. and Winn, C.B., "Validation of Computer Models for Predicting Radiation Levels on Tilted Surfaces", 'Energy, The International Journal', August, 1979, Vol. 4, No. 4, Pergammon Press.

 Code No. US-120

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ________________
NAME OF ORGANIZATION Suntek Research Associates	ADDRESS: 506 Tamal Plaza Corte Madera, CA 94925
NAME OF PRINCIPAL RESEARCHER Day Chahroudi	

TITLE OF PROJECT: Research in Active Films for Energy Modulation in Buildings and Development of Passive Components Using Advanced Materials

OBJECTIVE AND NATURE OF THE PROJECT: The basic optical, thermodynamic and quantum mechaaical properties of optical shutter will be studied in the Active Films work.

In the Passive Components section of the project, specific candidate translucent wall panels will be designed, fabricated, and tested.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Inorganic optical shutters appear to be commercially infeasible while polymeric optical shutters look promising.

Translucent wall panels were fabricated and tested with "U" values as low as 0.27 BTU/ft^2·Hr and solar transmission as high as 72%

PERIOD OF PROJECT:
October 1978 to November 1979

FUNDING IN $ U.S.:
$213531.00

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report will be published at the conclusion of the project

IEA SURVEY OF COMPONENTS FOR SOLAR HE/-
COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. US-121

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ____________
NAME OF ORGANIZATION Suntek Research Associates	ADDRESS: 506 Tamal Plaza Corte Madera, CA 94925
NAME OF PRINCIPAL RESEARCHER Charles Tilford	

TITLE OF PROJECT
High Performance Apertures for Passive Solar Heating

OBJECTIVE AND NATURE OF THE PROJECT: Design, fabricate, and test specific candidate window and skylight assemblies which utilized existing advanced materials.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Just started

PERIOD OF PROJECT:
October 1979 to July 1980

FUNDING IN $ U.S.:
$75,137.00

IMPORTANT REPORTS OR PUBLICATIONS:
Final Report will be published at conclusion of project.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-122

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☒ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION Thermacore, Inc.	ADDRESS: 730 Eden Road Lancaster, Pa. 17601
NAME OF PRINCIPAL RESEARCHER Donald M. Ernst	

TITLE OF PROJECT Cost Effective Solar Collectors Using Heat Pipes

OBJECTIVE AND NATURE OF THE PROJECT: The object of the program is the demonstration of high performance, cost effective solar collectors using heat pipes. The end product will be directly applicable to efficient use with absorption and Rankine cycle chillers. Low cost, long lived heat pipes with a non-toxic working fluid capable of surviving the environmental limits of $-40^{\circ}C$ to $400^{\circ}C$ with a working range of $38^{\circ}C$-$165^{\circ}C$ and a minimum heat transport capability of 110 watts over 1.2 meters were to be developed and integrated into low concentrating evacuated tube collectors.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Results to date show that to fully utilize the heat pipe's potential in evacuated solar collectors, the collectors must be in series rather than parallel. This reduces the field plumbing to inter-collector joints rather than dual header manifolds running the entire length of the installation. This lowers the materials and installation costs and significantly reduces the thermal losses and pump parasitics such that the system cost per watt delivered has the potential of being reduced by at least 15%. Less quantifiable benefits arise from the thermal diode effect of the heat pipe which reduces to near zero the normal thermal loss from the system into the thermal sink created by a highly degraded or broken evacuated shroud, also the heat pipe collector has the potential to be used in a drain down system with additional improved performance and reduced system costs. Prior to this program no heat pipe envelope-fluid combination was known which was capable of 20 years of undegraded operation while fulfilling all of the system requirements. To date the following has been demonstrated.
*20,000 hours of undegraded operation of water - low alloy steel heat pipe at $225^{\circ}C$.
*400 freeze-thaw cycles without heat pipe failure.
*300 days stagnation testing with no heat pipe performance degradation.

PERIOD OF PROJECT:

1 September 1977 - 30 September 1980.

FUNDING IN $ U.S.: $271,324

IMPORTANT REPORTS OR PUBLICATIONS:

Interim Progress Report #1 - May 1978
" " " #2 - September 1978
" " " #3 - June 1979
Cost Effective Solar Collectors, Ernst, D. M. and Eastman, G. Y.
Paper #78 9593 - 13th JECEC San Diego, California, August 1978.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING,
COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-123

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☒ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ________
NAME OF ORGANIZATION VERSAR, INC.	ADDRESS: 6621 Electronic Dr. Springfield, Va. 22151
NAME OF PRINCIPAL RESEARCHER Ralph D. Gift	

TITLE OF PROJECT Survey and Evaluation of Available Thermal Insulation Materials for Use on Solar Heating and Cooling Systems

OBJECTIVE AND NATURE OF THE PROJECT:

The objective of this study is to provide a tool to aid in the selection of the optimum insulation for use on solar heating and cooling components. Data on various insulation materials were compiled by surveying the insulation industry. The results of this study will provide guidance to the manufacturer in the design and control of his product; to standard-setting organizations in evaluating and improving specifications codes and standards; and to the consumer in selecting the optimum insulation for his hardware.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

The survey has been completed and the data are being tabulated and evaluated in preparation for writing the final report.

PERIOD OF PROJECT:
September 18, 1978 - January 31, 1980

FUNDING IN $ U.S.: $115,624.00

IMPORTANT REPORTS OR PUBLICATIONS:

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-124

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☒ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ MANAGEMENT SUPPORT

NAME OF ORGANIZATION
Hittman Associates, Inc.

NAME OF PRINCIPAL RESEARCHER
Dr. H. M. Curran

ADDRESS: Hittman Associates, Inc.
9190 Red Branch Road
Columbia, MD 21045

TITLE OF PROJECT
Solar Cooling Systems Evaluation

OBJECTIVE AND NATURE OF THE PROJECT:

Under this contract assistance is provided to the Lawrence Berkeley Laboratory in the management of solar cooling contracts. These contracts are in the Rankine and absorption technology areas. Tasks include site visits to contractor projects; review and evaluation of contractor reports, and unsolicited proposals; participation in DOE progress review conferences on solar cooling projects; and comparative technical and economic evaluations of projects.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

PERIOD OF PROJECT:
1 April 79 to 31 Jan 1980

FUNDING IN $ U.S.: $102,000

IMPORTANT REPORTS OR PUBLICATIONS:

The Use of Organic Working Fluids in Rankine Engines
Hittman Report No. H-C1007/2000-79-902, Sept. 1979

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-125

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Controls

NAME OF ORGANIZATION
Colorado State University

NAME OF PRINCIPAL RESEARCHER
Dr. C. Byron Winn

ADDRESS:
Department of Mechanical Engineering
Colorado State University
Fort Collins, CO 80523

TITLE OF PROJECT
OPTIMAL CONTROL STUDIES

OBJECTIVE AND NATURE OF THE PROJECT:

Construction and testing of the optimal controller of the second kind (the control of collector fluid flow rates); analysis of optimal controllers used with off-peak storage devices; analytical studies of controllers used in solar heating and cooling systems.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Controller test facility completed; optimal controller of the second kind built and installed in CSU Solar House II.

PERIOD OF PROJECT: June 1978-Dec 1979 FUNDING IN $ U.S.: $80,000

IMPORTANT REPORTS OR PUBLICATIONS:

1. Winn, C. B. and D. Nguyen, "An Optimal Control Strategy for Peak-Load Reduction Applied to Solar Structures," Proceedings of the First Workshop on the Control of Solar Energy Systems for Heating and Cooling, AS/ISES Publishing Office, University of Delaware, Newark, Dela., 1979.

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2. Winn, C. B. and D. E. Hull, "Optimal Control of Active Solar Systems," Proceedings of the First Workshop on the Control of Solar Energy Systems for Heating and Cooling, AS/ISES Publishing Office, University of Delaware, Newark, Dela., 1979.

3. Winn, C. B. and D. E. Hull, "Optimal Controllers of the Second Kind," Proceedings of the First Workshop on the Control of Solar Energy Systems for Heating and Cooling, AS/ISES Publishing Office, University of Delaware, Neward, Dela., 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. US-126

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☐ ______
NAME OF ORGANIZATION Lawrence Berkeley Laboratory NAME OF PRINCIPAL RESEARCHER Ron Kammerud/Wayne Place	ADDRESS: 1 Cyclotron Road Berkeley, California 94720

TITLE OF PROJECT
Passive Solar Analysis and Design

OBJECTIVE AND NATURE OF THE PROJECT: To satisfy appreciable fractions of the heating, cooling, and domestic hot water loads of buildings by "passive" means, the system designer must have a quantitative and qualitative understanding of the collection, dissipation, storage, and distribution of thermal energy within the boundaries of the structure in terms of the building parameters and the environmental conditions under which the building is used. The objective of this project is to provide a basis for this improved understanding of passive systems: (1) to develop analytic tools on which this general understanding of the thermal behavior of both residential and commercial buildings can be based; (2) to develop, analyze, and test innovative passive design concepts for application to specific building types, especially within the commercial sector; (3) to utilize the analytic capabilities in generating design and engineering tools for use by the building community. Where appropriate the analysis capabilities will be provided in the existing public domain building energy analysis computer program, BLAST.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:
Models for the following passive solar and hybrid systems are currently being added to BLAST: movable insulation, ventilation cooling, thermocirculation/Trombe walls, thin film stacks on glazing, roof ponds, and daylighting. Validation of BLAST for direct-gain systems has been completed and is under way for the other models which have been developed. Utilizing these new analysis capabilities, (1) parametric studies of the performance of generic passive solar structures in different climates and (2) case study examinations of specific passive designs are under way. The results will be in the form of architectural design tools and system engineering sizing data. In addition, both analytic and experimental studies of thermosiphon hot water heaters are in progress; the purpose is to develop a design for a positive freeze-protected system so that the regional applicability of passive hot water systems is increased.

PERIOD OF PROJECT:

FUNDING IN $ U.S.:

IMPORTANT REPORTS OR PUBLICATIONS:

"The Effect of Occupant Use Patterns on the Performance of Direct-Gain Passive Solar Systems," Int'l Conf. Energy Use Management, Los Angeles, October 1979.
"Thermal Mass: Its Role in Residential Construction," Int'l Conf. Energy Use Management, Los Angeles, October 1979
"Mean Monthly Performance of Passive Solar Water Heaters," 4th Passive Conf., Oct. '79
"The Passive Solar Design Process for a Small Office/Laboratory Building," Int'l Conf Energy Use Management, Oct. 1979.

IEA SURVEY OF COMPONENTS FOR SOLAR HEAT....,
COOLING AND HOT WATER SUPPLY SYSTEMS   Code No. 127

COUNTRY: UNITED STATES

COMPONENTS	TYPE OF RESEARCH
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☒ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ Solar Control Survey

NAME OF ORGANIZATION
Rho Sigma, Inc.

ADDRESS:
11922 Valerio St.
No. Hollywood, CA 91605

NAME OF PRINCIPAL RESEARCHER
Andrew Davis

TITLE OF PROJECT
Assessment of the need for new solar controllers

OBJECTIVE AND NATURE OF THE PROJECT:

Survey the thermal energy solar control market. Identify new areas which may require controls in the near future.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Complete survey and published report on June 30, 1978.

PERIOD OF PROJECT: Nine Months   FUNDING IN $ U.S.: $47,000.

IMPORTANT REPORTS OR PUBLICATIONS:

Final Report: June 30, 1978
Assessment of the need for new solar controllers
Contract No. EG 77-C-03-1597

IEA SURVEY OF COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS

Code No. 128

COUNTRY: UNITED STATES	
COMPONENTS	**TYPE OF RESEARCH**
☐ SOLAR COLLECTOR ☐ THERMAL ENERGY STORAGE ☐ AIR CONDITIONING UNIT ☐ OTHER SUBSTANTIAL COMPONENTS	☐ MATERIALS RESEARCH ☐ COMPONENT DEVELOPMENT ☒ COMPUTER SIMULATIONS
NAME OF ORGANIZATION Science Applications, Inc.	ADDRESS: 1764 Old Meadow Lane McLean, Virginia 22180
NAME OF PRINCIPAL RESEARCHER Jeffrey H. Morehouse	

TITLE OF PROJECT
ADVANCE SOLAR SYSTEM ANALYSES

OBJECTIVE AND NATURE OF THE PROJECT:

To model and compare advanced-concept solar heating and cooling systems for residential and commercial application.

PRESENT STATUS OR SUMMARY OF SIGNIFICANT ACCOMPLISHMENTS:

Analyzed solar-assisted heat pump systems for thermal/economic performance using the newly developed "standardized" simulation methodology.

PERIOD OF PROJECT: 4/79-4/80

FUNDING IN $ U.S.: 400,000

IMPORTANT REPORTS OR PUBLICATIONS:

1) Survey of Available SHAC Computer Programs
2) Solar-Assisted Heat Pump Comparison (Residential)
3) Rankine-Absorption Commercial Systems Comparison

Appendix 1

MATRIX CODING OF SOLAR HEATING & COOLING COMPONENTS

(Format 1)

The Format 1 Matrix Coding is a summary of the reports sent from the Task II Participants as of February 1980. These reports are limited to those included in the compilation of "Survey and Review of Components for Solar Heating, Cooling and Hot Water Supply Systems - Parts I, II and III. It has been found that matrices based on the Format 1 were quite useful in understanding the present R & D situation of solar heating and cooling components and in identifying solutions to critical problems of key components.

The matrix coding of components such as solar collectors, heat storage units and other substantial units indicates the distribution of component R & D projects among the Task II participating countries. It also suggests areas of effort and interest among Participants in these fields. It may further show the qualitative scope of existing critical problems associated with specific components and will suggest topics for discussion on component development. Duplication of R & D efforts among the Participants may be avoided as well.

The number of R & D projects by component as reported in this format are: solar collectors, 116; heat storage, 57; air conditioning units, 36; and other substantial units, 75. There are a total of 284 projects, an indication of the recent tendency toward increased Solar Energy R & D by the Task II participating countries. It is suggested that the Format 1 Matrix Coding will be interpreted more effectively in connection with an analysis of the matrix coding on technical problems.

Solar Collectors

The quantity of solar collectors manufactured has rapidly increased as world-wide solar energy R & D projects grow and the solar energy industry expands. Among solar collector projects on flat plate collectors, those for hot water supply system still show about 31% of them while projects on high performance collectors are counted as 62 including those of the evacuated tube collector. About 74 % of the total 118 projects are concerned with the flat plate type. The concentrating collector, with or without a sun tracking mechanism, does not occupy a major position in solar heating and cooling systems at this moment. The other 12 projects may be concerned with soft technologies such as computer simulation, heat transfer analysis etc.

Heat Storage

Among the projects on thermal energy storage, 32 projects (56%) are directed toward sensible heat storage. Water heat storage technology appears to play the major role, while the concept of underground seasonal heat storage has also attracted attention of the participants. So far, "latent heat storage" and "chemical reaction" still face technical barriers that are not yet solved. Alternative materials and techniques are being investigated.

Air Conditioning Units

Major R & D efforts on air conditioning units are concentrated on Rankine cycle machines and absorption units in almost equivalent numbers. Desiccant systems may be considered in passive solar systems.

<u>Other Substantial Units</u>

There are few hardware R & D projects in progress in the category of other substantial units. Fifty-six projects are underway on detailed analysis of components such as heat transfer analysis, computer simulation, etc.

* 1 - 3

MATRIX CODING ON SOLAR COLLECTORS

	Flat Plate Collector	One Pane Black Paint	Two Pane Black Paint	One Pane Selective	Two Pane Selective	Honeycomb Collector	Tubular Collector	Evacuated Collector	Heat Pipe Collector	Concentrating Collector	Without Sun-Tracking	With Sun-Tracking Device	Others
AUSTRIA		2	1	2	-	-	-	-	-		-	1	1
BELGIUM		2	2	2	2	-	-	-	-		-	-	-
DENMARK		-	-	-	-	-	-	-	-		-	-	-
F.R.G.		9	5	2	7	3	1	3	4		-	-	1
GREECE		-	-	-	-	-	-	-	1		1	1	-
ITALY		1	-	1	-	-	-	-	-		-	-	3
JAPAN		-	1	1	1	2	1	3	-		-	-	-
NETHERLANDS		2	-	5	-	-	-	1	1		1	-	-
NEW ZEALAND		6	-	-	-	-	-	-	-		-	-	-
SPAIN		-	-	-	-	-	-	-	-		-	-	-
SWEDEN		-	-	2	-	-	-	-	-		-	-	-
SWITZERLAND		-	-	-	-	-	-	-	-		-	-	3
U.S.A.		1	7	3	1	2	-	3	2		5	1	4
Total	75	23	16	18	11	7	2	10	8	12	7	3	12

* 1 - 4

MATRIX CODING ON HEAT STORAGE

	Sensible Heat Storage	Water	Liquid	Liquid-Solid Mixtures	Solid Materials	Ground	Others	Latent Heat Storage	Organic Materials	Inorganic Hydrate	Fused Salts	Other Phase Change	Others (Absorption, Dilution, etc.)	Chemical Reaction	Others	Heat Transfer Media
AUSTRIA		3	1	-	-	2	-		-	1	1	-	-	-	-	-
BELGIUM		-	-	-	-	2	-		-	-	-	-	1	1	-	-
DENMARK		-	-	-	-	-	-		-	2	-	-	-	-	-	-
F.R.G.		8	-	-	-	-	-		1	1	-	1	-	-	-	-
GREECE		-	-	-	-	-	-		-	-	-	-	-	-	-	-
ITALY		-	-	-	-	-	-		-	-	-	-	-	-	-	-
JAPAN		1	-	-	-	-	-		-	2	-	-	-	-	-	-
NETHERLANDS		3	1	-	-	1	-		-	-	-	2	-	2	-	-
NEW ZEALAND		1	-	-	1	-	-		-	-	-	-	-	-	-	-
SPAIN		-	-	-	-	-	-		-	-	-	-	-	-	-	-
SWEDEN		3	-	-	-	-	-		-	2	-	-	-	-	-	-
SWETZERLAND		-	1	-	-	-	-		1	-	-	-	-	-	-	-
U.S.A.		2	-	-	-	-	2		2	-	-	1	-	1	1	2
Total	32	21	3	0	1	5	2	18	4	8	1	4	1	4	1	2

* 1.- 5

MATRIX CODING ON AIR CONDITIONING UNIT

	Rankine Cycle Unit	Absorption Unit	LiBr - H_2O	NH - H_2O	Other Pairs	Heat Pump	Others	Control System	Desiccant	Assessment and Optimization	Prime Movers
AUSTRIA	-		1	-	-	-		-	-	-	-
BELGIUM	-		1	1	-	-		-	-	-	-
DENMARK	-		-	-	-	-		-	-	-	-
F.R.G.	-		1	-	-	-		1	-	-	-
GREECE	-		-	-	-	-		-	-	-	-
ITALY	-		-	-	-	-		-	-	-	-
JAPAN	2		1	-	-	-		-	-	-	-
NETHERLANDS	-		1	1	-	-		-	-	-	-
NEW ZEALAND	-		-	-	-	-		-	-	-	-
SPAIN	1		-	-	-	-		-	-	-	-
SWEDEN	-		-	-	-	-		-	-	-	-
SWITZERLAND	-		-	-	-	-		-	-	-	-
U.S.A.	10		2	1	4	-		-	5	2	1
Total	13	14	7	3	4	0	9	1	5	2	1

* 1 - 6

MATRIX CODING ON OTHER SUBSTANTIAL UNITS

	Control System	Heat Exchanger	(Heat Pump)		Passive System	Solar powered refrigeration by a solid absorption system	Others	Coating	Collectors	Storage
AUSTRIA	3	2	1		2	-		-	-	-
BELGIUM	-	-	1		-	-		-	-	-
DENMARK	-	-	-		-	1		-	-	-
F.R.G.	-	-	-		-	-		3	-	-
GREECE	1	-	-		-	-		-	-	-
ITALY	-	-	-		-	-		-	-	-
JAPAN	-	-	-		-	-		-	-	-
NETHERLANDS	2	1	-		-	-		-	4	-
NEW ZEALAND	-	-	-		-	-		-	-	-
SPAIN	-	-	-		-	-		-	-	-
SWEDEN	-	1	-		-	-		-	-	-
SWITZERLAND	-	-	-		-	-		-	-	-
U.S.A.	2	1	1		-	-		-	38	11
Total	8	5	3	3	2	1	56	3	42	11

* 1 - 7

Appendix 2

MATRIX CODING ON MAJOR TECHNICAL PROBLEMS

Introduction

This matrix coding system is designed to allow researchers from any country to rapidly determine what research for solar heating and cooling components is being pursued in other countries that might be of direct use in resolving specific technical problems. It also serves to provide an overview of the world research community's perception of where the major emphasis in research is needed to make solar a viable energy source. In order to exploit these valuable features of a matrix presentation, the matrix organization requires a dual level of detail--an indication of work being done by broad technical problem, and details of how the problem is being addressed, limited to a short paragraph in the R & D Project Summary compilation.

Annex 2 is a summary based on the R & D projects in this report and contains 3 matrices on solar collectors, thermal energy storage and solar cooling, with brief statements on other substantial components. The technical problems categories are listed across the top of the page, and the country name of the Task II participants are listed down the left hand side. Each country indicated the technical problem area it is actively addressing by making an "X" at the intersection of the country name and technical problem (up to a limit of 10 problems per country).

A description sheet for the problem areas follows each matrix. The short paragraph is a summary of material submitted by the Participants which indicated what the problems are and the general methods of solution being pursued.

SOLAR COLLECTORS

MAJOR TECHNICAL PROBLEMS IN SOLAR COLLECTORS

TECHNICAL PROBLEM \ COUNTRY	AUSTRIA	BELGIUM	DENMARK	F.R.G.	GREECE	ITALY	JAPAN	NETHERLANDS	NEW ZEALAND	SPAIN	SWEDEN	SWITZERLAND	UNITED STATES
ABSORBER HEAT LOSS			X	X			X					X	X
SELECTIVE COATINGS			X	X			X				X	X	X
MANIFOLD HEAT LOSS													
INSULATION DETERIORATION							X						
GLAZING MATERIALS	X		X				X					X	X
GLASS/GLASS TUBE BREAKAGE													
HEAT TRANSFER			X	X	X							X	X
PANEL INTERCONNECTION				X								X	
CONCENTRATOR DESIGNS					X		X				X	X	X
REFLECTOR MATERIALS/COST							X						
STRUCTURAL DESIGNS												X	
STAGNATION SURVIVAL			X									X	
FREEZE PROTECTION													
CORROSION	X				X		X					X	X
TEST AND EVALUATION	X		X	X	X							X	
MANUFACTURING COST	X		X	X								X	X
INSTALLATION COST	X											X	X
REFRACTOR MATERIALS/COST													
SOLAR PONDS					X								X
CASING				X									
DURABILITY AND RELIABILITY			X										
NEW DESIGNS			X										
GLAZING LOSSES				X									
ABSORBER DESIGNS				X									

* 2 - 2

Absorber Heat Loss

Heat loss from the absorber by convection and radiation is dominant in flat plate collectors while radiation and conduction are most important in evacuated tube collectors. A considerable effort has been made to reduce heat losses in flat plate collectors for higher efficiency by developing techniques such as double glazing, selective coatings, honeycomb structures, IR reflective coatings on glazing, etc. Similar techniques have been applied to evacuated tubular collectors.

References: G-1, J-8, J-13, US-28, US-63, Univ. Wisconsin, Univ. Pennsylvania, VPI, O-I, Lockheed, Honeywell, Sandia.

Selective Coatings

Solar selective coatings absorb strongly in the visible part of the spectrum, but reflect in the IR. They are therefore beneficial in reducing radiative heat losses from the absorber surface. Black chrome, black nickel, and black copper coatings, as well as others, have been used for this purpose. The main problems concern durability, lifetime, and cost. Selective paints and coatings that are vapor deposited on continuous film offer potential cost savings.

References: FRG-1, FRG-2, FRG-5, FRG-9, FRG-13, FRG-18, FRG-31, J-6, J-7, J-8, J-13, SWED-2, US-4, US-28, US-40, US-41, US-52, US-63, Berry, Honeywell.

Insulation Deterioration

Leakage due to insulation deterioration identified in an earlier stage of R & D of evacuated tubular collectors has been solved by improving the structure and connections.

References: J-1.

* 2 - 3

Glazing Materials / Glazing Losses

Glass is generally used for the outside cover of solar collectors because it is a strong, durable and a good transmitter, but it is limited in module size, relatively heavy and brittle. Polymers offer reduced weight and cost and can be made in virtually unlimited sizes, but are susceptible to degradation of optical and mechanical properties due to uv, high temperature, and environmental exposure. R & D activities on strong and durable polymers and glass are still going on. Another topic is prevention of soiling by dust and industrial dirt which are only partly removed by rain.

References: A-1, A-3, A-4, A-5, A-6, A-9, A-14, FRG-16, J-7, J-8, US-58,US-67, Springborn, Honeywell, Univ. Wisconsin, Research Triangle.

Heat Transfer

Heat transfer between the absorber plate and the working fluid, the absorber and the glazing, and the glazing housing and the environment are significant impediments to improved performance. Fundamental heat transfer studies and economical means of augmenting heat transfer in air heating collectors, and reducing convection to heat pipe collectors have been conducted.

References: FRG-3, US-28, US-42, US-53, US-66, Univ. Pennsylvania.

Panel Interconnection

One of the problems in developing high efficiency collectors is the water vapor diffusion between the absorber and the cover plate in flat plate collectors. The industrial welding of inlet and outlet pipes to a water film flat plate absorber is a problem unsolved, especially in the case of natural conVection.

References: FRG-1, FRG-13.

Concentrator Designs

Improvement of performance over conventional flat plate collectors, particularly in the higher temperature ranges, can be obtained by using optical concentrators. Studies and development projects are in progress that range from the use of simple planar mirrors to augment flat plate collectors, through the use of stationary or periodically adjusted nonimaging concentrators, to one or two axis line and point focus tracking collectors.

References: J-13, SWED-1, US-4, US-9, US-21, US-22, US-25, US-26, US-27, US-43, US-44, US-49, Intertechnology Corporation, Honeywell, Univ. Chicago, Sandia Albuquerque.

Reflector Materials / Cost

Polyester film coated with aluminum or silver and with a protective layer gives a practical and flexible reflecting film with a reflectivity of over 90%. It is important to increase the durability of the protective coating layer.

References: J-8.

Structural Designs / Stagnation Survival

The lifetime and durability of solar components are critical for economical performance. Long time tests in real installations, based on a sufficient number of comparable units, are necessary. They should be accompanied by laboratory tests to improve structural designs.

References: -----

Corrosion

Corrosion is expected to be a major problem for solar collectors. Information on long term effects in multi-metallic systems is sparse. Sufficient information to assess the lifetime economics of corrosion control is not available at present. Solutions might deal with corrosion protective fluids, special absorber materials and absorber designs.

References: A-1, A-3, A-4, A-5, A-6, A-7, A-9, A-13, A-14, A-16, FRG-2, FRG-4, FRG-6, FRG-13, J-6, US-6, US-12, US-18, US-35, Dow Corning, Univ. Florida, Argonne, Olin Brass.

Test and Evaluation

The scatter of solar collector testing data is primarily caused by systematic errors when conducting the test and by the fact that ambient conditions are not sufficiently considered. To a lesser extent, the data range is caused by production dependent changes of the collector properties. Evaluation procedures are indispensable for R & D and dissemination of solar collectors. In addition to performance tests of collectors such as the NBS-ASHRAE Method and BSE Methods, procedures must be established for tests of corrosion, performance under no flow conditions, stagnation and durability.

References: A-1, A-3, A-4, A-5, A-6, A-7, A-8, A-10, A-14, A-16, A-20, A-22, FRG-7, FRG-9, FRG-10, FRG-19, FRG-21, FRG-22, FRG-24, FRG-25, FRG-26, FRG-27, FRG-28, FRG-29, FRG-30, FRG-32.

Manufacturing Cost

Collector cost remains the greatest single deterrent to widespread use of solar heating and cooling. Reduction in manufacturing cost may be effected by the use of inherently low-cost or low-mass materials - polymers, etc. - and the design of products that lend themselves to low cost mass production.

References: A-1, A-4, A-5, A-6, A-7, A-14, A-17, FRG-2, FRG-6, FRG-26, FRG-30, US-1, US-3, US-5, US-7, US-14, US-26, US-32, US-34, US-36, US-37, US-51, US-56, US-64, US-65.

Installation Cost

Manufacturing cost and installation cost of solar collectors are closely linked. The common approaches to reducing the cost of collector installation are to increase the module size and/or to decrease the collector dry weight. Studies of structural requirements and array optimization are also aimed at reducing installation cost.

References: A-1, A-3, A-4, A-5, A-6, A-14, A-17, US-1, US-3, US-7, US-32, US-34, US-54, US-55, US-56, NBS.

Solar Ponds

Salt-gradient stabilized solar pond technology has evolved most rapidly in Israel. Ponds are most attractive at low latitudes where they collect substantial solar energy throughout the year. They may also be effective in high altitudes if their ability to provide integrated thermal energy storage can be adequately matched to the load. At present, most of the research is focussed on understanding the fundamentals of pond behavior.

References: US-29, US-38, US-60, Ohio State Research Center, Desert Research, Intertechnology Corp., ANL, SERI.

Durability and Reliability

Durability and reliability of solar collectors are closely related to collector economics. The testing procedures on these factors are not yet established. Technical problems with degradation of collector absorbers, broken glass, leaks and coloring of plastic covers and insulation materials must be resolved.

References: -----

New Designs

A prototype to integrate the collector into the loft structure of a house has been tested. Other new designs such as aesthetic collectors, which may be used for historic buildings, etc. are also being considered in collector R & D.

References: FRG-16.

Absorber Design

Performance of flat plate collectors is directly infuenced by the absorber design. Construction proposals deal with low concentrating devices, heat pipes, direct evaporating collectors, and others.

References: FRG-8, FRG-11, FRG-12, FRG-15, FRG-17.

THERMAL ENERGY STORAGE

MAJOR TECHNICAL PROBLEMS IN THERMAL ENERGY STORAGE

TECHNICAL PROBLEM \ COUNTRY	UNITED STATES	SWITZERLAND	SWEDEN	SPAIN	NEW ZEALAND	NETHERLANDS	JAPAN	ITALY	GREECE	F.R.G.	DENMARK	BELGIUM	AUSTRIA
STRATIFIED WATER TANKS	X	X					X				X		X
WATER TANK LINERS	X						X						X
UNIFORM FLOW ROCKBEDS	X												
HEAT LOSS		X					X				X		
HEAT EXCHANGE		X					X				X		
HEAT TRANSFER/TRANSPORT		X					X						
PCM STORAGE	X	X	X				X			X	X		X
CHEMICAL STORAGE		X	X						X		X		X
CHEMICAL HEAT PUMPS	X										X		
STATE-OF-CHARGE METER													X
LEAK DETECTION													
LARGE-SCALE, LONG-TERM STORAGE	X	X	X							X	X		X
RETROFIT STORAGE	X												
SOLAR CHILLER STORAGE	X												
SAHP STORAGE	X												
PCM STRUCTURAL MATERIALS							X						
INSULATION							X						
STORAGE COST/UNIT HEAT	X	X					X				X		X
STORAGE DENSITY							X				X		
SAFETY/DURABILITY							X				X		
OTHER													
COMPUTER SIMULATION													X

Stratified Water Tank

With regard to water flow problems in heat storage tanks, it is important that the dead water regions be minimized and that water flow be brought close to the piston flow to give stratification. The maintenance of a high degree of temperature stratification in storage deveces can improve collector performance by 8 - 12 %, with similar improvements in the efficiency with which heat is delivered from storage to the load. R & D is centered on location of the flow control, the design of inlet and outlet ports and the introduction of flow and convection baffles.

References: A-1, A-2, A-5, A-19, A-22, J-4, J-15, US-33, US-71, US-87.

Water Tank Liners

Water heat storage tanks installed outside require completely water tight liners to prevent heat losses and insulator deterioration. To make large scale water tank storage possible, temperature resisting liners must be developed, especially for concrete underground storage tanks. It is also suggested that the use of flexible membrane liners offer a means for controlling the serious problems of leakage and corrosion. These liners permit the design of tanks using low cost containment structures which are readily built or assembled on site for retrofit and new construction applications.

References: A-1, A-2, A-19, J-15, US-70, US-87.

Uniform Flow Rockbeds

Non-uniform flow rockbeds reduce the available storage capacity and temperature stratification of the bed. This phenomenon is particularly troublesome in shallow rockbeds and in horizontal flow rockbeds installed in areas where available space or economics make a deep vertical rockbed undesirable or impossible. Approaches under study include the design of manifolds for better flow and pressure distribution at the inlet and outlet, partitioning of the bed by baffles and innovative structural shapes and materials. A detailed 3-dimensional model for use in analysis and design of more uniform flow rockbeds is required.

References: US-70, US-71.

Heat Losses

Heat loss from a thermal storage tank is one of the critical problems in energy storage. It is necessary that the capacity of a storage tank be appropriately designed, the difference between the temperature of the stored water and that of surroundings be minimized, its surface area be minimized and appropriate insulation be effected. Modification of the thermal properties of the ground might also be effective in preventing heat losses from seasonal storage in the ground.

References: J-4, J-14.

Heat Exchange

The poor heat transfer characteristics of the PCM thermal energy storage are due to the low thermal conductivity of the PCM and the high viscosity of the liquid phase, which inhibit the convection within the liquid phase. The use of fins or fillers is one approach to improving the heat transfer. Also, the lay-out of the heat exchangers has to be improved to increase overall system efficiency.

References: J-14.

Heat Transfer / Transport

Total heat transfer characteristics of a solar system are based on the operating temperature range and flow rate of the transfer fluid. It is important to minimize the power necessary for transporting heat as well as heat loss during the heat transporting process, and to evaluate the performance of terminal heat transfer devices. The lay-out of the piping and of the control parts has to be improved.

References: J-4, J-14.

Phase Change Materials (PCM)

A high volumetric storage density is often required where adequate space is not available or is too costly to accommodate the volume needed for the required storage capacity of a sensible heat storage system. PCM storage systems offer a potential for reducing this required volume to at least one-half and as much as one-sixth in practical devices. In addition, a PCM storage unit can store and deliver heat at a very narrow and fixed range of temperature which can provide an improved efficiency in the performance of collectors, heat pumps and chillers. The problems being addressed are the development and testing of: PCM media with high and stable heats of transition, low cost and durable containment and heat exchange materials, and designs which provide a high proportion of the theoretical storage heat capacity over an acceptable number of cycles and efficiently and rapidly deliver the heat from storage to the load. Criteria for selecting phase-change-materials are based on experimental data such as melting point within suitable temperature ranges, large heat of fusion, congruent melting, degree of supercooling, stability, flammability, toxicity and expense, etc. Materials such as salt-hydrate, polyethylene wax and organic eutectic compounds which may satisfy these conditions are being surveyed and tested.

References: A-2, DK-3, FRG-23, J-14, SWED-3, SWED-4, US-70, US-72, US-73, US-75, US-76, US-78, US-79.

Chemical Storage

Chemical storage subsystems have not yet been applied to solar heating and cooling systems because of charging and discharging problems. Because of the high energy output of various chemical reactions, chemical storage systems will be very interesting. Different chemical reactions will have to be investigated in detail and technologies for simple and efficient charging and recovery will have to be found for use in thermal energy storage, including seasonal heat storage.

References: SWED-5.

Chemical Heat Pump

The heat of reaction of a reversible chemical reaction offers a very high heat storage density. By coupling two such reactions, which occur at two different and appropriate temperatures, with a common product of the two reactions, one can create a solar driven heat pump system which combines the capability for heating, cooling and high energy density storage in a single device. The major problems being addressed are the development of designs to provide high rates of heat transfer in a compact, economical device, the identification and testing of low-cost containment materials capable of providing long lifetime durability, and the design and testing of practical, economical and environmentally acceptable devices with adequate overall coefficients of performance.

References: DK-2, US-11, US-74, US-82.

State-of-Charge Meter

For the consumer and for the constructor of heating systems, it is important to know the state of charge. Since the state of charge cannot be evaluated by direct temperature measurement of the storage containment in PCM and Chemical Storage Systems, research on state of charge measurement has to be done. Thermal and electrical conductivity, density, refraction index and others will be considered as a basis for the measurement.

References: A-2.

Large-Scale, Long-Term Storage

Large scale storage systems permit singificant economies of scale for providing heating and cooling for large loads such as district heating, apartment houses and commercial buildings. They permit practical solar systems using annual storage in climates or locations where diurnal solar systems are significantly less cost-effective or even impossible. The chief generic problems are to achieve a very low cost per unit of heat capacity and low heat loss rate. The major technologies being explored are aquifers, direct heat storage in earth, and large, deep salt gradient ponds (which also serve as collector). Problems being addressed for these technologies include the crucial problem of seasonal storage, practical design of low cost installations, heat transfer and exchange methods, environmental effects, and for salt gradient ponds, maintaining the stability of the insulating salt gradient.

References: A-2, DK-5, FRG-20, SWED-7, SWED-8, SWED-9, US-24, US-38, US-60, US-62, US-71, US-84.

Retrofit Storage

The approach here is to develop low cost sensible heat storage devices which can be readily built, or assembled from pre-fabricated parts, on-site in existing buildings. Membrane lined water tank studies are one approach. Others include the development of modular, readily assembled tank components small and light enough to be moved into usable space in existing buildings. The alternate approach is to develop storage units of high volumetric storage density, such as PCM devices. Devices which are designed to be readily moved into and installed in an existing building, such as small PCM packages, micro-encapsulated PCM and site filled containers are especially applicable for this, and are being developed and tested.

References: US-48, US-72, US-73, US-81, US-87.

Solar Chiller Storage

Solar driven chillers have very special thermal energy storage requirements, namely: storage at a fixed and very narrow temperature range, hot side as well as cold side storage, and very high heat input in some operational modes. For a given solar driven chiller system a lot of options exist for where, how, when and what kind and size of storage to use in order to maximize system efficiency. A key system problem which is being addressed is to evaluate the storage trade-offs for each chiller system under development, and to determine the corresponding optimum storage design parameters. Specific storage systems which meet these requirements, as well as they are currently known, are also being developed.

References: US-59, US-72, US-73.

Solar Assisted Heat Pump (SAHP) Storage

By utilizing a consistent relatively high temperature input (10°C - 38°C) a SAHP can be designed to operate at a considerably higher COP than conventional heat pumps. However, this requires that the storage volume be large enough to insure that this heat source is never depleted. This requires a very low cost of storage per unit of heat stored. In addition, since the SAHP will usually require very rapid heat input and extraction rates from storage, heat exchange is a serious problem which is being addressed, particularly in systems utilizing direct storage of heat in earth, where drying out of the soil next to heat transfer surfaces can reduce heat exchange rates. Since the economics of SAHP generally require the use of a large area of low cost collectors, which operate at low temperatures, a high degree of temperature stratification in storage is desirable to increase collector efficiency. These problems are currently being studied.

References: US-13, US-24, US-45, US-84.

PCM Structural Materials

Salt-hydrate, polyethylene wax and organic eutectic compounds are prospective materials for the PCM. Problems being addressed are to select the structural materials for each PCM, such as polymers, films, aluminum alloys and ferrous alloys.

References: J-14.

Insulation

Optimum designs of the insulation for thermal energy storage depend on heat losses and cost. Studies are underway to specify the insulation for the operation conditions.

References: J-14.

Storage Cost / Unit Heat

The cost of heat storage per unit of storage capacity and per unit of heat delivery rate is a significant factor in itself. However, the evaluation of the actual storage cost can only be realistically conducted in the context of the entire system since storage performance affects system performance and therefore cost (eg., stratification, heat loss, compactness and retrofitability, etc.). This problem is being addressed by developing lower cost storage systems, by improving performance in the storage devices, by optimization of the storage unit size, and by possible adaptations to different heating systems and different temperatures.

References: A-2, A-4, A-6, A-9, A-16, A-19, A-22, J-14, J-15, US-15, US-70, US-78, US-81, US-86, US-87, US-88.

Storage Density

Comparing the heat content per unit volume, PCM storage can show much greater heat storage density per unit volume when allowable temperature swings are small. Problems are being addressed by increasing the storage density using PCM with large heat of fusion and optimum design of insulation.

References: J-14.

Safety / Durability

When using phase change materials such as salt-hydrates, steel containers have not been adequate to prevent internal corrosion. Experiments have been carried out with plastic capsules for the salt-hydrates.

References: J-14.

Computer Simulation

Heat transfer analyses in complex systems involving latent and sensible thermal energy storage may not be well established at present. Computer simulation on these problems is in progress.

References: A-1, A-2, A-3, A-4, A-6, A-9, A-11, A-15, A-16, A-17, A-19, A-22.

THERMAL ENERGY STORAGE SYSTEMS

ADDITIONAL PROJECTS

UNITED STATES

ANL, "Development of Uniform Flow Rockbeds"
P.I.: E. I. H. Lin and W. T. Sha - subcontracted to Solaron Corp, Denver, Co.

Laboratory scale and experimental measurements are to be made in support of the rockbed model development. Improved rockbeds are to be built, in accordance with designs evolved with the use of the model, and tested.

ANL, "Experimental Salt Gradient Pond"
P.I.: E. I. H. Lin and W. T. Sha

A 1/4 acre experimental salt gradient pond will be built at ANL, with internal funding, and used for experiments to support and validate the modeling work.

ANL, "Development of Stratified Water Tanks"
P.I.: R. L. Cole

Water tanks designed, with the guidance of COMMIX-SA simulations, to provide a maximum degree of temperature stratification, will be built and tested.

ANL, "Passive Cooling System Utilizing Winter Formation and Storage of Ice"
P.I.: A. J. Gorski

This system uses heat pipes to passively manufacture ice in an underground, insulated water tank whenever the ambient temperature is below freezing. A laboratory scale system was built and tested successfully. A full scale system has been built outdoors at ANL and is being tested.

(ANL = Argonne National Laboratory, Argonne, Illinois 60439)

NBS, Washington, D.C.

"Interface Between US Model Building Codes and Thermal Energy Storage Devices"
P.I.: Joseph Greenburg

An examination of the four major Model Building Codes and the characteristics of new advanced TES systems under development, chiefly PCM devices, to determine of any conflict exists which will interfere with the application of these new devices. Also recommended changes in the codes and/or the devices, to eliminate conflicts, will be developed.

HAI (Hittman Assoc.), Columbia, MD

"Determination of Design Characteristics of TES Units for Solar Driven Chillers"
P.I.: Larry Carter

Performance characteristics of solar driven chillers currently under development will be obtained and used to prepare design specifications for the TES units that will be needed in solar systems utilizing these chillers.

Unibersity of Nebraska, Lincoln, NE

"Three Dimensional Temperature Measurements in a 43,000 Gallon Rectangular Hot Water Storage Tank"
P.I.: Edward Anderson

The purpose of this project is to obtain temperature measurements for further validation of the ANL 3-Dimentional Water Tank Code COMMIX-SA, in rectangular coordinate systems and for larger scale tanks.

Monsanto Corp., and Dayton Lab., Dayton, OH

"Development of Cross-Linked High Density Polyethylene Pellets for Thermal Energy Storage"
P.I.: R. Bottom-Whittiker, and Ival Salyer

HDPE pellets with a fusion transition at 256 to 266°F and a heat of fusion of about 80 BTU/lb, without loss of pellet shape or integrity, were developed and tested through numerous freeze-melt cycles. A chemical method of cross-lining of the polyethylene was used. Radiation induced cross-linking is presently under investigation, with very promising results to date.

Colorado State Univ., Ft. Collins, CO

"Direct Contact Liquid-Liquid Heat Exchanger"
P.I.: S. Karaki

A prototype water tank, direct contact liquid-liquid heat exchanger has been under test in Solar Houses I and III, in both heating and cooling applications, to determine if this method will improve system performance significantly due to the elimination of the heat exchange ΔT. An organic liquid, immiscible with and heavier than water, circulates through the collector and is injected into the water storage tank at the top, and extracted at the bottom. Results are as yet inconclusive.

Colorado State Univ., Ft. Collins, CO

"Measurements of Soil Heat Transfer and Water Migration"
P.I.: Wynn Walker

Laboratory experiments to measure thermal conductivities of various soils as a function of moisture content, and of changes in moisture content with time, are underway. In addition, a field experiment using a plastic-liner-contained wet soil heat storage volume, surrounded by dry insulating soil, is underway.

George Washington Univ., Washington D.C.

"Storage of Heat in Moist Soil"
P.I.: S. W. Yuan

A system study was conducted of direct heat storage in soil for a large scale, annual heat storage solar heating system. Currently, a small scale field experiment is underway, testing the long term storage of heat in a plastic contained wet soil heat reservoir, surrounded by dry soil.

Auburn Univ., Auburn, AL

"Storage of Hot Water in Aquifers"
P.I.: F. J. Moby

An experimental project, using two wells, one for injection and the other for extraction, (reversed in discharge), for long term storage of hot water in an underground aquifer is underway. Two charge and discharge cycles of about 10 million gallons, with a 6 week storage period were successfully conducted. Heat recovery efficiency was 65% in the first cycle and over 70% in the 2nd. An improved design is being prepared.

L.B.L., Berkeley, CA

"Analysis of Aquifer Energy Storage"
P.I.: C. F. Tsang

A simulation code has been developed and analyses have been conducted of the storage of hot or cold water in aquifers using single and dual well systems.

Texas A & M Univ., College Sta., TX.

"Storage of Winter Chilled Water in Aquifers"
P.I.: D. L. Reddell

An experiment was conducted using a spray pond to chill water in the winter. This was then pumped through a well into an aquifer. The first experiment was not successful since the aquifer used was not confined and an exceptionally rainy spring caused loss of the chilled water. A new experiment is planned using a more suitable aquifer.

Rocket Research Corp., CA

"A Chemical Heat Pump Using the H_2SO_4/H_2O system"
P.I.: E. C. Clark

A prototype chemical heat pump, using two tanks, one for H_2SO_4/H_2O and the other for H_2O was successfully tested. A full scale system is currently being constructed. The main immediate application is for industrial process heat.

SOLAR COOLING

MAJOR TECHNICAL PROBLEMS IN SOLAR COOLING

TECHNICAL PROBLEM		AUSTRIA	BELGIUM	DENMARK	F.R.G.	GREECE	ITALY	JAPAN	NETHERLANDS	NEW ZEALAND	SPAIN	SWEDEN	SWITZERLAND	UNITED STATES
Rankine Machines	WORKING FLUIDS STABILITY													X
	HEAT EXCHANGER DEVELOPMENT													
	AUXILIARY DRIVE SYSTEMS													
	AIRCOOLED CONDENSERS													
	MANUFACTURING COSTS													X
	AUXILIARY ENERGY SOURCE													X
	TURBINE-COMPRESSOR MATCHING AND COUPLING													
	INTERNAL COMPONENT COOLING AND LUBRICATION							X						X
	TURBINE VS. ROTARY ENGINE TRADEOFFS							X						
	CLOSE INTERNAL TOLERANCES													
	OTHER													X
Absorption Machines	MANUFACTURING COSTS													X
	MODULAR SYSTEM DESIGN				X									X
	HEAT EXCHANGER OPTIMIZATION				X									
	CORROSION RESISTANCE	X												
	DEVELOPMENT OF NEW ABSORBENT/ REFRIGERANT PAIRS	X												X
	IMPROVING COP	X						X						X
	CRYSTALLIZATION							X						
	AIRCOOLED CONDENSERS													X
	MINIMIZING PARASITIC POWER													
	PHYSICAL SIZE REDUCTION							X						
	OTHER													

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DESCRIPTION SHEET - SOLAR COOLING

- RANKINE MACHINES -

Working Fluid Stability

Several Rankine engine cooling projects have progressed to the prototype hardware stage without detailed analysis of the thermal stability of the working fluids. Typical refrigerants used as working fluids are R-11, R-113 and FC-88. Individual contractors have conducted screening tests and sampling during prototype operations, but little research has been done using detailed dynamic tests. A project is being prepared to conduct the detailed tests required to evaluate these working fluids used in Rankine cooling systems on a long-term basis.

References: US-94, US-101, US-124.

Manufacturing Cost

One of the major considerations of solar cooling systems has been the cost effectiveness and period of pay-back of investment. Rankine cooling system hardware has been expensive to produce. The cost is expected to decline as the market increases, allowing for mass-production. The Rankine cooling contractors who have produced working hardware are being asked to estimate contraction costs based on varied production levels. They are also refining their designs to reduce manufacturing costs. The USA is conducting (through subcontractors) marketing assessment studies to aid manufacturers in setting cost goals for acceptance of solar cooling systems in the marketplace.

References: US-16, US-94, US-113.

Auxiliary Energy Source

The auxiliary energy sources considered for Rankine systems are applied in two ways: 1) auxiliary heat applied to the working fluid and 2) electric motor drive to back up the turbine. Overall COPs and costs are being compared between the different concepts. After the hardware prototypes have been proven, a closer analysis of the back-up can be made. Computer modeling and comparative assessment programs are being developed to assist in this analysis.

References: US-16, US-59, US-69, US-94, US-109, US-113.

Internal Component Cooling and Lubrication

There has been a history of overheating of bearings and seals in several of the Rankine cooling systems developed to the prototype stage. Heat shields, lubrication passages and coolant pumping are being redesigned in the troubled systems to help solve these problems. Leakage of oil and/or heat media may occur in the expander and compressor of the open type Rankine cycle engine. This might cause the difficulty in maintenance and control of the subsystem.

References: J-16, US-59, US-69, US-109.

Turbine vs. Rotary Engine Tradeoffs

Since the control method of a solar Rankine cycle is not established yet, the control system may become rather complicated. It is nesessary to increase the reliability of the system.

References: J-16.

Others - Refrigerant Pumping

Refrigerant pumping is required in the Rankine Cooling Units. All manufacturers are developing their own pumps or designing systems using off-the-shelf pumps. There has been considerable time and money spent on this component, and not all of the effort has been fruitful. Manufacturers are being asked to discuss this component design with each other and share ideas to develop more efficient and reliable pumping systems.

References: US-16, US-59, US-94.

Manufacturing Costs

Solar absorption cooling units are expensive to produce and system costs are high due to the cost of supporting components required; e.g., collectors, storage, pumps, towers, etc. Unit costs are being reduced by redesigning hardware and developing limited mass production processes. As the market increases a more efficient production plant can be developed. Supporting components are likewise being redesigned to lower the costs to the system. More efficient collectors are under development to reduce the quantity of collectors required for system operation. Computer models are being developed for comparative assessment of solar cooling systems.

References: US-91, US-95.

Modular System Design

Modular system design is being considered to 1) reduce field labor, 2) improve product reliability, 3) reduce mechanical equipment space and 4) simplify solar cooling design. Manufacturers are developing 2nd and 3rd generations of their prototypes to accomplish the objectives of Modular System Design.

References: US-91, US-95.

Development of New Absorbents

Lithium bromide/water and ammonia/water absorption units have been proven in the HVAC and other cooling markets. With the application of solar heat to absorption systems, lower generator temperatures and intermittant heat sources are often encountered. Research has been underway to identify alternative absorbent/refrigerant pairs through literature searches, laboratory testing and computer modeling. To date, very little new useful information has resulted from these efforts.

References: A-12, US-95, US-97, US-99, US-101, US-124.

Improving COP

Single effect absorption machines have commonly produced COPs of about 0.6. By increasing generator temperatures and especially heat exchanger effectiveness, COPs of over 0.7 are being achieved. Double-effect cycles are now also being considered; these should have COPs of over 0.9. Research to improve the COP of absorption machines is being done at the manufacturing level as well as in system simulations using advanced computer modeling programs. A large scale single and double effect absorption liquid chiller operated in single effect of high efficiency by auxiliary heat source has been manufactured and tested. A control system to establich effective use of auxiliary heat during variable insolation is being investigated.

References: A-12, US-48, US-91, US-92, US-95, US-99, US-101, US-116, US-124.

Air-Cooled Condensers

Water cooled absorbers and condensers have been common in large absorption cooling systems. There is the ever present problem of water quality; water treatment is necessary to minimize scaling and clogging of system components. Much of the solar absorption development has been directed at the 2-25 ton market. To minimize the problems associated with water cooled units, air cooled units are being developed for residential applications. The basic disadvantages of air-cooled units are the increase in possible electrical power needed for the cooling fans, and the degraded system performance as a result of higher absorber and condenser temperatures. Prototypes are being designed, operated and redesigned to minimize these disadvantages. Computer analysis is being used to optimize the components.

References: US-95, US-97, US-99, US-101.

Physical Size Reduction

The improvement of heat transfer coefficients in a low collecting temperature generator is useful to reduce the physical size of an absorption machine, which is an impediment to improving the solar percent. A film heat transfer system is under investigation to improve performance.

References: -----

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OTHER SUBSTANTIAL COMPONENTS

In addition to R & D on the major solar heating and cooling components such as solar collectors, thermal energy storage and air conditioning units, participating countries have investigated many other components such as control systems, heat exchangers, heat pumps, passive systems and others. Four topics have been suggested as major technical problems in other substantial units: Solar Heat Collecting System with Phase Changes of Working Fluids, Plastic Convectors, Heat Pumps, and Lay-out of Solar Systems.

Appendix 3

COMPREHENSIVE LIST OF SOLAR ENERGY R & D PROJECTS REPORTS

FOR SOLAR HEATING AND COOLING COMPONENTS

Subtask A, TASK II IEA

Brief Note

This Comprehensive List is prepared from the SURVEY AND REVIEW ON COMPONENTS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS, Compilations from Parts I, II, III and IV, which have been compiled by the Operating Agent, based on the reports sent from the Task II Participants. The list covers all the names of R & D project title included in these compilations. The code numbers might be self-explanatory and abbreviated symbols indicate the following meanings:

A - IC - 1 — Project number

- A: Abbreviated name of country
- I: Compilation number (I, II, III and IV)
- C: Component
  - C: solar collector
  - S: thermal energy storage
  - A: air conditiong unit
  - O: other substantial component

SOLAR COLLECTORS

AUSTRIA

A-IIC-1	MULTI-COMPONENT SYSTEM FOR DOMESTIC WATER HEATING AND SPACE HEATING AT THE "INSTITUT FÜR MOLEKULAR-BIOLOGIE" OF THE "ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN" IN SALZBURG
A-IIC-2	DEVELOPMENT OF A LOW TEMPERATURE SOLAR COLLECTOR
A-IIC-3	DEVELOPMENT OF A MEASUREMENT AND CONTROL SYSTEM FOR SOLAR ENERGY SYSTEMS
A-IIC-4	DOMESTIC WATER HEATING AND SPACE HEATING WITH SOLAR ENERGY
A-IIC-5	SOLAR ENERGY TEST STATIONS IN AUSTRIA
A-IIC-6	DEVELOPMENT OF A PROTOTYPE OF A SEMI-CONCENTRATING COLLECTORS
A-IIC-7	COMPACT SOLAR SYSTEM FOR DOMESTIC WATER HEATING
A-IIC-8	INSTALLATION OF A SOLAR ENERGY STATION IN MALTA
A-IIIC-1	MULTI-COMPONENT SYSTEM FOR DOMESTIC WATER HEATING AND SPACE HEATING AT THE "INSTITUT FÜR MOLEKULAR-BIOLOGIE" OF THE "ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN" IN SALZBURG
A-IIIC-2	DEVELOPMENT OF A LOW TEMPERATURE SOLAR COLLECTOR
A-IIIC-3	DEVELOPMENT OF A MEASUREMENT AND CONTROL SYSTEM FOR SOLAR ENERGY SYSTEMS
A-IIIC-4	DOMESTIC WATER HEATING AND SPACE HEATING WITH SOLAR ENERGY
A-IIIC-5	SOLAR ENERGY TEST STATIONS IN AUSTRIA
A-IIIC-6	DEVELOPMENT OF A PROTOTYPE OF A SEMI-CONCENTRATING COLLECTOR
A-IIIC-7	COMPACT SOLAR SYSTEM FOR DOMESTIC WATER HEATING
A-IIIC-8	INSTALLATION OF A SOLAR ENERGY STATION IN MALTA
A-IIIC-10	SOLAR ENERGY TEST STATION IN BLUNDENZ, VORARLBERG
A-IIIC-12	SYSTEM FOR DOMESTIC WATER HEATING WITHOUT AUXILIARY HEATING AT THE "BIOLOGISCHE VERSUCHSANSTALT" AT ILLMITY/NEUSIEDLERSEE
A-IIIC-13	UTILIZATION OF SOLAR SYSTEMS AND HEAT PUMPS IN THE INSTITUTE OF LIMNOLOGY

A-IIIC-14	SOLAR ENERGY TEST STATION AT SISTRANS
A-IIIC-15	CONTINUATION OF MEASUREMENTS AT THE SOLAR ENERGY TEST STATION OF THE INSTITUTE OF MOLECULAR BIOLOGY OF THE AUSTRIAN ACADEMY OF SCIENCES
A-IIIC-17	DEVELOPMENT OF SELECTIVE ALUMINUM ABSORBERS
A-IIIC-18	CONSTRUCTION AND OPERATION OF A SOLAR COLLECTOR TEST STATION
A-IIIC-19	CONSTRUCTION OF A DOMESTIC WATER HEATING SYSTEM
A-IIIC-20	OUTDOOR SOLAR COLLECTOR TESTING
A-IVC-1	MULTI-COMPONENT SYSTEM FOR DOMESTIC WATER HEATING AND SPACE HEATING AT THE "INST. F. MOLEKULAR-BIOLOGIE" OF THE "ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN" IN SALZBURG
A-IVC-2	SOLAR ENERGY TEST STATION IN AUSTRIA
A-IVC-3	INSTALLATION OF A SOLAR ENERGY STATION IN MALTA
A-IVC-4	SOLAR ENERGY TEST STATION AT BLUDENZ, VORARLBERG
A-IVC-5	SYSTEM FOR DOMESTIC WATER HEATING WITHOUT AUXILIARY HEATING AT THE "BIOLOGISCHE VERSUCHSANSTALT" AT ILLMITY/NEUSIEDLERSEE
A-IVC-6	SOLAR ENERGY TEST STATION IN SISTRANS
A-IVC-7	DEVELOPMENT OF SELECTIVE ALUMINIUM ABSORBERS
A-IVC-8	CONSTRUCTION AND OPERATION OF SOLAR COLLECTOR TEST STATION
A-IVC-9	CONSTRUCTION OF A DOMESTIC WATER HEATING SYSTEM IN OUAGADOUGOU
A-IVC-10	OUTDOOR COLLECTOR TESTING
A-IVC-11	SOLAR HOUSE VIENNA-FLÖTZERSTEIG (AUSTRIAN SOLAR HOUSE)
A-IVC-12	SOLAR-POWERED ABSORPTION COOLING SYSTEM
A-IVC-13	DEVELOPMENT AND TEST OF A PHOTOVOLTAIC THERMAL HYBRID-COLLECTOR
A-IVC-14	DEVELOPMENT OF A LOW TEMPERATURE SOLAR COLLECTOR
A-IVC-15	DEVELOPMENT OF A MEASUREMENT AND CONTROL SYSTEM FOR SOLAR ENERGY SYSTEMS

A-IVC-16	DOMESTIC WATER HEATING AND SPACE HEATING WITH SOLAR ENERGY
A-IVC-17	DEVELOPMENT OF A PROTOTYPE OF A SEMI-CONCENTRATING COLLECTOR
A-IVC-18	COMPACT SOLAR SYSTEM FOR DOMESTIC WATER HEATING
A-IVC-22	DEVELOPMENT AND TESTING OF COMPONENTS FOR SOLAR HEATING SYSTEM
A-IVC-23	DWELLING WITH ALL ELECTRICAL ENERGY SUPPLY AND EXTREMELY LOW SPECIFIC ENERGY DEMAND

BELGIUM

B-IC-1	FLAT PLATE COLLECTOR DEVELOPMEMT

DENMARK

D-IC-1	DEVELOPMENT AND TEST OF COMPONENTS FOR SOLAR HEATING SYSTEMS
D-IC-2	EVALUATION OF SOLAR COLLECTORS
D-IVC-1	FLOATING SOLAR COLLECTORS
D-IVC-4	LOFT COLLECTOR WITH SLAB ON GRADE-HEAT STORAGE

FEDERAL REPUBLIC OF GERMANY

FRG-IC-1	DEVELOPMENT OF LARGE-SCALE INDUSTRIAL SOLAR HEATING SYSTEMS
FRG-IC-2	SERVICE WATER HEATING BY SOLAR ENERGY
FRG-IC-3	DEVELOPMENT OF HIGH TEMPERATURE RESISTANCE SOLAR ABSORBER AREAS
FRG-IC-4	HOT WATER PREPARATION WITH SOLAR ENERGY USING SYNTHETIC SOLAR COLLECTORS
FRG-IC-5	DEVELOPMENT OF AN INDUSTRIAL PROCESS FOR PRODUCTION OF In_2O_3 COATINGS FOR IMPROVEMENT OF THE κ VALUE OF INSULATING GLASS PANES
FRG-IC-6	FLAT-PLATE SOLAR ENERGY COLLECTOR

FRG-IC-7	SOLAR COLLECTORS FOR FLAT ROOFS
FRG-IC-8	PRODUCTION OF A SOLAR COLLECTOR INSTALLATION FOR HEATING AN OPENAIR SWIMMING POOL
FRG-IC-9	HEAT PIPE SOLAR ABSORBER
FRG-IC-10	HOT WATER PREPARATION WITH SOLAR ENERGY
FRG-IC-11	DEVELOPMENT OF SELECTIVE SOLAR ABSORBERS ON THE ALUMINUM ROLL BOND HEAT EXCHANGER BASIS
FRG-IC-12	DEVELOPMENT OF LARGE-SCALE INDUSTRIAL PRODUCTION METHODS FOR COMPONENTS OF SOLAR HEATING SYSTEM
FRG-IC-13	DEVELOPMENT OF ECONOMICAL SOLAR HEATING SYSTEMS WITH REASONABLY PRICED COLLECTORS
FRG-IC-14	DEVELOPMENT OF LARGE-SCALE INDUSTRIAL PRODUCTION METHODS FOR COMPONENTS OF SOLAR HEATING SYSTEM
FRG-IC-15	DEVELOPMENT OF LARGE-SCALE INDUSTRIAL PRODUCTION METHODS FOR COMPONENTS OF SOLAR HEATING SYSTEM
FRG-IC-16	DEVELOPMENT OF LARGE-SCALE INDUSTRIAL PRODUCTION METHODS FOR COMPONENTS OF SOLAR HEATING SYSTEM
FRG-IC-17	RATIONAL USE OF ENERGY AND UTILIZATION OF SOLAR ENERGY IN BUILDING
FRG-IC-18	MODULAR SOLAR HOUSE HEATING SYSTEM - PHASE 1
FRG-IC-19	MODULAR SOLAR DOMESTIC HEATING SYSTEM - PHASE 2
FRG-IC-20	SOLAR HEATING SYSTEM FOR UNTERENSINGEN GYMNASIUM (HIGH SCHOOL)
FRG-IVC-1	FLAT PLATE SOLAR ENERGY COLLECTORS
FRG-IVC-2	DEVELOPMENT OF INDUSTRIAL SCALE MANUFACTURING PROCESS FOR SOLAR HEATING SYSTEM COMPONENTS, ESPECIALLY SOLAR COLLECTORS-PROJECT MANAGEMENT
FRG-IVC-4	DEVELOPMENT OF LARGE SCALE PRODUCTION METHODS FOR COMPONENTS OF SOLAR ENERGY COLLECTION - 3 SUBPROGRAM OF METALLGESELLSCHAFT
FRG-IVC-5	DEVELOPMENT OF SOLAR SELECTIVE ABSORBER COATINGS FOR ALUMINIUM ROLL BOND HEAT EXCHANGERS
FRG-IVC-6	DEVELOPMENT OF ECONOMIC SOLAR HEATING SYSTEMS USING INEXPENSIVE COLLECTORS
FRG-IVC-7	TESTING A MEASURING STATION FOR THE EVALUATION OF SOLAR COLLECTORS

FRG-IVC-8	SOLAR COLLECTORS FOR FLAT ROOF
FRG-IVC-9	IMPROVEMENT OF THERMAL EFFICIENCY OF FLAT PLATE SOLAR COLLECTORS
FRG-IVC-10	BBC-CONTRIBUTION TO THE SOLAR COLLECTOR TEST PROGRAM, IEA-SUBPROJECT III
FRG-IVC-11	ROLL-BONDED HEAT PIPE PANELS
FRG-IVC-12	FLAT PLATE HEAT PIPE COLLECTORS MADE BY ROLL BONDING
FRG-IVC-13	DEVELOPMENT AND OPTIMIZATION OF HERMETICALLY SEALED FLAT PLATE COLLECTORS WITH GAS FILLING/SELECTIVE ABSORBING THIN FILM
FRG-IVC-15	DEVELOPMENT OF DIRECT EVAPORATING COLLECTORS FOR SMALL SOLAR POWERED PLANTS AND SMALL SOLAR COOLING FACILITIES
FRG-IVC-16	INVESTIGATION OF LOSS OF LIGHT TRANSMISSION OF SOLAR COLLECTORS DUE TO DIRT
FRG-IVC-17	DEVELOPMENT OF A FLAT SOLAR ENERGY COLLECTOR FOR LOW TEMPERATURE HEATING USING STAINLESS STEEL PLATE-BARS AND POLYURETHANE
FRG-IVC-18	DEVELOPMENT OF HIGH TEMPERATURE RESISTANT SOLAR ABSORBER COATING
FRG-IVC-19	ENERGY CONSERVATION AND THE USE OF SOLAR ENERGY IN BUILDINGS
FRG-IVC-21	DOMESTIC WATER HEATING BY SOLAR ENERGY
FRG-IVC-22	TECHNICAL AND SCIENTIFIC INVESTIGATIONS CARRIED OUT AT THE SOLAR ENERGY EXPERIMENTAL FACILITY IN WIEHL/FRG
FRG-IVC-24	MEASURING PROGRAM FOR HOT WATER SUPPLY IN PRE-FABRICATED HOUSES USING SOLAR ENERGY
FRG-IVC-25	SOLAR ENERGY PLANT TO SUPPLEMENT A CONVENTIONAL HEATING SYSTEM
FRG-IVC-26	SOLAR EQUIPMENT SYSTEM-PACKAGE FOR OLD AND NEW BUILDINGS TO PROVIDE WARM WATER AND PARTIAL HEATING
FRG-IVC-27	CREATION OF AN ECONOMICAL SOLAR HEATING SYSTEM FOR A NEW AND AN EXISTING RESIDENTIAL HOME COMPLEX CONSTRUCTION-HEGBACHER INSTALLATIONS
FRG-IVC-28	HEAT-PIPE SOLAR ABSORBER
FRG-IVC-29	FLAT PLATE COLLECTORS AS FACADE ELEMENTS FOR WATER PREHEATING AND HEAT INSULATION

FRG-IVC-30	SOLAR HOUSE FREIBURG
FRG-IVC-32	TECHNICAL USE OF SOLAR ENERGY

GREECE

G-IVC-1	HEAT PIPE

ITALY

I-IIC-1	EFFECT OF PHYSICAL AND OPERATIVE PARAMETERS ON SOLAR COLLECTORS HEAT TRANSFER COEFFICIENTS
I-IIC-2	DESIGN OF NON-FOCUSING COLLECTORS; TEMPERATURE RANGE: 90 - 130°C
I-IIC-3	RADIATIVE EXCHANGE COMPONENTS
I-IIC-4	EVALUATION AND TEST PROCEDURES FOR SOLAR COLLECTORS
I-IIC-5	FLAT-PLATE SOLAR ENERGY COLLECTOR
I-IVC-4	SOLAR PLASTIC PLATE COLLECTOR
I-IVC-5	RUBBER PLATE SOLAR COLLECTOR
I-IVC-6	LONG TERM PERFORMANCES OF SOLAR SYSTEMS

JAPAN

J-IC-1	RESEARCH AND DEVELOPMENT OF SOLAR ENERGY SPACE HEATING, COOLING AND HOT WATER SUPPLY SYSTEM
J-IC-2	GLASS HONEYCOMB COLLECTOR
J-IC-3	RESEARCH AND DEVELOPMENT OF PLASTIC MATERIALS FOR SOLAR COLLECTOR
J-IC-4	RESEARCH AND DEVELOPMENT OF SOLAR COLLECTORS FOR SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEMS IN MULTI-FAMILY RESIDENCE
J-IC-5	DEVELOPMENT OF TUBULAR EVACUATED SOLAR COLLECTOR
J-IIC-1	GLASS HONEYCOMB COLLECTOR
J-IIC-2	SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM FOR LARGE BUILDING

J-IIC-3	DEVELOPMENT OF TUBULAR EVACUATED SOLAR COLLECTOR
J-IIC-4	R & D OF SOLAR COLLECTOR, SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM IN MULTI-FAMILY RESIDENCE
J-IVC-1	DEVELOPMENT OF TUBULAR EVACUATED SOLAR COLLECTOR
J-IVC-3	SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM FOR LARGE BUILDING
J-IVC-6	RESEARCH AND DEVELOPMENT OF SOLAR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM (R & D OF METALLIC MATERIALS)
J-IVC-7	R & D OF COLLECTOR OF GLASS BASE
J-IVC-8	DEVELOPMENT OF SOLAR COLLECTORS AND THEIR COMPONENTS MAINLY CONSISTING OF PLASTIC MATERIALS
J-IVC-9	RESEARCH ON SOLAR COLLECTOR MATERIALS
J-IVC-13	R & D OF SOLAR COLLECTOR FOR HEATING, COOLING AND HOT WATER SUPPLY SYSTEM IN A MULTI-FAMILY RESIDENCE

NETHERLANDS

NL-IC-1	NATURAL CONVECTION IN FLAT PLATE SOLAR COLLECTORS
NL-IC-2	SOLAR WATER HEATING SYSTEMS
NL-IC-3	SPECTRAL SELECTIVE LAYERS FOR PHOTOTHERMAL CONVERSION OF SOLAR ENERGY
NL-IC-4	FLAT PLATE SOLAR COLLECTOR WITH HALOGENATED CARBONS AS THE HEAT TRANSFER MEDIUM
NL-IC-5	HEAT TRANSFER IN FINNED AIR COLLECTOR
NL-IC-6	HEAT PIPE COLLECTOR FOR LOW TEMPERATURES
NL-IC-7	INVESTIGATION OF THE PHYSICAL PROPERTIES OF SPECTRAL SELECTIVE LAYERS
NL-IC-8	DEVELOPMENT OF DURABLE SELECTIVE COATINGS OF HIGH PERFORMANCE COLLECTORS
NL-IC-9	SOLAR BOILERS FOR DOMESTIC HOT WATER SUPPLY AND SOLAR HEATING INSTALLATIONS FOR SWIMMING POOLS
NL-IC-10	PRODUCTION AND DEVELOPMENT OF FLAT PLATE ALUMINUM SOLAR COLLECTOR

NL-IC-11	DEVELOPMENT OF AN INTEGRATED SOLAR BOILER SYSTEM
NL-IC-12	RESEARCH AND DEVELOPMENT ON FLAT PLATE - AND CONCENTRATING SOLAR COLLECTORS
NL-IC-13	RESEARCH AND DEVELOPMENT ON SOLAR-THERMAL COMPONENTS
NL-IVC-1	NATIONAL PROGRAMME ON SOLAR ENERGY RESEARCH
NL-IVC-2	APPLICATION OF SOLAR ENERGY FOR CLIMATE CONTROL, IF NECESSARY COMBINED WITH HEAT PUMP AND/OR HEAT RECOVERY SYSTEM
NL-IVC-6	SUPPRESSION OF NATURAL CONVECTION IN THERMAL SOLAR COLLECTOR
NL-IVC-7	HEAT PIPE COLLECTOR FOR LOW TEMPERATURES AND INVESTIGATION OF THE PHYSICAL PROPERTIES OF SPECTRAL SELECTIVE LAYERS
NL-IVC-8	SPECTRAL SELECTIVE LAYERS FOR PHOTOTHERMAL CONVERSION OF SOLAR ENERGY

NEW ZEALAND

NZ-IIC-1	DEVELOP LOW COST SOLAR COLLECTOR
NZ-IIC-2	PRECOMMERCIAL DEVELOPMENT OF DSIR SOLAR WATER HEATING PANELS
NZ-IIC-3	DEVELOP PACKAGED SOLAR WATER HEATER
NZ-IIC-4	DEVELOP SOLAR WATER HEATER FOR DOMESTIC USE
NZ-IIC-5	DEVELOP ECONOMIC DOMESTIC SOLAR WATER HEATER
NZ-IIC-7	INTEGRATED SOLAR WATER HEATING SYSTEM

SWEDEN

SWED-IC-1	RESEARCH AND DEVELOPMENT ON SEMICONCENTRATING COLLECTORS FOR APPLICATIONS IN EXISTING BUILDINGS
SWED-IC-2	AMPLITERM
SWED-IC-3	SOLAR ENERGY AND BUILDINGS - THERMAL EMISSIVITY OF SURFACES
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FEDERAL REPUBLIC
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US-IVO-110 NOVEL CONTROL STRATEGIES THAT REDUCE ELECTRIC UTILITY PEAKS

US-IVO-111 SELF CONTROLLING, SELF PUMPING HEAT CIRCULATION SYSTEM STUDY

US-IVO-112 CONTINUED EXPOSURE TEST AND EVALUATION OF REFLECTIVE MATERIALS FOR SOLAR APPLICATIONS

US-IVO-113 DESIGN AND DEVELOPMENT OF SINGLE FAMILY, MULTI-FAMILY, LIGHT COMMERCIAL SIZE SOLAR HEATING, COOLING AND HOT WATER SYSTEMS

US-IVO-114 MEASUREMENT OF CIRCUMSOLAR RADIATION

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US-IVO-116 EXPERIMENTAL AND THEORETICAL EVALUATION OF CONTROL STRATEGIES FOR SOLAR HEATING AND COOLING

US-IVO-117 EVALUATION OF ADVANCED CONTROLS FOR BUILDING ENERGY CONSERVATION

US-IVO-118 PROGRAMMABLE SOLAR CONTROLLER

US-IVO-119 MODEL VALIDATION STUDIES OF SOLAR SYSTEMS

US-IVO-120 RESEARCH IN ACTIVE FILMS FOR ENERGY MODULATION IN BUILDINGS AND DEVELOPMENT OF PASSIVE COMPONENTS USING ADVANCED MATERIALS

US-IVO-121 HIGH PERFORMANCE APERTURES FOR PASSIVE SOLAR HEATING

US-IVO-122 COST EFFECTIVE SOLAR COLLECTORS USING HEAT PIPES

US-IVO-123 SURVEY AND EVALUATION OF AVAILABLE THERMAL INSULATION MATERIALS FOR USE ON SOLAR HEATING AND COOLING SYSTEMS

US-IVO-125 OPTIMAL CONTROL STUDIES

US-IVO-126 PASSIVE SOLAR ANALYSIS AND DESIGN

US-IVO-127 ASSESSMENT OF THE NEED FOR NEW SOLAR CONTROLLERS

Appendix 4

LIST OF CONTACT PERSONS - TASK II

"COORDINATION OF RESEARCH AND DEVELOPMENT ON SOLAR HEATING AND COOLING COMPONENTS"

Country	Institution	Contact Person	Telephone & Telex
AUSTRIA	Austria Solar and Space Agency (ASSA) Garnisongasse 7 A-1090 Vienna	Prof. G. Faninger	(0222) 1438177 Tlx: 76560 assa a
BELGIUM	Faculté polytechnique de Mons 31 Boulevard Dolez 7000 Mons	Prof. André Pilatte	(065) 338191
DENMARK	Thermal Insulation Laboratory Technical University of Denmark Building 118, DK-2800 Lyngby	Mr. Ove Jorgensen	(02) 883511 Tlx: 375 29 DTH
FEDERAL REPUBLIC OF GERMANY	Kernforschungsanlage Jülich GmbH Programmgruppe Systemforschung und Technologische Entwicklung Postfach 1913, D-5170 Jülich	Dr. Michael Meliss	(02461) 613001 Tlx: 0833556 kfa d
GREECE	Nuclear Research Center Democritos, Agis Puraskevi Attikis	Prof. A. Spyridenos	651 31 11-119
ITALY	Istituto di Fisica-Tecnica Facolta D'Ingegneria Piazzale Tecchio Universita di Napoli Napoli	Prof. Fabio Fittipaldi	081-611922
JAPAN	Sun Shine Project Headquarters Agency of Industrial Science and Technology MITI 1-3-1 Kasumigaseki, Chiyoda-ku Tokyo	Mr. H. Hayashi	(03) 434-5647 Tlx: 22916 EIDMITI J

Country	Institution	Contact Person	Telephone & Telex
NETHERLANDS	Stichting Energieondersock Centrum Netherland Westerduinweg 3 Petten (NH)	Mr. W. F. Heshuysen	02246-6262 Tlx: 57211
NEW ZEALAND	Physics and Engineering Laboratory Dept. of Scientific and Industrial Research Private Bag Lower Hutt	Mr. R. F. Benseman	66919 Wellington Tlx: PHYSICS NZ 3814
SPAIN	Instituto Nacional de Téchnica Aeroespacial Torrejon de Ardoz Madrid	Dr. Ing. L. R. Nadal	---------
SWEDEN	AB Svenska Fläktfabriken S-551 84 Jönköping	Mr. Ove Strindehag	036-118500 Tlx: 70100
SWITZERLAND	Ecole polytechnique fédérale de Lausanne Dept. de physique 33 Ave. de Cour CH-1007 Lausanne	Dr. André Faist	021-264621 Tlx: 24478 EPFVDCH
UNITED STATES OF AMERICA	U.S. Department of Energy Office of Conservation and Solar Energy 1000 Independece Ave. S.W. Washington D.C. 20585	Dr. F. H. Morse	(202) 252-8084 Tlx: 710 8220176 DOE FRSTL WSH

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