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Solar Energy and Energy Conversion Laboratory 1954

UNIVERSITY OF FLORIDA

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The Solar Energy and Energy Conversion Laboratory

with the Erich A. Farber Archives

The SEECL was originally located at the Gianesville Regional Airport. Early experimental devices stood on the pad near the WW II bunker (early 1950s).

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Introduction

The Solar Energy and Energy Conversion Laboratory (SEECL) was established in 1954 by Erich A. Farber, then professor of Mechanical Engineering at the University of Florida. The SEECL became one of the largest and most complete solar energy laboratories in the world. It developed techniques and devices to convert solar energy (our largest energy source) to all forms of energy which we use in our daily life, including water heating, swimming pool heating, distillation, detoxification, cooking, space heating and air-conditioning, refrigeration, electricity, and transportation.

Farber, who served as the SEECL director for 37 years, is now the Past Director of the SEECL and Distinguished Service Professor Emeritus of Mechanical Engineering at the University of Florida. The laboratory has pioneered research in many areas of solar energy, conversion, energy conservation, and space power systems. Many of its developments are now used world-wide.

Parabolic dish at the SEECL, now located at the Energy Research and Education Park, University of Florida (2002).

The Laboratory continues to study the basic characteristics of solar energy, and the processes needed to convert it to useful forms, and then designs equipment to match these characteristics using the best materials.

Because of the work at the Solar Lab and the Solar House, Dr. Farber was inducted into the Solar Hall of Fame in 1976. The Solar Hall of Fame aims to promote excellence by honoring outstanding contributors in the field of solar energy utilization. The Hall of Fame was established by Congressman John R. Foley during the Bicentennial in 1976. In 1986 the SEECL received both the State of Florida and the National Awards for “Energy Innovation.” In 1992 the University and State of Florida established the Dr. Erich A. Farber Archives in the Old Solar House. In 1999 the “Solar Hall of Fame” was made part of the Archives and the Laboratory.

A father and daughter view a solar still at an alternative and renewable energy fair, College of Engineering, University of Florida, in 1960. In the background stands the football stadium.

The Benefits of Solar Energy

* Solar is a renewable, clean energy resource in abundant supply;
* Devices powered by solar energy can save money, help conserve our depletable fossil fuel resources, and reduce our dependence on imported oil;
* Solar photochemical processes can clean and disinfect water and indoor air, as well as produce hydrogen;
* Unlike petroleum, the price and availability of solar energy are not subject to manipulation by any nation or cartel;
* Solar applications help create jobs;
* Solar energy is a decentralized power source that is very flexible, ranging from heating water to generating electricity.

"The Solar Capital of the World"

Prof. Erich Farber (r) making adjustments to the ASHRAE/UF calorimeter, at the early SEECL experimental pad, at the Gainesville Regional Airport (mid 1950s).

In the 1970s research generated by the Solar Energy Laboratory made Gainesville the "Solar Capital of the World", and Dr. Farber the "Sunshine Superman" (*Mother Earth News, "The Handbook of Homemade Power," 1974*). Gainesville's solar features included one of the few solar powered coin laundries in the world, and the world's largest solar heated and cooled building, the Gainesville Regional Airport.

Uses of solar energy were being widely implemented at that time, with applications at the University of Florida's credit union and its teaching hospital, campus married student housing, apartment complexes, a photolab, homes, clinics, swimming pools, and even a Ronald McDonald House. Additionally, Farber was instrumental in implementing installation of solar hot water heaters on low-cost housing for the city of Gainesville, with the water heaters being built by Florida State prisoners.

National media covered the Solar Lab for many years, following their ground - breaking research. Through Farber's lectures and demonstrations, he was able to highlight the great potential of solar energy use throughout the US and abroad. His practical approach toward implementing solar systems was widely respected by professionals, governmental officials, and laypeople.

The 744 flat plate solar panels provided heating, cooling, and hot water for the Gainesville Regional Airport (early 1970s).

Gainesville's solar airport was the largest commercial building in the world to hitch a free ride from the Earth's own star. The $1.6M project saw 744 solar panels marching row-after-slanting-row across the roof of the terminal, covering 16,000 square feet -- almost a third of an acre. The solar panels provided heating and cooling for the building, as well as all hot water needs. Two 30,000 gallon water storage tanks were buried beneath the parking lot.

The solar system used an absorption air conditioner, whose primary source of heat was the solar subsystem. The solar subsystem of the airport provided 75% of the energy required to heat, cool and provide service hot water on a yearly basis. The roof-mounted flat plate collectors provided 180° - 190°F water to the chiller. Operating on water at this temperature range, the absorption air conditioner was rated at 120 tons.

Early SEECL student demonstrates solar cooking on a collapsible umbrella cooker. The concentrated solar radiation heated the teapot water quite effectively -- and the collapsing umbrella made storage easy (mid 1950s).

"Gainesville is called the solar capital of the world because it has more large-scale solar installations than any other city in the world," said Erich A. Farber in 1983. Farber was dubbed "the pioneer of solar energy" at that time. Farber has spent his life trying to get people to understand that we can use our energy from the sun to provide for most of our energy needs. He made working models of everything from solar ice makers to solar generators to solar irrigation pumps, demonstrating their use in lectures.

Still vigorous and enthusiastic today, Farber muses "The purpose of the Solar Lab is to provide permanent solutions to our energy problems, and ways of learning to live off an 'energy income' (solar energy) rather than our 'energy savings' (fossil fuels)."

Research at the SEECL has included hands-on work into solar energy, solar-powered engines, measurement of solar radiation and the characteristics of this resource. Other ground-breaking work has included heat transfer, properties of materials, solar distillation, crop drying and solar ovens, solar furnaces, solar electric generators, and solar Stirling Engines.

It's been the transfer of the technology developed at the SEECL, which focused Farber's work. "Through research we have to find better methods of converting solar energy, our largest and most permanent energy income, into the forms of energy that we use in our daily lives. This will free our fossil fuels (oil, coal, gas) for medicines, preservatives, pesticides, fertilizers and plastics, which are just as vital to our survival," Farber said in 1977.

Prof. Erich Farber working on hot water panels at the early SEECL. Hands-on research remains a hallmark of the laboratory (mid 1950s).

Training in Alternative Energy Technologies (TAET) Program

In the late 1970s, some $2M was awarded to the SEECL by the US State Department's Agency for International Development (US AID) to train professionals and ranking government officials from developing nations in alternative energy sources. The Training in Alternative Energy Technologies (TAET) program trained professionals from fifty Third World nations in a broad range of alternative energy technologies until the project ended in 1984.

Prof. Erich Farber (r) discusses a stationary high temperature collector which produced steam to drive an engine, at the early SEECL (1950s).

"We trained engineers and technicians, policy makers and heads of laboratories. These were all people who could make a difference in their own countries, either by influencing or legislating their energy policy, or by educating, or starting up companies to produce and distribute the technologies we taught them," Farber recalled.

The 4-year program was "set up in response to a constant stream of requests for help from Third World countries wanting to use alternative energies," explained Farber. "Now they can come here, see devices which work in our laboratory, and get first hand experience making their own designs work." Then University President Robert Q. Marston also lauded the TAET program in 1982.

Prof. Erich Farber (r) adjusting the ASHRAE/UF calorimeter, with an early SEECL student (mid 1950s).

The TAET was able to address concerns raised by the World Bank in 1983: "Most developing countries urgently need to begin formulating strategies for renewable energy development." William Eilers of the US AID said in 1980, "This offers one of the greatest hopes of moving toward solving not only the energy problems of developing countries but our own energy problems as well. We must reduce oil use worldwide, not just concentrate only on our own energy problems."

Jerome Singh, of the Caribbean Development Bank echoed Eilers hopes, at that time. "I feel confident that the purchase and acquisition of solar technology and manpower from the USA will be meaningful and successful, especially because of my participation in the TAET." P.M. Noike, of the Ministry of Energy in Nairobi, Kenya said "Our Ministry of Works is particularly interested in solar water heating applications, as we are responsible for construction of government buildings, residential houses, hospitals and schools."

A SEECL student monitors the energy generated by these early Selinium photovoltaic cells (late 1950s).

After their 15 weeks of whirlwind study, building, testing, and visits to US alternative energy projects, TAET students went back to their homelands prepared to use their own local materials and expertise in new ways to make their own energy resources work better for them. Not only were participants putting their new knowledge to work, but also in more than 30 developing countries, TAET-trained technologies made a direct contribution to their national energy planning and policy.

"We should not wait for the perfect answer, but put to work the knowledge which we have now, for the conversions which make economic sense -- such as solar energy used for water-heating and cooling."

Erich Farber, Professor Emeritus, University of Florida.

U.S. Representative Don Fuqua was chairman of the committee on science and technology in 1983. He strongly supported the TAET program. "I know the participants will return to their own countries admirably equipped to deal with energy problems in ways which are suited to their own environment and to their own cultural milieu," he said.

TAET participants hailed from Latin America, Europe, Africa, and the Far East. Participants reported that they were working in a wide variety of alternative energy technologies, such as: solar thermal, biogas, photovoltaics, energy conservation, crop drying, wind pumping, and gasification. Also under investigation at that time were alternative energy cooling systems, solar cookers, improved stoves, fuel alcohol geothermal energy, wind-electric systems, and energy crops.

Then director of US AID Alan Jacobs attributed the success of AID's solar program worldwide to Dr. Farber's "profound knowledge of solar and other energy technologies, coupled with a personal understanding of LDC limitations."

The "Solar House"

The "Solar House" wasn't originally solar. Built of typical Florida construction of the late 1950s, it was in a state of continual retrofit through the decades, with solar systems gradually being installed to demonstrate their feasibility in already constructed homes. The first solar system to be installed was a hot water system. Prior to its being retrofitted to a solar house, it was used as an air conditioning research residence.

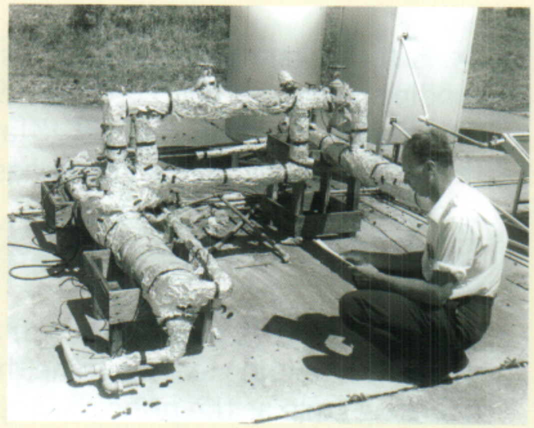
Photo: Barbara J. Graham, SEECL, Dept. MAE, CoE

The "Solar House" as it is currently situated at the Energy Research and Education Park, at the University of Florida (2002). The house was moved to this site in the 1970s. While no longer used as a residence, ongoing experimentation continues within it. The house is also the site of the Erich A. Farber Archives.

For a total of about 30 years, graduate students and technicians with their families lived in the house to provide real-world data about the solar systems integrated into the household. The biggest energy users in any home are heating, hot water, and cooking; and in Florida, we must also consider air conditioning. At one point, according to Dr. Farber, up to 96% of all the energy used in the house was provided by the sun -- driven by flat plate collectors to power solar-thermal systems.

It was during the energy crisis of the early 1970s that the retrofit of the house took on a more pressing perspective. Following the installation of the solar space heating and domestic hot water heating system, a solar air conditioning system was implemented.

Solar heated water was used for more than hot water for bathing and cooking. It was also used for room perimeter baseboard heating. The hot water was run through the baseboards with it's temperature adjustable via a standard thermostat. Solar-powered air conditioning was also installed into the house. An ammonia-water absorption a/c system used the solar heat from the storage tank to generate the necessary energy to cool the house.



Prof. Erich Farber monitors data generated by a low temperature ammonia-water absorption air conditioning system, at the early SEECL (early 1960s).

Not only the house, but also the appliances were retrofitted to solar. The solar stove used oil heated by a concentrating trough collector, which was then circulated through the copper-coiled burner elements for cooking. A clothes dryer also used solar heated water. Ingeniously, the electrical heating element in the dryer was replaced with a heat exchanger that used solar heated water as a source of heat. The hot water was circulated through coils set in the back of the dryer, and a small fan blew across the coil, drying the clothes. A clothes washer was also adapted for use with solar systems.

While the solar house's systems were primarily based on solar-thermal heat exchange, some photovoltaics were used to generate electricity to charge batteries to power a TV set and a lamp. About ½ kW of electricity was generated for this purpose. Experiments were also conducted on retrofitting an automobile to electric power.

Other research conducted during this time included a PV powered air circulation pump, selective coatings on solar flat plate collectors, and solar swimming pool heating. The SEECL was selected by ASHRAE to receive their Solar Calorimeter which measures solar properties of glazing materials. Data collected by the SEECL using the calorimeter were used to calibrate solar ratings and published in the ASHRAE Guide.

The Solar Energy Laboratory conducted research on the antenna concept to convert sunlight to electricity. A revolutionary approach was patented by Prof. Robert L. Bailey of the University of Florida in 1972.

His “electromagnetic wave energy converter” is based around the wave nature of light (as opposed to the particle or quantum nature, which is used in photovoltaic conversion). Bailey suggested the use of broadband rectifying antennas (rectennas) for solar to DC electricity conversion. These rectennas would not have the fundamental limitation of semiconductor band gap limiting energy conversion efficiencies.

Dr. Farber later demonstrated this technology using microwaves. Receiving funding from the Air Force in 1988, SEECL’s “Antenna Solar Energy to Electricity Converter (ASETEC)” laid the groundwork for today’s innovative research into nanoscale rectennas.

Florida State Energy Policy

During the 1970s SEECL research and initiative provided state lawmakers with data, helping to determine that solar industry had identified the State licensing code as the principal impediment to the widespread use of solar. The requirement at that time limited installation to a licensed plumber and used the conventional building codes.

State HB 833 proposed: “Persons who install solar energy equipment be licensed and regulated by the State, and that a licensing board with jurisdiction in this area be created. In addition to its licensing duties, this board should also develop both short-range and long-range State solar energy policy and make specific recommendations for action.”

The assistance of the Solar Lab was invaluable in helping members of the legislative branch initiate Florida’s response to energy legislation and to initiate concern for the development and application of solar energy techniques, according to Rep. Terrell Sessums in 1979.

SEECL’s early devices, near the airport bunker (1950s).

In the late 1970s Farber and the SEECL urged then Fla. Governor Bob Graham and the State Energy Office, to set up a Florida Solar Energy Center, to reflect Florida’s world leadership in solar energy research, at that time.

Then Chairman of UF’s Department of Mechanical Engineering, R.B. Gaither said, “Without Dr. Farber’s dedication to serving the needs and interests of students, colleagues and Florida’s citizens, it is doubtful that we would have a Solar Energy Center, much less a distinguished one."

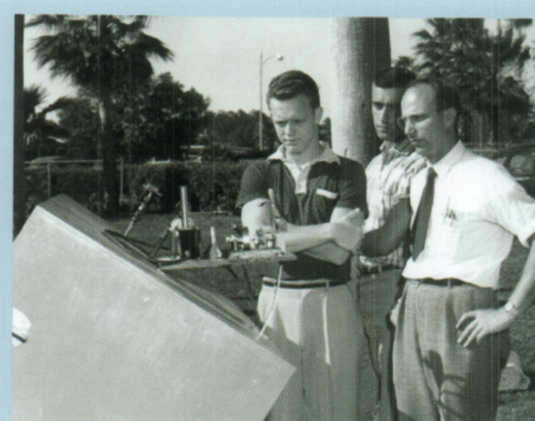
In 1979 both Houses of the Florida Legislature recognized the SEECL's work as "having a profound effect on the public acceptance of solar energy", by presenting an official commendation for continuing "outstanding contributions to the field of solar energy conservation."

Experimental devices on the pad of the early SEECL, at the Gainesville Regional Airport (mid 1950s).

The SEECL was also providing data to the State Energy Office for their series "Save It At Home: Save It, Florida!" These pamphlets covered solar hot water heaters, passive solar heating/shading, heating/cooling systems, attic ventilation, and heat recovery systems.

Today's Research at the SEECL

Ongoing research at the SEECL continues to provide ground-breaking insights into the refinement of solar energy systems, along with fundamental work into energy conversion, heating, air conditioning and refrigeration, and fenestration properties. Current work into photocatalytic detoxification and disinfection of indoor air has been very timely - the device created and patented by current SEECL Director Yogi Goswami, has proven effective in destruction of airborne VOCs and micro-organisms such as bacteria, viruses, and spores. The photocatalytic technology has been shown to be effective in combatting threats of bioterrorism. The photocatalytic air cleaning technology is an outgrowth of another exciting solar technology developed at the laboratory, solar detoxification and disinfection of water. The solar photocatalytic technology has been successfully



Spectators examine the engine of a solar steam power plant, at a renewable energy fair on the UF campus (1960).

demonstrated to clean groundwater contaminated with MTBE, gasoline, and other organics. It has also been shown effective in cleaning industrial wastewater from industries such as pharmaceuticals and textiles. Ongoing research in photocatalytic technology is investigating its use in deep space exploration, to recycle air and water in space stations and vehicles.

Photo: Barbara J. Graham, SEECL, Dept. MAE, CoE

This device uses photocatalytic coated composite magnetic particles, in scrubbing the air of manned spacecraft during deep space missions (2002).

A new thermodynamic cycle has been invented at the laboratory that can utilize low temperature heat sources, such as flat plate solar collectors, geothermal and waste heat from existing nuclear power plants, and convert this heat into electrical power and refrigeration. The technology when fully developed, is expected to result in self-contained devices that provide electricity and air conditioning to buildings using flat plate solar collectors.

An exciting opportunity to investigate the solar production of hydrogen for deep space exploration has just begun. Also ongoing, is fundamental work into heating, refrigeration and air conditioning, solar optical properties of fenestration systems, and development of nanoscale antennas for direct solar energy to electricity conversion.

Solar Energy Education

The Solar Energy and Energy Conversion Laboratory continues to be one of the pioneers in solar energy teaching. Its staff have taught solar energy courses continuously since the early 1950s, and through it's Training in Alternative Energy Technologies program have trained energy experts from around the world. Its students have produced more than two hundred theses and dissertations. The availability of faculty members, researchers and students with backgrounds in a variety of engineering and scientific disciplines gives the laboratory a remarkable capacity for interdisciplinary research.

Photo: David Blankenship, UF College of Engineering Publications

Current SEECL director, Professor Yogi Goswami, stands near his innovative geothermic cycle which produces both refrigeration and electricity (2002).

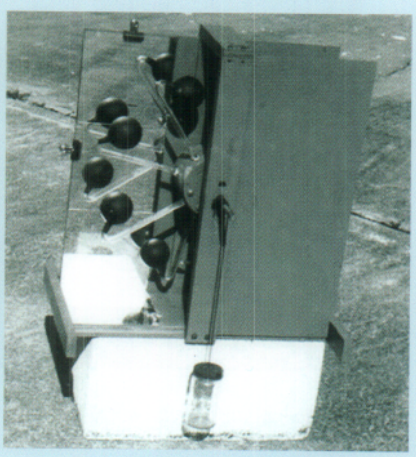
Conclusion

The Solar Energy and Energy Conversion Laboratory with the Erich A. Farber Archives has provided solutions to energy problems long before solar energy was considered a viable source, and it continues to provide solutions for today and the future. The world's petro-resources are fast being depleted -- the only question is when will it happen? The Laboratory feels an obligation to provide energy efficient solutions which will mean a cleaner environment for us all.

Photo: Barbara J. Graham, SEECL, Dept. MAE, CoE

Hands on experimental research on solar air conditioning using liquid desiccants continues at the SEECL. Here a graduate student replaces a seal on a packed bed column.

For Further Reading -- ***More than 300 papers have been published since 1954; this is a representative sample of selected publications by E.A. Farber et al.***

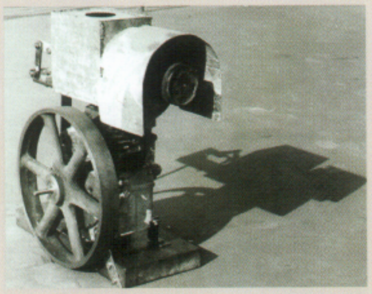


Early SEECL solar gravity motor (mid 1950s).

"Selective Surfaces and Solar Absorbers" (April 1959). *Journal of Solar Energy Science and Engineering,* Vol. III, No. 2.

"Solar Energy Studies: Selective Surfaces and Solar Absorbers; Solar Water Heating; Solar Water Heating-Present Practices and Installations; Solar Energy Used to Supply Service Hot Water; Solar Air Conditioning with an Ammonia-Water Absorption Refrigeration System" (1960). *Engineering Progress at the University of Florida,* (Vol. XIV, No. 2) College of Engineering, University of Florida, Gainesville.

"Theoretical Effective Reflectivities of Drapery Materials as a Function of Geometric Configuration" (May 1963). University of Florida Solar Energy Symposium, May. Also published in *Solar Energy: The Journal of Solar Energy Science and Engineering,* (Oct.-Dec. 1963) Vol. 7, No. 4, pp. 176-179.



A Stirling Engine, at the early SEECL (early 1960s). Interestingly, Prof. Farber built this out of a lawn mower engine, to get an idea of cost per engine for mass production.

"Theoretical Method for Determining the Apparent Radiation Properties for Materials in Sinusoidal Configuration" (October 1964). *ASME Transactions,* Vol. 86, Series A, No. 4, pp. 472-474.

"Power from the Sun" (1965). Presented at the Solar Science Exhibit for the United States Information Agency (USIA) , No. 65-218 pp. 1-16.

"CLosed-Cycle, Solar Hot Air Engines -- Part1: A 1/4 HP Engine. Part II: A 1/3 HP Pressurized Engine" (1965). *Proceedings of the Winter Annual Meeting of the ASME,* New York. Also published in *Solar Energy: Journal of Solar Energy Science and Engineering,* Vol. IX, No. 4, pp. 170-174 and 175-176.

"University of Florida Solar Air-Conditioning System" (1966). *Solar Energy: Journal of Solar Energy Science and Engineering,* Vol. X, No. 2, pp. 91-95.

"Supercharged and Water Injected Stirling Engine," (1969). ASME publication 69/WA/Sol-3.

"Solar Energy, Its Conversion and Utilization" (1971). *Proceedings of the International Solar Energy Society Conference.* Also published in the *Proceedings of the DuPont Environmental Engineering Seminar,* pp. 21-36. Also published in *Solar Energy,* V. 14, No. 3, (1973), pp. 243-252. Also in *Proceedings of the NASA Space for Mankind's Benefit* series. Also in *Building Systems Design,* June 1972, pp. 25-33.

A solar pump, at the early SEECL (early 1960s).

"Selection and Evaluation of the University of Florida's Solar Power Absorption Air Conditioning System" (1974). ASME Paper #74-WA/SOL-6.

"Methodology of Research of Flat-Plate Solar Collector Absorptive Coatings" (1975). *Proceedings of the 21st Annual Meeting of the institute of Environmental Sciences,* Anaheim, California.

“An Experimental Determination of Shading Coefficients for Selected Insulating Reflective Glasses and Draperies” (1976). *ASHRAE Journal and ASHRAE Transactions.* This paper was awarded the Best Paper of 1976, and the ASHRAE Crosby Field Award of 1976.

“Solar Energy and Legislative Requirements” (January 1979). *Proceedings of the Florida State Energy Committee of the Chamber of Commerce* series, Tallahassee.

The Solar Energy and Energy Conversion Laboratory in 1954.

Acknowledgments

We wish to thank Erich A. Farber for his help in developing this brochure, and indeed for his 40 years of seminal research into solar energy as a viable alternative to fossil fuels. His determination and enthusiasm for solar energy and the development of the SEECL has been instrumental in building the solar energy program at the University of Florida.

We also wish to thank the ASME History and Heritage Program for their support in naming the SEECL an ASME Landmark. Specifically we would like to thank Ron Bannister, Burton Dicht, Wil Haywood and Diane Kaylor.

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ASME International

The History and Heritage Program of ASME International

The History and Heritage Landmarks Program of ASME International (the American Society of Mechanical Engineers) began in 1971. To implement and achieve its goals, ASME formed a History and Heritage Committee initially composed of mechanical engineers, historians of technology and the curator (now emeritus) of mechanical engineering at the Smithsonian Institution, Washington, D.C. The History and Heritage Committee provides a public service by examining, noting, recording and acknowledging mechanical engineering achievements of particular significance. This Committee is part of ASME's Council on Public Affairs and Board on Public Information. For further information, please contact Public Information at ASME International, Three Park Avenue, New York, NY 10016-5990, 1-212-591-7740.

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Since the History and Heritage Program began in 1971, 222 landmarks have been designated as historic mechanical engineering landmarks, heritage collections or heritage sites. Each represents a progressive step in the evolution of mechanical engineering and its significance to society in general. Site designations note an event or development of clear historic importance to mechanical engineers. Collections mark the contributions of a number of objects with special significance to the historical development of mechanical engineering.

The Landmarks Program illuminates our technological heritage and encourages the preservation of the physical remains of historically important works. It provides an annotated roster for engineers, students, educators, historians and travelers. It helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery.

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The Plaque

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THIS HIGHLY DIVERSE FACILITY HAS PIONEERED THE DEVELOPMENT OF SOLAR ENERGY APPLICATIONS WORLDWIDE. THE LABORATORY WAS UNIQUE IN DEVELOPING PRACTICAL SOLAR ENERGY DEVICES BASED ON ESTABLISHED PRINCIPLES OF THERMODYNAMICS, HEAT TRANSFER, AND FLUID MECHANICS LONG BEFORE SOLAR ENERGY WAS CONSIDERED A SERIOUS ENERGY ALTERNATIVE.

AMONG ITS MANY SIGNIFICANT TECHNOLOGICAL ACCOMPLISHMENTS ARE ADVANCED SOLAR COLLECTOR DESIGNS, SOLAR-ASSISTED HVAC SYSTEMS, SPACE POWER SYSTEMS, BREAKTHROUGHS IN SOLAR-BASED HOUSING, AND DEVELOPMENT OF ADVANCED MATERIALS INCLUDING GLAZINGS AND HIGHLY SELECTIVE SURFACES. BOTH THE U.S. DEPARTMENT OF STATE AND THE UNITED NATIONS HAVE RECOGNIZED THIS FACILITY FOR ITS GLOBAL ACCOMPLISHMENTS IN TRAINING AND INNOVATION.

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2002