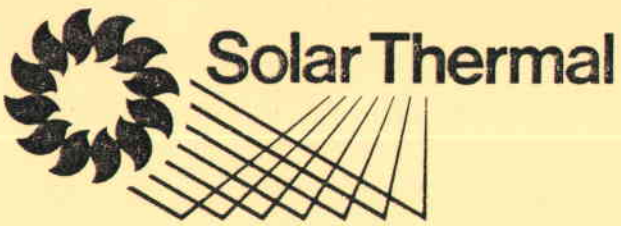
SERI/MR-251-1471 April/May



Solar Thermal Research Program

Status Report

April 1985
May 1985

Issued June 18, 1985

SERI

Solar Energy Research Institute
A Division of Midwest Research Institute

1617 Cole Boulevard
Golden, Colorado 80401

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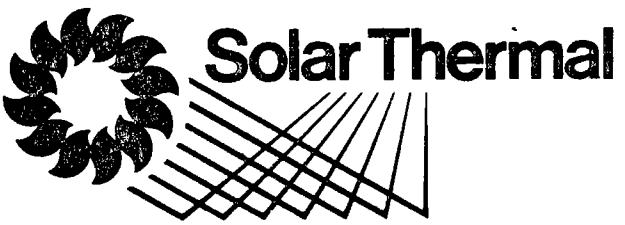

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SERI

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Solar Thermal Research Program

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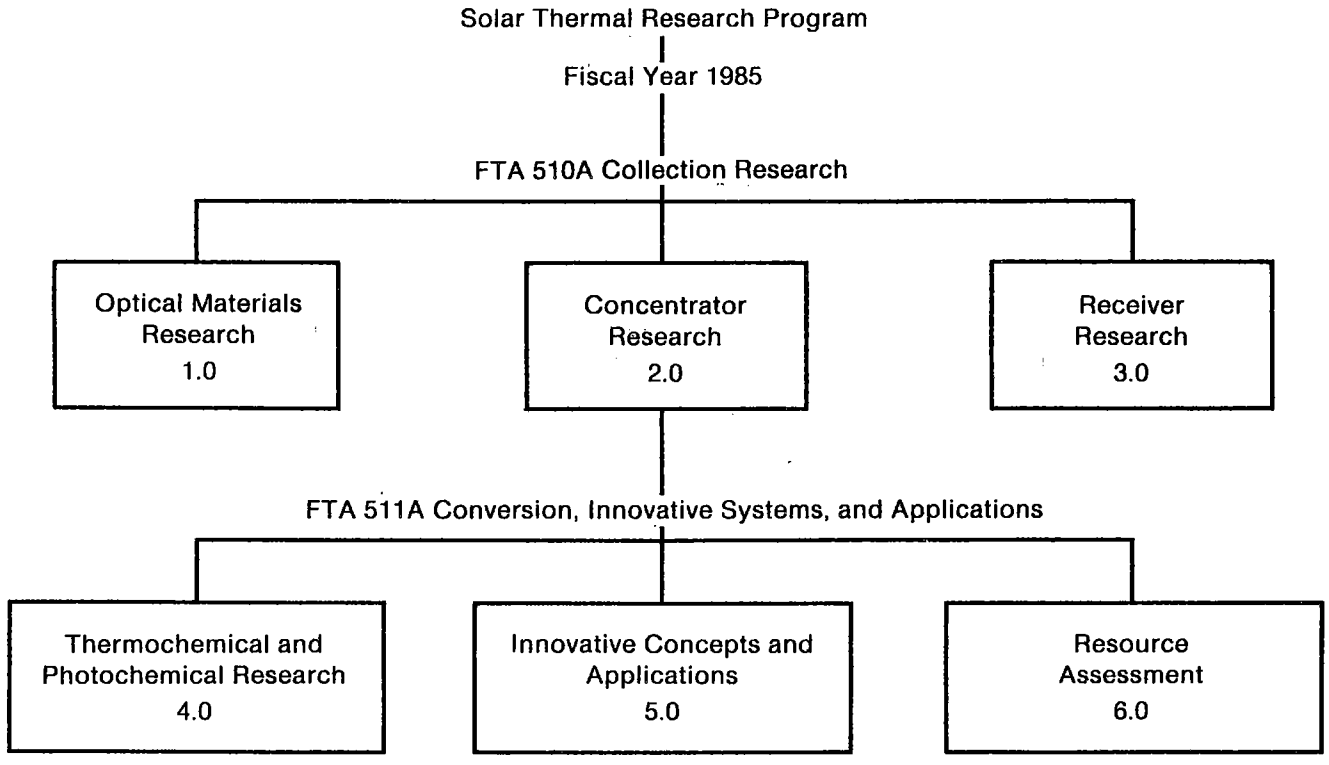


SUMMARY

SIGNIFICANT EVENTS

SERI researchers have attained the performance goal of fiscal year 1985 for silvered polymer mirrors. Staff achieved specularity whereby better than 90 percent of the reflected flux is contained within a cone of 7 milliradians. (Page 3)

A study comparing the performance of glass metal heliostats and the expected preformance of stretched membrane heliostats resulted in the finding that the expected optical performance of the latter can be made to equal the performance of glass metal heliostats, at a much lower cost. (Page 8)

The sequence of testing of direct absorption receivers, including flow tests of molten carbonate salt down the inclined (near vertical) open flow channel which constitute the absorber plate, is proceeding on schedule. The salt is easily wetting the entire surface even at minimual flow rates. The proof-of-concept, feasibility test remains on schedule. (Page 12)

Unique equipment fabricated at SERI for measuring the spectral-optical properties of both solids and liquids at very high temperatures (higher than 900°C) is operational and has been used to measure the absorptance of ionized gas at 500°C to 900°C.

Experiments at the University of Houston on photo-assisted decomposing of methanol show that direct flux benefically increases the yield of desired products. Further data will be collected to define this potentially solar-unique effect. (Page 16)

Hughes Aircraft has operated the electrochemical cell in the thermoelectrochemical conversion system to give very encourgaging results. Performance was excellent with data indicating a high efficiency in the cell. (Page 16)

The thermophotochemical reaction system for studying hazardous waste detoxification has been completed, and collection of data is progressing at the University of Dayton. Spectral absorption by typical wastes has been shown to increase with temperature and is a beneficial phenomenon. (Page 16)

A preliminary study by the Colorado School of Mines shows transport of high fluxes through optical fibers is technically feasible but economically unrealistic at present.

Initial analysis of the conical concentration by SERI indicates very promising potential in costs. An analysis of innovative air-inflated drives has also been initiated. (Page 8)

Efforts to support activities in resource assessment with a contract have resulted in placement of a contract with Bluefield State College for evaluating solar trackers and in issuing a Request for Purchase to design and to build an ultraviolet spectroradiometer to measure ultraviolet spectral bursts. (Page 20)

TECHNICAL DESCRIPTION

A. FIELD TASK AGREEMENT 510A COLLECTION RESEARCH

This research encompasses optical materials, concentrators, and receivers. Optical materials research centers on improving reflector materials and obtaining better absorber coatings. Concentrator concept research is focused on light-weight, low-cost innovative collector designs. Receiver concept research is focused on low-cost and high-efficiency configurations with good durability, and on extending the temperature range beyond the current technology.

PROGRAM ELEMENT 1.0 OPTICAL MATERIALS RESEARCH

Optical materials research is directed at three areas: mirrors, absorbers, and windows. The objective of mirrors research is to obtain reflecting surfaces which meet high performance requirements in specularity and which satisfactorily operate in the solar environment. Absorber coatings improve the thermal performance of receivers by increased absorptance. Some receiver concepts require a closed cavity with a window to contain reactants. Research on windows aims at understanding the unique effects of high solar flux on specific candidates for window materials capable of sustained operation at elevated temperatures.

Mirror research in this fiscal year amplifies research from fiscal year 1984 on silver/polymers. During fiscal year 1985, it is anticipated that SERI will identify silver/polymer combinations which show no short-term ultraviolet degradation, will produce and test silicon nitride film deposits on both sides of a silver mirror, and will identify the sources of optical irregularities inside, as well as on the surface of commercially available polymers. SERI expects to identify the controlling factors determining metallic surface roughness, and will produce and test metallic substrates with polymeric leveling layers. SERI expects to identify the factors affecting black chrome performance when deposited on stainless steel. In research on windows, SERI, in conjunction with Georgia Institute of Technology, expects experimentally to characterize at least one coating material and to understand mechanisms in devitrification.

PROGRESS

Silver Polymer Reflectors

SERI researchers have attained the performance goals of fiscal year 1985 for silvered polymer mirrors. In the immediate future they are emphasizing two aspects of the work: long-term goals for specularity; study of stabilizing polymers. They are to demonstrate that silvered polymers can attain the requisite long-term goals of specularity even before weathering. Researchers have measured the reflectance from unsilvered, transparent polymers to check the viability of this method to determine the initial optical quality of the polymer and to differentiate initial quality from degradation caused by the silvering process. Preliminary measurements are very encouraging and indicate that, with proper equipment, the method can be effective.

SERI researchers have some results of measuring transparent films and mirrors. A series of optical measurements with ECP 300 mirrors, fabricated by the 3M Company, identified a discrepancy in the optical measurements by 3M and SERI. At small

acceptance 1/2-angles (3.5 mr), SERI's measurements yielded lower reflectances than did measurements by 3M. This observation prompted a series of measurements to elucidate the differences. Some of the measurements are listed in Table 1.

Item 1, Table 1, corresponds to a new, wet-processed silver mirror on 7809 glass, made and measured at SERI and sent to 3M for measurements. The agreement between 3M and SERI is excellent, and the ratio, 3.5/7.5, indicates that this is a very specular mirror.

Items 2 and 3 are representative of the ECP 300 mirrors made by 3M. At the larger acceptance angles, the agreement is excellent; at 3.5 mr, the SERI values are lower. Note that the smallest aperture on the SERI instrument is 3.5 mr (1/2-angle) while for the 3M instrument it is 4.2 mr.

Items 4 through 7 are mirrors made by Acurex and were measured at Sandia. Note that Sandia's values are the average of reflectances at 3 mr and 4 mr; however, the interpolation to 3.5 mr is negligibly different. For items 4,5,7, and 8, the values at larger acceptance 1/2-angles are in reasonable agreement, while the SERI values at the lowest acceptance angle are again low. Item 6 does not show the decrease in reflectance at small acceptance angles.

As a further check, the ECP 300X samples that are on long-term outdoor, weathering tests also do not show the drop at low acceptance angles.

Table 1 Optical Measurements

	Mirror	Laboratory	Acceptance 1/2-Angle			Ratio
			12.5	7.5	3.5**	3.5/7.5
1.	New Glass/Ag	SERI	—	95.6	94.0	0.983
		3M	95.6	95.4	94.9	0.995
2.	ECO300, #12, Coated	SERI	98.1	97.7	83.5	0.855
		3M	98.0	97.7	91.5	0.983
3.	ECP300, #12, Uncoated	SERI	97.7	97.2	77.8	0.800
		3M	97.7	97.3	92.7	0.953
4.	Acurex 9B	SERI	96.4	96.1	67.1	0.698
		SANDIA*	—	92.3	91.8	0.996
5.	Acurex 5A	SERI	94.5	90.6	72.7	0.802
		SANDIA*	—	93.0	92.6	0.997
6.	Acurex Bare Aluminum	SERI	83.6	82.0	78.8	0.961
7.	Acurex Aluminum + SiN, (500 nm)	SERI	79.4	77.1	57.9	0.751
		SANDIA	—	79.8	78.2	0.980
8.	ECP300X, Outdoors 51 weeks	SERI	—	95.1	92.2	0.970
	ECP300X, Outdoors 57, weeks	SERI	—	94.7	90.4	0.955

*Sandia's values are the average in two orthogonal directions.

** D&S aperture for 3M is 4.2 mr; Sandia's values are the average of values at 3 mr and 4 mr.

A tentative explanation of these differences is that the SERI-owned Devices and Services reflectometer has effectively a smaller acceptance angle than the 3.5 mr 1/2-angle quoted by the manufacturer. Thus, the highly specular mirrors (items 1, 6, 8) do not decrease in reflectance at this anomalously low acceptance angle while less specular mirrors do. If this conjecture is correct, SERI researchers are underestimating the quality of the polymer mirrors.

Chemically bonding stabilizers to the polymer glazing is one approach to improving mirror durability. The following steps have been taken in the process leading to the chemical incorporation of a benzophenone stabilizer into polymethylmethacrylate glazings on silver mirrors. The structure of the purified, monomeric ultraviolet-stabilizer 4-methacryloxy-2-hydroxy-benzophenone (MHB) was verified, and homopolymerization of MHB was carried out under several conditions. Two copolymers of MHB and methylmethacrylate have been synthesized with the incorporating of 6 w-percentage and 7.3 w-percentage of MBH, and with molecular weights of 38,000 and 50,000. Gel formation is observed after some copolymerizations.

The wet-processed silver mirroring facility is reactivated, and the new dip-coating equipment is in place. The copolymerized materials will be formed into glazings on silver to determine the effects on mirror durability.

Other Reflector Materials Research

Discussions were held with representatives from the Department of Metallurgical Engineering of the Colorado School of Mines that have resulted in the establishment of a subcontract to determine the state-of-the-art for making smooth metal surfaces and to identify areas of research to improve the quality or reduce costs for metal finishing.

The subcontract with Acurex has been extended. Under this extension Acurex will investigate the improvement in metal substrate quality by buffing and electropolishing and by using borophosphosilicate glass as a leveling coating in place of polymer levelizer coating used in the previous experiments. The glass coating should provide the needed surface smoothness and stability. Acurex will also continue experiments on transparent, inorganic overcoats to protect silver from corrosion.

PROGRAM ELEMENT 2.0 CONCENTRATOR RESEARCH

Concentrator research at SERI in fiscal year 1985 is investigating ways of reducing current support structure requirements. Research on concentrators utilizing silvered polymers aims at development of potentially lightweight, low-cost, durable concentrators with high performance; in particular, the stretched metallic and polymeric membrane heliostat and dish concepts are considered. Demonstration of the technical feasibility of lightweight stretched membrane concepts through experimentally verified analyses of subscale test modules is to be accomplished. Greater durability (at least five years) with retention of optical quality in solar reflector use is to be evaluated and verified by environmental testing. Configurations for the various concepts are to be defined, and cost comparisons are to be carried out.

During fiscal year 1984, concentrator research focused on the study of the stretched membrane concentrator. Structural analysis, fabrication of a number of experimental prototypes, and measurements of their structural behavior advanced to the point that the technical feasibility of the membrane concept has been established, and the static structural/optical response of the membrane is predictable with sufficient accuracy. Also during this period, wind-load reduction and abatement studies were initiated at Colorado State University.

During fiscal year 1985, the research aimed at understanding and reducing wind loads on collector fields, including heliostats, dishes and troughs, will continue. The possibility of using composite materials for reflector surface backing as well as for structural members is to be studied. Structural and optical testing of the three-meter modules will take place. The definition of the structural response of membranes to static and dynamic loading and the preferred membrane attachment configurations are to be studied. A separate effort is to define the structural requirements for stretched membrane concentrators to be used for higher receiver temperature systems. Effort is to be initiated to define the performance of polymers as possible structural membranes. Finally, a research effort will aim at studying alternative mechanisms and strategies for focusing concentrators. Assessment of the performance and the cost characteristics of selected Fresnel lens concentrators is to be initiated.

PROGRESS

Stretched Membrane Module Testing and Analysis

Researchers completed the testing of the single-membrane, test modules and achiev ed the milestone for April 30 on schedule. They have about 150 frames of data taken on the modules, with each frame providing mappings of the surface contour slope for the reflector corresponding to various loads, tensions, attachment configurations, and support conditions. A method of analysis which has been applied to predict the performance of full-scale modules is now being applied to the tests modules, and correlation of the experimental and analysis results is in progress.

To support this evaluation researchers completed the two data-reduction, software elements which will be used in the correlation. One package converts the digitized pixel space in the monitor/recorded image to physical dimensions and compensates for nonlinearities in the system optics, for small misalignments in the target and collector, and for rigid body motions of the collector. The second package provides the fit of a generalized (least squares) equation on membrane shape to the data on measured slope.

A proposed extension to the existing (researching flutter of the stretched membrane) contract with Colorado State University on investigating wind loads has been submitted to SERI's contracting officials. This work will assist Sandia, Livermore, in the design of cost-effective, stretched membrane modules. SERI staff also prepared a consultant agreement for a professor at the University of Texas at El Paso to work during the next few months to incorporate the experimental wind data being generated at Colorado State University into the SERI design and structural studies for concentrators, as well as to assist in formulating recommendations on preferred approaches to reduce wind loads on collectors.

Staff has supported Sandia, Livermore, in the development of the stretched membrane contracts by participating in the design review of the contract with Solar Kinetics, Inc (SKI) at Sandia, Livermore; by transferring the SERI variational analysis code to Sandia, Livermore; and by providing analysis of the stretched membrane structural response to SKI, Science Applications, Inc., (SAI) and Sandia, Livermore.

The draft of the report titled "System Performance and Cost Sensitivity Comparisons of Stretched Membrane Heliostat Reflectors with Current Generation Glass/metal Concepts" is being reviewed at SERI. The report includes an overview of the structural work on the stretched membrane heliostat, extensive anaylses of system performance on a broad range of system parameters—including system size, system operating temperature, hemispherical reflectivity, surface normal errors, specularity, and heliostat diameter. The principal conclusions of the study are that focused, stretched membrane heliostats can achieve performance which is approximately equal to currently available glass/metal heliostats, and that unfocused stretched membrane heliostats have significant potential for providing cost-effective performance for a range of plant sizes which are larger than focused modules and deliver temperatures lower than focused modules. Further, it was found that within the range of system sizes and temperatures considered and for reasonably expected specularity-induced errors (90 percent of the reflected energy in a half-cone angle of 6 mrad), the specularity does not seem to be a major factor governing the applicability or performance of stretched membrane heliostats.

New Concentrator Concepts

Researchers are currently evaluating the engineering and cost/performance of several potentially attractive new concentrator subsystems and components. They accomplished a number of beneficial actions in this period.

The contract for work on fresnel lenses with Entech is in the final stage of review/evaluation by the auditors. This contract will be used to complement SERI's techno/economic evaluation of the concept with Entech's unique experience. SERI's activity has focused on performance modeling and on identifing key engineering issues and benefits for the concept.

In research on inflatable conical concentrators, SERI staff are in the process of iteratively configuring and costing conceptual concentrator prototypes to evaluate this concept for medium temperature (200°F to 1000°F) applications. They anticipate one or two more iterations on the costing and design process to complete the initial evaluation.

The research on the inflatable heliostat drive has resulted in another analysis from Oklahoma State University. The major technical uncertainty which SERI researchers are investigating is the ultimate tracking accuracy attainable with the concept. They have nearly completed an initial design and a corresponding cost estimate for the concept.

The objective of the contracted effort on holographic concentrators with the Acurex Solar Corporation is to define the potential of using holograms to collect and to concentrate solar energy. As they are justified for research, proof-of-concept experiments will be performed. Research is answering questions such as how to achieve high spectral efficiency and whether mechanical sun tracking is required. Indications from a fundamental analysis are that stacked holograms are the best approach to multiplexing. Reflective holograms are preferred over transmission holograms. Hologram response must be square wave and broadband (>150 n). All research is directed toward accomplishing these requirements and toward defining the necessity of mechanical sun tracking.

Through SERI, also, the research contract on spiral concentrators with GTRI is to construct and to evaluate one small-scale spiral concentrator with a concentration ratio between 500 and 1,000 suns. Work in this period focused on wind up and experimental investigation on concentration ratio. A concentration ratio as high as 400 suns by experimenting with various wind-up techniques was obtained. Also a method of evaluating wind-up techniques while they are being implemented was developed. A reflected image of the spiral is monitored at a distance past the focal point while the spiral is illuminated by a point source and is being assembled. A clean spiral reflected image should be obtained.

PROGRAM ELEMENT 3.0 RECEIVER RESEARCH

Receiver research at SERI in fiscal year 1985 primarily is directed at defining durable configurations for metal and ceramic tube receivers as well as direct absorption concepts. Analytical and experimental study is being used to define the performance drivers corresponding to various receiver concepts and approaches to enhance their performance. Materials research which is of primary importance is directed at developing high performance and long-life absorber surfaces and containment tubes. Metal or ceramic tubes for receivers are to face higher temperatures and more aggressive fluids such as molten salts or liquid sodium. Metal tubes for external receivers to about 600 C are now identified as research targets, but there is a need for diagnostic instruments to measure these and advanced receiver surface temperatures in operation. Research on solar blind pyrometry continues to produce the basis for needed instruments. Studies on cavity configuration and phenomenology have broad application to dish and central receivers and correspond to fluid in tube and direct absorption concepts for a wide range of temperature applications up to 900 C. These investigations include detailed descriptions of loss mechanisms and techniques to reduce these losses, research leading to the development of secondary concentrators, and instrumentation to measure the thermal transport and structural performance parameters in situ during operation.

It is expected that the test loop for conducting the ACTF tests of the direct absorption concept will be constructed and checked out, and some early experiments will have been completed during fiscal year 1985. Also during fiscal year 1985, preliminary experimental data and analysis of sufficient quality are to be available for an initial evaluation of the direct absorption receiver concept. Historical data on failures of cavity tubes are to be collected. Analysis leading to modeling is to begin. Also, it is expected that quantitative correlations of the degradation of absorber coating as a function of impinging solar flux will be completed. It is expected that needs for diagnostic instrumentation will have been specified. An assessment of current errors in estimating convective losses from cavity receivers, including recommendations and a preliminary evaluation of the benefits of secondary concentrators, is also to be completed.

PROGRESS

Receiver Testing - Molten Salt

Researchers have completed all testing using the 500°C test apparatus. Of particular importance were tests of the viscosity of carbonate salt, since data reported in the literature were inconsistent. Viscosity was calculated from measurements of salt film thickness by using known fluid mechanics equations for the flow regimes of interest. An excellent fit was obtained between measured values of film thickness and viscosity values when the latter were approximately 3.5 times the viscosity values reported by the National Bureau of Standards. A second method was attempted, using capillary tube flow, but was not successful due to frequent blockage flow in the tube. To resolve the discrepancies between the various viscosity data now available on viscosity, SERI researchers contacted the professor at Rensselaer Polytechnic Institute who performed the original set of viscosity measurements for the National Bureau of Standards. The professor agreed to provide SERI with a new set of measurements by using an existing, experimental oscillating cyclinder.

The 700°C test loop has become operational. Researchers calibrated the salt flowmeter. A maximum flow rate of 3.4 gpm was measured as compared to the expected 4.0 gpm. The difference is attributable to the higher than expected viscosity. Soon after completion of the calibration of the flowmeter, a leak was discovered near the top welds of the two storage tank heaters. This leak forced a drainage of the tank and a cooldown to room temperature. A manhole was cut into the tank. Inspection revealed two cracks approximately three inches long. It is believed that the cracks were the result of the assymetrical location of the heaters on the hemispherical head and the lack of adequate support for the heaters. The tank was repaired, and tests of the near vertical receiver section were begun. Flow over the receiver test section spread over the entire surface. No "dry-spots" were observed. The rate of flow was varied, and measurements of the film thickness were taken. The flow wets the surface and is stable over a range of flow rates at a nearly vertical angle. Researchers now plan to remove the receiver test section and to install it in the 900°C test loop for ACTF tests. The 700°C loop will be inspected and a redesign of the heaters penetration will ensue.

Progress on the fabrication of the 900°C test loop remains on schedule for completion of the loop in mid-July. The plan is to send the absorber section to Industrial Welding and Supply (IWS) for assembly. Shipping to Georgia Tech Research Institute (GTRI) will probably be done by truck. Test of the insulation indicates that no substantial embrittlement occurs when heated to 900°C. The loop will be checked at GTRI on the ground for integrity prior to ACTF testing. SERI researchers met with representatives from IWS and GTRI at the Company's facilities in Sterling, Colorado, in May. After touring the hardware assembled to date, SERI researchers met to update the drawings; to review the diagrams of piping and instrumentation; to discuss interface drawings and the cavity flux redirector; and to review the SERI draft test plan, Safe Operating Procedure, and the Document of Understanding. The valve bonnets and the pump have been received at IWS. With the exception of the Chromalox heaters, this shipment completed the list of items produced by other manufacturers and enables the fabricator to complete the 900°C loop on schedule.

Researchers have begun a systems study comparing the performance and cost of a conventional salt-in-tube receiver system and a Direct Absorption Receiver delivering the same amount of thermal energy at the same temperature to the system boundary. In contrast to previous studies, the DAR is an intermediate temperature system. Both receivers would deliver 190 MW_{th} at 566°C to the system boundary. With the exception of the receiver, all component costs were drawn from the Multi-year Program Plan.

The Cyclic Corrosion Studies of Inconel 600 in carbonate salt were completed. This work suggests that cycling caused no accelerated corrosion. The microstructure of the corrosion product after cycling was a dense oxide layer on top of a porous corrosion product layer; this is the same structure as seen on constant tests of 900°C corrosion coupons under oxidizing conditions. This structure and the cycling results suggest that the porous under-layer can accommodate a mismatch in thermal expansion between the dense outer-layer and the metal.

Optical Properties Measurements

Researchers at SERI completed the measurement of the reflectance of Inconnel 600 at temperatures from 500°C to 900°C. Spectral measurements were obtained over the entire solar spectrum. The solar-weighted average value (over a number of samples) of the hemispherical reflectance at 900°C was .10, giving an absorptance of .90. However,

considerable scatter of data exists-depending on sample preparation. Nonetheless, these data are adequate to estimate the DAR thermal performance. Next are scheduled measurements of the absorptance of Inconel 600 when covered with a larger molten carbonate salt.

Photodegredation Workshop

Plans are in progress at SERI for a workshop to be held in the latter part of July on the status of research on photodegradation of materials. Workshop participants are from the Department of Energy's Solar Thermal Technology Program as well as participants from academic and other national laboratories with expertise in related fields.

Research at Georgia Tech Research Institute

Research to improve the four-color pyrometer continued at Georgia Tech Research Institute (GTRI). GTRI identified possible solutions to nine of the more serious deficiencies of the current pyrometer design. These all must be addressed in any second-generation four-color design. Other achievements include a significant noise reduction in the electronic circuitry of the four-color pyrometer. Signal-to-noise ratio has been improved by approximately a factor of 100. The benefits of such a noise-reduction are several: (1) improved system sensitivity; (2) some lowering of the low temperature detectability limit; (3) improved capability to assess effects such as 4.3 m wavelength atmospheric absorption and solar blindness.

A first-surface corner reflector has been constructed. This device mounted on a computer-controlled, two-axis stage will permit real-time observations of real, sample, and black body radiation sources on the computer-controlled, four-color pyrometer. The intent of these observations is to validate the use of the four-color pyrometer while looking at sample images from a first surface reflector.

In ceramic materials research, work concentrated chiefly on debugging the Monte Carlo thermal analysis computer program, defining the Fourier Transform Infrared Spectrometer (FTIR) system, and planning the ACTF test program which is scheduled to be conducted in June. In addition, a short test was performed at the small Georgia Tech Solar Furnace to observe the melting behavior of a carbonate salt mixture.

The Monte Carlo thermal analysis program has been debugged and was shown successfully to reproduce published temperature profiles. The FTIR spectrometer was specified, bids were obtained, and the order was placed. A short test to observe melting of a carbonate salt mixture in solar flux was conducted. Contrary to expectations, the melted phase did not appear to darken.

In research on window materials, good quality welded joints were obtained on trial mosaic window specimens by using silica cement for making connections. Further work to optimize joint strength will be carried out during the next reporting period, and an ACTF test program is scheduled to include mosaic window specimens in the test cavity.

Research at the University of Houston

Studies on photodesorption have been completed on the silicon system at the University of Houston. A number of common, simple molecules were adsorbed onto silicon with the samples subsequently exposed both to full beam solar simulator irradiation. Photodesorption was observed on all of these samples. CO and CO_2 were found to be the only desorbing species when CO and CO_2 were adsorbed onto clean silicon. NO was found to desorb from silicon exposed to NO, and SO was photodesorbed from a surface exposed to SO_2. The threshold energy for desorption for the different species ranged from 2.50 eV to 2.62 eV with the desorption signal varying linearly with incident flux. The basic mechanism for photodesorption in this system is a prototype system for semiconducting surface oxides found on most metals and is currently being more fully defined.

B. FIELD TASK AGREEMENT 511A CONVERSION, INNOVATIVE SYSTEMS, AND APPLICATIONS

This research encompasses direct conversion from concentrated solar radiation to electricity or chemicals, transport and storage of thermal energy, and generation and assessment of innovative concepts.

PROGRAM ELEMENT 4.0 THERMOCHEMICAL AND PHOTOCHEMICAL RESEARCH

Research on process definition at SERI in fiscal year 1985 is to identify usable adsorption phenomena and processes. The research includes high-flux and high-temperature chemical bond interactions. Reaction research seeks to evaluate side reactions and other major reactions affected by high temperatures, and addresses the unique effects of a large radiant flux on such reactions. The aim of this research is to identify potentially useful conversion reactions and to quantify the effects of high flux and temperature on desired reactions. Research is also to be performed on hybrid processes to use combined solar energy and other fuel sources.

PROGRESS

Solar Photochemical Production of Fuels and Chemicals at the University of New Hamphsire

Researchers at the University of New Hampshire have begun a literature survey of processes for hydrocarbon fuel production from inexpensive sources of carbon and hydrogen by using photochemical means. Much of the literature is centered on the water-splitting reaction for hydrogen production. The synthesis of hydrocarbons from carbon monoxide and hydrogen (syn gas) is well-established by conventional catalytic procedures like the Fischer-Tropsch process. Use of solar energy to assist or initiate such conversions is still in its infancy. An attractive method for fuel synthesis from the waste products of fossil fuel combustion (carbon dioxide and water) has been reported recently. Halmann and co-workers have found that photo-driven reduction of carbon dioxide in an aqueous suspension of semiconductors (e.g, n-TiO_3, $SrTiO_3$) produced hydrocarbons like methane, methanol, formaldehyde, and formic acid. Although the efficiency of this conversion is still low, it is a promising avenue for research, especially in light of the possible use of the infrared portion of solar radiation for product distillation and separation. A variation using biological enzymes has also been reported. A combination of a photoelectric (onP-InP) process with the enzyme format dehydrogenase is reported to yield formaldehyde from carbon dioxide and water by using light of less than 900 nm in wavelength. This is basically artificial photosynthesis, but with higher efficiency, and is more specific than the natural process.

The work on setting up the apparatus for conducting several experiments for caprolactam manufacture is in progress. Due to the highly toxic and corrosive nature of the chemicals used in these experiments, special safety precautions are taken to avoid any injury to the workers. A special chlorine detector has been ordered. All tubing, pressure gauges, and rotameters are of materials which are comparatively resistant to chlorine corrosion. Workers have been provided with safety glasses and gas masks as a precautionary measure.

Solar Detoxification of Hazardous Wastes at the University of Dayton

The thermophotochemical reaction system for studying hazardous waste detoxification has been completed and shake down tests are underway. The apparatus is a net package containing the solar simulator, appropriate reactors and analytical equipment. The system is specifically designed to separate thermal and photoytic effects. It is anticipated that data collection will begin in June.

Spectral measurements on acetone, benzaldehycle, dimethylaniline and trichlorobenzene have indicated favorable shifts in absorption intensity as the temperature is increased. this implies that photolytic effects may be even stronger than hoped. Measurements were limited to 250°C by the spectrometer. The spectrometer is being altered to allow measurements at much higher temperatures. Also spectra of actual wastes will be measured.

Photo-Assisted Reactions at the University of Hawaii

Experiments have been completed in the 30 KW arc image furnace to show that copious free radicals are generated when an initiator, such as acetone, is subjected to simulated sunlight containing UV. This implies a beneficial effect when a reaction, which proceeds by a free radical mechanism is carried out simultaneously. The 1.5 KW arc image furnace and reactors were completed, tested for operability and have been shipped to SERI. M. Antal will report to SERI on June 3 for a three month collaborative research effort using this equipment and a time-of-flight mass spectrograph to experimentally characterize the beneficial effects of the free radicals on the cracking of ethane to ethylene.

Radiant Heating of Solids at Lawerence Berkeley Laboratory

Research is on schedule, with the DOE-SAN contract modified to include 32.6K from SERI to bring the total FY 1985 funding to $225K. The incremental funding will be used for an assessment to determine the potential of this research. The existing chemical reaction data base will be used to identify the most likely reactions for the assessment. Initial efforts include definition of methods of producing particles and methods of removing particles from an entraining gas flow. The research on optical calculation continues and will be an important part of the assessment since the reactant particles must also be good absorbers.

TECH Convertor at Hughes Aircraft Company

Construction and initial shakedown of a small continuous flow electrochemical cell were completed. Studies of electrode polarization as a function of temperature, solution composition, and electrode activation procedure have begun. Initial results indicate that electrode activation is the primary factor affecting performance. Optimization of the electrode activation procedure is currently underway. Initial data on cell performance are very encouraging, with indication of excellent performance.

Photocatalysis, Photo-Assisted Bond Breaking, and Chemical Energy Storage at the University of Houston

The quartz tube reaction chamber for proof-of-concept of a photocatalysis effect has been constructed at the University of Houston. The reaction chamber is complete with a heated and cooled ceramic sample holder.

Experiments on the apparatus for photo-assisted solar thermal chemical reactions have indicated a significant photolytic enhancement of methanol decomposition to synthesis gas (Co, H_2) compared to a straight thermal decomposition. Data from the experiments are the following:

	Heat Only	Heat & Light
% CH_3OH to $(CH_3)_2O$ and H_2O	44	24
%CH_3OH to CH_4, H_2O, CO_2	27	17
% CH_3OH to CO and H_2	24	45
% CH_3OH reacted	95	86

These data are encouraging, and the experimental apparatus performed well. Additional check-out experiments will be performed by using both methanol and ethanol decomposition for comparison. Then the planned experimental program will begin by using the reactions identified as most promising in an extensive literature search.

Emphasis continues on identifying a compatible molten salt (CMS) in which the ammonium hydrogen sulfate decomposition would be performed and that would serve as a thermal working fluid. Investigation of mixtures containing Li^+, Na^+, K^+, Zn^{+2} and SO_4^{-2} continued with important results:

- Discovery of a mixture with lower liquidus point — mixture (H-1) with composition: Li_2SO_4 = 31.58%, Na_2SO_4 = 15.93%, K_2SO_4 = 7.66%, and $ZnSO_4$ = mixture (C-1);
- Reduction in the melting temperature range — mixture (H-1) with a melting temperature range of 8°C, cf. 14°C for mixture (C-1) indicating that mixture (H-1) has a composition very close to that of a eutectic.

The lowering of the melting point to 371 + 4°C is significant, since the lowest melting eutectic of Li_2SO_4, Na_2SO_4, and K_2SO_4 has a melting point of 512°C. The addition of $ZnSO_4$ has lowered the melting point by 136°C. When the final CMS has been chosen, the physical and chemical properties will be measured, and the AHS decomposition reaction will be performed to ensure that CMS is acceptable.

PROGRAM ELEMENT 5.0 INNOVATIVE CONCEPTS AND APPLICATIONS

Researchers' systems and applications technology at SERI in fiscal year 1985 will emphasize generation and characterization of innovative concepts and applications. Innovative concepts and applications are guided by the need to make significant improvements in solar energy cost-effectiveness by providing a much more attractive application or a new concept. The approach is: (1) to identify the concept or application; (2) to do sufficient research to characterize the concept or application; (3) to perform a comparative analysis of alternatives; and (4) if attractive, to integrate any further research into the primary program.

It is planned that during fiscal year 1985 the definition and technical feasibility of various new concentrator concepts will have been completed, with identification of those that show promise for further development. Also, a preliminary assessment of the technical feasibility of the holographic concentrator is to be completed. SERI plans to complete the assessment of non-equilibrium, rapid reactions and to identify the most promising ones. A survey of current scientific developments with relevance to solar thermal systems is to be completed. As a result of planned workshops, new ideas with potential are to be pursued.

PROGRESS

New Concepts: Technology and Applications

The computer simulation to calculate the heating rate of small particle/gas mixture has been completed. Based on the single particle model and properties of carbon, the results indicate that smaller-particle (in sub-microns), gas mixture has better chance to be heated to higher temperatures (2000°C) in a short time (1 second).

A group of students at Colorado School of Mines performed a preliminary study of optical transmission for power purposes. They concluded that transporting solar energy through optical fibers is technically feasible, but economically unrealistic at the present stage. They estimated that to transport 10 MW of solar energy over 16 Km the cost (with no active cooling) is about $270 million. This study was performed under the guidance of SERI researchers.

Compound Secondary Concentrators at the University of Chicago

Researchers at the University of Chicago are investigating compound secondary concentrators. The concept is to use a low optical tolerance primary concentrator (concentration ratio of 40 to 60) coupled with a secondary concentrator (concentration ratio of 5 to 8) to give an overall concentration ratio of 200 to 500 with a receiver temperature of 500 to 600°C and an optical efficiency of 65 percent to 70 percent. This combination should prove much more cost-effective than conventional concentrator concepts. The University of Chicago has designed and is building a promising design for test at the Advanced Components Test Facility at the Georgia Tech Research Institute.

Spectral Shifting at Hughes Aircraft Company

Staff members at Hughes Aircraft Company have been working on spectral shifting. The spectrum can be shifted, as desired, by use of the Welsbach effect. Welsbach materials absorb radiation but emit only at characteristic wavelengths-thus shifting the spectrum. Welsbach materials have been identified and samples have been obtained and fabricated

into appropriate shapes for testing. Physical properties are being measured and tests are underway to characterize performance. An assessment is progressing to estimate conversion enhancement by use of a Welsbach material. Specific measurements include the absorption spectra of various Welsbach materials. Ways of using the Welsbach effect for achieving both quantum and thermal conversions have been conceived and are being evaluated.

Spectrally Selective Beam Splitters (SSBS) at the University of Arizona

Optimal conversion of the solar spectrum requires that the spectrum be split and that individual fractions be converted by the technique best suited to the specific spectral bandwidth. This research at the University of Arizona is defining best techniques for selectively splitting the solar spectrum and is producing Spectrally Selective Beam Splitters (SSBS) for experimental evaluation and for application to specific solar thermal conversion processes, as justified. Research has resulted in conceptual designs of stacked interference SSBS and liquid filter SSBS, which should give reasonably efficient spectral splitting. These conceptual designs are being fabricated into experimental models, which will be evaluated by using well-defined quantum processes. Solar-thermal-specific conversion processes have been defined and are being assessed. Concepts are being evaluated for both medium-temperature and high-temperature applications. Preliminary evaluation of the liquid filter has indicated that it is very suitable for photovoltaic applications. The emphasis at the University of Arizona is on the higher temperature applications more suitable for solar thermal applications.

Novel Front Surface Mirror Protective Coatings at Southern Research Institute

Many solar thermal conversion schemes are more efficient if front surface silver mirrors are used. However, this requires that an effective technique exists to protect the silver from corrosion and abrasion. Langmuir-Blodgett monolayers provide dense, low permeability films which should be easy to apply to mirrors. Such coatings have the potential to make front surface mirrors cost-effective, with very little loss in performance. Ten materials in research at Southern Research Institute were chosen for evaluation as Langmuir-Blodgett coatings. Physical and chemical properties are being measured. Mirrors are being prepared and coated. Various evaluations will be performed-including specularity effects, film stability, and durability by short-term, real-time, and accelerated exposure tests.

PROGRAM ELEMENT 6.0 RESOURCE ASSESSMENT INSTRUMENTATION

The two objectives of this program element during Fiscal Year 1985 are: (1) to evaluate, establish the uncertainty, and to improve the National Direct Beam Insolation Data Base and Monitoring Network; (2) to develop instrumentation to measure and to characterize the nature of terrestrial spectral ultraviolet (UV) solar radiation and suspected bursts of such radiation. The Instrumentation and Measurement Workshop in fiscal year 1984 established the improvement of the National Direct Beam Insolation Data Base and Monitoring Network as a number one priority for instrumentation and measurement in the Solar Thermal Program. This critical need is the direct result of two unrelated circumstances affecting the National Direct Beam Data Base. First, prior to 1975 almost no direct beam measurements had been made within the United States. For this reason, the direct beam data contained within the SOLMET and ERSATZ data bases and the Solar Radiation Energy Resource Atlas of the United States were generated in their entirety by computer models. Recent evaluations of these models have shown the potential for 10 percent to 30 percent errors. The second unfortunate circumstance, solar tracker and data recording failures, has seriously degraded the quantity and quality of direct beam data collected by the National Weather Service Solar Radiation Network since 1977. In cooperation with NOAA, SERI will assist in the evaluation of improved solar trackers.

There has been recent speculation that short bursts of ultraviolet energy at wavelengths less than 300 nm may initiate and/or accelerate the degradation of polymer materials. Since there are no known instruments capable of detecting and measuring bursts of ultraviolet energy in selected spectral bands, the development of such an instrument is being undertaken. The results of this research will directly impact the development of silver polymer reflectors under Program Element 1.0.

PROGRESS

Solar Tracker Evaluations

Two position sensors, using solid-state quadrature detectors, have been constructed and tested. Their use at SERI's Solar Radiation Research Laboratory (SRRL) and at Bluefield State College have been delayed by a number of factors, including the establishment of a subcontract with Bluefield State and electrical power problems at SRRL. The subcontract with Bluefield State should be effective June 1, 1985, and a plan for solving the electrical problems at SRRL should be accomplished by late June or early July. It is anticipated, therefore, that the solar tracker evaluations will begin at both locations during the month of July. The significance of this work has been increased by NOAA's plans to upgrade the National Solar Radiation Network. A major part of this upgrade will include the replacement of solar trackers at 31 of the 38 stations in the Network. Solar radiation measurments at the other 7 stations will be discontinued. SERI has entered into a cooperative program with NOAA to assist in the collection, processing, and archiving of high quality solar radiation data suitable for the DOE solar energy programs and for NOAA's climate change and energy balance projects. The first two actions taken to implement such cooperative efforts are: (1) SERI's tracker evaluation effort, and (2) NOAA's appointment of E. L. Maxwell, Task Leader for Program Element 6.0, to serve on the technical evaluation board which will evaluate proposals for the development of improved trackers. Both of these initial efforts are specifically directed toward the improvement of the National Direct Beam Data Base, which is of vital importance to the Solar Thermal Program.

Direct Beam Data Base Evaluations

The direct beam data base evaluations were delayed by the request from DOE to provide assistance to Babcock and Wilcox toward the assessment of direct beam solar resources at a proposed solar thermal power plant in the Dominican Republic. A plan for participating in the assessment of direct beam resources at Monte Cristi was completed. The equipment required for this project was ordered, and a request for foreign travel was submitted and subsequently granted. Currently, the effort for the Dominican Republic is on hold until Babcock and Wilcox receives a Letter of Credit authorizing expenditures for the project.

With the Dominican Republic project on hold, a renewed effort to evaluate the direct beam data bases is being undertaken. This activity includes the evaluation of the models used in generating the SOLMET and ERSATZ data bases, an evaluation of the sensitivity of these models to errors in the data input to the models, and the development of an improved procedure for evaluating the quality of the direct beam data measured from 1977 to the present. A significant report on this effort will be available in draft form by the end of calendar year 1985.

Ultraviolet Spectroradiometer Development

A Request for Purchase (RFP) for the development of an ultraviolet spectroradiometer and for the collection of ultraviolet radiation data was issued during the month of May. Preliminary studies of ultraviolet burst phenomena failed to establish any sound basis for the existence of such phenomena. Therefore, the RFP calls for the development of a simple unsophisticated instrument capable of determining if such phenomena do exist. If significant bursts of ultraviolet energy are detected as a result of this initial effort, a more sophisticated instrument will be required for long-term monitoring and more precise characterization. The results of the proposed evaluations will be reported in the next bimonthly report. Awarding the contract should be accomplished during this fiscal year, but most of the work will be carried out during fiscal year 1986.

REPORT CONTRIBUTION

A. Field Task Agreement 510A COLLECTION RESEARCH

1.0	Optical Materials Research	P. Schissel
2.0	Concentrator Research	M. Murphy
3.0	Receiver Research	M. Carasso

B. Field Task Agreement 511A CONVERSION, INNOVATIVE SYSTEMS AND APPLICATIONS

4.0	Thermochemical and Photochemical Research	G. Nix
5.0	Innovative Concepts and Applications	G. Nix
6.0	Resource Assessment	E. Maxwell

SOLAR THERMAL RESEARCH PROGRAM SUBCONTRACTS

Subcontractor	WBS Number	Subcontract Title/Activity	Value (000$)	Type Business	Status	Technical Monitor
The 3M Company	1.0	Silver/polymer reflector material research	Cost Shared Subcontract of 199.5	Industrial Firm	Awarded	P. Schissel
Jet Propulsion Laboratory	1.0	Stabilization of polymer materials against UV degradation	To Be Determined	Federal Laboratory	Planned for award in April, 1985	P. Schissel
University of Denver	1.0	Stabilization of Silver/ Polymer reflector materials against UV degradation	To Be Determined	University	Planned for award in April, 1985	P. Schissel
To Be Determined	1.0	Protection of front surfaced mirrors from environmental exposure	To Be Determined	To Be Determined	Planned for award in June, 1985	P. Schissel
University of Denver	1.0	Polymer-protected silver mirrors and mirror degradation mechanisms	42.0	University	Awarded in FY 1984 and continuing into FY 1985	P. Schissel
Southern Research Institute	1.0	Development of novel protective coatings for solar reflectors	68.3	Not-for-profit Corporation	Awarded	G. Nix
To Be Determined	1.0	Optically uniform surfaces	To Be Determined	To Be Determined	Planned for award in July, 1985	M. Murphy
To Be Determined	1.0	Polymer laminates for stretched membrane reflectors	To Be Determined	Industrial Firm	Planned for award in July, 1985	M. Murphy

SOLAR THERMAL RESEARCH PROGRAM SUBCONTRACTS

Subcontractor	WBS Number	Subcontract Title/Activity	Value (000$)	Type Business	Status	Technical Monitor
DAN/KA Products	2.0	Design and fabrication of five scale-model stretched membrane reflector modules	110.0	Solar Thermal Industrial Firm/Small Business	Awarded in FY 1984 and continuing into FY 1985	M. Murphy
Colorado State University	2.0	Identification and evaluation of wind avoidance/reduction schemes for concentration collectors	70.0	University	Awarded in FY 1984 and continuing into FY 1985	M. Murphy
Consulting Agreement with Dr. Sachin Bhaduri (University of Texas/El Paso)	2.0	Provision of technical support to SERI on wind avoidance/ reduction schemes for concentrating collectors	7.0	Consulting Agreement	Awarded in FY 1984 and continuing into FY 1985	M. Murphy
Consulting Agreement with Dr. Bing Chen (University of Nebraska/Omaha)	2.0	Design, fabrication and evaluation of experimental RF systems for controlling heliostat fields	7.0	Consulting Agreement	Awarded in FY 1984 and continuing into FY 1985	M. Murphy
Consulting Agreement with Dr. James Pearson (John Brown University, Siloam Springs, AK)	2.0	Design, fabrication and evaluation of experimental RF systems for controlling heliostat fields	7.0	Consulting Agreement	Awarded in FY 1984 and continuing into FY 1985	M. Murphy
University of Arizona	2.0	Fabrication and evaluation of graphite fiber composite solar concentrators	30.0	University	Awarded in FY 1984 and continuing into FY 1985	M. Murphy
Acurex Solar, Inc.	2.0	Silver/metal reflector materials evaluation	11.0	Solar Thermal Industrial Firm	Awarded in FY 1984 and continuing into FY 1985	P. Schissel

SOLAR THERMAL RESEARCH PROGRAM SUBCONTRACTS

Subcontractor	WBS Number	Subcontract Title/Activity	Value (000$)	Type Business	Status	Technical Monitor
Consulting Agreement with Dr. A. H. Soni (Oklahoma State University)	2.0	Analysis and design of adjustable cable restraints for air-inflated heliostat drive/supports	10.0	Consulting Agreement	Awarded in FY 1984 and continuing into FY 1985	R. Wood
Acurex Solar Corporation	2.0	Holographic solar concentrators	205.7	Solar Thermal Industrial Firm	Awarded Follow-on anticipated in November, 1985	G. Nix
University of Nebraska/Omaha	2.0	Stretched membrane reflector dynamic analysis	To Be Determined	University	Final Negotiations in Progress	M. Murphy
Colorado State University	2.0	Wind response on stretched membrane reflectors	To Be Determined	University	Follow-on research planned for award in April 1985	M. Murphy
University of Arizona	2.0	Composite structural materials for stretched membrane reflector modules	78.8	University	Awarded	M. Murphy
ENTECH, Inc.	2.0	Evaluation of refractive concentrators	40.0	Solar Thermal Industrial Firm/Small Business	Final Negotiations in Progress	M. Murphy
Dan-Ka Products, Inc.	2.0	Stretched membrane reflector structural requirements definition	To Be Determined	Small Business	Follow-on planned for award in May, 1985	M. Murphy

SOLAR THERMAL RESEARCH PROGRAM SUBCONTRACTS

Subcontractor	WBS Number	Subcontract Title/Activity	Value (000$)	Type Business	Status	Technical Monitor
Georgia Institute of Technology	1.0 3.0	University research in support of the FY 1985 Solar Thermal Research Program (Thermal materials, direct absorption, etc.)	660.0	University	Awarded	G. Nix
Georgia Institute of Technology	3.0	Operation and maintenance of the Advanced Components Test Facility (ACTF)	235.0	University	Awarded	G. Nix
Consulting Agreement with Dr. Richard Bradt (University of Washington)	3.0	Four-point flexural testing and provision of technical support to SERI on high temperature materials	9.0	Consulting Agreement	Awarded in FY 1984 and continuing into FY 1985	T. Coyle
Black & Veatch Consulting Engineers	3.0	Research program planning support to SERI	75.0	Solar Thermal Industrial Firm	Awarded in FY 1984 and continuing into FY 1985	L. Shannon
Consulting Agreement with Mr. Conrad M. Vineyard (Loveland, CO)	3.0	Solar thermal technology cost estimation technical support	10.0	Consulting Agreement	Awarded in FY 1984 and continuing into FY 1985	M. Murphy

SOLAR THERMAL RESEARCH PROGRAM SUBCONTRACTS

Subcontractor	WBS Number	Subcontract Title/Activity	Value (000$)	Type Business	Status	Technical Monitor
Consulting Agreement with Mr. George M. Kaplan (Reston, VA)	3.0	Solar Thermal Research Program Support	5.0	Consulting Agreement	Awarded in FY 1984 and continuing into FY 1985	B. Gupta
Industrial Welding Supply	3.0	Fabrication of a 900°C molten salt test loop	226.0	Industrial Firm	Awarded	M. Carasso
To Be Determined	3.0	Cyclic heating effects	To Be Determined	To Be Determined	Award Date to Be Determined Later	P. Schissel
To Be Determined	3.0	Acquisition of high flux experiment hardware	To Be Determined	To Be Determined	Planned for award after completion of detailed engineering design	A. Lewandowski
University of Houston	3.0 4.0	University research in support of the FY 1985 Solar Thermal Research Program (Photodegradation research, thermochemical energy storage systems, etc.)	350.0	University	Awarded	G. Nix
Hughes Aircraft Company	4.0	Thermoelectrochemical converter research	221.7	Industrial Firm	Awarded	G. Nix
University of New Hampshire	4.0	Solar photochemical production of fuels and chemicals	56.0	University	Awarded	G. Nix
Lawrence Berkeley Laboratory	4.0	Direct radiant heating of solid suspensions	To Be Determined	Federal Laboratory	Follow-on research	G. Nix

SOLAR THERMAL RESEARCH PROGRAM SUBCONTRACTS

Subcontractor	WBS Number	Subcontract Title/Activity	Value (000$)	Type Business	Status	Technical Monitor
University of Hawaii	4.0	Direct flux decomposition of particles	To Be Determined	University	Follow-on research planned for award in May 1985	G. Nix
Hughes Aircraft	4.0	Thermoelectrochemical conversion devices	To Be Determined	Industrial Firm	Follow-on research planned for award in January, 1986	G. Nix
To Be Determined	4.0	Nonequilibrium reactions	To Be Determined	To Be Determined	Award date to be determined Later	D. Johnson
University of Arizona	5.0	Spectrally selective beam splitters for thermally decoupled quantum/thermal hybrid systems	69.5	University	Awarded	G. Nix
Hughes Aircraft Company	5.0	New ideas for solar thermal conversion (Welsback Effect Research)	58.9	Industrial Firm	Awarded	G. Nix
University of Chicago	5.0	Compound optical systems with maximal concentration for solar thermal conversion	77.1	University	Awarded	G. Nix
To Be Determined	5.0	Innovative Concentrators	To Be Determined	To Be Determined	Planned for award in late FY 1985	M. Murphy

SOLAR THERMAL RESEARCH PROGRAM SUBCONTRACTS

Subcontractor	WBS Number	Subcontract Title/Activity	Value (000$)	Type Business	Status	Technical Monitor
Radiation Research Associates	6.0	Generation of Monte Carlo simulation estimates of attenuation and scattering between heliostats and a receiver	25.0	Small Business	Awarded in FY 1984 and continuing into FY 1985	G. Maxwell
Bluefield State University	6.0	Resource data monitoring	7.5	Historically Black University	Awarded	G. Maxwell
To Be Determined	6.0	UV burst effects	To Be Determined	To Be Determined	Planned for award in June, 1985	G. Maxwell

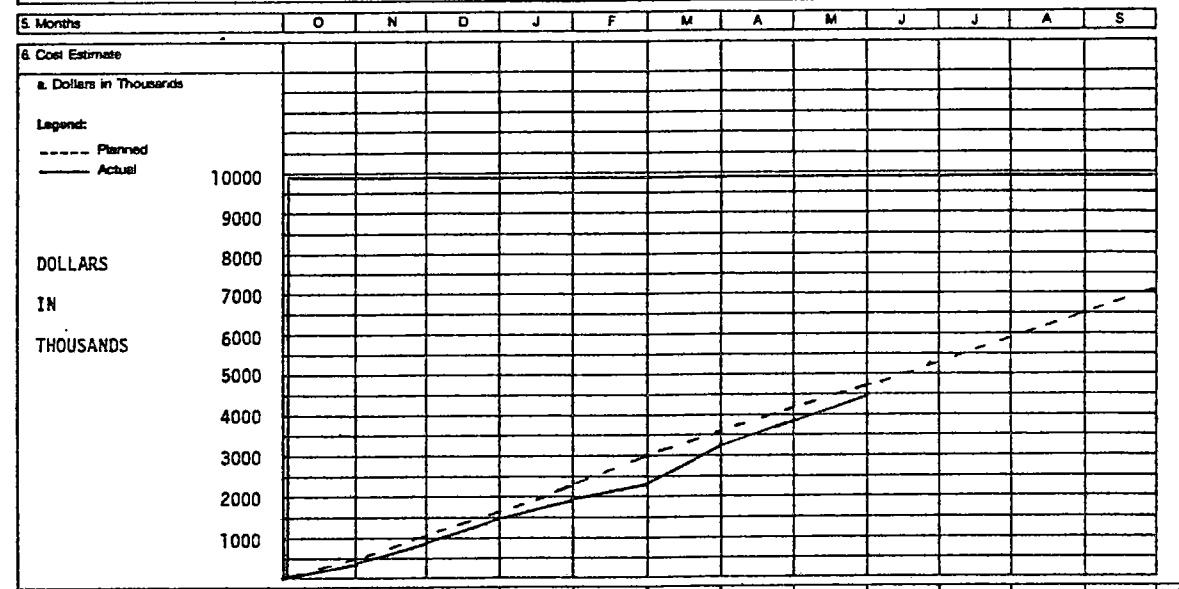
APPENDIX B

RESOURCE EXPENDITURE

RESOURCE EXPENDITURE

Budget Status

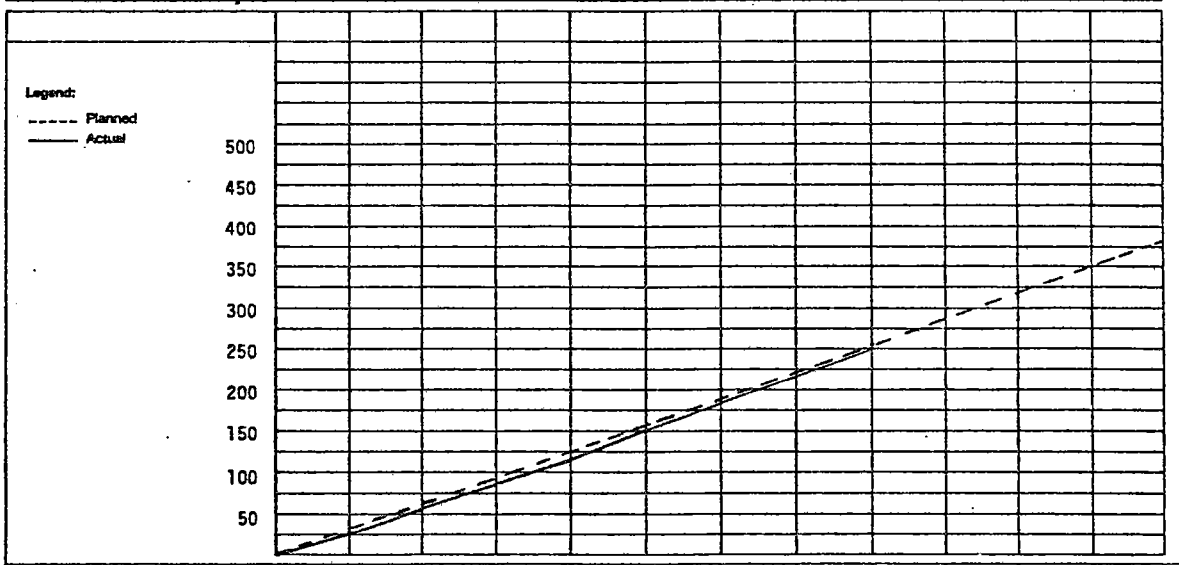
1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401	From: 10/1/84 To: 9/30/85
3. Program Identification: FY1985 Solar Thermal Research Program	
4. WPA/Task: COST SUMMARY: OVERALL PROGRAM TOTALS	



Accrued Costs		O	N	D	J	F	M	A	M	J	J	A	S	
	b. Planned	499	1047	1608	2350	3030	3568	4172	4752	5353	5916	6468	7021	b. Planned
	c. Actual	458	969	1517	1936	2398	3231	3862	4432					c. Actual
	d. Variance	41	78	91	414	632	287	310	320					d. Variance

Manpower

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401	From: 10/1/84 To 09/30/85
3. Program Identification: FY1985 Solar Thermal Research Program	
4. WPA/Task: FTE SUMMARY: OVERALL PROGRAM TOTALS	

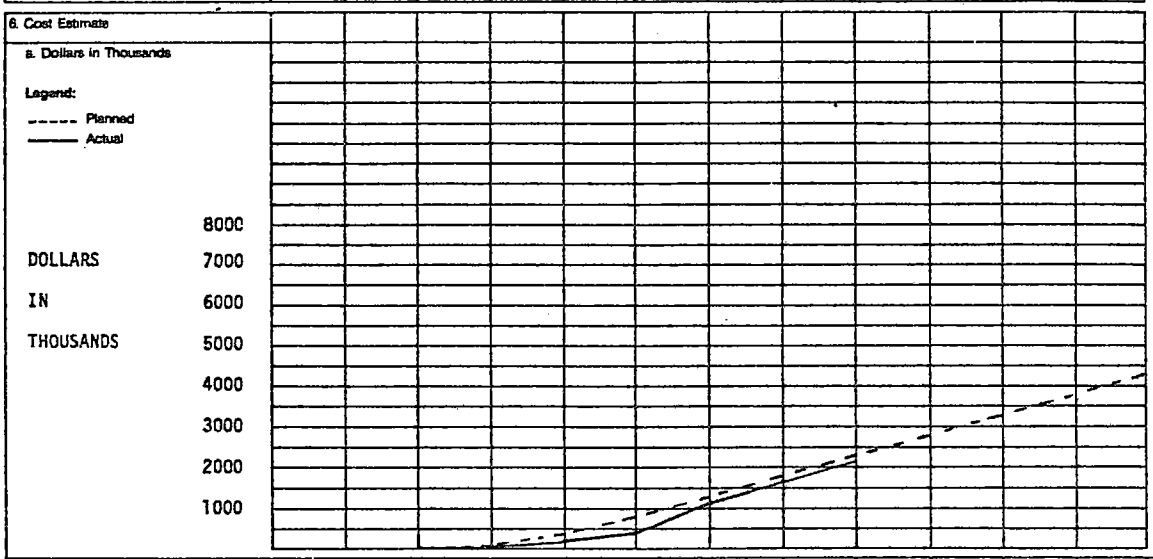


		O	N	D	J	F	M	A	M	J	J	A	S	
	Planned	29.8	60.1	89.4	126.4	160.9	191.7	225.93	256.7	287.6	318.3	348.9	380.0	Planned
	Actual	26.7	56.3	83.8	119.7	155.4	188.5	222.92	253.5					Actual
	Variance	3.1	3.8	5.6	6.7	5.5	3.2	3.01	3.2					

RESOURCE EXPENDITURE

Budget Status

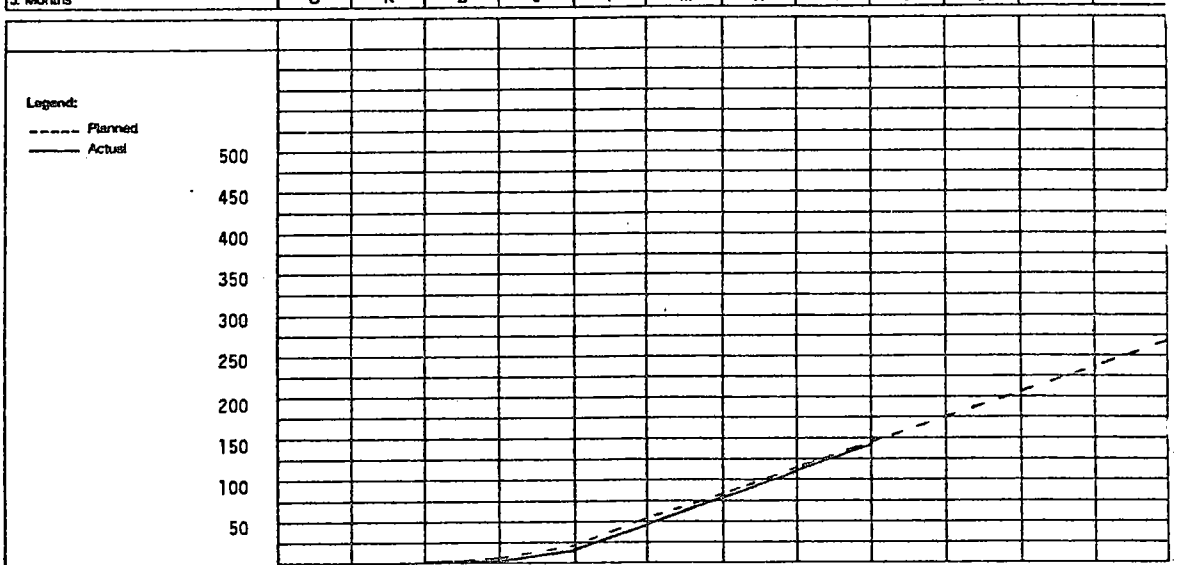
1. Contractor (name and address)	Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401
2. Reporting Period	From: 10/1/84 To: 9/30/85
3. Program Identification	FY1985 Solar Thermal Research Program
4. WPA/Task	COST SUMMARY: FY1985 FTA 510 and FTA 511



Accrued Costs		O	N	D	J	F	M	A	M	J	J	A	S	
	b. Planned	0	0	22	417	858	1303	1802	2292	2776	3256	3725	4193	b. Planned
	c. Actual	0	0	12	189	469	1202	1693	2133					c. Actual
	d. Variance	0	0	10	228	389	101	104	159					d. Variance

Manpower

1. Contractor (name and address)	Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401
2. Reporting Period	From: 10/1/84 To 09/30/85
3. Program Identification	FY1985 Solar Thermal Research Program
4. WPA/Task	FTE SUMMARY: FY1985 FTA 510 and FTA 511

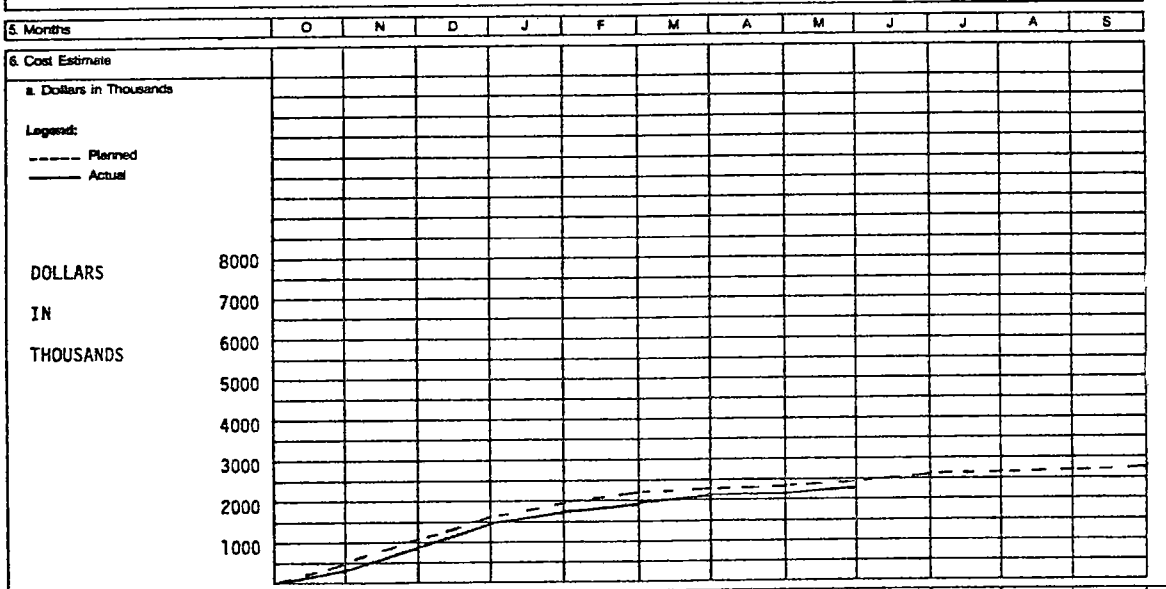


		O	N	D	J	F	M	A	M	J	J	A	S	
	Planned	0	0	2.5	23.7	52.8	82.4	116.6	147.3	178.2	208.9	239.5	270.6	Planned
	Actual	0	0	1.1	22.5	49.8	79.8	114.2	142.7					Actual
	Variance	0	0	1.4	1.2	3.0	2.6	2.4	4.6					

RESOURCE EXPENDITURE

Budget Status

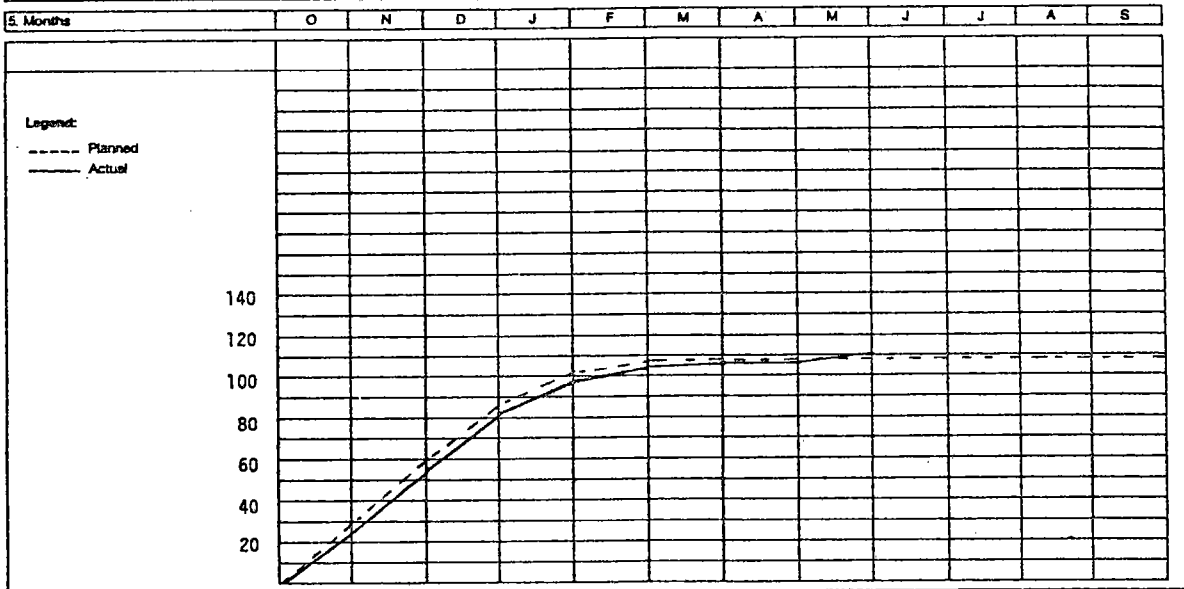
1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401	From: 10/1/84 To: 9/30/85
3. Program Identification: FY1985 Solar Thermal Research Program	
4. WPA/Task: COST SUMMARY: FY1982 - FY1984-FTA 416, FTA 417, FTA 440, FTA 463	



Accrued Costs		O	N	D	J	F	M	A	M	J	J	A	S	
	b. Planned	499	1047	1586	1933	2172	2265	2370	2460	2577	2660	2743	2828	b. Planned
	c. Actual	458	969	1505	1747	1929	2079	2164	2299					c. Actual
	d. Variance	41	78	81	186	243	186	206	161					d. Variance

Manpower

1. Contractor (name and address)	2. Reporting Period
Solar Energy Research Institute 1617 Cole Boulevard Golden, Colorado 80401	From: 10/1/84 To 09/30/85
3. Program Identification: FY1985 Solar Thermal Research Program	
4. WPA/Task: FTE SUMMARY: FY1982 - FY1984 - FTA 416, FTA 417, FTA 440, FTA 463	



		O	N	D	J	F	M	A	M	J	J	A	S	
	Planned	29.8	60.1	86.9	102.7	108.1	109.3	109.33	109.4	109.4	109.4	109.4	109.4	Planned
	Actual	26.7	56.3	82.7	97.2	105.6	108.7	108.72	110.8					Actual
	Variance	3.1	3.8	4.2	5.5	2.5	.6	.61	(1.4)					

SERI
SOLAR THERMAL ENERGY PROGRAM
PUBLICATIONS

Clausing, A., (In progress) Effect of Variable Fluid Properties on Convective Losses from Solar Receivers. Golden, CO: Solar Energy Research Institute.

Copeland, R. J.; Newell, T. A.; Wang, K. Y. (In progress) A Report on Direct Absorption Receiver Falling Film Flow Characteristics. SERI/TR-252-2641. Golden, CO: Solar Energy Research Institute.

Coyle, R. T., Thomas, T. M., and Schissel, P. (In progress) The Corrosion of Material in Molten Alkali Carbonate Salt at 900°C: FY 1984 Progress Report. SERI/PR-255-2553. Golden, CO: Solar Energy Research Institute.

Coyle, R. T., Thomas, T. M., and Schissel, P. (In progress) The Corrosion of Selected Alloys in Eutectic Lithium-Sodium-Potassium Carbonate at 900°C. SERI/TR-255-2561. Golden, CO: Solar Energy Research Institute.

Gee, R. (In progress) A Simple Energy Calculation Model for Solar Industrial Process Heat Steam Systems. SERI/TR-253-1871. Golden, CO: Solar Energy Research Institute.

Gordon, R. (In progress) A Simple Energy Calculation Model for Solar Industrial Process Heat Steam Systems. SERI/TR-253-1871. Golden, CO: Solar Energy Research Institute.

Lazaridis, A.; Copeland, R.; Althof, J. (In progress) Temperature Distribution in a Solar Irradiated Liquid Layer Flowing Over a Wall of an Optical Cavity. SERI/TR-252-2221. Golden, CO: Solar Energy Research Institute.

Masterson, K.; Jorgensen, G.; Burrows, R.; Schissel, P. (In Progress) An Integrating Sphere Spectrometer for Optical Characterization of High Temperature Materials. Golden, CO: Solar Energy Research Institute.

Maxwell, E. (In progress) An Assessment of Instrumentation and Measurement Needs of the Solar Thermal Technology Program. SERI/TR-215-2611. Golden, CO: Solar Energy Research Institute.

Maxwell, E. (In progress) Spectral Measurements at the Solar One Power Plant. SERI/TR-215-2612. Golden, CO: Solar Energy Research Institute.

Meyer, R. T. Hersch, P., editors. (In progress) Silver/Glass Mirrors for Solar Thermal Systems. SERI/SP-281-2293. Golden, CO: Solar Energy Research Institute.

Murphy, L. M. (In progress) A Variational Approach for Predicting the Load Deformation Response of a Double Stretched Membrane Reflector Module. SERI/TR-253-2626. Golden, CO: Solar Energy Research Institute.

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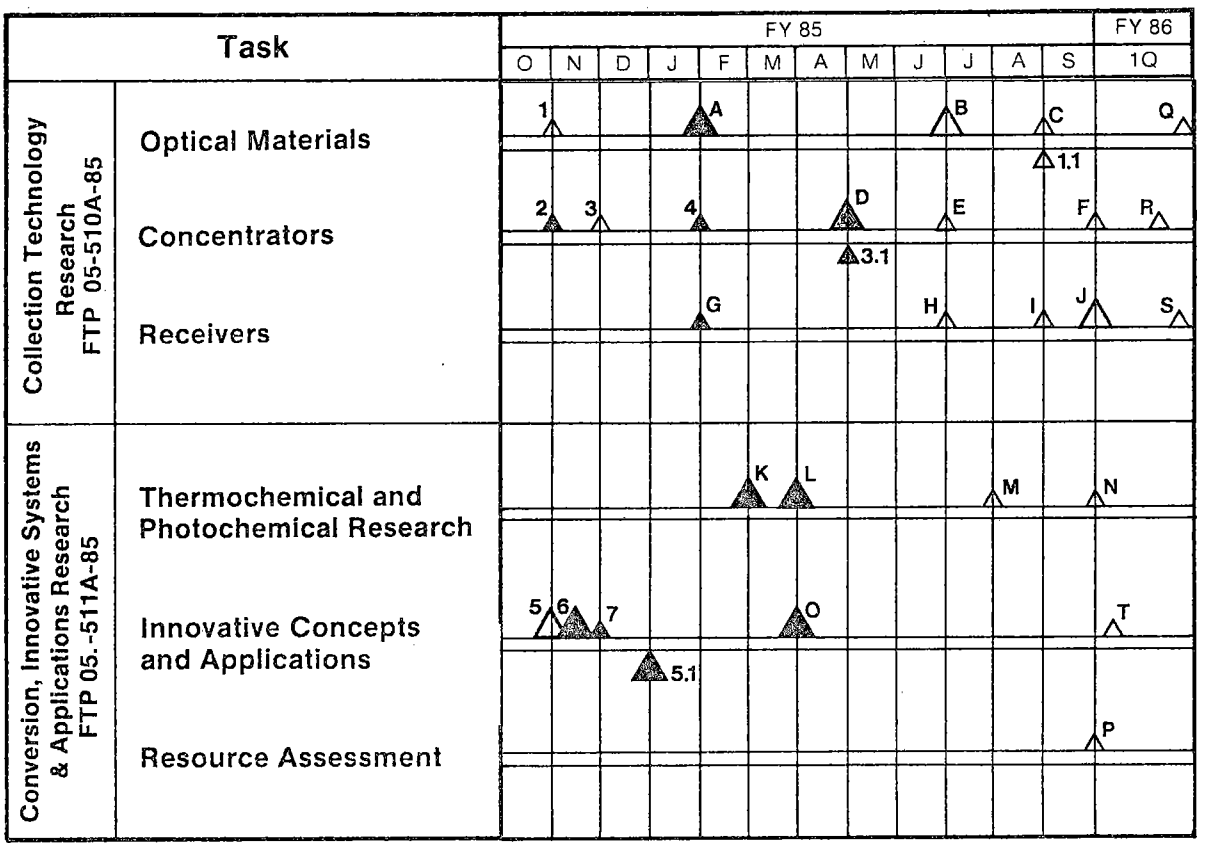
Solar Thermal

Major Milestone Schedule



FY84 Funded Effort (FTP 05-463--84)

1. 3M film surface durability improvement
2. Membrane surface deformation and tension load effects
3. Membrane comparison with glass/metal heliostat
4. Membrane frame coupling concept
5. Award Phase II innovative research contracts
6. Award new innovative research contracts
7. Experimental H yield from 10 sun photoconversion process

FY85 Funded Effort

A. Silver/polymer UV protection approaches
B. Solar test on mosaic windows
C. Silver/polymer film samples with UV protection
D. Steel membrane module performance projection
E. Wind load reduction concepts for concentrators
F. Fresnel lens concept assessment
G. Award 900°C loop fabrication contract
H. Carbonate salt and Inconel optical properties up to 900°C
I. Four wavelength pyrometer experience and data
J. Direct absorption receiver concept feasibility
K. Evaluate research progress in unique and beneficial use of concentrated solar flux
L. Concentrated flux effects on surface reaction
M. Materials effects experiments with concentrated flux
N. High flux experiment support equipment
O. Direct thermal conversion concepts evaluation
P. UV radiation measurement instrumentation
Q. Silver/polymer film useful service life prediction
R. New, innovative concentrator concepts assessment
S. Direct absorption concept benefits assessment
T. Recommend concepts for further evaluation

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