

Mapping Ocean Energy by Satellite

Scientists at the Research Triangle Institute (RTI) are studying patterns of ocean heat under contract to the Department of Energy. Their studies may have an important bearing on where the new ocean-going OTEC power plants should be located, perhaps helping to determine whether such plants are feasible at several sites near the mainland of the United States.

Current RTI research directly studies the resource base of OTEC. The temperature differentials in the oceans determine

Energy officials are very interested in being able to foresee such problems because OTEC plants, which are estimated to be more expensive to build than conventional power plants, must operate very reliably to be economical. Simply put, the plants are going to have to work full-time if they are to pay off their mortgages.

"Most of the information we now have on ocean temperature is based on long-term averages of in-situ (in-the-water) readings," said Dr. Vukovich. "Spatially and tempo-

rally, it's not great data, it's not very refined. We're interested in short-term phenomena that aren't well defined in these earlier studies," he said, citing "current migrations, upwelling of cold subsurface water, river outflows, and eddies of cold shelf water".

One place OTEC systems might be sited is in the Gulf Stream beyond the edge of the continental shelf extending from Florida. An "extension cord" would hook the plant into the Florida power grid.

At times, however, tongues of cold water over the continental shelf extend into the Gulf Stream, dropping the surface temperature as much as 10 degrees centigrade, enough to paralyze an OTEC plant in these waters.

"The eddies form about 60 miles northeast of Miami and move north," said Dr. Vukovich. "We're finding out where the affected regions are, and finding what regions are not affected. There are places where OTEC shouldn't go, and other places where it might do well."

(continued on Page 2)

The OTEC Liaison

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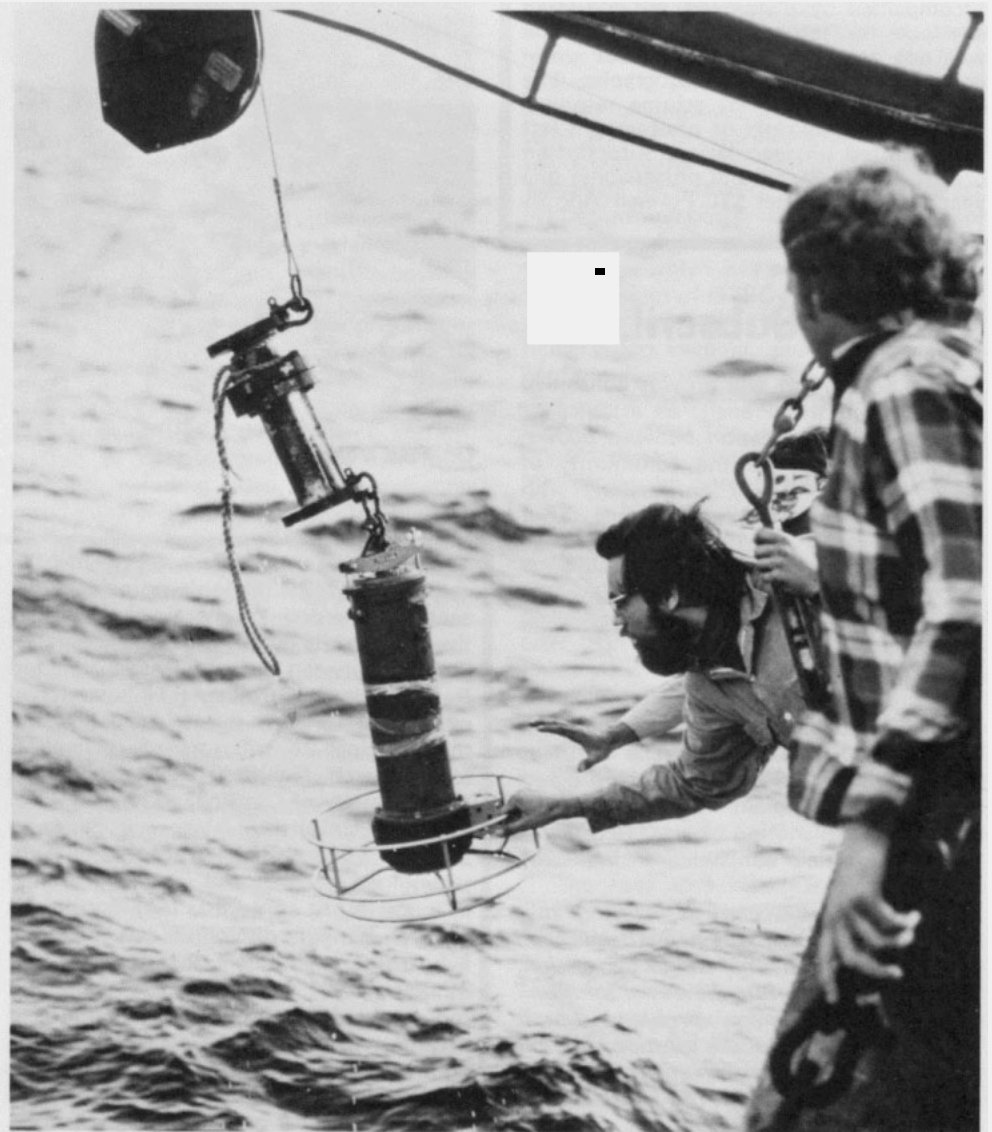
how much energy may be usable in a given area and at what efficiency. By studying these patterns RTI researchers can determine the frequency of occurrence of ocean-surface temperature changes which could shut down OTEC plants.

"OTEC needs a minimum difference of around 18 degrees centigrade (32 degrees Fahrenheit) between the temperature of the surface waters and of colder sub-surface waters," said RTI's Dr. Fred Vukovich, one of the nation's chief developers of means to use satellite data to map ocean temperatures. His work started in 1967, and since then Dr. Vukovich has used radiometry, computer enhancement methods, and a variety of other tools for ocean-temperature mapping by satellite.

The data come from satellites of NASA and of the National Oceanic and Atmospheric Administration (NOAA). Such satellites are often used for resource studies, but the most familiar product of NOAA satellites are the infrared weather images seen on TV weather reports. The satellites scan the earth and its atmosphere to detect infrared radiation, the intensity of which varies with the temperature of the land, sea, or clouds emitting the radiation. The temperature images which result are essentially photographs made with infrared, instead of visible, radiation.

The first real success for RTI ocean-temperature mapping came in 1972, when Dr. Vukovich began using satellite data specifically developed by NOAA for ocean-temperature mapping. Since then Dr. Vukovich has been able to describe ocean temperatures in great detail over areas thousands of miles square.

A key research goal is to describe and predict the intrusion of cold water into warm surface waters. Such intrusions could shut down an OTEC plant.



Meteorologist Bill King retrieves instrument.

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The OTEC Liaison will provide continued liaison [from the French: *an* instance *or* means of communication *between* bodies, groups, or *units*] to the community of ocean thermal-energy conversion, with response to your expressed needs. Your comments and criticisms are welcome

THE COUSTEAU SOCIETY ENDORSES OTEC

An article entitled "OTEC Update" in the November-December 1977 issue of the Calypso Log, published by The Cousteau Society, related to its readers the progress of OTEC development in recent years, including an explanation of an OTEC power plant. The article concluded with the following:

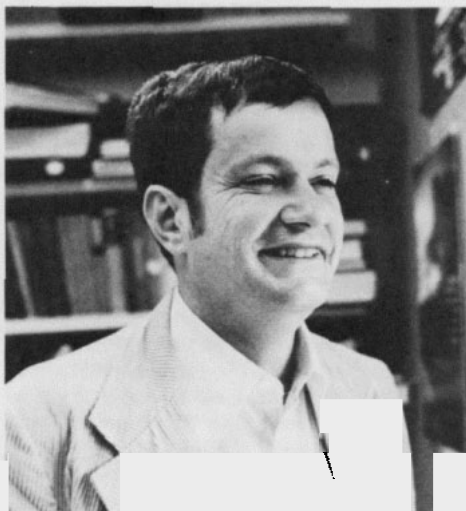
The Cousteau Society is delighted that the *US Department* of Energy has funded testing of ocean thermal energy conversion. OTEC is probably not the "final solution" to our nation's energy problems, but *it* might well be part of the solution. It looks technically feasible, and environmentally preferable to many of the other energy sources being considered today.

MAPPING OCEAN ENERGY BY SATELLITE

Preliminary studies by the Energy Research and Development Administration (ERDA, now a part of DOE) indicate that OTEC plants would not be feasible on the West Coast of the United States. Sites off the East Coast in the Gulf Stream are under study, as are sites in the Gulf of Mexico, although current changes and intrusions of cold Mississippi River water pose some problems there. Two areas which seem to have ideal ocean thermal resources are off Hawaii and Puerto Rico.

On Dr. Vukovich's team, Bobby Crissman is analyzing the Gulf of Mexico temperature variations. Bill King and Mark Bushnell are studying the Gulf Stream off Georgia and the east coast of Florida.

"I took the easy one," said Dr. Vukovich, "Puerto Rico." The waters there have very few temperature perturbations, he said, offering good potential for OTEC year-round.



Dr. Fred Vukovich

Research Triangle Park (RTI) has become one of the nation's prime research centers, reversing the "brain drain" from the South of its brightest college graduates. Situated between Durham, Chapel Hill, and Raleigh, North Carolina, RTI is stretched over 5400 acres in this triangle between the principal contributors of researchers and research facilities: Duke University, the University of Carolina, and North Carolina State University.

Since 1968 this major center of high-technology research and industry, formed as a non-profit corporation doing contract research in many disciplines, has employed a full-time staff of about 900 with about 12,000 people occupied in jobs directly related to RTI. Both governmental and private organizations have facilities there, with volume tripling over the last five years, resulting in contract revenues of \$26 million for the fiscal year ending September 30th.

Ocean-temperature mapping by satellite (see the accompanying story) can only give information on the temperature of surface waters. To see the temperature profile of an eddy of cold water and understand how it mixes with warm waters such as the Gulf Stream, researchers have to get away from their labs and offices and onto the deck of a ship.

An RTI team headed by Bobby Crissman has recently completed ocean-going missions to gather data on ocean temperatures on depths down to 500 meters.

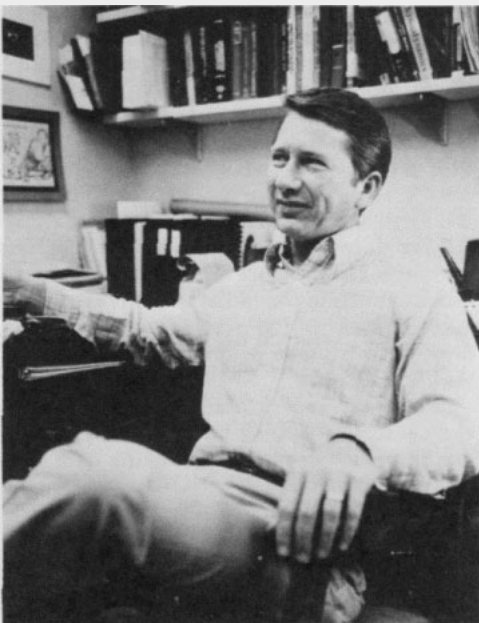
The team studied the formation of long tongues of cold water extending from the continental shelf and into the Gulf Stream off the North and South Carolina coasts.

Working under contract to NOAA, researchers manned a receiver at RTI to scan satellite images of the ocean area. When they saw one of the eddies developing between Cape Romaine and Cape Hatteras, a phone call to NOAA officials arranged for the most detailed satellite images—by Very High Resolution Radiometer—to be saved by NOAA for later analysis at RTI.

Then Crissman's team left for the coast. The captain of the North Star, a research vessel owned by Cape Fear Technical Institute in Wilmington, welcomed them aboard and then cast off to sail into the eddy. Traversing the eddy, the ship stopped every 10 miles and instruments were lowered to measure temperature and salinity. Free-drifting buoys were launched and, by automatically signaling their position via NASA satellite, transmitted data on the eddy currents they were riding.

In this way, surface temperatures and currents were mapped and deep-water temperatures probed.

Four such sea-going missions were carried out since the project began in March. The resultant data are now being prepared for analysis.



Bobby Crissman

US GOVERNMENT
PROCUREMENT INVITATIONS
AND CONTRACT AWARDS

Listed below are procurement invitations and contract awards related to OTEC in particular and ocean resources in general, culled from the Commerce Business Daily. This is not to be construed, however, as a complete list.

Dec 8: Determine Potential for Application of Energy Systems at Navy Sites: Phase I shall consist of development of survey approach which includes methodology for matching critical operational and economic characteristics of alternative power sources to Navy base energy demand and siting factors. If a computer program is the most expedient means of performing the calculations for such a survey, it must be completed prior to beginning Phase II. Phase II shall consist of a survey of power systems leading to energy self-sufficiency at Navy bases, and preparation of a report comparing the alternative power sources available to the Navy shore establishment and the potential application scenario for these alternatives optimally applied at all Navy bases. Selection evaluation criteria shall consist of (1) capability and experience in design and operations characteristics of power systems, many of which are in the development stage; (2) experience and expertise in formulating complex analytical models and translating models to efficient computer logic for use by others; (3) knowledge of energy systems as utilized at Navy activities; and (4) location of the firm in the general geographical area of CEL. Interested firms submitting a completed Standard Form 2541255 within seven calendar days after the publication of this announcement will be considered for selection. Firms having a current SF 254 on file with this office must submit a completed SF 255. This is not a request for proposal. No other general notification will be made. Direct all inquiries to Opal Forde, (805) 982-5506. Reference 78009. See Note 63. (P339) Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme CA 93043, Attn: Code L23.

Dec 9: Research Concerning Leading Edge Cavitation: Negotiations are to be conducted with Hydronautics Inc., 7210 Pindell School Road, Laurel MD 20810.

Dec 9: Research on Partially Cavitating Cascade Flows: Negotiations are to be conducted with Tetra Tech Inc., 630 North Rosemead Boulevard, Pasadena CA 91107.

Dec 12: System Support Services for the Atmospheric and Oceanographic Information Processing System (AOIPS) Facility at GFSC: Job RFP 5-96633-256. GSFC intends to negotiate a contract with General Electric Company. See Notes 27 and 40. NASA, Goddard Space Flight Center, Attn: Ron Atherholt, Greenbelt Road, Greenbelt MD 20771.

Dec 19: Computer Program: "Special Oceanwave Model": Contract N00228-77-C-3161, 30 Sep 77 (N00228-77-R-3161), four items, for \$63,842 to Control Data Corporation, 205 Montecito Avenue, Monterey CA 93940. Naval Supply Center, Oakland CA 94625.

Dec 23: Survey and Analysis of Solar Energy Procurement Activity for Small Business and Minority Business Participation: Negotiations are being conducted with Techmatics Corporation, Falls Church VA 22042. Contract ET-78-C-01-2869. (P354) Department of Energy, Office of Procurement Operations, Washington DC 20545.

Dec 23: Basic Research in Oceanography including physical, chemical, and biological oceanography and marine geology, geophysics, and acoustics: Contract N00014-75-C-0152, 22 Nov 77 (no RFP) for \$75,000 to University of California, La Jolla CA 92093.

Dec 27: Deep Ocean Cable Burial System Subsystem Concept and Feasibility Study: Based on an overall Deep Ocean Cable Burial System configuration provided by the Government, the contractor shall develop concepts for; assess feasibility of; and produce cost, weight, and size estimates for the required auxiliary subsystems. The subsystems include thrusters, power, control navigation, and support-ship requirements.

The contractor shall conduct a literature search, perform preliminary design analyses as necessary to determine the feasibility of the required subsystems, identify possible problem areas, recommend development work required, and predict the probability of success relative to the operational requirements. Selection evaluation criteria shall consist of experience of personnel in: (1) design, analysis, development, and operation of deep-ocean remote-controlled systems, including video, sonar, and command/control systems; (2) electro/hydraulic servo systems, feedback controls, and deep-ocean power-conditioning and power-conversion systems; (3) high-power transmission to deepocean equipment and electromechanical (E/M) cable design and/or specifications; and (4) developing concepts and Performing engineering feasibility studies and trade-off analyses in deep-ocean remote-controlled systems and subsystems as in (1) through (3) above.

Interested firms submitting a completed SF Form 2541255 within 15 calendar days after publication of this announcement will be considered for selection. Firms having a current SF 254 on file with this office must submit a completed SF 255. This is not a request for proposal. No other general notification will be made. Direct all inquiries to Opal Forde, (805) 982-5506. Reference 78-0013. See Note 63. (P356) Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme CA 93043. Attn: Code L23.

Dec 27: Study: Feasibility of Mangane Nodule Industry in Hawaii: Contract 7-35369 for \$25,000 to State of Hawaii, Honolulu HI 96804.

Dec 27: Systems Program Definition for a National Oceanlab System: Contract 7-35252 for \$1,167,000 to General Electric Company, Philadelphia PA 19101.

Dec 27: Marine Instrument Technology Assessment: Contract 7-35281 for \$48,479 to MAR Inc., Rockville MD 20652.

● **Dec 30:** System Integration Contractor (SIC) to Design, Fabricate, Convert/Modify, Assemble, Test, Deploy, Manage, and Operate an Ocean Test Platform for DOE's Ocean Thermal Energy Conversion (OTEC) test program: The platform and test loop are designated OTEC-1. The mission of the OTEC-1 Early Ocean Test Platform system is to conduct tests for evaluation of heat exchangers and other components composing an OTEC energy plant. This project is part of the DOE Solar Energy Division program to demonstrate technical and engineering feasibility of the concept of converting ocean thermal energy into realistic quantities of usable energy. Objectives of testing OTEC plant components under ocean operating conditions on a platform include: (1) assessing developing heat exchanger technology; (2) determining long term effects of biofouling and corrosion; (3) determining the effect of cleaning techniques on performance of heat exchangers; (4) performing power-cycle operations; (5) supporting data collection and processing test results which will provide the data for future designs of OTEC plants; and (6) providing ocean-engineering baseline data on hull, station keeping, and cold-water pipe configuration.

The work is proposed to be accomplished in three phases. The first phase will be the system design. The second phase will be fabrication (or modification) of the platform, cold-water pipe, other piping, and the OTEC closed-cycle ammonia loop; installation of the OTEC systems and heat exchangers; and site deployment. These two phases are anticipated to be complete no later than 18 months from contract award. Phase III will be operation of the OTEC-1 system on site (which will continue for approximately three years), and disposition of the OTEC-1. The SIC will be required to propose a site for the planned operation of OTEC-1 which satisfies DOE requirements and is compatible with the SIC's proposed designs.

The heat exchangers to be tested on OTEC-1 will be provided as Government Furnished Equipment (GFE). The Hughes Mining Barge (HMB) will also be provided as GFE (in its present state) should the SIC decide to use the HMB for conversion as the OTEC-1 platform. The actual test and evaluation of the heat exchangers is not included in the SIC's scope of work; however the SIC will be required to provide test-support services.

In order to contract with DOE, proposers must be financially sound and must have an acceptable accounting system and the ability to comply with Government regulations, including equal-opportunity and minority-business requirements. The Government is currently planning to award one cost-plus-fixed-fee contract for the first two phases of effort. The contract will include an option for Phase III, Operations, which is currently anticipated to be a cost-plus-award-fee arrangement. DOE intends contract award to be approximately September 1978.

For those interested in inspecting the Hughes Mining Barge, a tour will be conducted at Hunters Point Naval Shipyard, San Francisco, between 2 and 4 pm 6 Feb 78. A preproposal conference will be held 7 Feb 78 at the San Francisco Operations Office, 1333 Broadway in Oakland CA, beginning at 9:30 am in Room 620. Written questions regarding the RFP or the requirements to be satisfied for this procurement will be responded to at the conference provided the questions are received on or before 30 Jan 78.

Proposals will be evaluated on the following criteria: (I) **Technical Proposal:** (A) Proposed technical approach including demonstrated comprehension of objectives and roundness of technical approach (within the prescribed technical requirements and schedules) for (1) cold-water pipe; (2) vessel conversion; (3) power system; (4) site selection; (5) operations, including expected system availability and integrated logistics support; and (6) instrumentation, control, and testing support. (B) Project organization including the SIC's technical experience on comparable projects; top management involvement: proposed facilities; and subcontracting arrangements. Adequacy of key personnel and project team including resources; ability to manage interfaces; and relationship to company structure. Management systems and overall management approach for this project including proposed project controls: planning, cost estimating, and scheduling; contracting methods; overall project documentation; safety; quality assurance; and value engineering. (III) **Business Proposal:** including reasonableness of proposed costs and probable costs to the Government; acceptance of the pro-forma contract (or acceptability of proposed deviations and/or exceptions); acceptability of any technical data proposed to be withheld; proposed usage of GFE equipment other than listed GFE equipment/facilities; demonstrated commitment of organization or team; and extent of small business/minority business participation.

The principal point of contact for this procurement is the OTEC-1 SEB Secretary. The RFP associated with this procurement will be available on or about 5 Jan 78. Concerns which have not responded previously and which desire to be put on the mailing list for receipt of RFP ET-78-R-03-1785 should submit a written request with three self-addressed labels. Telephone requests will not be honored. The Govern-

ment plans to prepare a reference-information package summarizing DOE-conducted studies of various aspects of the OTEC-1 design to date. The package includes site environmental profiles and studies of the HMB platform, CWP, and other subsystems related to this project. This package is available upon written request to the SEB Secretary. All requests must include a non-refundable remittance of \$100 per package for printing. Checks should be made payable to: Department of Energy. This package is for reference only, and the Government, Government employees, or contractors make no warranty expressed or implied and assume no legal liability or responsibility for the accuracy, completeness, or usefulness for any purpose of the reference information package. This is not a request for proposal. (P362) Department of Energy, 1333 Broadway, Oakland CA 94612, Attn: M. Voytilla. OTEC-1 SEB Secretary.

Jan 3: Study and Report to Compare Three Department of Interior Planning Methodologies Involving Outer Continental Shelf Development: A sole-source contract is being negotiated with David C. Williams, 1751 S Street NW, Washington DC. See Note 46. (P362) Department of the Interior, Office of the Secretary, Branch of Supply, Room 2659, Interior Building, 1800 E Street NW, Washington DC 20240.

UNIVERSITY OF MIAMI COMPLETES VIRGIN ISLANDS TESTING

Ocean engineers and marine scientists at the University of Miami have successfully completed a series of field experiments from a deep-moored barge in the Virgin Islands for testing of OTEC concepts.

Dr. H. Lee Craig, an ocean engineer; Drs. Barrie F. Taylor and Jack W. Fell, marine biologists; and Dr. Thomas N. Lee, an oceanographer, of the University's Rosenstiel School of Marine and Atmospheric Science, supervised tests run with aluminum-alloy pipe samples in experiments designed to determine the feasibility of using aluminum heat-exchanger surfaces in an OTEC plant and to evaluate the deep-water site.

The experiments were carried out from July to September 1977 from a US Navy research barge moored in more than 12,000 feet of water seven miles north of Christiansted, St. Croix. The barge is operated for the Navy by Tracor Marine Incorporated of Fort Lauderdale. Corrosion and biofouling research is managed for the Department of Energy by the Battelle Pacific Northwest Laboratories.

"This was the second series of tests aimed at determining the economic feasibility of an OTEC plant using aluminum instead of some more expensive metal," said Dr. Craig. "A third set is being planned for a location in the Gulf of Mexico."

Warm surface seawater was pumped to a biofouling experimental pipe array on the deck of the barge and through a bank of aluminum pipes for corrosion tests. Flow rates in the pipes were set at six feet per

second, the planned velocity in early heat exchangers, and three feet per second.

In addition to analyzing samples, living and preserved, of organisms that settled on intake lines and experimental pipes, Drs. Taylor and Fell conducted a water-characterization study that will aid in future OTEC siting. Productivity experiments were augmented by chlorophyll, ATP, and light-intensity profiles.

The measurement of oceanographic parameters was supervised by Dr. Lee with support from the National Oceanic and Atmospheric Administration. Daily salinity, temperature, and depth (STD) profiles were taken from the barge. Current speed and direction near the surface and weather observations were logged. "The favorable characteristics of this site include a delta-T of at least 20 degrees between surface water and deeper water all year round," Dr. Lee reported.

Ocean engineer Bob Munier served as scientific co-ordinator for the operation, and he and graduate student Paul Afring worked on board the Navy barge with Tracor technicians for more than two months while the experiments were in progress. They had high praise for the co-operation they received from Tracor marine personnel who operate the barge, which provides an excellent work platform in an interesting deep-water environment.

REMEMBER THIS DATE!

● Feb 20-22: 5th Ocean Thermal Energy Conversion Conference, Miami Beach FL
Info: T. Nejat Veziroglu, Director, Clear Energy Research Institute, Univ. of Miami
PO Box 248294, Coral Gables FL 33124

Dr. Veziroglu advised *The OTEC Liaison* January 12th that conference program! were being mailed within a few days.

"2001" AUTHOR CLARKE LAUDS OTEC'S ENERGY POTENTIAL

Famed science and science-fiction writer Arthur C. Clarke, author of 2001: A *Space Odyssey* and 500 other articles, stories, and books, was in Boston recently to receive the Washburn Award from the Boston Museum of Science. A proponent of oceanic development as well as outer space, Mr. Clarke commented on the relationships between ocean and space technology, saying: "Anything that happens in one helps the other. Much of the work in oil drilling depends completely on satellites for positioning. It's the only way to place yourself anywhere in the ocean, anytime, day or night."

Clarke is convinced that the future of many things lies in the oceans. "I have a hunch that future mining lies in the sea," he says. "There are cracks in the earth's crust with hot brine coming out loaded with metals. One of the greatest resource potentials of the sea is thermal power—the temperature differentials in the upper hot waters of tropical oceans and very cold waters about a mile down."