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The OTEC Liaison

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OTEC Heat Exchanger Development Test Program Begins

PRELIMINARY DATA NOW COMING IN

The *OTEC Liaison's* editor was recently invited to Argonne National Laboratory for a tour of the test facility recently completed there to test high-performance heat exchangers being considered for the 1-MWe ocean test of OTEC heat exchangers. When shown photographs of the installation prior to actual viewing, the writer was duly impressed by its size and complexity; but he was still further awed on visiting the site first-hand.

Located in a huge building, approximately 370 feet long by 100 feet wide, with a 35-foot ceiling, the multi-colored tanks, pipes, tubes, and pumps of the installation were made still more impressive when Dr. Norm Sather, the director of the program and my host, pointed out that the units being tested were only about 1/40th the size of those to be used for the ocean test. The facility consists of three loops: warm water, cold water, and ammonia.

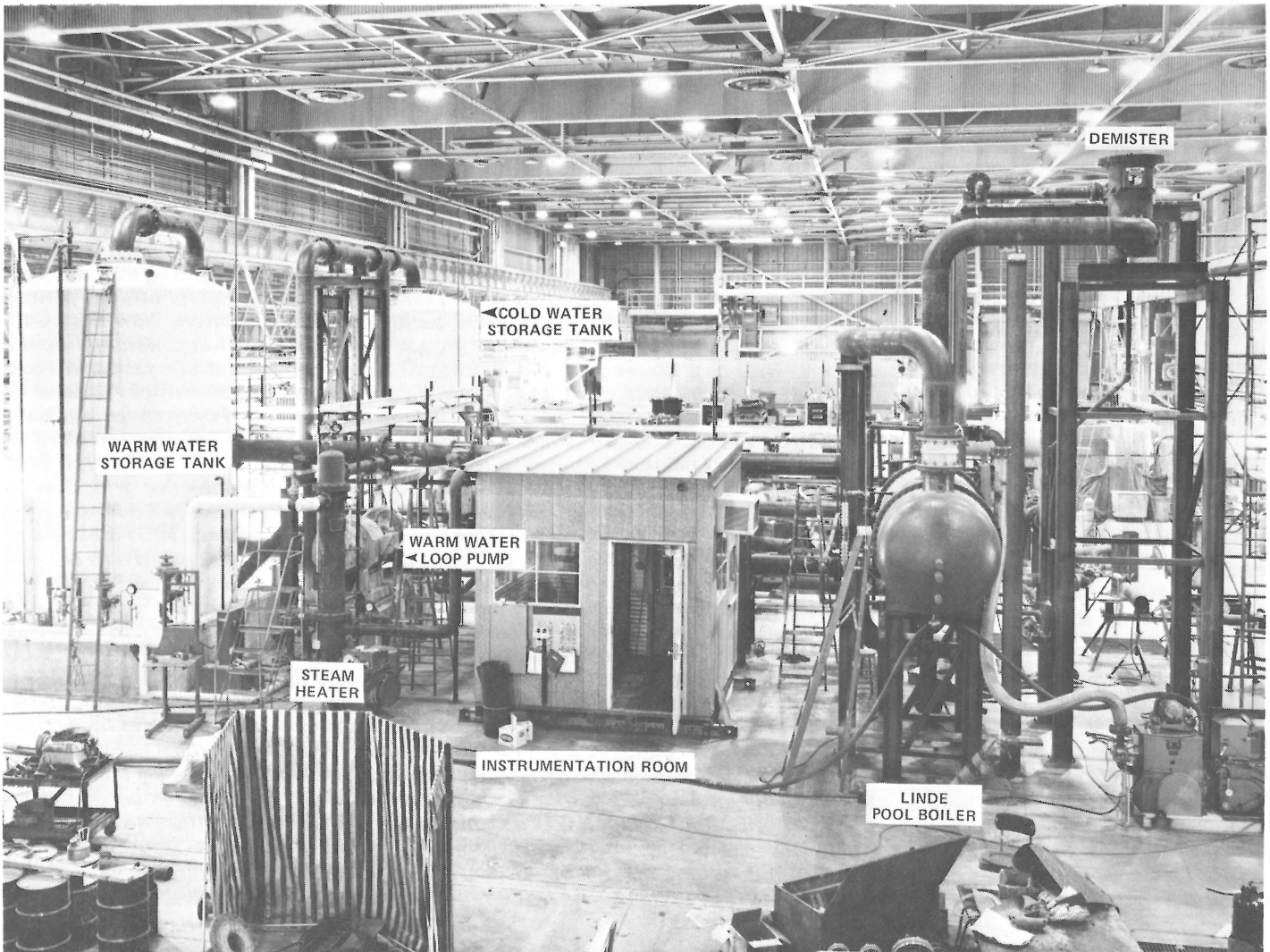
Fresh water will be substituted for ocean water, but with that single exception test conditions will be typical of the forthcoming ocean test program.

The objectives of the program are to measure the performance of various units and to compare this with the performance projected by data obtained from single-tube tests and design calculations. Testing of the first group of heat exchangers—three evaporators and two condensers—has just begun, with the first data obtained the day before Thanksgiving, a milestone long awaited. The day *The OTEC Liaison* visited the facility (November 17th) the ammonia had just arrived and was first being pumped into the system. Hopefully, before this issue is mailed some nominal data may be published; if not, a more detailed report will appear in the next issue.

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The OTEC Liaison

VOLUME 1 NUMBER 4
NOVEMBER 1977



An overall view of Argonne's Heat Exchanger Test Facility

Photo credit: ANL

The OTEC Liaison

AN INTERNATIONAL NEWSLETTER
ENGAGED AS LIAISON FOR THE
COMMUNITY OF OCEAN THERMAL
ENERGY CONVERSION

VOLUME 1 NUMBER 4
November 1977

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Please Subscribe!

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 welcomed.

NOTICE

This is the last issue of *The OTEC Liaison* being sent at no charge to the attendees of the March New Orleans OTEC conference who are not currently subscribers.

NOTICE

Letters to the Editor

William D. Metz's OTEC article in the October 14th issue of *Science* has created a considerable amount of controversy, resulting in additional comments from readers. The letter below from Dr. David F. Mayer of the University of New Orleans to the editor of *Science* was quite lengthy and has been edited; however it addresses itself to many pertinent factors concerning the validity of OTEC.

Philip H. Abelson
Editor
Science
1515 Massachusetts Avenue
Washington DC 20005

Dear Sir:

I read the article by William D. Metz on ocean thermal energy with considerable care, and I am replying in detail. This article gives the erroneous impression that OTEC is some form of advanced technology which needs years of development before it can be applied on a large scale. As one of the co-ordinators of the 1977 OTEC conference in New Orleans last March, I am in a unique position to comment upon the ERDA program.

The fact that thermal efficiency would be only about 3% is one of the old shibboleths of OTEC. If the plant owner had to pay \$2 per million BTU for heat, then this would indeed be uneconomical. However, since the heat is free, and only the cost of the equipment needed to pump the water is actually paid for, the thermal efficiency has no direct bearing upon power cost. Mr. Metz gives the incorrect impression that the water flow through the OTEC plant would have to be unreasonably high in comparison to its output. The OTEC plant would be able to produce about one tenth as much power as a hydroelectric plant with the same water-flow rate. Although this is not a small flow rate, it is well within the realm of reason.

The comment that the energy balance of an OTEC plant is "scandalously poor" (since a significant fraction of the power output is used to drive the pumps) is misleading. Every power plant has parasitic losses which reduce its gross output somewhat. Modern scrubbers use about 5% of the output of a coal power plant. About 5% of the output of an LWR is required to enrich the fuel. If the energy expenditures for fuel mining and transport are included, it turns out that both coal and nuclear power plants have parasitic losses of about 10%. Actually, it is possible to design an OTEC plant in which the total parasitic losses comprise less than 10% of the gross output of the plant. But plant optimization requires that the designers get the most power possible out of heat exchangers of fixed size, so that the 30% figure is more desirable than the 10% which is achievable. Nonetheless, there is a very wide margin for conservative design.

The list of proposed power plants conspicuously excludes the best design of all, that of Sea Solar Power, Inc. This design for a 100 MWe plant has a displacement of only 25,000 tons, less than one tenth that of the Lockheed and TRW designs of comparable output. Based upon the figure of \$2,000 per ton, which is typical for offshore platforms, it should cost only about \$50,000,000, which is a mere \$500/KWe. Now this plant has been considered by two independent groups, TRW and United Engineers and Constructors. Their cost figures are about \$150 to \$225 million. Even at this excessively conservative figure, this design is a bargain. Mr. Edwin Hartzman, president of Avondale Shipyards (a leading maker of offshore rigs), has seen the Sea Solar Power design, and has told me that the \$50,000,000 estimate seems consistent with his experience. It is worth mentioning that Anderson Engineering (which is affiliated with Sea Solar Power), is building the world's first closed-cycle geothermal power plant for Magma Energy at East Mesa, California. This plant will utilize a Delta-T of only 60 degrees C in its 2.5 MWe secondary stage, the lowest ever used in a commercial power cycle of such a size. This plant is being built for only \$500/KWe, which is far lower than nuclear power plants now being built.

There is ample precedent for the fabrication of water pumps for OTEC plants. Mr. Metz states that the pumps required for an OTEC plant will be very large. Supertanker propellers and hydroelectric turbines have been built with diameters well exceeding 10 meters, the size for a cold-water pump handling all of the needs of a 100 MWe OTEC plant. A propeller is really an unducted pump, and a hydroturbine is a pump in reverse. Both of these operate on gravity heads equivalent to about 50 meters of water. The water pumps for an OTEC plant need provide only about two or three meters of head. Thus the water pumps for an OTEC plant represent a routine exercise in turbine technology.

Although ERDA has tentatively decided upon ammonia as a working fluid, the incompatibility of ammonia with aluminum prevents the theoretical advantages of ammonia from being utilized by an OTEC plant. Ammonia was the first refrigerant, yet it has been totally replaced by the halocarbons because of the corrosion problems. Pure ammonia does not corrode aluminum, but the presence of the tiniest quantity of water in the ammonia, or the presence of a comparable concentration of ammonia in seawater, creates a

(continued on Page 6)

The OTEC Liaison has recently received a summary of the findings of a Department of Energy-sponsored OTEC Resource and Environmental Assessment Workshop held at the Florida Solar Energy Center in Cape Canaveral June 27th and 28th. The meeting was attended by 65 individuals who heard 15 papers presented. The summary below was provided by Ms. Leslie Diane Sivak of the Center, which is a part of the State University System of Florida.

Design and ocean-engineering characteristics of OTEC test platforms and demonstration plants are critically dependent on the oceanographic characteristics of the sites chosen for their operation. The adequacy of existing archival data was assessed and future oceanographic-data acquisition needs were outlined at a Department of Energy (DOE)-sponsored OTEC Resource and Environmental Assessment Workshop held June 27th and 28th, 1977 at the Florida Solar Energy Center (FSEC), Cape Canaveral.

Selected papers describing DOE's resource and environmental-assessment activities in support of the OTEC program were presented on the first workshop day. These activities were divided into five general categories: physical and climatic impact and hydrodynamic modeling, biological and ecological impact, ocean data for design, archival data, and the DOE *in-situ* measurement program.

The second day was devoted to three simultaneously-held working-group sessions: "Physical and Climatic Impact and Hydrodynamic Modeling", "Biological and Ecological Impact", and "Ocean Data".

Members of the Physical and Climatic Impact and Hydrodynamic Modeling group examined three broad areas: near-field recirculation in the vicinity of an OTEC plant, near- and far-field physical effects within 10 kilometers of an OTEC plant, and large-scale effects of one or more OTEC plants over distances exceeding 10 kilometers.

While the group did not formulate any specific recommendations, some suggestions for future research directions were offered as a majority consensus. These are: (1) The near-field recirculation problem might be minimized by proper choice of intake and outlet designs, and the optimum configuration could be obtained by comparing various conceptual designs against critical oceanographic parameters such as current shear and reversal, and mixed-layer depth variability. (2) The use of existing physical and numerical models can provide a starting point for the analysis of large-scale physical and environmental effects. However some numerical models may have to be developed, particularly those relating to the operation of several large OTEC plants. (3) It may be necessary to obtain

additional field data for future application of predictive techniques to specific plant sites.

Discussions of the Bio-Ecological Impact group centered on what can and should be done in this area with both a near-term (OTEC-1 deployment) and a far-term (100 MWe demonstration plant) view. Questions were raised on subjects ranging from trace-metal toxicity to the mortality of organisms trapped within the OTEC plant or impinged on the intakes and outlets. Bio-ecologists and design engineers should work closely together to develop an OTEC system with minimal adverse environmental effects. Group recommendations include: (1) Begin taking bio-ecological data at projected OTEC deployment sites. (2) Plan and initiate specific bio-ecological studies and experiments. (3) Select a technical advisory board. (4) Institute an OTEC public-information office.

The Ocean Data group scrutinized needs for at-sea measurement and expressed some frustration over the lack of specific guidance from designers as to the nature of relevant oceanographic data. One conclusion was that OTEC design is an iterative process requiring input from both environmentalists and engineers. The group proposed two measurement programs: the first at candidate sites in support of the design of 100 MWe plants, and the second focusing on utilizing OTEC-1 as a platform. Oceanographic parameters relevant to both measurement programs include currents (both surface and subsurface), waves, profiles of salinity, temperature, and Ph as a function of depth, and meteorological information.

Site-specific measurement-program results will be used primarily in design, while OTEC-1 measurement-program test results will be applied to actual OTEC plant operations. The site-specific program is iterative in nature and will be influenced by changes in design and measurement techniques.

Finally, the group recommended that DOE publicize the data requirements in the hope that additional archival information might be obtained from universities, other governmental agencies, and private industry. DOE should also try to persuade other government agencies to do their planned testing in locations of interest to DOE.

The complete working-group reports can be found in *Proceedings: Ocean Thermal Energy Conversion (OTEC) Resource and Environmental Assessment Workshop*, Drs. Ross McCluney and Lloyd Lewis, co-editors, published in October 1977 by the Florida Solar Energy Center. For more information, the reader should contact the workshop chairman: Dr. Lloyd Lewis, DOE, Assistant Secretary for Energy Technology, 600 E Street NW, Washington DC 20545.

RENEWABLE OCEAN ENERGY SOURCES

While *The OTEC Liaison* specializes in providing our readers with information pertaining to ocean thermal-energy conversion, we will also bring to our readers' attention newsworthy items concerning other forms of ocean energy, as developments warrant.

Robert Cohen, Program Manager of the Ocean Systems Branch of the US Department of Energy, recently advised *The OTEC Liaison* that his division is responsible for wave energy, salinity-gradient energy, and energy from ocean currents, while tidal power is the responsibility of DOE's Division of Geothermal Technology. The R&D in these areas is still on a fairly modest scale.

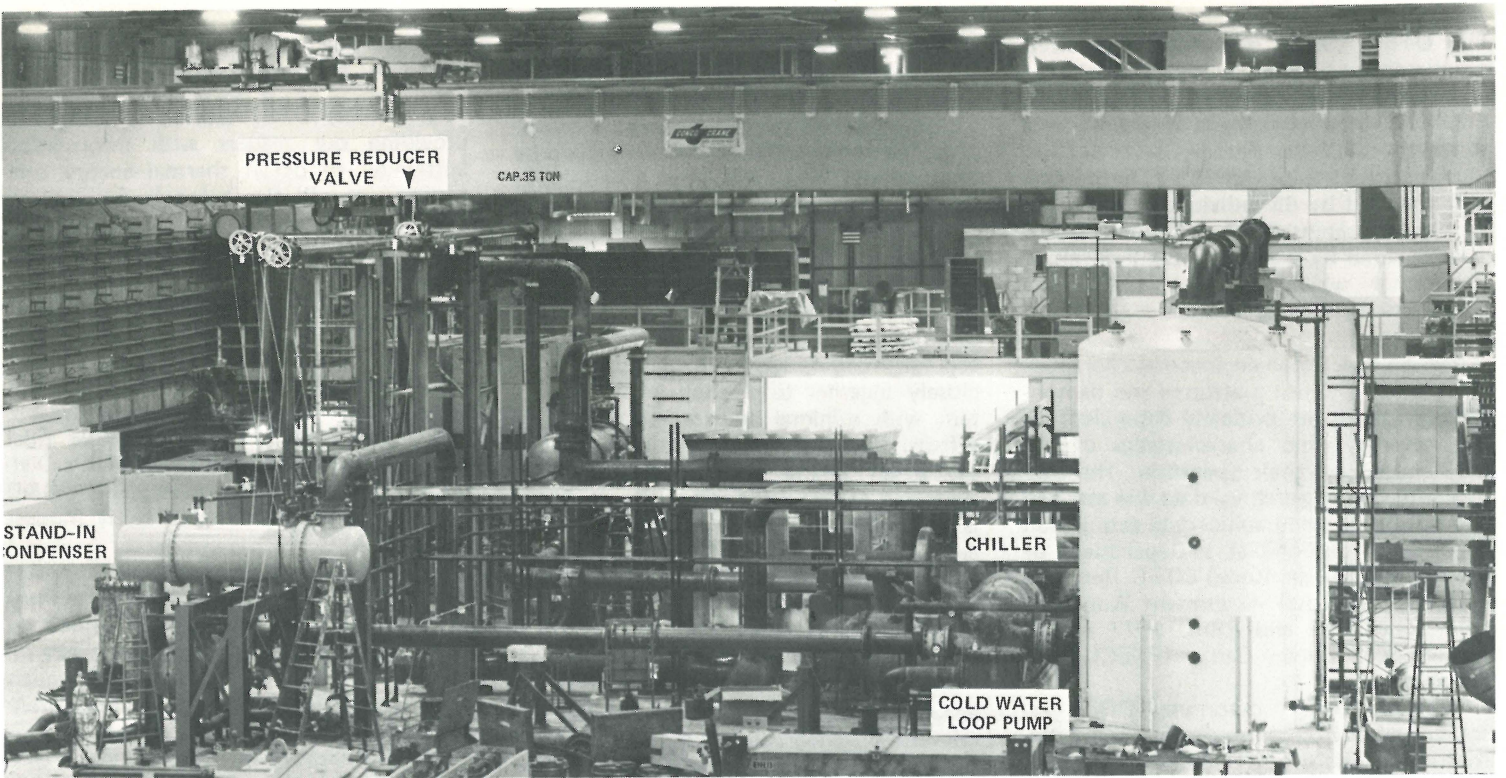
Bob further advised that *the power potential of ocean currents in the vicinity of the United States may be limited to about 1000 MWe. However wave energy and salinity-gradient energy have much more promising potentials. Unfortunately the density of wave energy near the Continental US appears to be too low for economic exploitation.* The US and British governments are working closely together on wave energy, with the United Kingdom investing about \$5 million in that area.

RUNNING SEAWATER FACILITY FOUNDED

Significant advanced research and instruction in controlled laboratory conditions using running seawater will soon be possible at the Center for Coastal Marine Studies at the University of California, Santa Cruz. A federal grant of \$556,500 provided by the Public Works Employment Act of 1976 (through which the state of California is receiving approximately \$56.3 million in grants) will give the UCSC center opportunities for flexible experimentation with marine mammals, small plants and animals, geology, and sea chemistry using seawater directly from the Pacific Ocean.

INTERNATIONAL ENERGY AGENCY SIGNS NINE NEW R&D AGREEMENTS

Members of the International Energy Agency (IEA) have recently signed nine new agreements in research and development in the fields of coal, solar, fusion, geothermal, wind, and hydrogen. Germany and the US are co-operating on coal gasification; Austria, Belgium, Germany, Greece, Italy, Spain, Sweden, Switzerland, and the US are participating in two solar-electricity plans; and Germany, Sweden, Switzerland, the UK, and the US are working on geothermal development. Other joint efforts include multi-national agreements on wind and fusion and a co-operative study by Japan, the US, and European communities of the commercial production of hydrogen from water.



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Another view of Argonne's Heat Exchanger Test Facility

Photo credit: ANL

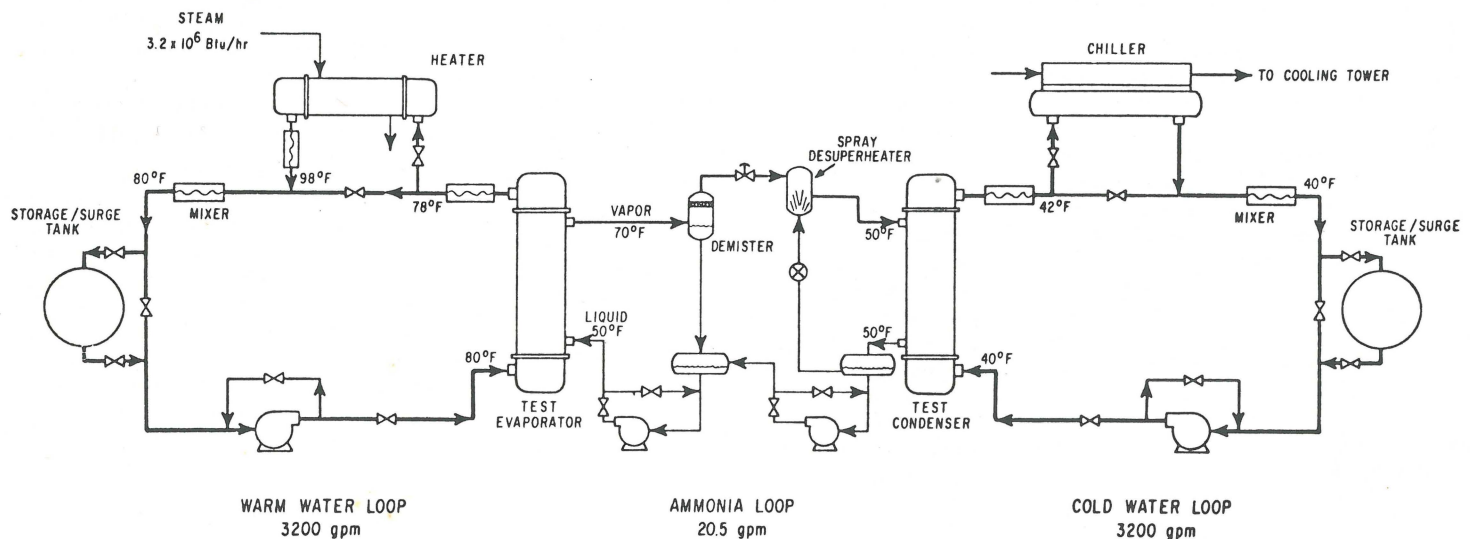
VARIOUS DESIGNS TO BE TESTED

Five heat-exchanger types will be investigated in the first round of testing. The first unit—currently producing data—is from Union Carbide's Linde Division, utilizing horizontal tubes with enhanced surfaces. These surfaces are supposed to enhance the rate of nucleation of the boiling ammonia, and thereby improve the rate of heat transfer. This type of surface was developed by Linde for its cryogenic applications (liquid air plants and the like) and is a patented, proprietary surface. This

"pool boiler" consists of titanium tubes with a porous coating on the outside, where the ammonia boils in a pool as opposed to the film which the other units use.

There are two phases of tests, each expected to take about two weeks—even less if they were to be run round-the-clock. Each test will make overall heat-transfer-coefficient and pressure-drop measurements over a reasonable range of temperatures and flow rates—something like several dozen test runs—with a few hours necessary to change from one set of operating conditions to another. Ideally, tests could be performed each day, or several dozen in

a week's time. This first phase of testing is designed to confirm the test data obtained on single tubes in the laboratory. If the data are not confirmed, the second phase would be designed to make internal measurements inside the heat exchanger to obtain local heat-transfer coefficients and to determine if there are non-uniformities from one tube to another. This second phase may be undertaken at a later date anyway to obtain possible relevant data for design studies, though Sather pointed out that if this is done after the first phase of testing on all five exchangers is completed, it will prolong the overall test pro-



OTEC HEAT EXCHANGER TEST FACILITY

gram. This is due primarily to DOE's earnestness to obtain *some* test results in their overall efforts to move the OTEC program along at all possible speed.

Argonne's heat-exchanger test facility was built at a cost of almost \$1million,* designed by Lester B. Knight and Associates Incorporated of Chicago, aided by Globe Engineering, also of Chicago, in design and construction. The construction contractor was Power Systems Incorporated of Chicago. Dr. Sather explained that while the parameters of construction were a joint effort of the Department of Energy and the heat-exchanger manufacturers, it is with the makers of the apparatus that Argonne's personnel work most closely.

Expected to be received at Argonne momentarily were two units from Carnegie-Mellon University, one evaporator and one condenser, built by Foster-Wheeler of Panama City, Florida. These units originally had plans to incorporate a great deal of instrumentation for internal measurements which were later eliminated due to DOE's efforts to economize. The CMU units are the falling-film type. The fourth and fifth units, also from Union Carbide's Linde Division, are a horizontal spray-tube type and a high-performance horizontal condenser. A possible sixth unit is that of the Applied Physics Lab, in which the ammonia boils inside and the tubes run through a tank of water. The latter type will cause some problems, Sather said, in designing it to fit the Argonne facility. DOE is also talking with DSS Engineers Incorporated about a plastic unit, and with the University of Massachusetts and the Andersons' Solar Sea Power (a plate-fin unit) about testing their designs.

The heat exchangers being tested at Argonne are all new types of equipment—not the conventional type—designed specifically for the high heat-transfer efficiency that an economically operative OTEC plant demands. "We're looking for overall heat-transfer coefficients two and a half to three times as high as normally achievable by the best state-of-the-art methods," Dr. Sather said. As data is received, it will be reported promptly in *The OTEC Liaison*.

● LAST-MINUTE NEWS RELEASE ●

Pursuant to a conversation with Dr. Norm Sather on December 9th, *The OTEC Liaison* was advised that tests of the Union Carbide Linde pool boiler had been running all week at the designed flow rate, resulting in an overall coefficient of between 750 and 800 BTUs per hour per square foot per degree Fahrenheit.

Six runs were made under these conditions, with results all in that range. Dr. Sather feels that it is fairly safe to say that this is good representative information—if these results are confirmed by further testing. He said this is considered good performance and welcome news—"better than expected".

Readers should be cautioned that these are preliminary data only, based on a limited number of runs, and are subject to further testing.



Argonne National Laboratory's 1700-acre wooded site is 27 miles southwest of Chicago.

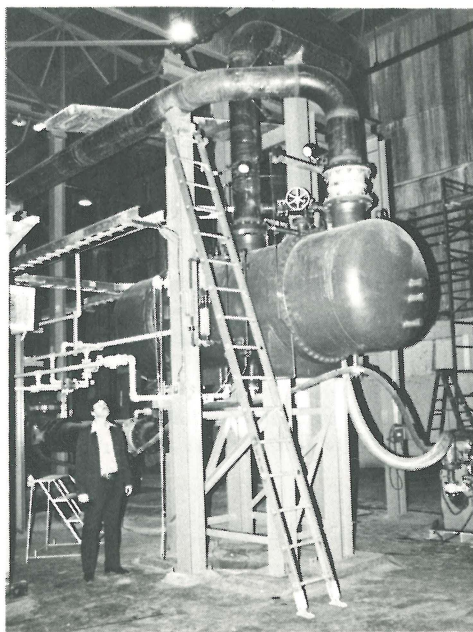
Argonne National Laboratory is a major center for energy studies and conducts a broad research program in the environmental, biomedical, and physical sciences.

One of the country's largest federally-funded research-and-development laboratories, Argonne is operated under a tripartite contract between the Department of Energy (DOE), the University of Chicago, and the Argonne Universities Association, a group of 30 Midwestern universities. The Laboratory's facilities are owned by the federal government, while the University of Chicago operates Argonne for DOE according to policies established jointly with

the AUA. About 1700 of the Laboratory's 4850 employees are professional scientists and engineers.

Most Argonne activities are supported by DOE funds; however a substantial number of research, development, and planning projects are sponsored by local, state, and other federal agencies. The Laboratory's operating budget for the 1977 fiscal year was nearly \$163 million, of which about 7% represents non-DOE funding.

Today, under DOE, Argonne's total assets exceed \$450 million, and its programs span many scientific and engineering disciplines.



Dr. Sather views Linde pool boiler.

* (actually \$780,000)



Engineers install girders which will support other heat exchangers.

NEW OCEAN MINING CONSORTIUM FOUNDED

Joining three other international firms, Lockheed has formed a joint venture to develop technology for mining valuable manganese nodules from the deep-ocean floor. Participating are: Amoco Minerals Company of Chicago, a subsidiary of Standard Oil (Indiana); Billiton BV of the Hague, a member of the Royal Dutch/Shell Group; BKW Ocean Minerals BV of Papendrecht, The Netherlands, a subsidiary of Bos Kalis Westminster Group NV; and Lockheed Missiles and Space Company of Sunnyvale CA, a subsidiary of Lockheed Corporation. The new organization—called Ocean Minerals Company—will be based in Mountain View CA. While Lockheed is the prime contractor, various personnel will be employed from the ranks of Bos Kalis, Amoco, and Billiton. James Wenzel, Lockheed vice-president for ocean systems, will be president and chairman.

The goal of the company is "to use existing technology to complete development of a new system for mining and processing manganese nodules", the potato-size objects found in vast quantities over several areas of the deep-ocean floor. While the nodules are approximately 25% manganese by weight, the new venture is concentrating its efforts not on that mineral, since there is currently an ample supply, but on the 3% of their content made up of nickel, copper, and cobalt. Nickel is the primary target at present, but as land ores continue to be depleted, copper and cobalt are expected to be more in demand.

CARTER BOOSTS SPENDING FOR SCIENTIFIC RESEARCH

National Science Medals, the nation's highest scientific awards, were presented to 15 persons in a ceremony in Washington on November 22nd by the President. During the presentations Carter said that he was concerned that science in the United States had been allowed to decline recently and that "the number of top-ranked research centers had been falling off in recent years". He said he has directed the Office of Management and Budget to boost federal spending for research and development. (Editor's note: Hooray!)

ARGONNE OPERATING CONTRACT EXTENDED

The contract with the University of Chicago and Argonne Universities Association (AUA) to operate ERDA's Argonne National Laboratory (ANL) has been extended for three years. ANL has facilities in Illinois near Chicago and in Idaho near Idaho Falls which represent a total federal investment in excess of \$490 million. Its FY 1977 operating budget is more than \$162 million. The contract extension covers the period from October 1st, 1977 to September 30th, 1980.

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corrosive mixture. It is not impossible to create leak-tight heat exchangers which will prevent such contamination, but they would be very costly. The leakage problem in the sodium-water heat exchangers for the breeder reactor has contributed greatly to the cost of this technology, and OTEC plants would require even larger heat exchangers per unit output than a breeder. Although slow hydrolysis of halocarbon refrigerants does take place, the resulting acid can be continuously removed. The use of purge systems for such removal is common in large air-conditioning systems.

Although the area of heat-exchange surface required for an OTEC plant is large, it does not follow that the heat exchangers need be terribly large or expensive. Most of the designs proposed for OTEC plants use conventional shell and tube heat exchangers, simply because some of the ERDA contractors adapted the standard power-plant layout to the OTEC system. There are three alternatives to the tube and shell heat-exchanger design, two of which require no heat exchangers whatsoever!

- (1) pressure-balanced plate-fin heat exchangers
- (2) Claude cycle
- (3) Beck-Zener lift cycle

(1) J. Hilbert Anderson (Sea Solar Power), who wrote the first modern paper on the closed cycle, transferred the idea for the use of plate-fin heat exchangers from his experience with refrigeration systems as chief engineer of the York Division of Borg-Warner. Plate-fin heat exchangers are available for less than \$10 per square meter, as opposed to about \$100 per square meter for shell and tube units. This means that the 700,000-square-meter heat exchangers for a 100 MWe OTEC plant will cost only \$70/KWe. Plate-fin heat exchangers are commonly utilized by ships for engine cooling and air conditioning. The containing shell can be eliminated altogether by the stratagem of pressure balancing. The boiler can be located at the depth at which the hydrostatic pressure equals the vapor pressure at the boiling temperature, and the same can be done for the condenser. The total volume of the heat exchangers in this design is only 8,000 cubic meters, comparable to the size of the heat exchangers in a conventional power plant of the same output.

(2) In 1929 the French government built a 6 KWe OTEC plant near Havana, Cuba. This project was headed by Georges Claude, who came up with a modification of D'Arsonval's original idea. This experiment was repeated three decades later on a larger scale by Bryn Beorse at the University of California. The open cycle uses water as the working fluid, and the warm water boils at reduced pressure and is condensed by a spray of cold water (or optionally by condensers).

(3) Earl Beck and Clarence Zener (the inventor of the Zener diode) have come up with a cycle which circumvents the large turbine required by the Claude cycle. The sea water is flashed into a mist which has a very low density, because it is mostly vapor. This mist rises into a condenser where the vapor is condensed by a cold-water spray. Then the re-liquefied sea water flows down through an ordinary hydro turbine. Lest anyone think that such a process is physically impossible, Zener has built a small device which operates successfully upon this principle.

Plant motion will put a very small stress on the cold-water pipe if it is suspended from a gimbeled platform, as was done on the Glomar Explorer and the Discoverer Seven Seas. Leakage is a problem only with ammonia. If the heat exchangers are positioned upon the pressure-balanced principle, and a slight overpressure from the sea water is engineered into the design, then major leakage can occur only in the inward direction. The water is not miscible with the halocarbon working fluid, so that they can be easily separated by the difference in density.

We can have OTEC on line on a prototype basis by 1981, not 1984 as now planned. The sooner we have accumulated the necessary experience, and have convinced the skeptical elements in industry, the sooner we can begin massive deployment. We can be building thousands of megawatts of OTEC capacity annually by the middle 1980s. Mr. Metz is right when he says: "The longer the task takes, the more it will cost." The sooner we get on with it, the more rapidly we will begin to enjoy the fruits of the OTEC technology. I have shown above that OTEC is based upon present technology and requires no technical breakthroughs for its commercial success; therefore it involves minimal risk. The risk of a couple of hundred million dollars on a project which can return billions annually for the indefinite future must surely be justified.

Yours truly,

David F. Mayer
Department of Mathematics
University of New Orleans
New Orleans, Louisiana 70122

CONTRACT AWARDS

Several respondents to the April questionnaire suggested that current RFPs and contract awards for OTEC-related subjects be regularly listed in *The OTEC Liaison*. While no current RFPs were indicated by our sources, we have listed below some recent contract awards by the government. This is not to be construed, however, as a complete list.

Nov 15: Assessment of Titanium Use (835241): Contract NAS3-21151, 21 Oct 77 for \$28,450 to I. Irving Pinkel, Fairview Park OH. NASA, Lewis Research Center, Cleveland OH 44135.

Nov 29: Presolicitation Conferences on the Procurement of Hydrographic (Coastal) and Deep Ocean Surveys on a world basis will be held on 14 & 15 Dec 77 at the Naval Oceanographic Office, NSTL Branch, NSTL Station, MS 39522. The conference meeting places and schedules are as follows: 14 Dec Hydrographic (Coastal) Surveys, Room 146 (Gainesville Room), Building 1100; 15 Dec Deep Ocean Surveys, Projection Room, Building 1105. Each conference will begin at 9:30 am CST and will discuss draft specifications and other requirements. Due to the size of the conference rooms, firms are requested to limit representation to two persons. Firms desiring to attend the above conferences should notify the office below by 13 Dec 77. Firms should also state whether they will attend one or both conferences and furnish the names of attendees. Early respondents will be mailed a copy of the draft specifications for both surveys; otherwise, copies will be available at the conferences. (P327) Notify the Contracting Officer, Naval Oceanographic Office, National Space Technology Laboratories, NSTL Station, MS 39522, Code 8411, D. Burkell, (601) 688-4162.

● **Nov 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, designated OTEC-1, will be configured for a one-megawatt (equivalent electric) OTEC system. The mission of the OTEC-1 Early Ocean Test Platform system is to conduct tests for the evaluation of government-furnished heat exchangers and other components comprising an 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 biofouling and corrosion effects,

(3) determining the effect of cleaning techniques on heat-exchanger performance, (4) performing power-cycle operations, and (5) supporting data collection and processing test results which will provide the data for future designs of OTEC plants. The work is anticipated 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 and installation of the OTEC test heat exchangers. These two phases are anticipated to be completed no later than 18 months from contract award. Phase III will be deployment and operation of the OTEC-1 system, which will continue for approximately three years. Proposers will be required to demonstrate experience in management of design, fabrication/modification, and operation of ocean systems, power systems, ocean engineering, and naval architecture. This synopsis is published for advance information purposes only. No other information or solicitation documents are currently available. A notice of RFP availability and further details regarding this procurement will be published in the *Commerce Business Daily* at a later date. Concerns which desire to be put on the mailing list for receipt of RFP ET-78-R-03-1785 should send a written request with three self-addressed labels to Department of Energy (DOE), 1333 Broadway, Oakland CA Attn: M. Voytilla, OTEC-1 SEB. Telephone requests will not be honored. This is not a request for proposal.

Dec 2: Biological Consequences of Pulse Versus Continuous Wave Radiofrequency Radiation Study: Contract F33615-77-C0619 (F33615-77-R0619) for \$88,077 to Georgia Tech Research Institute, Georgia Institute of Technology (Administration Building), Atlanta GA 30332. Sponsor USAF SAM/TSZ N. Fuquay Brooks AFB TX 78235.

Dec 2: Biological Consequences of Pulse Versus Continuous Wave Radiofrequency: Contract F33615-77-C0623 (F33615-77-R0623) for \$112,799 to University of Washington, One Administration Building, Seattle WA 98195. Sponsor USAF SAM/RAP J. Merritt Brooks AFB TX 78235. Directorate of R&D Procurement, Attn: ASD/PPM-1 Wright-Patterson AFB OH 45433.

Dec 5: Re-evaluate the NDBO Discus Buoy Hull Design, perform buoy stability tradeoff, and conduct scale-model tests. Any firms wishing to be added to the source list should contact W. Smith (601) 688-2810. Copies of the RFP will be available upon written request. Availability of this solicitation is limited and will be furnished under a first-received, first-served basis until supply is exhausted. Telephone requests will not be honored. Requests must be accompanied by a self-addressed stamped envelope if a notice of non-availability is desired. (P334) NOAA Data Buoy Office, Code OE1x4B, National Space Technology Laboratories, NSTL Station, MS39529.

Dec 5: Res. for High-Strength Aluminum & Titanium Alloys: Contract Number F33615-77-C5260 (F33615-77-R5260) for \$59,997 to Wright State University, Research Services, Dayton OH 45435, Sponsor: AFML/LLM, F. Gegel, (513) 255-5430.

Dec 6: Studies on the Effects of Surface Roughness and Real Ocean Environment on Boundary Layer Characteristics (Supported by ARPA). Contract N00014-77-C0005, 16 Nov 77 (No RFP) for \$227,087 to Dynamics Technology, Inc., 3838 Carson St., Suite 110, Torrance CA 90503.

Dec 6: Research to Study Energy Transfer Processes of Internal Waves in the Ocean: Contract N00014-78-C0050, 16 Nov 77 (No RFP) for \$55,618 to The Regents of the University of California, M-11 Wheeler Hall, Berkeley CA 94720.

Dec 7: Determine Potential for Application of Energy Systems at Navy Sites: Phase 1 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. 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 254/255 within seven 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 78009. See Note 63. (P339) Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme CA 93043, Attn: Code L23.

CONTRIBUTIONS INVITED

To add to THE OTEC LIAISON's function as an informative and useful instrument of communication, the editor invites readers to contribute. This may take the form of informally written reviews of research underway or planned, letters to the editor, or collect telephone calls. Inquiries of any form are also invited, as we are generally well-informed of OTEC progress as well as projected planning by researchers, government and private industry.

CALENDAR

Listed below are conferences and symposiums pertinent to the OTEC community, ocean energy, and oceanographic technology. Major meetings recently completed are still listed for the benefit of any readers who might wish to contact conference organizers for reports of proceedings.

Dec 5-7: Alternative Energy Sources: A National Symposium, Miami Beach FL. Info: T. Nejat Veziroglu, Director, Clean Energy Research Institute, Univ. of Miami, PO Box 248294, Coral Gables FL 33124.

Dec 15: American Oceanic Organization luncheon, Washington DC. Info: (703) 527-0888.

Jan 14-19: Congress of the International Solar Energy Society, Vigyan Bhawan, New Delhi, India. Info: Program and International Activities Committee of ISES, Atlas Corp., 2060 Walsh Ave., Santa Clara CA 95050, Attn: Mr. F. de Winter, (408) 246-9664, or Dr. J. Gururaja, General Secretary, ISES Congress Secretariat, Department of Science and Technology, Bhawan, New Delhi 11029, India. Cable: Scienctech, Delhi, India, Phone 678417.

Jan 23-27: Deep-Sea Oil Production Structures Course, Univ. of Calif., Berkeley CA. Info: Continuing Education in Engineering, University Extension, Univ. of Calif., 2223 Fulton St., Berkeley CA 04720.

Feb 12-17: 144th National Meeting of American Association for the Advancement of Science, Washington DC. Info: AAAS Meetings Office, 1776 Massachusetts Ave. NW, Washington DC 20036, (202) 467-4487.

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

Feb 27: Solar Energy for Industry: A Technical Meeting of the United Kingdom's Section of the Institute for Solar Energy Society, Royal Institute, 21 Albemarle St., London W1X 4BS, England.

Feb 27-Mar 1: 5th Energy Technology Conference and Exposition, Sheraton Park Hotel, Washington DC. Info: Energy Technology Conference Inc., 4733 Bethesda Ave. NW, Washington DC 20014, (301) 656-1090.

Mar 5-10: Oceanology International '78, Brighton, UK. Info: Conference Secretary, OI 78, BPS Exhibitions Limited, 4 Seaford Court, 220-222 Great Portland St., London W1N 5HH, England.

Mar 7-8: The Working Diver 1978, Battelle Columbus Laboratories, Columbus OH. Info: c/o Betty Alkire, Battelle-Columbus, 505 King Ave., Columbus OH 43201, (614) 424-7648.

Apr 8-12: Second International Alternate Energy Conference and Exhibit, Palm Springs CA. Sponsored by the Solar Energy Development Institute, Palm Springs, and the University of California, Riverside.

Info: International Alternate Energy Conference, Univ. of California Extension, Riverside CA 92521, (714) 787-4105.

Apr 16-18: Energy '78, Tulsa OK. Concerns maximizing energy use, investigating and applying new techniques, processes, and sources. Info: Institute of Electrical and Electronics Engineers, 345 E. 47th St., New York NY 10017.

Apr 24-27: Middle East Solar Technology Exhibit and Conference, Hilton Hotel, Bahrain.

May 8-11: 1978 Offshore Technology Conference (OTC), Astrohall, Houston TX. Info: Offshore Technology Conference, 6200 N. Central Expressway, Dallas TX 75206.

Jun 18-24: International Symposium-Workshop on Solar Energy, Cairo, Egypt. Info: T. Nejat Veziroglu, Director, Clean Energy Research Institute, University of Miami, PO Box 248294, Coral Gables FL 33124.

Aug 21-24: 2nd World Hydrogen Energy Conference, Zurich, Switzerland. Info: Walter Seifritz, Chairman, 2nd World Hydrogen Energy Conference, Swiss Federal Institute for Reactor Research, CH-5303 Wurenlingen, Switzerland.

LOCKHEED'S APRON STRINGS CUT

The arrangement between the US and Lockheed whereby the government's Emergency Loan Guarantee Board guaranteed the company's bank debts up to \$250 million was terminated on October 14th. The agreement had been in effect for the last six years, during which the US earned some \$31 million in commitment and guarantee fees, but did not advance any funds.

At the time the loan agreement was terminated, \$60 million was guaranteed; but this was replaced by an unguaranteed \$100 million revolving credit from Lockheed's banks. Lockheed is a prime contractor in several key aspects of the OTEC program.

NEW DEPARTMENT OF ENERGY CONFIRMATIONS

Dale D. Myers of California to be Under Secretary of Energy; John F. O'Leary of New Mexico to be Deputy Secretary of Energy; Alvin L. Alm of the District of Columbia to be an Assistant Secretary of Energy (Policy and Evaluation); Harry E. Bergold Jr. of Florida to be an Assistant Secretary of Energy (International Affairs); and David J. Bardin of New Jersey to be Administrator of the Economic Regulatory Administration.

NOTICE

This is the last issue of *The OTEC Liaison* being sent at no charge to the attendees of the March New Orleans OTEC conference who are not currently subscribers.

NEWSBRIEFS

IMPORTANT NEW STUDY PUBLISHED ON OTEC'S LEGAL AND POLITICAL ASPECTS

The OTEC Liaison recently received a copy of a study published under the auspices of the American Society of International Law entitled "Ocean Thermal Energy Conversion: Legal, Political, and Institutional Aspects". It contains 11 articles ranging from international jurisdictional disputes, international environmental aspects, and legal responsibilities to federal and state regulatory factors and financing. Also included are reports of the working groups dealing with these subjects and with related matters.

Published in book form, copies may be obtained by contacting Lexington Books, D.C. Heath and Company, Lexington, Massachusetts. It has been edited by H. Gary Knight, Campanile Charities Professor of Marine Resources Law, Louisiana State University Law Center; J. D. Nyhart, associate professor of management, Sloan School of Management and Department of Ocean Engineering, and Co-ordinator of Law-related Studies, Massachusetts Institute of Technology; and Robert E. Stein, director of the North American Office of the International Institute for Environment and Development in Washington DC and adjunct professor of environmental law, American University Washington College of Law.

OTEC ADVOCATE ENCOURAGES OCEAN-ENGINEERING CAREERS

William E. Heronemus, a long-time proponent of OTEC development, published an article in the July 1977 issue of *Mechanical Engineering* titled "New Career Paths in Engineering". In his comments encouraging engineering students to seek employment in ocean engineering, he points out that "The waters of the sea constitute the largest powerhouse on earth, one that will require the employment of thousands of engineers." He details the numerous fields now opening up, such as solar power, tidal power, ocean windpower, mariculture, and, of course, oil. Not mentioned in Bill's article is the growing interest in deep-sea ocean mining, which has received added impetus from the recent formation of a new international firm. (See NEW OCEAN-MINING CONSORTIUM FOUNDED in this issue.)

COMING IN NEXT ISSUE

PHOTO REPORT OF ALTERNATIVE ENERGY SYMPOSIUM IN MIAMI

MAPPING OCEAN ENERGY BY SATELLITE