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AN UPDATE ON THE JAPANESE OTEC PROGRAM

The following article is extracted from a paper authored by Dr. Takenobu Kajikawa of the Ocean Energy Section, Electrotechnical Laboratory, Japan Ministry of International Trade and Industry. The paper was originally presented at the May 1982 meeting of the Marine Facilities Panel of the US/Japan Co-operative Program in Natural Resources (see story in this issue), held in Japan. At the request of Joe Vadus, chairman of the Panel, Dr. Kajikawa also presented this paper at the OTEC Workshop which followed the Oceans '82 Conference in Washington DC in September.

Research and development of OTEC in Japan was initiated in 1974 as part of the New Energy Technology Research and Development Program, commonly known as the Sunshine Project, under the auspices of the Agency of Industrial Science and Technology and the Ministry of International Trade and Industry. The Japanese Government's OTEC R&D has been aided by private industry, primarily the electric-utility companies.

The primary goal of the Japanese OTEC program is to promote the development of commercially-viable OTEC technology to help meet national energy needs. Japanese researchers are optimistic that this goal will be attained by the end of the century.

Major OTEC R&D efforts in the Sunshine Project have been directed at:

(a) developing commercially-viable heat exchangers via laboratory tests, small-scale at-sea tests, and simulation tests;

(b) developing ocean-structure technology including cold-water pipe and mooring structures via simulation analysis and model tests in the laboratory and at sea; and

(c) investigating candidate sites and potential domestic thermal resources.

R&D funding in FY 1982 is about 216 million yen ($800,000), but this figure does not represent the total effort being put into OTEC R&D from all sources.

Following is a summary of the research under way at this time.

Power-Systems Research

The objective of the power-systems research is to optimize the design, from the economic point of view, under the conditions where the facility is to be deployed. Dr. Kajikawa pointed out that in Japan these parameters include a relatively-low delta-T (20°K at best) which experiences diurnal and seasonal variations, and modest sea-floor slope near shore, implying that plants must be floating or moored in offshore waters. The power-system optimization will, therefore, need to include maximizing the energy-conversion system, reducing the parasitic losses, and minimizing sensitivity to sea-state variables.

Current power-systems research directed at the deployment of a 1000-kilowatt pilot plant is focused on two approaches: computer simulation and conceptual design. The results of this work will facilitate decision-making in the eventual construction and scale-up of the pilot plant (up to a 10-megawatt demonstration plant).

Heat-Exchanger Research

Heat-exchanger technology, according to Kajikawa, is still the key to substantially reducing the overall system cost. R&D efforts have been focused on enhancement of working-fluid-side heat-transfer performance and low-cost heat-exchanger performance. Evaporator enhancement has been successfully accomplished via micro-surface modification to increase porosity. The evaporator material is a "sandwich" of stainless-steel fibers on the working-fluid side and a thin titanium layer on the

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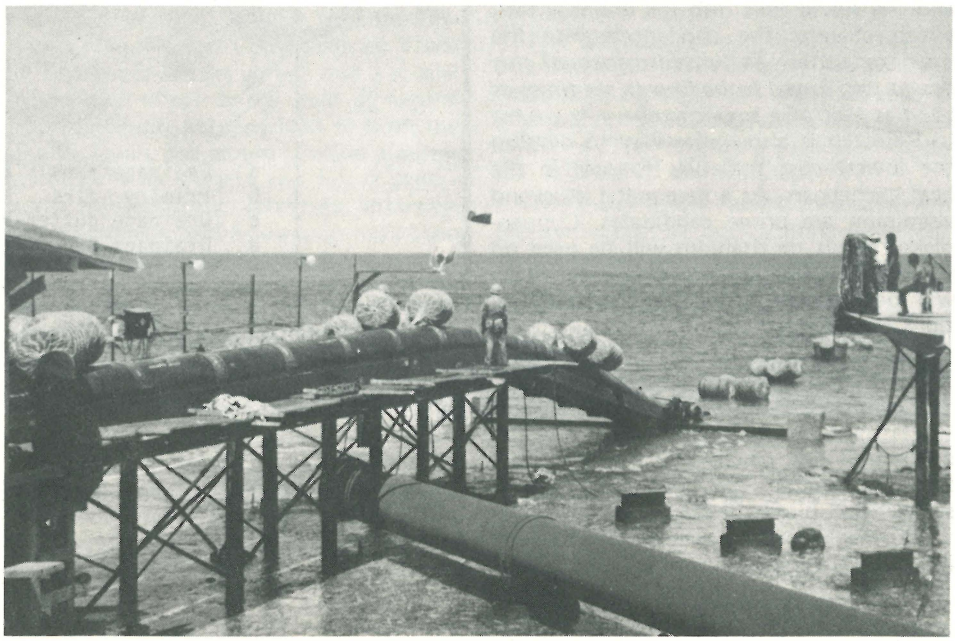
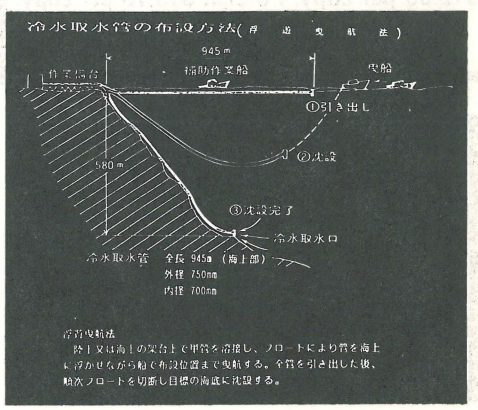


COLD-WATER-PIPE DEPLOYMENT for the Japanese OTEC demonstration plant in Nauru is illustrated in the photograph below left and the diagram below right, in three stages: (1) Pipe sections connected on shore; with floats attached, pipe is drawn out to sea, pulled into position by towboat. (2) Weight added at terminal end; floats released. (3) Sinking to final position. The polyethylene pipe is 945 meters long, with an OD of 750 millimeters and ID of 700 millimeters.



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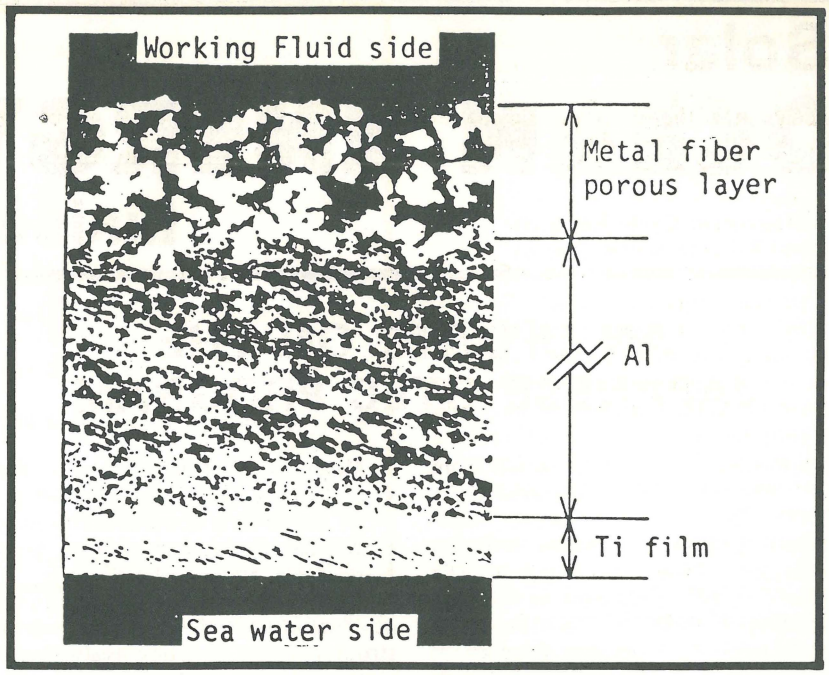

Figure 1. Metal-fiber sintered surface clad with titanium film.

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seawater side, over an aluminum core (see Figure 1). According to the experiment results, the boiling heat-transfer coefficient is about 14.1 KW/m^2K at the heat flux $q = 11.6$ Kw/m^2 using R11 as the working fluid. *This represents a ten-fold increase in the heat-transfer coefficient over a smooth surface at the same heat flux.*

Condenser enhancement has focused on reducing the thickness of the condensed liquid on the condenser surface, and rejecting the condensate from the surface as quickly as possible. An innovative design has been developed by the Electrotechnical Laboratory, utilizing spiraled double-fin tubes with a drainage gutter to achieve high condensing heat-transfer performance. A condenser tube is diagrammed in Figure 2. The vapor of the working fluid is condensed mainly on the primary fins, and the liquid falls into the drainage fins, which channel the condensate into the drainage gutter. *The performance of this design was found to be four to six times as good as that of a smooth tube.*

Research is also under way to develop the lowest-cost materials for use in the heat exchangers. As a base metal, steel and aluminum are prime candidates. Copper-nickel alloys or titanium will be used on the seawater side, and stainless-steel fibers will be used on the enhanced-working-fluid side.

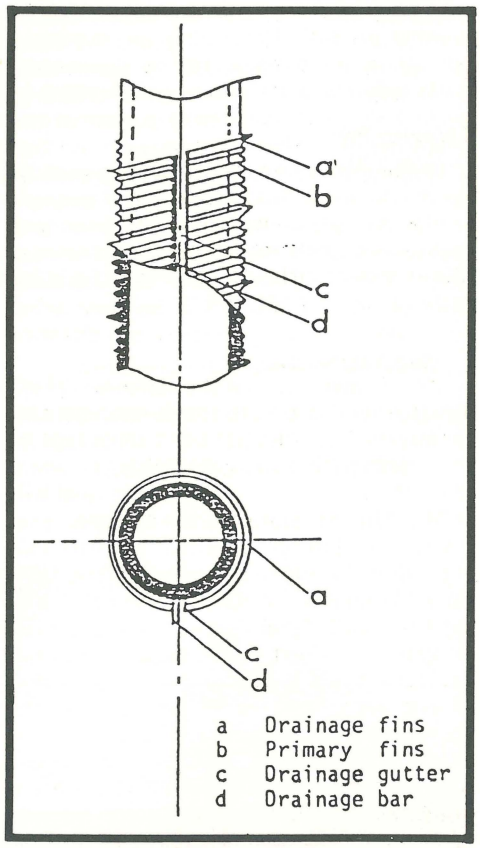

Figure 2. Schematic cross-sectional view of spiral double-fin tube with drainage gutter for a vertical condenser.

Ocean Engineering Development

Platform and cold-water-pipe research are also under way in Japan. Studies are being conducted for both floating and submersible plants based on the layout of a 100-megawatt commercial OTEC facility. Computer simulation for dynamic analysis of the performance of the entire system (consisting of platform, cold-water pipe, and moorings) under variable environmental parameters is being conducted by the Engineering Advancement Association of Japan. The program being used

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in the computer analysis can calculate by both frequency-domain and time-domain methods, and incorporates a sub-program which calculates the drag coefficient of platforms of different shapes under different wave and current variables.

Alternative-Cycle Research and Environmental Studies

The primary focus of OTEC R&D in Japan has been on closed-cycle systems. However feasibility studies and experimental work are being conducted on the use of thermoelectric OTEC systems. This work will be summarized in an upcoming issue of *Ocean Energy* in a separate article covering worldwide thermoelectric OTEC developments.

In environmental studies, research has concentrated on parameters which present restraints on plant siting and operations, and evaluation of potential research. A calculation of the potential contribution of OTEC to Japan's energy supply indicates that 5×10^{10} kilowatt-hours a year could be produced, roughly equivalent to the total projected energy consumption in that country in 1987. Detailed water-temperature and current measurements are already under way for areas which will potentially become the resource base for Japan's domestic OTEC industry.

Dr. Kajikawa concluded his presentation by pointing out that once a breakthrough is attained in heat-exchanger enhancement technology, plans for the construction of a 1000-kilowatt offshore pilot plant will be initiated.

US-JAPAN CO-OPERATIVE PROGRAM IN NATURAL RESOURCES INCLUDES MARINE FACILITY PANEL

The United States/Japan Co-operative Program in Natural Resources (UJNR) was established in 1964. At that time the US-Japan Cabinet-Level Committee on Trade and Economic Affairs agreed that a special co-operative effort in the field of natural resources would be beneficial to both the US and Japan and would provide a better environment for present and future generations. Subsequently, scientists, information, equipment, and knowledge have been freely exchanged, and several joint experiments have been achieved. The result has been more-efficient scientific research and technological development in both countries, and a strengthened bond of friendship.

The UJNR holds a conference every three years, alternately in Tokyo and Washington DC. The main purpose of this conference is to review and examine ongoing co-operative activities and to study proposals for new co-operative efforts. UJNR administrative staff meetings are held between conferences.

The UJNR includes 17 panels. Seven of these panels deal with marine science and are under the Marine Resources and Engineering Co-ordination Committee of the UJNR (MRECC). Ten panels deal with non-marine activities. A co-ordinator from the Science and Technology Agency of Japan and co-co-ordinators from the US National Oceanic and Atmospheric Administration (NOAA) in marine areas and the US Department of Agriculture in non-marine areas are appointed to co-ordinate the work of the panels.

CO-OPERATIVE ACTIVITIES OF THE UJNR

- publications
- conferences and symposia
- presentation of papers
- field excursions and tours of research facilities and industrial operations
- joint projects and study cruises
- exchange of information, data, and literature
- communication and co-operation between individual scientists and technical specialists
- exchange of scientists
- exchange of samples and research equipment

The MRECC is composed of the people chairing the marine panels, and is chaired by the UJNR co-co-ordinator from NOAA. The 17 panels and the MRECC are composed mainly of scientists from the two national governments. However scientists from the academic and private sectors also make significant contributions to the program. Proposals for new activities under the UJNR are considered by the panel responsible for the particular program area involved.

Marine Panels

The MRECC reviews marine programs, examines new requirements, and co-ordinates and provides for the exchange of information concerning all UJNR marine activities. The following panels are under the auspices of the MRECC:

The Aquaculture Panel is concerned with the cultivation of both marine and freshwater aquatic products.

The Diving Physiology and Technology Panel is involved chiefly in the fields of diving technology and medicine and the application of this technology to underwater work and marine science.

The Marine Electronics and Communications Panel is concerned with such areas as ocean circulation, currents, tides, measurement of water depths, fisheries assessment, ocean climatology, and water pollution.

The Marine Geology Panel is active in such fields as seabottom geology and environmental geology of continental shelves.

The Marine Mining Panel studies the mining of deep-ocean manganese nodules and continental-shelf sand and gravel, and the environmental aspects of recovering offshore oil and gas.

The Seabottom Surveys Panel promotes the exchange of marine geophysical and bathymetric research data and analyses relating to seabottom surveys.

The Marine Facilities Panel discusses and reviews ocean and coastal engineering, offshore platforms, undersea systems, marine transportation, ocean energy systems, marine pollution, and ocean disposal.

The US delegation to the Marine Facilities Panel currently includes 14 Government representatives and 12 advisors from industry and academia. The Japanese delegation includes 21 Government representatives and 16 advisors.

For more information on marine programs, write to the US Co-ordinator, US-Japan Co-operative Program in Natural Resources, National Oceanic and Atmospheric Administration, 6010 Executive Boulevard, Rockville, Maryland 20852.

OCEAN ENERGY COUNCIL ELECTS NEW BOARD OF DIRECTORS

On June 30th the Ocean Energy Council held its annual election. The new Board of Directors, to serve for one year, are as follows (affiliations are noted for identification purposes only):

Dr. John P. Craven (University of Hawaii)
Harry D. Foust (Trane Corporation)
Edward Y. Hirata (Hawaii Electric)
W. Lloyd Jones (Dillingham Corporation)
Malcolm S. Jones, Jr. (Ebasco Services)
Richard Meyer (Solar Ocean Energy Liaison)
Fred Naef (Lockheed Missiles and Space)
Robert Scott (Gibbs and Cox)
Jay Yaffo (Ocean Thermal Corporation)

The first annual meeting of the Board will be held during the forthcoming OTEC Workshop in Washington, at which time new officers will be elected.

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.

Jun 16: Digitizing of Additional Bathymetric Data From Past Scripps Cruises: Negotiations on an unsolicited proposal are being conducted with the University of California at San Diego, Scripps Institution of Oceanography, La Jolla, California 92093. Defense Mapping Agency Hydrographic/Topographic Center, Contracting Division (LOCC4), 6500 Brookes Lane, Washington DC 20315, Attention J. H. Everett, (202) 327-3795.

Jun 16: Provide Impact of Reliability and Maintainability on ASW Mission Effectiveness and Establish Measures of Effectiveness on Open Ocean and Water Scenarios: Contract Modification N62269-82-C-0412 is being negotiated exclusively with Information Spectrum Incorporated, 1040 Kings Highway North, Cherry Hill, New Jersey 08034. Commander, Naval Air Development Center, Warminster, Pennsylvania 18974.

Jun 16: Gulf of Mexico Physical Oceanography Study: Designed to provide the necessary field-measurement program, using a diverse set of techniques, to characterize the important circulation features in the Gulf of Mexico. The total program is multi-year in nature. The initial contract will be for the first year effort (25 months from award to final report). US Department of the Interior, Bureau of Land Management, Branch of Contract Operations, Code 851, 18th and C Streets Northwest, Washington DC 20240.

Jun 21: Support of the Development and Deployment of the Marine Seismic System (MSS): Negotiations are to be conducted with Gould Incorporated, Chesapeake Instrument Division, 6711 Bay Meadow Drive, Glen Burnie, Maryland 21001. Office of Naval Research, 800 North Quincy Street, Arlington, Virginia 22217.

Jun 21: Test of Prototype Reverse Osmosis Energy Recovery Device and Correction of Its Deficiencies: Contract 14-34-0001-2412, for $192,412, awarded to Polymetrics Incorporated, 1005 Timothy Drive, San Jose, California 95133. US Department of the Interior, Office of Water Research and Technology, 18th and C Streets Northwest, Washington DC 20240.

Jun 22: Hybrid Solar Steam-Powered Rankine-Cycle Cooling: Contract DE-AC-03-78-ET-20110.A007, June 15th, 1982, for $147,625, awarded to the University of Pennsylvania, 3451 Walnut Street, Philadelphia, Pennsylvania 19104. US Department of Energy, San Francisco Operations Office, 1333 Broadway, Oakland, California 94612.

Jun 22: Intramolecular Energy Transfer Reactions as a Method for Metal-Complex-Assisted Production of Hydrogen: Contract Modification DE-AS-09-80-ER-10671, for $110,900, awarded to Clemson University, Clemson, South Carolina 29631. US Department of Energy, Savannah River Operations Office, Contracts and Services Division, PO Box A, Aiken, South Carolina 29801.

Jun 24: Complete and Publish Results of Oceanographic Studies Based on the Analyses of Samples Gathered in Cruises in the Northern, Central, and Western Pacific Ocean Basin: Contract N00014-82-C-0380, June 2nd, 1982 (no RFP), for $1,301,872, awarded to the University of Hawaii, Hawaii Institute of Geophysics, Honolulu, Hawaii 96822. Office of Naval Research, 800 North Quincy Street, Arlington, Virginia 22217.

Jun 28: Continued Operation of the Saline Water-Conversion Test Facilities Operated by the Office of Water Research and Technology at Wrightsville Beach, North Carolina and Roswell, New Mexico: The Department will consider plans from industry, universities, non-profit organizations, state and local governments, or other qualified entities including consortia, that would provide for at least one year's operation of either or both of the test facilities, but at no further cost to the Federal Government. These facilities are fully equipped and in current use. It is the intent of the Department to enter into a cooperative agreement with the selected entity for a period of one year. As a result, substantial involvement should be anticipated between OWRT and the successful recipient. Involvement by OWRT during this period would consist of periodic on-site visits to ascertain both the condition of the facility and the purposes for which it is being utilized. The Department would also have the right of unrestricted access to the facilities for the purpose of conducting special tests during this period. Such tests would involve test units of such a size that only a small portion of the facilities' capabilities would need to be utilized. These tests would be conducted wholly at government expense. The successful recipient would also be required to submit quarterly reports to OWRT describing the work accomplished during the reporting period. During this time, the Department would retain title to the facilities. Subsequently, subject to Congressional approval, steps would be taken by the Department to eventually transfer the facilities for the purposes intended to the participating organization. The Seawater Saline Conversion Technology Test Facility at Wrightsville Beach, North Carolina occupies a site of about 15 acres. The intake and effluent pipelines cross North Carolina State Highway Commission property and are provided for under an assignable agreement. The facility is housed in approximately 36,500 square feet of building space, including offices, laboratory, storage space, service facilities, and research and development space. The brackish-water saline conversion technology test facility at Roswell, New Mexico occupies a site of around 13 acres. The facility is housed in over 51,000 square feet of building space, including offices, laboratory, service facilities, storage space, and research and development space. All plans must be based on there being no Federal funds appropriated for the operation and maintenance of these facilities after September 30th, 1982. Those plans which provide the best opportunity for the continued development and testing of saline water-conversion technology will be given the highest priority by the Department. Other possible interests regarding alternative uses of the facilities may be expressed. In this case, and in the event that suitable plans which would have the facilities utilized for their original intended purpose are not received, priority would be given to the extent possible to making the properties available to state or local governments for beneficial uses. Any transfer would be subject to the policies of EO 12348 (asset management). This notice does not constitute a solicitation of invitation for bids for the sale of property or equipment, or for the rendering of a service for a fee. It is not intended as a notice of disposal or sale or intent thereof, but is an inquiry into the public interest in the continued operation of these facilities. Any subsequent decisions affecting sales, transfers, or other forms of conveyance will be treated in accordance with the appropriate Federal property requirements. It is further intended that selections of the best plans will be made by August 31, 1982, with implementations during Fiscal Year 1983, but even as early as October 1, 1982. OWRT reserves the right to reject any and all plans. Interested parties are invited to visit the two test facilities. It should be noted that some of the test equipment currently located at the facilities is not owned by OWRT and may not be available for future operations. Information on the current costs of operating and maintaining the facilities is available at each site. Expressions of interest should be submitted not later than the close of business on July 30th, 1982. These expressions of interest should contain a plan describing specific purposes for which the facility would be utilized, include the extent of financial support that would be provided, and indicate financial capability with respect to continued operation of the facilities for a period of time. The plan should identify all participating organizations and be in sufficient detail on which to base a preliminary evaluation by the Department of the relative merit of the plan. Requests for additional information may be directed to Robert Robinson, Technology Development, (202) 343-4341. Director, Office of Water Research and Technology, US Department of the Interior, Washington DC 20240.