INTERSOCIETY ENERGY CONVERSION
ENGINEERING CONFERENCE
1968 RECORD

Held at The University of Colorado
Boulder, Colorado
August 13-17, 1968

Paper Review Criteria .............................................. 2
Chairman's Message .................................................. 3
IECEC '68 Information ............................................... 4
Technical Program Personnel ...................................... 6
Table of Contents .................................................... 7
Papers Start on Page ................................................ 13
Index Starts on Page ................................................ 1044
Table of Contents

The six-digit number listed with each paper is used in the indexing system developed for the 1968 IECEC: These papers will be included in a cumulative index in the publications of future conferences. See page 1044 for the first index.

### ELECTROCHEMICAL POWER SOURCES

- "Adhydrode Control of Ni-Cd Battery Charging to Evaluate Charging Methods," J. D. Dunlop and R. W. Bounds, Comsat 689002 19
- "Progress in Development of a Heat-Sterilizable Ag-Zn Battery," R. Lutwack, JPL 689003 25
- "Theoretical Evaluation of Hot Spot Temperature of Silver-Zinc Batteries," R. E. Meredith, Oregon State with A. A. Uchiyama, JPL 689004 32
- "Heat Generation in Sealed Batteries," S. Gross, Boeing 689005 38
- "Progress in the Development of the Lithium-Chlorine Electrochemical Cell," T. G. Bradley, General Motors 689008

### SOLAR ENERGY CONVERSION — TERRESTRIAL USES

- "Desalting of Seawater With Solar Energy," G. O. G. Löf, Consulting Engineer 689013
- "Energy Gap — DEC Teaching," R. L. Bailey, University of Florida 689015 105

### SOLAR ENERGY CONVERSION — SPACE USES

- "Electrical Characteristics of Silicon Solar Cells as a Function of Cell Temperature and Solar Intensity," J. D. Sandstrom, JPL 689020 138
- "Particle Radiation Effects on Solar Cells for Near Sun Missions," R. G. Willis, Martin-Marietta Corp. 689021 148

### ISOTOPIC HEAT SOURCES

- "Nuclear Properties of Plutonium-238 Fueled Sources," P. J. Gingo and H. L. Bermanis, JPL 689024
- "On Optimized Design of Radioisotope Capsules for Impact," C. A. Bodenschatz, Nuclear Materials & Equipment 689024 181
- "SNAP-29 Nuclear Safety," D. M. Ruwe, Martin Marietta 689025 189
- "SNAP-29 Heat Source Design and Development," W. W. Wachtl, Martin Marietta 689026 194

---

*This paper is being presented at the Conference; it is not published in this Conference Record. It may appear in a future issue of IEEE Transactions on Aerospace and Electronic Systems or IEEE Transactions on Electron Devices.
<table>
<thead>
<tr>
<th>Title</th>
<th>Author(s)</th>
<th>Location</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>250-Watt Radioisotope Thermoelectric Generator with Capability for Controlled Intact Reentry</td>
<td>W. F. Ekern, Lockheed Missiles &amp; Space</td>
<td>689027</td>
<td>200</td>
</tr>
<tr>
<td>An Advanced 2000 kWth Nuclear Heat Source</td>
<td>C. Walter, N. Brown, V. Hampel, T. Wilcox and E. McCauley, Lawrence Radiation Laboratory</td>
<td>689028</td>
<td>210</td>
</tr>
<tr>
<td>Rapid Procedure for Simultaneous Determination of Thermoelectric Properties of Materials, and Their Operating Characteristics in a Thermoelectric Generator</td>
<td>J. D. Richards, 3M Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seebeck Voltage Probe for Examination of Thermoelectric Elements</td>
<td>J. Mueller and G. Farrow, Battelle Memorial Institute</td>
<td>689029</td>
<td>222</td>
</tr>
<tr>
<td>On the Efficiency of Segmented SiGe-PbTe Thermocouples</td>
<td>H. E. Bates and M. Weinstein, Tyco Laboratories</td>
<td>689030</td>
<td>229</td>
</tr>
<tr>
<td>Development of a High Efficiency Cascaded Thermoelectric Module</td>
<td>S. Rocklin, Atomics International</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application of Factorial-Designed Experiments to Study of Thermoelectric Properties of Lead Telluride</td>
<td>D. B. Evans and J. W. McGrew, Martin Marietta</td>
<td>689031</td>
<td>234</td>
</tr>
<tr>
<td>Flat-Plate Thermoelectric Generators for Solar Probe Missions</td>
<td>V. Raag and R. E. Berlin, RCA with W. J. Bifano, NASA-Lewis</td>
<td>689032</td>
<td>241</td>
</tr>
<tr>
<td>The STAR Thermoelectric Panel</td>
<td>N. Miller, Atomics International</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particulate Thermal Insulations for Thermoelectric Energy Conversion Devices</td>
<td>J. O. Collins, Johns-Manville</td>
<td>689036</td>
<td>249</td>
</tr>
<tr>
<td>High Temperature Multi-Foil Thermal Insulation</td>
<td>M. L. Paquin, Thermo Electron Corp.</td>
<td>689037</td>
<td>256</td>
</tr>
<tr>
<td>Multifoil Type Thermal Insulation</td>
<td>W. D. DeWitt, N. C. Gibbon, and R. L. Reid, Union Carbide Corp.</td>
<td>689038</td>
<td>263</td>
</tr>
<tr>
<td>Method to Arrest Weight Loss of Lead Telluride at Elevated Temperature in Vacuum</td>
<td>J. Killian, US Naval Ship Research and Development Center</td>
<td>689039</td>
<td>272</td>
</tr>
<tr>
<td>Rankine Cycle Systems Studies for Nuclear Space Power</td>
<td>J. H. Pitts and M. H. L. Jester, Lawrence Radiation Laboratory</td>
<td>689041</td>
<td>290</td>
</tr>
<tr>
<td>Thermal Design Procedure for Potassium Rankine Cycle Boilers</td>
<td>J. R. Peterson, GE, with M. Gutstein and R. N. Weltmann, NASA-Lewis</td>
<td>689043</td>
<td>313</td>
</tr>
<tr>
<td>A SNAP-8 Breadboard System — Operating Experience</td>
<td>J. N. Hodgson, Aerojet-General, with R. P. Macosko, NASA-Lewis</td>
<td>689045</td>
<td>338</td>
</tr>
<tr>
<td>Two-Phase Spherical Heat Transfer to Mercury in Vortex Forced Convection</td>
<td>A. Koestel and R. J. Ziobro, TRW</td>
<td>689046</td>
<td>352</td>
</tr>
<tr>
<td>Technical Assessment of a Turbine Powered Heat Exchanger</td>
<td>J. P. Norton, American Air Filter</td>
<td>689049</td>
<td>370</td>
</tr>
<tr>
<td>Ten Years of Research, Development and Operation of Rankine Cycle Power Units in Israel</td>
<td>L. Bronicki, Ormat Turbines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Organic Rankine Cycle</td>
<td>G. S. Leighton, Atomic Energy Commission</td>
<td>689053</td>
<td>398</td>
</tr>
<tr>
<td>Thermal Stability Determination of Biphenyl and the Eutectic of Biphenyl and Phenyl Ether in a Rankine Cycle System</td>
<td>A. W. Adam, R. E. Niggeman and L. W. Sibert, Sundstrand</td>
<td>689054</td>
<td></td>
</tr>
<tr>
<td>2 to 10 Kw Solar or Radioisotope Brayton Power System</td>
<td>J. L. Klann, NASA-Lewis</td>
<td>689055</td>
<td>407</td>
</tr>
<tr>
<td>Comparison between Vapor Chamber and Conducting Fin Brayton Radiators</td>
<td>J. W. Larson, GE, and J. P. Couch, NASA-Lewis</td>
<td>689056</td>
<td>416</td>
</tr>
</tbody>
</table>
Table of Contents

“Automatic Turbine Speed Control for a 300 Kw Closed Brayton Cycle System,” J. M. Janis, Aerojet-General Corp. 689058 ........................................... 434


SMALL SPACE POWER SYSTEMS

“Development of a Two-Watts/lb Radioisotope Fueled Space Thermoelectric Generator,” N. DesChamps and H. E. Rexford, Sanders Nuclear 689061 ...................................................... 448

“Radioisotope Thermoelectric Generator for Voyager Surface Lander,” K. H. Dufrane, Martin Marietta 689062 ......................................................... 456

“SNAP-11 Radioisotope Thermoelectric Generator,” W. M. Brittain, Martin Marietta Corporation 689063 ...................................................... 464

“250 Watt Radioisotope Thermoelectric Generator with Capability for Controlled Intact Reentry,” W. F. Ekern, Lockheed Missiles and Space ............................................. 468

“SNAP-29 System Design and Development,” M. Scheve, Martin Marietta 689066 ..................................................... 469

“Application of Heat Pipes to SNAP-29,” W. Bienert, S. Frank, R. Hannah, and J. T. Peters, Martin Marietta 689067 .......................................... 477


LARGE SPACE POWER SYSTEMS


“Nuclear Organic Rankine Thermoelectric Hybrid Systems,” J. M. Howard, Atomics International 689072 ..................................................... 533

“Analysis of an Out-of-Core Thermionic Space Power System,” W. E. Loewe, Lawrence Radiation Laboratory ........................................... *

“Liquid Metal MHD Pulse Power Space Generating Systems,” J. E. Bruning, and L. L. Prem, Atomics International ........................................... *


“Integration of Large Power Systems to Manned Space Stations,” W. E. Murray, and R. L. Gervais, McDonnell-Douglas ............ *

“A Design Concept for a 30 Watts Per Pound Roll-Up Solar Array,” N. F. Shepard, Jr., and K. L. Hanson, GE 689075 ........................................... 549

“Thin Film Multikilowatt Solar Arrays,” W. Luft, and R. A. Boring, TRW 689076 .................................................. 560

“Lunar Surface Array Characteristics,” R. A. Boring, TRW 689077 .................................................. 571


“Flat Pack Flexible Solar Cell Array,” D. R. Lott, and R. C. Bixbee, Lockheed Missiles & Space ........................................................ 592

“Development of Interconnectable Solar Panels for Large Array Systems,” L. G. Chidester, and J. A. Mann, Lockheed Missiles & Space 689080 ........................................ 600


SPACECRAFT ELECTRICAL POWER SYSTEM SELECTION


“Spacecraft Power System Reliability and Weight Design Optimization,” W. G. Binkley, TRW Systems ........................................... *

“RTG-Spacecraft Interaction Considerations for Deep-Space Probes,” W. J. Dixon, R. D. McGarrigle, and F. Ridolphi, TRW Systems 689084 ........................................... 615

“Power System Configurations for Extended Science Missions on Mars,” M. Swerdling, JPL 689085 ........................................... 625

# Table of Contents


**POWER CONDITIONING**

"Low Voltage Conversion from Primary and Secondary Sources," E. R. Pasquiuti, NASA — Goddard 689089 ........................................ 653

"Computerized Design of DC/DC Voltage Converters," S. A. Kolenik, Nuclear Materials and Equipment Corp. 689090 ......................................... 662

"Power Conditioning for Thermoelectric Generators," H. W. Gayek, GE 689091 .............................................................. 669

"Direct Simulation of A-C Machinery Including the Effects of Space and Time Harmonics," R. J. W. Koopman, Washington University, with F. C. Trutt, U. S. Army ERDL 689092 .................................................. 680

"An Inductor Alternator Rotor for Space Application," J. L. McCabria, Westinghouse 689093 .............................................................. 689

"Magnetic Force Unbalance and Flux Distribution in Inductor Alternators," C. C. Kouba, Westinghouse 689094 .............................................................. 698

**COMMERCIAL APPLICATIONS OF ENERGY CONVERSION TECHNOLOGY**

"Technology Survey of Electrical Power Sources," Dr. Z. Levine, Hittman Associates .............................................................. 693

"Commercial Thermoelectric Generator Applications and Economic Considerations," M. A. Rubinstein, General Instrument Corp. ........................................... 681


"Commercial Applications of Advanced Battery Technology," S. Lerner, and W. E. Ryder, Gulton Industries 689098 .................................................. 718

"Bio-Medical Applications of Energy Conversion Systems," Dr. L. T. Harmison, National Institutes of Health .............................................................. 757

**IMPLANTABLE POWER SOURCES**


"Design of an Implantable, Rankine-Cycle, Radioisotope Power Source," F. N. Huffman, R. J. Harvey, and S. S. Kitrilakis, Thermo Electron Corp. 689103 ........................................ 750

"An Implantable Artificial Heart Power Source," J. R. Lance, and A. Selz, Westinghouse 689104 ........................................ 758

"Radioisotope Powered Cardiac Pacemaker: An Implantable Thermoelectric System," T. F. Hursen, Nuclear Materials and Equipment Corp. 689105 ........................................ 765

"MiniatuRE Isotope Thermionic Electrical Power Supply," K. A. Gasper, and J. G. DeSteele, Douglas Laboratories 689106 ........................................ 773

**TERRESTRIAL VEHICLE PROPULSION**

"Low Pollution Heat Engines," D. J. Patterson, and J. A. Bolt, University of Michigan 689107 ........................................ 779

"Batteries and Fuel Cells as the Power Source for Terrestrial Vehicles," R. C. Shair, Gulton Industries 689108 ........................................ 785

"System Design Implications of Electric and Hybrid Vehicles," N. A. Richardson, TRW 689109 ........................................ 789

"Electric Drives," R. Hopkins, U. S. Army ERDL ........................................ 797

"High Frequencies Motors for Electric Propulsion," R. D. Thornton, MIT 689111 ........................................ 805


**UNDERWATER SYSTEMS**


"Underground and Undersea Radioisotope Thermoelectric Generator Development Review," J. F. Williams, Nuclear Materials and Equipment Corp. 689114 ........................................ 821

"A Radioisotope Energized Undersea Stirling Engine," C. E. Leach, and B. C. Fryer, Battelle Northwest 689115 ........................................ 830

IECEC '68 RECORD
# Table of Contents


“Characteristics of an Improved Inert-Cathode/Magnesium-Anode Seawater Battery,” B. J. Wilson, US Naval Research Laboratory 689117 852

**CENTRAL STATION POWER GENERATION**

“A Pollution-Free Hybrid Fossil Nuclear-Fueled MHD Power Cycle,” M. Steinberg, J. R. Powell, M. Beller, and B. Manowitz, Brookhaven National Laboratory 689118 .......................... 861


“Electrodynamic Power Generation — II.” T. Gunzler, K. Martinot, and M. C. Gourdine, Gourdine Systems 689122 .......................... 899

“Closed Cycle Gas-Turbine and N₂O₄ Chemonuclear Reactor,” P. H. C. Yu, Bell Aerosystems .......................... *

**PHYSICS OF DIRECT ENERGY CONVERSION**

“A Closed Loop MPD Energy Conversion Experimental System,” Dr. M. E. Talaat, University of Maryland 689124 .......................... 904

“Recombination Coefficients and Transport Properties of an Ionized Suspension,” S. L. Soo, C. Wu, and R. C. Dimick, University of Illinois 689125 .......................... 915

“Computer Study of Electrofluiddynamic Colloid Generator,” J. Minardi, University of Dayton 689126 .......................... 926

“Basic Design Considerations for Radioisotope Electrogenerators,” W. R. Michelsen, The DANE Company 689127 .......................... 935

**ADVANCED CONCEPTS**

“Application of the Supercritical Cycle to Electric Power Generation in Space,” E. G. Feher, Douglas Missle and Space 689128 .......................... 951

“A Study of Thermal Transpiration for the Development of a New Type Gas Pump,” E. Hopfinger, and M. Altman, University of Pennsylvania 689129 .......................... 961


“Development and Flight Test of a Hydrazine-Fueled Turboalternator Power Supply,” D. J. Hucker, Sundstrand Aviation 689133 .......................... 996

“A Thermoelectric Generator Powered by Waste Heat,” B. L. Embry, and J. R. Tudor, Utah State University 689134 .......................... 1008

“Military Applications of Stirling Cycle Machines,” G. Walker, The University of Calgary 689135 .......................... 1008

**PLENARY SESSION**

“Technology Readiness,” W. H. Woodward, NASA *

“Status of Thermionic Energy Conversion,” D. S. Beard, AEC *

“Plasma MHD Power Generation,” R. J. Rosa, Avco 689136 .......................... 1017

“Liquid Metal — MHD Power Generation, W. Jackson, Avco-Everett 689137 .......................... 1024


**SYSTEM PANEL and TECHNOLOGY PANEL**

Presentation by Session Chairmen of Critiques & Summaries

The following sessions are listed for information only. The contents of these sessions is published here for information only. Access to classified papers is available to U.S. Nationals only; contact the personnel arranging the classified sessions (listed under Technical Program Personnel, page 6) for all information regarding these sessions or the papers presented thereat.

**HARDSITE POWER**


“Army Applications and Requirements,” J. F. Bruton, Department of the Army

“Nuclear Blast Effects on Electrical Power Generators,” Dr. A. J. Pazycz, U. S. Naval Civil Engineering Laboratory

“Battery Couples for Hardened Site Applications,” R. J. Glockling, Boeing
Table of Contents


"Fuel Cell Power Plants for Hard Sites," W. C. Thurber, Union Carbide

"Nuclear Systems for Hard-Site Power," Dr. A. Selz, Westinghouse


"Closed Cycle Engine Operation," H. Fairclough, Boeing

"Hardsite Power Applications in Air Force Hardened and Dispersed Missile Launch Facilities," E. J. Robb, TRW Systems


"Nuclear Power Systems for Hard Sites," P. Duchon, Aerojet-General

NUCLEAR POWER SYSTEMS


"Development of High Temperature Radioisotope Fuel Capsules," Dr. L. Topper, Atomic Energy Commission


"Compact Thermoelectric Converter Program," J. Kenney, Westinghouse

"Design of a Si-Ge Tubular PbTe Cascaded Radioisotope Thermoelectric Generator," J. Schmidt, and W. Parker, Westinghouse, with R. E. Berlin, RCA


"Modular Advanced Thermionic Thermal Reactor System (MATTRAC)," M. B. Eck, Hittman Associates
