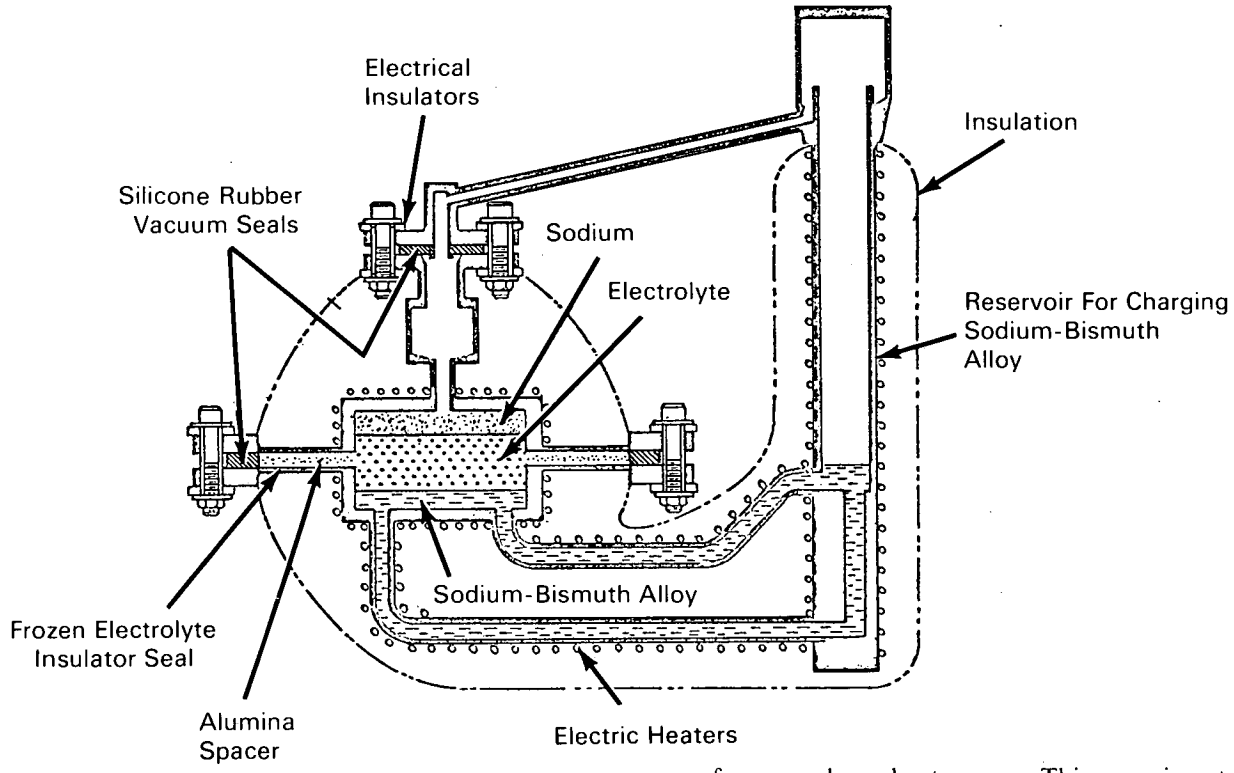
AEC-NASA TECH BRIEF

New Bimetallic EMF Cell Shows Promise in Direct Energy Conversion



The problem:

To develop a system capable of economically and effectively converting thermal energy into electrical energy. The system would be coupled with a nuclear reactor or isotropic heat source. At the present time, nuclear power is used to produce steam, which is converted to electricity via conventional turbogenerators. A direct energy conversion process would eliminate the expensive, bulky, and inefficient steam interface.

The solution:

A concentration cell, based upon a thermally regenerative cell principle, which can produce electrical energy from any large heat source. This experimental bimetallic EMF cell (without a thermal regenerator) uses a sodium–bismuth alloy cathode and a pure liquid sodium anode. The cell has been operated for 17 months without failure, exhibiting reliability, corrosion resistance, and a high current density performance. Although there are presently material problems related to the regenerator, when these are solved, the regenerative bimetallic EMF cell system should be a promising direct energy conversion device.

How it's done:

The experimental bimetallic EMF cell for a Na–Bi system, shown in the figure, is constructed of type

(continued overleaf)

18-8 stainless steel. The electrodes are cylindrical and have a 76.2 mm i.d. Spikes 2 mm in diameter on the anode act as electron collectors.

The anode and cathode are electrically insulated by a high purity alumina disc. A portion of the molten salt penetrates into gaps between the alumina spacer and the stainless steel flange and freezes. This frozen electrolyte, together with a silicone rubber gasket, provides a vacuum and pressure seal. Nichrome heater wires, insulated with alumina powder and sheathed by stainless steel, are used for the heaters. A high temperature insulating material covers the heaters.

The cell is charged under an inert gas atmosphere since the sodium alloys are highly reactive and the salt mixtures are hygroscopic. To charge the cell, first the cathode material, 20 at/o Na–Bi alloy, is charged into the cell under argon atmosphere and melted. After freezing the alloy (the electrolyte) a eutectic mixture of NaI–NaCl–NaF, is charged. The alloy and salt mixture are then melted in an argon atmosphere. At each step, the liquid levels of metal and salt must be checked, since bismuth expands upon freezing, which raises the metal level and may short-circuit the cell.

The cell was electrically charged every 48 hours. The cell temperature was varied up to 650°C, however, a major portion of the time, the temperature was kept at approximately 550°C. The melting point of the salt is 535°C. The cell current was varied by external resistance and loaded up to 10 amperes and the charging current ranged from 1 to 2 amperes.

Cell discharge current densities of 90 and 110 ma/cm^2 at 0.5 and 0.45 V, respectively, were achieved at an anode fuel efficiency of approximately 87%. The internal resistance was about 0.05 Ω at 550°C, which decreases with increasing temperature and increases very rapidly when cooled to near the melting point.

After 17 months of operation, the cell, including the frozen electrolyte insulator seal, showed no signs of failure. An interior inspection revealed little corrosion, with only 0.05 mm dissolution of stainless steel at the electrodes. X-ray analysis of the molten salt showed no signs of dissociation.

Notes:

1. This information may be of interest to gas and power utility suppliers.
2. Users and producers of electricity may develop or employ sufficiently inexpensive heat sources and suitable use conditions to permit further development in this area.
3. The significance of this item is dependent upon the further development of regeneration system materials to withstand the boiling sodium and molten sodium–bismuth alloy environment.
4. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 South Cass Avenue
   Argonne, Illinois 60439
   Reference: B68-10415

Source: H. Shimotake and J. C. Hesson of the Chemical Engineering Division (ARG-10183)

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 South Cass Avenue
Argonne, Illinois 60439