Date: 12/5/80

Project Title: Electrochemical Concentration of Gaseous Sulfur Oxides in a Molten Salt Cell

Project No: E-19-626

Project Director: Dr. Jack Winnick

Sponsor: National Science Foundation; Washington, D.C. 20550

Agreement Period: From 9/15/80 Until 9/30/81
(Includes usual six (6) month unfunded flexibility period)

Type Agreement: Grant No. CPE-8020630

Amount: $45,000 NSF
         921 GIT (E-19-350)
         $45,921 TOTAL

Reports Required: Final Project Report

Sponsor Contact Person(s):

Mr. William A. Weigand
NSF Program Officer
Chemical and Biochemical Processes
Division of Chemical and Process Engineering
Directorate for Engineering and Applied Science
National Science Foundation
Washington, D.C. 20550
202/357-9606

Defense Priority Rating: None

Contractual Matters
(through OCA)

Mr. Al Rice
NSF Grants Official
Section I
AAEO/EAS Branch
Division of Grants and Contracts
Directorate for Administration
National Science Foundation
Washington, D.C. 20550
202/357-9626

Assigned to: Chemical Engineering
(School/Division)

Library, Technical Reports Section
EES Information Office
EES Reports & Procedures
Project File (OCA)
Project Code (GTRI)
Other
OCA Research Property Coordinator

CA-3 (3/76)
GEORGIA INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 11/1/83

Project No. E-19-626

School/Dept Ch E

Includes Subproject No.(s) N/A

Project Director(s) Dr. Jack Winnick

Sponsor National Science Foundation

Title Electrochemical Concentration of Gaseous Sulfur Oxides in a Molten Salt Cell.

Effective Completion Date: 9/15/80 (Performance) 9/30/81 (Reports)

Grant/Contract Closeout Actions Remaining:

- [ ] None
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Final Inventory or Final Fiscal Report
- [ ] Classified Material Certificate
- [ ] Closing Documents
- [ ] Other
- [x] Final Report of Inventions if positive

Continues Project No. N/A

Continued by Project No. N/A

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/EES Supply Services
Research Security Services
Reports Coordinator (OCA)
Legal Services

Library
GTRI
Research Communications (2)
Project File
Other Ina Newton

Form OCA 58-11001
## PART I—PROJECT IDENTIFICATION INFORMATION

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### 6. Project Title

Electrochemical Concentration of Gaseous Sulfur Oxides in a Molten Salt Cell

### PART II—SUMMARY OF COMPLETED PROJECT (FOR PUBLIC USE)

See attachment.

### PART III—TECHNICAL INFORMATION (FOR PROGRAM MANAGEMENT USES)

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2. Principal Investigator/Project Director Name (T) prd

Jack Winnick

3. Principal Investigator/Project Director Signature

4. Date

7/21/81

NSF Form 98A (5-78) Supersedes All Previous Editions
II. Summary -- NSF ENG 7810828/8020630

An electrochemical device was conceived to remove sulfur oxides from low levels in streams such as flue gas. The process, as conceived, operates as a concentration cell utilizing a molten salt electrolyte. The product would be concentrated SO\textsubscript{3} if operated with power input, or elemental sulfur if operated as a fuel cell with reducing-gas supplied. Since this is an entirely new concept, many areas needed exploration. First, the electrochemical reactions needed verification. Second, materials for the electrolyte, supporting matrix and electrodes needed identification. Half-cell tests were necessary to determine thermodynamic and rate parameters. Finally, full-cell tests would verify design concepts.

Thermodynamic analysis quickly identified the reactions:

\[
\text{SO}_2 + O_2 + 2e^- \rightarrow \text{SO}_4^{2-} \quad \text{cathode}
\]

and \[
\text{SO}_4^{2-} \rightarrow \text{SO}_3 + 1/2 O_2 \quad \text{anode}
\]

as desirable and expected with a sulfate electrolyte. The lowest melting, stable eutectic was found to be (Li, K, Na)\textsubscript{2} SO\textsubscript{4} (512°C). All experiments used this eutectic. The support matrix was first chosen as MgO due to its tile-forming capability. Later, LiAlO\textsubscript{2} replaced MgO due to its successful use in the molten carbonate fuel cell program. Choice of electrode materials was the most difficult. Thermodynamics showed no non-noble metal to be stable. It was hoped some might form a stable, passive oxide form. Experiments were negative. However, a ceramic material has proven very stable, both chemically and physically. Its conductivity, at temperature, is equivalent to metallic materials.

** X-ray diffraction and scanning-electron-microscopy were used in this analysis -- performed prior to and after long-term tests.
The half-cell studies showed that the proposed reactions occur as expected in free electrolyte. Further, as expected, high concentrations of CO₂, as found in flue gas, have insignificant effect. Full-cell tests with the ceramic electrodes have only just begun. They are however, very encouraging. The economics projected for a full-size device appear highly favorable. Installed costs would be about one-third existing technology. Operating costs would likewise be about one-third. No reagents would be required and the only output would be concentrated sulfuric acid (>100%).