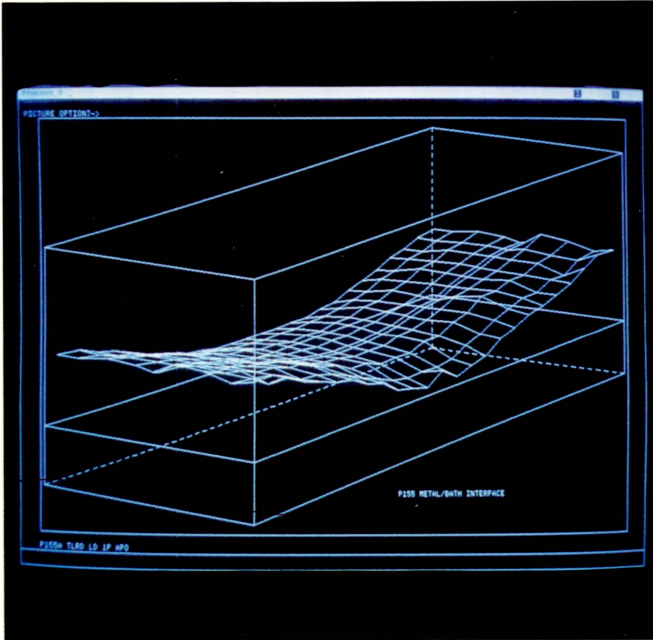


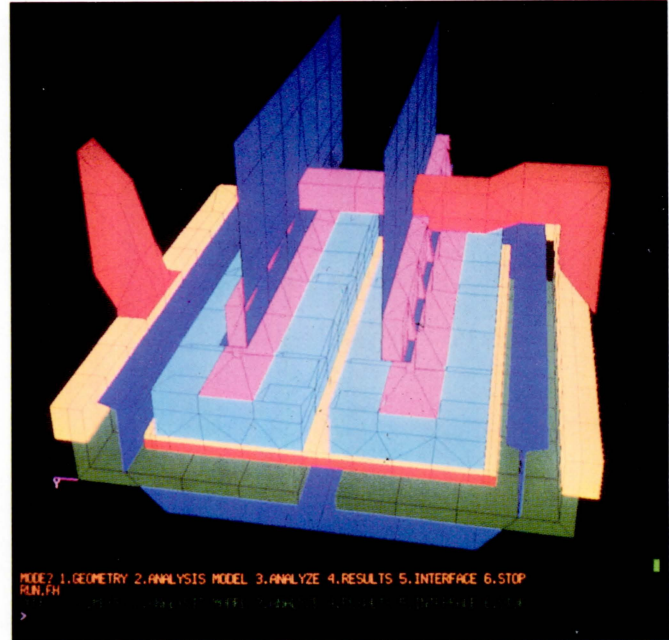


CONVEX

## HYDRODYNAMIC MODELING: An Applications Profile from Convex Computer Corporation



Calculated aluminum/electrolyte interface shape for a Hall-Heroult cell (vertical dimension exaggerated).



Rendering of Hall-Heroult cell magnetics model by PATRAN®.



In these Hall-Heroult cells cryolite is heated to a temperature of 900 to 1,000° C.



Shown here is the Rockdale, TX plant of the Aluminum Company of America (Alcoa).

More than a century ago, an Oberlin College chemistry student, Charles Martin Hall, devised a way to produce aluminum through electrolysis. After decades of technological change and research on alternative methods,

this invention, known as the Hall-Heroult Process, remains the only industrial production process for aluminum.

The Hall-Heroult Process requires vast quantities of

electrical power. Since electricity is an expensive and essential part of the manufacturing process, aluminum producers devote substantial resources to scientific investigations of ways to use it more efficiently in electrolysis.

At the Aluminum Company of America (Alcoa), the nation's top producer of aluminum, computer simulations have an important role in this research.

### **THE PROBLEM**

Industrial electrolysis of aluminum begins with cryolite in which aluminum oxide has been dissolved. The solution is heated in a special cell to a temperature of about 950° C. Anodes suspended from a bus overhead are dipped into the electrolyte, while steel bars pressed into the bottom of the vessel function as cathode current collectors. During electrolysis, the aluminum metal, which is slightly heavier than the electrolyte, pools on the bottom of the vessel.

One critical aspect of the electrical efficiency of this process depends directly on the distance between the anodes and the aluminum metal, a gap that usually ranges from one and one-half to two inches. But achieving greater efficiency is not as simple as moving the anodes closer to the metal. Wave motions occur in the fluids during electrolysis, and there are associated deformations in the interface between the metal and the electrolyte. If the interface is disturbed and the aluminum metal laps against the anode, a short occurs and no product is created. Moreover, movement of the anodes during electrolysis disrupts the cell and interferes with the process.

To develop a better understanding of electrolysis, Alcoa scientists use computer simulation to model fluid flow in the cell, and in particular, to determine what occurs along the interface between the metal and the electrolyte. The analyses require considerable computing power even when they focus on the relatively simple phenomena of steady states. Transient fluid flows are far more complex phenomena and demand correspondingly greater computing capabilities.

In 1985, the Chemical Systems Division of Alcoa Laboratories, where the firm's research on electrolysis takes

place, was using Apollo® workstations for steady state simulations. While these machines achieved an accept-

able turnaround time for such analyses, usually completing a run in a matter of hours, they would have required months to complete transient simulations. Since research on fluid flow promised to provide critical insights into electrolysis, it became important that the Division acquire the increased computing capabilities that would allow it to undertake such studies.

### **THE SOLUTION**

After investigating a variety of possibilities, Alcoa selected the Convex C1, the first affordable supercomputer. The C1 combines the memory and vector processing capabilities previously found only on large-scale supercomputers with the



Dr. Walt Wahnsiedler shows results of a Hall-Heroult cell hydrodynamic model on an Apollo® workstation.

software and price advantages of minicomputers.

In its search for expanded computer capabilities, Alcoa initially considered an attached array processor, but soon concluded that its applications required a standalone system. The flow simulations demanded a machine with large real memory, and Alcoa wanted the convenience of having virtual memory available as well. In addition, Alcoa sought to avoid the I/O bottleneck that can occur with an attached array processor, and was concerned about the connectivity of such a device.

In comparing the Convex C1 with other available systems, the decisive factor for Alcoa was the company behind the machine. Alcoa found that Convex Computer Corporation was equipped to provide timely conversions of the needed code,

and was committed to building long-term relationships with its customers. Coupled with the system's performance on critical benchmarks, these considerations made the case for the C1.

**"Alcoa is eager to keep the competitive advantage that comes from being on the leading edge in technology, so the C1's performance made it appealing from the start.**

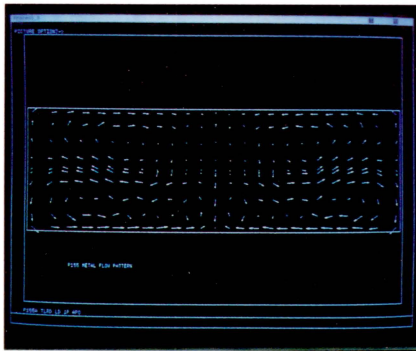
**We're conducting important studies of fluid flow phenomena — simulations we simply couldn't do before we got the C1.**

**"Although we wanted to be on the forefront technologically, we didn't want to be wholly on our own. It was critical to us that we deal with a company that's really committed to supporting its customers. We found that in Convex. We've been very impressed by the resources and professionalism at Convex, and the company has bent over backward to give us the support we need."**

**Dr. Walter E. Wahnsiedler,  
Staff Scientist, Chemical  
Systems Division, Alcoa  
Laboratories**

Installed in December, 1985, the Convex C1, a 64-bit integrated scalar and vector processor with a Cray®-like architecture offered a strong price/performance ratio. Its large real and virtual memory — up to 128 megabytes of physical memory plus four gigabytes of virtual memory — could handle the transient state simulations Alcoa needed.

The investment is expected to yield dividends rapidly. Using the Convex C1, Alcoa accomplished in a matter of months transient flow research that is providing significant and practical insights into its smelting operations.



Calculated flow pattern map for a Hall-Heroult cell.

### Selected Software Currently Supported on Convex C1 at Alcoa

PHOENICS (Steady-state and transient fluid flow; "finite domain")

ESTER (Specialization of PHOENICS for Hall-Heroult cells)

FIDAP (Steady-state and transient fluid flow; finite element)

IMSL

SOLGASMIX (Chemical equilibrium calculator; in process)

SAVE.CHADOC (Current distribution calculator for electrolytic cells)

PLOT-10 (Tektronix 2-D graphics)

CUSTOM PROGRAMS (Hall-Heroult cell stability calculator, FFT, etc.)

Software supported on the Convex C1 at Alcoa includes PHOENICS™, FIDAP™, IMSL™, PLOT-10™, ESTER, SOLGASMIX, SAVE.CHADOC, and various custom programs such as the cell stability calculator and FFT.

### Software Used with Convex C1 but Running on Apollo

PATRAN (Finite element mesh generation/postprocessing)

GRAFFIC (Postprocessor for PHOENICS-81)

PHOTON (Post processor for PHOENICS-84; in process)

FXP (File transfer to/from VAX computers and others)

DATAVIEWS (2-D and 3-D graphics)

PLOT-10 (Tektronix 2-D graphics)

CUSTOM PROGRAMS (PHOENICS field separator, etc.)

Alcoa found that FIDAP runs that had consumed more than half an hour on the Apollo could be completed in just over a minute of CPU time on the Convex C1. ANSYS® runs that took 36 minutes on a VAX™ 780 required only 3.7 minutes of the C1's CPU time.



Dr. Don Ziegler shows a PATRAN rendering of a Hall-Heroult cell magnetics model on an Apollo workstation.

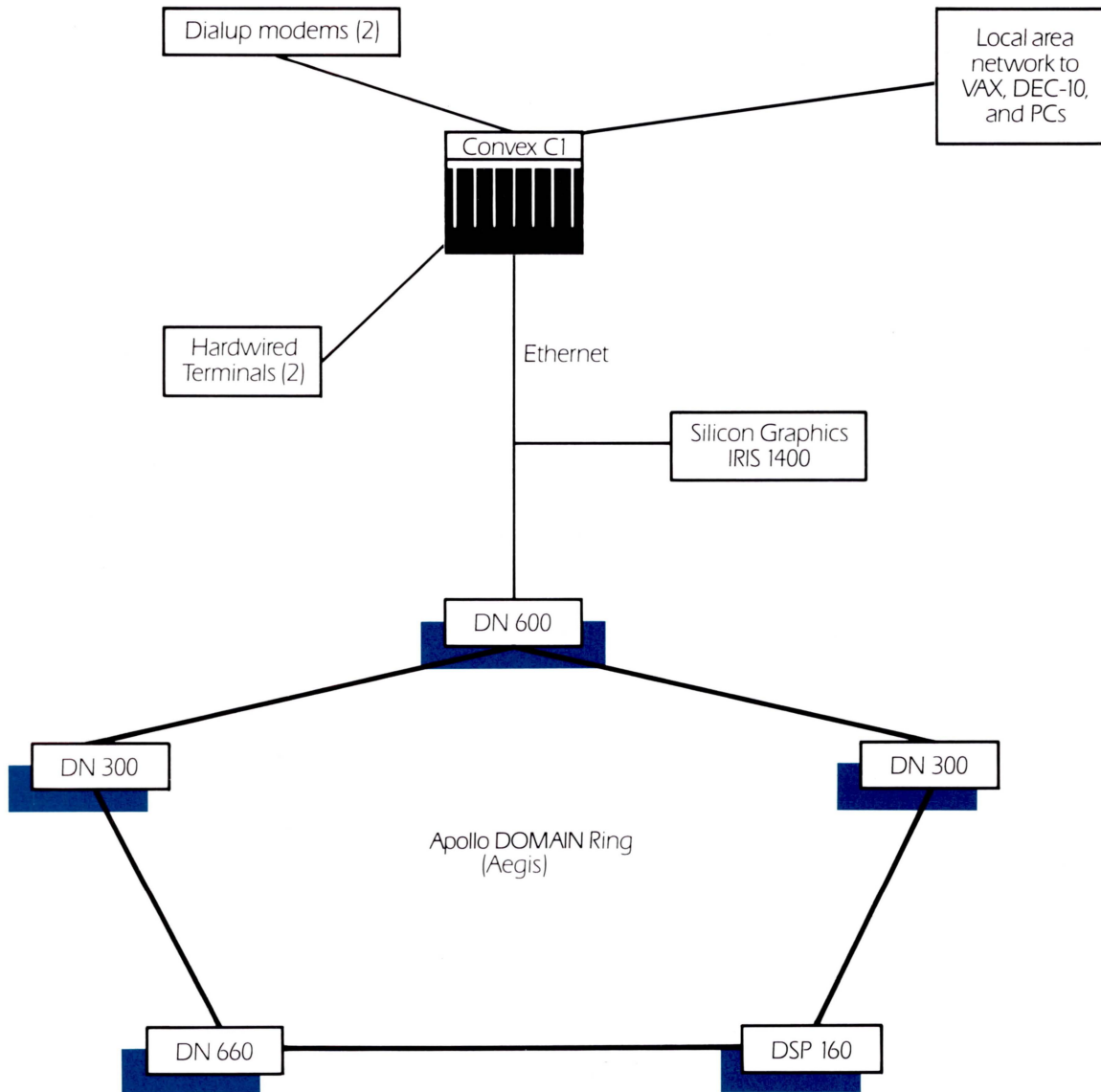
The Convex C1 at Alcoa Laboratories is linked via Ethernet™ to an Apollo DOMAIN® network. Software running on the Apollo workstations and used in conjunction with the C1 includes PATRAN®, GRAFFIC, PHOTON, FXP, DATAVIEWS, and various custom programs.

### THE ORGANIZATIONS

Alcoa is the nation's leading producer of aluminum. Headquartered in Pittsburgh, Pennsylvania, the company has five operating groups: packaging systems, aerospace and industrial products, metals and chemicals, materials science, and international.

Convex Computer Corporation, based in Richardson, Texas, was founded in September 1982 to design, manufacture, market and service affordable supercomputers for a wide range of technical users. The company's first product, the Convex C1, began shipment in March 1985. The C1, which features a Cray-like architecture, combines 64-bit scalar and vector processing capabilities previously found only on large-scale supercomputers with software and price advantages of minicomputers. A worldwide network of offices provides service and support to customers using Convex systems for such applications as geophysical research, computer-aided engineering and design, defense, aerospace, and general research.

## Alcoa Convex C1 Environment



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