the story of the early graphite reactors was the design and procurement of the coolant tubes that contained the fuel slugs. The tubes were made from pure aluminum, except for two longitudinal aluminum-alloy ribs along the bottom of each horizontal tube. Ribs made of pure aluminum would have stuck to the aluminum-clad slugs by diffusion and reaction over several months of exposure to flowing water. The slugs would have been impossible to push out of the reactor without the possibility of loss of integrity.

The production process for those composite tubes was proprietary to Aluminum Co of America (now Alcoa). The company's draw bench was the only one in the world long enough to produce 50-foot-long tubes. At the time it was being used to draw the main wing spar for the B-59 bombers of the Pacific campaign. The spar consisted of a strong aluminum-alloy body with a thin, pure aluminum covering to resist seawater corrosion. It took considerable effort to convince company officials that three academics from the University of Chicago's Metallurgical Laboratory understood the problem and furthermore, that they had a directive from the federal government to shut down the wing spar production to make about 2000 tubes, each about 50 feet long, according to their design. Suffice it to say that the rapid reversal of body and thin covering materials was accomplished after some quick experimentation, and things progressed satisfactorily after that.

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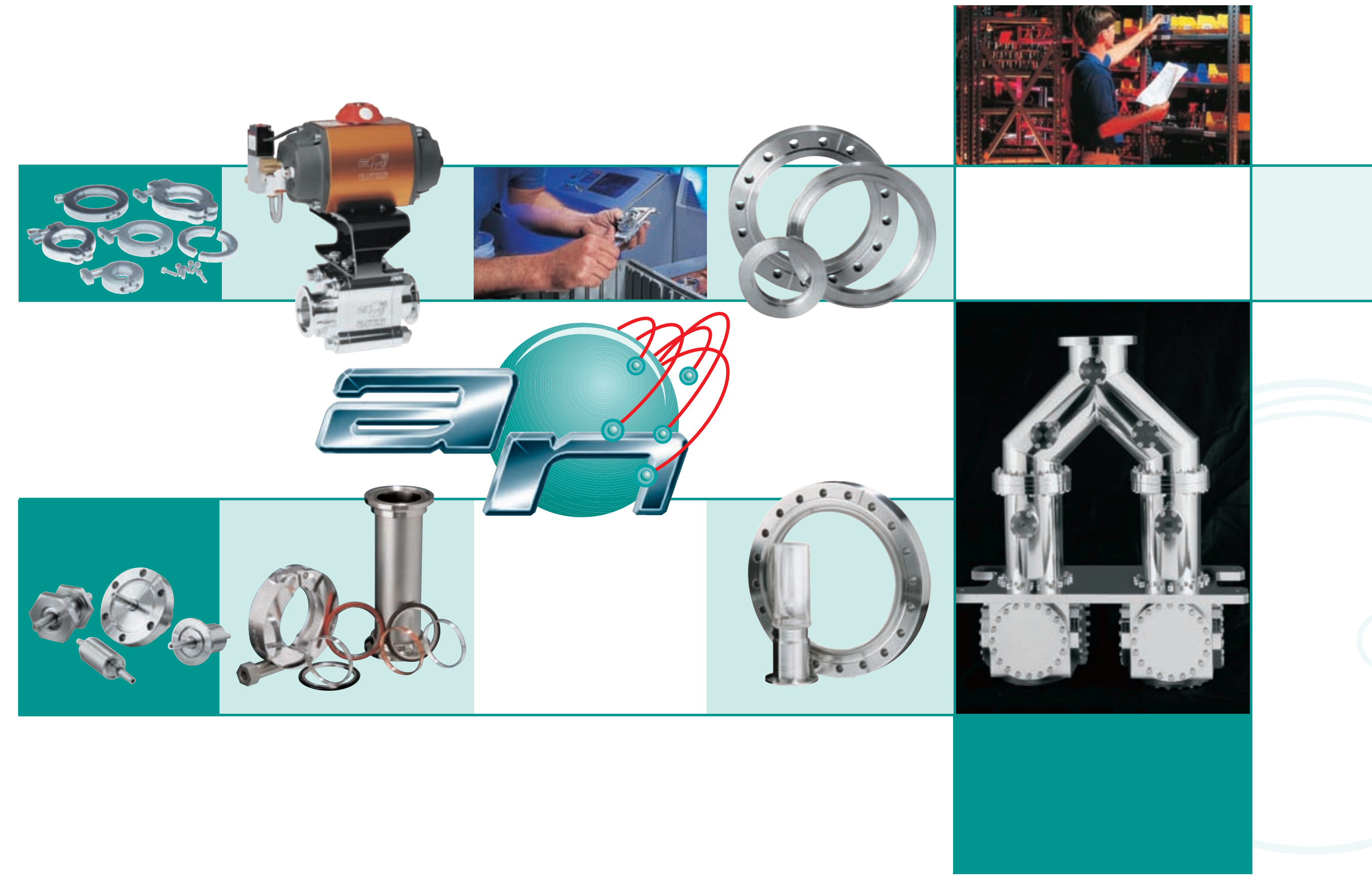
Weinberg replies: George Bankoff raises a touchy point about the relationship between Eugene Wigner, who holds the patent on the Hanford reactors, and the DuPont company, which built the reactors. As I point out in my book *The First Nuclear Era: The Life and Times of a Technological Fixer* (AIP Press, 1994), Wigner viewed the Hanford project as a quick and dirty way of making plutonium, whereas DuPont, in Wigner's view, was unnecessarily slow and deliberate. In his memoirs, Wigner offers a silent apology for having implied that the company was motivated by other than a desire to produce as much plutonium-239 as possible as quickly as possible.

As to the size of the Hanford reactors—1500 tubes in the Wigner design compared to 2004 in the DuPont design—there are two explanations for the discrepancy. When Arthur Compton assigned the water-cooled reactor design to Wigner in the spring of 1942, uranium was very scarce. Compton told Wigner and me that we had to do the job with only



200 tons of uranium—that is, the 1500-tube reactor. By the time DuPont came on the job, much more uranium was available. The first to suggest enlarging the reactor to 2004 tubes was Enrico Fermi, according to Volney C. Wilson, who was present when the suggestion was made. I have been told by John Wheeler that George Graves, a DuPont engineer, was the one who actually made the decision to add 504 tubes to the reactor, even though that exceeded Compton's 200 tons of uranium by about 50 tons.

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New Facilities Expand Protein Crystallography Opportunities

The story "Neutron Diffraction Overcomes Flux Limits to Resolve a Large Protein Structure" (PHYSICS TODAY, November 2003, page 17) captures the excitement that has been generated in the structural biology community by recent results from neutron diffraction studies of large protein structures. As the scientists who built and operate the protein crystallography station (PCS) featured in the report, we felt compelled to write in order to avoid any misunderstanding about the role of the PCS in the development of neutron protein crystallography.

Experiments in the late 1960s led to a neutron protein crystallography program at the reactor run by Brookhaven National Laboratory (BNL); that program provided important insights into the structure and function of a number of proteins. A similar program was started at the Institut Laue–Langevin (ILL) reactor in France in the 1980s, and another in the 1990s at the reactor run by the Japan Atomic Energy Research Institute (JAERI). The BNL reactor experienced frequent shutdowns in the 1990s, including its permanent shutdown in 1996. Those incidents, coupled with the shutdown of the ILL reactor in 1991, terminated neutron protein crystallography in North America and Europe for most of the 1990s.

After the ILL restarted in 1995, a new type of protein crystallography station, the Laue diffractometer (LADI), was built; it uses the Laue method and the detector technology of neutron image plates. The image plate technology was developed at JAERI on another new protein crystallography station called BIX-3. The two stations have recently started to produce results.

The construction of the PCS at the Los Alamos Neutron Science Center has added to the rebirth of this field. The PCS explores the capabilities of spallation neutrons. Next-generation spallation sources are being built throughout the world and offer the promise of significant gains (in performance and also an increase in the number of protein crystallography stations).

We must emphasize that the increasing availability of optimized neutron protein crystallography stations in general, and not the unique capabilities of the PCS, has made possible a number of recent neutron diffraction studies of large proteins. Readers who are interested in carrying out experiments are welcome to contact us for information on the proposal process and for technical advice.

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