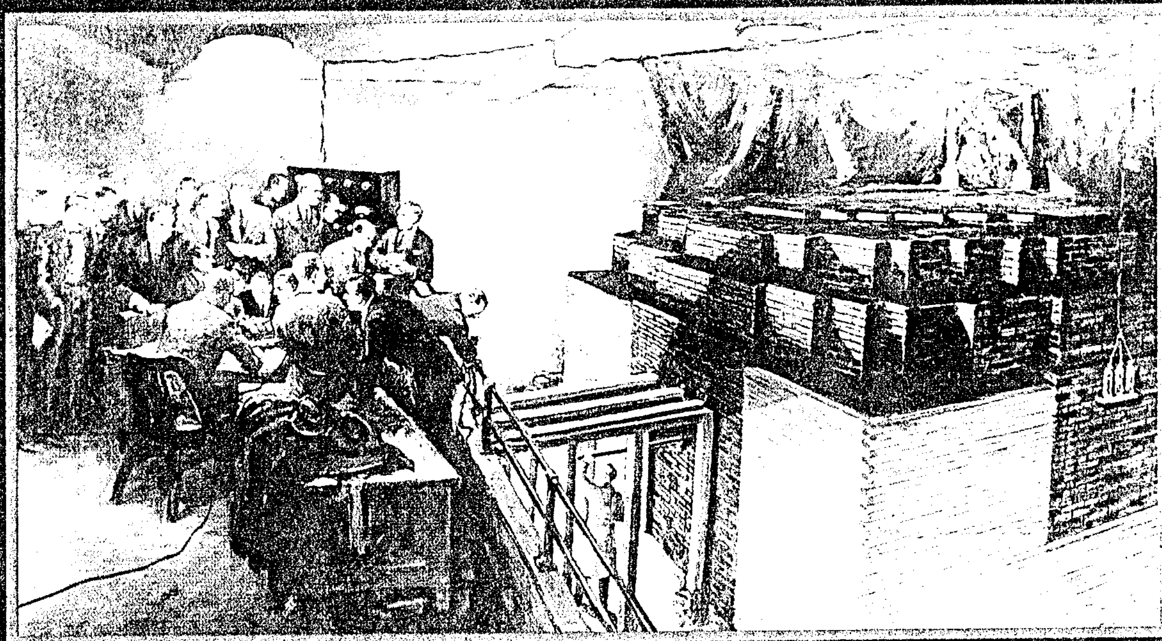
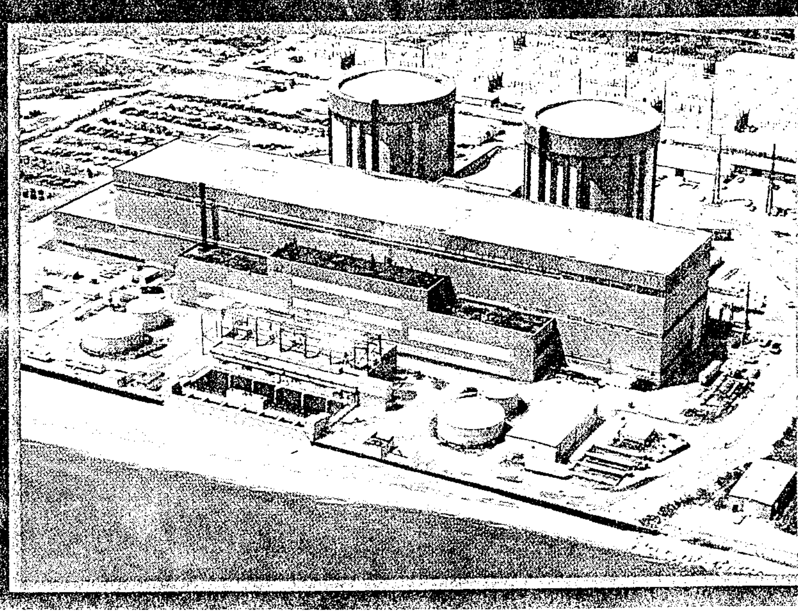
CONTROLLED NUCLEAR CHAIN REACTION



THE FIRST 50 YEARS



Controlled Nuclear Chain Reaction

The First 50 Years

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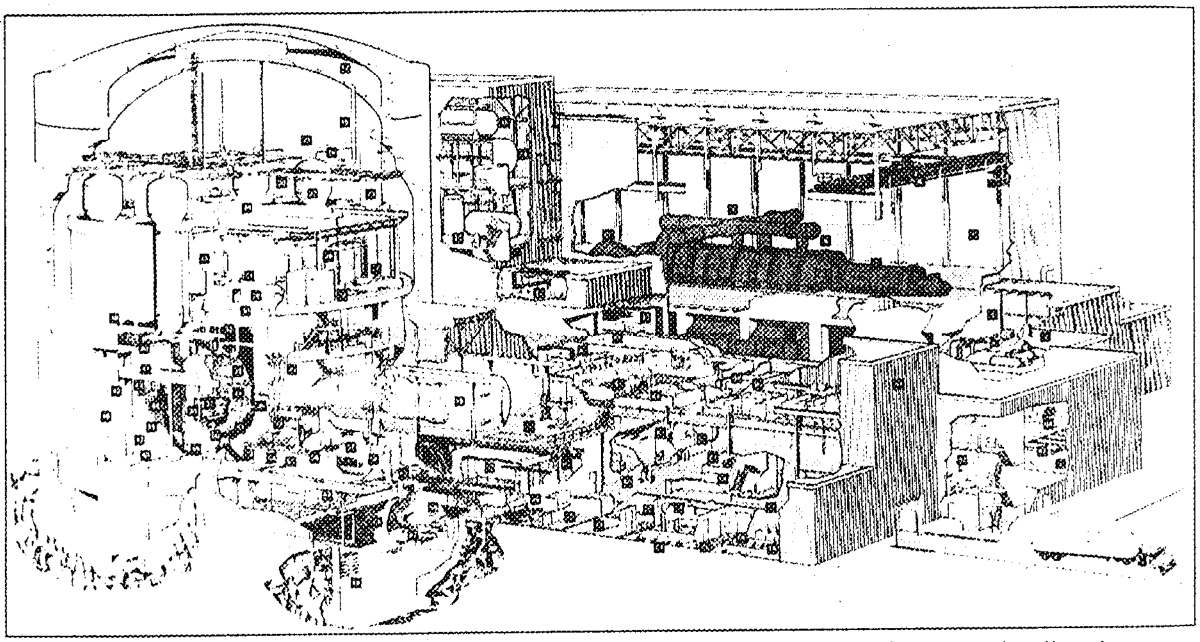
Canada[1]

Canada alone seized on the potential of the natural uranium reactor for its long-term nuclear development program. Canadian scientists concentrated on research, including some of the earliest applications of radiation therapy. Without a need for plutonium or highly enriched uranium, and with expertise developed through experience with heavy water research reactors, Canada developed the successful pressurized heavy water reactor that is known as CANDU (*CAN*adian *D*euterium *U*ranium reactor).



CANDU 600-MW(e) reactor. (Courtesy of AECL–CANDU Pub. & Gov. Communications)

CANDU Reactors

CANDUs use heavy water for both cooling and moderation. Because they operate using natural uranium, CANDU reactors are quite large. To avoid constructing very large high-pressure vessels, a system of pressure tubes was developed in which only the coolant water is under pressure, not the moderator. The heavy water moderator is contained in a large tank called a *calandria*, which has several hundred tubes running through it. The fuel bundles and coolant are in horizontal pressure tubes within the calandria tubes, an arrangement that allows the reactor to be refueled while at power and still connected to the grid. With this advantage, CANDUs have the potential for operating with a high capacity factor. On the down side, CANDUs operate at a relatively low temperature, resulting in a lower thermodynamic efficiency than LWRs. As enriched uranium became available for power reactors, it was demonstrated that CANDUs could be made more compact and have improved operating characteristics if the uranium oxide pellets were enriched to slightly more than 1% in U-235.

[1]Drawn extensively from *AECL 1991 Annual Review*, Atomic Energy of Canada Ltd. (1991).

In the late 1930s, Canadian scientists began their country's nuclear research by experimenting with fission at the Ottawa laboratories of the National Research Council. By early in World War II, a research group in Canada was considering the effectiveness of graphite and heavy water as potential moderators to sustain a chain reaction in natural uranium. In 1942, this group, led by George Laurence, was joined by a Cambridge team of scientists, led by Hans von Halban, one of Joliot-Curie's Paris colleagues. The Cambridge group brought along most of the world's supply of heavy water, which Norway had loaned to the United Kingdom.[2] Heavy water appeared likely to be the more effective moderator, but was difficult and expensive to obtain, whereas graphite of adequate purity was more readily available. Experiments with both materials had already taken place in Canada, the United Kingdom, and the United States.

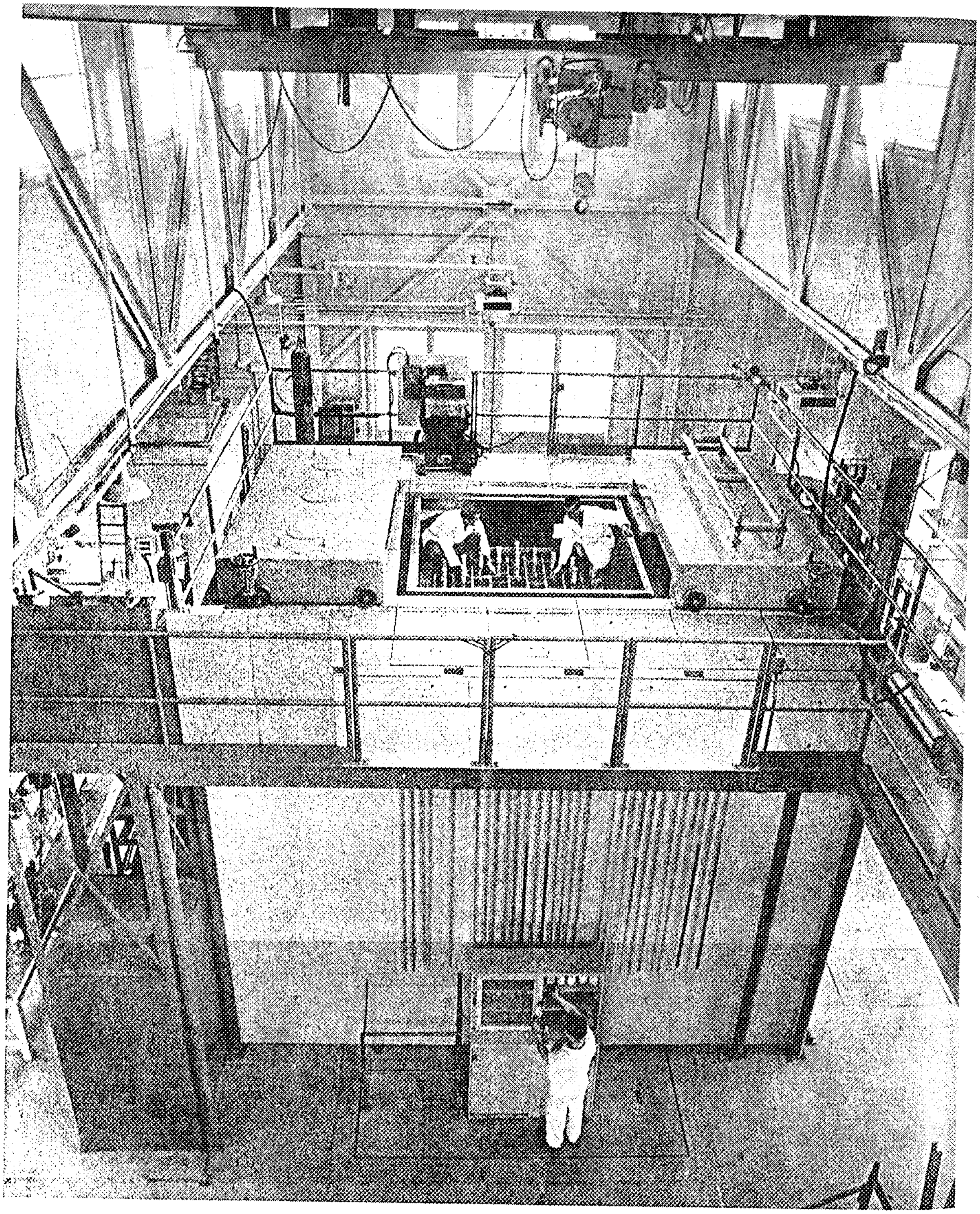
There was a series of high-level meetings, agreements, and understandings between the British and Americans throughout the duration of the war. However, the American concern for maintaining secrecy in view of the mixed-European nature of the British-Canadian effort, misunderstandings about supplies, and political differences limited the degree of information exchange for considerable periods. Eventually, in April 1944, agreement was reached on the design and construction of a heavy-water-moderated reactor in Canada by a joint British and Canadian team led by John Cockcroft, a British physicist. This agreement initiated a flow of information, supplies, and other help from the United States to the project that established the Chalk River Laboratory at a wilderness site on the Ottawa River. Thus, Canada became the only nation besides the United States to start nuclear development during the war.

> AECL was created to conduct research and development into the peaceful uses of nuclear science and technology.

On September 5, 1945, the Chalk River international scientific team started up the Zero Energy Experimental Pile (ZEEP), the first nuclear reactor outside the United States. It provided information for the design of an advanced research reactor, the National Research Experimental (NRX) reactor, which began operating two years later.

In 1951, the Chalk River scientists started work on a new, world-class research reactor, the National Research Universal (NRU) reactor. NRU was designed to allow more experiments and to back up NRX in the production of

[2]B. Goldschmidt, *The Atomic Complex*, American Nuclear Society, La Grange Park, IL (1982).



ZEEP (Zero Energy Experimental Pile), the first nuclear reactor outside the United States, was started up September 5, 1945, at Chalk River, Ontario. It was heavy-water-moderated and was used to assist in the design of the NRX. (Courtesy of AECL–Research)

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