STATUS REPORT ON
THE DOUGLAS POINT PROJECT

by

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and
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The Douglas Point Project is a 200 000-kW nuclear power station which has been under construction on the shore of Lake Huron, about ten miles north of Kincardine, since December 1960. A photograph of the architectural model is shown as Figure 1. A design review and progress to September 1961 were given in a paper presented at the Seventh Symposium (AECL-1318, paper 6). It is the purpose of this paper to describe progress during the last twelve months, to review the present status in the manufacture of major items of equipment, and to present the latest picture on costs and completion schedule.

DESIGN SUMMARY

Referring to Figure 1, the reactor building is the cylindrical concrete structure topped by a hemispherical steel dome. It is 130 ft in diameter and overall height is 140 ft. This building contains the reactor vessel (calandria) within an inner heavy-concrete vault extending from some 20 ft below grade to 35 ft above. Large openings in the end walls of the vault are filled by heavy steel-and-water shields through which the fuel-carrying coolant tubes project. On-power refuelling machines operate at each end of the reactor within auxiliary concrete vaults. The general arrangement of the reactor components and shielding vaults is shown in Figure 2. The calandria holds the moderator heavy water and 306 horizontal tubes pass through it. These enclose the coolant pressure tubes which are supported by the end shields. Garter springs are provided to maintain separation between the coolant and calandria tubes. The reactor building contains reactor auxiliary

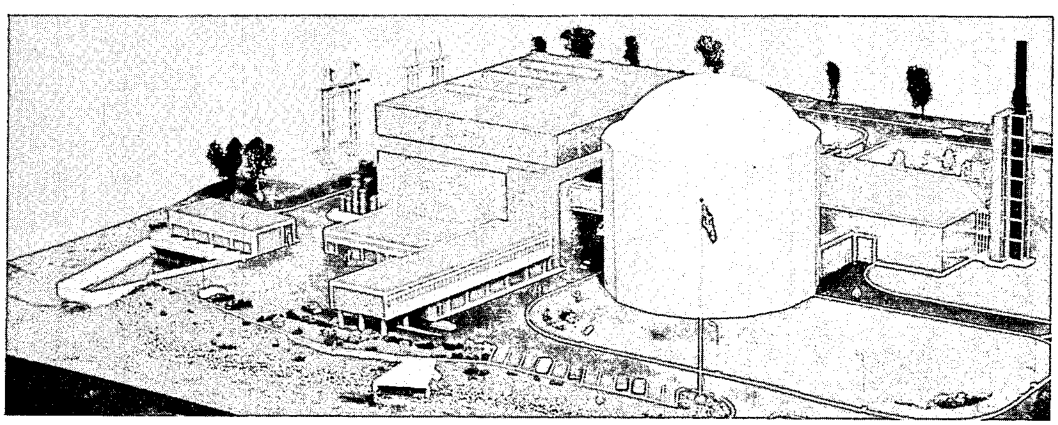


Figure 1: Architectural Model of Douglas Point Generating Station

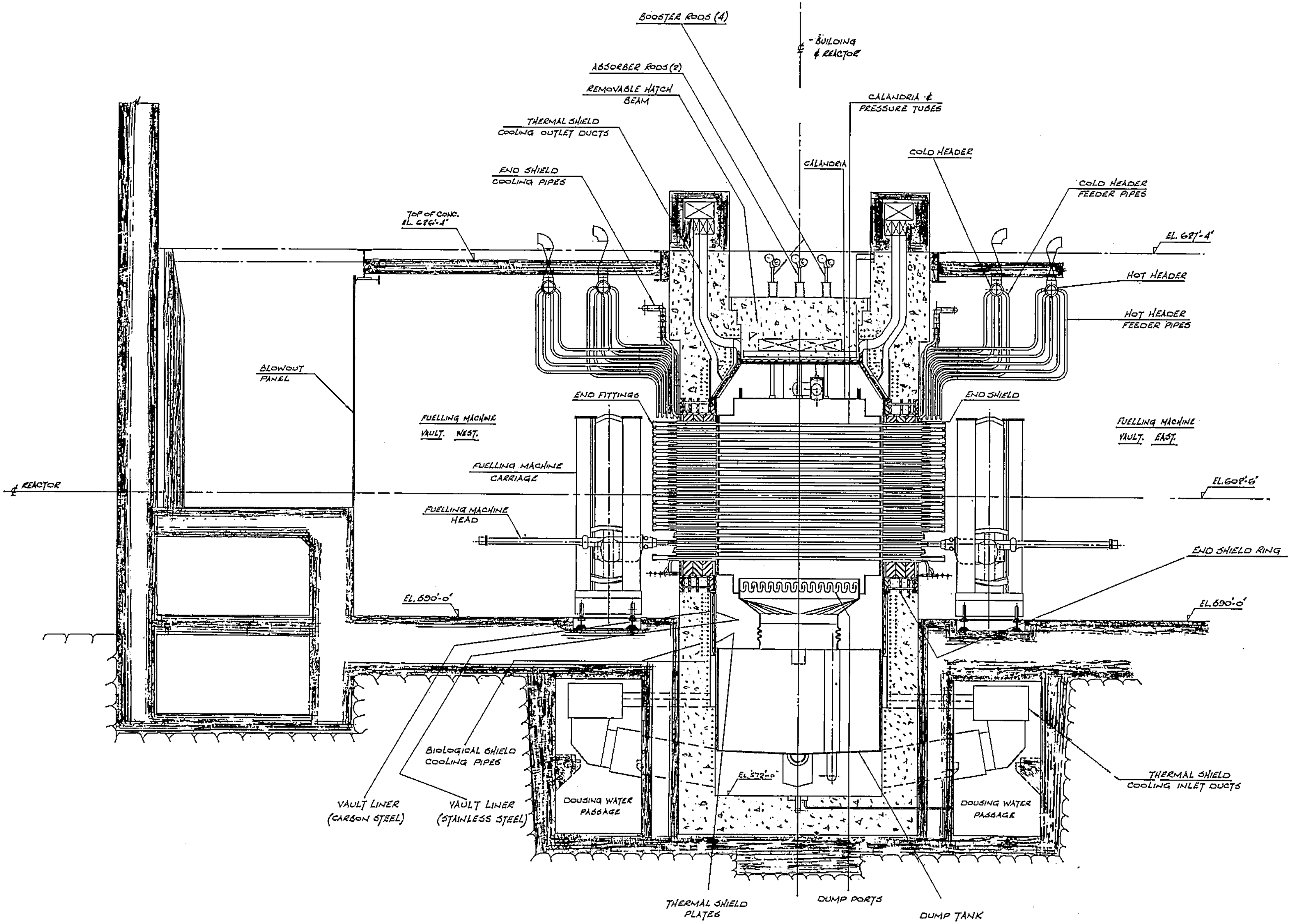


Figure 2: Reactor Vault - Section Looking North

TABLE I

Reactor	
Type	natural-UO_2 fuel; heavy-water moderator; heavy-water coolant; horizontal pressure-tube construction.
Thermal rating	694 MW
Number of fuel channels	306
Coolant exit conditions	560°F (293°C) 1345 lb/in^2 (absolute)
Coolant entrance conditions	480°F (249°C) 1441 lb/in^2 (absolute)
Heavy water quantity	47 tons in coolant system 155 tons in moderator system
Fuel quantity	52 tons in reactor core
Boilers	
Quantity	8
Type	Ten vertical U-tube heat exchangers and one steam drum per boiler.
Evaporation rate	2.56 x 10^6 lb/h total
Turbine	
Type	Tandem compound; one H.P. cylinder, one L.P. single-flow and one L.P. double-flow cylinder; moisture separator and reheater fitted between H.P. cylinders and L.P. cylinders.
Rating	220 MW, 1800 rev/min
Steam conditions at turbine stop valve	482°F (250°C) 565 lb/in^2 (gauge)
Generator	
Type	3 phase, alternating current; hydrogen-cooled rotor; water-cooled stator; motor-driven exciter.
Rating	244,444 MVA, 18 kV, 1800 rev/min 90% power factor.
Transmission	230-kV double-circuit line to Ontario Hydro's Southern Ontario System
Station Efficiency	29.1% overall.

components including equipment for moderator circulation, cooling and purification, and end-shield and biological-shield cooling circuits on the lower floors, a fuelling-machine maintenance bay on the ground floor and primary-coolant and steam-raising system components on the upper floor above the reactor.

The fuel consists of 3060 bundles in the reactor core. A bundle is composed of 19 cylindrical elements, each 19.5 in. long and consisting of a Zircaloy tube of diameter 0.6 in. containing 24 pellets of natural uranium dioxide.

Some of the main design features of the plant are summarized in Table I.

Access to the reactor building is from the two-storey service building via an air-lock at ground level. The service building houses change rooms, maintenance shops, decontamination centre, waste collection and disposal equipment and the spent-fuel storage bay. Used fuel is transferred to this bay from the reactor vault through an underground passage. Steam is carried from the boilers in the reactor building to the turbine in two 26-in. overhead pipes. The turbine building, 95 ft high, contains the turbine-generator and auxiliaries, the station service switchgear and the main control room from which the whole station is operated. A two-storey administration wing and a single-storey wing housing the diesel generators and water-treatment equipment are provided. Cooling water is pumped from the lake via a 750-ft concrete tunnel.

During the last year, good progress has been made in the detailed design of plant components. The civil engineering is nearing completion. The complete design of the reactor plant and reactor services as well as project management is being carried out at the Nuclear Power Plant Division of AECL in Toronto, where a staff of about 190 is employed on this work (excluding development). Detailed architectural and civil design and design of the conventional plant is being carried out by Ontario Hydro, where about 100 are presently assigned to this work. In both of the above manpower figures, professional engineers account for about one-third of the total.

DEVELOPMENT

The development activities of NPPD consist of work in their laboratory in Toronto and contracts with outside firms. In the laboratory the bulk of the work has centred on the main test rig which operates at reactor temperature and pressure conditions. Pumps and pump seals have been tested, numerous studies have been made on fuel-bundle behaviour and the performance of various reactor components, joints and fittings have been examined, and thermal cycling and hydraulic tests have been carried out. A fuelling-machine carriage has been set up with its full controls and the complete machine will be on test later this year. Some fundamental studies on wear, corrosion and steam condensation by water-spray dousing have been done. Full-scale dousing and pressure-tube-rupture experiments are under way now. In all there are about 75 active projects in the laboratory at the moment, and some 35 have been completed. The laboratory staff numbers about 40.

There have been over 50 development contracts placed with Canadian industry. Over 20 firms have been involved from time to time. The first work involved nine companies in the preparation of conceptual designs for steam generators (main boilers). These were narrowed down to three alternative designs for development of further details, and finally the John Inglis design was chosen and used as the basis for the Douglas Point tendering specification. A good deal of work has been done on tube-to-tubesheet welding and on corrosion tests on different tube materials.

Canadian Westinghouse have carried out an extensive program of investigation into alloys suitable for brazing Zircaloy, as applicable to fuel-bundle fabrication. They have also done very useful work on leak erosion and hydriding of thin Zircaloy foil.

Extensive programs have been conducted on methods of joining to be used in end-fitting fabrication and on wear (galling

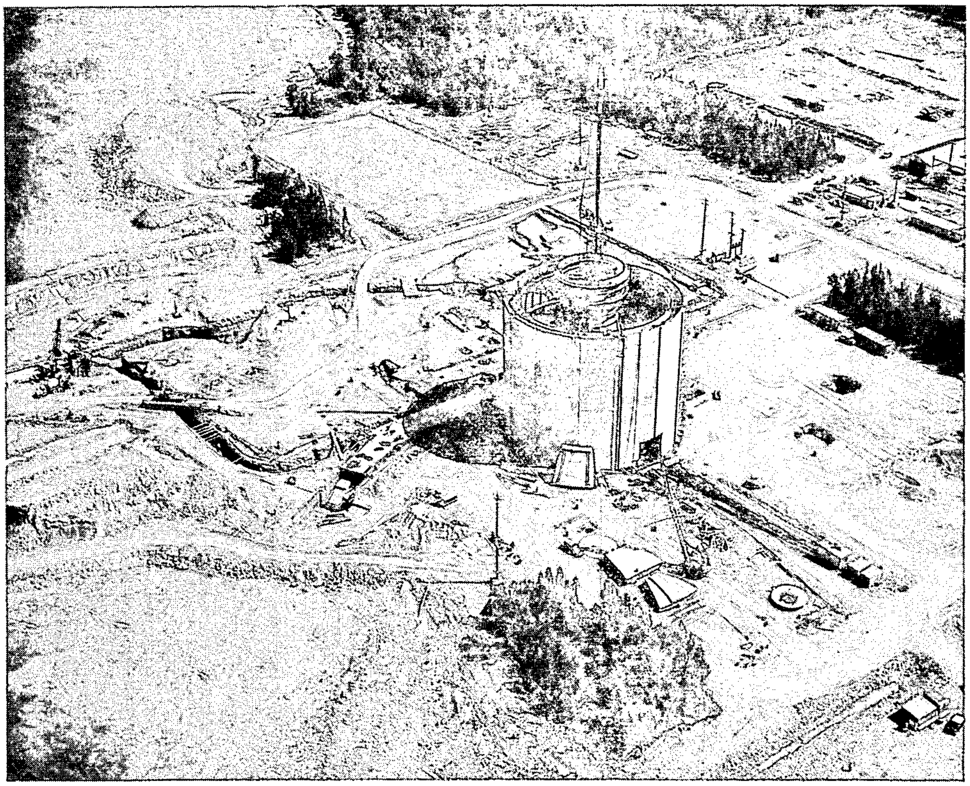


Figure 3: Air View Looking North-East, Aug. 1961

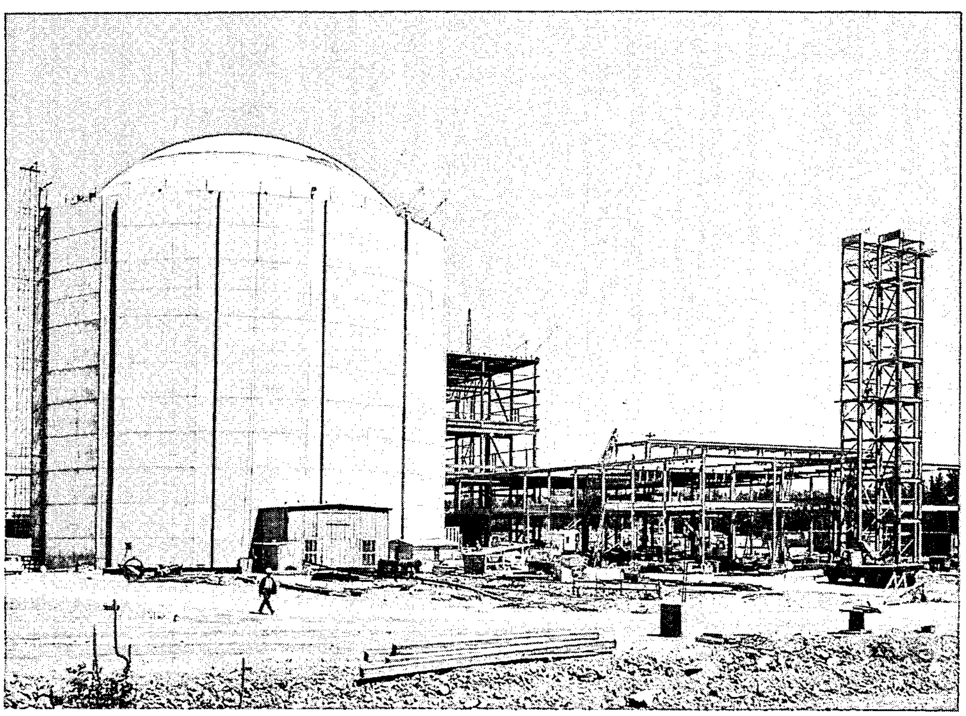


Figure 4: View Looking North-East, Aug. 1962

and seizing) problems on various combinations of materials associated with different reactor components. An important work has been that associated with rolling of Zircaloy tubes and this has resulted in improved joint designs for CANDU.

CONSTRUCTION PROGRESS

A year ago the site structures consisted of a reactor building concrete shell with a partially-complete steel dome, excavations for other buildings, some circulating-water ducting and the first stage of the water intake tunnel, as shown in the photograph (Figure 3). Now the scene has changed considerably (Figure 4). The reactor building dome has been completed; structural steel is in place and roofing is partially on for the turbine, service and administration buildings; intake and discharge ducting for the circulating water is complete; rapid progress is being made on the pumphouse and the extension to the intake tunnel. The total work force on site (mostly Ontario Hydro Construction Division personnel) grew from about 260 last September to a peak of over 520 last month. Up to August 31, 1962, 33 600 yd^3 of ordinary concrete and 725 yd^3 of heavy concrete had been poured.

Within the reactor building, work continued all through last winter. Internal structural-steel erection commenced at the end of November, after a delay of a month due to the erectors' strike. This time was not all lost, however, as concrete pouring in the basement areas was advanced to fill the gap. Frankel Steel completed their work in this building by mid-January. Concrete work continued from this point and today approximately 90% of the interior walls and floors are complete.

The first heavy-concrete pour was made in the calandria-vault floor in mid-April. Prior to this, a full-scale mock-up of a single vault-wall pour had been made in order to gain experience in placing to a high degree of accuracy the multitude of embedments including two rows of cooling pipes, thermal-shield support anchors, end-shield ring anchor bolts and vault-liner support tees; all this as well as miscellaneous

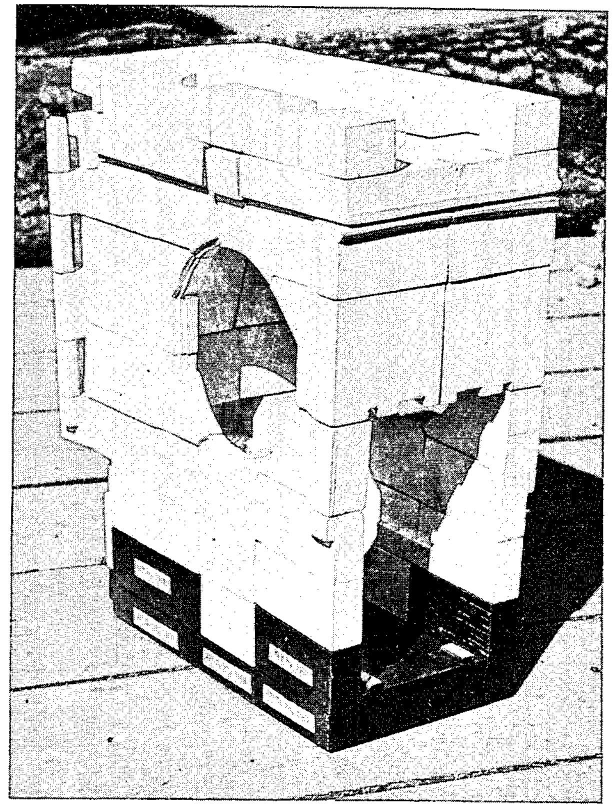


Figure 5: Model of Calandria Vault

sleeves, thermocouples and anchor inserts in a wall only three feet thick in some places with five rows of reinforcing bars. Valuable experience was also gained on the handling of the heavy concrete. The first wall pours were made early in May. Figure 5 shows a model of the vault made up of blocks representing individual pours. The shaded blocks are those completed by May 10, 1962. Since then, the walls have been completed to the fifth lift and work is now in progress on the sixth. The complexity of the embedments and reinforcing has forced abandonment of some of the vertical construction joints, as it was proving next to impossible to insert and remove bulkheads. Closer control of pouring and curing has been specified to ensure no cracking results. An interior view of the vault construction is shown in Figure 6. This part of the job has proved much more time-consuming than had been originally estimated; it will probably take seven months to finish the heavy-concrete work, compared with an estimate of three and a half.

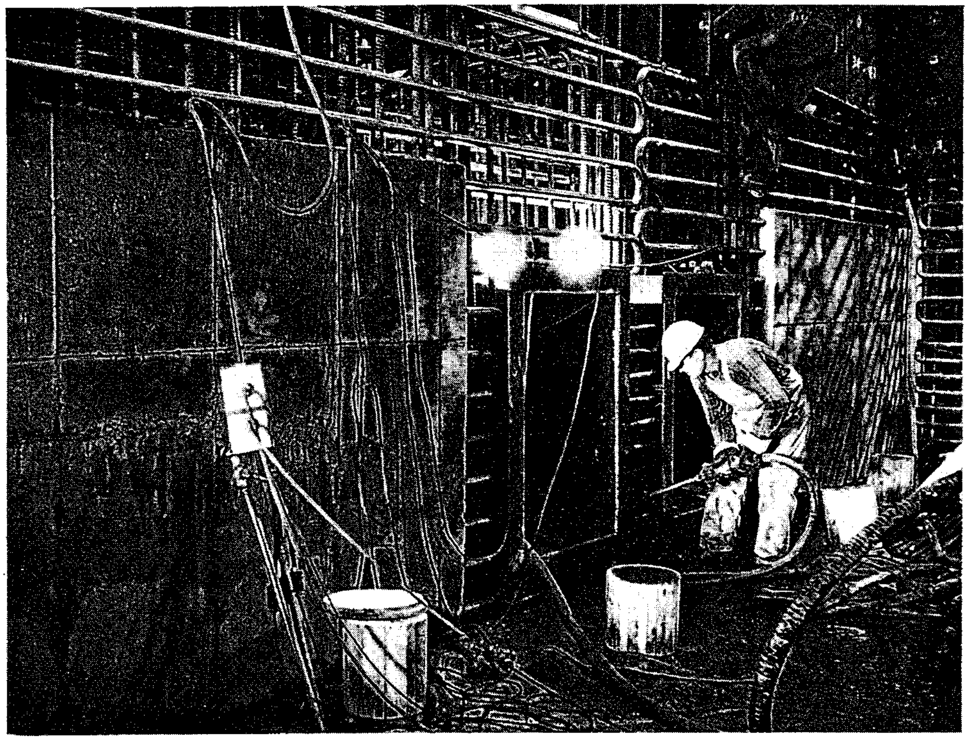


Figure 6: Calandria Vault, May 1962

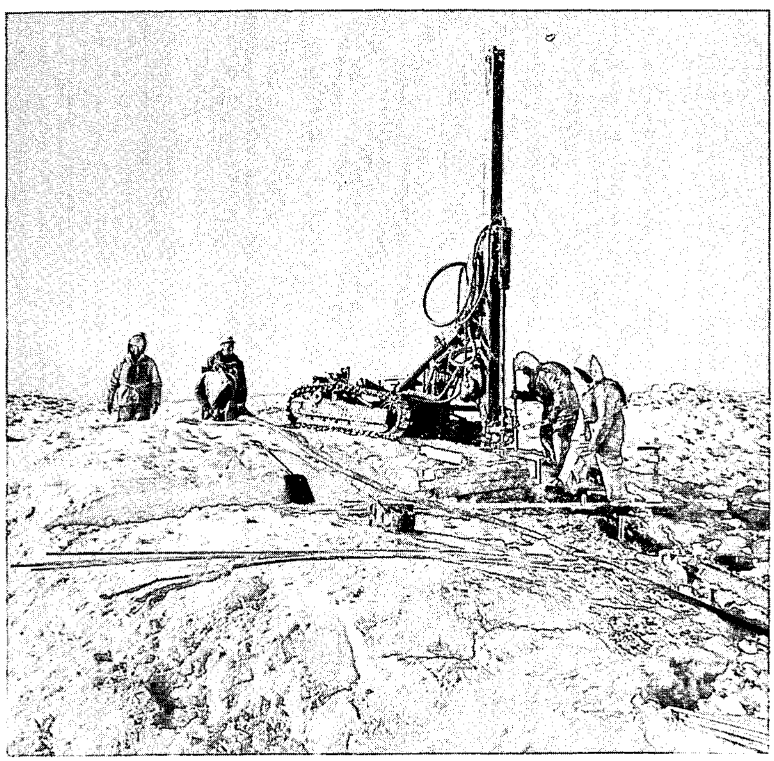
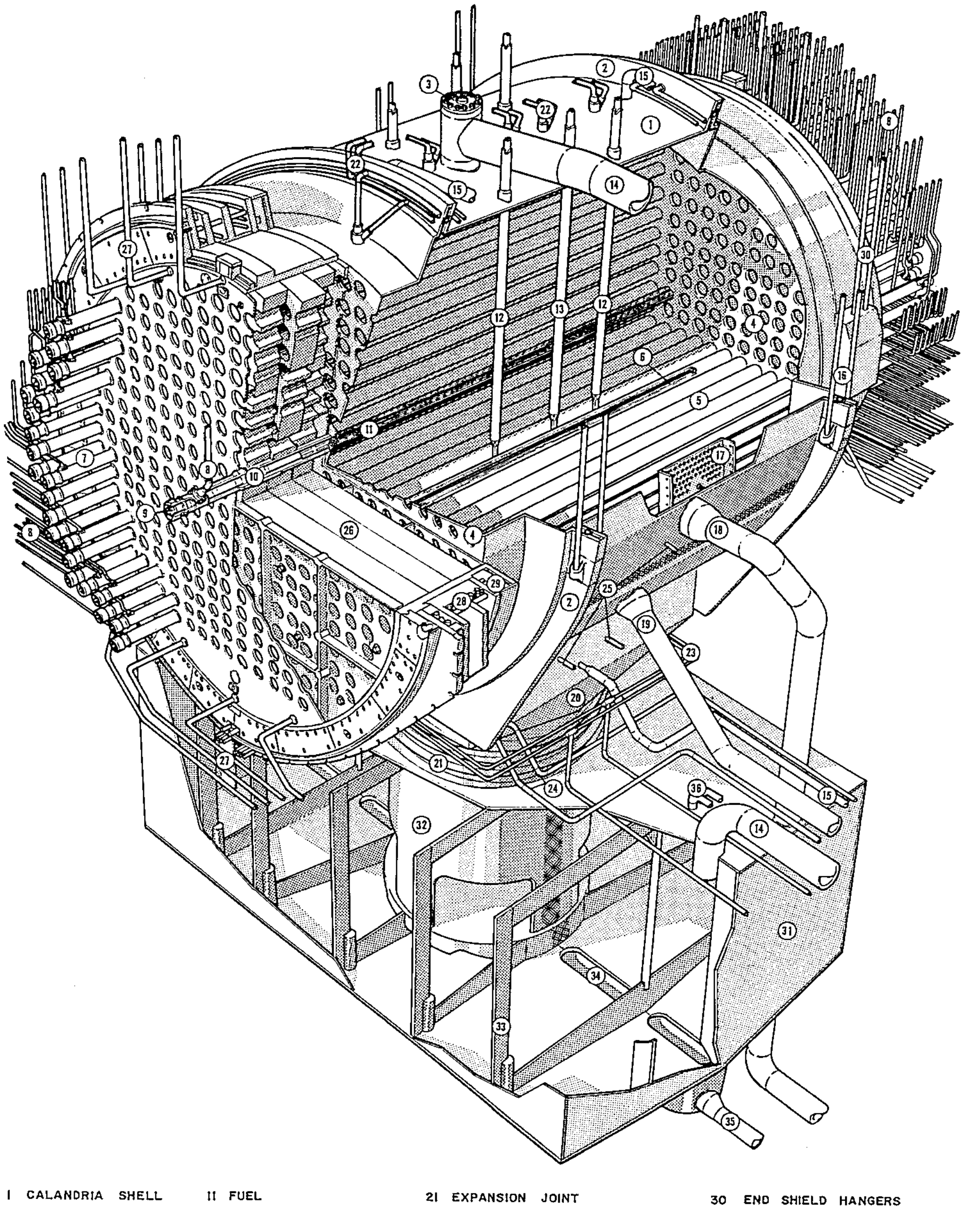


Figure 7: Drilling Outfall Channel, Feb. 1962



1 CALANDRIA SHELL
2 STIFFENER RING
3 INSPECTION HATCH
4 TUBE SHEET
5 CALANDRIA TUBES
6 PRESSURE TUBE
7 END FITTINGS
8 FEEDER PIPES
9 SEALING PLUG
10 SHIELDING PLUG
11 FUEL
12 BOOSTER RODS
13 ABSORBER RODS
14 HELIUM LINE
15 HELIUM PURGE LINE
16 CALANDRIA HANGERS
17 MODERATOR MANIFOLD
18 MODERATOR OUTLET
19 MODERATOR INLET
20 TRANSITION SECTION
21 EXPANSION JOINT
22 CALANDRIA SPRAY COOLING
23 DUMP BOX SPRAY COOLING
24 TRANSITION SECTION SPRAY COOLING
25 LEVEL INDICATING INLETS
26 END SHIELD
27 END SHIELD COOLING PIPES
28 END SHIELD RING
29 THERMAL SHIELD BLOCK
30 END SHIELD HANGERS
31 DUMP TANK
32 SHIELDING & STIFFENER STRUCTURE
33 STIFFENERS
34 DRAIN SLOTS
35 DUMP TANK OUTLET
36 DUMP TANK & EXPANSION JOINT SPRAY COOLING

Figure 8: Cutaway View of Reactor

In July, application of permanent insulation on the reactor-building dome started. It is a sprayed-on polyurethane foam of minimum thickness one inch, and is being applied by Insulmastic-Eastern Ltd. Although this material is rapidly gaining acceptance for a wide variety of uses such as upholstery, toys and tank insulation, this is the first large-scale exterior application in the construction field. The rigid foam which has been extensively tested by AECL and shows excellent adhesion and insulating characteristics will be protected with a coating of vinyl paint.

In the turbine building area, there was very little done during the winter months. The turbine foundation mat was poured last fall, and the first lift of the turbine block was made in March. Late in April, York Steel started the structural-steel erection and this is now completed. The de-aerator heater and storage tank were lifted into place in June and the 200-ton turbine-hall crane in August. The precast concrete roof slabs were placed in August and a start has been made on the brick and block walls.

Excavation for the service building continued during the winter and was finished in April. The structural steel has been erected by Dominion Structural Steel, and the concrete work is now progressing.

A new drilling and blasting technique was used successfully to excavate the outfall channel which extends some 400 ft out into the lake with maximum depth 15 ft. No cofferdam was used, but, instead, the work was performed from a platform of thick ice (Figure 7). Six tons of nitrone explosive were loaded and blasted on February 24.

Later, in the spring, the cofferdam was built for construction of the second stage of the concrete intake tunnel; dewatering was effected in July. Concrete work is now in progress.

It is expected that all buildings will be closed in before this winter, so installation of equipment will be able to start early in 1963.

MANUFACTURING STATUS OF MAJOR EQUIPMENT

Let us now look briefly at the component manufacturing picture to see how some of the major items are progressing.

Reactor Components

Figure 8 shows a cutaway view of the reactor and indicates the relative position and size of the calandria, end shields, and end-shield rings. The calandria is a horizontal stainless-steel vessel, some 20 ft in diameter and $16\frac{1}{2}$ ft long, and is being fabricated by Dominion Bridge Co. Ltd. in Montreal (Figures 9, 10, and 11). It will be tubed there and shipped by barge to the site next spring. When completed it will weigh about 60 tons. Prototype dump-port sections were tested at the NPPD laboratory where considerable work had been done on achieving a configuration to give the fast moderator-dumping time required. The calandria is further complicated by the necessity for Zircaloy manifolds at the moderator inlets and outlets to promote good mixing and the fitting of sprays for cooling the calandria shell and tubes. Both of these design details resulted from extensive laboratory experimentation.

The Zircaloy calandria tubes are now being produced by NTH Products Ltd. in St. Diego, Calif., to extremely fine tolerances on straightness and end skew (the ends are

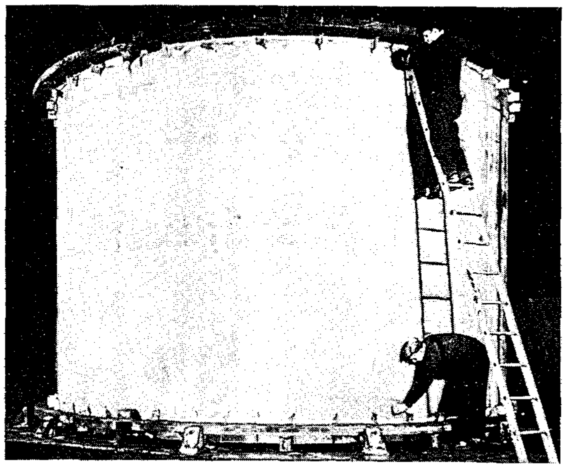


Figure 9: Calandria Shell - Stiffener Rings in Place

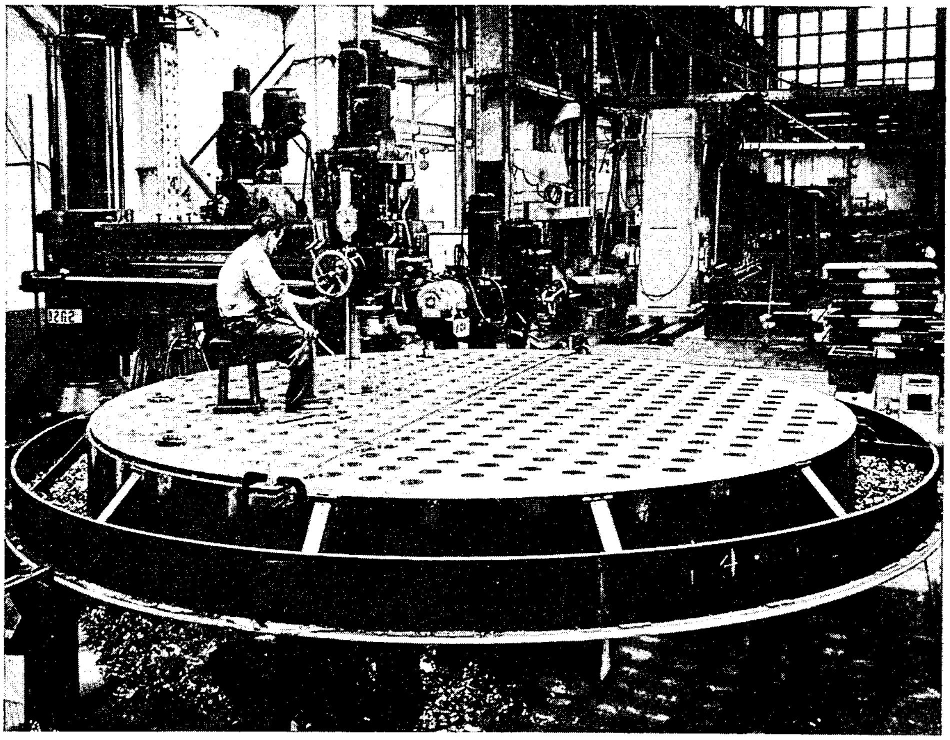


Figure 10: Calandria Tube Sheet

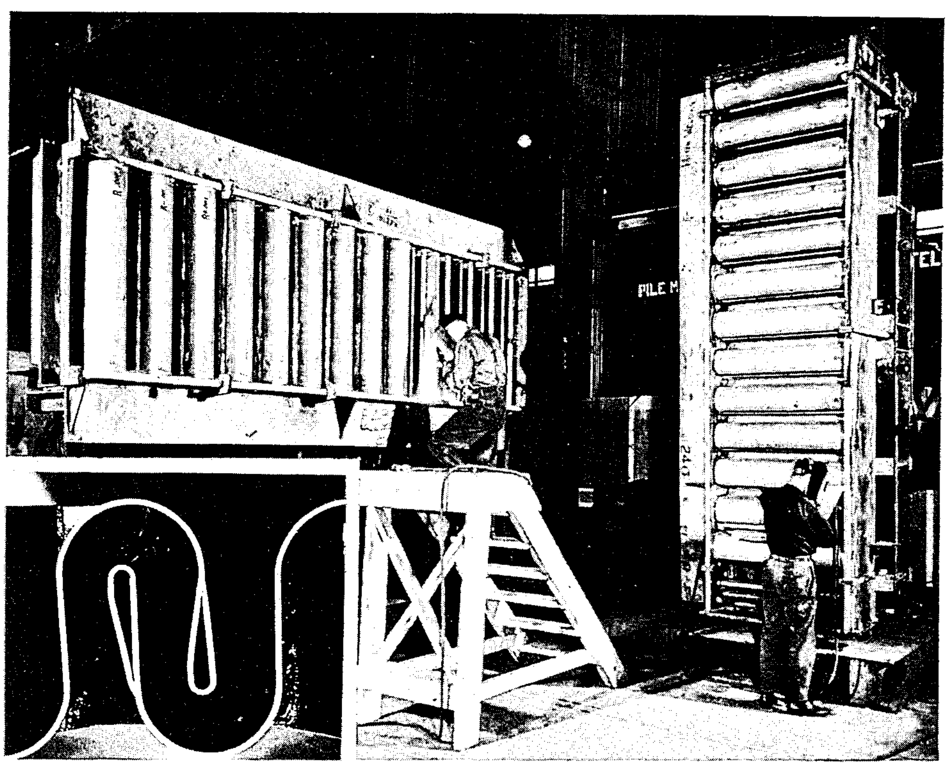


Figure 11: Calandria Dump Ports - Inset Shows Port Cross Section

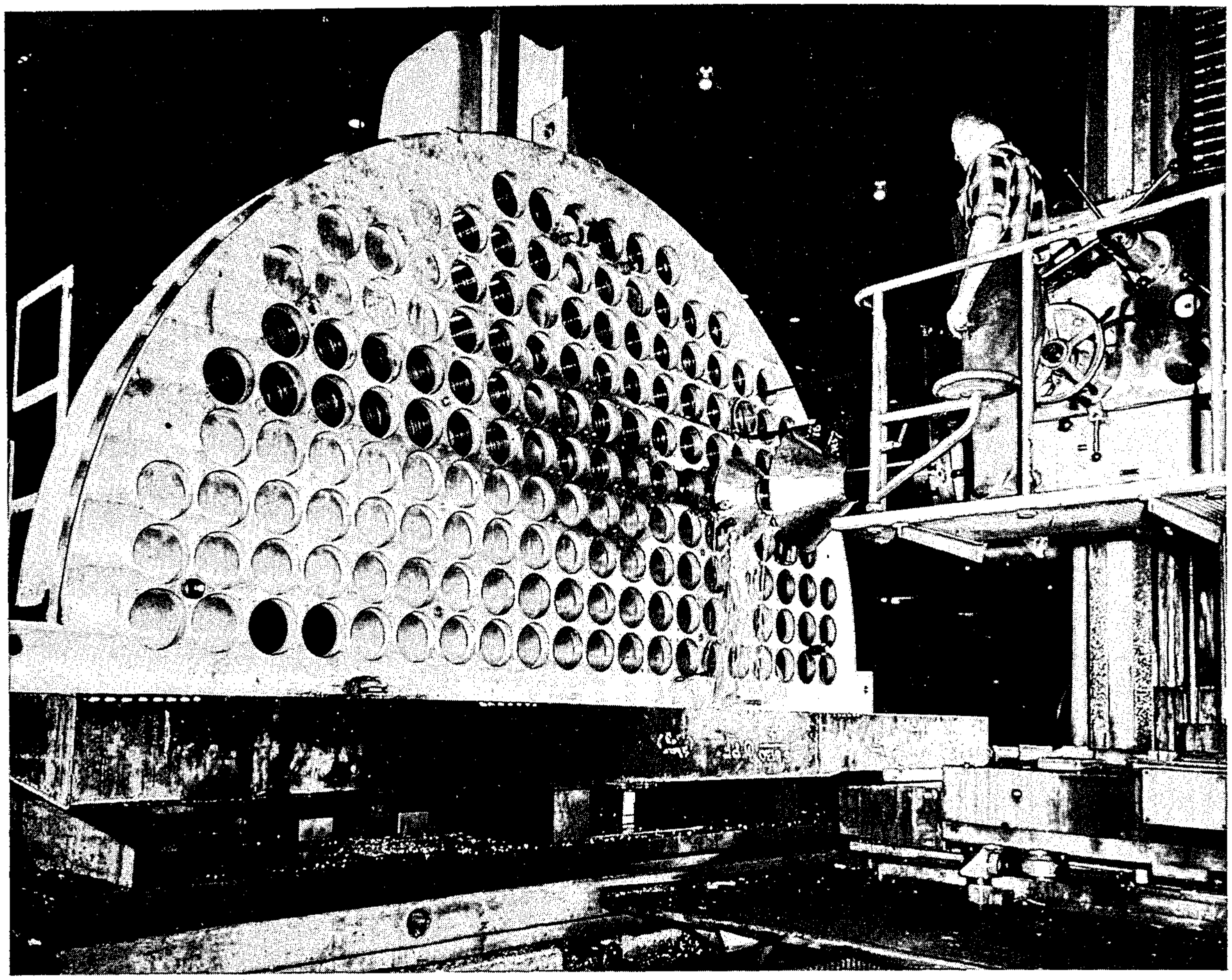


Figure 12: End Shield Fabrication

expanded where they will be rolled into the calandria).

The reactor end shields are massive steel slabs with internal water cooling which provide radiation shielding for equipment and personnel in the fuelling-machine vaults and also provide support for the 306 coolant pressure tubes. At the Montreal works of Dominion Bridge, fabrication is in progress and Figure 12 shows the trepanning operating on one of the 12-in. thick slabs. Each shields is made up of six such slabs and will weigh about 120 tons when shipment is made next spring.

The end-shield rings, which are the embedded portions of the end shields and carry their own cooling pipes, weigh $41\frac{1}{2}$ tons each. They are being fabricated at Canadian Vickers plant in Montreal and are to be delivered in November of this year.

The Zircaloy coolant pressure tubes are being produced by Chase Brass. An interesting feature of this contract is a bonus clause for achieving an overall weight of Zircaloy lower than a certain set figure, while staying within the tolerances specified. A 1% reduction in the total weight of coolant tubes represents about 30 MWd/tonne additional burn-up from the fuel; this is estimated to be worth about $100 000 equivalent capital.

The contract for end fittings has recently been placed with Curtis-Wright. These are to be machined from full-length stainless-steel extrusions.

Fuelling Machine

A prototype fuelling-machine carriage has been constructed by Canadian Vickers and set up in the Toronto laboratory of AECL for testing (Figure 13). It is operated by self-contained hydraulic motors supplied by a catenary of cables and coolant hoses. Three sets of castings have been made for the prototype head in an effort to get a mechanically-suitable unit. So far, the last one appears satisfactory and is being readied for thermal cycling tests.

In the meantime, the various head components - snout, ram, fuel stop sensor, retractor device, etc. - are being tested in the laboratory under full temperature and pressure conditions. These components have been manufactured by Standard Modern Tool Co.

Fuel

CANDU fuel is now being produced at CGE at the rate of about eight bundles per day. Figure 14 shows the final assembly operation - welding on the end plates. The contract is for 4100 bundles. These are very similar to those manufactured by the same company for NPD. This is a practical instance of the common evolution of NPD and Douglas Point.

Boilers and Primary Pumps

The design arrangement of a boiler and pump is shown in Figure 15. There will be eight such boilers and ten pumps at Douglas Point. Each boiler consists of ten

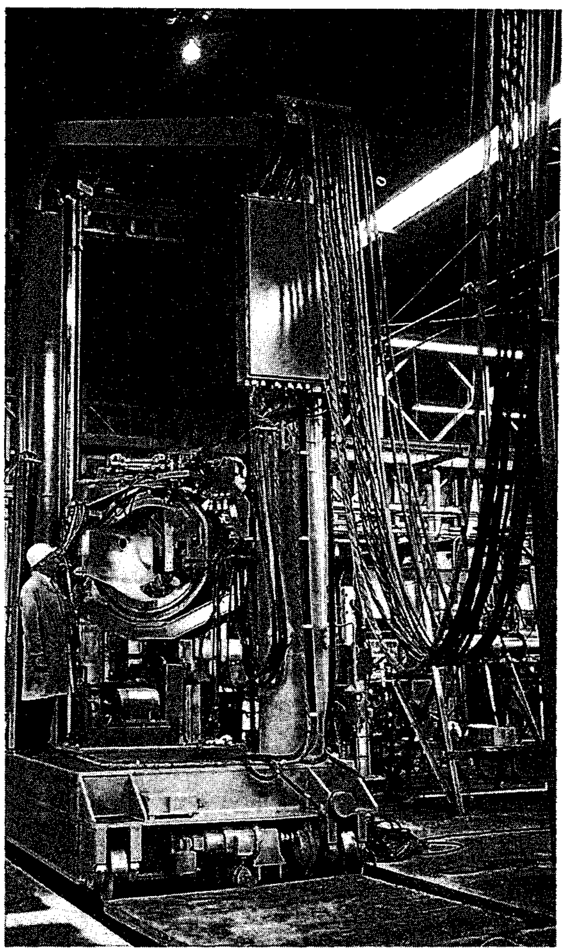


Figure 13: Fuelling-Machine Carriage

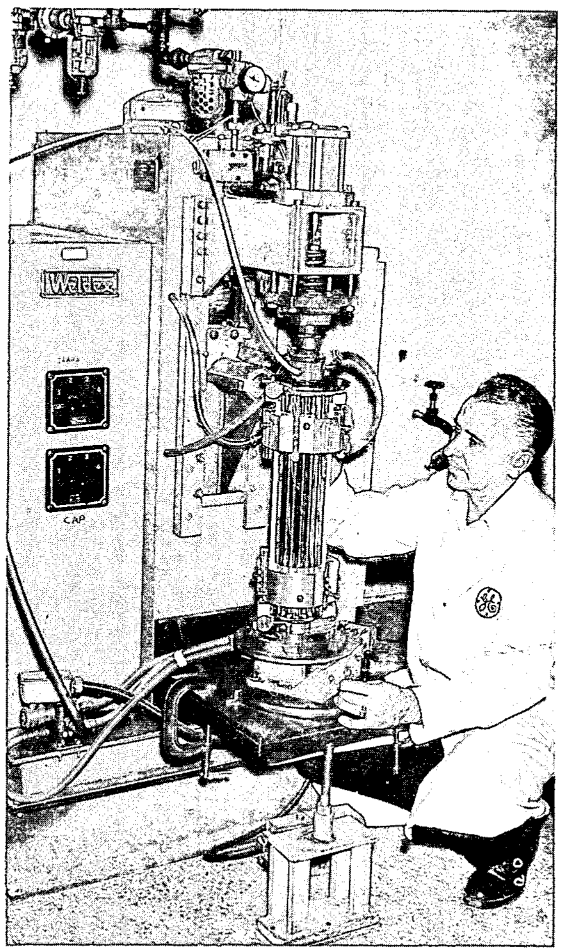


Figure 14: Fuel Production: Welding End Plates

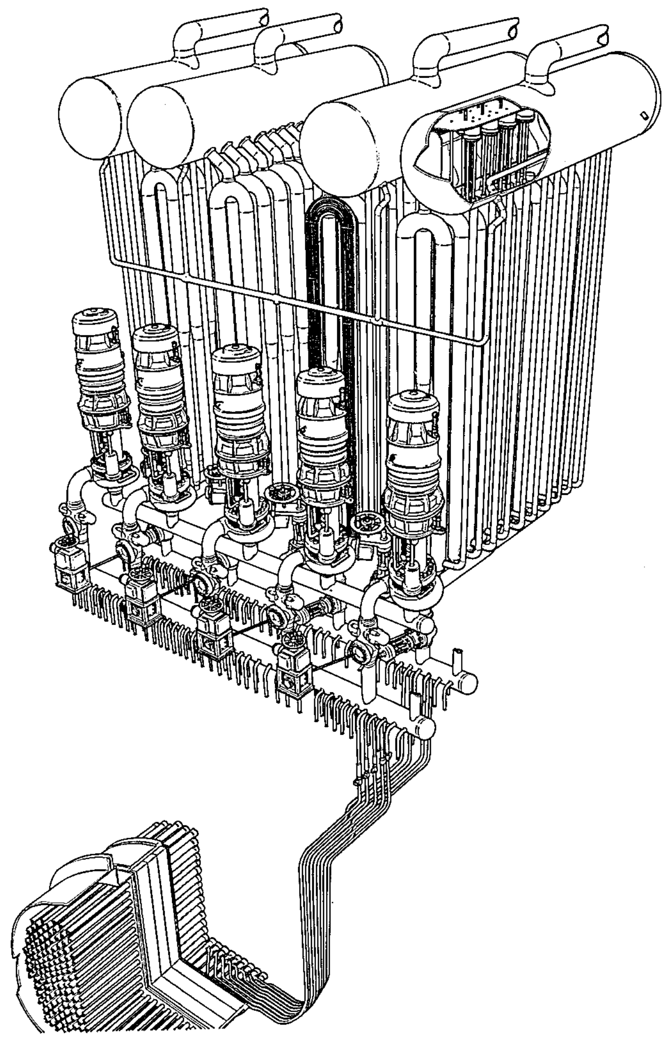


Figure 15: Boiler and Pump Arrangement

vertical U-tube heat exchangers together with a steam drum. A prototype heat exchanger has been manufactured by Montreal Locomotive Works and is now on test in the U. S. A. under the AECL-USAEC cooperative agreement. Work on the production units is advancing at MLW. The tight spacing, critical leakage requirements, and the materials used have caused considerable difficulty in arriving at a satisfactory welding technique, but this has now been done. The Monel tubing is being supplied by Wolverine Tube. Tube sheets are of Monel; shells and channel covers are mild steel.

The primary-pump contract has been placed with Byron-Jackson. It is hoped to have a prototype unit operating next month. The pumps are vertical centrifugal units each rated at 5670 gal(UK)/min, 522-ft head and 1480 lb/in^2 (absolute) outlet pressure and the sealing arrangement incorporates a throttle bushing and low-pressure mechanical seal. English Electric motors are being provided.

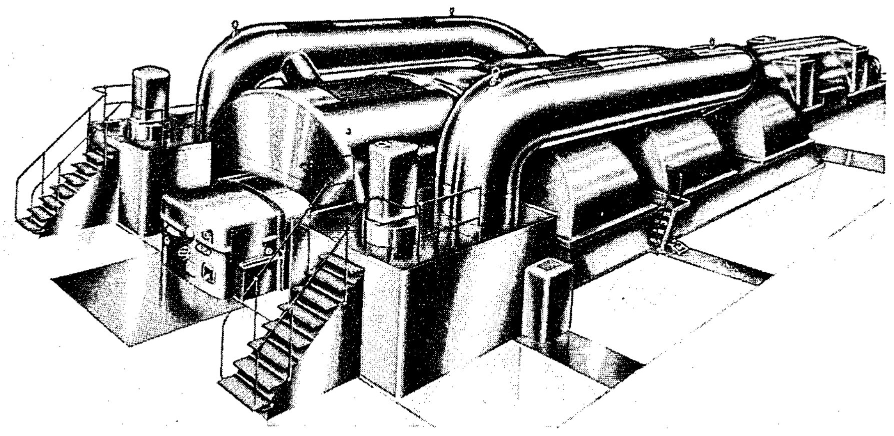


Figure 16: 220-MW Turbine Generator

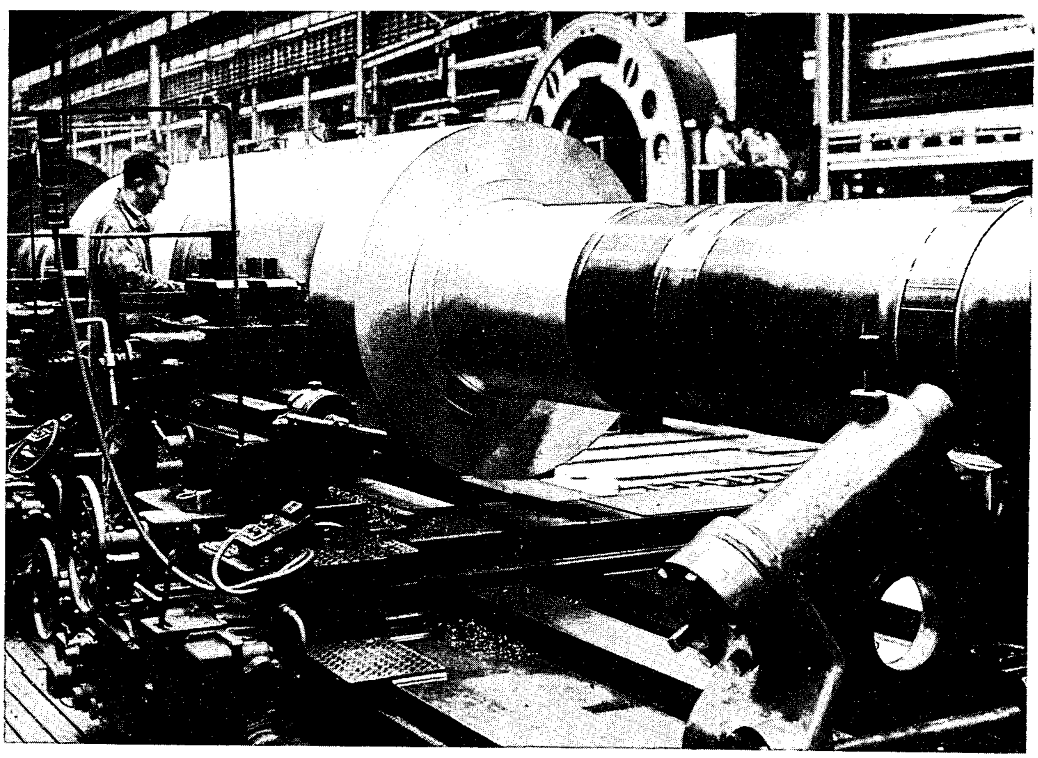


Figure 17: Generator Rotor Machining

Turbine Generator

Work on the 220 000-kW turbine-generator is progressing at Associated Electrical Industries Limited. Figure 16 shows an artist's view of the completed unit. The three cylinders are fabricated and being machined. The blades and wheels have been produced, and spindle shafts are ready. The generator rotor is being machined (Figure 17) and work has started on the stator coils. The stator is being built by CGE and the frame is shown in the Peterborough works in Figure 18. The turbine is due to be shipped in March, 1963.

Figure 18: Generator Stator Frame

Condenser

The condenser for this unit has a total surface area of 158 000 ft^2 and will be the largest condenser in Canada. It is being built by Foster-Wheeler Limited and shell fabrication will be completed on site during this winter.

Digital Computer-Controller

A contract was let to Daystrom Limited last April for a digital computer-controller for the Douglas Point plant. It is composed of solid-state components and has a core memory of 8000 words and a drum memory of 16 000 words. The detailed design is now under way. It will act largely as a plant monitor but will also be capable of exercising a number of control functions in relation to the station power output.

COSTS

The original cost estimate for the Douglas Point station, made in 1959, was \$81½ million. This included \$11½ million for heavy water. As of today 50% of this total has been spent or committed and we are running about \$2 million under estimate (without any transfer from the contingency allowance). This is in spite of a setback of \$1½ million due to the drop in exchange rate. The present favourable position as far as costs are concerned appears to be due largely to the highly-competitive atmosphere in industry over the last few years and also to smaller escalation than allowed for and less interest during construction.

SCHEDULE

Field construction is running a few months later than the 1959 schedule, but this is not expected to hold up installation of major equipment. We feel that there is a good prospect of finishing construction in 1964 as scheduled, with full-scale commercial operation being achieved early in 1965.