IPEC TELEPHONE 685-5131

W. F. MILES
DIRECTOR AND GENERAL MANAGER

INTERNATIONAL POWER AND
ENGINEERING CONSULTANTS LIMITED
570 DUNSMUIR STREET
VANCOUVER 2, B.C.
CANADA

BECHTEL TELEPHONE 366-3521

C. E. WHITE

SENIOR VICE-PRESIDENT
CANADIAN BECHTEL LIMITED

25 KING STREET WEST
TORONTO, ONTARIO

PROPOSAL: ENGINEERING AND CONSTRUCTION MANAGEMENT SERVICES

For The: Tri-University Meson Facility

PRESENTED BY: INTERNATIONAL POWER AND ENGINEERING CONSULTANTS LTD. AND CANADIAN BECHTEL LTD.

CONTENTS

SUMMARY

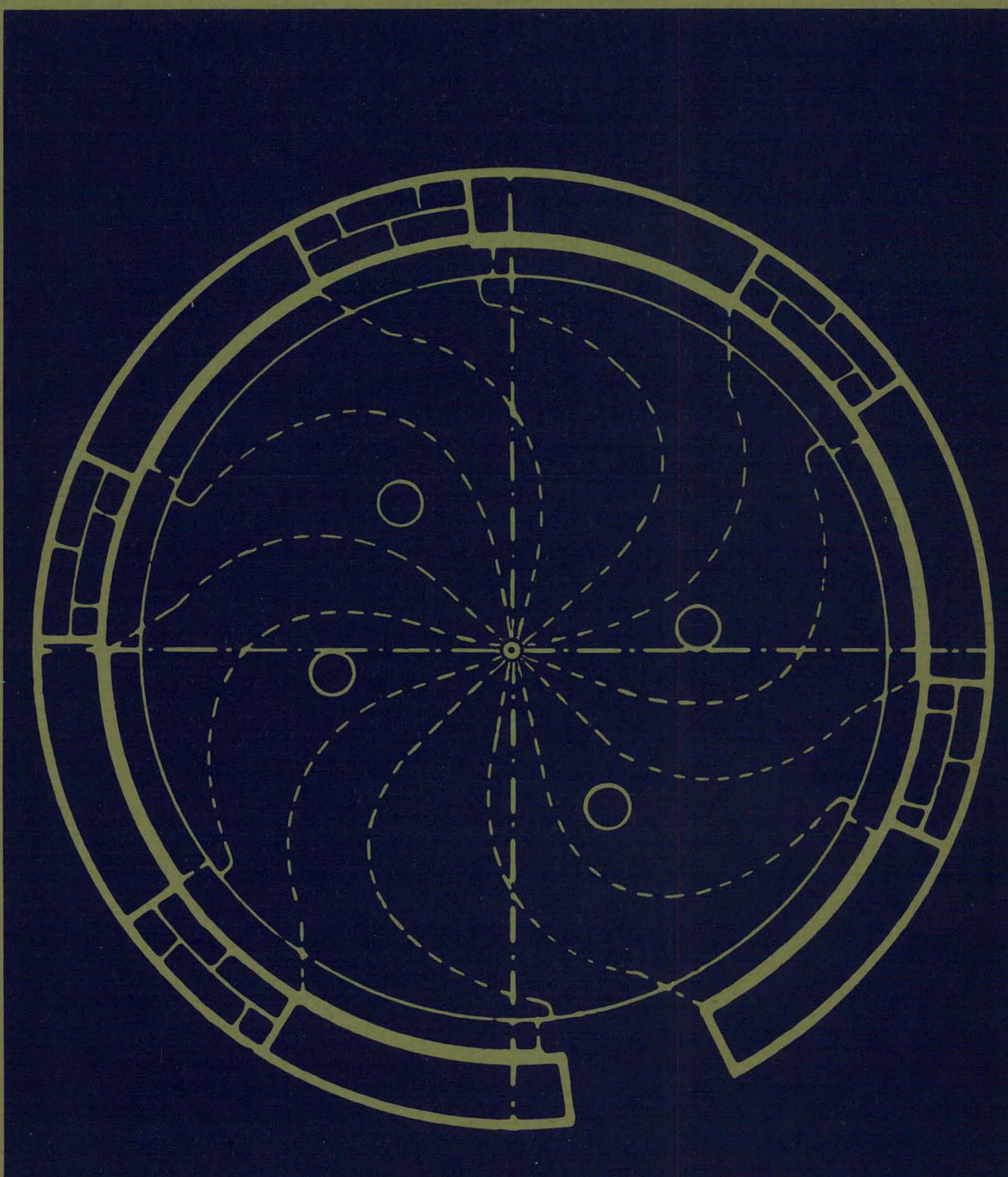
This document presents a Joint Venture proposal for the development, engineering, construction, and testing of the Tri-University Meson Facility (TRIUMF) to be located at the University of British Columbia, by International Power and Engineering Consultants Limited (IPEC) and Canadian Bechtel Limited (CBL). The proposal, which is intended to be fully responsive to the needs of the University of British Columbia and its associates, includes a Statement of Work to be performed, Technical and Management Plans, and a Summary of IPEC-CBL background and experience.

IPEC-CBL is aware of the significant development work already performed by those associated with the TRIUMF project. The purpose of this proposal is to present a plan to translate the scientific concepts so developed into an operational facility.

IPEC-CBL will furnish engineering, procurement, and construction management services required for completion of the TRIUMF project. The principal engineering offices will be located in Vancouver, B.C. The suggested plan is based upon experience growing out of the design and construction of many other complex, highly technical, extensive facilities and will provide a highly effective method of completing the TRIUMF project within the requirements of the TRIUMF Board.

The IPEC-CBL proposal offers:

- A staff experienced in the engineering and construction of cyclotrons, able to perform any and all phases of the project under the direction of the TRIUMF Project Director
- Control of costs, within an established budget, from inception of detailed design to completion of the facility
- Continuous monitoring and intensive expediting of all activities to assure their accomplishment in conformance with a preestablished time schedule
- Availability of an experienced technical and management staff for the direction of the work, thereby greatly reducing the University's need to recruit, select, train, and direct temporary personnel
- Close inspection of the work to assure its completion in accordance with the design criteria and contract documents

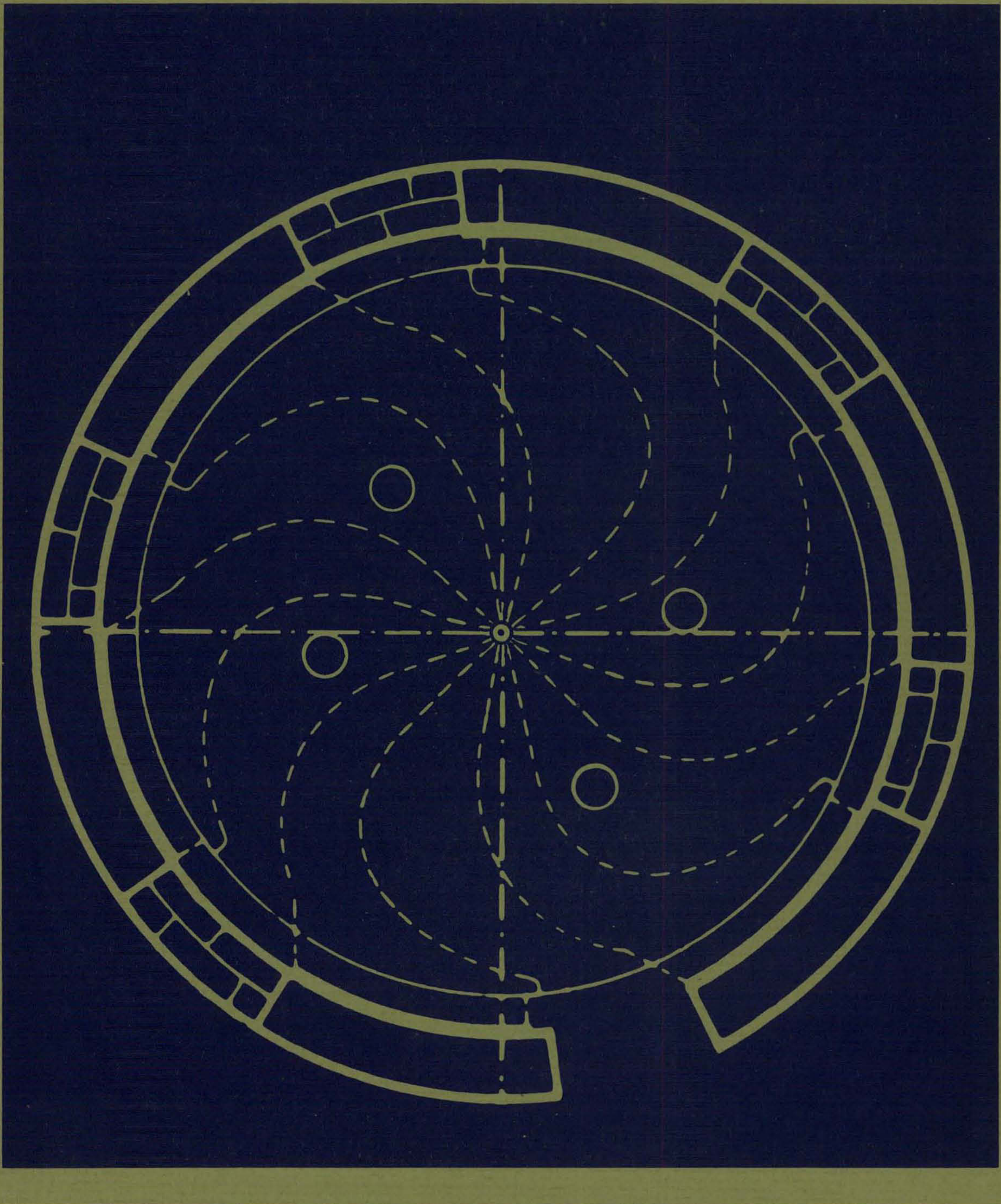


Section 1

INTRODUCTION

International Power and Engineering Consultants Limited (IPEC) of Vancouver, British Columbia, and Canadian Bechtel Limited (CBL) of Toronto, propose to act as a Joint Venture (hereinafter referred to as IPEC-CBL) to provide engineering and construction management services for the Tri-University Meson Facility (TRIUMF) at the University of British Columbia.

This proposal contains a Statement of Work and a Technical Plan, a Management Plan, and a Capabilities Description - personnel resumes for a typical staff, corporate services and related corporate experience of IPEC-CBL.



Section 2

STATEMENT OF WORK

IPEC-CBL proposes to provide, under a single contract, engineering and construction management services for the development, design, engineering, procurement, facility construction-management, cyclotron assembly, testing, start-up operations, and personnel training for the TRIUMF project.

This proposed approach will result in a fully-engineered operational cyclotron and facility. Engineering for both the facility and the cyclotron will be conducted concurrently. Thus, procurement of long-lead cyclotron items will be made parallel with building construction permitting optimum interfacing of cyclotron and facility.

Engineering will be essentially completed prior to cyclotron installation, resulting in the lowest procurement and installation cost. Total cyclotron systems engineering will allow procurement of individual systems and components on a competitive bid basis largely in Canada. The cyclotron systems will be engineered to utilize as many commercially available components as possible to reduce requirements for stocking of replacement parts. Complete as-built engineering drawings and specifications will facilitate cyclotron maintenance and training of TRIUMF personnel.

The principal project functions will include: project administration and planning, technical services, construction management and testing and start-up.

2.1 PROJECT ADMINISTRATION AND PLANNING

2.1.1 Administration

IPEC-CBL will group together, as a project team, an administrative organization of personnel familiar with projects of this type to perform the functions necessary to provide a complete and operational facility. This organization will be under the direction of the IPEC-CBL Project Manager. One of the first tasks will be the preparation of a Project Scope and Procedures Manual to identify responsibilities, specify form and frequency of reports and other working documents, and determine the required approval procedures and document distribution. IPEC-CBL in association with the TRIUMF Director will prepare a Reference Design Criteria Document (RDCD). The RDCD will delineate the desired cyclotron specifications and will establish the basic specifications of each of the systems and sub-systems. The RDCD after approval by both the IPEC-CBL and the TRIUMF Board will be the basis for the facility budget. Detail engineering will be based on the approved RDCD. Deviation from this document will require approval of the TRIUMF Director. IPEC-CBL will prepare a list showing the capabilities of pre-qualified manufacturers, suppliers, and constructors in Canada and world-wide. This list of reference firms will be the basis for subsequent equipment procurement and will permit the design of equipment compatible with the manufacturing capability of multiple firms to achieve maximum competitive bidding.

2.1.2 Project Planning

Scheduling. IPEC-CBL will prepare and implement a Critical Path Network (CPN), including development, design, detailed engineering, procurement, construction, testing, and start-up. Use of a CPN will assure that long lead-time items will be available when required for installation and if significant procurement delays do result, alternate installation plans may be implemented. The CPN will also identify which items require expediting. The CPN approach has been applied by both IPEC and CBL in other projects of similar magnitude and has resulted in the shortest possible completion time and the lowest cost for complex projects.

Estimating and Cost Control. IPEC-CBL will prepare a budgetary cost estimate in accordance with the items identified in the RDCD. Subsequent cost forecasts will then be made against the original budgetary estimates as engineering proceeds. If items are found to be in excess of the original budget estimate additional development engineering may be recommended to reduce the cost of these items. This procedure will allow regular and timely project cost control. Prior to initiation of construction of each major phase of the facility, a definitive cost estimate will be prepared for the approval of the TRIUMF Director. These definitive cost estimates and subsequent cost forecasts will serve as a reference number for comparison with bids received from vendors. Estimating will be performed by experienced estimators who have worked on similar projects.

Procurement Services. IPEC-CBL will receive tenders from manufacturers and subcontractors and will make recommendation for award of contract; alternatively IPEC-CBL will award the necessary contracts with the approval of the TRIUMF Director. Purchase orders will be

expedited by the procurement services of IPEC and CBL. Their expeditors are located at major facilities and areas throughout the world.

Inspection of conventional equipment and facilities will be made by the procurement groups of IPEC and CBL. Technical elements of the project requiring special analysis will be handled by the IPEC-CBL engineering group.

2.2 Technical Services

IPEC-CBL will coordinate or provide architectural services in the layout and design of the building to ensure that the cyclotron and beam transport system are properly installed. A local architect may be engaged so that the most qualified personnel will be available to assure that the facility conforms to architectural standards established by UBC. Substantial economies in structure can be accomplished through the proper selection of materials for the facility. IPEC-CBL will provide the engineering services necessary for the preparation of the plans and specifications of the cyclotron facility (i.e., buildings, utilities, etc.). The specifications will be prepared so that various elements of the facility will be procured on a competitive basis.

IPEC-CBL will prepare detailed drawings and specifications for cyclotron components and subsystems; receive and evaluate tenders and recommend contract and subcontract awards; provide technical inspection of components and subsystems incorporated into the cyclotron; and provide technical assistance to the TRIUMF group for systems testing, cyclotron start-up, and personnel training. IPEC-CBL will prepare installation drawings for the cyclotron. IPEC-CBL will coordinate and monitor other organizations engaged in engineering

and fabrication of elements of the cyclotron on a performance specification basis. IPEC-CBL is prepared to monitor and coordinate the work of project consultants.

2.3 Facility Construction Management and Cyclotron Assembly

Construction Management will consist of the planning, direction, and coordination of contractors engaged in constructing separate portions of the project. It will include selection of appropriate construction methods; review and coordination of individual contractor's construction schedules, manning schedules, and forecasts; contract administration; authorization and negotiation of change orders; budgeting of funds and cost control and handling requests for extras; reviewing and establishing uniform labor policies including wage scales, working hours, and general working conditions; enforcement of good housekeeping; scheduling and arranging for inspection of work in progress and of completed work; monitoring adherence to drawings and specifications; liaison with other construction representatives; approval and acceptance of contractor's work.

Assembly of the cyclotron will be performed directly by IPEC-CBL because of the critical aspects of the assembly requirements. Personnel experienced in installation projects of this type are available on our staff and will be utilized.

2.4 Test, Start-up, and Personnel Training

IPEC-CBL will perform final tests and prepare start-up procedures with the assistance of TRIUMF operation and maintenance personnel and conduct a technical training program for designated TRIUMF personnel. Manuals for test procedures, operation, and maintenance will be prepared by IPEC and CBL publications services to the specification of the Client.

Section 3

TECHNICAL PLAN

3.1 GENERAL

The following Technical Plan describes the IPEC-CBL approach for engineering and construction management services for the TRIUMF project. The function of the project engineer construction manager will be to engineer and construct an operational facility based on the technical data developed at the UBC.

To define clearly the project scope, the Technical Plan is broken down into five phases: Development Engineering, including technical consultant activities; Detailed Engineering; Procurement; Construction Management; and Start-up and Training. A detailed discussion of each phase is presented below.

3.2 PHASE I: DEVELOPMENT ENGINEERING

A considerable amount of preliminary design has been performed by the TRIUMF Study Group. However, IPEC-CBL is prepared to undertake additional studies and model testing programs should this be required to define critical cyclotron parameters.

During the development stage of the program, the basic ground rules for engineering and construction management of the facility will be established.

The results of development engineering will consist of specifications for the various elements of the facility based on theoretical and model studies. It is anticipated that the basic physics parameters for the cyclotron will be established by the Client. However, IPEC-CBL will assure that the specifications delineated are compatible from an engineering standpoint; that a facility designed to these specifications can be constructed; and that special consideration is paid to meeting these specifications by the capabilities of Canadian industry. IPEC-CBL will coordinate the development effort and will prepare the RDCD which will be based on the model studies and theoretical physics performed by the Client.

Economic trade-offs will be developed during the development phase to arrive at a design which will result in the lowest facility cost and shortest construction schedule consistent with performance requirements. Detailed engineering will be based on the RDCD. During the development phase and the preparation of the RDCD the work will be segregated into individual Material Requisitions (MR's) which will later result in the preparation of bid packages correlated to the MR's. The MR identification will also form the basis for budget and forecast estimates.

Additional consultants required for model and theoretical studies may be under the direction of the IPEC-CBL Project Manager at the discretion of the Client.

3.3 PHASE II: DETAILED ENGINEERING

In the detailed engineering phase of the program, engineering will be performed for the preparation of bid packages for the procurement of the cyclotron and its facilities.

3.3.1 Cyclotron and Beam Transport Detailed Engineering

IPEC-CBL project engineering will be responsible for:

- Development of performance specifications for systems, subsystems, and major components
- Preparation of installation designs for mechanical systems including water, air, vacuum, etc.
- Development of cyclotron electrical distribution systems (one-line electrical)
- Preparation of mechanical drawings and specifications necessary for procurement of the cyclotron mechanical equipment such as magnet systems, injection systems, RF systems, etc.
- Development of instrumentation systems for machine operation and data analysis
- Preparation of specifications for procurement
- Preparation of control schemes, functional block diagrams and wiring schedules
- Analysis of bids, and technical inspection of sophisticated components
- Preparation of system test and checkout procedures

3.3.2 Facilities Engineering

IPEC-CBL project engineering will be responsible for:

- Site planning and coordination with the UBC site requirements
- Architectural design coordination
- Engineering and display models
- Building mechanical system and subsystem design
- Building shielding and cyclotron foundation requirements
- Procurement plans and specifications preparation
- Analysis of contractor tenders
- Auxiliary facilities (cooling tower, power substations, etc.) design and specification

3.3.3 Estimating

A budgetary cost estimate will be prepared based on the RDCD. Subsequent cost forecasts will be made as engineering progresses and as actual bid data are received. A detailed cost analysis for the total project will be performed regularly or as requested by the Client. Estimating personnel also assist design engineers in the evaluation of alternative design approaches to determine the optimum configuration within budget limitations. Anticipated maintenance costs will be considered as a factor in such evaluations. Capability to upgrade the facility for future requirements will be considered.

3.3.4 Codes and Standards

The design and construction of all systems and assemblies for the TRIUMF project will be in accordance with the standard practices as established by the codes and standards of British Columbia and Canada. All drawings and specifications will be reviewed to ensure that these codes and standards are met. Equipment purchased outside Canada will be accepted if it meets codes and standards equal to Canadian standards.

3.3.5 TRIUMF Director Approval

All drawings and specifications prepared for bid packages will be submitted to the TRIUMF Director to review and approve prior to issuance. After bids have been received and analyzed, a contractor or vendor will be selected, subject to Client approval.

3.3.6 Test Specifications

Vendor Shop Tests. Specifications for items procured on the basis of performance specifications shall be prepared by the vendors and approved by IPEC-CBL and the TRIUMF Group. Tests will be performed with simulated loads at the vendor shop prior to shipping, and may be witnessed by both TRIUMF and IPEC-CBL personnel. Equipment performance will be the basis for acceptance. Where detailed engineering drawings are prepared, they will be used to evaluate specification conformance

On-Site Tests. Test specifications in this case will be prepared by IPEC-CBL and approved by the TRIUMF Group. The tests will be conducted on each system after installation, with equipment connected to the actual loads. Equipment performance will be the basis for final acceptance.

3.3.7 Installation Procedures

Installation procedures will be prepared to facilitate cyclotron assembly and maintenance. After systems are installed, these procedures will also serve as maintenance aids. In addition to covering normal assembly sequences, the procedures will also provide detailed methods for such items as cleaning, leak testing, insulation resistance measurements, etc.

3.3.8 Bid Packages

Typically, bid packages will consist either of drawings, specifications, or performance specifications to required guarantees. Where components and subsystems are purchased on the basis of vendor performance specifications, vendor drawings will be reviewed before construction to ensure compatibility.

3.3.9 Changes and Modifications

Changes and modifications may be required which will result in a deviation from the RDCD or in a purchase order change after a purchase order has been issued. Changes may result either from technical or economic considerations. When a change is initiated by either the TRIUMF Group or IPEC-CBL, it will be analyzed and submitted with recommendations, a cost proposal for associated

engineering and construction, and an analysis of its effect on the schedule. If the change is approved by the TRIUMF Director, it will be integrated into the system.

3.4 PHASE III: PROCUREMENT

3.4.1 General

In order to complete the project at the lowest possible cost, it is imperative that all procurement activities, including selection of bidders, purchasing, expediting, and quality assurance, be performed by a procurement group highly experienced in these functions. IPEC-CBL, therefore, will use its own procurement personnel through the project. A Procurement Manager selected by IPEC-CBL will direct the project effort. Individual procurement actions will occur within the IPEC-CBL structure.

3.4.2 Preferred Vendors

Every effort will be made to obtain equipment from Canadian industries. If necessary, technical know-how and information on special manufacturing techniques will be made available to selected Canadian firms.

When Canadian suppliers are not available, procurement will be made in the United Kingdom, the United States, West Germany, Switzerland, Japan, or other countries, in accordance with Canadian import regulations and consistent with project requirements.

Based upon IPEC-CBL worldwide procurement experience and activities, a Preferred Vendors List will be prepared to assure that only the most competent companies, consistent with the desire to maximize participation of Canadian firms, are requested to submit proposals to perform the required work. This list will be subject to the approval of the TRIUMF Director.

3.4.3 Construction Contracts

IPEC-CBL will recommend and/or award construction contracts required for the installation of the equipment, and construction of the facility, except for cyclotron and beam transport installation. All construction contracts will be under the direction of the IPEC-CBL construction manager.

3.4.4 Bid Packages

Bid packages will be submitted to pre-qualified vendors. Bid requests will be based on performance specifications and/or fabrication drawings. Emphasis will be placed on completing as much fabrication as possible at the vendor's shop.

3.4.5 Quality Assurance

Quality assurance requirements will be clearly spelled out in specifications and on drawings.

A quality assurance program will be initiated to ensure the reliability of design, fabrication, and installation of the cyclotron. The program will verify that vendor and subcontractor components, subassemblies, and systems meet all specifications and drawing requirements. Vendor

processes and components will be inspected as necessary in the vendor's shop during the manufacturing cycle by qualified personnel. No changes in design specifications will be allowed prior to approval by the TRIUMF Director. All changes will be properly documented.

3.4.6 Schedule Control

IPEC-CBL, with the backing of associated worldwide organizations, is in a favorable position to monitor vendor contractual commitments. IPEC and CBL have resident inspectors and expediters in many countries and in the shops of many major manufacturers. Therefore, vendor performance can be readily and regularly checked, discrepancies noted immediately, and corrective action initiated promptly.

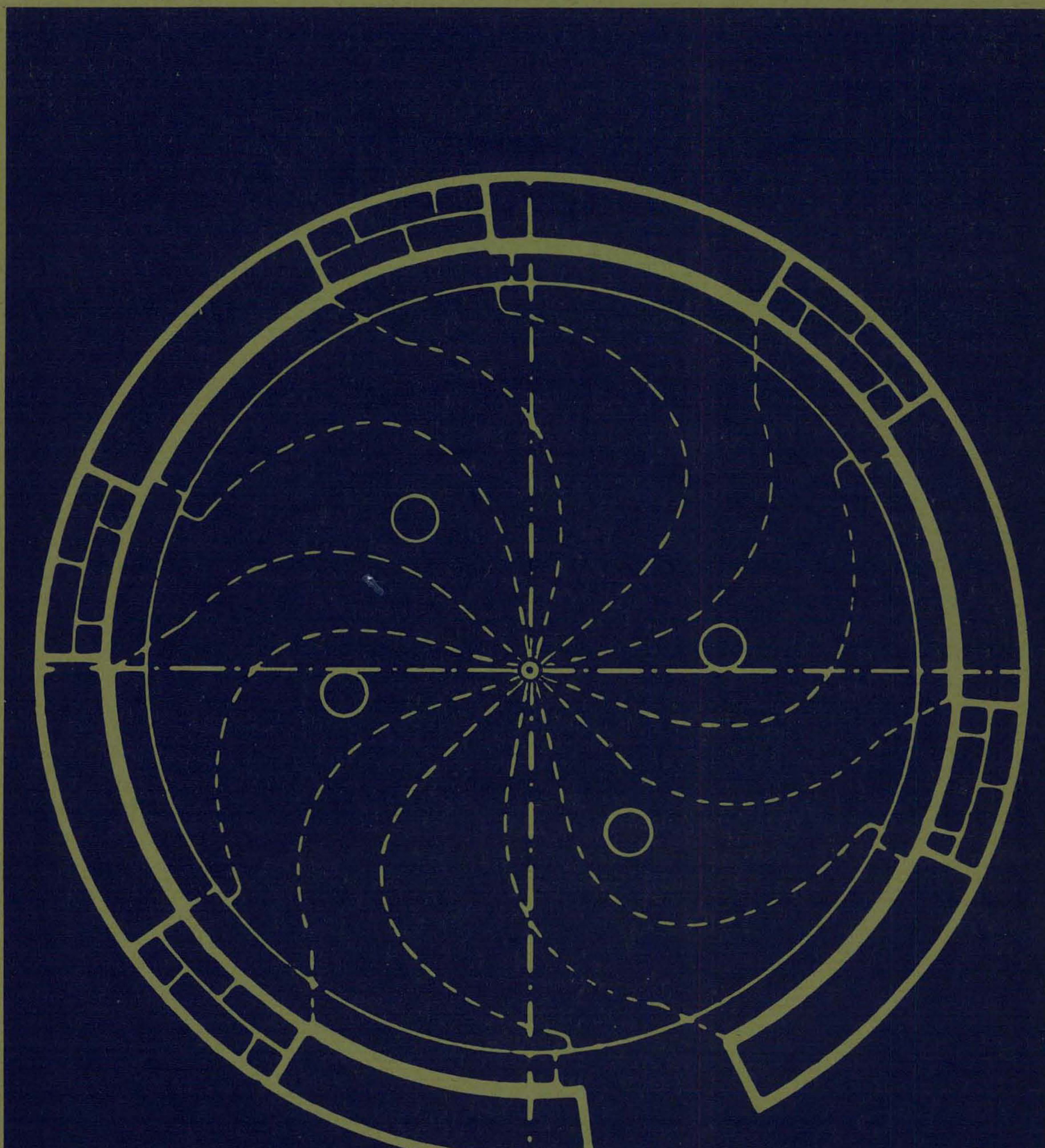
The procurement schedule, together with the engineering schedule, will be controlled by a Critical Path Network which can be continuously updated and checked by computer. Reports will be published and submitted to the TRIUMF Director monthly or as requested.

3.5 PHASE IV: CONSTRUCTION MANAGEMENT

IPEC-CBL proposes to furnish complete services for managing the facility construction and for erecting the cyclotron. These services also include checkout and testing of equipment, components, and systems.

3.6 PHASE V: START-UP AND TRAINING

It is anticipated that prior to equipment installation and testing the TRIUMF organization will be expanded to include the engineers and technicians required to operate and maintain the facility. It is anticipated that the TRIUMF staff will participate in the equipment checkout program, in writing start-up and operational procedures, and in the cyclotron start-up. Experience has shown that "debugging" and testing with personnel who later will be in charge of the cyclotron operation provides the best possible training for them.



Section 4

MANAGEMENT PLAN

4.1 PROJECT ORGANIZATION

The IPEC-CBL Joint Venture for the TRIUMF project will have a Project Committee consisting of four members who will be the governing body of the Joint Venture. Two members will be appointed by IPEC and two by CBL. A project organization chart is shown in Figure 4-1.

This Committee will report to the TRIUMF Director. The functions of this Committee will be:

- To establish jointly with the Client the project scope, budget, and schedule
- To review periodically the project status
- To resolve with the Client all changes in contract scope that affect cost and schedule
- To help resolve any outstanding contractual and technical problems
- To provide the capabilities of the component organizations to the Project Manager

A Project Manager will be appointed by the Project Committee who will be responsible to the TRIUMF Project Director. The Project Manager within the context of the RDCD will be responsible for project direction, for organizing and directing all phases of the work, and for establishing the proper working relationship with TRIUMF's planning, scientific, and engineering personnel. He will be the focal point for all client-contractor communications.

The assignment of full project implementation responsibility to a single individual ensures optimum utilization of manpower, effective interfacing of the accelerator and the facility, and minimum elapsed time from initiation to engineering to start-up of the cyclotron.

Consultants from IPEC, CBL, Bechtel Corporation, Allgemeine Electricitats Gesellschaft (AEG), and other organizations as required will report to the IPEC-CBL Project Manager and will work closely with the TRIUMF staff and consultants on cyclotron preliminary design and model studies.

Estimating and Scheduling, Project Administration, and Procurement supervisors will be assigned as permanent staff to the project, reporting to the Project Manager.

In charge of construction and engineering and also reporting directly to the Project Manager will be:

- The Resident Construction Engineer, who will administer Building Construction Contracts and supervise all construction activities. A Cyclotron Assembly Superintendent will report to the Resident Engineer.

- The Project Engineer-Cyclotron will control all engineering work on cyclotron equipment, shielding, beam transport, data systems, equipment test, start-up, and personnel training.
- The Project Engineer-Facility will control all engineering work on facility, utilities and building design.

IPEC-CBL will be responsible for the development and dissemination of basic design criteria, the approval of completed drawings for submittal to the Client, the preparation of specifications and purchase requisitions, and the analysis of vendor's quotations.

The Project Engineers will be responsible for the Project Scope and Procedures Manual; development and maintenance of engineering schedules; and estimating, reporting, forecasting, and controlling engineering manhour requirements.

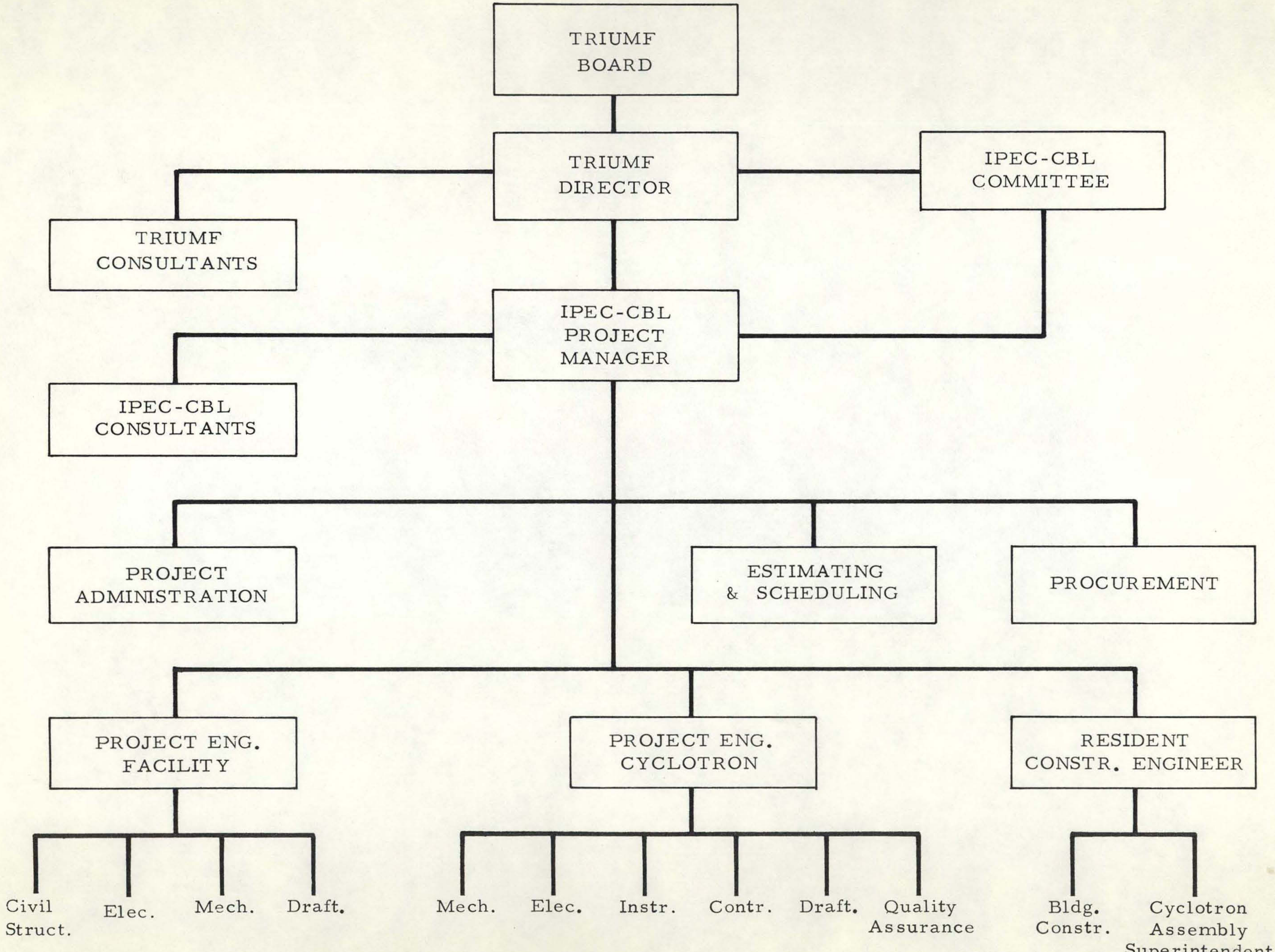

TRIUMF BOARD
TRIUMF DIRECTOR
IPEC-CBL COMMITTEE
TRIUMF CONSULTANTS
IPEC-CBL PROJECT MANAGER
IPEC-CBL CONSULTANTS
PROJECT ADMINISTRATION
ESTIMATING & SCHEDULING
PROCUREMENT
PROJECT ENG. FACILITY
PROJECT ENG. CYCLOTRON
RESIDENT CONSTR. ENGINEER
Civil Struct.
Elec.
Mech.
Draft.
Mech.
Elec.
Instr.
Contr.
Draft.
Quality Assurance
Bldg. Constr.
Cyclotron Assembly Superintendent

FIGURE 4-1

Section 5

IPEC-CBL CAPABILITIES DESCRIPTION

AVAILABLE STAFF

IPEC-CBL will draw personnel as required from existing staff of International Power and Engineering Consultants Limited in Vancouver, Canadian Bechtel Limited offices throughout Canada, and from the worldwide offices of Bechtel Corporation. This reservoir of experienced specialists will provide IPEC-CBL with flexible capability in all the major engineering disciplines and in the supporting areas of estimating, procurement, and management of construction.

In general the IPEC-CBL design staff for the facility will be largely drawn from IPEC and CBL. The design staff for the cyclotron will be largely drawn from the Bechtel Corporation and in particular key engineers from the Scientific Development Department. The Scientific Development Department, with over 80 engineers and physicists, was responsible for the Texas A&M University 88-inch variable energy cyclotron which has been successfully completed on schedule and on budget.

SPECIAL RESOURCES

Computer Services

IPEC-CBL will draw on computer services available in the International Power and Engineering Company Limited and Bechtel Corporation facilities. Both of these companies have been applying computer technology to engineering and design since 1955. Machine time will be available from existing contract services in Vancouver and from Bechtel's GE 625 in San Francisco. Alternatively UBC's own computer machine availability would be utilized.

Currently, over 550 scientific, engineering, and administrative programs are available for use. These include several critical path scheduling programs as well as design programs for stress analysis, piping network pressure analyses, determination of multigroup neutron diffusion, slope stability analysis, EHV radio interference analysis, piping flexibility analysis, and a program for developing isometric drawings from model takeoff points.

IPEC-CBL would also have available through a consulting agreement with AEG the following computer programs which can be used for TRIUMF beam dynamics analysis:

POL 2. This program is designed to determine the optimum magnetic field for a machine when the following parameters are given: machine dimensions; kind of particle; maximum energy; number of sectors; magnet gaps; ion frequency; average magnetic field along the last orbit; and axial number of betatron oscillations per turn (or spiral angle as a function of radius). By means of a two-dimensional solution of the

potential theory, magnetic field correction requirements are determined in such a way that deviation from the average isochronous field will remain within the allowable limits. The program is also used to specify the optimum steel configuration, i.e., the configuration of the pole plates.

POL 3. This program, a modification of POL 2, provides a step-by-step solution for the total magnetic field.

DEPOL. This program allows study of the degree of depolarization of polarized ions in a given magnetic field.

RUKU. With RUKU, it is possible to accomplish numerical integration of the motion equations. Time-dependent electric fields, used to simulate the ion beam in the cyclotron, permit analysis of beam behavior under field errors and various resonance conditions.

SEA. Although primarily intended to allow analysis of the beam orbit by a sharp-edge approximation method, SEA is also useful in determining beam extraction requirements.

QUAL. This program develops the beam phase space characteristics so that extracted beam quality may be studied.

MFB. The MFB computer program is used to analyze the magnetic field under saturated iron conditions.

Bechtel Laboratories

Bechtel maintains a metallurgical laboratory equipped and staffed to evaluate fabrication techniques and determine environment service characteristics of metals. Principal investigations conducted include studies of corrosion and materials and coatings. A new laboratory facility is engaged in development of industrial applications of microwave power and RF components.

AEG Facilities

The Nuclear Energy Division of AEG has extensive facilities for the construction and testing of accelerator models. These can be utilized by IPEC-CBL in direct support to the TRIUMF project. The accompanying brochure entitled "ACCELERATORS, Development/Design/Engineering/Construction" describes in greater detail these AEG facilities and capabilities.

APPLICABLE EXPERIENCE

The following projects are indicative of IPEC-CBL experience in applicable complex assignments:

Nuclear Research and Service Facilities

Bechtel staff capabilities in the design of nuclear research facilities are demonstrated by successful design work on the Materials Testing Accelerator (MTA), the Texas A&M Variable Energy Cyclotron (TAMVEC), Hot Cells, Reactor-in-Flight Test Facilities, large and complex space simulation chambers for testing nuclear rocket engines and components, the SNAP-8 test facility, and the General Electric Vallecitos Atomic Laboratory.

These projects were conducted under a variety of contractual relationships, including cost-plus, target-price, and fixed-price. In addition to normal design, engineering, and construction, services provided included site investigation and selection, master planning, system analysis and selection of optimum plant size, and review of manufacturing capabilities and recommendation of suitable suppliers for facility systems. The advanced nature of these facilities also required specialized capabilities in cryogenics, shielding, control and instrumentation, hazards analysis, and remote handling.

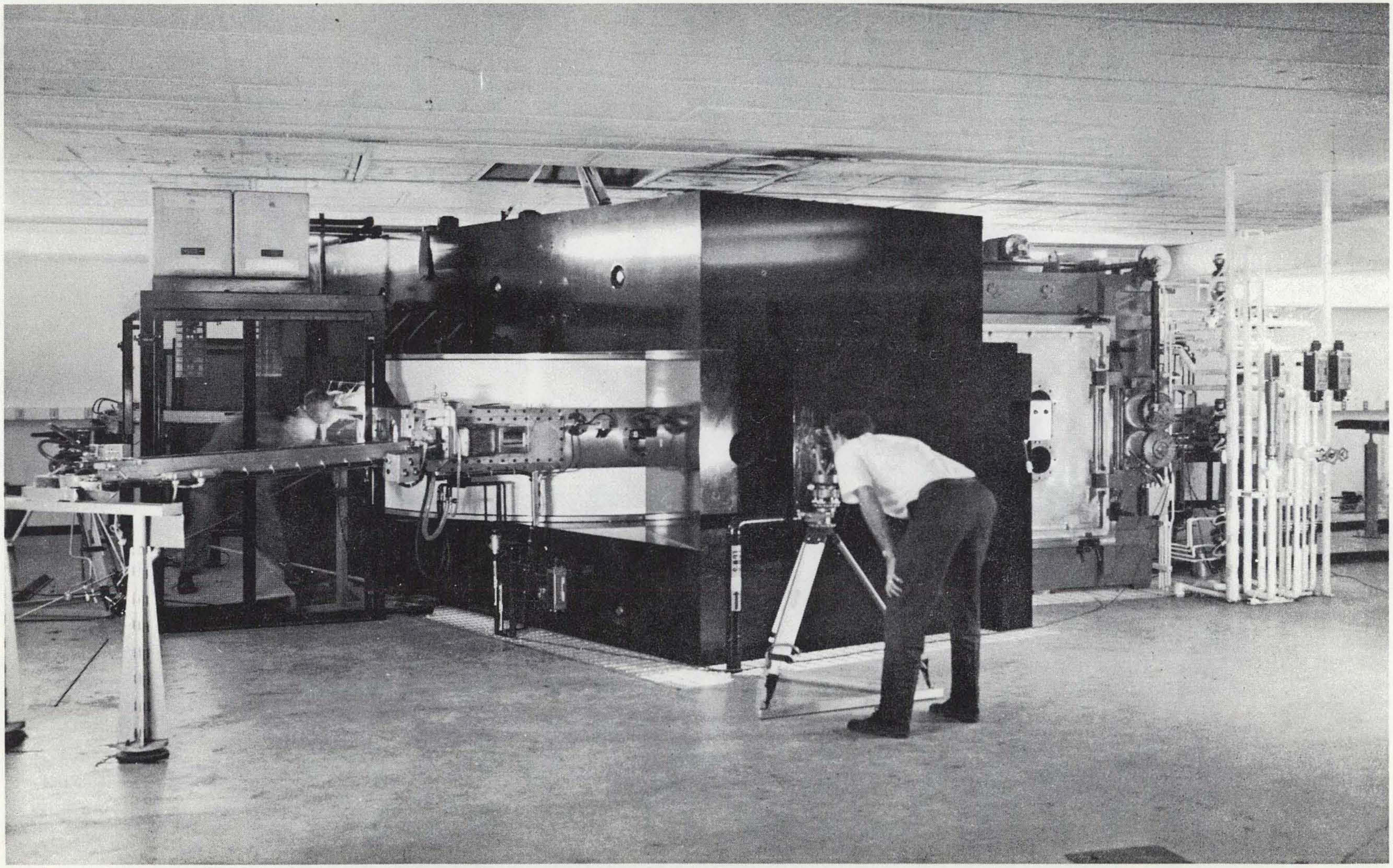
Texas A&M Cyclotron (TAMVEC)

Responsible for engineering and construction services for the Texas A&M Variable Energy Cyclotron (TAMVEC), Bechtel completed engineering and installation in June, 1967, and an internal beam was achieved in August. This particle accelerator is one of the highest energy sector-focused cyclotrons in the world. Funds for construction were provided by the Atomic Energy Commission. TAMVEC, located at the Cyclotron Institute at Texas A&M, College Station, Texas, is similar to the 88-inch cyclotron completed in 1963 at Lawrence Radiation Laboratory at the University of California, Berkeley. Protons, deuterons, and alpha particles can be accelerated to high energies (60, 65, and 130 MeV, respectively) for basic research in such fields as physics, chemistry, biology, and medicine. The magnet weighs over 270 tons.

Each time the particle completes one half a revolution, it receives an electrostatic "kick" of 70 KeV. After about 350 revolutions, the particle will have reached its maximum energy at about 40 inches radius. At this time it is electrostatically deflected out of the machine into the beam transport system.

Materials Testing Accelerator (MTA)

Bechtel's experience in the design and construction of accelerators began with preliminary design work in 1950 on a large accelerator for the manufacture of plutonium. At this time a project was initiated by the Atomic Energy Commission and California Research and Development Corporation (CR&D) to apply the electronuclear process for manufacturing plutonium in what was to be a $427, 000, 000 facility at Weldon Springs, Missouri. The first stage of the project was design and construction at Livermore, California, of a giant linear accelerator (Mark I Materials Testing Accelerator.)



Overall TAMVEC View, Looking Toward Beam Port.

After doing site and vessel work on the Mark I, which went into operation in 1952 as a full-scale prototype of the front end of the final device, Bechtel Corporation was appointed general contractor for the Weldon Springs facility. As such, the Company performed over one million dollars worth of engineering, including essential completion of the equipment layout, power supply requirements and design, and mechanical design of the accelerator and supports.

Fast Reactor Test Facility (FARET)

Bechtel prepared designs for the Argonne National Laboratory Fast Reactor Test Facility (FARET). The plan called for a reactor capable of investigating the neutronics of large, dilute fast reactors and the performance capability of various potential fast reactor fuels. Facility design included the three-bay reactor building which houses the reactor; radioactive and nonradioactive reactor cooling systems; and the cell, vault, and reactor cavity with their individual gas cooling systems, fuel transfer facilities, and auxiliary systems. The cell, vault, and cavity provide containment; controlled inert argon gas or air atmospheres; and biological shielding for the reactor and all radioactive systems.

Allied Chemical Corporation

During the past two years Bechtel, under contract to Allied Chemical Corporation, has conducted numerous engineering studies related to a spent nuclear fuel plant capable of processing up to five metric tons of uranium daily. The work began with an estimate and conceptual design for an aqueous process facility, and subsequently included a comparative evaluation of aqueous and fluoride volatility processes. Other studies involved capital cost vs capacity, site selection criteria, analysis of satellite facilities, and design optimization of specific plant areas. At present Bechtel is preparing a safety analysis report for presentation to the AEC as part of a request for a construction license.

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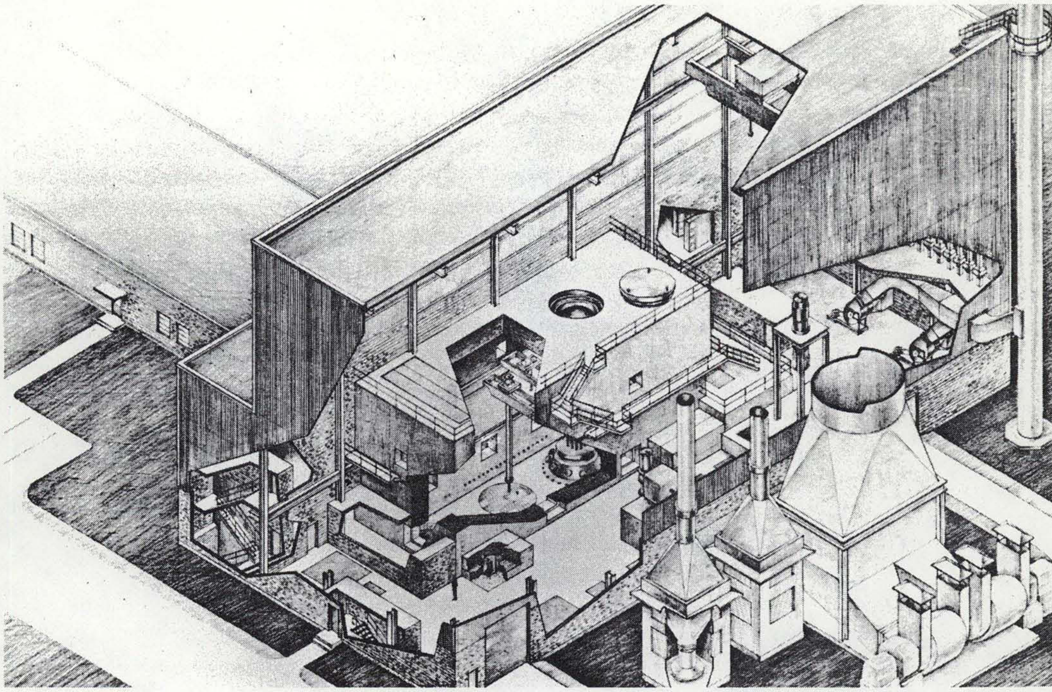
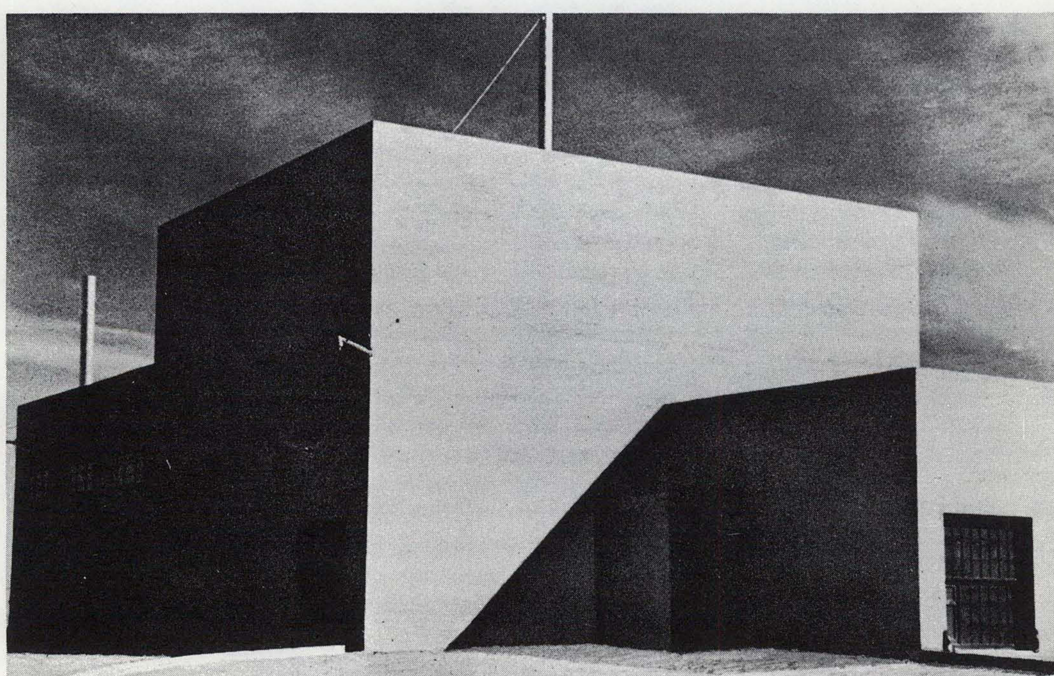
tive evaluation of aqueous and fluoride volatility processes. Other studies involved capital cost vs capacity, site selection criteria, analyses of satellite facilities, and design optimization of specific plant areas. At present Bechtel is preparing a safety analysis report for presentation to the AEC as part of a request for a construction license.



Fast Reactor Test Facility (FARET)



Experimental Breeder Reactor No. 1

Experimental Breeder Reactor No. 1

In 1949 Bechtel constructed Experimental Breeder Reactor No. 1 (EBR-1) at the U.S. Atomic Energy Commission National Reactor Testing Station, Arco, Idaho. This is a liquid-metal-cooled, enriched-uranium-fueled fast reactor surrounded by a blanket containing depleted uranium. The reactor was designed to demonstrate for the first time the experimental practicability of creating more fissionable materials than are consumed during operation. In addition, EBR-1 was used in the first successful application of nuclear-reactor-generated heat to the generation of electric power.

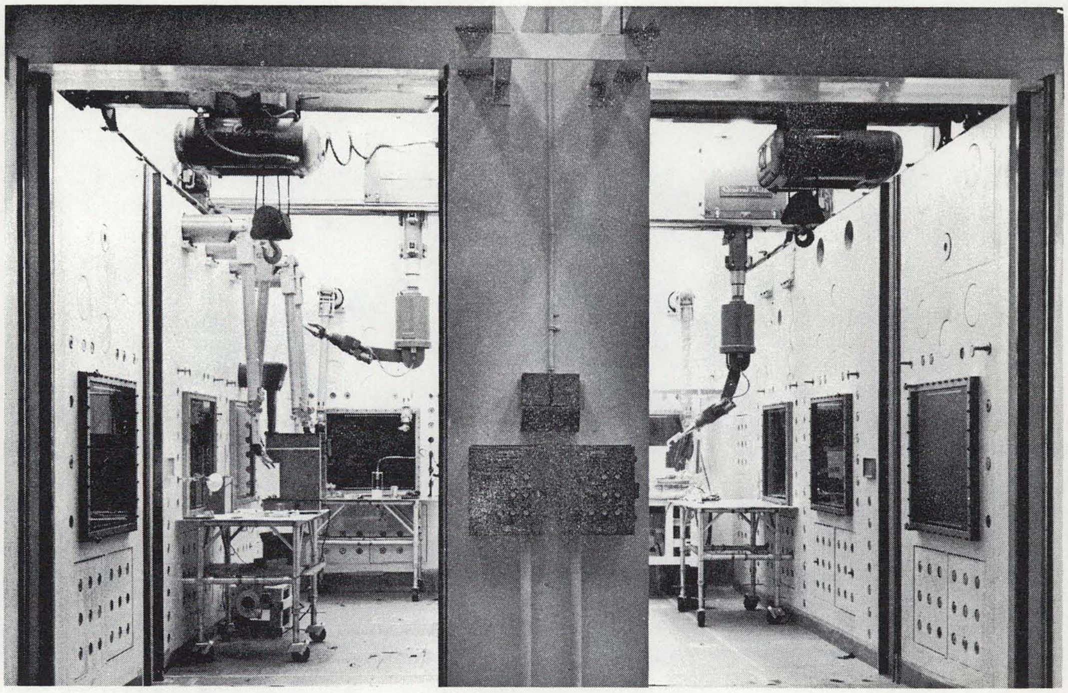
Vallecitos Atomic Laboratory

Vallecitos Atomic Laboratory is the largest privately financed nuclear research facility in the United States. The laboratory, engineered and constructed by Bechtel for General Electric in 1957, includes a developmental power reactor, an experimental physics lab, and a radioactive materials facility. Nuclear equipment development programs and studies for atomic power reactors are conducted at this facility. Development work for the Dresden Reactor was performed here.

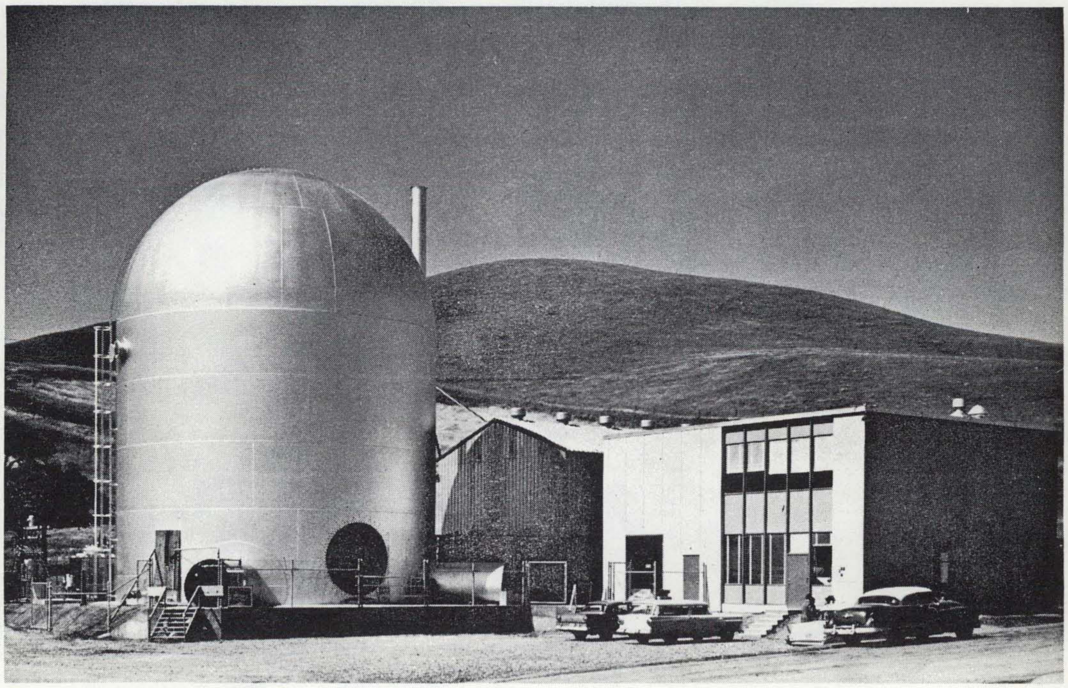
Hot Cells

Bechtel has performed engineering design work and construction for three hot cell facilities which are currently in use for nuclear research and development.

The General Electric Company hot cells at Vallecitos Atomic Laboratory, discussed above, were the first constructed by Bechtel. Bechtel responsibility began with site selection and continued through construction. The



Hot Cell, Vallecitos Atomic Laboratory



Vallecitos Boiling Water Reactor

adaptation of the basic Vallecitos Hot Cell design by other companies indicates the validity of Bechtel's original concepts.

The second hot cell facility was built at the John Jay Hopkins Laboratory, La Jolla, California, for General Atomic, a division of General Dynamics. It consists of a high-level cell, a low-level cell, and a metallographic cell, along with the necessary supporting areas for hot-cold changes, health physics, dark room mock-ups, offices, underwater storage, and decontamination facilities.

Atomics International subsequently retained Bechtel to design and construct a hot cell facility at its Field Test Laboratory near Los Angeles.

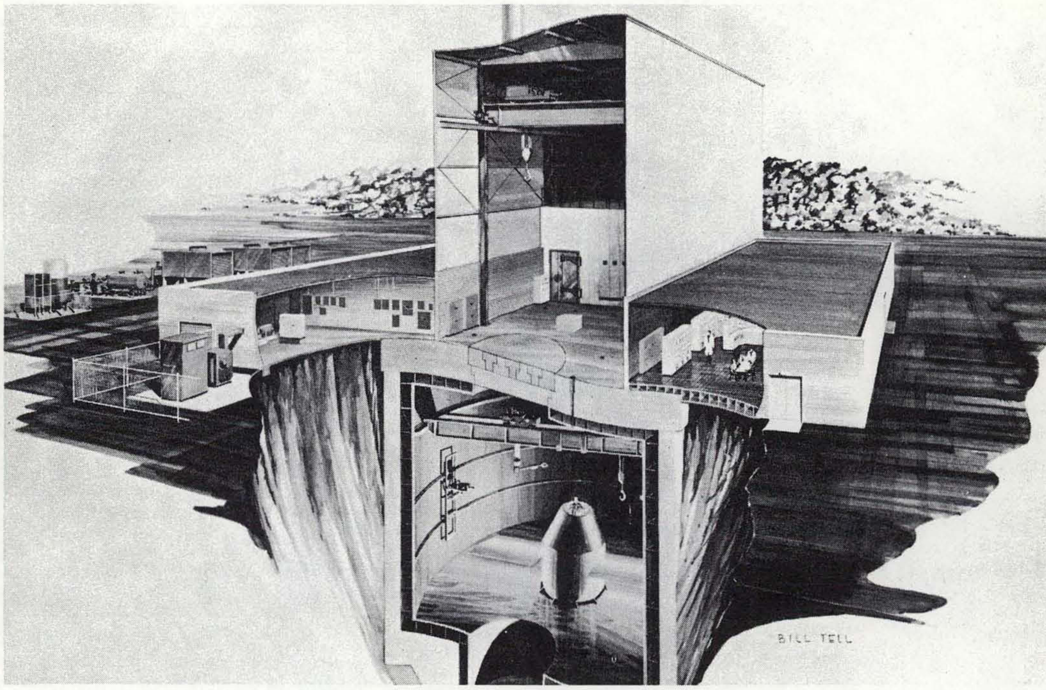
Vallecitos Boiling Water Reactor

This reactor, the first privately owned commercial nuclear power plant, was engineered and constructed by Bechtel for the owners — General Electric Company and Pacific Gas and Electric Company. Used to test new reactor designs at the Vallecitos Laboratory, the reactor is also a thermal source for generation of electricity distributed over the PG & E transmission system.

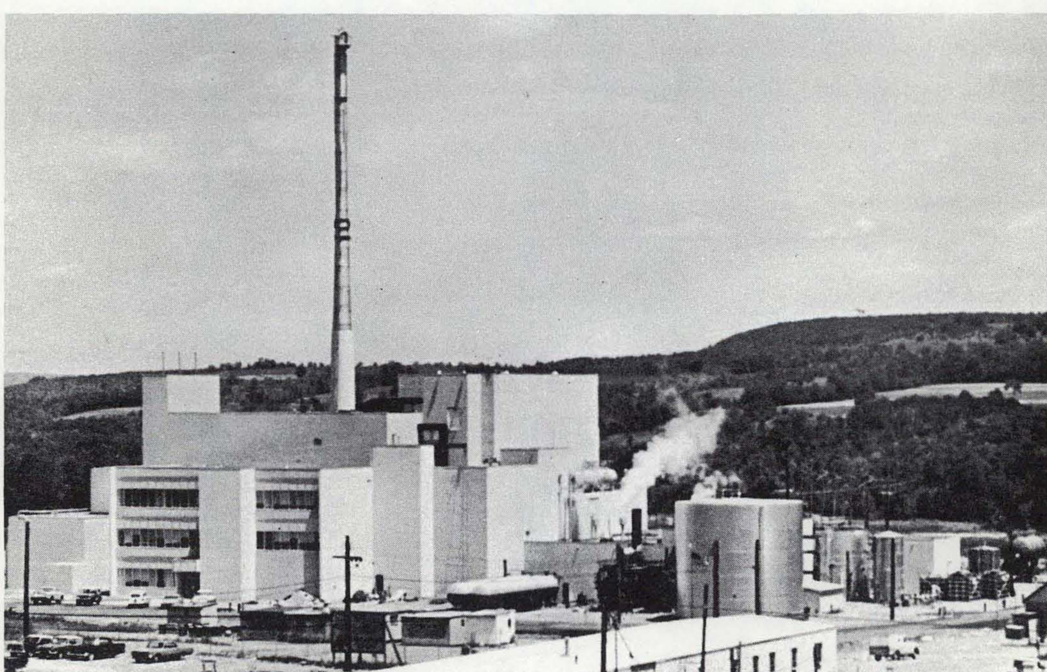
SNAP-8 Test Facility, U.S. Atomic Energy Commission

Bechtel designed the nuclear power supply test facility located in the Santa Susana Mountains north of Los Angeles. This facility permits on-the-ground, 10,000-hour, unattended operation of a 600-kwt power supply for use in space.

The complex includes an aluminum-lined, shielded vacuum tank 70 feet in diameter and 35 feet high. Within the test vault is a large-capacity,



SNAP-8 Test Facility



Nuclear Fuel Services, Fuel Reprocessing Plant

remotely controlled manipulator and television system and the associated experimental equipment necessary to set up a full-scale, complete test of SNAP-8. Heat is transferred by radiation to the walls of the facility at pressures as low as 0.01 atmospheres; and the capability for remote disassembling, repair, packaging, and shipping of used radioactive equipment is provided.

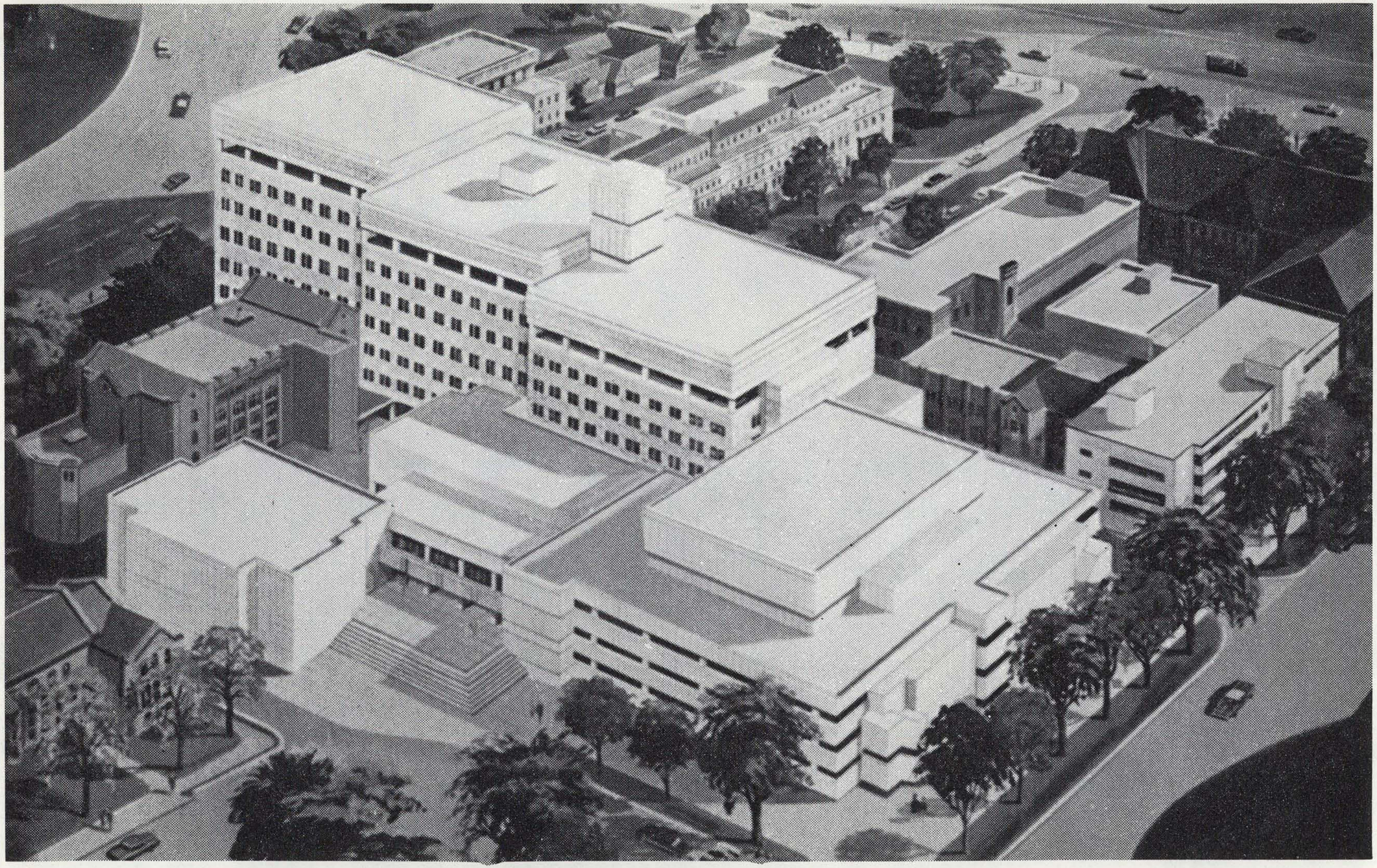
Nuclear Fuel-Services — Spent Fuel Reprocessing Plant

Bechtel Corporation was responsible for engineering, procurement, and construction of the nuclear fuel reprocessing plant for Nuclear Fuel Services. The plant consists of facilities for receiving fuel elements in casks; handling and storage of elements in a pool; mechanical processing for removal of extraneous material, and dissolving and conditioning for feed preparation; extraction of product values and wastes; handling and shipping of products; and storage of wastes. Auxiliary facilities include utilities, laboratories, and offices. The plant reprocesses atomic fuel elements used in nuclear research to produce heat for electrical power generation. Operations are carried on a 24-hour-per-day, seven-day-per-week basis. Fuel elements are stored underwater at a minimum depth of 11 feet and are handled by remote control.

REPRESENTATIVE PROJECTS

University of Toronto, Medical Sciences Building

Under the project management services of Bechtel, a new major Medical Sciences Building is being designed and constructed for the University of Toronto. This building, devoted to medical teaching and research, will contain approximately 500,000 square feet of floor area. Its location — on the main campus and close to the Ontario Provincial Legislative



Artist's Concept, University of Toronto Medical Center.

Buildings and Queen's Park area — presents many problems, since the building must harmonize with its surroundings.

The mechanical features to be incorporated in the building are varied and complex. There will be areas that must be made free of vibration, dust, germs, light, sound, and electrical interference. Some experiments undertaken in the building will be carried out at sub-zero temperatures, others in tropical heat. Certain rooms will require negative air pressure to prevent the spread of odors or infection; others will require positive pressure to maintain sterile conditions. Literally hundreds of fume hoods will be exhausting air continuously from all parts of the building. Some types of scientific equipment will weigh tons and require specially reinforced floors; other types will be so delicate that they can only be operated under controlled conditions of temperature and humidity.

Great Canadian Oil Sands Limited (GCOS)

The first major steps in developing the Athabasca oil sands deposits in Northern Alberta have been undertaken by Great Canadian Oil Sands Limited. Bechtel furnished all process design, detailed engineering, procurement, construction, and overall project management services for this $240 million project. Previously, Bechtel designed and constructed a test plant to prove the economic and technical feasibility of the process for removing oil from the sands.

Construction work began in the summer of 1964 and was completed in the spring of 1968. The work force hit a peak of approximately 2000 during the course of the project.

Development of the project required construction of temporary living facilities for construction personnel, and the building of new roads to the [illegible] and [illegible] -- [illegible] many problems, since the [illegible] with [illegible].

[illegible] down the building and [illegible] and [illegible] of [illegible], dust, [illegible] experiments [illegible] temperature, [illegible] negative [illegible] quite pos- [illegible] hundreds of [illegible] specific [illegible]

[illegible]

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[illegible] 1960 [illegible] during the course of the project.

Development of the project required construction of temporary living facilities for construction personnel, and the building of new roads to the site, including a 1550-foot bridge across the Athabasca River. The completed plant will handle 100,000 tons of oil sands per day and produce 45,000 barrels of synthetic crude oil per day.

The facilities included large, heavy-duty, bucket-wheel excavators, a high-speed conveyor system, an extraction plant, processing units, a steam plant, electric generating facilities, and a pipeline from the project to the Edmonton area.

Asbestos Corporation Limited, Quebec-Asbestos Hill Project

Bechtel is providing project management for construction of the Asbestos Hill project for Asbestos Corporation Limited, near Deception Bay, Ungava, Quebec.

This major project involves the construction of a recovery plant capable of producing asbestos fiber from ore initially obtained by open-pit mining and later by underground mining. Associated facilities include crushing, milling, power generation, warehousing, and maintenance shops. The project requires building a townsite for approximately 1100 people, with such related facilities as water supply and sewage disposal, an access road, an airport, and complete harbor facilities.

Iron Ore Company of Canada, Iron Ore Concentrating and Pelletizing Plant

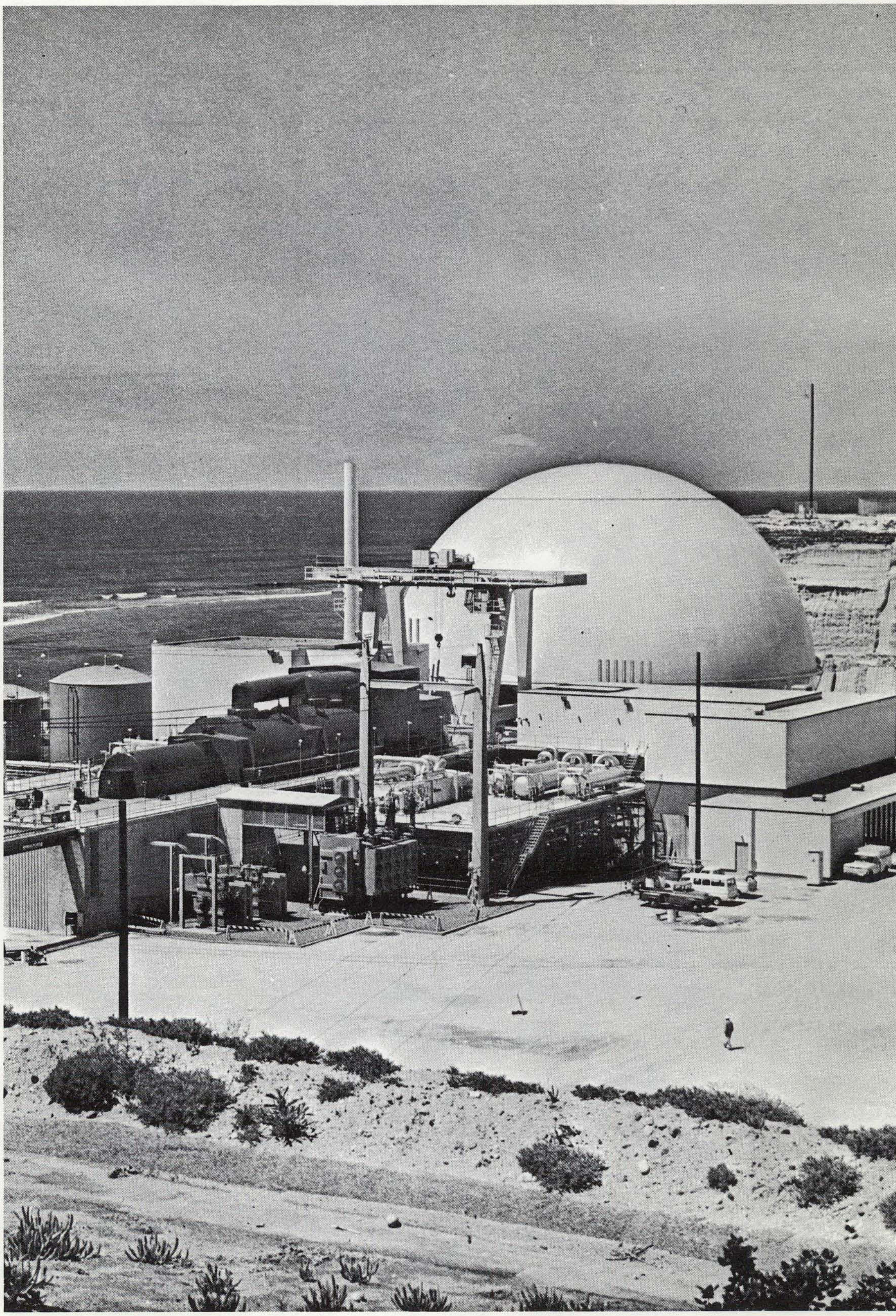
Bechtel provided design engineering and construction management for the Iron Ore Company of Canada's $200 million iron ore development in Labrador.

This project, located in the isolated Wabush Lake area, required the development of complete townsite facilities, an access railroad, and an airport.

REPRESENTATIVE NUCLEAR POWER PLANTS

Owner and Description	Scope	Location
Philadelphia Electric Company, Peach Bottom 1, 2, and 3 - 2170 Mw(e)	EPC	Pennsylvania
Duke Power Company, Oconee 1, 2, and 3 - 2517 Mw(e)	E (Consulting)	South Carolina
Florida Power and Light Company, Turkey Point 3 and 4, 1442 Mw(e)	EPC	Florida
Wisconsin Michigan Power Company, Point Beach 1 and 2 - 910 Mw(e)	EPC	Wisconsin
Consumers Power Company, Palisades - 700 Mw(e)	EPC	Michigan
Boston Edison Company, Pilgrim I - 625 Mw(e)	EPC	Massachusetts
Northern States Power Company, Monticello - 471 Mw(e)	EPC	Minnesota
Rochester Gas and Electric Company, Ginna - 420 Mw(e)	PC	New York
Southern California Edison Company, San Onofre - 429 Mw(e)	EPC	California
Government of India Tarapur 1 and 2 - 380 Mw(e)	EPC	India
Commonwealth Edison Company, Dresden-1 202 Mw(e)	EC	Illinois
Union Electrica Madrilena, Zorita, 160 Mw(e)	E (Consulting)	Spain
Consumers Public Power District and Atomic Energy Commission, Hallam - 76 Mw(e)	E	Nebraska
Consumers Power Company, Big Rock Point - 72 Mw(e)	EPC	Michigan

E = Engineering   P = Procurement   C = Construction



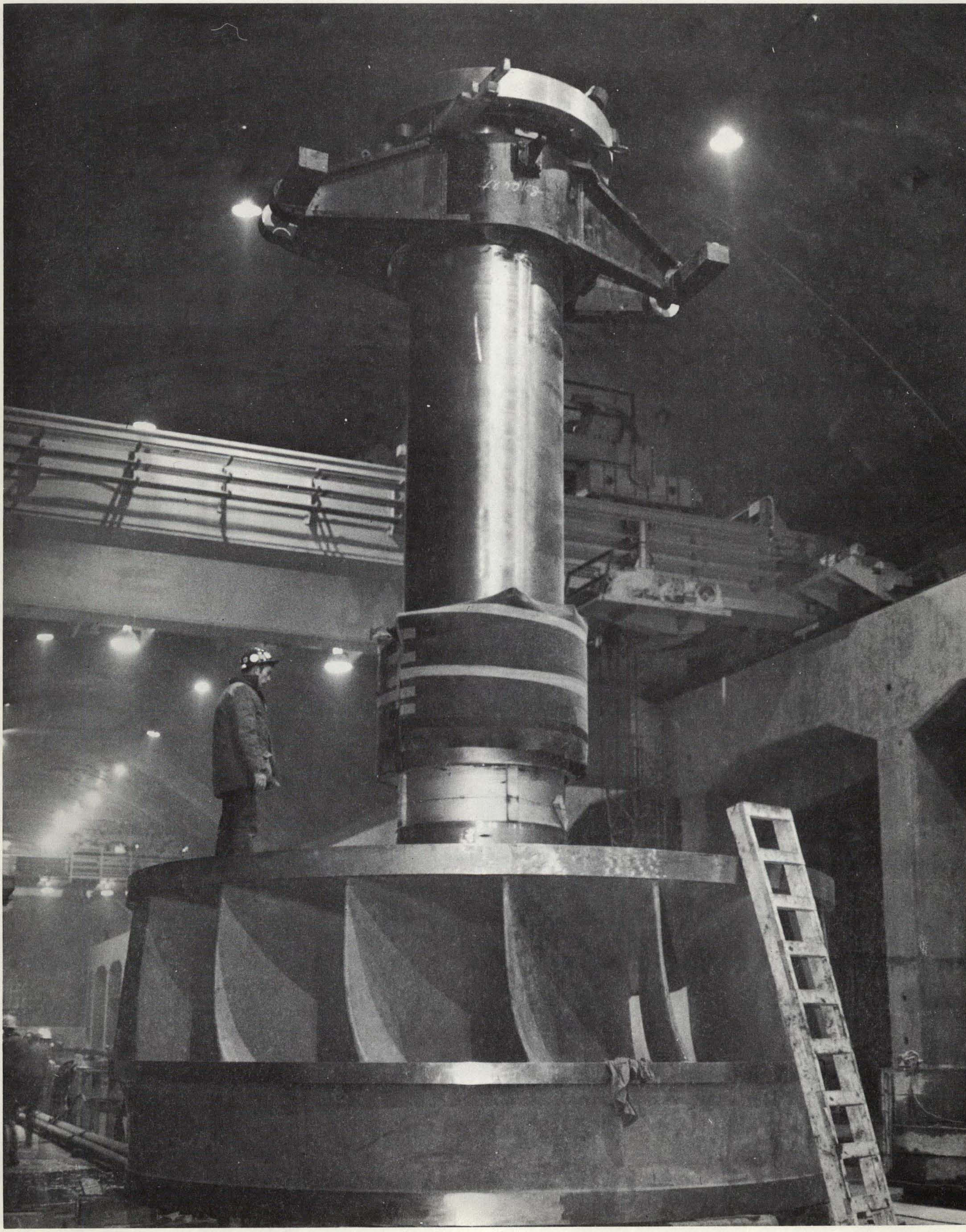
San Onofre Nuclear Generating Station, San Clemente, Calif.

Peace River Hydro-Electric Project

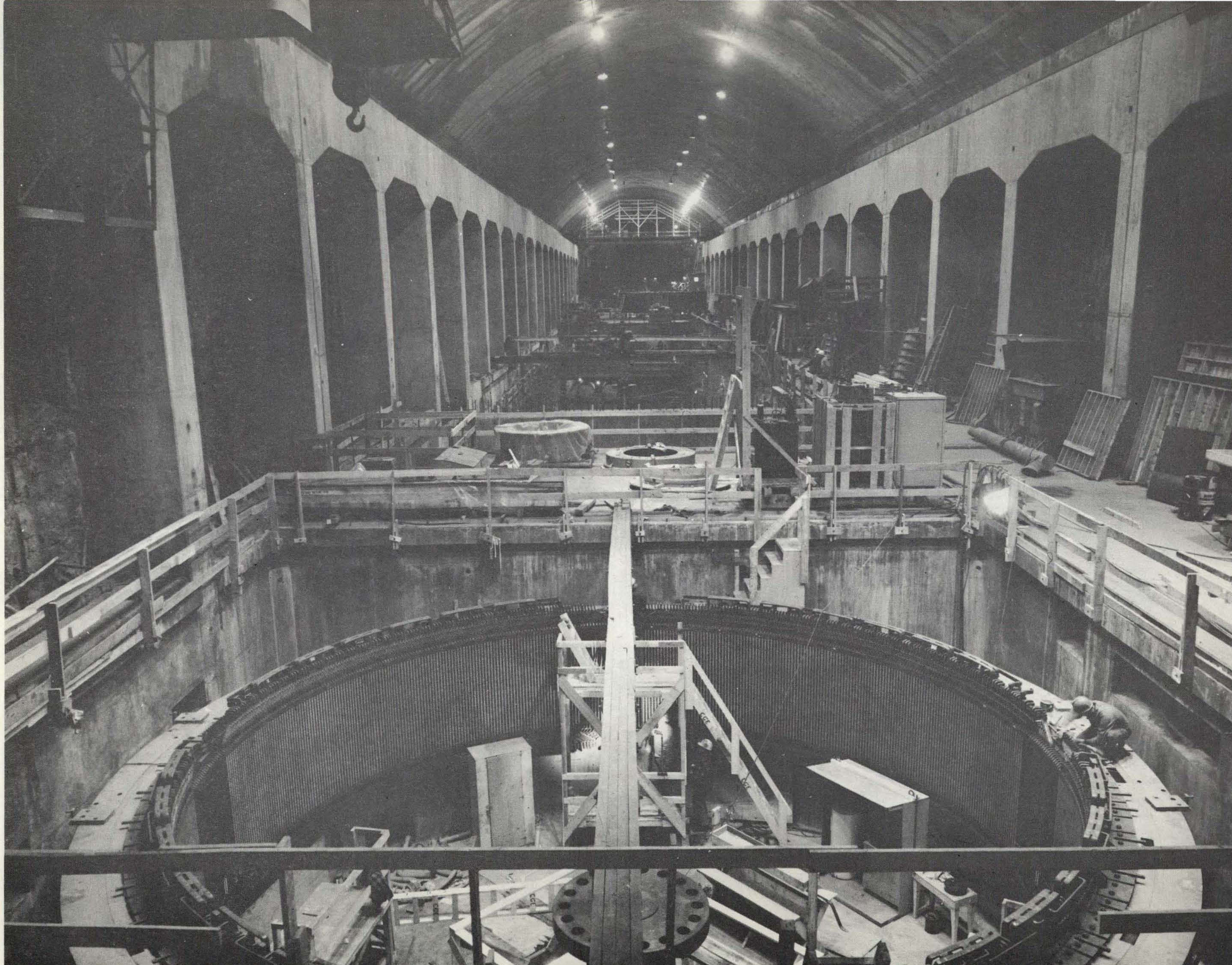
IPEC is responsible for feasibility and planning studies, design engineering and construction inspection for the British Columbia Hydro and Power Authority's approximately $700 million Peace River Hydro-Electric Project.

The largest component of the Peace River Project is Portage Mountain Development. At this site diversion of the Peace River was accomplished through three 48-foot internal diameter, horseshoe shaped, concrete lined tunnels, each approximately 2280-feet in length. The W.A.C. Bennett Dam (formerly Portage Mountain Dam) is a zoned rolled earthfill structure some 600-feet high, 6700-feet long at the crest, 2600-feet wide at the base and utilizes 57,000,000 cubic yards of fill material. Extensive soils exploration and stability analysis programs were carried out in connection with the earthfill dam. The 200 mile long reservoir, when full, will impound some 60,000,000 acre-feet of water. The underground powerhouse at Portage Mountain is 890-feet long, 65-feet wide, 140-feet high and with the associated draft tubes, manifolds, tailraces, and penstocks required over 1 million cubic yards of underground rock excavation. When completed the powerhouse will contain ten generators and Francis turbines of 2,390,000 KVA total capacity. The power intake structure includes ten concrete towers each about 180-feet high with an operating deck on top. The design of this structure included a thorough seismic loading analysis based on the most advanced methods of determining dynamic responses. The spillway is a concrete lined channel 2800-feet long and 100-feet wide at the invert. Discharged water will pass through nine slide gates, each 6-feet wide by 8-feet high, and under three radial gates, each 50-feet wide by 61-feet high. Approximately 1 million cubic yards of concrete will have been

PORTAGE MOUNTAIN DEVELOPMENT SHOWING DAM AND INTAKE TOWERS



PORTAGE MOUNTAIN DEVELOPMENT
SHOWING ASSEMBLED TURBINE SHAFT AND RUNNER INSTALLATION



PORTAGE MOUNTAIN DEVELOPMENT - UNDERGROUND POWERHOUSE SHOWING STATOR BEING INSTALLED

placed for the first stage of the develpment, much of it being highly stressed or otherwise critical mass concrete. Commercial power from the first three generating units at Portage Mountain Development is scheduled to be generated in the fall of 1968.

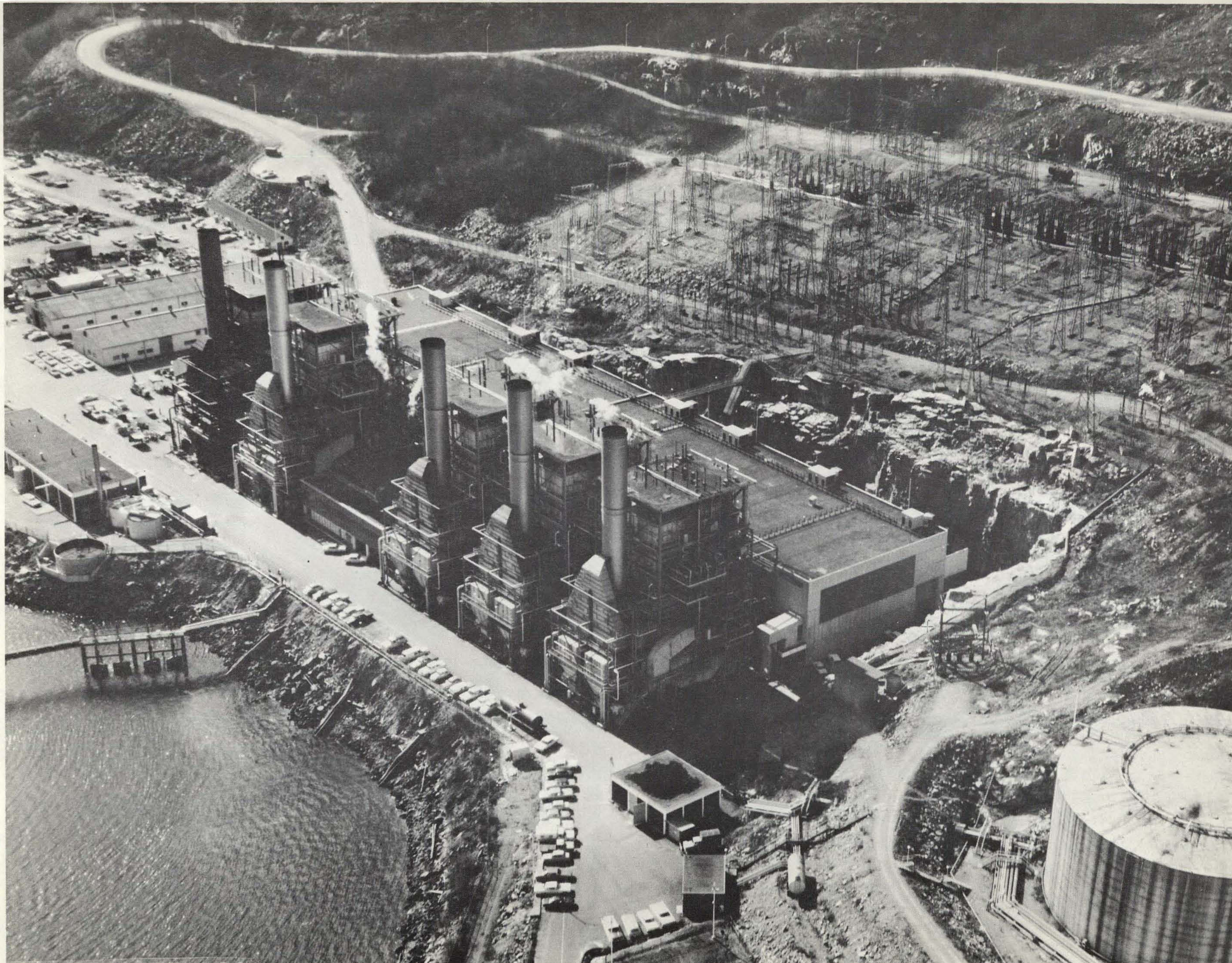
Unique features of the electrical design are the static excitation, braking resistors power bypass, and the development of the concept of solid state relaying.

Power from the Peace River Project will ultimately be delivered to the main load centre, some 600 miles distant, by means of three 500 kv transmission lines. The first of these lines, together with intermediate and terminal switching stations, is scheduled to be placed in operation in the fall of 1968.

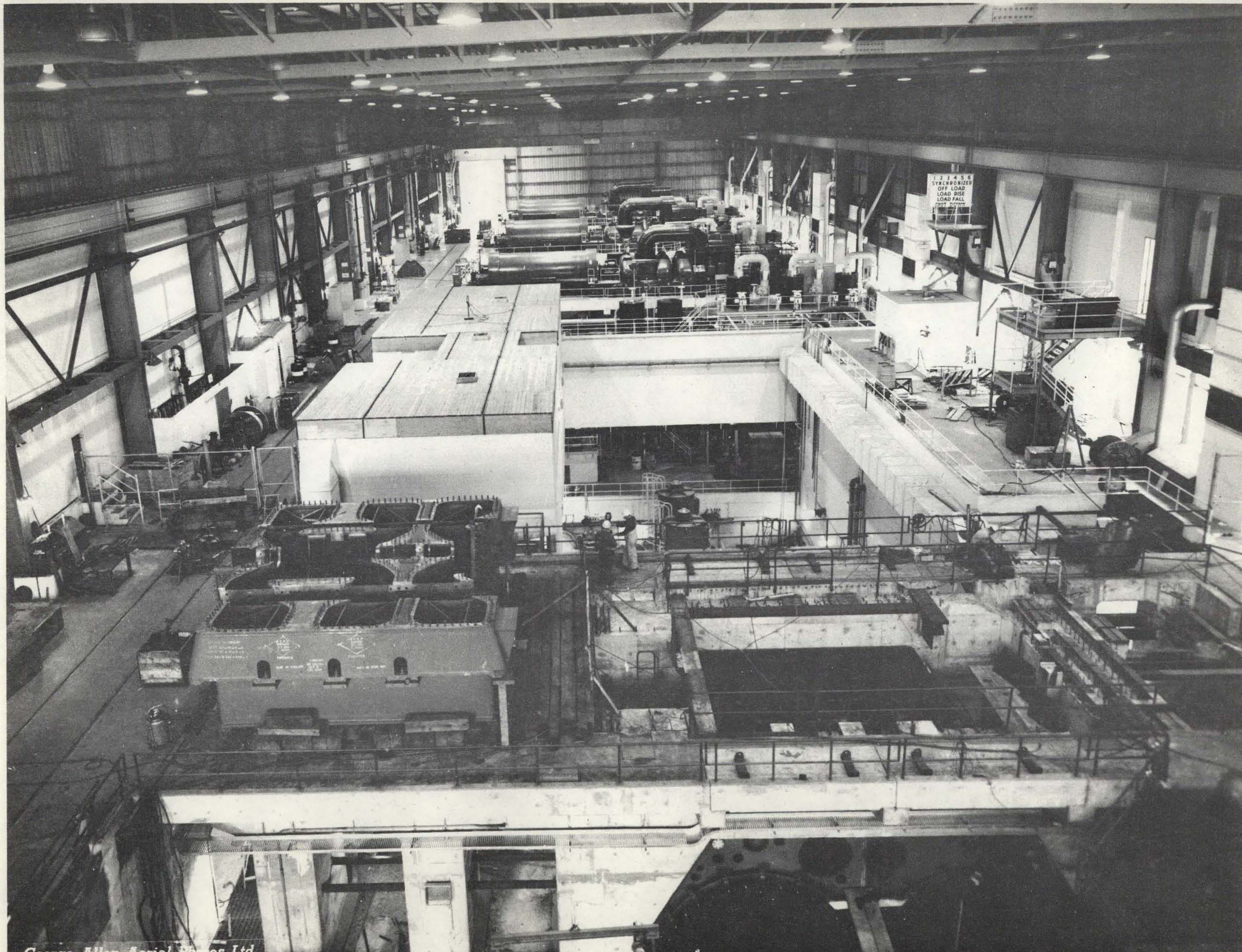
Feasibility studies have been completed for a second generating station on the Peace River at Site 1 about 12 miles downstream from Portage Mountain Development. These studies envisage the installation of six generating units, operating at a head of 134-feet, and developing 915,000 KVA.

Burrard Thermal Generating Station - Vancouver

Responsible for the planning, engineering design, procurement services, and supervision of construction of a 900 MW (6 x 150 MW hydrogen cooled units) plant in Vancouver, No. 5 unit presently under construction to be in service in 1968. The design of this plant is on a unit connected basis, e.g. one boiler, turbine, generator, unit step up, and unit auxiliary transformation, with each overall unit operating at critical limits with respect to temperature, pressure, and speeds, requiring a rapid sensing of failure, or condition that may require failure and a



BURRARD 900 MW THERMAL PLANT



BURRARD MACHINE HALL

fast acting protection system to prevent or minimize damage. The protective and interlock schemes designed together with the provision of automatic control of the boilers, the automatic start-up facilities designed for the turbines, the automatic data processing and the alarm system incorporated into the programs have been successful in providing safe protection for the units.

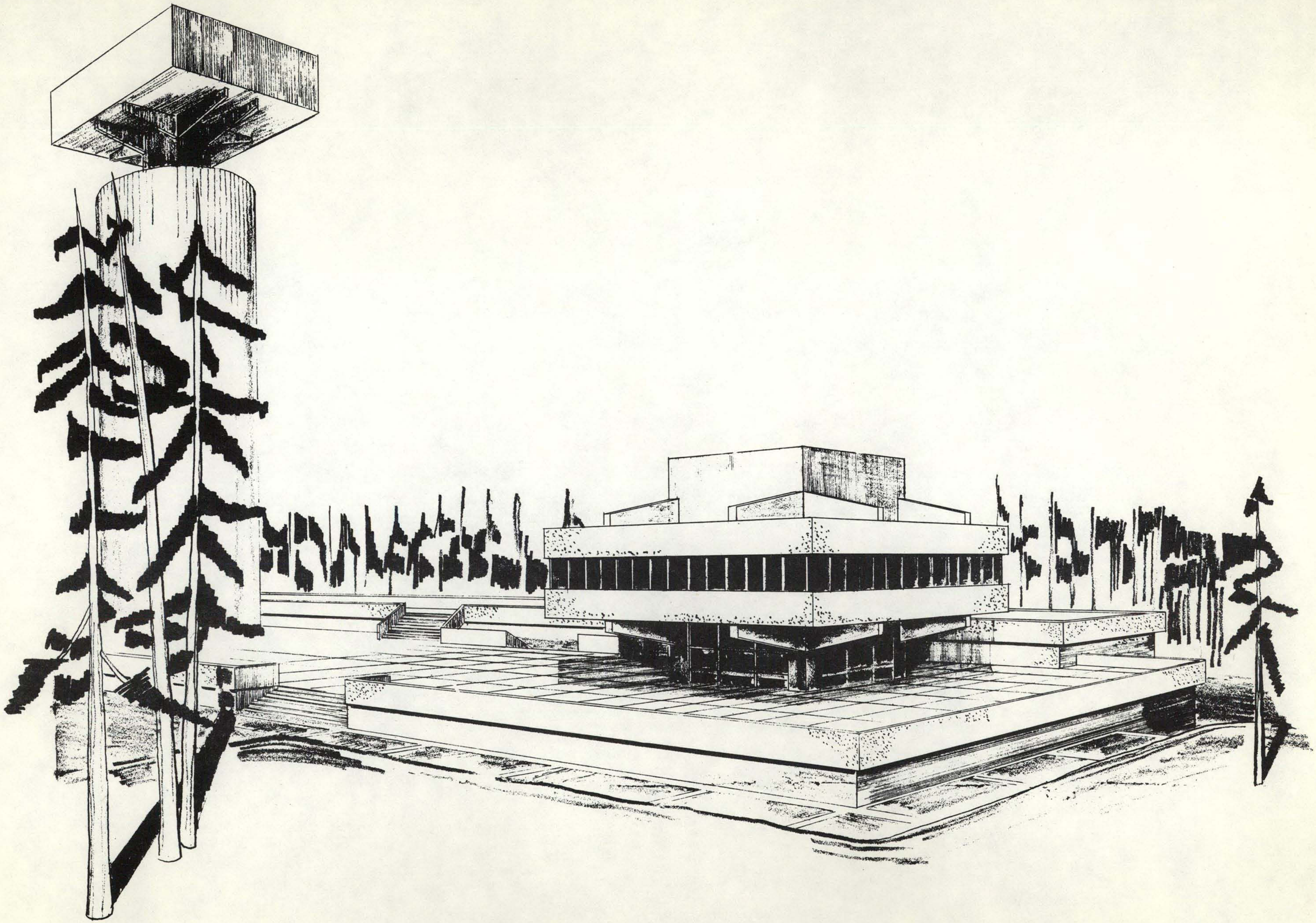
Burnaby Mountain System Control Centre

Responsible for the design of the system control centre for British Columbia Hydro and Power Authority's electrical network.

This centre is located at Burnaby Mountain, Vancouver, and is adjacent to the Simon Fraser University and the design was required to conform to the architectural concept of the campus.

This centre will be the prime control point for the electrical network in British Columbia by means of automated remote control linked by microwave to all major installations.

A significant part of this centre is a data logger and computer complex which provides automatic and instantaneous correlation of all system functions.



BURNABY MOUNTAIN SYSTEM CONTROL CENTRE

Gas Turbine Plant - Port Mann

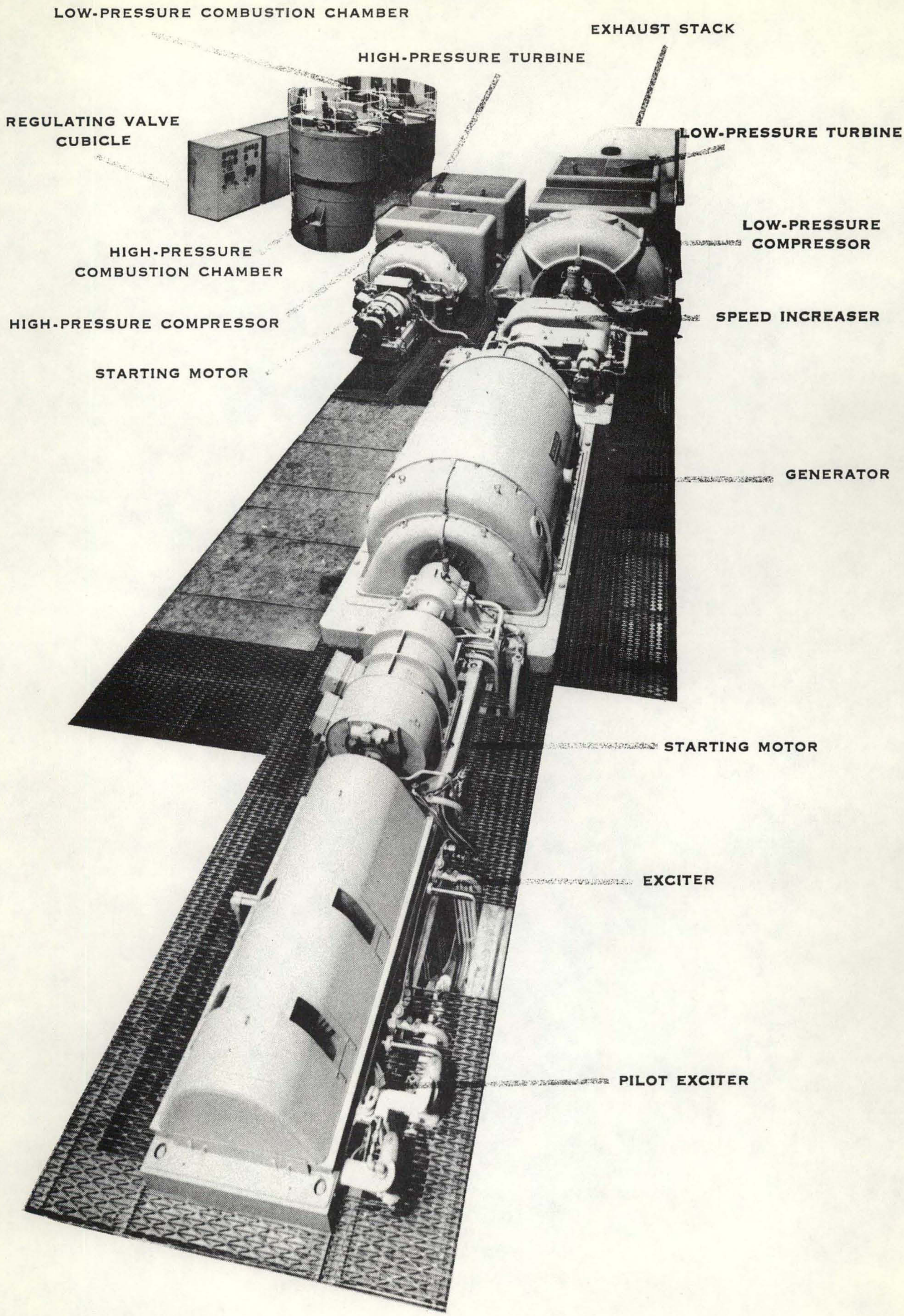
Responsible for the planning, engineering design, and supervision of construction of the Port Mann Gas Turbine Power Station which is one of the largest of its kind in the world.

It contains four double shaft turbo sets, without air preheating, with intercooling and with a total output of 108 MW. The complete powerplant is automatically controlled from the main load dispatching centre approximately 15 miles distant. The gas turbines can be started up from there, brought up to load and switched off without the presence of any operating staff in the power station. Since the plant is located in a residential district the air intake ducts and exhaust stacks are fitted with silencers which appreciably diminish the noise. Since the plant operates without any supervisory staff, a safe and complete automatic supervisory system had to be designed.

Vancouver Island HVDC Link

Responsible for the design and supervision of construction of the AC terminal facilities at the Arnott and Vancouver Island Terminal Stations, and associated with ASEA Sweden in the design of the extra high voltage DC switchyards at these locations. In this complex, electrical energy is accepted at Arnott at 230 kv AC where it is converted to $\pm$ 260 kv DC for delivery to the Vancouver Island Terminal Station. There inversion to 230 kv AC occurs. A unique feature of this installation is the operation of the DC cables in parallel with the existing AC cables.

Of special interest is the screening of the valve halls at both terminal buildings designed by IPEC. This screening reduces the radio interference emanating from these halls to below 1 microvolt, at 1 megacycle, at a distance of 1500-feet.



GAS TURBINE PLANT