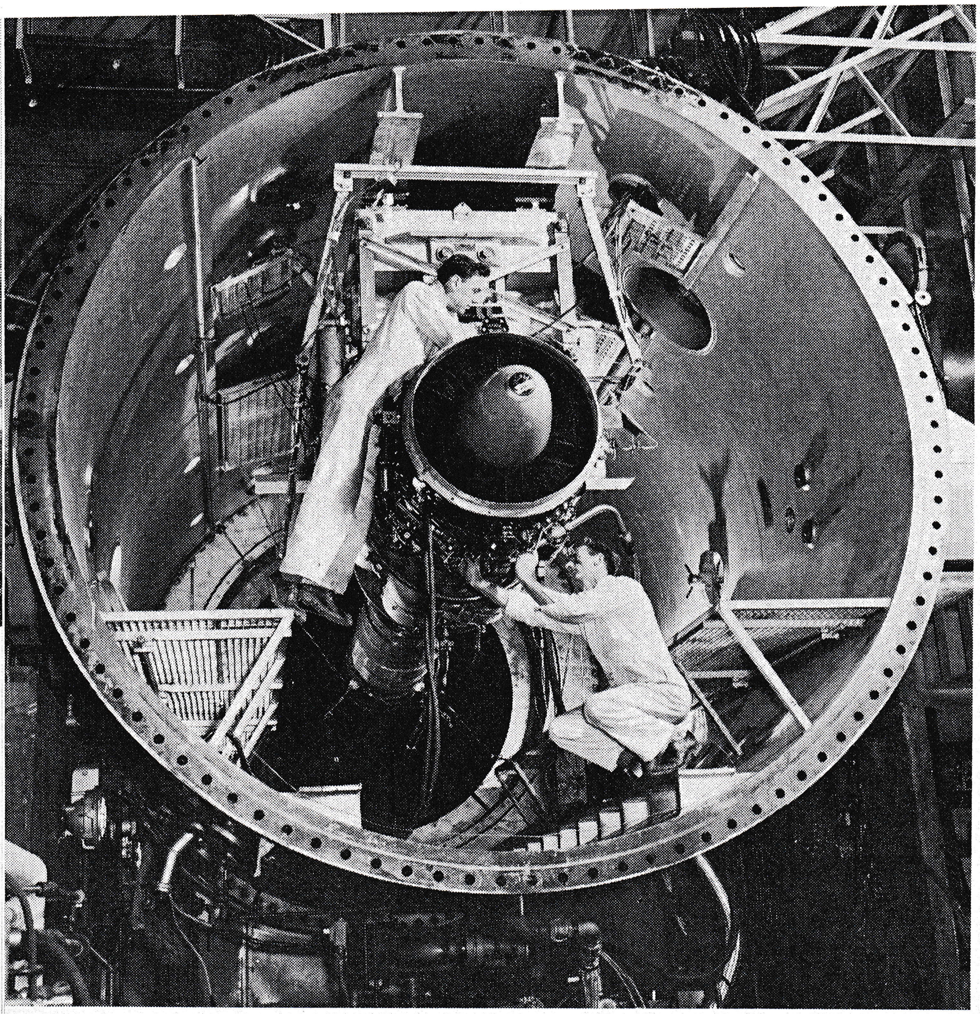


SECTIONED CELL. An Orenda series engine being positioned for a run in the new altitude facility at Malton. Pressure cell is in movable sections easing access.

Altitude Test Cell Covers

By Ernie Hemphill

New facility at Orenda provides industry

With valuable test and development tool.

Design, fabrication ingenuity establish

Basic system with ram jet capability.

Canada's aero engine designers and builders can now probe flight characteristics and performance under conditions approaching what is believed to be the ultimate for air breathing power plants right in their own backyard—and without ever leaving the ground.

That rather generally describes capabilities in the new high altitude test facility which went into operation recently at the Malton plant of Orenda Engines Ltd.

Fundamental development equipment, designed with the object of testing out existing hardware and exploring avenues of further refinement, is what Orenda engineers aimed for in setting up the estimated $6,500,000 high altitude chamber. Construction of the Malton cell was part of a program which has seen Orenda add some $11,000,000 in new facilities to its test and development potential over the past three years.

Expediency, efficiency and economy were prime factors in the decision by Orenda, with the approval and financial assistance of the defense department, to establish the high altitude test plant.

Swift broadening of the flight envelope which followed successful application of turbine principles to aero engines brought with it a tremendous increase in the amount of running required to carry out a full test and development program. With the wide range of conditions to be flown, carrying out such a program in a flying test bed became prohibitive from points of view of both time and dollars consumed.

This was particularly true of the extensive test program envisaged in full development of the supersonic Iroquois, on which design and engineering teams were working at the outer reaches of current research and theory.

Bringing the Iroquois concept into production as an operational engine within acceptable time and cost limits was predicated on availability of an engine altitude test facility capable of simulating conditions over the proposed operating range of the power plant.

In the words of Charles A. Grinyer, Orenda's Vice-President Engineering, "We required a basic facility in which we could test out and develop an actual power plant as opposed to equipment for undertaking applied or basic research.

Full Air Breathing Range

Future Needs

"While we were primarily concerned with filling our needs for the Iroquois development, we also had to keep in mind the tremendous rate of progress in the design and development of power plants. An expensive tool like an altitude test chamber cannot, of course, be designed to meet the needs of a single project.

"We had to try to assess the future in aero engines and build our facility with enough flexibility (within reasonable cost limits) to cover subsequent test and development programs."

Grinyer is satisfied that within acceptable limits, the Orenda aim has been achieved.

Basic concept for the Malton altitude cell and its control system originated with Orenda. In charge of the project was P. K. "Pete" Peterson, Chief Equipment Engineer. Head of the design team was Tom McCloghry, who is now Chief of the Altitude Test Facility. The Orenda designers visited existing engine altitude facilities in the United States and Europe and made a careful study of different approaches to the problems involved before launching their own project.

The function of the altitude test cell is to simulate conditions which the engine will encounter in operating at various altitudes over its complete range of forward speeds. The environmental variables associated with changes in altitude occur in air pressure and temperature. The problem in designing a test facility then is to control air pressure and temperature at the functioning parts of the engine under test.

The critical pressures and temperatures for simulating flight characteristics in the operation of a pure jet turbine engine at altitude are the pressure at the engine inlet; the ambient pressure of air around the outside of the engine, particularly the jet pipe where the ingested air exhausts into the simulated atmosphere; the temperature of the air at the engine inlet.

There is a further requirement, under operational conditions up to the point where the speed of the air stream at the tail pipe attains sonic speeds and above, to exercise rigid control over the ram pressure ratio, which expresses the comparison between the air pressure at the engine compressor and the outside ambient pressure. When the speed of the air at the jet pipe exceeds that of sound, however, the ram pressure ratio is no longer a factor in simulating the engine operation.

In the interests of economy, the air supply plant which serves the test chamber has been set up to carry the double functions of either supplying pressurized air at the inlet of the engine under test, or evacuating air to simulate the reduced ambient pressure of altitude at the jet pipe of the test unit. But it cannot do both simultaneously.

This arrangement places a limitation on the flight operating range of the facility and precludes the running of a continuous test of an engine in trajectory (at varying speeds over a different range of altitudes). The engine may be tested in transient (through varying speeds at a specific altitude) but moving to another altitude requires a shutdown of the plant and a resetting of controls.

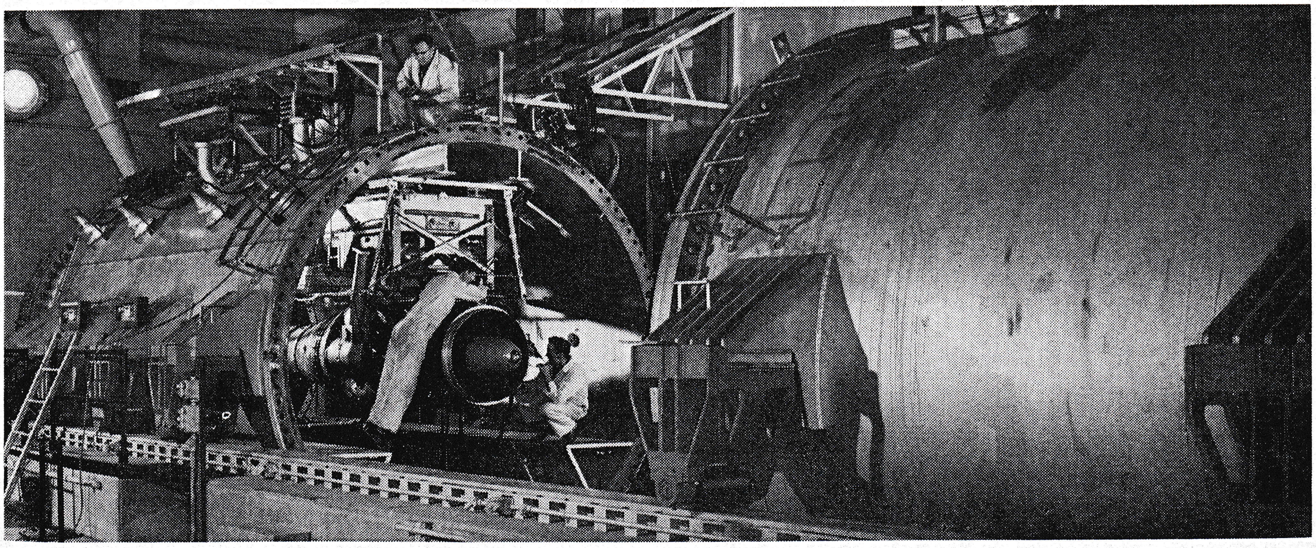
The compressor/exhauster units which control the air flow through the test facility are axial flow compressors which were economically salvaged for their new role from surplus Series 2 Orenda engines.

There are a total of 10 compressors in the test facility's air plant, arranged mirror image in two banks of five. There is a separate electric power supply to each of the two compressor banks, permitting use of one side or the other independently, as well as combined operation depending on the air demands for running a test.

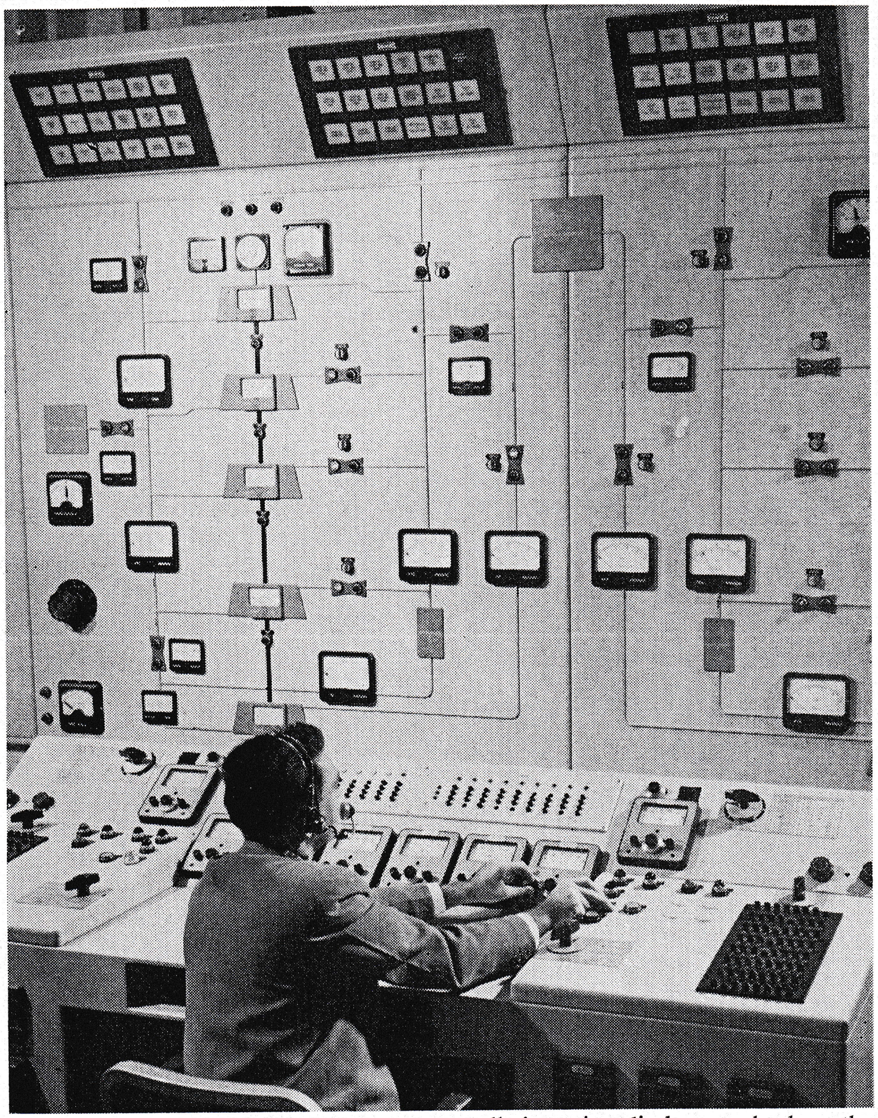
With these presently available configurations for air supply and its processing through valves and temperature control units elsewhere in the system, the flight operating range for the test cell, with an Iroquois engine under test, is from Mach 1.3 at 35,000 feet to Mach 2.9 at 100,000 feet. During the winter months, when outside air at a lower ambient temperature is available, the flight operating range of the cell may be extended to a minimum of Mach .6 at 20,000 feet, but this is not a year round possibility.

Control System

The decision to design the Orenda test facility for operation at a constant mass flow of air without regard for the varying demands of the test engine for air at different speeds, necessitated a somewhat unique departure in engi-



INSTALLING FOR TEST. Ease of access to test cell area for set-up of a run is illustrated. Cell sections travel on rollers.



INSTRUMENTATION. At the process controller's station display panels show the entire system layout in schematic diagram providing visual reference on operation.

neering the flow and control of air through the system. Key to the control system, as it relates to the delivery of air to the critical engine inlet and jet pipe areas of the test cell, is a by-pass loop around the test chamber.

The by-pass loop and associated valves control the pressure of the air delivered to the engine inlet and the ambient pressure of the air into which the test engine exhausts.

The temperature of the air at the engine inlet, also critical to operating characteristics of the test engine and of course variable with altitude and speeds, is controlled by a propane heater unit which preheats the air before ingestion at the cell inlet.

In any given sequence, appropriate pressures and temperatures are set up through positioning of the valves. During the test run, there is automatic interplay between the various valves to maintain the simulated pressures and temperatures of the altitude of operation through the programmed speed range under investigation.

The test chamber itself might best be described as a giant vacuum cell.

It is made up in three cylindrical sections of nickel steel alloy, each 20 feet in length and 12 feet in diameter. The cell is designed to permit evacuation simulating ambient pressures at altitudes in excess of 100,000 feet and decreases in temperature down to minus 60 degrees Centigrade.

Moveable Sections

All three sections of the test chamber are mounted on rollers which are supported by wide rails along the sides of a floor well so that in effect the entire cell is suspended. The chamber may be broken down into its three sections and the sections rolled apart to permit easy access to the area in which the test engine is mounted.

Over-all control of the system is maintained from a facility control room located in a room adjacent to the test cell. Both here and in the compressor control room, Orenda engineers have followed the new concept of graphic panel display showing all facility equipment and associated piping and valves in schematic arrangement. Operators are in this way able to follow the complete working of the system and have before them a visual reference on units which are in operation.

Associated with the system is a data handling room in which information from tests is accumulated and processed by computers.

An intercommunications system connects the facility control room with all other areas of control, for both the system and the specimen under test.

Ingenuity in design, engineering and fabrication by a variety of firms contributed to the building of the Orenda high altitude facility.

Among those involved were the John Inglis Co. Ltd., Toronto, which fabricated the giant test cell itself; Canadian General Electric which supplied the motors, gear boxes, substation and other units associated with the electrical power source for the facility; Humphrey & Glasgow (Canada) Ltd., Toronto, which supplied the complex ducting system; Salem Engineering Ltd., Toronto, which provided the air pre-heater unit; Foster Wheeler Ltd., Toronto, which was responsible for the treated water system gas cooler and heat exchanger; Fischer & Porter Canada Ltd., Toronto, which was responsible for graphic control panels and consoles and special instrumentation; Giffells & Vallet of Canada Ltd., Toronto, consulting engineers on the building and special services; CDC Control Services, Inc., of Hatboro, Pa., which designed and supplied the automatic control system; Pigott Construction Co. Ltd., Toronto, which handled the general building contract.

Orenda located its new high altitude facility on a site adjacent to its existing ground static test cells. In this way all of the company's engine testing and development running work can be readily co-ordinated and equipment in the new facility may, if need arises, be tied in with the static test cells.

The range of test and development cells gives the company the ability to test out the entire family of air breathing turbines, including ram jets. Such a capability comes at an opportune time taking into account the Canadian government's interest in the ram jet powered Boeing Bomarc ground-to-air missile.

While the test and development program proposed for the Iroquois was to have taken a good deal of the altitude facility time during the next months, Orenda is prepared to rent time in its facility to other companies requiring a test cell of this nature for test and development work.