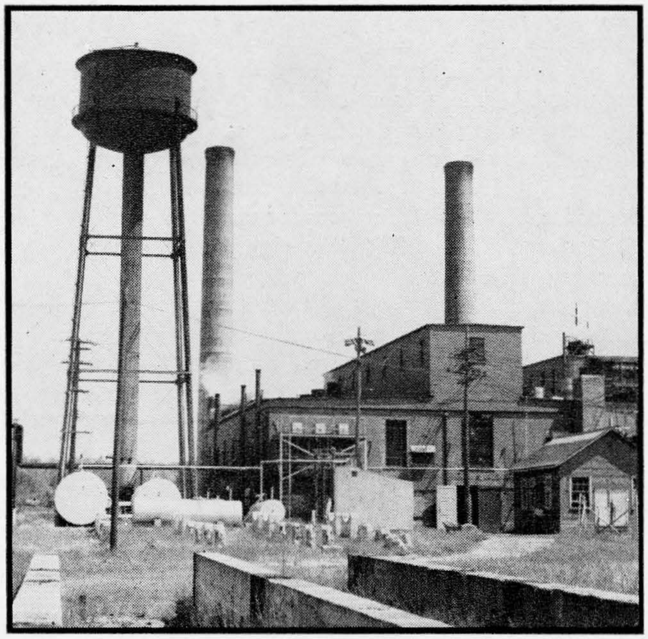
The Nobel Gas Turbine Test Establishment



The mystery of what goes on at Avro Canada's full scale Test Establishment at Nobel, Ontario, was clarified during late July when *Aircraft* and other representatives of the technical press were permitted to take a close look at this little known facet of Canada's booming gas turbine industry. This Avro Canada department forms the hard core of Canadian gas turbine development. From it comes new power and reliability for existing engines, and new knowledge for application to future engines.

No Jet Engines: While the Test Establishment is part of the Test Department of Avro Canada's Gas Turbine Engineering Division, it does no actual testing of jet engines as such. Rather, it is engaged in testing, with a view to improving, the aerodynamic and thermodynamic characteristics of the main components of the Orenda, while the main body of the Test Department, at Malton, concentrates upon the mechanical improvement of the components, fuel system development, and the proving of the combined aerodynamic, thermodynamic, and mechanical improvements as bench tests, and later flight tests, of the complete engine. At Nobel also, long term programs are pursued to provide design information for future designs of jet engines.

The main engine components tests at Nobel are the compressor, the turbine, and the combustion chamber. The testing facilities include a compressor test rig, a turbine test rig, an atmospheric combustion test rig, and a high pressure combustion test rig. Besides these, a new and additional compressor test rig is nearing completion.

Compressor Characteristics: The compressor test rig is used to determine such compressor characteristics as flow and pressure and efficiency relationships for various speeds. Most of the testing involves holding the compressor speed constant and closing the outlet valve in stages until a surge is reached or considered imminent. Instrumentation is sufficiently complete to enable the individual stage performance to be determined. Detailed traverses of the various sections may be required from time to time to determine the flow pattern of any apparently critical zone.

The variable incidence cascade wind tunnel is intended to provide basic information for the design of turbines and compressors. By varying the angles of special blades it is possible to determine the aerodynamic effects of the variation in direction of air flow on them.

The function of the diffuser test rig is to test on full scale models the efficiency of the conversion of the high speed low pressure air from the compressor outlet to the low speed high pressure condition before entering the combustion chamber.

THE PICTURES: At top of this page is shown the exterior of the Nobel gas turbine test plant. On the next page, top, an Avro Canada engineer is shown plotting data from the company's recording traverser which, with electronic computers, makes possible much basic research on jet engines. Chart at bottom shows how the gas turbine development work is divided between Malton and Nobel.

Combustion Chambers: The high pressure combustion rig is designed to permit testing of combustion chambers under conditions closely approximating those on the actual engine. The turbine test rig is used to determine turbine characteristics without being coupled to the compressor.

The altitude and atmospheric combustion test rig provides means for testing combustion chambers under low pressure conditions. Development tests at atmospheric pressure have a great advantage over pressure tests in that it is possible to look up the exhaust and observe hot spots and flame conditions. Altitude tests are necessary to predict the chamber performance at altitude—particularly blow-out and light-up characteristics.

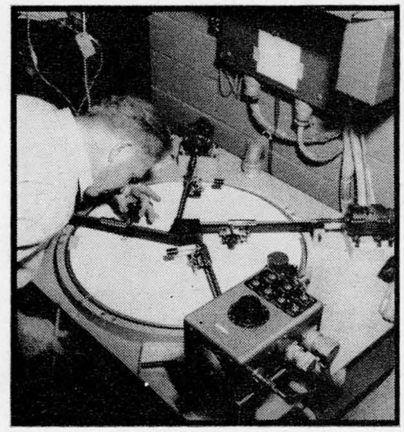
The "how", "when", and "why" of the Test Establishment is almost as engrossing as the work that is carried on there. To the casual onlooker, it seems paradoxical that this centre of research should be located in what is geographically a scientific wilderness, far removed from the centres of industry. The village of Nobel is in the heart of a holiday resort area, 170 miles north of the Avro Canada main plant at Malton. In the idiom of Avro Canada's employees, the Test Establishment is known as "the outpost". Actually, the Establishment was located at Nobel for the most practical of reasons: all the necessary equipment was already there, and the explosives plant of which it was part was being disposed of by War Assets Corporation. There was also an abundance of water and housing, the former essential to the research and test work that was planned, and the latter essential to the welfare of the employees. Malton lacked both of these. While the reasons for the choice of Nobel were these highly practical ones, it is fitting that the Test Establishment, as a basic part of an industry that was itself an offspring of World War II, should be located in the remains of the wartime explosives plant once operated by Defence Industries Limited.

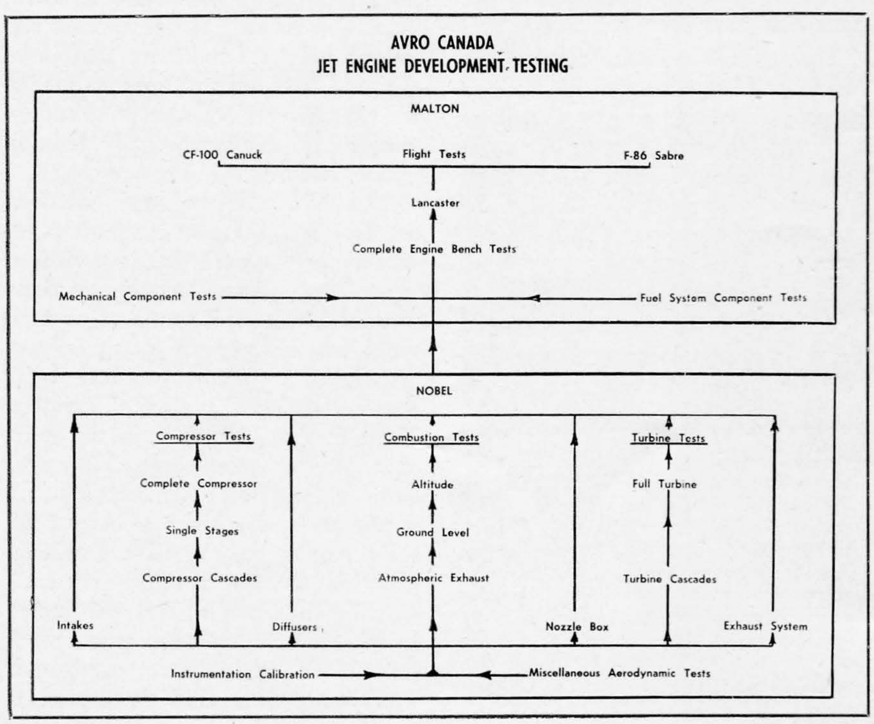
Turbo Research: The story of the Test Establishment really goes back to the time of Turbo Research Limited, the Crown company set up during wartime by the Canadian government to investigate, design, and ultimately build aircraft gas turbine engines. During the dying days of the war, Turbo Research was planning to build a test plant at Toronto, roughly comparable in size and scope to the U.K.'s National Gas Turbine Establishment, and similar test plants in the U.S. However, when Turbo Research was dissolved and its work taken over by Avro Canada, it was decided to take a more economical approach and try to make use of existing facilities.

A survey of these facilities resulted in the choice of the site at Nobel. Here Defence Industries had made explosives for the Allies until 1944, when manufacturing operations ceased and the plant was vacated, leaving behind basic facilities ideally suited to jet engine research and development. These included a power house containing four high pressure Vickers Keeler water tube boilers and two low pressure boilers of the same make and type, a standby steam turbine generator set, five 500 hp Canadian Ingersoll Rand two-stage reciprocating air compressors of 2780 cmf, a water pumping station ¾ mile from the plant, and a maintenance shop.

Compressor Testing: The steam turbine generator set was adapted to the testing of turbine compressors by the removal of the electrical generator. The steam turbine develops 6,000 hp and through a train of gears now drives the compressor on test at speeds up to 11,000 rpm. A second compressor test rig now coming into operation is indicative of the considerable ingenuity Avro Canada engineers have shown throughout the Test Establishment. The rig uses a surplus Chinook turbine (steam driven) which operates the compressor under test by means of direct drive. If a commercial test rig had been purchased, it would have required a gear box, the cost of this alone being equal to the complete home made rig. The Chinook has the added advantage of being compact and of saving time in that commercial rigs were not conveniently available.

So successful was Avro Canada's adaption of the equipment and plant, that the Establishment was got into operation at an initial cost of just over a million dollars, about one-tenth the outlay made to establish similar tests centres in other countries.





Diminishing Returns: During the initial development of the aircraft jet engine, enormous strides were made. However, the stage has now been reached where tremendous effort and ingenuity are required to effect continued improvements. One result of the "law of diminishing returns", as Avro Canada Engineers describe it, has been the development by the company and introduction at Nobel of semi-automatic recording and computing devices which allow, within a reasonable time, far more detailed investigation of the aerodynamic and thermodynamic characteristics of compressors, turbines, and combustion chambers, with a correspondingly greater volume of useful data, than was possible using hand traversing, visual reading of manometers, and slide rule computation of results.

Avro Canada engineers say that it is possible to make a complete investigation of the air flow through a cascade in a matter of hours and a three-dimensional investigation of the flow through the single stage of a compressor or turbine in weeks. Without such devices the cascade investigation would take weeks, while the time and running costs for a single stage investigation would make it completely impractical.

Rough Setting: Though the Test Establishment has an unimposing ramshackle exterior (it comprises nine buildings, the power plant being the only one of permanent type construction), Avro Canada is quick to state that in the amount of useful data produced, the Establishment is second to none anywhere. It is, however, expected that the unglamorous temporary buildings originally constructed for Defence Industries will in time be replaced by permanent structures.