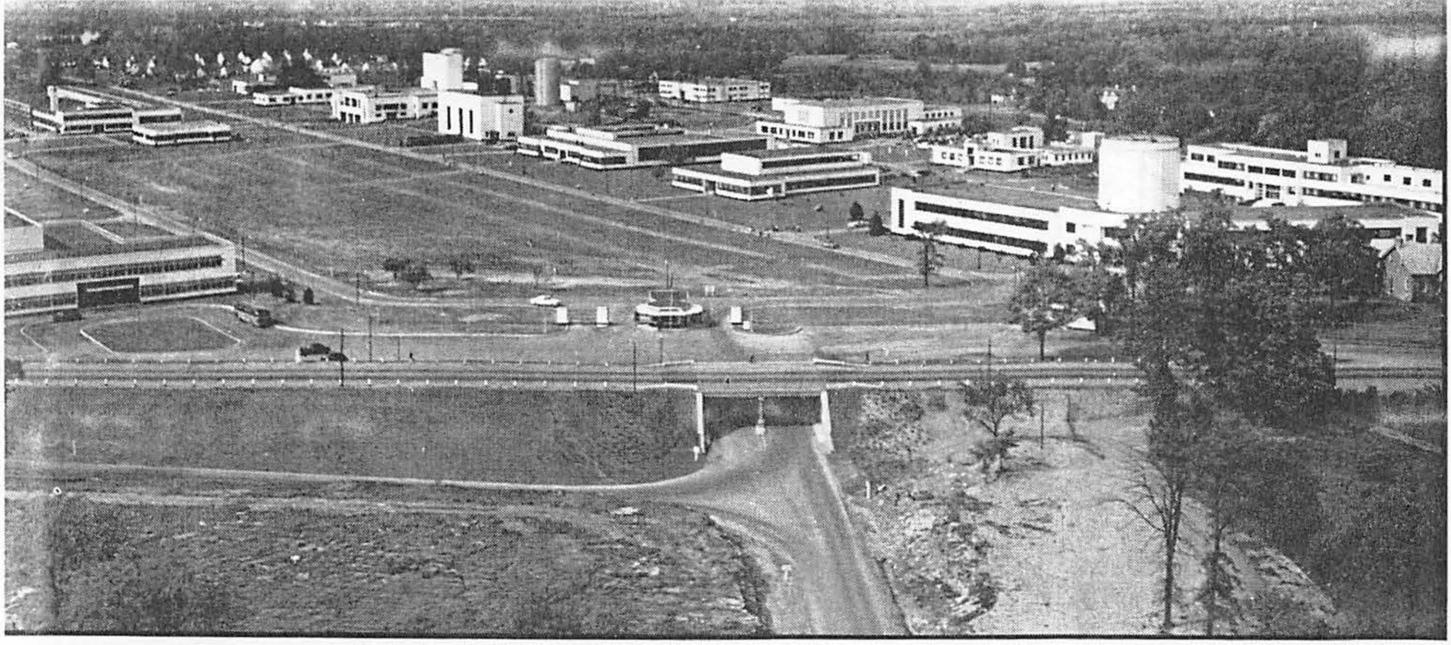


Centre for Aeronautical Science

FROM THE NRC COME SCIENTIFIC ANSWERS TO AERONAUTICAL QUESTIONS

WHENEVER aeronautical research is discussed in Canada, first thoughts always turn to the "NRC". No other agency in Canada has had such a long unbroken association with research in the field of aeronautics.

Specifically, it is the Division of Mechanical Engineering of the National Research Council of Canada* which has for many years been making such important contributions to the aeronautical sciences. And significantly, the Division is headed by John H. Parkin, who is one of the pioneers of aeronautical research in Canada. Mr. Parkin has held this post since the inception of the Division of Mechanical Engineering in 1937.

Centre of the Division's activities is a group of neat, white buildings, dotted around a sprawling 400 acre site just outside Ottawa, on the road that leads to Montreal. (Top of page).

Emphasis on Aeronautics: The division carries out work for other industries besides aircraft, but about 75% of its efforts are directed toward research and development that is aeronautical in nature. Most of the jobs the Division performs are described as "investigations" rather than research.

Testing occupies much of the personnel's time, but the testing done is usually of specialized types. John Parkin says that whenever possible they try to avoid doing any routine type of testing, and no work that a commercial laboratory can do, is undertaken.

While wind tunnel testing to a large extent comes under the heading of straight testing, nevertheless the Division devotes a great deal of time to this area, the main reason being that though the testing itself is more or less routine, the data derived requires interpretation by specialists.

Only a limited amount of "research" as opposed to "investigation" is conducted by the Division. "We have to carry on a certain amount of 'research' to keep up morale," says John Parkin. "Morale is all-important in a research organization; if that goes, you might as well get out."

Flexible: The Division has two principal features which enable it to tackle problems and find solutions with a minimum of fuss and expense. The first of these is flexibility . . . flexibility of organization, finance, the mind, and even of the very buildings which the Division occupies. This flexibility makes it possible to get into action quickly and provides maneuverability. The second feature is that the Division is mainly restricted to the giving of advice. That is, it investigates problems, seeking solutions, then passes these solutions on to the interested parties. It assumes no administrative responsibility for the application of these solutions.

Not all investigation or research are carried out on the request of industry or other Government agencies. The Division frequently initiates projects on its own; sometimes the need for such an original investigation becomes evident when work is being carried out on another project.

Among the programs recently receiving attention were ones on reheat and application of the area rule to the Canadair Sabre. The reheat project has resulted in the successful development of an afterburner for the Orenda 14, and the loose ends are currently just being tied up on this application. Initial development work in this connection was carried out with the Rolls-Royce Derwent. The NRC reheat differs from earlier developments elsewhere in that the extra raw fuel is injected before the turbine, rather than after, as is usually the practice. Among other advantages is the extra cooling of the turbine blades that is provided.

The area rule project had no newsworthy outcome, having no effect on performance of the Sabre to which it was applied. However, the NAE Flight Research Section (which is currently administered by the NRC's Division of Mechanical Engineering), which carried out the flight tests on a Canadair-modified Sabre, regards the absence of effect on performance as a

*Few people are aware that the full name of the Council is the "Honorary Advisory Council for Scientific and Industrial Research". National Research Council is, however, the official short form.

tribute to the clean design of the type. At the same time, this absence of effect is also viewed as being practical proof of the area rule theory. Otherwise, the extra drag of the bumps added to the fuselage sides to give the area rule effect, would logically have reduced performance.

Since completion of this program, the Sabre concerned has been returned to Canadair for de-modification.

Source of Supply: One of the unofficial functions of the NRC, and hence, the Division of Mechanical Engineering, is to be a source of supply of scientific personnel to industry. This is probably not a popular function among the men who administer the NRC's various agencies, because it represents a constant drain of talent and of course makes it difficult to carry out responsibilities in the research and development area.

The effect of this drain is to be found, in the case of the Division of Mechanical Engineering, in the Division's inability to maintain or even reach its authorized establishment of 475. At present the personnel roster hovers around the 400 mark, with approximately 20% of these being classed as scientists (i.e., degree men). The Division shares with industry the problem of filling vacancies on its staff with qualified personnel of the right calibre.

The flow of NRC personnel to industry does not, of course mean that the talent of these people is forever lost to the country. For example, among the notable graduates of the Division of Mechanical Engineering are such as Thor Stephenson and Dick Hiscocks, now respectively of Canadian Pratt & Whitney and de Havilland Canada. The Defence Research Board's Director of Engineering Research, John Orr, is also a product of the NRC Division of Mechanical Engineering.

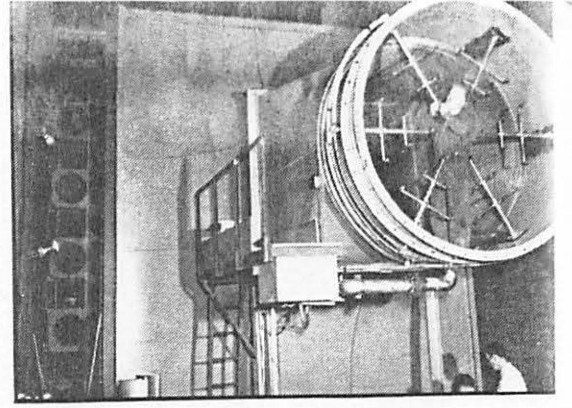
The attraction that industry has for Government scientific personnel is not, as might popularly be supposed, entirely financial. In many instances it is partially the feeling on the part of the individual that he should get some industrial experience. Consequently, there are infrequent cases where, after having a stint in industry, a scientist returns to Government research work.

Supporting Industry

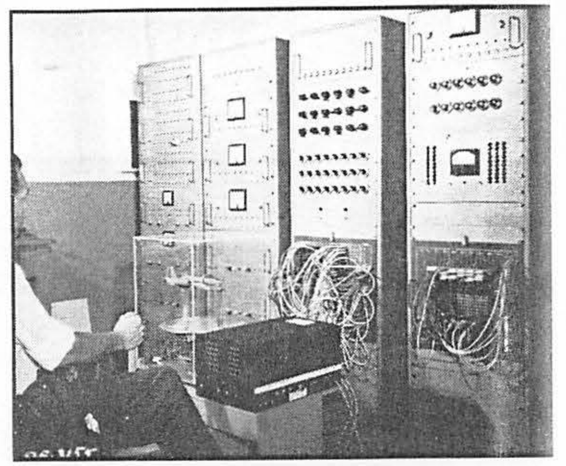
THE AERONAUTICAL research and development facilities operated by the Division of Mechanical Engineering have long been leaned on heavily by industry, which even now has only limited resources of this kind.

Discussing the relationship between research and aircraft design progress, John Parkin once said: "The extremely rapid development of military aircraft and the science of aeronautics in the last five to ten years has placed military aviation on the threshold of a new era of unbounded possibilities.

"At the same time, the problems facing the aircraft designer have grown in magnitude and in many cases he is working in hitherto unknown territory. If the industry is to progress, the designer must be more than ever

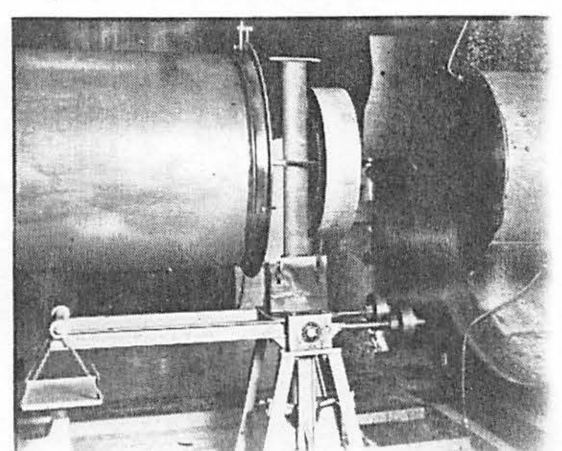


Above is shown the icing simulation spray equipment which is used in No. 4 test cell of the Engine Laboratory of the NAE, Montreal Road.

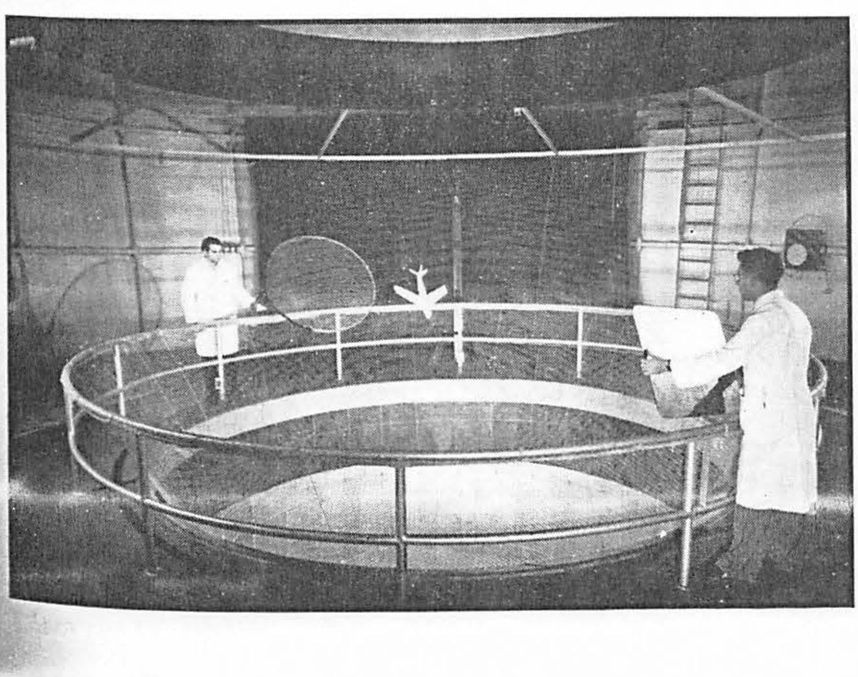


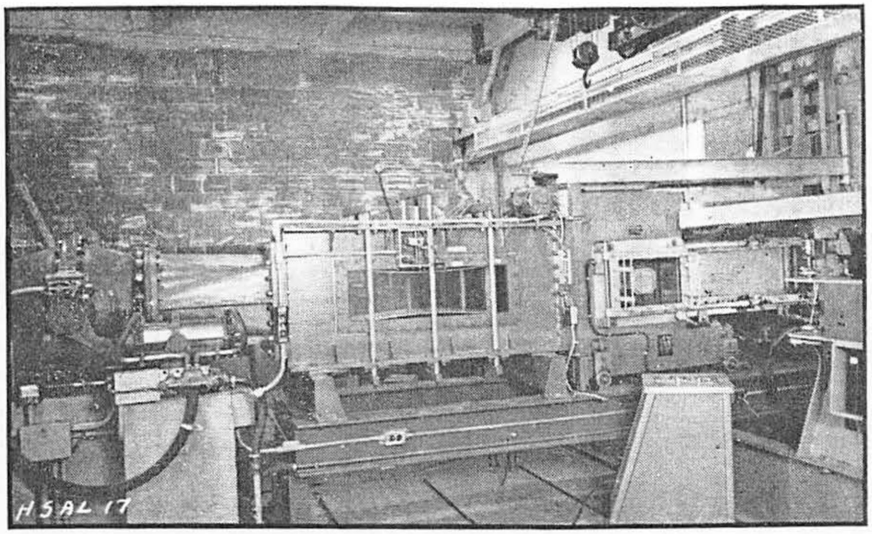
The NAE devised this simple flight simulator set-up on 'Ease' analog computer using servo-driven model to represent angular displacements.

Above, rig for investigating screeching combustion, in screeching condition. Below, balance for measuring drag of different flame stabilizers.

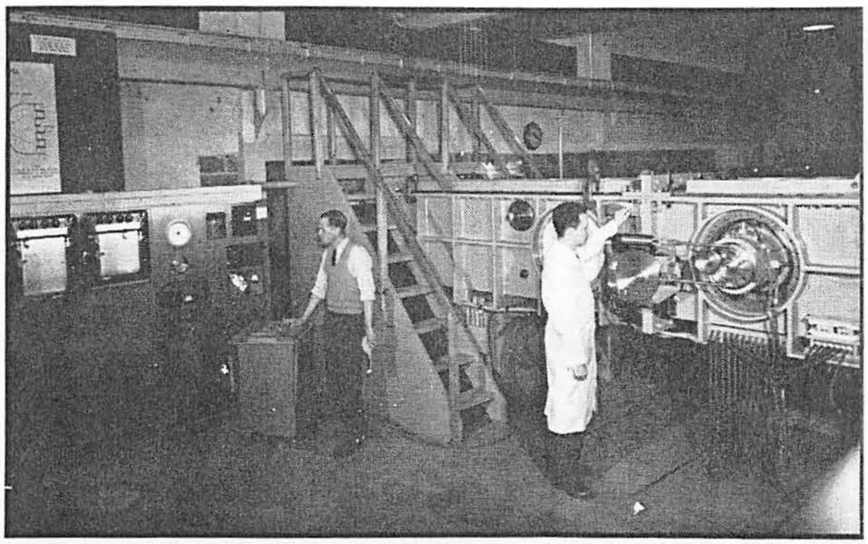


Below, NAE vertical wind tunnel, used for spinning tests with scale models.

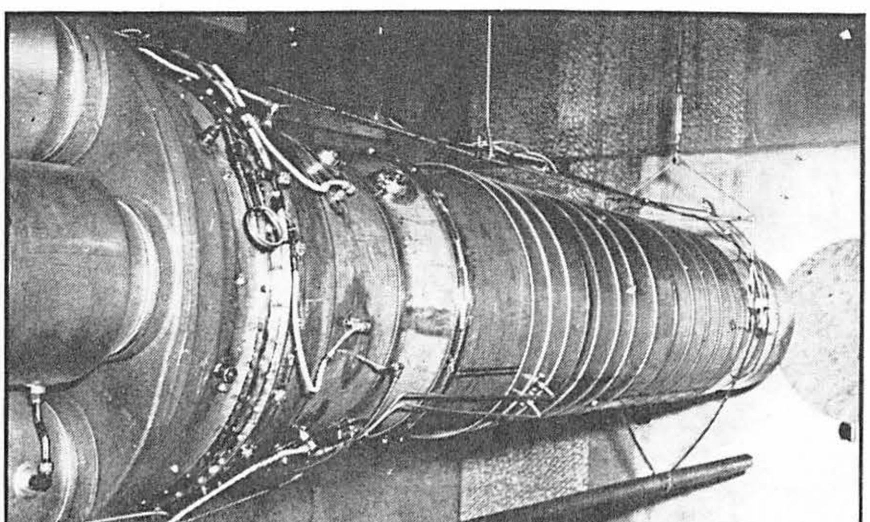




Above, NAE 10 inch supersonic wind tunnel. L to R, quick-operating valve, transition duct, variable diffuser, balance box and nozzle box. Tunnel control desk is in centre foreground. Below, 30 in. tunnel. Man at left is at tunnel control desk. Tunnel can be used for supersonic and transonic studies.



Below, the NAE-designed afterburner installed in an Orenda 14 turbojet. Engine is shown in the engine laboratory on Montreal Road. Flight tests have since been successfully carried out with engine installed in Sabre aircraft. First application of this unit was to R-R Derwents installed in a borrowed Meteor.



dependent on the results of aeronautical research. On the other hand, if they are to serve the needs of industry, the research facilities must be of the highest order of excellence. They must be of suitable scope to tackle the new problems created by the needs of military aviation and they must be staffed by people with the best training, experience and ability."

How close do the aeronautical facilities of the NRC come to meeting this description? Actually, they fall somewhat short insofar as equipment is concerned. There is a desperate need for a new supersonic wind tunnel such as is planned for construction at Uplands. Present wind tunnels at Montreal Road can still do useful work in the low speed regime, but the supersonic installations have definite limitations.

Working Tools: These are some of the tools the Division has for aeronautical research:

Wind Tunnels — (1) a low speed horizontal wind tunnel with a 10 ft. by 6 ft. working section and capable of a maximum airspeed of about 300 mph; (2) a vertical wind tunnel with an open working section some 15 ft. in diameter and a maximum speed of about 60 ft. sec., usually used for free spinning tests; (3) a high speed tunnel with a 16 in. by 30 in. working section, a running time of about 15 secs., and a speed range from Mach 0.5 to Mach 2.0; (4) a supersonic tunnel with a 10 in. square working section, capable of supersonic operation only at airspeeds up to approximately Mach 3.0 and having a running time of one minute or more.

The two low speed tunnels, which comprise the Low Speed Aerodynamics Laboratory, are both of the continuously operating type, while the other two tunnels, operated by the High Speed Aerodynamics Laboratory, are of the intermittent type, vacuum operated.

The 6 ft. by 10 ft. low speed unit, though regarded as obsolete, still is in constant use, even in connection with the development of the supersonic CF-105. As NRC scientists point out . . . "Such airplanes have to slow down to land and it is necessary to be familiar with their behaviour at such times." At the present time this so-called "obsolete" tunnel is in such heavy demand by Avro, Canadair and de Havilland Canada, that the NRC

THREE-WAY PARTNERSHIP FOR RESEARCH

To many in the aircraft industry, the relationship between the Defence Research Board, the National Research Council and the National Aeronautical Establishment is a confusing one. In the case of the latter two, especially, there is obvious overlapping of personnel and facilities. The following background is therefore presented by way of clarification.

Prior to 1951, the National Research Council and the Defence Research Board explored the possibilities of creating a National Aeronautical Establishment which could be administered as a joint military and civil establishment. The object of this was to achieve an orderly development of the facilities and a closer integration of the requirements for military and civil aeronautical research and development in Canada.

When the NAE was officially established in 1951, it was decided that detailed administration would be the direct responsibility of the NRC, with policy determined by a National Aeronautical Research Committeee. On civil matters, this Committee was made responsible to a Subcommittee of the Privy Council Committee on Scientific & Industrial Research. On defence matters, however, the National Aeronautical Research Committee would report directly to the Cabinet Defence Committee.

By organizing the NAE in this manner, the need for new legislation, was avoided and funds for the operation of the Establishment have since been regularly included in the estimates of both the NRC and the DRB.

The physical nucleus of the NAE has from the time its formation been made up of the NRC's Division of Mechanical Engineering on Montreal Rd., Ottawa, and the Flight Research Section at Uplands (formerly at Arnprior), near Ottawa. The director of the NAE since its formation has been J. H. Parkin, who has simultaneously continued as director of the NRC's Division of Mechanical Engineering.

Under the terms of the long range plan for the NAE, the Flight Research Section is eventually to be operated by the DRB. This transfer of administrative authority will take place following the completion of the new supersonic wind tunnel which is planned as part of the Uplands operation.

Thus, the NRC's Montreal Road facility and the greatly-expanded Uplands facility, will together continue to form the physical components of the National Aeronautical Establishment, with Montreal Road being operated by the NRC and Uplands being operated by the DRB. The costs are similarly to be divided between the two organizations.

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scientists can rarely get it for their own purposes.

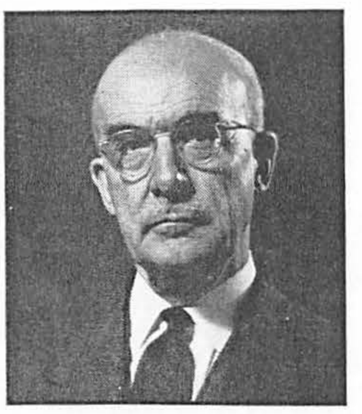
Round and Round: The spinning tunnel, in which the spinning characteristics of every type of Canadian built aircraft have at one time or another been tested, is currently being used to check out the CF-105 Arrow. Dimensionally and weight-scaled models are used to conduct these tests. The model being tested is thrown into the vertical air jet with its control surfaces preset to induce a spin. When the spinning characteristics have been noted, a magnetic field is set up in the tunnel. In the model is installed an electromagnetic device which is actuated by the magnetic field and "centres and controls", as it were. It is then possible to observe how readily the model recovers from its spin.

By varying the air speed of the tunnel, it is possible to simulate falling speeds of up to 60 ft./sec.

The models, usually of about 3 ft. span, were formerly fabricated of balsa wood, but recently the model builders of the Mechanical Engineering Division have been obtaining good results with moulded fibreglass.

The 16 in. by 30 in. high speed tunnel is used for dynamic model tests. The changes in Mach number are achieved variations in the size of the tunnel's throat. These variations are obtained through the use of replaceable throat sections which bolt in place on the floor of the tunnel; they are so shaped that they increase or decrease the restriction of the throat, as compared to the section used previously, thereby affecting the airspeed through the working section.

Model Tests: Two types of dynamic models can be used in this tunnel, one being the complete type, sting balance mounted; the other being the wall-mounted reflection plane kind. The latter is simply a half model, vertically split lengthwise. Shims are inserted between the model and the wall of the working section, holding it away from the wall and thereby clear of the effects of the boundary layer.



John Hamilton Parkin, CBE, BASc, ME, FRAS, FRSC, FIAS, MSAE, is one of Canada's foremost pioneers in aeronautical research. He has probably had a longer continuous association with this field than any other individual in Canada. Since 1937, Mr. Parkin has been Director of the NRC's Division of Mechanical Engineering, and since the formation of the National Aeronautical Establishment in 1951, he has also been its Director. He was responsible for the establishment of an aeronautical research program at the University of Toronto as long ago as the year 1917.

The 10 in. square supersonic tunnel is also used for testing of dynamic models. It was used extensively during the development of the Velvet Glove guided missile.

In addition to the foregoing, there is a 5 in. supersonic wind tunnel which is actually the one-twelfth scale "pilot" model of the 5 ft. square supersonic tunnel which will be built at the site of the NAE Flight Research Section at Uplands. Although the work so far done on this tunnel has been carried out by the Division of Mechanical Engineering, which will also, it is understood, see the project through the construction state, the tunnel will eventually be operated by the Defence Research Board*.

Of interest also is a small water tunnel which is operated by the Aerodynamics Section for flow visualization work. Flow visualization is achieved by means of aluminum particles in suspension in the water being directed past the model under surveillance. This particular piece of equipment is a German unit, captured when the Nazis were defeated, and regarded as one of the few useful things which the NRC got in the form of scientific booty from the conquest.

(Continued on page 109)

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*The relationship between the NRC, the NAE and the DRB, and who is or will be responsible for the operation of what facilities, is explained elsewhere on this page.

And I noticed in last month's *Aircraft* Magazine that de Havilland of Canada are advertising that their Beaver aircraft are "operating in 50 different countries on 7 continents, from Pole to Pole." This is an impressive record. It's impressive, too, to see that at the foot of the advertisement is the note, "Designed and built by The de Havilland Aircraft of Canada Limited."

Other Facets: There are many other facets to this do-it-yourself diamond. I asked L. H. Kottmeier, vice president, Sales, for the Aircraft Division of Canadian Car & Foundry Co. Limited, about them. Les Kottmeier has had a wide and varied career in all aspects of airplane design, production, inspection, and sales, in both the U.S. and Canada. Said he, "First and foremost, any license agreement is usually restrictive in territory, which cuts down your scope of action. Moreover, in the past many such deals have been of the 'one shot' variety. This means that the licensee is in a difficult position to supply continuing spares, since the spares market is based on the number of aircraft produced in the single run. Spares are a continuing and important part of any aircraft company's business, and in well established firms often account for 50% of the gross profit."

On the development side he points out an interesting sidelight: there are always "by-products of designing aircraft, as there are in all development fields. The Hi-shear rivets, the chem-mill process, and many other ideas are real money makers for their owners."

If we're going to reap dollars from our own developments, both from the major products and the side lines, we must have a preparedness program that leaves no point in doubt. Even the old Vickers Vedette depended on the University of Toronto's new, 1924 model, wind tunnel to establish its aerodynamic characteristics. So we, in this age of complexity, must have modern wind tunnels, static test rigs, and research facilities. We must also be prepared in the economic field.

Commercial Sales: I was talking to W. Stanley Haggett, Director of the Bristol Aeroplane Company of Canada, recently. He was telling me about some aspects of selling airplanes on the commercial market. One airplane may be technically better than another. But it the manufacturer making the better airplane doesn't have an easy payment plan to finance the sale, he may lose out to the firm that has the poorer plane, but the better payment plan.

All in all, then, we need to be prepared technically and economically, if we are going to get dollars from our own developments. I firmly believe that we are. However, there are many that are not so sure. As R. H. Guthrie, Engineering Manager for Canadian Pratt & Whitney, once told H. C. Luttman, Secretary of the Canadian Aeronautical Institute, as the latter reported it in an issue of the *C.A.I. Log*, "The trouble in Canada is that we don't know what we know.

"Dick Guthrie is right. But it's time we found out. For there are dollars in development. As an editorial in the *Montreal Gazette* put it, "All these sales mean that Canadian design and workmanship are becoming recognized throughout the world as first rate. There is no reason why Canada should not develop aircraft production as a major national industry; the Swiss, after all, did not invent the watch."

COMING EVENTS

April 8-12—Welding Show & Annual Meeting American Welding Soc., Convention Hall & Hotel Sheraton, Philadelphia, Pa.

April 22-24—Vickers Inc. Annual Jet Engine Hydraulic Symposium, Hotel Statler, Detroit.

April 25-26 — AITA Semi-annual Meeting, Empress Hotel, Victoria, B.C.

May 6-10—Industrial Tool & Production Show, Exhibition Park, Toronto.

May 22-24—Annual Convention, American Society for Quality Control, Masonic Temple, Detroit.

June 8 — Air Force Day across Canada.

June 24-25—29th Meeting, Aviation Distributors & Manufacturers Assoc., Grove Park Inn, Colorado Springs, Colo.

September 9-13—IATA Annual General Meeting, Madrid, Spain.

Sept. 30-Oct. 4—Canadian National Materials Handling Show, Show Mart, Montreal.

October 2-4—Annual Meeting and Forum, National Business Aircraft Assoc., Cosmopolitan Hotel, Denver, Colorado.

NATIONAL RESEARCH COUNCIL

(Continued from page 37)

Simulated Ice: In the Division's Low Temperature Laboratory is an icing tunnel in which models or full-scale components (e.g., jet engine air intake) may be subjected to conditions existing in flight through icing clouds. This tunnel is a closed circuit facility with a 4½ ft. square working section and a maximum airspeed of 200 mph. Refrigeration equipment can lower the temperature in the tunnel to 40°F. at maximum speed. Water injected through an array of nozzles and atomized to controlled droplet diameters duplicates the conditions of icing cloud.

In this same laboratory is a smaller icing tunnel, having a working section of only 8 in. by 10 in., but capable of speeds up to 500 mph. This is mainly used for work on instruments and other small equipment.

There are as well, three cold chambers where equipment under test can be subjected to temperatures ranging from as low as — 85° F. to +167°F., at winds up to 40 mph. The largest chamber, which is big enough to be used for cold soaking of large equipment such as fire trucks, tanks, etc., is 50 ft. long, 15 ft. wide and 15 ft. high. The two small chambers are 10 ft. square by 8 ft. high.

The helicopter spray rig located at Uplands, though regarded as part of the Low Temperature Laboratory, is operated by the NAE Flight Research Section. It is used for testing helicopters in free flight in simulated icing conditions. The spray rig is 70 ft. high and produces a large icing cloud 15 ft. by 30 ft. by atomizing water with steam in spray nozzles. It is useable during the winter months only, being located outdoors.

Structures: The Division of Mechanical Engineering's Structures Laboratory has well equipped facilities for work in the areas of statics, dynamics, aeroelasticity, and aircraft hydraulics.

Statics includes research on aircraft structures, civil and marine structures and a wide variety of structural components, as well as work on structural and plastic materials. The most imposing single piece of equipment used in connection with this phase of the laboratory's work is a testing machine which can apply tension, compression, or bending loads of up to 600,000 lbs.

Dynamics work includes investigations on aircraft landing gear, the determination of dynamic loads on military equipment, a variety of structural vibration problems and fatigue investigations and research. Fixed fatigue testing equipment provides facilities for flexure, direct stress and torsion fatigue tests. The load capacity of this equipment is slated to be increased to 130,000 lbs. Ancillary equipment includes a range of accelerometers up to 200 G's.

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The aeroelastic work is at present devoted to a study of the vibration modes and frequencies of swept wings and is assisted by facilities for the production of plastic and metal models. Experimental equipment includes a variety of experimental jigs and fixtures, transducers and dynamic recording equipment.

Subjects of Attention: Aircraft hydraulic, fuel and oil systems are the subject of a great deal of attention in the Structures Lab. The problems under study relate to the design and performance of such components as flexible and rigid conduit, valves, actuators, pumps, seals and rings. In terms of capacities the laboratory has equipment to handle static pressures up to about 35,000 psi., fluid temperatures from —80°F. to +500°F., flow rates up to about 20 gpm., and impulse pressures up to 12,000 psi.

The theoretical and analytical work of the laboratory is assisted by electrical computing machines and also by an electronic analogue computer, this having sufficient capacity to solve 12 simultaneous equations. It also includes function generators and multipliers.

Another important divisional laboratory is the Aircraft & Allied Instrument Lab., which designs and constructs special instrumentation and automatic control systems as required by other laboratories of the Division. It also conducts development tests of navigational instruments for the RCAF. The performance of these functions by the laboratory is backed up by comprehensive environmental testing facilities.

Powerplants: The Engine Laboratory is equipped for research and test work on reciprocating and jet engines. It has five test cells, the largest of which can handle any known jet engine, in existence or contemplated (up to 50,000 lbs. th.). This cell can also be used for work with the largest of turboprop engines, the only limiting factor in the case of this class being the size of the propeller which the engine swings. Originally designed for testing propeller engines, the cell has a diameter of 25 ft.

When used for turbojet testing, this particular cell is usually reserved for the most powerful types, those with lower thrust ratings generally being placed in one of the other cells, which vary in cross section between 15 and 20 ft.

The large cell is currently being used in connection with tests of the Orenda Iroquois. Prior to the beginning of work on the Iroquois in February, an investigation was completed into the icing troubles which were encountered in service by the Bristol Proteus turboprop engine.

The Division was able to duplicate in the laboratory the conditions which were causing the icing difficulties of the Proteus. This was accomplished in a relatively simple manner; blocks of ice were subjected to rough treatment by some 120 circular saw blades which were bolted together in two sets; the resultant fine ice crystals were blown into the intakes of the Proteus while it was running, and the engine proceeded to accumulate ice in the same manner as encountered in high altitudes flight in the tropics.

Interestingly enough, an NRC scientist, C. K. Rush of the Low Temperature Laboratory, several years ago predicted the eventual occurrence of icing trouble of the type experienced by the Proteus, but it has taken two or three years for the first case to turn up.

Mutual Advantage: The Engine Lab has also recently carried out tests on a Bristol Olympus. The NRC frequently performs low temperature engine tests of British engines because it finds it mutually advantageous to do so. An opportunity is given to study the latest British engines and get up to date information on new developments, as well as to see what mistakes can be made. From the British standpoint, the alternative to having the tests performed by the NRC would be to build expensive artificially refrigerated test cells. Whereas, as one NRC scientist puts it, "We have refrigeration by God."

In all, two of the test cells are especially equipped for icing tests on jet engines. The special equipment comprises banks of nozzles and of auxiliaries such as pumps, filters, controls, etc., for spraying water to simulate icing clouds. The nozzles are located inside ducts through which the engines draw in the cold winter air. One of the cells is, in addition, to be artificially refrigerated, using the plant capacity of the Low Temperature Laboratory, so that air temperatures below the winter ambient can be obtained.