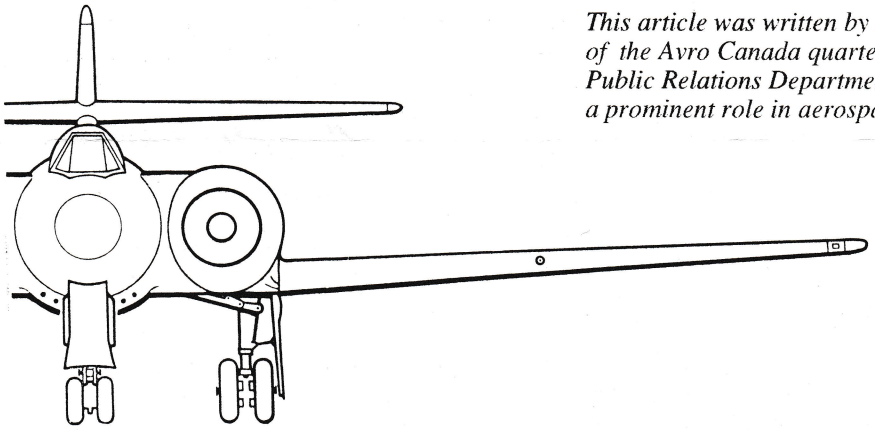
Pre-Flight

50 AVRO CANADA

A Publication of the Aerospace Heritage Foundation of Canada ,
P.O. Box 246, Etobicoke "D", Etobicoke ON M9A 4X4

Vol. 7, No. 3 **May 1996**



This article was written by the late F. H. Keast for the 1953 summer edition of the Avro Canada quarterly "Jet Age". The quarterly was published by the Public Relations Department of A. V. Roe Canada in Malton, which played a prominent role in aerospace history. Although it may seem somewhat dated, it does bring with it a sense of the exciting and challenging times that Canada's developing jet aircraft industry was experiencing in the late Forties and Fifties.

BLADING . . .

A New Science!

IF Webster walked into his office today, he'd start revising his dictionary. He would not last long. Too much has happened since his time. For example, take the five-letter word "blade". No longer does it simply mean the cutting edge of a knife or sword - or a shoulder of beef. This is the jet age. (!) Today, a blade is an essential and critical part of an axial-flow jet engine. There are nearly 1800 in Avro Canada's Orenda turbo-jet. And so exacting are the engineering requirements (some of the blades have as many as 40 dimensions, all of which must be held to minute tolerances) new manufacturing techniques, almost a new science, have been developed.

The mass production of jet engine blades is one of the most critical, complex and exacting of today's industrial tasks. It has challenged some of the ablest engineering brains in Britain and USA as well as in Canada. The peculiar air foil shape of the blades in the Orenda jet engine is neither round nor square, flat nor curved, triangular nor rectangular but a combination of all of these shapes. Each blade put into the Orenda must undergo 30 to 35 operations before it takes on the jewel-like finish and precise form needed for safe and dependable performance. So why are blades so important in the operation of a jet engine?

(cont'd on p. 2)

"If it seems to be impossible, do it anyway, because the nearly impossible task is usually the one most worthwhile." ***- James C. Floyd***

AHFC

President's mailing address:
14 Eagle Road
Etobicoke ON M8Z 4H5

The Aerospace Heritage Foundation of Canada (AHFC) is a federally-chartered not-for-profit organization. The current emphasis is on Avro and Orenda and the Foundation is actively trying to locate former employees of these companies.

√ Western Canada – please contact::
Michael L. Bullis, 164 Berkshire Close NW,
Calgary AB T3K 1Z4. Phone (403) 274-7497.
270 0492.

Cash donations over $25.00 and "gifts-in-kind" will be acknowledged by a receipt for income tax purposes. For more information on the AHFC and how to support its activities, please write to:

The Aerospace Heritage Foundation of Canada,
P.O. Box 246, Etobicoke "D",
Etobicoke ON M9A 4X2

24-HOUR
Information/Answering Machine
416-213-8044
BBS 905-845-0905
Internet e-mail:
sysop@aerohost.org

FROM THE PRESIDENT

Apparently someone forgot to tell the weather to be warmer. But at least now the people know that the big, round, shiny thing in the sky is the sun

On June 1st, someone will have won the car. By the time you receive Pre-Flight, it will have a proud new owner.

Lots of excitement about the movie featuring the Avro Arrow, with Dan Ackroyd the number one star. They're keeping their cards close to their collective chest, so I can't tell you much about it. We will try to have one of the principles to tell us about it at the Annual General Meeting. Please come and participate in the reports and deliberations.

I am finishing my second year as President of AHFC. This took a lot of my time and energy but was truly worth it. Being with a cooperative and supportive Board made it possible.

Nick Doran

Nick Doran, President AHFC

Blading ... a New Science, continued:

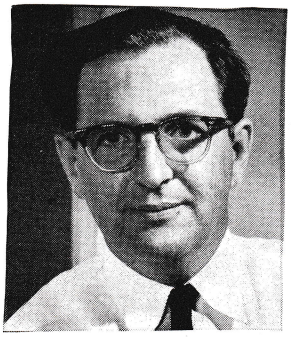
Well, first things come first, so let's consider first how a jet operates and go on from there. The operation of a jet is relatively simply. It takes in as much air as possible at the front end, compresses it, heats it to as high a temperature as possible and expands it at high velocity through the final or propelling nozzle. This is what gives the thrust or power. The compressor is the means whereby the air which is taken in is compressed to a pressure of a few atmospheres, between 5 and 6 in the case of the Orenda. On leaving the compressor, the air is heated as high as the turbine will stand. The turbine then takes some work out of the gases, thereby deriving the energy required to rotate the compressor. The remaining energy in the hot gases, which appears as a high velocity stream, provides the thrust of the engine.

In the case of the Orenda, an axial flow compressor is used which consists essentially of ten fans placed one behind the other. The air entering the compressor is first directed by a stationary row of inlet guide vanes, so that it meets the first rotating fan at the optimum angle. Between the ten rotating fans are placed rows of stationary blades in order to partially remove the whirl of the air on leaving the rotating fan immediately in front. All the way through the compressor, the air is whirling in the same direction as the rotor blades. Each row of rotor blades adds to the whirl and each of stator blades subtracts the whirl so that the net effect of each stage is to increase pressure without adding further to the whirl. The final or tenth row of stationary blades removes all existing whirl so that the air passes out of the back of the compressor in an axial direction into the combustion chamber.

There is a difference here between the operation of these compressor stages and the operation of the normal desk fan. The desk fan takes air which is stationary and accelerates it, i.e. increases its velocity. In the axial compressor, once the air has suffered its first initial acceleration into the compressor, succeeding stages do not increase the rearward velocity (which remains nearly constant at 480 ft./sec.) but merely increases the pressure. This is the reason the blades become progressively shorter from the front to the back of the compressor.

An important feature of a compressor blade is its shape which is like an aerofoil or aircraft wing in miniature and just as scientically arrived at. We have a parallel here between the old string-bag aircraft and the development of the modern high speed aircraft. The first aircraft had crudely formed wings consisting of canvas stretched over ribs with no attempt to produce a proper streamlined section. The

(cont'd on p. 3, col. 1)



F. H. Keast, Assistant Chief Engineer (Tech.), Gas Turbine Division, A. V. Roe Canada Limited, completed the aero-dynamics design of Avro's Chinook and Orenda engines. Graduate (1942) Cambridge University (Senior Scholar, Emmanuel College), he had previous experience with Power Jets Ltd., (Eng.) and the English Electric Company. He obtained his master's degree from Cambridge in 1946, the year he emigrated to Canada. Societies: A.M.I.Mech.E., A.F.R.Ae.S.

Blading , continued from p. 2

modern aircraft, in order to reduce drag and fly at higher speeds, has a carefully designed streamlined section so arranged to produce the maximum lift with the minimum of drag, and to be able to cope with the problems encountered on approaching the speed of sound. In a similar way, the blades of the Orenda compressor differ from the crudely formed blades of a desk fan, in the interests of high efficiency. At places in the compressor under extreme operating conditions, the relative speed of the blades is of the order of 80% of the speed of sound. The close tolerances call up on the blades are an attempt to maintain the compressor efficiency at a high value under these extreme conditions. The aerofoil shapes of the blades are specified, as was the case with the wings of high speed aircraft, in order to obtain maximum lift (which in the case of a compressor means maximum pressure rise) with minimum drag (which means minimum pressure loss or maximum efficiency of compression). In the case of the rotor blades, in addition to specifiying an aerofoil shape at each section, the blades must be tapered from a relatively thick section at the root to a thinner section at the tip in order to cope with the centrifugal stress. For example, the tip of the first stage rotor blade travels around at a speed of 725 mph in a circle of only 31 inches diameter and imposes a tensile stress of the order of 30,000 lbs./sq. in. This means that the blade pulls with a force of 3.25 tons against its root.

It requires about 14,000 horsepower to rotate the compressor on the test bed, and this power is supplied by the turbine. The air leaves the compresssor at a temperature of over 200 degrees C and is further heated by the addition of kerosene to a temperature of about 900 degrees C before reaching the turbine. The turbine is a type of windmill possessing one rotating row of blades. Ahead of this is a stationary row of guide vanes which direct the hot gases onto the turbine with a swirl velocity. This swirl velocity is completely absorbed by the rotating blades so that the gases leave the turbine at almost axial direction. On leaving the stationary row of guide vanes, the gases are travelling at a speed in excess of the speed of sound. The speed of sound in air at ground level is about 760 mph but this speed varies with the temperature and at the temperature existing in the Orenda turbine, the speed of sound is closer to 1400 mph. The turbine blades are rotating away from this high velocity at about half the speed so that they do not operate at a speed greater than the speed of sound under these particular conditions.

The turbine rotor blades, besides having to withstand high the centrifugal stresses in common with all rotor blades in the engine, have an additional requirement to meet – they must withstand these stresses at temperatures of the order of 825 degrees C, at which temperature the blades glow a bright red. No ordinary steel will withstand these conditions for more than a few minutes so that the utmost ingenuity of the metallurgist has been drawn upon to develop better and better alloys – alloys so rich in chromium, nickel and other relatively scarce metals that they can no longer be classed as steel at all. When you consider the important role the compressor and turbine blades play in the engine and the difficult requirements which they must meet, we can appreciate the importance of each and every blade meeting the exacting demands of the designer. If we add to these exacting demands the number of blades involved – a total of 1,745 blades for the Orenda – we can see that the job of producing blades for an aircraft gas turbine is one which has few counter-parts in modern industry.

NOTAMS

• By the time you receive this current issue of the AHFC Pre-Flight, some lucky individual will have won the 1956 Meteor "Niagara". We wish that person many kilometres of happy and safe motoring. Look for a report next month of the Draw at the AHFC office site, along with an interview with the winner.

• Thanks are definitely in order to the members of the Board of AHFC who generously gave of their time to sell tickets at the various public events for the past year. Thanks also to the members of Air Cadet 845 Avro Arrow Squadron for ticket selling, to the many individual AHFC members who made the effort to get out and sell to their friends and acquaintenances – and of course, thanks to all those who bought tickets and in doing so helped AHFC in its aim of Canadian aerospace research, preservation and education.

• Coming up in Autumn – the Avro 50th Anniversary Dinner. Probably in one of the hotels near Pearson Internation. Watch for more information in *Pre-Flight.*

• The Arrow Models Recovery Program is set for this summer. Official aurthorization has been granted for the dives. Bob Saunders will give more details as they are available in the coming issues of Pre-Flight. By the way, the lake gets rough in summer, so pray for good weather.

• Also look for a report on the movie being produced with the Avro Arrow as the central focus. Information is hard to come by, but we'll have some in the next issue.

• Non-Board members are welcome to attend meetings of the AHFC Board as friendly observers. Meetings are held on the third Wednesday of every month. They start on time at 1900 h and generally are over by 2100 h. If you want to come and observe how the business of the Foundation is conducted or are interested in becoming a Board member, please contact Nick Doran, AHFC President, for information and direction. Call him at 416-231-0438. If he is unavailable, please leave a message.

AEROSPACE HERITAGE FOUNDATION OF CANADA

TAKE NOTICE that the Ann;ual General Meeting of the members of the Aerospace Heritage Foundation of Canada will be held at the auditorium of Willowdale United Church in Willowdale, Ontario on or about the hour of 10:00 am on Saturday, June 15, 1996 to:

(a) receive and consider the annual report and the financial statements

(b) elect Directors

(c) appoint auditors

(d) transact such other business as may properly come before the meeting or any adjournment thereof.

Members who are unable to attend are requested to date and sign the attached proxy and return it to the Secretary before the Annual General Meeting. Please fill in the name of a member to act as your proxy in the space provided.

Dated at Toronto, this twenty-first of May 1996.

BY ORDER OF THE BOARD OF DIRECTORS.

John Robertson, AHFC Secretary
P.O. Box 246, Etobicoke "D"
Etobicoke ON M9A 4X4

Cut here!

AEROSPACE HERITAGE FOUNDATION OF CANADA

INSTRUMENT OF PROXY

I _____ a member of the Aerospace Heritage Foundation of Canada, hereby appoint Nicholas Doran or _____ as my proxy, to attend, act and vote for me on my behalf at the Annual General Meeting of the Aerospace Heritage Foundation of Canada to be held on the fifteenth day of June 1996, and at any adjournment thereof, unless and until I am present in person, and I hereby revoke any former instrument appointing a proxy for me at the said meeting or any adjournment thereof.

Dated this _____ day of _____ 1996

_____
Member's signature

Send to: AHFC Secretary
P.O. Box 246, Etobicoke "D"
Etobicoke ON M9A 4X4

AHFC

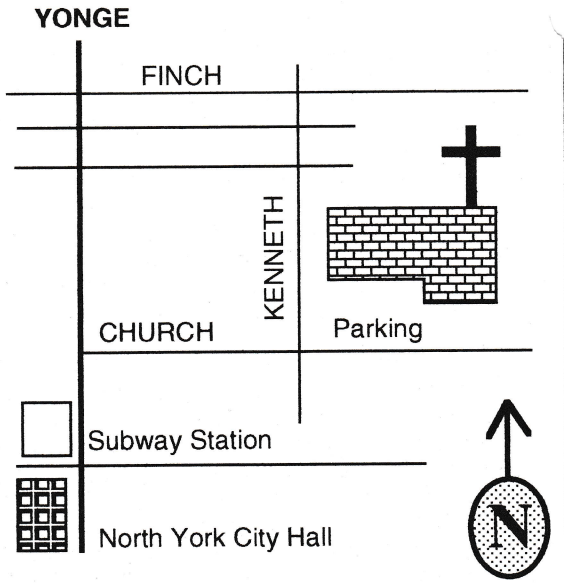
Aerospace Heritage Foundation of Canada

ANNUAL GENERAL MEETING

Saturday, June 15, 1996
10:00 h - 12:00 h

Basement Auditorium
Willowdale United Church
379 Kenneth Avenue
Willowdale

How to get there:
At the 1st light north of North York City Hall, turn right (east) for a long block to Kenneth, then turn north: the church will be on your right. There's lots of parking.



"Eternal vigilance is the price of liberty. Power is ever stealing from many to the few."

– Wendell Phillips in a speech (1852)