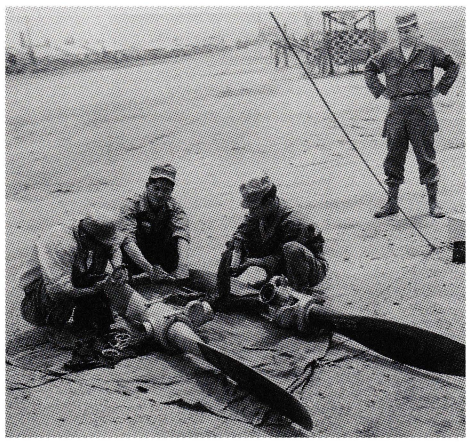
CAHS

The JOURNAL of the CANADIAN AVIATION HISTORICAL SOCIETY

Vol.38 No.3 Fall 2000

the Canadian Aviation Historical Society



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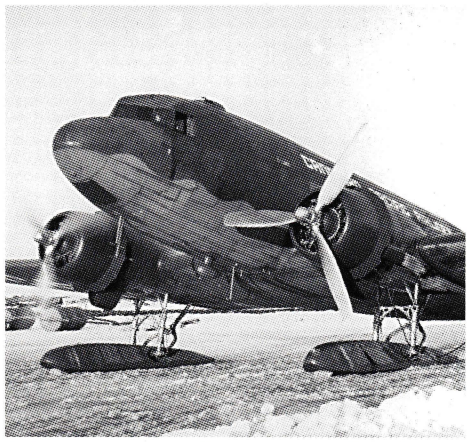

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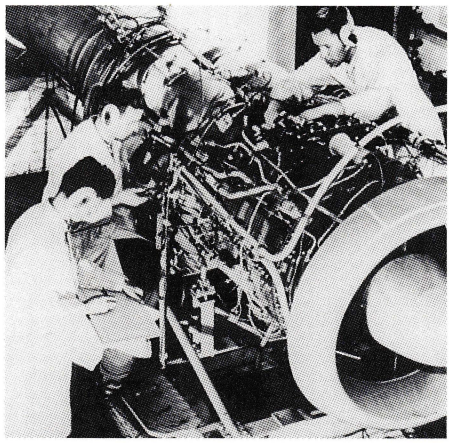

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Covers

FRONT: in this vigorous rendering, Graham Wragg depicts Arrow RL204 bleeding off speed on the runway at CFB Trenton on the only occasion when any of Avro's formidable fighters landed away from their Malton base.
BACK: Clark Seaborn (of Fokker Super Universal fame) supplies this rare shot of Sopwith Pup, CF-RFC, built by Stan Green and Tom Sigsworth, co-starring with the RCAF's Golden Hawk aerobatic team at a Calgary air show of some 40 years ago.

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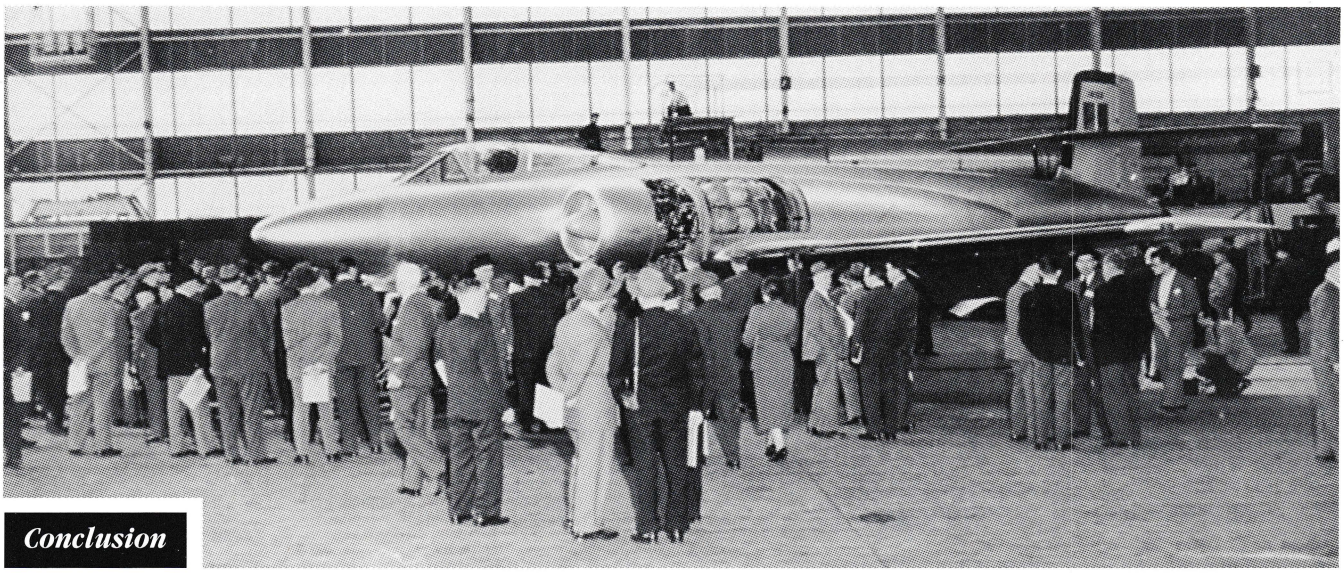
Members wishing to submit or undertake articles are requested to contact the Editor at 4 Rougecrest Drive, Markham, ON, L3P 3B6. (905) 294-4438 Fax: (905)294-5845. All manuscripts to be considered for *Journal* publication should be submitted on disk with hard copy included.

All material will be returned to owners immediately upon its appearance in the *Journal*. Membership in the CAHS is for one full calendar year commencing 1 January. A member joining anytime in the year up to 31 December will receive all quarterly *Journals* for the calendar year in which he joins. Regular Annual membership fees of $35.00 will be due for renewal on 1 January of each year. Articles appearing in this *Journal* are abstracted and indexed in *Historical Abstracts* and *America: History And Life*.

Digital Typesetting & Assembly by Alan Williams Design • Printed by DT&P International Ltd, Toronto

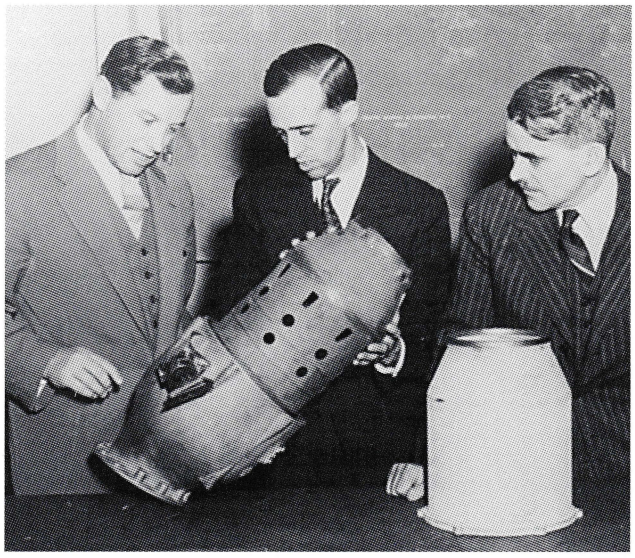


Conclusion

AB INITIO TO WORLD CLASS

CANADA'S BID AS A JET ENGINE LEADER

Paul B. Dilworth



With the Development of the Orenda, Canada Ranked in the Forefront of World Leaders in Jet Propulsion

In a letter of 20 March 1944 to C.D.Howe, Charles Banks recommended that Canada should proceed much more rapidly with the recommendations of the *The Banks Report*. In particular a Crown company should be formed, without delay, to undertake Research, Development and Production of gas turbine engines in "a broad way."

Banks came to Canada in May 1944 and was instrumental in organizing meetings with Mackenzie, Parkin, Bell, Steadman and with H. J. Charmichael who had been recommended to head up the new enterprise. These meetings produced the basic structure and mandate for the company. It was to be named "Turbo Research Limited" and would be set up in the plant of Research Enterprises Ltd. at Leaside in Toronto. It would have Charmichael as its President and Brigadier F. C. Wallace as Vice-President and General Manager.

Their concluding meeting on 18 May 1944 was followed by one between Charmichael and Howe at which Howe's approval was secured to proceed. Whereupon Charmichael set about incorporating and organizing the new company, Turbo Research Ltd.

As a chosen instrument of government, Turbo Research was to perform all government supported research and development work in Canada on gas turbines and jet engines. It was envisaged that this work would be based on the Whittle Patents. Manufacture of products developed would be performed by other firms under license. Royalties would supplement Government funds to help defray the cost of on-going research and development.

The company's mandate was very broad, extending beyond aero engines to encompass such applications as industrial type gas turbines for railways, automotive and ship propulsion and for electrical power generation and gas compression.

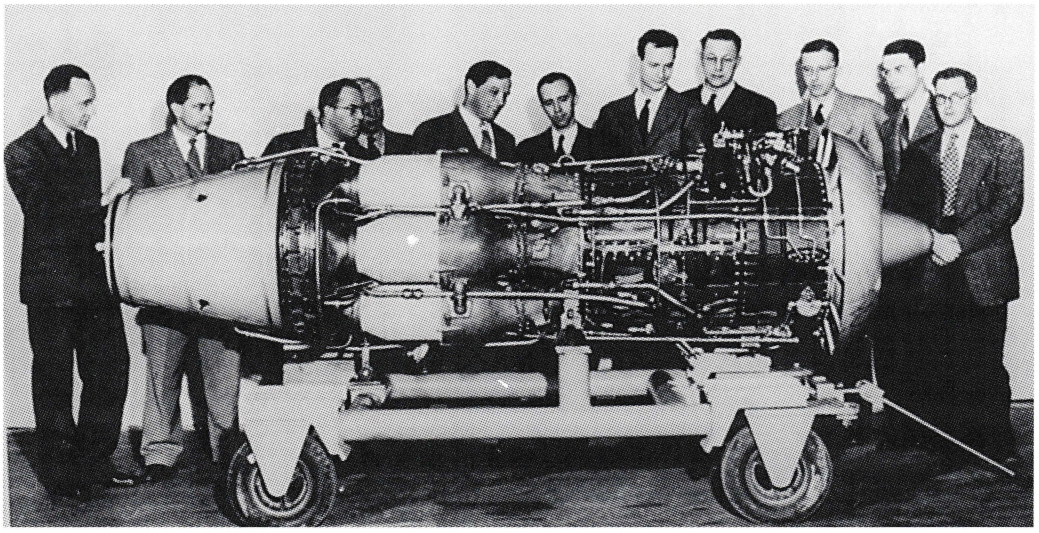
Tupper set about hiring a few key people at Leaside. He also effected transfer of Winn Boyd and Doug Knowles from NRC in Ottawa, including their work on the planned new plant for testing full scale compressors of gas turbines. As pre-

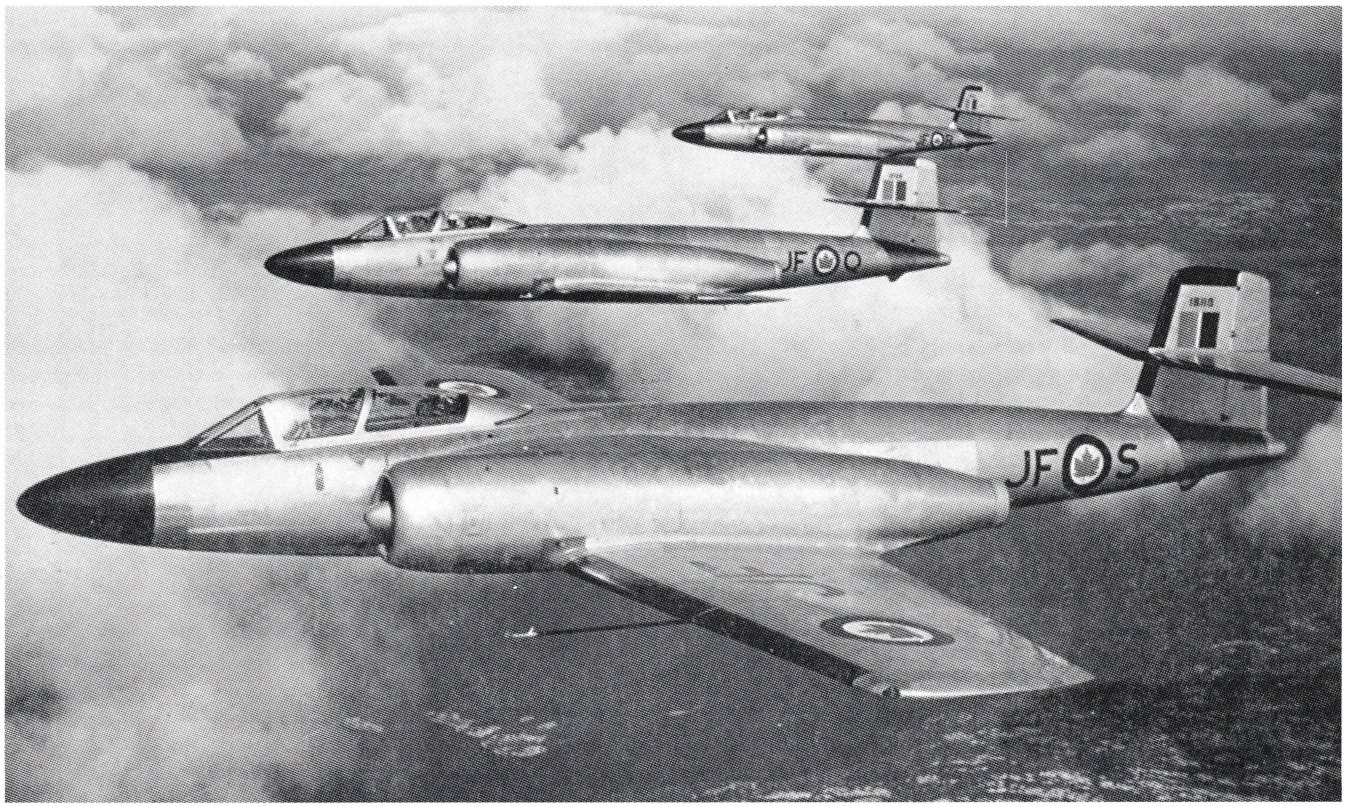
viously stated, this project was Boyd's first assignment on which he had worked continuously for some six months, initially at Power Jets, where he had been joined by Doug Knowles, and later at NRC and then at the Turbo organization at Leaside in Toronto. Ken added new key people including Stewart Rahmer for expertise in manufacturing, Fred Staines for manufacturing inspection and quality control and J. W. McBride for aerodynamic design. He likewise brought back Bert Marcouillier from Winnipeg as senior jet engine technician, and hired Percy Watt from NRC for his skills as pattern maker and for manufacture of wooden mock-ups and models.

The Cold Weather Test Station at Winnipeg was transferred from NRC to Turbo in September 1944 and continued operation under my direction until returned to NRC in May 1946.

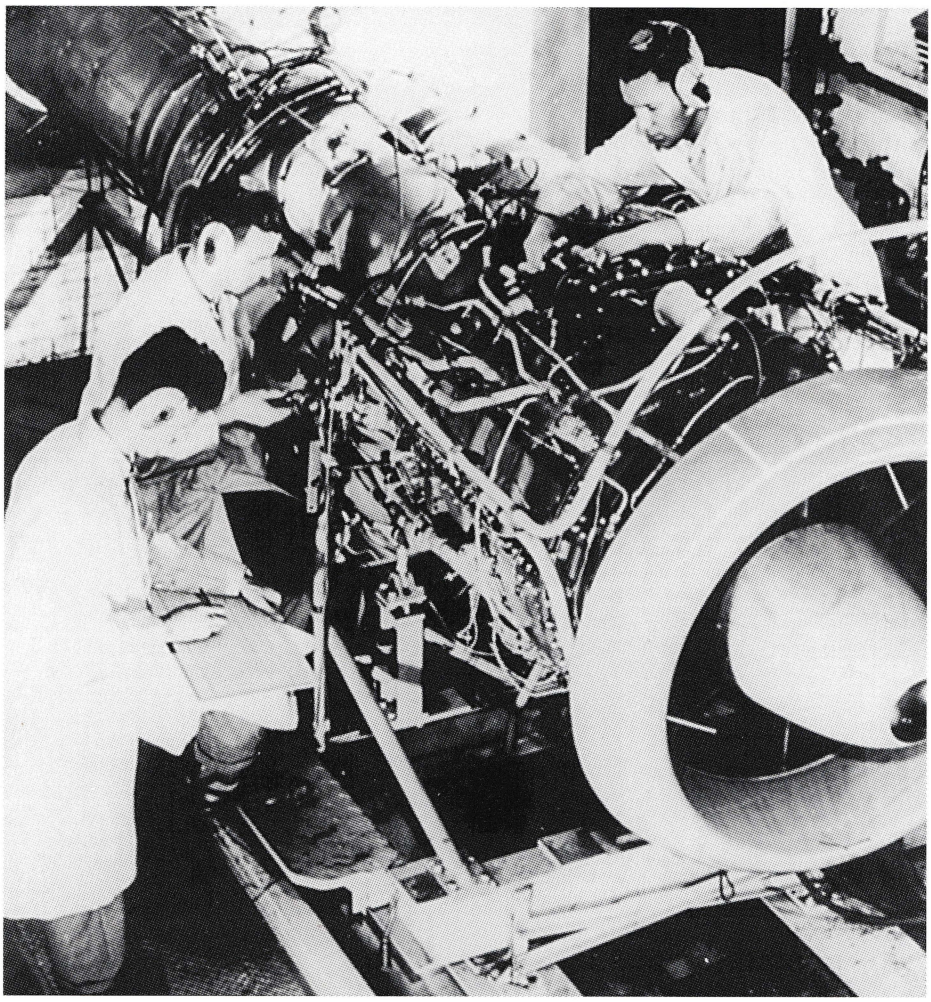
At Leaside, Turbo initiated design studies on jet engines for military aircraft in January 1945. Although extremely reluctant to cease work on design of the compressor test plant, then at an advanced stage in design, and turn over responsibility for its completion to Doug Knowles, with great reluctance Winn acceded to Ken's direction to initiate the new jet engine design studies. They included three centrifugal type engines, designated TR1, TR2 and TR3 and an axial flow engine designated TR4-later named *Chinook*. Ken's decision to place Winn in this role was undoubtedly the single most important factor in the early success of design and engineering of Canada's highly successful entry into the military jet engine field.

Concurrently, the government turned over to Turbo the complete powerplant and ancillary facilities of the Defence Industries Ltd wartime explosives plant at Nobel, near Parry Sound, Ontario, the plant having become redundant to the war effort. This gave





Heading, top: *roll-out of the first Orenda-powered Avro CF-100.* J. FLOYD. ***Heading, inset:*** *L-R, Winnett Boyd, author Dilworth and Frank Whittle inspect Orenda components at A. V. Roe Canada about 1949.* S. BROWN. ***Left:*** *the TR-4 Chinook, the first engine designed and built in Canada, initially run-up on 17 March '48. Key engineering team members, L-R: Ray Woodfield, John Brisley, Doug Knowles, Bill Barlow, Winnett Boyd, author Paul Dilworth, Mel Phipps, Fred Staines, "Dick" Shepherd, Dave Parker and Harry Keast.* S. BROWN. ***Below:*** *Orenda-powered CF-100 Mk 3s from Air Defence Command OTU at North Bay.* RCAF



Turbo a powerful steam turbine to use as a drive for full scale compressor testing, thereby saving some millions of dollars and about two years time otherwise needed to construct the plant designed by Boyd. It also included a large reciprocating air compressor plant which provided air for testing of combustion chambers and for operating a *cascade* wind tunnel and the performance of other aerodynamic experiments.

In the latter part of 1945, following a basic change in Government policy, a decision was made to wind up the operations of Turbo Research Ltd and transfer all such activity to private industry.

Fred T. Smye, as Director of Aircraft Production for the Federal Government, was assigned the task of finding it a new home — a task which he completed after joining the newly formed A. V. Roe Canada Ltd. Approaches were made initially to Rolls-Royce in Britain and later to Pratt & Whitney in the USA, to take over the Turbo staff and operations.

Rolls-Royce were not interested. The opinion expressed to Fred Smye by Pearson of Rolls was that jet engine development in Canada was quite impractical as there was no established pool of trained manpower in engine design and development, in experimental manufacture or production. Neither did Canada have the essential industry infrastructure upon which to draw for supply of such basic components as light alloy forgings and castings, and fuel or combustion system components. As an alternative, Pearson suggested setting up Canadian manufacturing and test facilities to produce their AJ65 Avon axial-flow jet engine then under design in England.

"Atkin was succeeded by the brilliant James C. Floyd who, up to that time, had dedicated his energies to the development of the world-leading Jetliner."

"You can even stick a Maple leaf on it if you wish," he said to Smye,

Pratt & Whitney, were very much interested, doubtless because it would give them access not only to Turbo's but much British jet engine technology as well as augment operations of their piston engine plant at Longueuil. This option was an exercise in futility as it had finally to be ruled out to protect British technology interests, those of Power Jets, in particular.

At this time, Roy Dobson (later Sir Roy), Managing Director of the A.V. Roe company in England, had negotiated take-over of the Victory Aircraft plant at Malton, Ontario. He had formed a high opinion of the job done by Canadians manufacturing Avro Lancasters at the Victory plant during the war. Sir Roy foresaw a great future for Canada in both design and development as well as the manufacture of aircraft. The new enterprise, A.V. Roe Canada Ltd, a wholly owned subsidiary of A.V. Roe, Manchester (and later a member of The Hawker Siddeley Group) was formed in December 1945.

Turbo's impasse with Rolls-Royce and Pratt & Whitney, lead Smye to arrange for negotiations by Dobson with C. D. Howe, then Minister of Reconstruction, to acquire Turbo Research Ltd. It resulted in the transfer of Turbo operations and most of its staff to this newly formed company taking place in April 1946. These numbered some 86 people and formed the nucleus of the A.V. Roe Canada Gas Turbine Engineering Division as a counterpart to its Aircraft Engineering Division.

The prospect of becoming an adjunct to an aircraft company, particularly as a group of neophytes with no track record in engine design and development, gave rise to some serious misgivings in that it

carried risk of a subordinate status to that of the Aircraft Division. An equally vexing problem was anticipated concern by other potential Aircraft customers over commercial security risk in disclosing their new project plans and related engine requirements to an engine company with a competitive sister Aircraft Division. There being no alternative, I decided to stay the course.

To my great regret, Ken Tupper decided to return to the NRC, having been offered the post of Deputy Director of its Chalk River Nuclear Laboratories. In consequence, it fell my lot to become the first Manager and Chief Engineer of Avro Canada's Gas Turbine Division. Later it became Orenda Engines Limited and recently, Orenda Aerospace Corporation, a member of the Magellan group of companies.

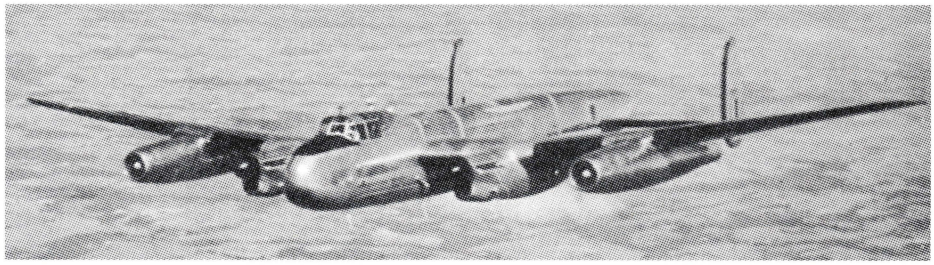
THE ORENDA STORY

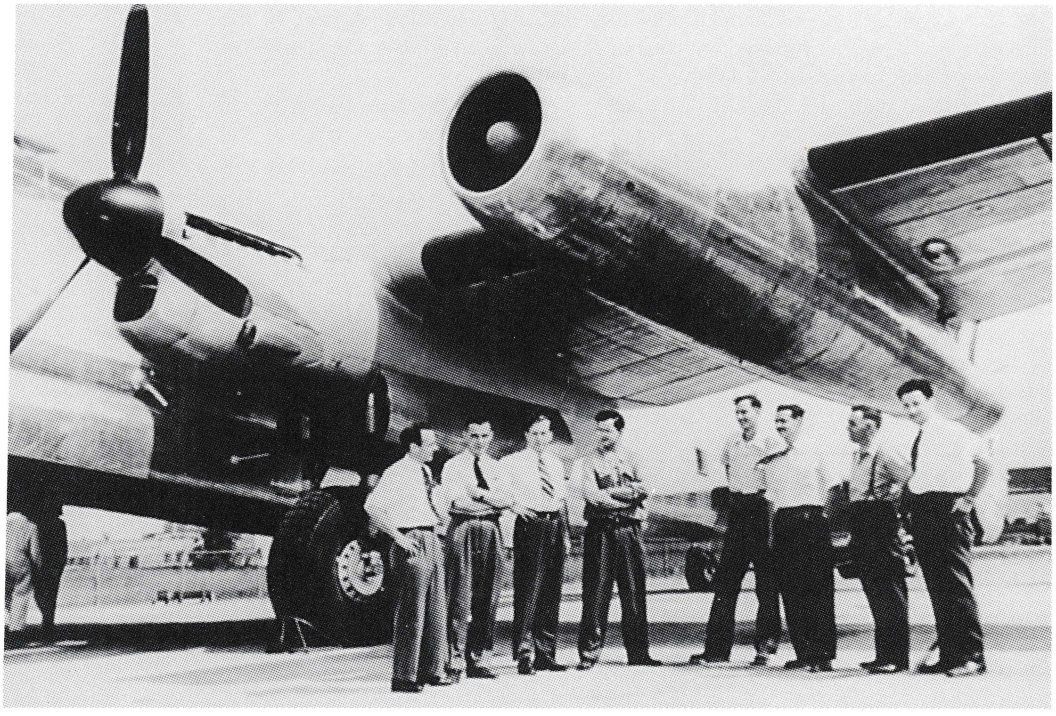
A comprehensive history of ORENDA is beyond the scope of this article. There follows, however, an account of some highlights which form an integral part of this early history.

Loss of Ken Tupper's immense talent was a sad blow to us all. He did, however, serve as consultant and adviser for a year and this proved extremely helpful in effecting a smooth start up of operations at Malton. At the outset I found myself working under the Direction of W. A. Deisher, the new firm's Vice President and General Manager. This proved an uncomfortable relationship for me and, I believe, for Walter Deisher who clearly had no feel for engine development. To my immense good fortune Walter delegated this role to Fred Smye, then Assistant General Manager. "Freddy," as he was affectionately known, was the principle architect of A.V. Roe Canada, behind the scenes, and one of Canada's unsung heroes in the development of our leading position in high speed aerospace technology. He became my third great boss and lifetime friend, until his premature death in 1986.

Much the same situation held true for the Aircraft Division which was initially under Edgar Atkin as Chief Designer. Later, under Fred Smye's direction, Atkin was succeeded by the brilliant James C. Floyd who, up to that time had dedicated his energies solely to design and development of the world-leading Avro Jetliner, still his favourite project. He went on to eclipse that record by his masterful direction of development of the supersonic Avro Arrow — without doubt the leading high-tech jet fighter project of its time. To this day Jim Floyd, emeritus world leader in engineering of both inter-city jet transport and supersonic jet fighters, remains my close friend and confidant.

To my chagrin, Fred later felt obliged to direct his full time and energy to the Aircraft Division's activities, the CF-100 having encountered some serious prob-





Opposite, left: *Chinook No 1 being readied for testing.* S. BROWN. ***Opposite, right:*** *F. Harry Keast.* D. KEAST. ***Top:*** *A/C/M Sir Arthur Tedder, RAF, author Dilworth, unidentified RAF air marshal and Winnett Boyd. Seated, Avro Gas-Turbine Division test technicians.* BROWN. ***Right, upper:*** *the Avro Lancaster X (RCAF FM209) converted as a flying test-bed.* AVRO. ***Right:*** *ground support staff with the Lancaster flying test-bed prior to its first flight. Orenda engines are housed in the outboard nacelles.* BROWN.

lems and was running behind schedule. Additionally, the Jetliner project having been rejected by its original sponsor, Trans-Canada Air Lines (which firm got cold feet over taking the world lead in introducing jet propelled inter city airliners) needed his abilities and many US contacts for marketing. It was these as well as problems in that division's management which lead to Jim Floyd's appointment, a decision which put Avro Canada on the road to pre-eminence.

Immediately following his decision to move to General Manager of the aircraft division Fred attempted to hire a counterpart for the Engine Division, a tall order indeed and one doomed to failure.

In April 1946, when the A.V. Roe Canada Gas Turbine Division was formed there was, as yet, no RCAF requirement for a jet engine — the specifications for the CF-100 were not yet finalized. Nevertheless, in a farsighted decision by government, authorization and funding were provided to complete the detail design, manufacture and initial testing of the Turbo Research TR4. This was in order to gain time in both engineering and manufacturing against an anticipated new engine requirement for the CF-100.

On Winn Boyd's recommendation it was decided to use Indian names for our engines and, in consultation with University of Toronto experts in Indian affairs, Winn formulated a roster of engine names.*Chinook* was chosen for the TR4 and later *Orenda* for the TR5. It will be noted that *Iroquois*, was not on Winn's list which, with the exception of Chinook, included only names of Indian spirits, such as Orenda and Wakanda. These, in Indian lore, had the ability to imbue great power. Chinook, of course, was adopted because it is the well known Indian name for the hot dry wind of the Alberta foothills.

A second serious loss, following Ken Tupper's Departure, was that of J. W. McBride, our senior (and only) aerodynamicist who had performed the original aerodynamic design of the TR4's axial flow compressor. Wally McBride went to one of our two major US competitors, the General Electric company at its new jet engine division at Evandale near Cincinnatti. Although we had no prior investment in Wally, who had not been one or our UK trainees, his loss was serious. It was judged impractical to build the Chinook compressor without his continuing input during that engine's development and, more particularly, the design and development of its successor, the Orenda.

This led to a mission to the UK by Winn Boyd to recruit a replacement. Having been stationed at Power Jets in 1943, Winn paid them a visit and explained our predicament. He was generously given permission to interview PJ personnel for the job and shortly returned, having hired F. H. Keast. Harry Keast came to Canada shortly thereafter and set about aerodynamic redesign of the Chinook compressor. Its outstanding performance and later, that of the Orenda compressor, were fundamental to the successful performance of both engines.

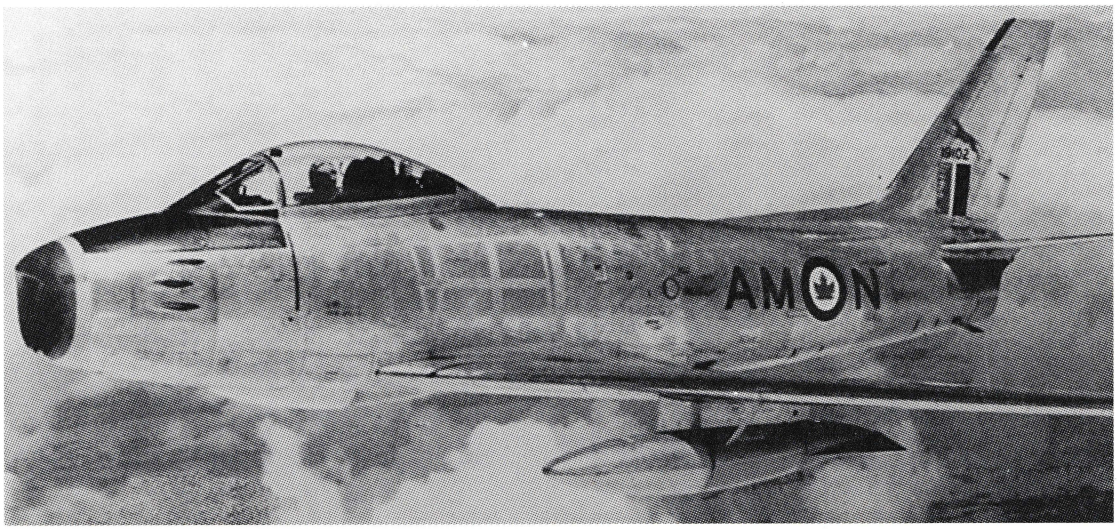
Harry Keast's outstanding ability in aerodynamics formed an essential complement to that of Winn Boyd in mechanical design. It is Winn, nevertheless, who deserves primary credit for the basic design concept and engineering of both those engines.

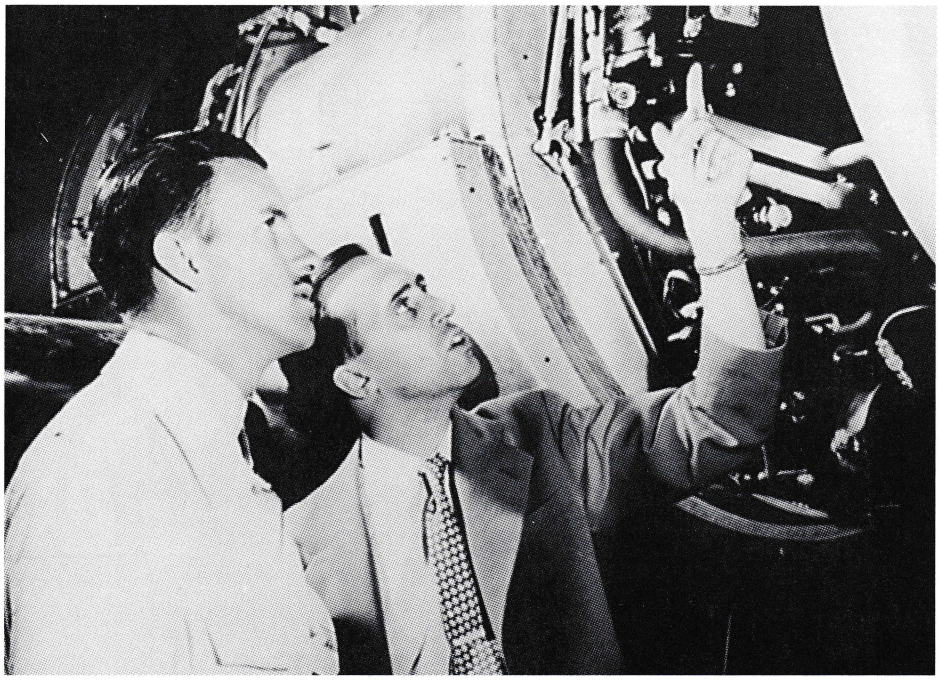
Not only their design configuration but also their design layout in great detail, together with essential stress and performance calculations were the product of Winn's work. Done without any prior experience or training, except for a short period of exposure to the work of others at Power Jets, this rightly earned him the reputation of a true genius and credit for laying the foundation for the great success of on-going development of the Orenda after his departure in 1951.

Backed by Keast's work on compressor aerodynamics, the detail design of the Chinook was quickly completed and drawings released to the experimental machine shop. After surmounting many problems in manufacture, under Bill Hall and Stu Rahmer, especially on both compressor and turbine blading, the first Chinook was finally assembled and put on the test bed. This had even seen Fred Smye going around asking people to give up blades which had been purloined for private souvenirs, they were in such short supply,

On St Patricks Day, 17 March 1948, the Chinook started on its first attempt and came up to idling speed without a whimper. Absent too were any flames from the jet pipe, so characteristic of many jet engines at that time. Thus came to life the first jet engine designed and built in Canada. It soon achieved its rated thrust of 2,600 pounds and, by the end of its short career, 3,000 pounds.

This event gave an enormous boost to morale. Of at least equal importance, it





Opposite, top: *test pilot Mike Cooper-Slipper DFC in the cockpit of the Sabre 2 FU-069 (US-built, but fitted with an Orenda engine) in which he set a Toronto-Montreal speed record averaging 665 mph.* V. MORSE. ***Opposite, bottom:*** *Canadair CF-86 Sabre powered by an Orenda engine.* AVRO. ***Above:*** *behind the second CF-100 prototype (FB-K) with Rolls-Royce Avon engines, is the first Orenda-powered USAF NA F-86A FU-616 converted by North American at their California plant and test flown on 5 and 6 October '50 by Major Bob Johnson and Major Bob Hoover repectively. On its delivery flight, 616 set several US point-to-point records.* S. BROWN. ***Left:*** *Don Rogers, Avro Canada's Chief Test Pilot, and the writer inspect the engine of a CF-100.* BROWN.

"Skeptics, of which there were many, predicted that all CF-100s would doubtless have to be powered by Avons."

silenced the many sceptics and vindicated the government's support for the whole engine development program. It further enabled the RCAF to raise funding for design and development of the Chinook's successor, the TR5 Orenda.

In late summer 1946, some months before Chinook's first run, a meeting took place in the Chateau Laurier Hotel in Ottawa attended by senior officers of the RCAF and Avro management. Among those present were Wilf Curtis, Fred Smye, and Edgar Atkin who represented the Aircraft Division, as well as Winn Boyd and myself on behalf of the Gas Turbine Division. Also in attendance was one of the senior Hawker Siddeley designers, W.W. Downing.

At this meeting it was determined that the CF-100 would be powered by a pair of 6,500 pound thrust jet engines to be developed and produced by A.V. Roe Canada's Gas Turbine Division. This new engine, (to become the TR5 Orenda), was to be the equivalent of the 6,500 pound thrust Rolls-Royce AJ65 Avon engine then under initial development in the UK. Avons were to power the CF-100 prototypes since that engine was already well underway in development. All production CF-100s would, however, be powered by the new Canadian engine. The sceptics, of which there were many, predicted that all CF-100s would doubtless have to be powered by the Avon.

For a neophyte organization, whose much less powerful TR-4 Chinook had yet to make its first run, this was indeed a monumental challenge. Winn and I excused ourselves from the meeting to discuss its implications. Outside, there were loud reports from a truck backfire. Fred Smye quipped to the rest of the

group "My God, Dilworth and Boyd must have shot themselves".

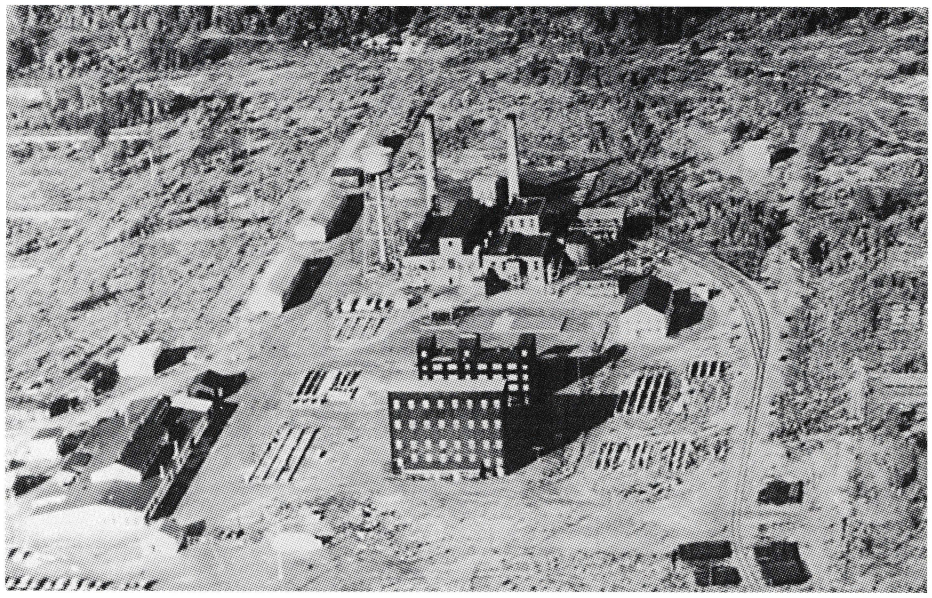
The first Orenda made its maiden run on 10 February 1949, just short of one year after that of the Chinook. On its first "build" it was approaching a targeted 1,000 hours total running when, at well over 900 hours, the test was inadvertently terminated. One of the test technicians had come too close to the engine intake. He wore a long white lab coat in the pocket of which lay a package of razor blades. The coat was sucked into the engine and the razor blades destroyed the initial stages of compressor blading, bringing the engine to a sudden, grinding halt.

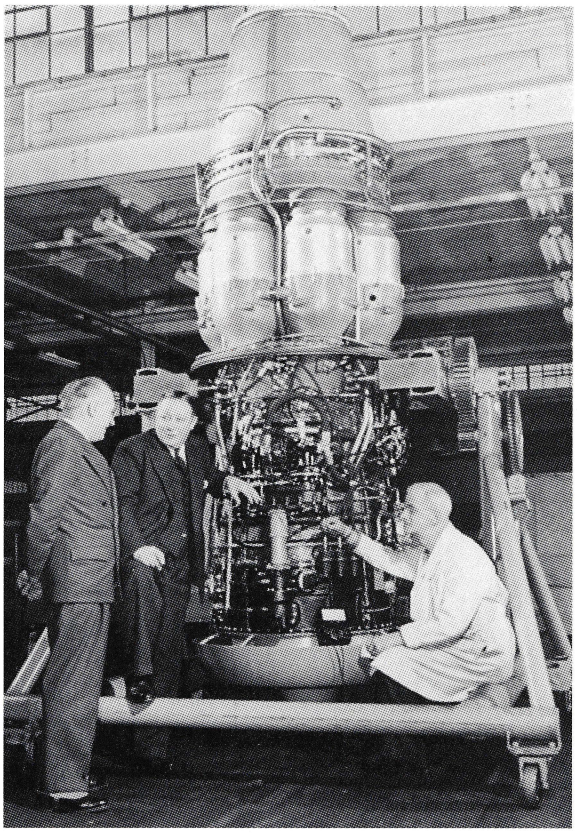
Word of the Orenda development had reached south of the border and caught the interest of General "Pop" Powers, head of USAF Materiel Command. This resulted in visits by USAF engineering officers which, evidently, further enhanced the General's interest. He saw an opportunity of getting a new lease on life for the Curtiss-Wright engine company by taking a license to produce the Orenda in the USA. They had lagged behind both Pratt & Whitney and General Electric in getting into the gas turbine field. Although we were appalled at the prospect of being over-run by visitors the plan held great appeal. It would open an avenue to selling our engines in the USA under a US flag, thereby circumventing anticipated lobbying by the US engine companies to thwart Canadian intrusion into their home markets.

Unfortunately, General Powers retired before this plan could gel. In its place, the Wright company took out a license to produce the Sapphire engine of our affiliated company, Armstrong Siddeley in the UK. This turned out to be a disaster. The Sapphire, at that stage, had a good margin of performance advantage over the Orenda and was further advanced in development. Unfortunately, it proved a very difficult and costly engine to produce and it evidently led to the Wright company's demise. In retrospect it was a misfortune for both Wrights and ourselves, and it failed to benefit Armstrong Siddeley.

In addition to its intended service in the CF-100, the Orenda was destined to power the famed North American F-86 Sabre which Canadair were later to produce as the CF-86 under license for the RCAF.

This followed an initiative suggested by Winn for an experimental installation in an F-86 (FU-616) to establish a new world speed record. The suggestion took hold and resulted in the USAF assigning an FU-616 for conversion to an experimental prototype employing one of the initial series of Orenda engines. This conversion was made by the aircraft's builder in California in late winter and early spring 1950. Following a visit by Winn, Syd Britton and Cece Woods were assigned from Malton to work with NAA in California on the project. Later, Syd ably managed our liaison and related engineering work for installation of the Orenda in the CF-86 at Canadair.



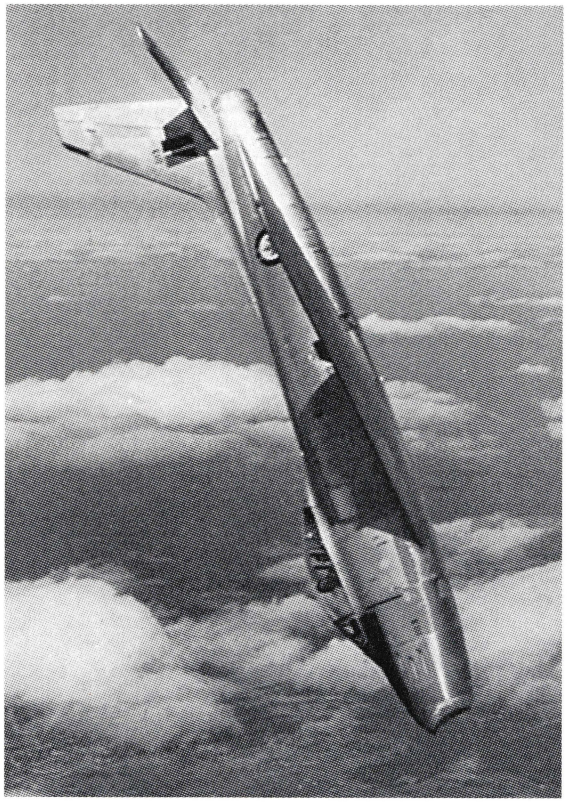


The first ground run of the Orenda in the USAF F-86 was made in June of that year. Although it was ready for its first flight Sir Roy insisted that the Orenda await flight testing in the Lancaster Flying Test Bed scheduled for the following month. The latter test took place on 13 July 1950 with two Orendas replacing the Merlins in the outboard nacelles. This, and most of the ensuing flight tests of Orenda in the Lancaster, were performed by Don Rogers, Avro's very competent and highly regarded Chief Test Pilot.

At this juncture a serious structural fault reared its head in the Orenda turbine. This was revealed when, in a routine assembly shop operation, a technician commenced lifting a turbine assembly by the tackle attached to the *stub shaft,* an integrally forged part of the turbine disc. To his surprise, the stub shaft and disc parted company, leaving the main disc and blading still sitting on its stand.

Out of the ensuing pandemonium came a major blitz; first on doing major tensile and bending tests on all remaining Orenda turbines, including those assigned to the Lancaster and F-86. Fortunately no other turbines failed under these tests. In parallel with the foregoing, however, changes were made in the forging process to ensure against any further such failures, evidently resulting from very high residual internal stresses locked in during the forging operation.

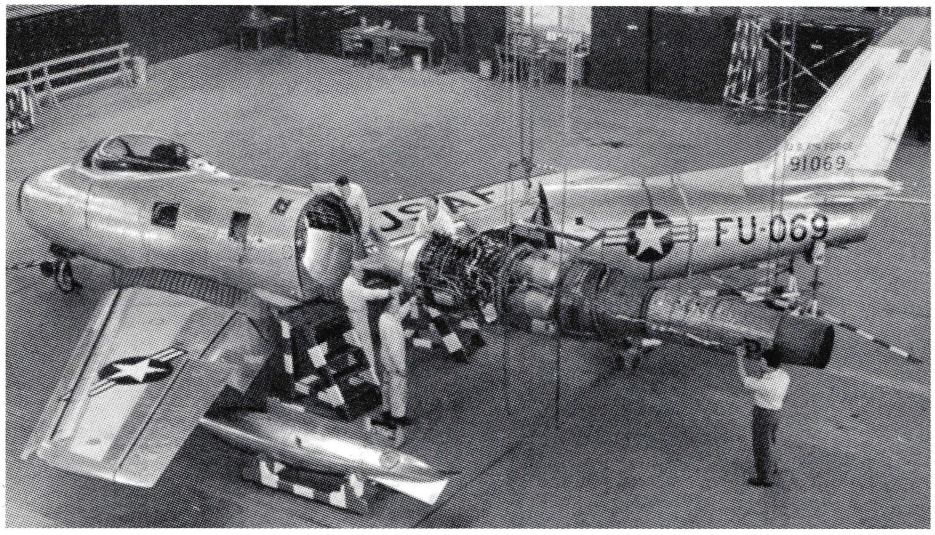
Following this harrowing experience the turbines were cleared for flight operation. The Lancaster continued its work and the F-86 was cleared for flight opera-



tion. Its initial flight with a USAF pilot at the controls took place at the Edwards Airforce Base at Muroc, California on 5 October 1950.

After completing its initial test program it was delivered to Malton. The final leg of its flight from Minneapolis, on 27 April 1951, was made in the record time of one hour and eight minutes. It arrived with a spectacular high speed low level pass over the heads of the large turn out of staff gathered to greet its arrival, ending in a vertical climbing role. Thereafter it was Mike Cooper-Slipper, Don Roger's right hand man, who took on and ably performed the Orenda flight tests in both the F-86 and later, the Canadair CF-86.

Opposite, top: *the Nobel Test Facility for compressors, combustion chambers and aerodynamic research experience.* I. FARRAR, ***Opposite, bottom:*** *L-R, Walter Deisher, Roy Dobson (later Sir Roy) and a technician with an Orenda on a building stand.* J. FLOYD. ***Left:*** *Orenda-powered, a Chatham NB-based Sabre 5 demonstrates its superb aerobatic qualities. RCAF/DND.* ***Below:*** *As a successor to FU-616, USAF F-86A Sabre FU-069 was delived to Malton about Sept '51 where its General Electric J-47 was replaced with an Orenda. It was in this a/c that Mike Cooper-Slipper set his Toronto-Montreal record.* AVRO. ***Bottom:*** *to mark an unidentified occasion (L-R) Fred Smye, Earl Brownridge, author Dilworth and Fred Taylor share a celebratory drink.* S. BROWN.



During this period the Korean war resulted in great pressure on both the aircraft and engine divisions to get the Orenda powered CF-100 into service. C. D. Howe went so far as to instruct the firm to cease work on the Jetliner project, notwithstanding its great promise for leadership in introducing jet transport into the US intercity airline service. It also brought a personal visit by both Brooke Claxton, the Defence Minister, and Wilf Curtis, RCAF's Chief of Staff, with a retinue of supporting personnel to impress upon us the urgent need for expediting development and production of both the CF-100 and Orenda.

Unfortunately, this pressure hampered the engine development programme as it saddled our experimental machine shop with producing the initial batch of Orendas for service aircraft pending the new production plant becoming operational. It had, however, a beneficial effect in lending support for an ensuing change in the Gas Turbine Division organization structure.

Regrettably Winn left the company in November 1950. His resignation had been precipitated over the above mentioned reorganization which I had judged essential for effective prosecution of the Orenda development program. We nevertheless remained good friends. He went on to further enhance his reputation through design of the highly successful NRU nuclear reactor for Atomic Energy Canada at Chalk River.

With responsibility for Design now under Lloyd Secord, assisted by Dave Parker and Mel Phipps, and with development the direct responsibility of Charles Grinyer and Doug Cramb under overall direction by Doug Knowles, the new Orenda test program started to disclose some hidden problems. To Boyd's credit these were not many but one, in particular, proved serious in the extreme. This was a veritable plague of fatigue failures of compressor blades as well as some in the turbine. Indeed it threatened the engine's very future. This problem was finally quelled but only after months of round-the-clock work effort, notably by Harry Keast and his staff, aided by vibration experts on loan from Armstrong Siddeley. It also placed immense stress on the experimental machine shop to produce and install new blades and on

the assembly shop to fit these rapidly into engines for test. The accelerated development program necessitated round-the-clock running of engines on the test bed.

Exhaust silencers had been ordered but delivery was delayed for several months. In consequence, the sustained and intense noise inflicted on the adjacent populace of Malton became a serious problem. We were unable to respond to a request to confine testing to daytime operation and our neighbours had to put up with many sleepless nights. As a result we were accused of accelerating Malton's birth rate.

Throughout this difficult period, operation of the engines cleared for flight operation were restricted from any prolonged running at certain RPMs known to produce dangerous blade vibration resonances. It was only after effective modifications had been proven that these restrictions were removed. There followed the first flight of a CF-100 with Orenda engines in June 1951 and delivery of the first CF-100 to the RCAF in October that year.

To satisfy production requirements for the rapidly expanding Orenda programme, Earl Brownridge, who had been working as assistant to Maurice Nix in managing the experimental machine shop, was assigned this monumental task by Fred Smye. It entailed creating a brand new major facility and organization from scratch. Earl set about the job in his characteristic dynamic style. The result was undoubtedly the finest and most efficient jet engine production plant of the time. From it emanated some 3,800 Orenda engines.

There followed completion of design of the two-stage turbine version of the Orenda. Put on test shortly after I left the company it not only resolved the Orenda's slow acceleration problem but added a major increase in thrust. It did, in fact, turn the Orenda into one of the two best high-powered military jet engines of its day.

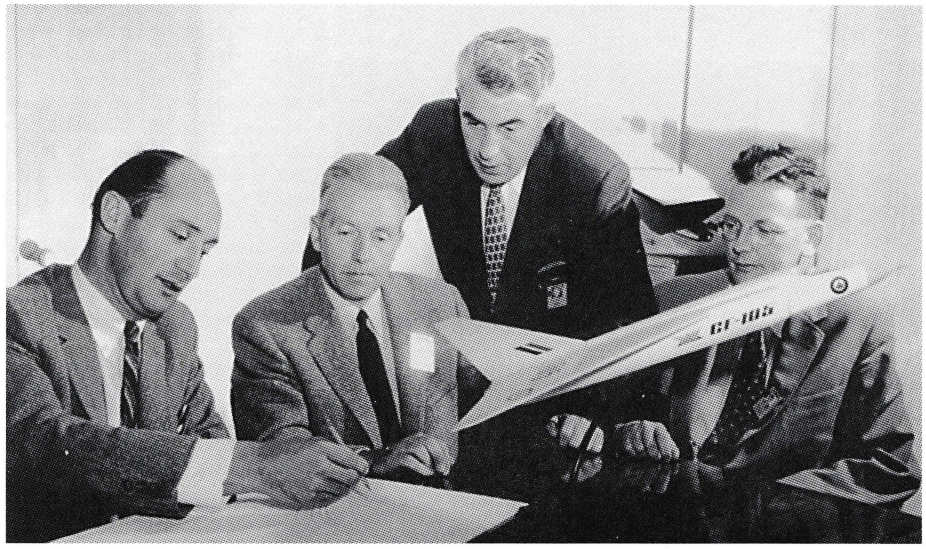
During this phase of the Orenda programme the company moved onward to complete the plan to separate its aircraft and engine operations. This ultimately resolved into Avro Aircraft Ltd, and Orenda Engines Ltd. It was finalized under Crawford Gordon Jr who arrived on 15 October 1951— just prior to delivery to the RCAF of the first Orenda-powered CF-100. It is worthy of note that my great mentor, Frank Trethewey joined Orenda as Vice-President Sales and Service during this period.

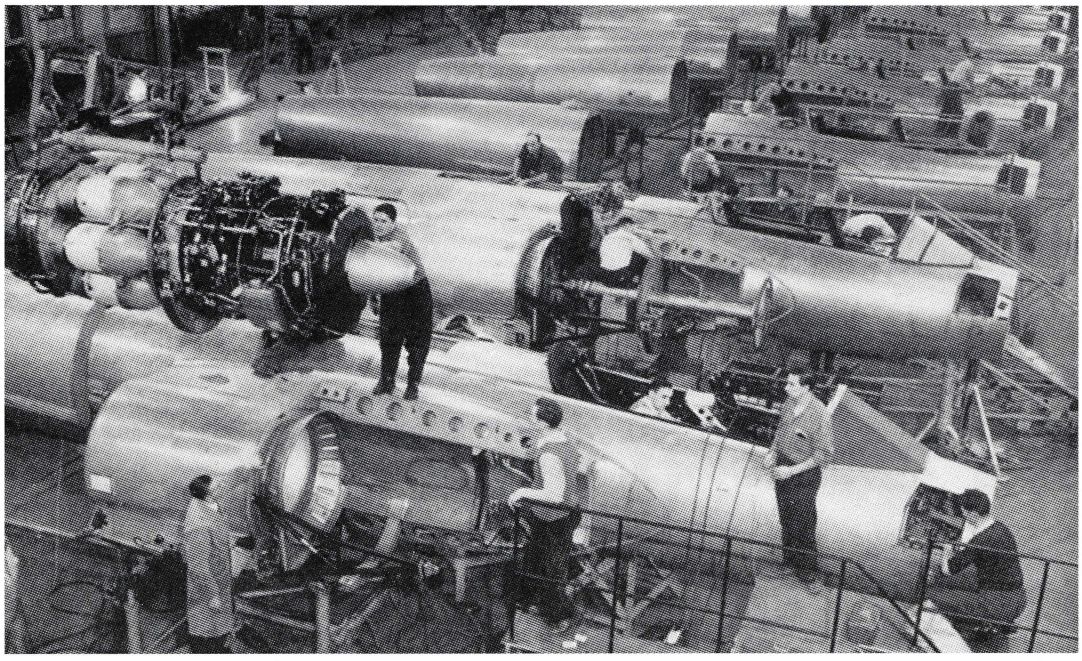
Crawford had been a year senior to me at Appleby School in Oakville. He had become one of C. D. Howe's "young turks." Little did I anticipate that he would one day become my boss. This role he played but a short time, until a full time General Manager could be found for the Engine Division.

During this period, resulting from a request by C. D. Howe to Charles Wilson, head of General Motors, T. S. McRae from GM's Allison Division was appointed the Engine Division's General Manager. Earl Brownridge and I thus found ourselves working for a new and very different boss than Fred Smye whom we had both admired and revered.

A chasm soon developed over administrative policy between Tom McRae and me and it proved too vast to bridge. After consultation with my close colleague, Earl Brownridge, who reluctantly agreed that I had no alternative, I handed in my resignation.

In a final meeting with Crawford, at which my concerns over the engine company's operations under the new manager, he said to me "Paul, for your sake I hope that you are right, but for that of the company, that you'll be proven wrong." With that I expressed my complete agreement. We shook hands and I

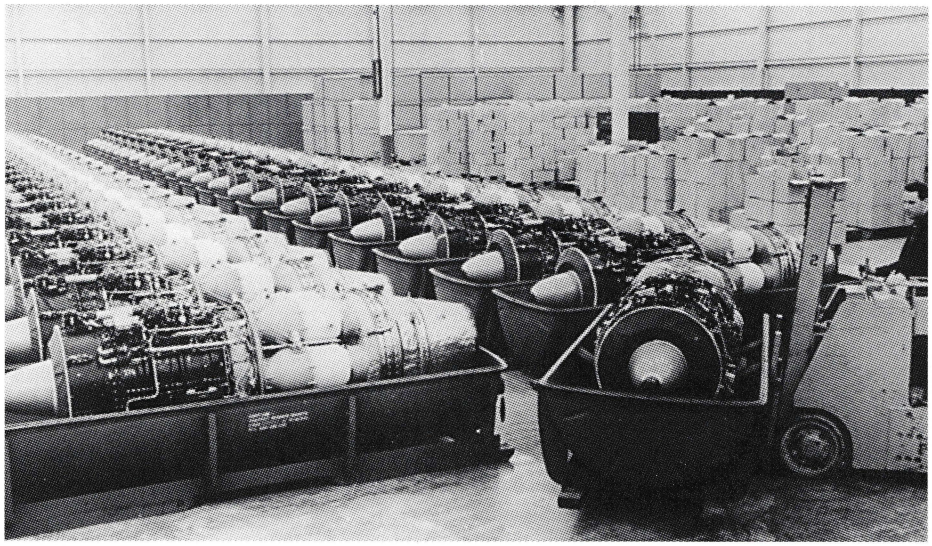


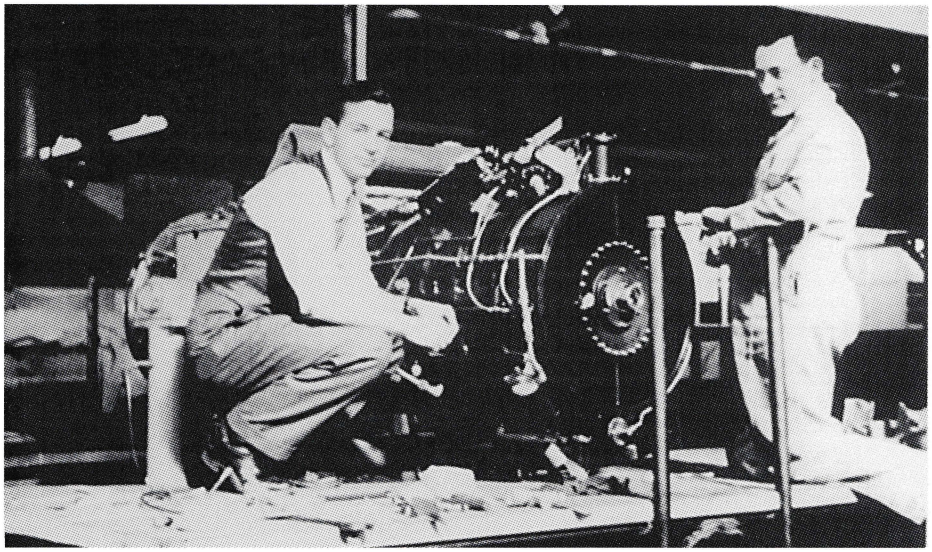


Top: *(L-R) Bob Lindley, Jim Floyd, Guest Hake and Jim Chamberlin with a model of the Arrow.* J. FLOYD. ***Above:*** *CF-100 front, centre and rear sections are mated and then fitted with Orenda engines at Avro's Malton plant.* AVRO. ***Opposite, top:*** *Orenda engines fresh off the assembly line.* FLOYD. ***Opposite, bottom:*** *Syd Britton (L) who played a major role in fitting Orendas into both Canadair and US fighters, with an Orenda in California.* FLOYD.

departed. It brought little satisfaction that McRae was later replaced by Walter McLachlan, a man whom I got to know and greatly respect. He was a former executive of the John Inglis company.

This is the logical end of the story, after which I departed and set up a new high-tech consulting engineering business. In this, Lloyd Secord joined me in 1953 as later did George Meagher, a former NRC colleague. I owe a further great debt to Phil Garratt. In spite of my turning down his offer to join de Havilland to manage its Special Products and Research division (later to become Spar Aerospace) he directed some design assignments to help get this new enterprise started. These tasks were supervised by DHC's Fred Buller(recently nominated for membership in Canada's Aviation Hall of Fame). A further such debt is owed to my former Malton colleagues, Joe Purvis and Bert Marcouillier who, as "moonlighters" and ex-gratia, made significant contributions to that start-up which, as a pioneer, grew to become a leading international high-tech consulting engineering enterprise. Its projects spanned a wide spectrum from large scale cyclotrons to both subsonic and supersonic aeronautical wind tunnels and full scale automotive environmental test plants.





EPILOGUE

A detailed story of Orenda history, including its struggle for survival after the infamous cancellation of the Arrow and Iroquois projects, has yet to be written. Fortunately, however, there does exist an excellent condensed account by the late Burt Avery entitled "The Orenda History." It may be found in the second quarter 1979 *Journal of the Canadian Aeronautics and Space Institute.* Its highlights, with some of my personal recollections, are summarized below. For this bit of plagiarism I offer due apology to both Burt and the CASI.

Development of the Orenda was an ongoing process throughout its full service life and very significant improvements were made after it first entered RCAF service. In all some 3,800 Orendas were manufactured and saw operational service in the AVRO CF-100 and Canadair CL-13 (CF-86) fighters. These formed the spearhead not only of the RCAF in Europe, but also the air forces of Belgium, The Netherlands, Germany, Pakistan and South Africa.

The Orenda ranked among the three most powerful jet engines of its day at a thrust rating of 7,400 pounds. Its delivered cost was some 30% less than its British and 10% less than its US competitors. It is also worthy of record that industrial versions of the Orenda were developed and sold internationally. Some of these are still in service. One, which I saw, was returned for routine overhaul in 1995, after some 29,000 hours service operation in a Venezuelan oil refinery. On strip down it showed only minor effects from this extraordinary time in service.

The Orenda's successor, the Iroquois, was pre-eminent in performance in its day, producing, on its initial 50-hour flight qualification test in July 1957, a dry thrust of 19,400 pounds and 25,600 pounds with afterburner. The Iroquois programme also entailed design, construction and operation of an innovative high-altitude engine test facility, conceived by Keast and named the Sopwith Laboratory. It was outstanding in terms of performance capability for minimum cost.

"The Orenda ranked among the three most powerful engines of its day at a thrust rating of 7,400 pounds . ."

The sixth and all ensuing Arrow aircraft were to be equipped with the Iroquois engine. The sixth Arrow, equipped with Iroquois engines, was being readied for flight when, on 20 March 1959, ("Black Friday") both the Arrow and Iroquois programmes were summarily cancelled. Under orders from the Diefenbaker government all aircraft, engines and the leading edge altitude engine test facility were reduced to and sold as scrap. Likewise all engineering drawings and performance records were ordered destroyed. Only four Iroquois engines survived this massacre and none of the Arrow aircraft.

Although the Orenda Company was

decimated by the Arrow-Iroquois cancellation it should not be forgotten that key players in the powerhouse of creative engineering talent which reached its zenith under the leadership of Charles Grinyer, Harry Keast, Syd Britton and Burt Avery, went on to new and significant achievements. Harry Keast became a consultant to and a significant number of them joined Pratt & Whitney Canada at Longeueil. They made major contributions to development and world wide sale of P&WC's stable of gas turbine aero engines. Notable among these were Clare Eatock, Bob Sachs, Ernie Clifford, Ray Woodfield and all four of Colin Wrong, Jack Beauregard, Ken Sullivan and Dick McLachlan who became Vice-Presidents.

It should also be remembered that it was Orenda's world class Production plant, an Earl Brownridge legacy, which played a major role in the Orenda company's survival and its evolution into the successful enterprise it has become.

SUMMARY

The Orenda and Iroquois programms all stemmed from a beginning, in 1943, when Canada had neither experienced personnel nor any facilities for engine design, development or manufacture. Likewise, it had very little related supporting industry infrastructure for supply of materials and components. All these had to be created from scratch. This accomplishment stands as a truly monumental broad-scale Canadian industrial achievement.

It is important to remember that credit for these achievements belongs not only to those individuals whose names feature in the foregoing account. It is equally due to all who worked so diligently throughout the whole company: in engineering (including those at Nobel), in experimental manufacture, in flight test, in sales and service, in procurement and those among a host of suppliers.

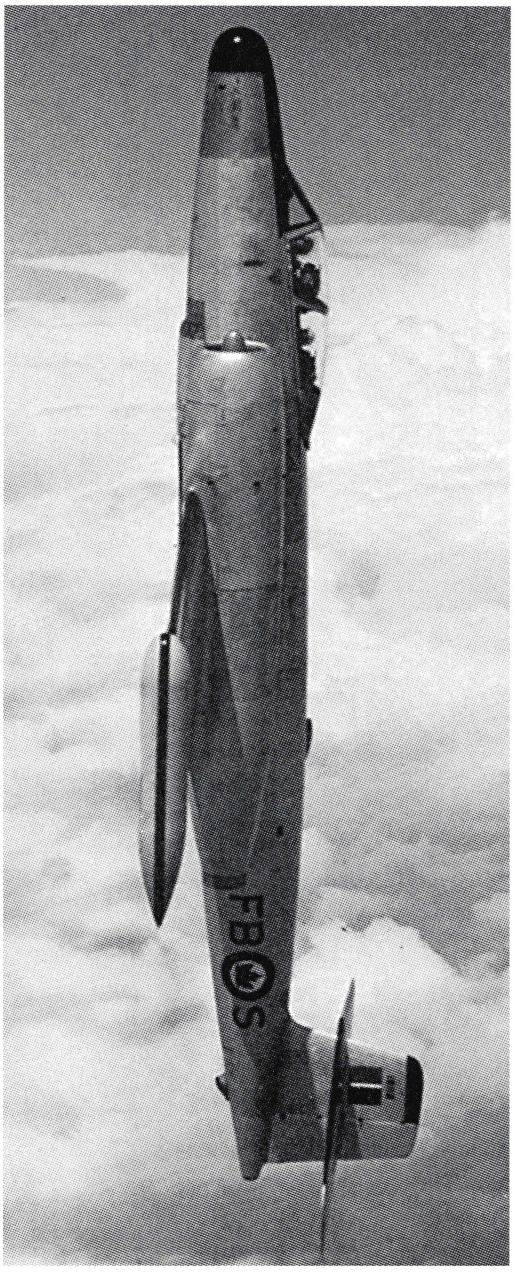
Such credit is also due to all those individuals in Avro Aircraft, Canadair and, earlier, at North American Aviation, who did such a magnificent job of adapting their aircraft for use of the Orenda engine. Last, but by no means least, was the highly cooperative and effective work by the RCAF resident engineering officers, Ray Foottit and Ed Bridgeland and test pilots. It is frustrating, in the extreme, that all these many people cannot be identified and suitably honoured. Without them, all that was accomplished in such a few short years would not have been possible.

As a final note it should be kept in mind that it all started with the RCAF initiative under Air Marshal Breadner and followed by Air Marshals Allan Ferrier and Wilf Curtis. It was their dogged determination that Canada ahould have an aero engine as well as an aircraft industry to relieve its total dependence on Britain and the USA for engines in time of war.

CONCLUSION

Historians continue to make hay over whether the Arrow/Iroquois programme should have been cancelled, or even started. Looking at the basic fact, however, that Canada had created two new world class aerospace development companies without peer, how can any rational person endorse the Diefenbaker government's actions to destroy such a major component of our country's industrial capability. That this was so ruthlessly done stands as a monument not only to stupidity, but worse, I believe, to cowardice in the face of pressure from the USA to protect its Aerospace Industry from a serious threat to its prestige and commercial interests. I find little fault in US action in this respect; only anger and sadness at Canada's pathetic lack of courage and determination to build rather than to destroy. Is this but another example of our national immaturity?

Without rancour; to the contrary; it is unfortunate that all those accomplishments have been overshadowed by the extensive publicity given to the three great aeroplanes, the CF-100, the CL-



Right: *CF-100, RCAF 18113, from CFB North Bay stands on its tail demonstrating the power of its twin Orendas.* RCAF/DND. ***Below:*** *L-R: Burt Avery, Stu Rahmer, John Brisley and Ray Joyce at Stu's retirement party. As a planner in the machine shop, Stu was a key man, devising many of the techniques for making the more difficult engine components. He also kept a most useful chronological log of events.* AVRO. ***Opposite, top:*** *an Orenda II being installed in a CF-100.* AVRO. ***Opposite, bottom:*** *Crawford Gordon, President and General manager of A. V. Roe Canada, poses with a pair of Orenda engines.* AVRO.

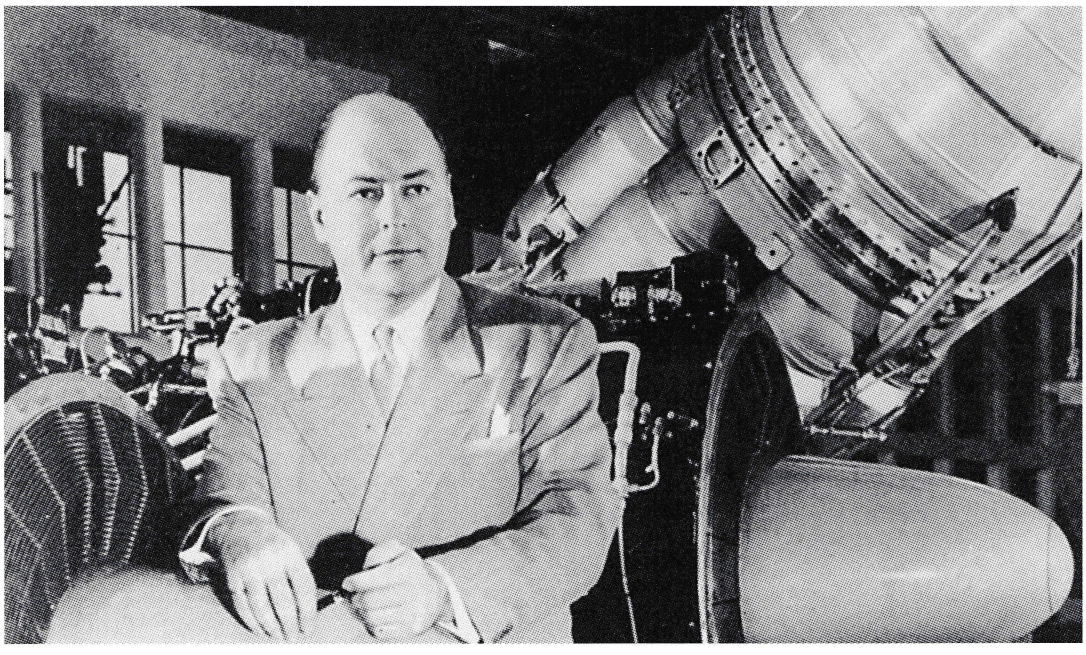
13 (CF-86), and the Arrow — all powered by engines developed by Orenda. Aeroplanes have some secret sex appeal to homo sapiens. The engines which provide their virility, do not.

ACKNOWLEDGEMENTS

For having urged me to write this account for the CAHS, I offer thanks to Don Evans, our dedicated Secretary-Treasurer of the Toronto Chapter — and my apologies for its lengthy gestation.

For his valued advice, support and editorial input, I wish to acknowledge and thank my great friend and former A.V. Roe Canada colleague, Jim Floyd.

My sincere thanks likewise go to Jim for his article on the subject in the Canada Heirloom Series Book *Visionaries* recently published, and to Charles Humber, its publisher, who kindly gave permission to use some of the same photographs.



For valued input and editorial critique I wish also to thank both Clare Eatock and Syd Britton.

My sincere thanks also to thank the following individuals and institutions:

Donald F. Parrott for historical facts concerning Will Trethewey and his discovery of the great silver mines at Cobalt Ontario;

My late sister Sylvia Hurst Brown, not only for a wealth of historical photographs which she gathered for me, including several used in this article, but also for her encouragement in its writing. Regretably, she did not live to read it.

The Rolls-Royce Heritage Trust and its Curator Richard Haigh for finding and supplying several photographs of early British jet engines;

Archives Canada for access to historical data, in particular concerning the important role played by the RCAF and especially by Air Marshal Breadner and Air Vice-Marshals Ferrier and Steadman in early Canadian initiatives to seek a solution to Canada's wartime aero engine supply problem;

In memoriam, John H. Parkin, for his courage in appointing me, a junior engineer, as a partner with Ken Tupper for the UK Jet Engine Mission.

Stewart Rahmer for access to his invaluable personal log of key events and dates, both at the CWTS and ORENDA.

Brian Lappin for the photograph of his father Bill and memorial accounts by both Rolls Royce and the RAF his outstanding record of service to both organizations as "Lp", prior to and during World War II.

Alan Wingate for providing the A. V. Roe house publications from which a number of illustrations were taken

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— Stu Rahmer's personal Log, as identified above.

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