

# ENGINEERING DIMENSIONS

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**COVER:** Biomedical engineer and APEO Gold Medalist John Smith, P.Eng., watches as the Hospital for Sick Children's Sharon Norris, Transport Team Leader, Neonatal Intensive Care Unit, places tiny Ian Barnett into a transport incubator. Dr. Smith is the hospital's Director of Medical Engineering, and designed the incubator.  
**Cover Photo—**Brian A. Kilgore

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# Bringing Down the Arrow: A 30-Year Retrospective

Our September/October feature on the Avro Arrow attracted more attention than we bargained for! It made the front page of the *Globe & Mail* on election day and was then carried in newspapers coast to coast. Several of the article's key characters were subsequently interviewed on TV. February 20 marks the 30th anniversary of the Arrow's cancellation. In this issue, we publish some of your responses to our call for memories of the Arrow.

## The Consequences

John L. Orr, P.Eng., then director of engineering research with the federal Defence Research Board, now retired, Victoria, B.C.

The cancellation of the Avro Arrow aircraft and its challenging development program had a profound impact on technological innovation in Canada, the adverse effects of which persist to the present day.

The obvious solution to the funding dilemma was to seek U.S. support for the Arrow program, based on our common concern with the air defence

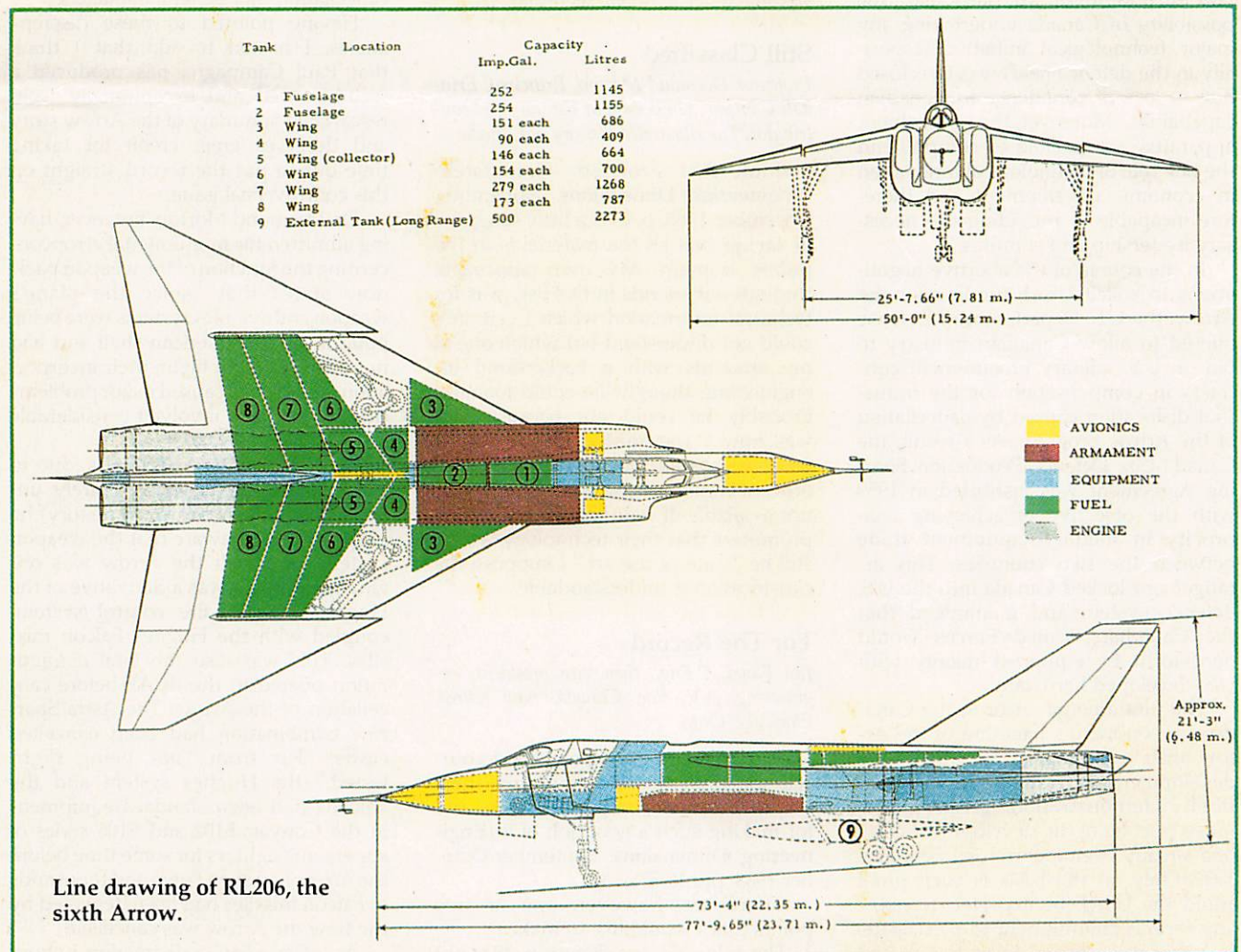
of North America. This was a realistic possibility, since in 1955 the U.S. Air Force had established a requirement for a "long range interceptor" aircraft (LRI) having similar characteristics to the RCAF specification for the Arrow issued in 1953. The LRI program was never implemented; the proponents of ballistic missiles wrongly insisted that manned fighter aircraft were obsolete.

Nevertheless, when the capabilities of the Arrow aircraft became apparent, strong interest developed in both the operational and technical echelons of the USAF. This interest was tangibly

demonstrated by the provision of access to USAF technology and testing facilities. Unfortunately, this interest was not consummated contractually before Prime Minister Diefenbaker prematurely terminated the Arrow development.

At the same time, the U.S. aircraft industry had become alarmed by the prospect that they might lose a major USAF procurement contract to Avro Canada. U.S. aircraft firms lobbied against procurement of the Arrow for the USAF in hopes that the LRI project would be revived.

Finally, when the Canadian government became concerned about the rising development costs of the Arrow, a confidential evaluation by USAF of its technical and operational capabilities was requested. It is my understanding that this task was assigned to a junior officer based in California and subject to influence from U.S. aircraft manufacturers having a potential interest in the outcome. Consequently, his report



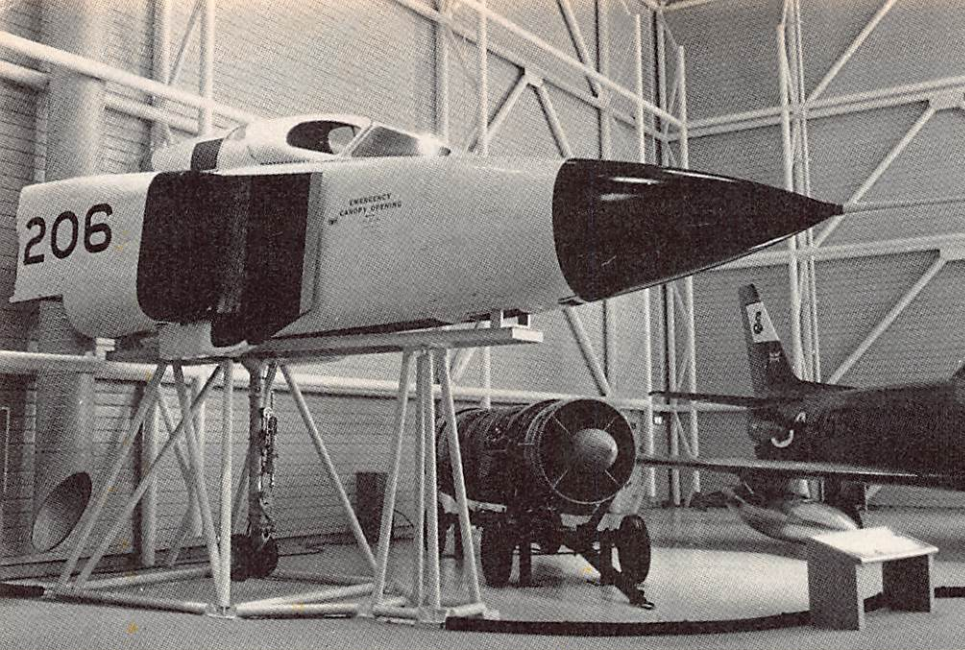


Photo: © Jeff Rankin-Lowe/SIRIUS 1988

Arrow nose section and Orenda Iroquois engine, National Aviation Museum, Ottawa.

was highly negative, but nevertheless was accepted unquestioningly by the Diefenbaker government without providing either Avro or the RCAF any opportunity to refute its criticisms.

The demise of the Arrow had a traumatic impact on government policies and public support for research and development. In particular, the possibility of Canada undertaking any major technological initiative (especially in the defence field) was foreclosed due to loss of confidence in Canadian capabilities. Moreover, the government apparatus was unable to comprehend the key role of technological innovation in economic development and therefore incapable of providing the necessary leadership and stimulus.

In the course of the abortive negotiations to solicit USAF funding for the Arrow, the U.S. Department of Defense offered to allow Canadian industry to bid on U.S. military procurement contracts in compensation for the industrial dislocation caused by cancellation of the Arrow program. As a result, the Canada-U.S. Defence Production Sharing Agreement was instituted in 1959 with the objective of achieving reciprocity in military equipment trade between the two countries. This arrangement locked Canada into the U.S. defence system and guaranteed that the Canadian Armed Forces would henceforth be equipped mainly with U.S.-developed hardware.

The fundamental error in the Canadian government's handling of the Arrow affair was its failure to pursue the development program through to feasibility demonstration, given that a major portion of the development costs had already been incurred by February 1959. Only on the basis of such proof could the USAF be expected to make any serious commitment to participate. In retrospect, the decision to proceed

with production concurrently with development substantially increased initial program costs and was evidently ill-advised. Finally, the destruction of all prototype aircraft and records was a vindictive act of vandalism which precluded all possibility of salvaging anything from our heavy investment in advanced aeronautical technology.

### Still Classified

*Professor Desmond Morton, Principal, Erindale Campus, University of Toronto, and contributor, The Illustrated History of Canada*

I think that Professor Granatstein (*Engineering Dimensions*, November/December 1988, p. 6) is a little sanguine in saying that all the material is in the public domain. My own approach, through our friends in D. Hist., was for technical information which I certainly could not understand but which one of my students with a background in engineering thought he could manage. Probably he could not because that was how I was misled on the Arrow weapons system but there were many other technical documents which were not available. If you believe the Arrow promoters that their technology would still be "state of the art," I suppose the classification is understandable.

### For The Record

*Jim Floyd, P.Eng., then vice president, engineering, A.V. Roe, Canada, now retired, Etobicoke, Ont.*

I congratulate Mr. Campagna and yourself for undertaking to address this controversial and important issue and for making such a good job of it (*Engineering Dimensions*, September/October 1988, pp. 46-53).

There are, however, one or two points that I would like to make.

1. The coloured drawing on p. 49 is not

of the Arrow! It is one of our early design studies carried out in 1953. The wing area is shown as 1,300 sq ft, whereas the Arrow wing was 1,225 sq ft. None of the dimensions in the sketch or the positioning of the avionics, equipment or fuel relate to the final configuration of the CF105 Arrow, which was also distinguished by the notch at the leading edge at mid-span and the extension of the leading edge on the outer wing.

2. On p. 52, under the heading "The Consequences," third paragraph, the article reads: "Back at Avro, the remaining 2,000 engineers continued . . ." In fact, we never had 2,000 engineers even at the peak and I think that fewer than 200 engineers were left after the cancellation.

3. Page 53: In the first of my suggested reasons for why Diefenbaker might have backed off from the Arrow project I mentioned the rising costs, but I also qualified that by saying that Avro's final fixed price of \$3.5 million for the aircraft, engines and all technical support was the "bargain of the century." I wish to make that point very firmly.

4. A couple of the titles of the Avro executives are misquoted. Joe Morley was Vice President—Sales and Service and Fred Smye was the Chairman of the Board at Avro at the time of the Arrow cancellation (not general manager).

Having pointed to these discrepancies, I hasten to add that I think that Paul Campagna has produced a well-balanced and exceptionally well-researched summary of the Arrow story and deserves great credit for taking time out to put the record straight on this controversial issue.

Dr. Desmond Morton, however, having admitted his monumental error concerning the function of the weapon pack, now states that "since the plane's weapon and avionics systems were being bought off the American shelf and had not been tested in flight, their incorporation would have caused major problems that would have involved considerable redesign."

As in his earlier statements, due to lack of adequate research, (surely unforgivable for a professor of history) he is apparently unaware that the weapon system for which the Arrow was originally designed was a derivative of the Hughes MX1179 fire control system coupled with the Hughes Falcon missiles. This was also the final configuration offered to the RCAF before cancellation of the Arrow. The Astra/Sparrow combination had been cancelled earlier. Far from "not being flight tested," the Hughes system and the Falcons had been standard equipment in the Convair F102 and F106 series of supersonic fighters for some time before the Arrow had even flown and thousands of Falcon missiles had been delivered by the time the Arrow was cancelled!

As a Canadian, a distinction I chose

almost 40 years ago, I feel privileged, humble and very lucky to have been chosen to lead one of the finest teams of engineers ever assembled in our country. Their loss to Canada can never be justified or reversed.

## Giving Credit Where Due

*Rodney Rose, unofficial historical for "The Canadians," ex-Avro employees who joined NASA, now with Rockwell Shuttle Operations Company, Houston*

In his article, Mr. Campagna is in error when he says on page 48 that "... At the time the combination of notch, droop, and leading edge extensions made the Arrow unique ..."

In fact, this combination was developed by Vickers-Armstrongs Supermarine for their "Sift" interceptor in the early 1950s—a fact I am very conversant with as I was Chief of Performance in the Supermarine Aerodynamics Department at the time! We also incorporated the best of these developments on the Supermarine N113 "Scimitar" which went into service with the Royal Navy. Incidentally, I left Supermarine to join Avro Canada, also in the Aerodynamics Department, in April, 1957.

When Mr. Campagna talks about the drag reduction on the Arrow, I'm surprised he doesn't mention the integrated intake/engine by-pass/aerodynamic ejector system used on the Arrow—again, well ahead of its time. This system placed the shock wave on the leading edge of the intake at all Mach numbers, giving maximum intake efficiency and therefore performance, while the aerodynamic ejector reduced the base drag at the back end significantly. It was really quite a system!

## Arrow Telemetry—A First

*Dennis E. Fielder, P.Eng., then a member of the Flight Test Department, A.V. Roe, now a consultant, Houston, Texas*

I think Mr. Campagna's article is as good a story as can be told in four pages and, as my memory serves, is correct. I worked at Avro in the Flight Test Department from 1955 until the infamous "Black Friday" on February 20, 1959. Then, I became part of the "brain drain reversed," and went with Jim Chamberlin to join NASA along with 23 other ex-Avro employees. It is sometimes difficult to accept that that was 29 years ago. I believe, with one possible exception, that none of those people remain with NASA, being either deceased (as is Jim Chamberlin), relocated within the industry or retired.

One item not mentioned, except in passing, was the telemetry system used to bring the flight instrument measurements to the ground test control area where the information was available in what today is often called "real time."

Other than the sensors that were distributed all over the initial aircraft, the instrumentation system, including the recorders and telemetry equipment, was located in the so-called armament bay. As I recall, two of these instrumentation bays served as the "payloads" for all the flight aircraft. To my knowledge, the test program had not progressed to the point of carrying any active armament. However, the ground development and testing of the armament pack and the deployment systems for the Sparrow IID was ongoing. In addition to these conventional weapons there was provision for deploying a weapon system then known as Genie which, I believe, had nuclear characteristics. All these systems were scheduled for flight development and qualification in the flight test program.

Whatever Dr. Morton's definition of "flawed," it seems to me that an in-production, all-weather aircraft, which in March of 1958 flew supersonic on its third test flight, and grew to a fleet of five operating aircraft with 66 test flights by February of 1959, and suffered only two landing gear problems, has to be classified as a success—even if it never carried any armament, ever!

The irony here is that the nuclear warheads for the Bomark, the then-cited NORAD missile to be deployed in Canada which (according to the infamous Honourable George C. Pearkes, Minister of National Defense at that time) pre-empted any need for such as the Arrow, were never made available in Canada.

## Designs Into Reality

*Eric A. Westall, P.Eng., then project supervisor, control surfaces and rear fuselage, on the Arrow, now retired, Willowdale, Ont.*

Congratulations on an excellent article, with correct facts as I recall, except for one minor point.

In your photograph (p. 52) you give Guest Hake a title that is misleading. Guest was head of production engineering with several project supervisors reporting to him, I was one of them.

Each supervisor was assigned sections of the aircraft, mine was control surfaces and rear fuselage. With my group of about 20 people, mainly manufacturing engineers, in those days called planners, we worked with the designers to ensure what was designed could be manufactured.

When design was finalized, we then designated equipment, tooling and methods to be used in the manufacture of components, sub-assemblies and final assembly of the sections.

Another group under Buz Gould was responsible for final assembly, the marrying-up of the sections into the complete aircraft.

The photograph must have been

taken in the very early days of the project because Guest was only with the company for, maybe, two years before resigning and returning to the United States; his replacement was a Canadian, Ron Drake, who still held the position at the cancellation.

While not in any way detracting from the credit given Jim Floyd, I have always thought there should be mention of the contribution to the design by a young Canadian, Jim Chamberlin.

In your credits you do not mention the Canadian Aeronautical and Space Institute, Ottawa. Founded in 1954 as the Canadian Aeronautical Institute, membership was only accepted from people with proven knowledge and experience in aeronautics, many Avro people were members. I was accepted in 1955, and remained a member until I retired in 1985.

## Weapons System Not Ready

*Ross W. Buskard, BGen (retired), Gloucester, Ont.*

It is true that the AIM 2 Falcon missile was originally considered, along with others, for the Arrow, but since the Falcon missile was linked to Hughes Airborne Intercept Radar, the only missile tested was the Sparrow 2. The decision to abandon the Sparrow was made by the RCAF test team (CEPE ultra west) at Point Mugu, California, not by Avro.

An operational fighter interceptor is an integrated weapon system combining engine, airframe, radar and weapon. The Arrow never was more than an airframe. As a member of the RCAF armaments test team at the U.S. Naval Missile Test Centre and directly involved in the weapons trials, it is my opinion that an integrated weapon system was at least four years away from operational capability when the decision to cancel was taken. As a result of the delays in the development of the ASTRA Radar system and the failure to integrate that system with the selected weapon, there is some doubt as to whether an operational system could ever have been attained.

I accept that the cancellation of the Arrow was a major blow to the Canadian defence industry from which it never recovered. However, as far as overall Canadian aviation is concerned, the failure to enter into serial production of the Avro Jetliner probably had a more lasting impact.

## Arrow Project Never Viable

*Professor Julius Lukasiewicz, P.Eng., Department of Mechanical & Aeronautical Engineering, Carleton University, Ottawa, Ont.*

The relative quality of an aircraft or any technology must be judged on the basis of performance. Such characteristics as range, rate of climb,

ceiling, maneuverability, endurance under combat conditions, effectiveness of the armament system are among the factors which determine the technical quality of an interceptor, apart from speed and economic considerations.

In Paul Campagna's article no data on the Arrow's performance (specified or attained) is given and no comparisons with the performance of other aircraft are made. An expectation of breaking "all speed records" is not a measure of performance.

The Arrow project, irrespective of its technical merits, was doomed for other reasons. Briefly:

- The establishment of the Avro organization was the result of aggressive entrepreneurship by Sir Roy Dobson of the parent British company. Dobson exploited the Canadian government's concern for the future of the huge wartime aircraft industry and the RCAF's

aspiration for an independent role in air defence, requiring an independent aircraft industry. The Arrow project cost Canadian taxpayers \$400 million, but Avro came through with flying colours. From 1955 on, it had diversified into manufacturing, steel and coal, and by 1958 became the third largest corporation in Canada with \$371 million in net sales. When Arrow was cancelled and cost-plus government contracts were no longer available, Avro took no risks and did not offer any financial backing for alternative aeronautical projects.

- A separate RCAF role in northern defence yielded specification for a heavy, extremely complex and expensive weapon system (aircraft, missiles and fire controls). Procurement originally forecast at 500 to 600 planes was reduced to about 100 by 1957, and the costs escalated; an armament system was never developed. The principle of

"independence" was compromised as adoption of major foreign components (missiles and fire controls) was necessary. Efforts to rescue the project through foreign sales were blocked by the same logic that led Canada to decide on the Arrow; neither the U.K. nor U.S. wished to depend on a yet to be developed foreign weapon.

- In embarking on the Arrow project, the politicians and the military, abetted by an eager contractor, did not appreciate the resources, experience and large markets necessary to pay for research and development costs. Sophisticated, expensive technologies and defence require a larger base than Canada and most countries can provide. Transnational industrial operations and military alliances (such as NATO and NORAD) are the answer. In aerospace particularly, international joint projects have become standard (such as the Tornado combat aircraft, Airbus jetliner, Ariane satellite launchers, etc.).

Canada's Arrow venture was not unique. Attempts to develop jet aircraft by Argentina, India and Egypt in the 1950s and 1960s also failed, for similar reasons. Lavi, a supersonic fighter developed in Israel, met the same fate in 1988, after an expenditure of over \$1.5 million (U.S.).

Contrary to the popular myth, the Arrow project was neither militarily nor economically viable, and its demise was inevitable. The mistake was to be swayed by notions of technological and military sovereignty, national pride and prestige while ignoring defence, financial and market realities. The mistake was not to cancel, but to start the project.

## More Economical To Proceed

Jeffery F. Briginshaw, P.Eng., Mississauga, Ont.

For most of the seven years before Black Friday, I was a project engineer in the A.V. Roe Canada Gas Turbine Division—later Orenda Engines Limited—putting 14 years' experience gained with the Rolls-Royce Aero Engine Division to work in the development of the Iroquois engine which received rather slim treatment in Paul Campagna's article, apart from the picture and caption on page 47. This engine was one of the 12 prototype/pre-production models which were bench-tested extensively to prove the design and continuing modifications to improve performance and reliability. All these objectives were achieved through the experience and dedication of all concerned, until the Arrow cancellation.

Much of my last year at Orenda (1958-1959) was spent in two areas: marketing research and proposals for other gas turbine applications, in the

(continued on page 55)

## Arrow Cancellation Backfires?

White House, Office of the Staff Secretary: Records; International Series, Box 2, Folder "Canada (2) (Sept. 1959-May 1960)".

May 27, 1960

### MEMORANDUM FOR DEPUTY SECRETARY OF DEFENSE

SUBJECT: Combined Procurement with Canada of F-101B and CL-44 Aircraft

1. As we have recently discussed, we have under very serious consideration an arrangement on the above subject which should prove to be of maximum benefit to both the United States and Canada. I believe that our defense position can be greatly enhanced while, as part of the same transaction, we will be able to make a substantial step toward our MATS modernization goal.
2. The proposal is that the Canadians procure 66 F-101B aircraft, now in U.S. inventory and procured with funds from previous fiscal years, for approximately \$105 million. As part of the transaction, the USAF would procure 35 CL-44 aircraft for \$155 million to be assigned to MATS to meet requirements for immediate modernization prior to procurement of the SOR aircraft. On a strictly FY 1961 cash basis, the U.S. would obtain 35 CL-44 aircraft for \$50 million, which is \$1.4 million each. This compares with a figure of \$4.4 million each, the actual program cost including spares.
3. From our point of view, modern interceptor aircraft will be deployed as far north as practicable with very significant gains to North American defense as an immediate benefit. In addition, the interim modern aircraft needed so badly in MATS, can be obtained on a much more economical basis than is otherwise possible.
4. There are also some significant related benefits to be realized. As I have previously mentioned, a sensitive political situation has arisen in Canada due to a series of events involving the CF-105 cancellation in favor of Bomarc and Sage joint procurement with the U.S., followed by reductions in Bomarc and Sage super combat centers. In addition, the production sharing program initiated 18 months ago has not produced the expected results from the Canadian viewpoint. The exchange-procurement discussed above presents an ideal opportunity to improve this situation while simultaneously attaining a significant benefit to the United States. In this regard, it is important to note that neither procurement would be likely to take place without the other also being made.
5. This suggestion has been given to the Canadians informally and their reaction is expected when their Prime Minister visits the President next month. The proposal is also subject to Congressional approval.

John V. Charyk  
Acting Secretary of the Air Force

## Bringing Down the Arrow

(continued from page 36)

interests of diversification and involvement in the negotiations with the then Department of Defence Production on the Iroquois aspects of the Arrow program, in cooperation with what had become our "sister" company, Avro Aircraft.

It is in this latter role that I would take issue with J.L. Granatstein's statement: "The Chiefs of Staff killed it here because it cost too much. . . ." Even as early as September 1958—when the writing began appearing on the wall regarding the Arrow's possible demise—about 70% of the *total* cost of the Arrow program, which included six squadrons of Arrows in service with the then Royal Canadian Air Force, had already been spent. In other words, we were past the "point of no return" and it would have been more justifiable economically to proceed. Senior DDP officials were in complete agreement and encouraged us to believe that a favourable decision would be taken . . . just a few days before Black Friday!

Why, then, the cancellation? Politics: U.S. pressure and a lesser-known, seldom mentioned personality conflict between two of the leading members of the cast, both now deceased: John Diefenbaker, Prime Minister, and Crawford Gordon, President of A.V. Roe Canada. Their notorious meeting in the P.M.'s office on September 17, 1958 may not be a matter of public record but is still recalled by contemporary Ottawa mandarins who claim the altercations could be heard from the next block!

John Diefenbaker's resulting "vindictiveness" is exemplified by his personal insistence that all the prototype Arrows be blowtorched and the scrap metal disposed of by the Crown Assets Disposal Corporation—2,785 tons of exotic, sophisticated scrap for \$304,370!—and that all photographs and documentary evidence of the Arrow's existence be destroyed. It could be said that the only person in Canada to benefit from the cancellation was the Hamilton, Ontario, junkman Morris Waxman of Sam Lax Bros.! Our American cousins benefited by selling us both Bomarc missiles (which soon became obsolete) and their McDonnell Douglas-built Voodoos (christened the CF0101 by the RCAF).

What happened to all the people involved? A group of aircraft designers under Jim Chamberlin joined NASA; other airframe personnel went to Boeing in Seattle, Washington, and other aircraft companies in California. Several of us engine people were almost immediately offered jobs by General Electric in Cincinnati, Ohio, and Pratt & Whitney in Hartford, Connecticut—at almost twice our Orenda salaries—

but most declined for patriotic reasons; others went to Pratt & Whitney in Longueuil, Quebec; still others, like myself, adjusted to the realities of defence and put our talents to work in Canada in the fluid handling field. I retired two years ago after 15 years with Ontario Hydro, involved with process systems for nuclear and conventional generating stations.

But for philatelists and other interested parties, the Arrow still exists: in the 5¢ postage stamps issued on February 23, 1959—only 3 days after the cancellation—to commemorate the 50th anniversary of J.A.D. McCurdy's

first flight in the Silver Dart at Bras D'Or Lake near Baddeck, Nova Scotia, the undersides of three Arrows are clearly visible. Obviously the Post Office had not been advised to destroy this "record."

A footnote regarding K.M. Molson, (*Engineering Dimensions*, November/December 1988, p. 6): Ken was too modest to record that he was almost single-handedly responsible for establishing at Uplands, Ottawa, what is now The Aviation and Space Division of the National Museum of Science and Technology and the National Aeronautical Collection.

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