ZURA TALKS ABOUT THE ARROW

By JAN ZURAKOWSKI

famed test pilot needs no introduction to our readers. On the 20th anniversary of the death of the Arrow his talk to the Canadian Aviation Historical Society says it all!

I will try to present to you my impressions as test pilot during what probably were the most exciting times of Canadian aircraft industry — 1949 to 1959.

Let me begin a few years before that period.

Close to the end of the war, when a victory was only a question of time and my superiors were trying to push me from operational flying into a staff job in London, I discovered that there was a place for one Polish pilot in the Empire Test Pilot's School. I put my application in, was accepted and started to learn to be a test pilot.

After a year's course I was posted to the Aircraft and Armament Experimental Establishment in Boscombe Down where I had the opportunity to test most of the Royal Air Force fighters, Fleet Air Arm aircraft and American Navy fighters.

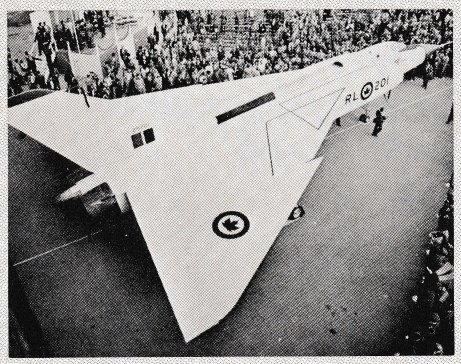
Two years later I left the Royal Air Force and accepted the position of experimental test pilot in Gloster Aircraft Company in England dealing mainly with the development of the Meteor, twin-jet interceptor aircraft.

The Meteor was first flown in 1943.

Five years of experimental testing taught me not to accept much at its face value, to doubt nearly everything until proven and to respect evidence and the importance of collecting flight test information by special instrumentation.

To the end of 1955 about 3500 Meteor aircraft were produced in more than ten variants and about 600 aircraft were exported to seven countries.

In the meantime the design of a new interceptor was progressing and in Nov. 1951 a prototype of the Javelin made its first flight. This aircraft was of "modern" design having delta type wing shape, but conventional tail.



The clean lines of the Arrow would impress even the layman.

On evidence of wind tunnel tests it became obvious to me more than 2 years before the first flight that longitudinal instability was present in the Javelin at lower speeds.

I was faced with a difficult problem. Urgent modifications were required, but control of the flight test program was in the hands of the Design Office which did not want to face the facts and the flight test stability program therefore called for stability measurement within only the stable range of speeds.

During one of the flights I decided to check the low speed range. It did not look safe so I climbed to 30,000 ft. and started slowly reducing speed. I reached conditions when the tailplane setting fully up, elevator fully down (both controls in diving position) the aircraft was still climbing, finally stalled and went into a spin. Spin recovery was satisfactory.

Of course, after this experience, I made it clear to the Design Office, that stability of the aircraft was unsatisfactory as proved by the flight recorder.

Unfortunately, the Design Office had the authority to issue the final flight report. Not all the evidence from the recorder was included and the only comments were, if I remember correctly: "Pilot investigated the stalling characteristic of the aircraft and height lost in recovery was recorded". There was no mention of extreme instability or spin.

This report convinced me, that I was wasting my time at Gloster and this conclusion accelerated my move to Canada.

Why Canada? Canada was a young country with high development potential, A.V. Roe Company were flying the Jetliner first jet transport on the American Continent and first Canadian twin engine jet interceptor.

I had flight testing and development experience on fighters so I could be useful, besides, I hoped for a good future for my two sons.

On April 21 1952 I landed in Canada and the next day I started work as experimental pilot for A.V. Roe at Malton.

The Toronto Telegram reported: "The 37 year old Zurakowski is small and balding and looks like anything, but a test pilot".

Another newspsper quoted me as follows: "One of the reasons why I came to Canada is because there is obviously a great future ahead for Canadian aviation. This country is now at the beginning of tremendous developments in this field. We have all the basic requirements for an aircraft industry: hydroelectric power, such raw materials as aluminium and we are close to the U.S.A. development, tooling and mass production methods. Provided Canada plans on producing for world markets, there are splendid sales opportunities for our aviation products".

I started work on the CF 100. This was the first interceptor aircraft designed and built in Canada. Built to the requirements of the Royal Canadian Air Force for the defence of Canada.

Requirements: Two engines for safety of flying in the North, crew of two, heavy armament, high speed and high ceiling and ability to intercept at night and under all-weather conditions.

I think, the CF 100 was the best design compromise at the time.

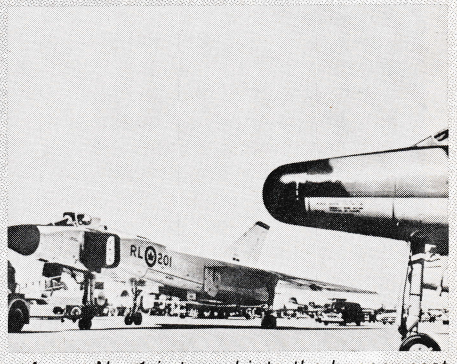
The Flight Test Section was under Mario Pesando, a very experienced engineer, with a clear, practical approach to any problem and, believe me, we had enough problems.

This small group of Flight Test observers and test project engineers was most enthusiastic and it was a pleasure to work with them.

Peter Cope, the experimental test pilot who arrived from England sometime ahead of me, was an excellent reliable pilot and helped me a lot by introducing me into the new organization.

In the experimental hangar undergoing all sorts of trials were the prototype CF 100 MK I with Rolls Royce Avon engines first flown on January 17 1950 and a few CF 100 MK II and III — a MK IV prototype was expected to be ready for first flight in a few months.

Meanwhile the Jetliner prototype with



Arrow No. 1 is towed into the hangar past several CF-100s.

Chief Test Pilot Don Rogers was somewhere in California with Howard Hughes, powerful personality in Trans World Airlines, who was gaining experience on jet aircraft and investigating the introduction of jet passenger transport.

Flight development work was very similar to that I carried out at Gloster on the Meteors and Javelins.

Let me give you three examples of the problems experienced in our flight test program:

First example: Diving speed.

The CF 100 had a maximum design speed of .85 M.N., but its level speed at high altitude was slightly faster. I asked experts what will happen if a pilot accidentally exceeded this speed? The answer was, that wind tunnel tests indicated that the aircraft could be uncontrollable and that besides Pilot's Notes clearly showed .85 M.N. to be the limiting speed.

For me, this answer was not satisfactory. The CF 100 was an all weather and night interceptor and if the pilot was not careful he could be past aircraft limitations in no time.

I considered it my duty to investigate behaviour of the aircraft at higher speeds and if dangers were discovered to recommend some action. With instrumented aircraft I ran a series of dives at high altitude, checking recorded results between flights. Finally I reached 1.08 Mach Number indicated in a dive at full power. A sonic boom on the ground confirmed surpassing the speed of sound. Behaviour of the aircraft was satisfactory.

The Flight Test Dept., Company Management and the Air Force were delighted, but to the Design Office, I discovered I was enemy No. 1.

Previously without the knowledge of either the Flight Test Section or the pilots, the Design Office had prepared a proposal for the R.C.A.F. recommending extensive redesign of the CF 100 by decreasing the thickness of the wings, sweeping them slightly back and increasing their area — all this mainly to obtain a maximum diving speed of .95 M.N.

The R.C.A.F. investigated the proposal, but when the MK IV reached the speed of sound and expensive improvements were expected to show lower performance, the proposal was rejected with some sharp remarks.

After this, there was hope in the Flight Test Section that the Design Office understood that cooperation with Flight Test Section and Pilots was necessary for future development.

Unfortunately the Design Office took a different view. A decision was taken to safeguard the Design Office from unexpected flight test results, by controlling the program of every flight test.

Example No. 2.

A heating and air conditioning system was designed for the CF 100. Specification was raised for manufacture of a unit delivering a specified amount of air per minute at a specified temperature and engine speed. The aircraft was instrumented to this system and flight tests were carried out according to the Design Office program. The Design Office technical observer was very happy. The system delivered everything as designed and in spite of my objections considered the results as satisfactory.

From my own experience I was sure that the system was poor. The cockpit heating/air conditioning system was designed for maximum cruising power (very close to maximum power) at the highest altitude, but at the most economical cruising speed engine power was so low that the temperature in the cockpit was around the freezing point.

I managed to squeeze in one more test. Before the flight, however, I secretly put on two sweaters and two pair of thermal underwear without saying anything to my satisfied observer.

After a one hour cruise my observer was so stiff from cold that upon landing he had to be pulled out of the cockpit. After a half-hour defrosting he agreed that the system required considerable improvement.

Example No. 3.

One of my last flights at Gloster was for canopy jettison on the two seater Meteor MK 7.

During jettison a canopy of about 160 lbs. and more than 6 ft. long had to be lifted by the airstream, pivoted at the rear hinge and after reaching about 30° was disengaged automatically and made to pass clear over the tailplane. The test was recorded from another aircraft by cine-camera.

The CF 100 had a similar size and shape of canopy, but to my surprise the hinging pin at the back of the canopy was a bolt 1/8 or 3/16" thickness when on the Meteor it was ½ inch.

Because the cabin of the CF 100 was pressurized I expected loads to be much higher so I suspected that something was wrong. I was assured that ground tests were satisfactory, but when a test report could not be produced, I requested a test.

More than twenty ground jettison tests were carried out, but results were not too satisfactory. Somebody arrived at the conclusion that ground simulations of the air loads are not representative enough so the only answer was to test the system in the flight.

I was sure that if something does not work on the ground it was unlikely to work in the air, but we started jettison tests.

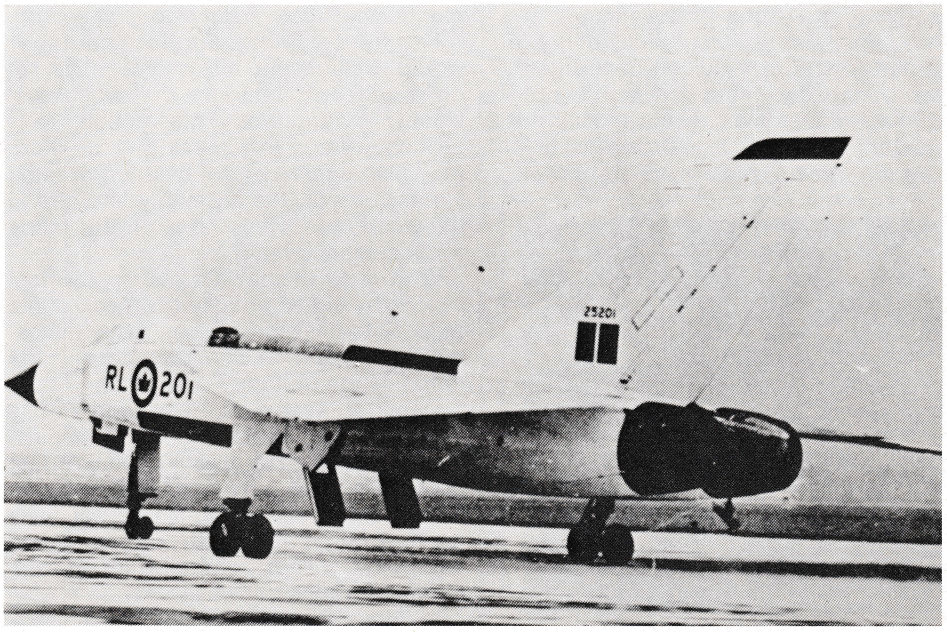
I jettisoned more than ten canopies over Camp Borden. The system was modified step by step, but results were not satisfactory and it was considered too risky to try at higher speeds.

One day I was sent to Los Angeles for a three day course about new missiles. I was surprised that the course was about storing and maintenance of Falcon rockets.

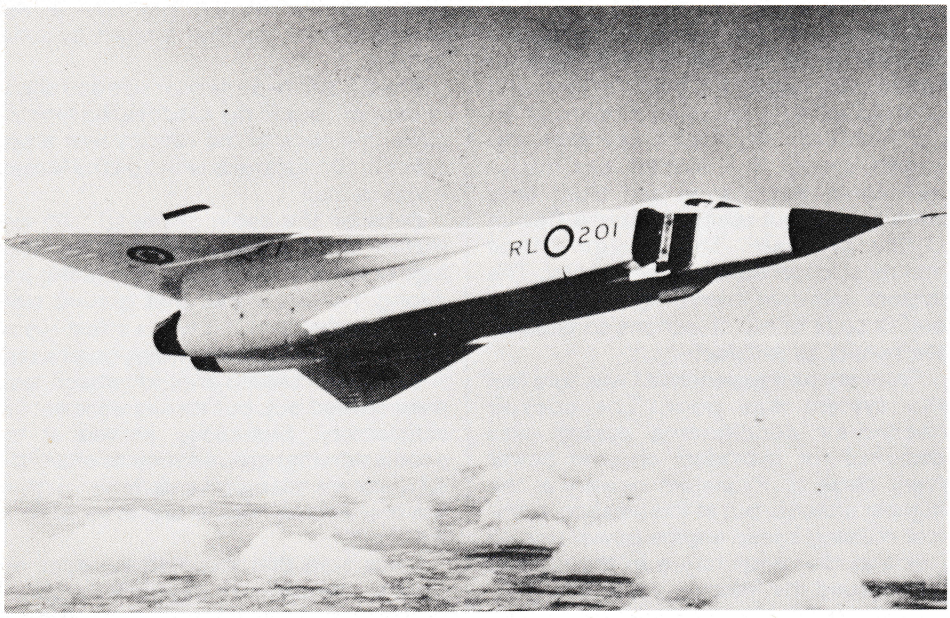
On my return to Malton I was informed that in the meantime a meeting was held between representatives of Design Office and the Air Force: Canopy jettison was presented as satisfactory, the Air Force was convinced and agreement was reached that no more work was needed.

I lost a battle. My own opinion was that Canada being a rich country can afford a higher safety for flying crew.

ALL PHOTOS FROM MURRAY PEDENS "FALL OF AN ARROW"



The Arrow taxies past with the rectangular panels of its speed brakes extended.



Maybe these battles were useful. On the new design Arrow, the crew emergency escape system was developed to a very high standard, for a much more wider range of speed. For cockpit air conditioning a ground testing rig was built to develop and prove the system and I had no serious problems during flight.

I would like to stress here that because I am making critical remarks about some features of design or some persons, I was fully aware of the problems facing Design Office and on the whole I was very impressed by the work done.

At other companies I observed test pilots lacking in critical approach and overly enthusiastic about their Company's design. Everything was fine until the aircraft was sent into service and pilots started killing themselves or the aircraft was grounded or just rejected by the Air Force Testing Establishment.

An experimental test pilot is not a popular person in a design department. Most of the designers are highly optimistic about their own design and it is not a pleasant task after a flight to explain or to prove that their optimism is not justified.

Avro Aircraft hangars at Malton.

Quite often the reaction of a designer is to say that everything is excellent, that the pilots are simply too "fussy' or that they want to have their own way or that they have the "primadonna complex".

But if everything was so excellent why then for example did such a successful aircraft as the Meteor require more than 1500 airframe modifications during its development and more than 500 engine modifications of which about 30% had to be developed and proved in flight?

Maybe because of the continuous effort to improve the Meteor and its engines, the speed and ceiling of the aircraft was increased by more than 20%, range and armament doubled with continuous improvement of reliability. Four Gloster Aircraft Co. pilots lost their lives on this work.

In a production department the experimental pilot again is not a popular person.

Nearly every production manager would like to set up his assembly line, set up a schedule and run the production smoothly without any interruption. He is furious when every week five or more modifications have to be incorporated somewhere on the assembly line and in the worst case when the aircraft is ready for acceptance flight.

Who is to blame? Of course the test pilot. Why did he not discover the trouble before? Is the modification really necesary? Why did it take so long to prove the modification in flight? And so on.

Dept. of Technical Sales and Public Relations was usually the only department which was not always cross with test pilots. But when priority was given for an urgent development flight and not for a demonstration of an aircraft for some important or not so important guests, relations were strained quickly.

In September 1952 A.V. Roe Company purchased a jet engine plant at Malton from the government — later known as Orenda Engines.

I would like to mention that the Orenda engines in the CF 100 and the Sabre due to their high reliability and serviceability were a great asset in speeding up the development flying.

In 1956, if I remember correctly, the Royal Canadian Air Force sent four CF 100's to the U.S. for comparative armament trials at Elgin Air Force Base.

The tests were carried out by U.S. Air Force crews. During our visit there one of the American officers said to me: "your armament is the best we have ever tested, but actually I want to congratulate you Canadians on the design of your engines: simple in operation and reliable".

1954 was an unlucky year for me. The Air Force requested an investigation into heavier armament for the CF 100 and a proposal was put forward to install another 50 rockets in the fuselage in a special pack

which would be lowered for a fraction of a second to fire rockets followed by immediate retraction.

Initial tests indicated that lowering of a square pack produced very strong vibrations, buffeting of aircraft and strong change of trim.

The Engineering Division insisted on measurement of stability at all speed ranges with the pack up and down, so that an automatic correction system to the controls could be designed to eliminate any change of trim occuring at the critical firing moment.

During one of these tests an unexplainable explosion occurred at 5,000 ft. in the rear of the aircraft which locked the flying controls in a position that forced the aircraft to turn and dive. I jettisoned the rocket pack and prepared to abandon the aircraft. After jettisoning the canopy I heard another explosion and assumed that my observer John Hiebert had

ejected. Now I used my own seat ejection. When the parachute opened I realized that my right ankle was probably fractured. I landed on my left foot on a hard field near Ajax.

In the hospital I learned that the second explosion was not the ejection of my observer but rather another explosion which probably damaged his ejection mechanism or incapacitated him. He was killed in this crash.

My impression was that the cause of the accident was probably ignition by an electric spark of fuel spilled in the rear fuselage from fractured fuel lines due to excessive vibration of the aircraft with the rockets pack down.

The Daily Press stories that I was trying to save populated areas by directing the aircraft to open fields have no relation to the facts. After the first explosion I was unable to move the controls even a fraction of an inch.

My second accident in 1954 was a bit strange. After a routine experimental flight on the CF 100 I realized during my landing run that the undercarriage was retracting. Since my speed was too low to get airborne again I switched off the engines and the aircraft skidded to a stop damaging the flaps badly.

After an investigation had been carried out in the hangar it was detemined that everything was in perfect order: lowering and raising of the undercarriage functioned properly and the indicators were correct. Conclusion: pilot's error.

I was called to the hangar to see for myself. I set all controls and switches as I had during landing. I operated the undercarriage several times and sure enough everything was just fine.

I was getting out of the cockpit when the foreman said: "you see that's a really good old aircraft" — and enthusiastically slapped the fuselage with his hand. That started it. All by itself the undercarriage retracted.

It was later established that somehow the wiring of the master auto-observer switch was mixed up with the undercarriage selector wiring and that a short caused by the vibration of the aircraft as it touched down caused the undercarriage to retract.

Too many "Gremlins" — that was how a case like this would generally be described in England!

In the meantime, production of the CF 100 and the Orenda engines was going at a good pace. The aircraft had a good name in Canada and abroad and the Avro Company decided to demonstrate the aircraft at the Farnborough Show organized every second year by the Society of British Aircraft Constructors.

I demonstrated the CF 100 MK. IV at Farnborough in 1955 and we made an attempt to sell the aircraft in Holland and Belgium.

The Dutch Air Force had a rather poor fighter aircraft from the U.S.A. and needed a replacement but they didn't want to upset their American friends.

The Belgian Air Force had had a bad experience with American aircraft so they purchased the Hawker Hunter from England. The Hunter was in its early development and the cost of essential modifications in the first year was higher than the original cost of the aircraft.

In night fighter class the Meteor NF 14 in the Royal Air Force was inferior to the CF 100 in range, speed and armament and the Gloster Company was still solving low speed instability of the Javalin by redesigning the wings, but the loss of two pilots and an aircraft was delaying development.

We were in a favorable position and a contract for sale of 53 CF 100 MK. V was signed with Belgium.

F/L Jack Woodman, RCAF

In the Canadian Aviation magazine dated March 1975 I noticed the statement that sales to other countries were restricted for security reasons because the CF 100 was equipped with the Hughes radar produced in the United States.

Small comparison:

Between the first flight of the Javelin and the first Javelin in a squadron there elapsed over six years.

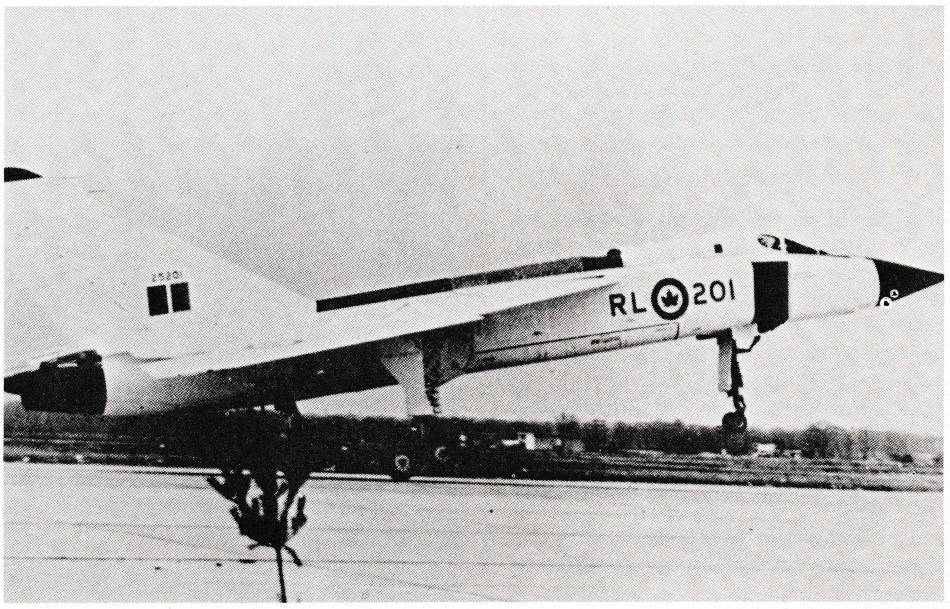
The CF 100 MK II took less than two years.

For MK IV less than four years.

Looking back 20 years, I think that the CF 100 was a very good and reliable aircraft which at the time satisfied the operational requirement of the Air Force.

Taking into account that it was the first military aircraft designed and built in Canada by a very young company I think it should be considered a great success.

In August 1955 the U.S. Air Force announced a contract with Avro Aircraft to explore "a new design concept" — later known as a flying saucer. "Spud" Potocki was the development pilot on this project whereas I was concentrating on the development of the Arrow.



The idea of a supersonic interceptor, known later as the Arrow, started in 1951 when the A.V.Roe team under Jim Floyd submitted a brochure to the RCAF containing three proposals for supersonic fighters. In March 1952 an operational requirement was received from the R.C.A.F. for an All Weather Interceptor. In June 1952 the Company presented two proposals: single and twin engine delta wing interceptors with crews of two.

Air Marshal Hugh Campbell, Chief of Air Staff, RCAF, 1957-1962. Air Marshal Campbell, and his Deputy, Air Marshall C.R. Dunlap, were both convinced of the necessity of retaining manned interceptor aircraft as an element in a balanced defence force. Air Marshal Campbell fought against cancellation of the Arrow to the bitter end.

In June 1953, after long consultations with the Air Force and the National Aeronautical Establishment, the Company presented the CF 105 proposal and obtained instructions to go ahead with design study.

A series of wind tunnel tests followed at N.A.E. Ottawa, Cornell Aeronautical Laboratories in Buffalo and N.A.C.A. in Cleveland and Langley Field. Simulation of free flight at supersonic speeds was carried out by rocket propelled models.

Later in 1954 changes in the proposed power plant were made. Because Royce Rolls R.P. 106 development was delayed and Curtis Wright J67 was expected to be too late, as well so the installation of a Pratt & Whitney J75 as an interim measure was accepted and the Orenda Iroquois engines were intended for production models.

As design investigation progressed it became apparent that there were new problems connected with the increase in speed from Mach N. .87 of the CF 100 to more than 2.00 M.N. of the new interceptor. This increase of more than 750 m.p.h. called for a lot of electronic systems needed for successful interception, dealing with automatic flight, weapon fire controls and navigational systems.

I would like to point out that during the five years of the war, a time of most intensive development, the speed of Royal Air Force fighters increased only about 100 mph.

We, in the Flight Test Section, hoped that we would be part of the team and participate in the solution of problems which we would have to face sooner or later.

There was a rumor that the directional stability of our new aircraft was poor and at this time a number of American fighters desintegrated in the air and some designs were quickly modified to provide a bigger fin area.

We asked Design Office for aerodynamic reports. We met with refusal because "there could be a wrong interpretation of the reports by the pilots".

I asked my Chief Test Pilot Don Rogers for help, but when his efforts were stalled, I tendered my resignation as the Chief Development Pilot. This title created the impression that I was to some extent responsible for development — but how could I be, if I was kept in the dark?

It came to the attention of Jim Floyd — Vice President Engineering that the latest estimations of landing speed of the Arrow were much higher than the initial ones, so a meeting was called of aerodynamic experts and I was invited. After a short discussion he asked me what I thought about it. My answer was that I did not know because my request for reports had been refused. It was a bit of a shock to him because he had previously instructed that reports be made available to the Flight Test Section. After this, one of the aerodynamicists refused once again to supply reports. He was promptly fired and the next morning all required reports were in the Flight Test Section.

Yes, there was a problem with aircraft directional stability under some flight conditions.

Which solution was right?

First: To increase stability by aerodynamical changes which would involve a weight penalty without any guarantee that all the flight conditions would be satisfactory.

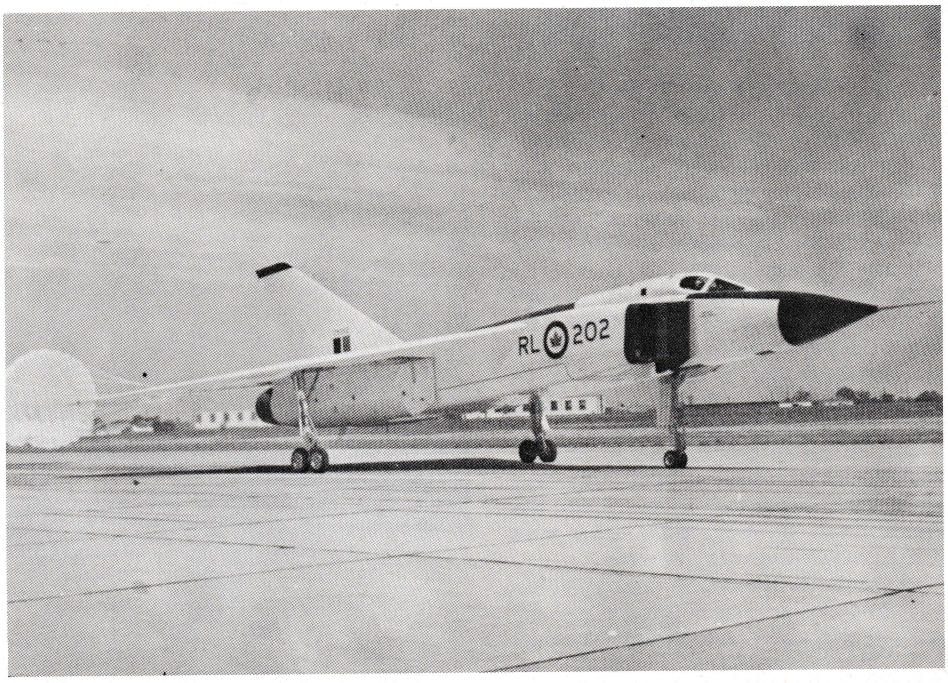
Second: Introduce reliable electronic stability augmentation needed anyway for the weapon system.

The latter choice was made but it involved the risk of developing and proving the system on an aircraft otherwise unsafe, under some conditions, if the system failed.

Loss of an aircraft in early development would be a disaster for the Company.

Cooperation, of the other sections with Flight Test Section was good. Freshly introduced human factors engineers helped in finalizing the cockpit layout. The number of instruments, switches etc. was reduced in the Arrow to 70% of that in the CF 100 and a master warning light was introduced with a panel indicating the trouble.

A Royal Canadian Air Force detachment was established at the Company



under S/Ldr. Ken Owen with F/LT. Jack Woodman, a highly experienced test pilot. This detachment was most useful in an advisory and crosschecking capacity.

The problem we had with wheel brakes can best illustrate the necessity of a crosschecking system.

An engineer was instructed to write the specifications for wheel brakes for the Arrow. Standards specifications at the time, if I remember correctly, required brake capacity to have kinetic energy absorption equal to 1.2 stalling speed squared multiplied by the aircraft landing weight. Checking by phone he got his figures: stalling speed quoted was completely unrealistic for use in estimation of landing speed. Wings of 60° degrees delta reach stalling speed at an angle of attack of about 45° degrees, when during landing the geometry of the undercarriage does not allow use of more than about 15°.

The specification went to the sub/contractor and after the necessary design, development and proving time, the wheels arrived, the brakes were found to be completely inadequate for the aircraft, especially since in the meantime the aircraft weight was increased.

A crash program to develop new brakes was required to prevent delay in the flight testing.

The Flight Test Instrument Section was developing a system known as telemetry which would provide in flight information consisting of a large number of parameters transmitted automatically to the ground. This system increased safety of the flight, helped to warn the pilot, if he was approaching a limiting stress or other limiting conditions and could be of high value if an aircraft crashed or desintegrated in unknown circumstances.

With the help of an I.B.M. 704 computer a flight simulator was created using as many parts and systems from the aircraft as possible. Designers were very optimistic, promising to teach the pilots to fly the Arrow.

Unfortunately the simulated aircraft was very difficult "to fly". I lost control of it in 3 seconds and Spud Potocki who was much better on instrument flying managed to fly 11 seconds before crashing.

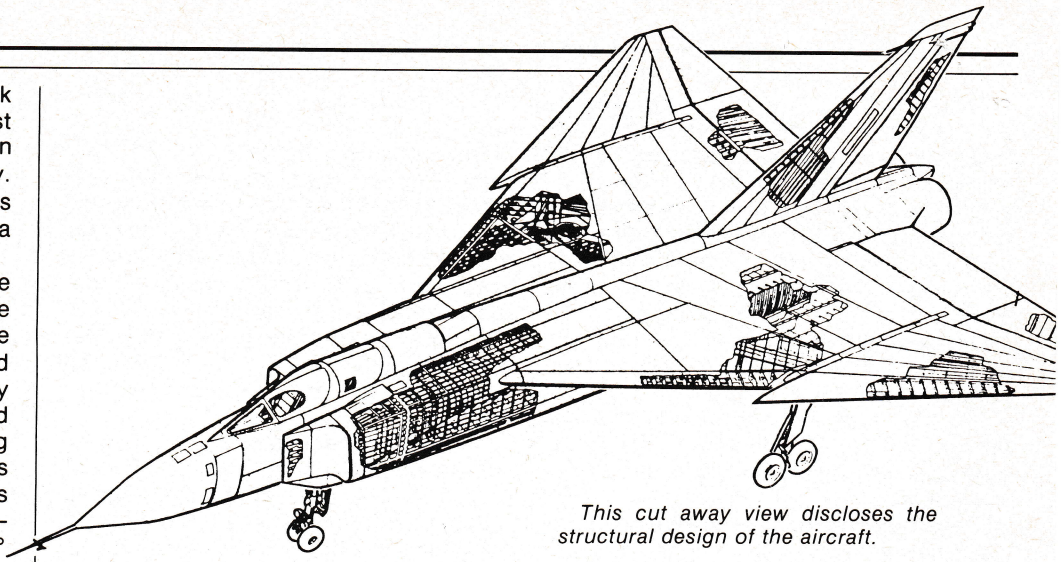
On an actual Arrow I was completing taxying tests in preparation for the first flight. An unpleasant situation was created: if the simulator is unflyable is the aircraft safe for flight?

A specialist from the U.S.A. was called to assess the situation but he was not very optimistic.

What next? — To develop this simulator to flyable conditions or to fly the actual aircraft?

I recommended disregarding this simulator for the time being and to go ahead with the first flight.

It turned out later that there was much more to the art of simulating a flight than just feeding parameters into a computer and transmitting the results into cockpit instruments.



This cut away view discloses the structural design of the aircraft.

The first flight of the Arrow on the 25th of March, 1958 was very simple. Just check the response of controls, engines, undercarriage and air brake operation, handling at speeds up to 400 knots and low speed in a landing configuration.

Certainly there was more excitement for the several thousand AVRO employees watching my first flight than for myself seated in the cockpit trying to remember hundreds of do's and don'ts.

The aircraft flying characteristics were similar to that of other delta wing aircraft like the Javelin or Convair F-102, but the Arrow had a more positive response to control movement.

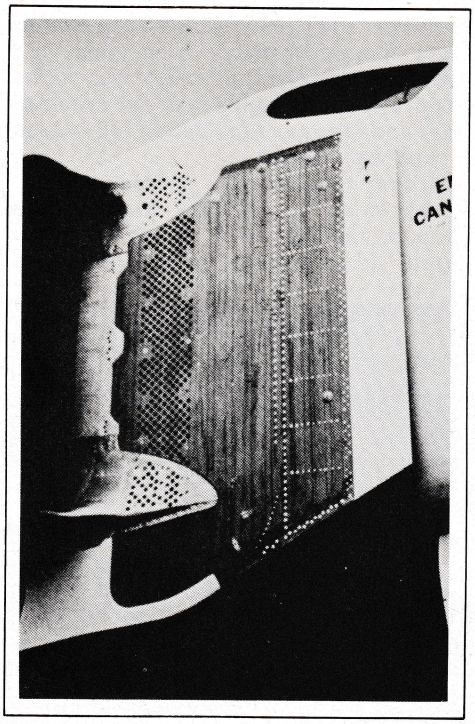
The unpleasant part of my first flight was the feeling of responsibility combined with the realisation that the success of this aircraft depends on thousands of components especially electronic and hydraulic with only a small percentage under my direct control. But total responsibility for the flight was mine.

Flight by flight with ground monitoring based on telemetry results, I was going a bit faster and a bit higher.

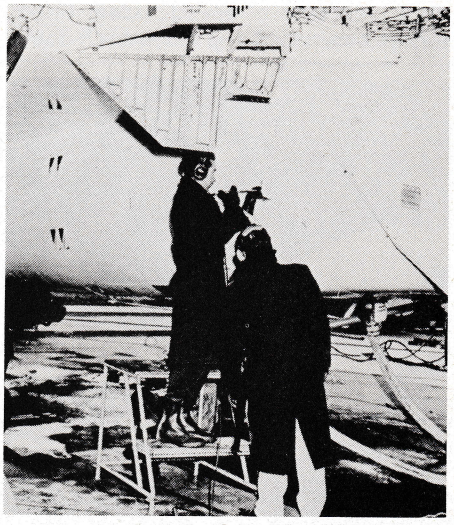
On flight No 7, climbing at 50.000 ft, I exceeded 1000 mph and that was the only performance released by Air Force Headquarters.

Phase one of the Arrow Flight test Program was successfully completed and F/LT Jack Woodman made a familiarization and initial assessment flight.

In August the same year I started tests on a second prototype No 202 and in September on the first flight of the third prototype No 203 I exceeded the speed of sound.



The fixed geometry inlet ramp of the Arrow is clearly shown here. The chisel-edged style of the 12 degree intake ramp is apparent, as are the perforations on its face, the latter comprising a form of boundary layer bleed.



Servicing the Arrow after a test flight. Ease of maintenance had been an important objective in the design of the Arrow.

Shortly after, Prime Minister John Diefenbaker in a statement released to the Press declared that two Canadian bases for U.S. Bomarc missiles would be established and the current development program on the Avro Arrow and Oranda Iroquois engines will continue, but that the program would be reviewed next March.

Development flying was speeded up when "Spud" Potocki and Peter Cope joined in testing.

For me time to retire from testing arrived! — Normal retirement age from high speed flying was 40 years and I was already 44.

I was leaving experimental flying in good hands.

"Spud" Potocki, Peter Cope and F/LT. Jack Woodman were all excellent pilots, already with some experience on the Arrow.

I moved to Engineering Division as staff engineer.

"Spud" Potocki did the first flights on two more Arrows: Number 204 and 205 increasing the number of test aircraft to five.

Testing was progressing well but was slowed down by two accidents:

In the first one I was involved. During a landing run on 201 I suddenly realized that the aircraft was pulling to the left and I could not maintain direction. Suspecting that the braking parachute did not open evenly I jettissoned it: there was no improvement and at about 30 mph the aircraft left the runway and the undercarriage collapsed in the soft ground.

On investigation it was established that the left undercarriage leg did not complete the lowering cycle and during the landing run the wheels were at about a 45° angle to the direction of movement producing a higher drag than the power of the brakes on the right side could provide.

With decrease of speed rudder effectiveness decreased and the aircraft could not be prevented from changing direction.

This accident probably could have been avoided had the warning light indicated that the undercarriage was not locked properly or had a chase plane pilot watched me during landing and reported trouble by radio. Unfortunately he was short of fuel and landed first.

If I had known of the fault I could have landed slightly across the runway taking correction for the expected turning moment.

The second accident took place on aircraft No 202 flown by Spud Potocki. During a landing run all four wheels skidded and the tires burst. The pilot lost directional control and the aircraft ran off the runway damaging the right undercarriage leg.

The initial impression was that it was a pilot error. The pilot applied too much braking pressure too early and locked the wheels.

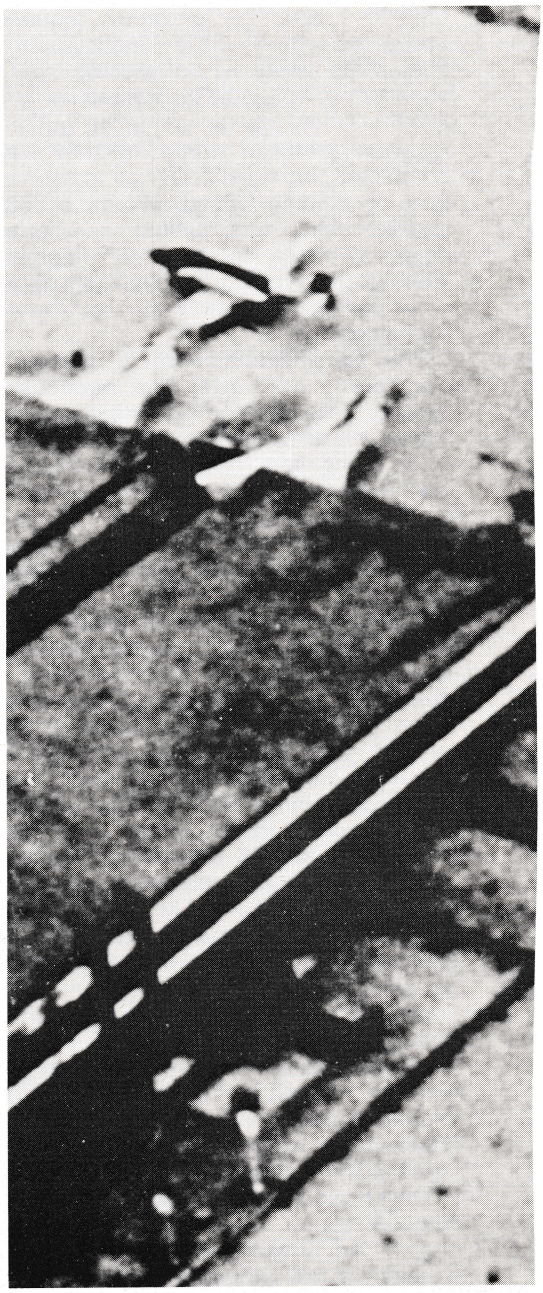
As I mentioned before we had the telemetry system recording basic parameters of flight. It was recorded that during touch-down the elevators suddenly moved full 30 degrees down.

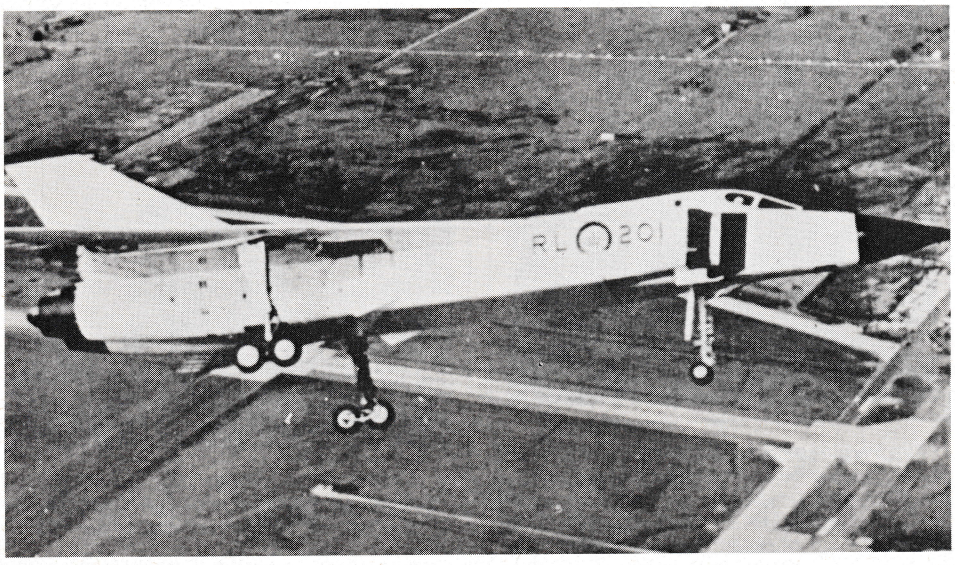
"Spud" was sure that he did not move the controls. Instrumentation experts suspected an error in recordings.

Fortunately, a photograph of this landing run was discovered in the possession of a suspected spy, showing that the elevators were fully down. Now the cause of the accident was clear. The Arrow's elevators were large and when deflected fully down acted as powerful flaps, increasing wing lift so much that only 20% of the aircraft weight was on the main wheels. The pilot was not aware of this and normal application of brakes locked the wheels.

During this landing, a small aircraft vibration as the wheels touched the ground, resulted in a wrong electrical signal to the stability augmentation

The Diefenbaker government ordered all photographers excluded from the area while this $125,000,000 act of vandalism was perpetrated. They succeeded in keeping photographers on the ground away from the area; but one photographer took to the air to obtain this





Arrow No. 1 turns crosswind and prepares for the downwind leg parallel to the main runway.

shot of the Arrow being hacked to death on the tarmac in front of the Avro Aircraft hangars. The stricken Arrow on the right lies collapsed, with the bulk of the right mainplane hacked off. This picture is perhaps the best commentary on the whole sorry affair.

system calling for full elevator down.

The pilot was lucky: if the elevator moved fully down in flight at any speed faster than 300 knots desintegration of the aircraft was likely in a fraction of a second.

Performance results were collected on flights of five Arrow MK One aircraft fitted with Pratt and Whitney J 75 engines was used to estimate the performance of the MK II Arrow fitted with Iroquois engines.

The Arrow with J 75 engines was heavier than with the Iroquois' and had to be balasted for a correct center of gravity position. Mark II with Iroquois engines did not need a ballast and was about 5000 lbs. lighter and had more thrust.

It was estimated that we had a high chance to beat the world speed and altitude records held at that time by the United States.

The first MK II No 206 was expected to fly at the end of February 1959.

On the 19th of February 1959, President of AVRO Co. informed all working personnel over the Public Adress system that the Prime Minister had just announced the termination of the Arrow and Iroquois programmes.

A telegram received later in the day by the Company instructed: You shall cease all work immediately, terminate subcontractors or orders and instruct all your subcontractors and suppliers to take similar action.

From this moment approximately 13.000 were no longer employed. The next day in Toronto's Royal York Hotel, representatives of American Companies were hiring our specialists to work in United States industry, and thousands of unemployed were looking for jobs.

The destruction of everything connected with the Arrow followed. Five aircraft which were flown and others on the production line were cut to pieces for scrap. Blueprints, brochures, reports and photographs all were reduced to ashes.

There was a common impression at the time that politicians wanted all tangible evidence rubbed out to prevent it returning to haunt them in later years.

For many months before the cancellation of the Arrow a strong anti-Arrow campaign was run by the press.

Many arguments were presented in a highly misleading manner and to my surprise suddenly we had plenty of experts on aviation. The press was full of articles, by high ranking retired army officers, about the uselessness and obsolescence of the Arrow.

The Telegram on Sept. 24, 1958 reported a statement by Lt.Gen. Guy Simmonds:

"The day of the airplane is finished as a defense mechanism. It has been replaced by the missile as the primary weapon." Gen. Simmons said that he had criticized from the beginning any plan to spend large sums of money on "the last of the fighters".

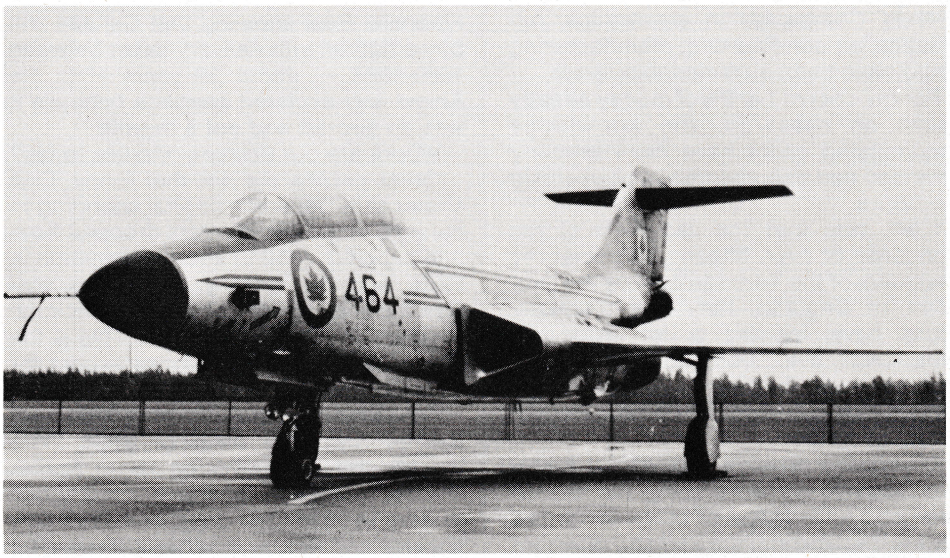
The Arrow is just that! — The last of its line and kind."

Canadian Air Force Officers were prohibited from discussing or even asking questions about the Arrow.

The Globe and Mail dated 21 Febr. 59 reported the statement by Air Marshal Roy Sleman, second in command in North America Air Defence: "Regardless of what the actual decision is and it certainly must be a proper one, I will be unable to comment on it."

Reading 18 years later the text of the Prime Minister's announcement of the decision to scrap the Arrow I have the impression that army experts convinced Mr. Diefenbaker that the aircraft was dead as a weapon and missiles only have the future.

I like best this statement: "Although the range of the aircraft has been increased it is still limited." — I suppose that the Voodoo which the Prime Minister ordered shortly after had unlimited range.



Just two years later, in 1961, the same government made arrangements with the United States to acquire supersonic F-101 Voodoos like the one shown at right.

The press was quick in catching the idea. In the Toronto Telegram the next morning were the headlines: "Arrow short range." — and later: "Operational range of the Arrow (700 miles) was less than the Government had hoped for."

I do not know what the Government had hoped for, but certainly the Canadians were convinced of the short range of Arrow.

The employees of Avro and Orenda were shocked by the Prime Ministers statement: "And frankness demands that I advise that at present there is no other work that the Government can assign immediately to the Companies that have been working on the Arrow and its engine."

Going back for a moment to the aircraft industry in England. I remember that only a small percentage of new prototypes flown, reached the production stage and probably even a lower percentage reached operational use. Cancellation of programs in the initial stages of development, or during initial production was quite common, but I had never heard of sudden cancellation without preparation being made to use released manpower and facilities.

In England it was generally accepted that the aircraft industry was a national asset, a national asset which helped so much in saving the country in the most difficult times like the Battle of Britain, that destroying it would be against the national interest.

It looks like the Canadian Government did not make any effort to save the design teams or production facilities of Avro and Orenda. As I mentioned before everything about the Arrow was destroyed. No attempt was made to save the results of millions spent in research, results which could have been useful in other countries like England and France which were working on the design of a supersonic transport or useful to other industries in Canada which experience of Avro and Orenda Companies in electronics, hydraulics, air conditioning, manufacturing could have been a tremendous asset.

For the cost of 1 or 2% of money already spent on research, the knowledge accumulated could have been properly collected and documented to be useful in the future.

I am sure that the designers of the Concorde or even fifteen years later the designers of the Tornado built by the joint effort of England, Italy and Germany could have learned a lot from our experience, even from our errors. It is strange how the same problems are showing up in design and development of nearly all aircraft.

During the development of the Arrow and Iroquois we were using the experience and knowledge of other countries, mainly England and the United States, but we destroyed the results of our work. Does that make any sense?

With the cancellation of the Arrow and without any program for the large part of the aircraft industry, Canada lost the opportunity to establish an advanced industry, which had a very good chance to become an economical means of satisfying a large part of our demand in Defence and to become an exporting industry.

For a long time I have been out of touch with aviation problems, but occasionally old friends send me something interesting.

A year ago I got a copy of an American Magazine: Machine Design. August 1975. On the first page: F-16 First with fly-by-wire. *Described there was a flight control system similar to that in the Arrow.*

I think that the only first here was the use of the name Fly-by-wire, but how can you prove that their first is fifteen years too late if most of the evidence is destroyed?

About new designs, I do not know much. A special report in the Financial Post dated shows some photographs of aircraft likely to be in future Canadian service. Apparently all these aircraft in the fighter attack class carry external armament and fuel.

There was one feature of the Arrow which I liked very much: this was an armament bay. Really big armament pack 18 ft. long by 8 ft. wide and 3 ft deep, I think, was attached to the aircraft at four points and easy removable.

An arrangement like this allowed quick changes in the type of armament (missiles) and a flexible role for the aircraft, for example for long reconnaissance or bomber. Internal carriage of armament and fuel did not alter flying characteristics and performance of the aircraft.

Somehow on the latest aircraft I can't see good high speed performance: with all those stores under the wings.

It is a bit funny to see a graph in the Financial Post showing that Canada will buy a fighter with delivery dates between 1980-1988 — about 30 years after the Arrow was declared obsolete because it was an aircraft and not a missile.

Where are our Bomarc missiles today?

Other graphs are not that funny. One shows that Canadian capital spending in defence in the last 20 years dropped from one billion in 1956 to about 400 million in 1976, and the next graph shows that Canada spends 2.3% of its gross national product on national defence. This is the lowest of all NATO countries except for Luxemburg.

The Globe and Mail reports a statement by the American chief of Staff: "The Soviets are outproducing us in fighter aircraft by a factor of approximately two to one. In 1976 they produced 1200 new fighters and fighter bomber aircraft. The Russian Backfire bomber has the capability to strike the United States".

Are we, in Canada, taking our defence seriously?

Mr. James Eayrs, a reporter for the Ottawa "Citizen" writes: "The Arrow was a superb piece of machinery, a really splendid aircraft. It also happened to be the wrong aircraft, produced by the wrong country, at the wrong time."

I agree with the first statement, and disagree with second. Arrow was the right aircraft, produced by the right country, at the right time, only our leaders did not realize that not everything is possible to calculate in dollars and cents.

How is it possible for example to assess the effect of a Canadian success or achievement on an average Canadian? If he is proud to be a Canadian how will his effort compare to one who is forced to believe that Canadians can not succeed in anything?

I think that if a Canadian is not proud of common achievement and success in Canada and he does not feel he is taking part in successful efforts he doesn't care about Canada.

It is easy to understand that a gentleman from Alberta doesn't care for the eastern provinces and a gentleman from Quebec doesn't care for the rest of Canada or that someone from British Columbia sees his better interest in the United States.

I think that the cancellation of the Arrow was a nasty shock to the pride of the average Canadian and this was probably a highly depressing factor for years.

This has been my recollection of a very interesting period of aviation in Canada.

I do not claim that my presentation is 100% accurate, but that is how I remember it.