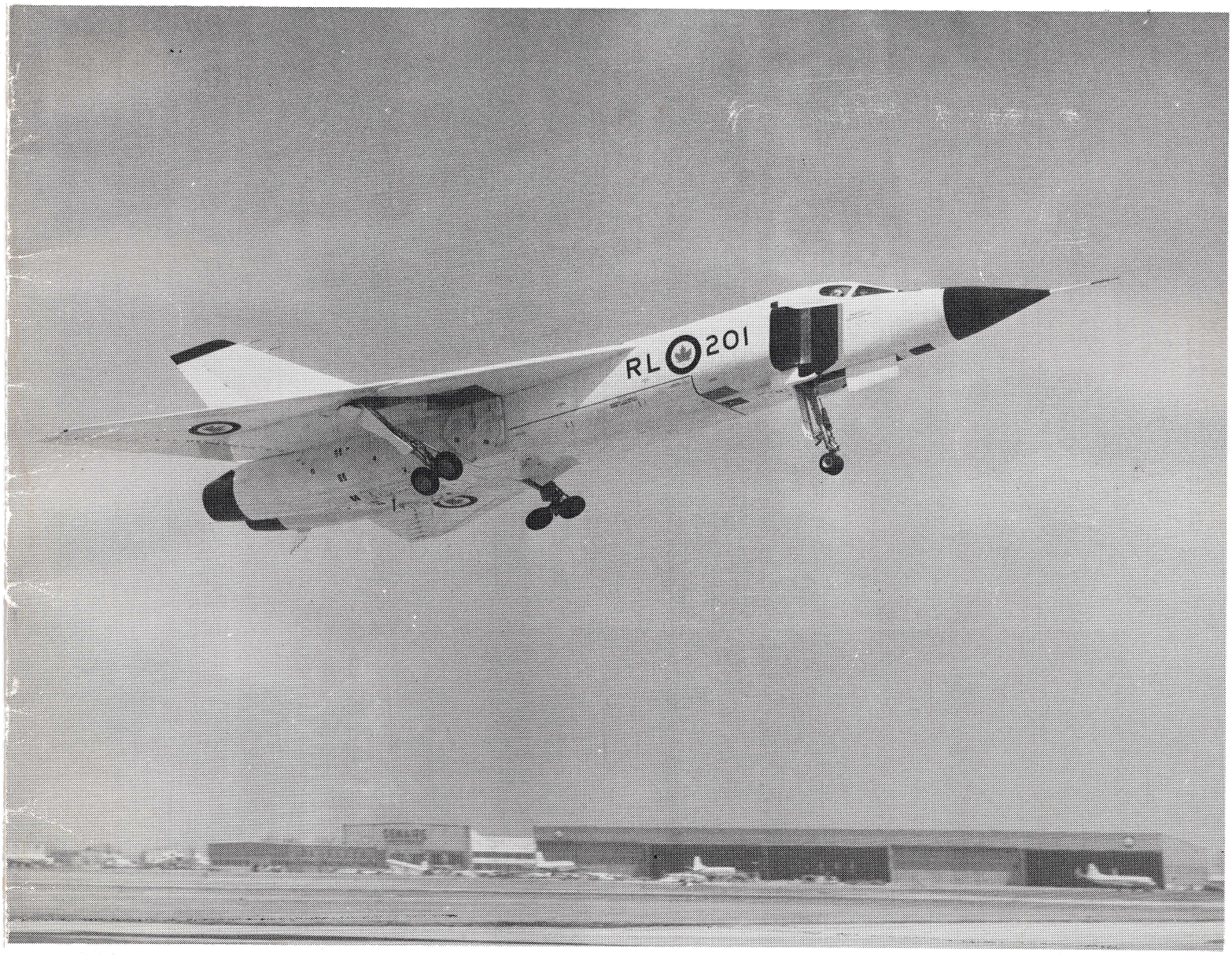
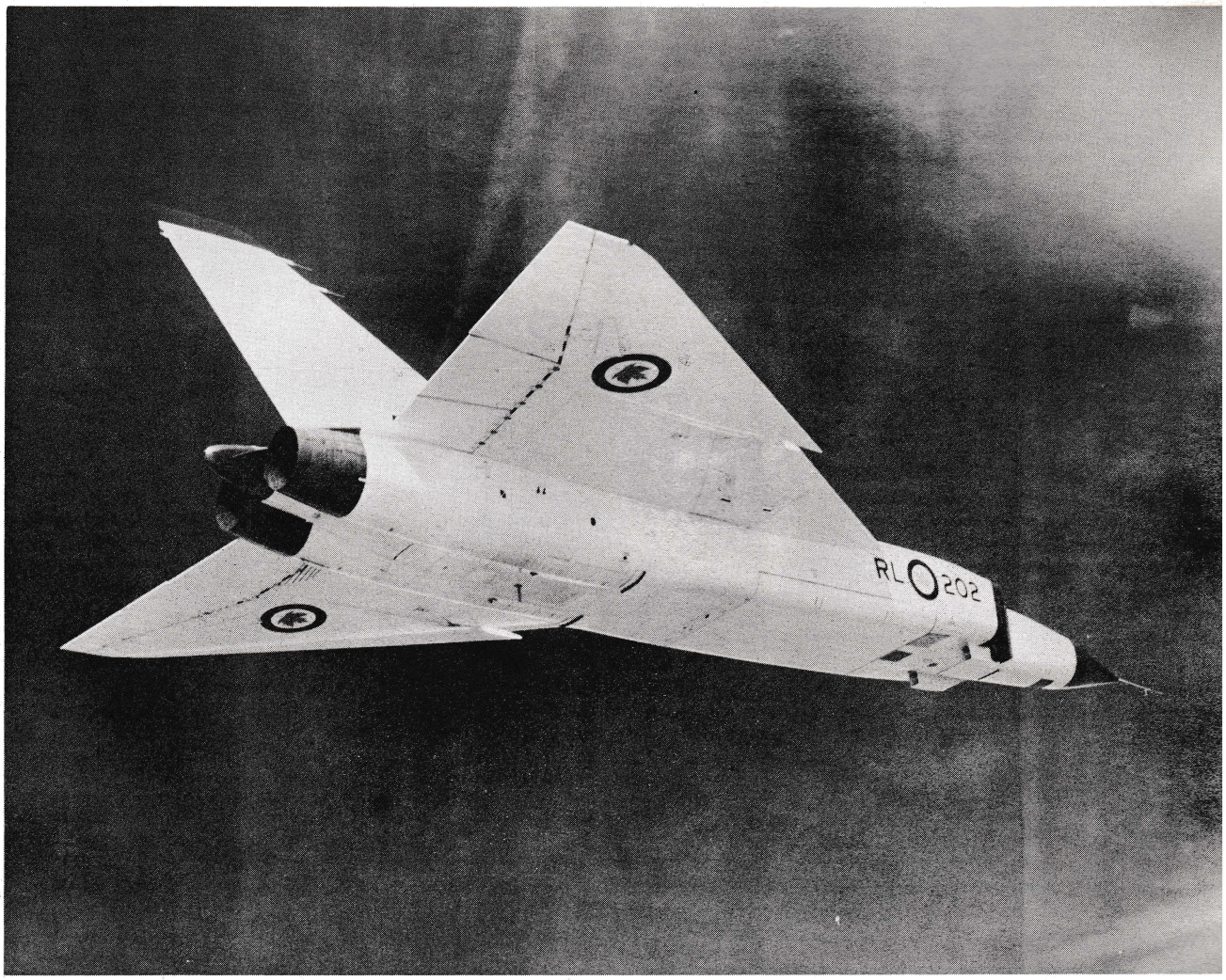
CANADIAN AVIATION HISTORICAL SOCIETY

SPECIAL PRESENTATION





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A FEW WORDS FROM JAN ZURAKOWSKI

I am proud to see that the CANADIAN AVIATION HISTORICAL SOCIETY has reproduced the transcript of my talk to the TORONTO CHAPTER of C.A.H.S.

It was very satisfying to have been part of the AVRO ARROW team that produced such an advanced Aircraft. I hope Canadians will remember this achievement for years to come...

Sincerely,

J. Zurakowski

The Canadian Aviation Historical Society is a non-profit organization dedicated to preserving Canada's aviation history.

Information and copies are available from Les Wilkinson.
15 Penhale Drive, Weston, Ontario, Canada M9P 2X3.

TEST FLYING THE ARROW

JAN ZURAKOWSKI

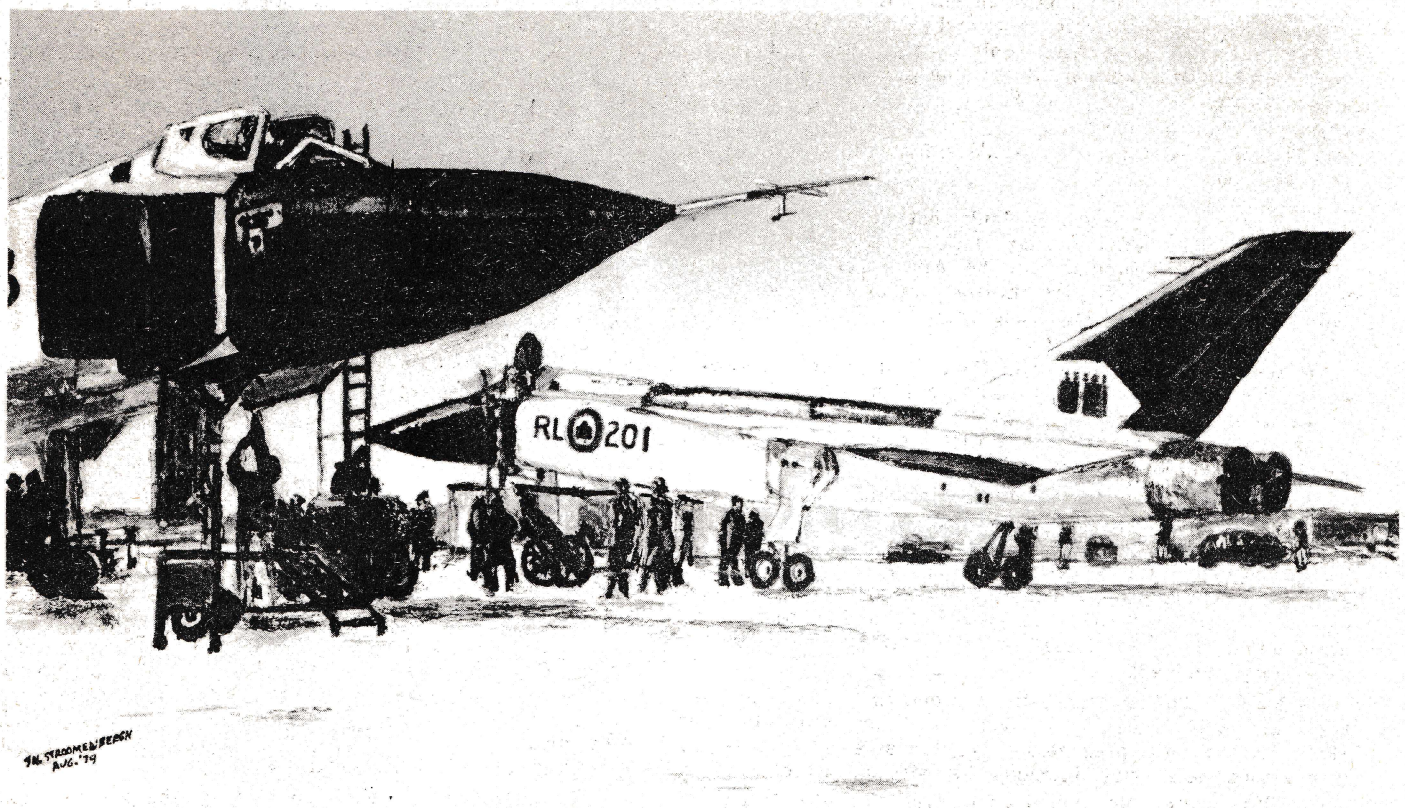


ILLUSTRATION BY JAN STROOMENBERGH

A talk by Jan Zurakowski, principal test pilot of the Avro Arrow, given to the Toronto Chapter CAES

INTRODUCTION: Don Rogers.

I am pleased to introduce our speaker tonight, for I had the happy privilege of spending seven years working with him at Avro Aircraft. Janusz Zurakowski was born in 1914 and had his first flight at the age of 15 when he was in high school. He learned to fly on gliders during 1932 in Poland and joined the Polish Air Force in 1934. Before the end of the thirties, he was an instructor in a Polish fighter squadron, and when Germany invaded Poland, had the rather unique opportunity of shooting down the first enemy aircraft while flying an obsolete fighter-trainer. When Germany finally overran Poland, Zurakowski was able to escape to England and arrived in time to join the Battle of Britain with the RAF. He was credited with three more enemy aircraft during that period.

After the Battle of Britain, he joined the Polish Squadron of the RAF. He was mentioned in dispatches twice for his work with the fighter squadron, and also received the Polish Military Cross of Valour with two bars during that period. At the end of the war, he was accepted as a pilot at the Empire Test Pilots' School at Boscombe Downs, and posted to the Aircraft and Armament Experimental Establishment. He became heavily involved with the acceptance flying and the early development flying on the de Havilland Vampire, which was the first RAF jet fighter. In 1946 he went to Gloster Aircraft as chief development pilot and did much of the early test flying on the Meteor and later the Gloster Javelin, a delta-wing fighter. He came to Canada to join A. V. Roe Canada Limited as chief development test pilot in 1952 and did much of the development work on the CF-100, which was being built at that time.

When he was with the Gloster company, he demonstrated, to the surprise of the people at Farnborough, the first all-new aerobatic maneuver seen in a long time. With a fully-loaded Meteor fighter, he climbed vertically until it was almost stationary in the vertical plane, and then, by cutting one engine, made the aircraft cartwheel in the vertical plane as it fell. This was given the name of the "Zurabatic Cartwheel" and was considered to be quite an outstanding maneuver. He again surprised the folks at Farnborough while demonstrating the CF-100 in the mid-fifties. He didn't try to compete with the rest of the fighter aircraft, swooshing by at high speed, but instead put on an absolutely outstanding display, doing a complete aerobatic performance within the confines of the airfield.

It was during this period that the initial work of the Avro Arrow was progressing. Zurakowski did the first flight of the Arrow in 1958 and was awarded the McKee Trophy during that year for his contribution to Canadian test flying. The sad part of the story comes in 1959, when, as most of you remember, the Arrow project was cancelled and the Avro company went downhill after that. Jan Zurakowski retired from flying in 1959 and built up a thriving resort business. He was appointed as a member of the Canadian Aviation Hall of Fame in 1973, for his contribution to Canadian aviation and Canadian test flying. Despite the various honours, he remains a very quiet, unassuming gentleman. A typical case in point occurred during a reception given for him at the Toronto City Hall a few years ago. He was presented with official City of Toronto cuff links by the Mayor of Toronto. Someone asked him what does it feel to fly so fast, at twice the speed of sound. With his typical understatement, he said: "It feels just like flying slowly, only faster."

So, without any more from me, let us welcome our speaker for tonight, Jan Zurakowski, to tell us about flying slow and flying fast.

Nearly twenty years ago, on the 25th of March 1958, the first Canadian supersonic fighter aircraft, the Avro Arrow, became airborne. The development and proving flights were progressing well, aircraft performance was up to specification, the initial five Mk. I aircraft were flight tested and the production line was set up.

In less than one year, on 20th February 1959, by a decision of the Canadian government, all work on the aircraft was stopped suddenly and nearly everything related to this project was destroyed. This was a very sad end to what were probably the most exciting times of the Canadian aircraft industry: 1949 to 1959.

I would like to present to you my impressions as a test pilot during those times and to add a few remarks about the situation today.

Looking back 25 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 of this project, whilst 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. I would like to mention here that for the first time a Canadian, Jim Floyd, was awarded the Wright Brothers Medal for outstanding achievement in aeronautical science. All previous winners had been Americans.

In March 1952 an operational requirement was received from the RCAF for an all-weather interceptor. In June 1952 the company presented two proposals: a single- and twin-engine delta-wing interceptors with crews of two. 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 NAE (Ottawa), Cornell Aeronautical Laboratories (Buffalo) and NACA (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 powerplant were made. Because Rolls-Royce RP-106 development was delayed and the Curtiss-Wright J-67 was expected to be too late as well, the installation of a Pratt & Whitney J-75 as an interim measure was accepted with the Orenda Iroquois engine intended for production models.

As design investigation progressed it became apparent that there were new problems connected with the increase in speed from Mach 0.87 of the CF-100 to the more than Mach 2 of the new interceptor. This increase of more than 750 MPH called for a lot of electronic systems needed for successful interception, 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 RAF fighters increased by 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 rumour that the directional stability of our new aircraft was poor, and at this time a number of American fighters disintegrated in the air and some designs were quickly modified to provide a bigger fin area.

We asked the 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 an impression that I am 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 of Engineering, that the latest estimates of landing speed of the Arrow were much higher than the initial one, so a meeting of aerodynamic experts was called 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 aerodynamic changes which would involve a weight penalty without any guarantee that all the flight conditions would be satisfactory. Or second, introduce reliable electronic stability augmentation needed anyway for the weapons 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 could be a disaster for the company.

Cooperation of other sections with the 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/L Ken Owen, with F/L Jack Woodman, a highly experienced test pilot. This detachment was most useful in an advisory and cross-checking capacity. The problem we had with wheel brakes can best illustrate the need for a cross-checking system.

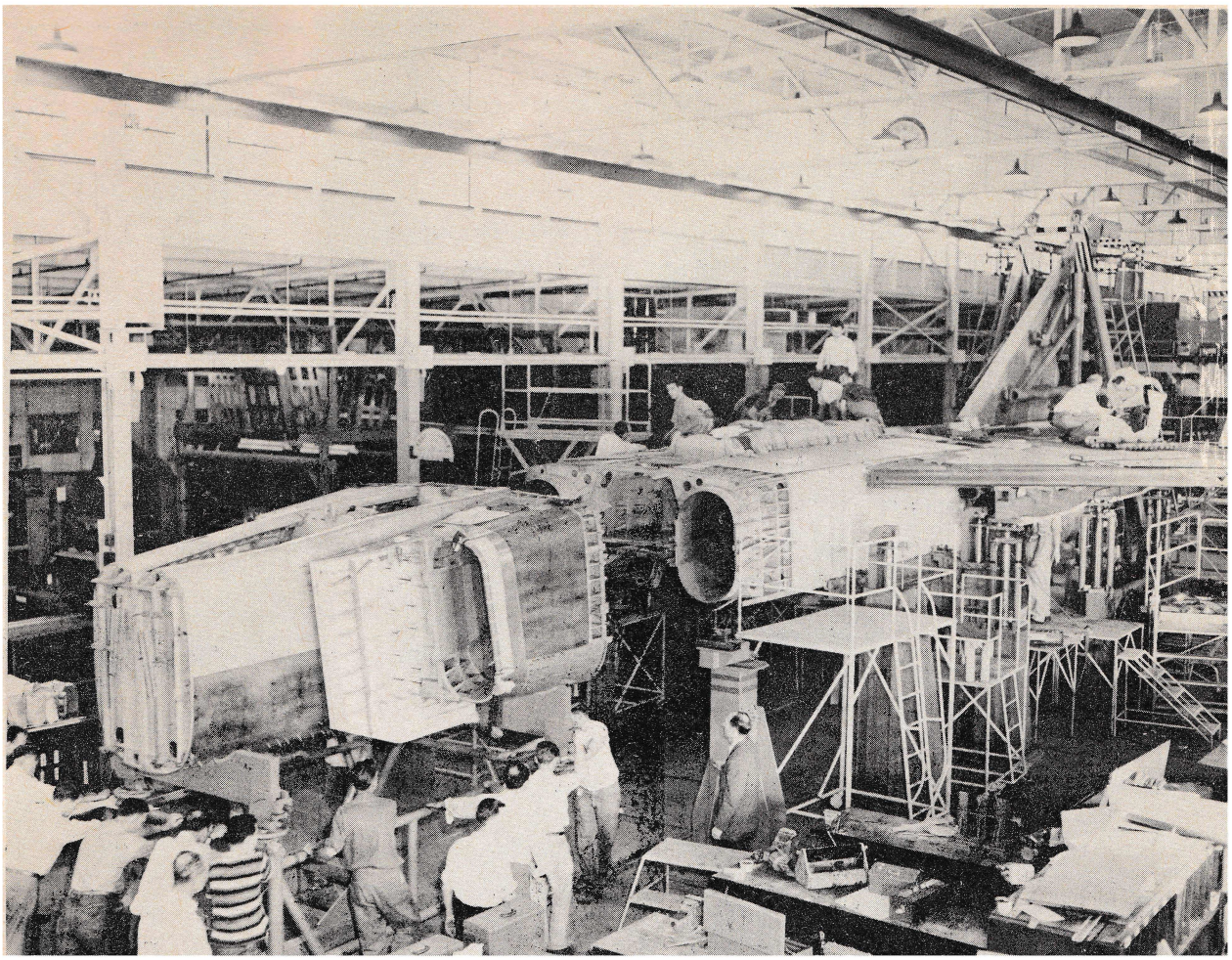
An engineer was instructed to write the specification for wheel brakes for the Arrow. The standard specification at the time, if I remember correctly, required brake capacity to have kinetic energy absorption equal to 1.2 times stalling speed squared, multiplied by the aircraft landing weight. Checking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

The specification went to the subcontractor and after the necessary design, development and proving time, the brakes were found to be completely inadequate for the aircraft when the wheels arrived, specially since in the meantime the aircraft weight was increased. A crash programme 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 disintegrated in unknown circumstances.

With the help of an IBM 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 three seconds; Spud Potocki, who was much better on instrument flying, managed to fly eleven seconds before crashing.

I was completing taxiing tests in preparation for the first flight on an actual Arrow Mk. I. An unpleasant situation was created: if the simulator is unflyable, is the aircraft safe for flight? A specialist from the U. S. was




25201
RL 201

AVRO CF-105 ARROW mk.1

Roll-Out : Oct. 4, 1957
First Flight: March 25, '58
Cancelled : Feb. 20, 1959

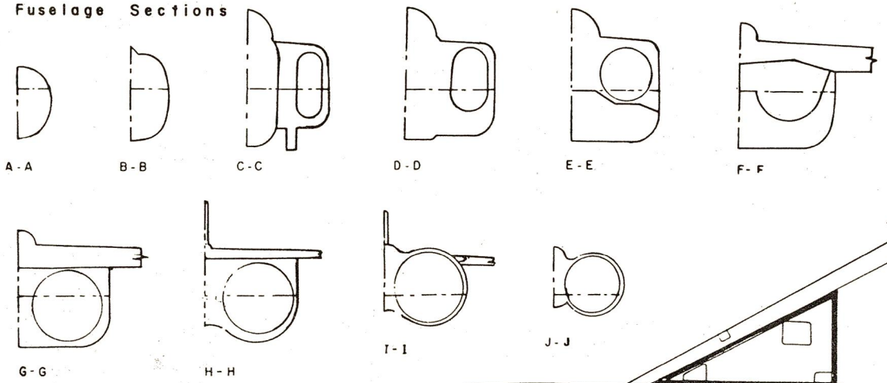
Span:	50 ft. 0 in.	Armament:	Hughes MX-1179 weapons system with 8 Falcon Missiles or 4 Sparrow II with Astra 1 fire control.
Length:	77 ft. 9.65 in.		
with probe:	82 ft. 2 in.		
Height: Tail	21 ft. 3 in.	Fuel:	19,561 Lb. (2,508 Imp.gal.) plus 3900 Lb. (500 Imp.gal.) Drop Tank
over Cockpit	14 ft. 6 in.		
Wheel Base:	30 ft. 1 in.	Combat Weight:	64,000 Lb
Wheel Track:	25 ft. 5.66 in.	Max. Speed:	Mach 2 range
Wing Area:	1,225 sq.ft.	Service Ceiling:	65,000 ft.- plus

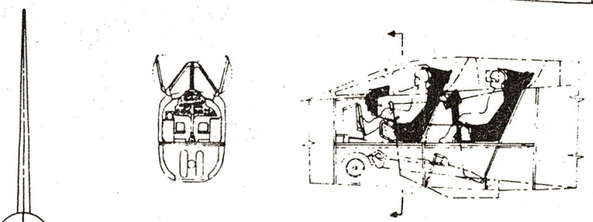
Mk.1 Engines (Two)

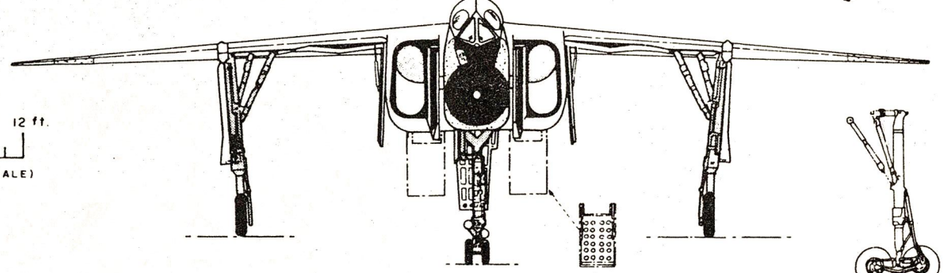
RL-201: Pratt & Whitney J75 P-3
RL-202-205: Pratt & Whitney J75 P-5
12,500 Lb. Static Thrust (dry)
18,500 Lb. Thrust with Afterburner
15 stage - 2 spool compressor, 8 flame tubes.

SCALE
0 ft. 6 ft. 12 ft.
(ORIGINAL DRAWN AT 1/72 SCALE)

Fuselage Sections







Colour Scheme

White	Red	Dayglo - Scarlet
Black	Blue	Metallic

Dayglo was applied and changed frequently during the later stages of the flight test program. The example illustrated here was also seen on the following aircraft:-
RL-203, same plus the Canadian-(Red Ensign)- Flag shown above the fin flash.
RL-204 and RL-205, same minus the black stripes on the wings.
RL-202 and RL-206 (mk.11) had no dayglo applied.

FEB. 1979

J.H. Stroomenbergh
Canadian Aviation Historical Society

called to assess the situation, but was not very optimistic.

What next? To develop this simulator to flyable condition, or to fly the actual aircraft? I recommended disregarding the simulator for the time being and going ahead with the first flight. It turned out later that there was much more to the art of simulating flight than just feeding parameters into a computer and transmitting the results into cockpit instruments.

The first flight of the Arrow on 25 March 1958 was very simple. Just check the response of controls, engines, undercarriage and air brakes, handling at speeds up to 400 knots, and low speed in a landing configuration. There certainly 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 realization that the success of this aircraft depended 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 50000 feet, I exceeded 1000 MPH, and that was the only performance released at that time by Air Force headquarters.

Phase One of the Arrow flight test programme was successfully completed, and F/L Jack Woodman made a familiarization and initial assessment flight. In August of 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.

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 programme of the Arrow and Orenda Iroquois engines would continue, but would be reviewed in the next March.

Development flying was speeded up when Spud Potocki and Peter Cope joined in testing. For me, the time to retire from testing had arrived. Normal retirement age from high speed flying was 40, and I was already 44. I was leaving experimental flying in good hands. Spud Potocki, Peter Cope, and F/L 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 (No. 204 and 205), increasing the number of test aircraft to five. Testing was progressing well, but was slowed down by two accidents.

I was involved in the first one. 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 had not opened evenly, I jettisoned 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 had not completed the lowering cycle and during the landing run the wheels were at about a 45° angle to the direction of travel, producing a higher drag than the brakes on the right side could compensate for. With decrease of speed, rudder effectiveness decreased and the aircraft could not be prevented from changing direction.

This accident probably could have been avoided if the warning light had indicated that the undercarriage had not locked properly, or if the chase plane pilot had watched me during landing and reported the 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, making correction for the expected turning moment.

The second accident took place on aircraft No. 202, flown by Spud Potocki. During a landing roll 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 pilot error. The pilot was thought to have 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 touchdown the elevators suddenly moved full 30° 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 the elevators 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 had resulted in a wrong electrical signal to the stability augmentation system, calling for full elevator down.

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

Performance results collected on flights of five Arrow Mk. I aircraft fitted with Pratt & Whitney J-75 engines were used to estimate the performance of Mk. II Arrow fitted with Iroquois engines. The Arrow with J-75 engines was heavier than with Iroquois and had to be ballasted for a correct centre of gravity position, Mk. II with Iroquois engines did not need ballast and was about 5000 lbs lighter, and had 40 to 50% more thrust. It was estimated that we had a high chance of beating 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 20 February 1959, the President of the Avro Company informed all working personnel over the public address 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."

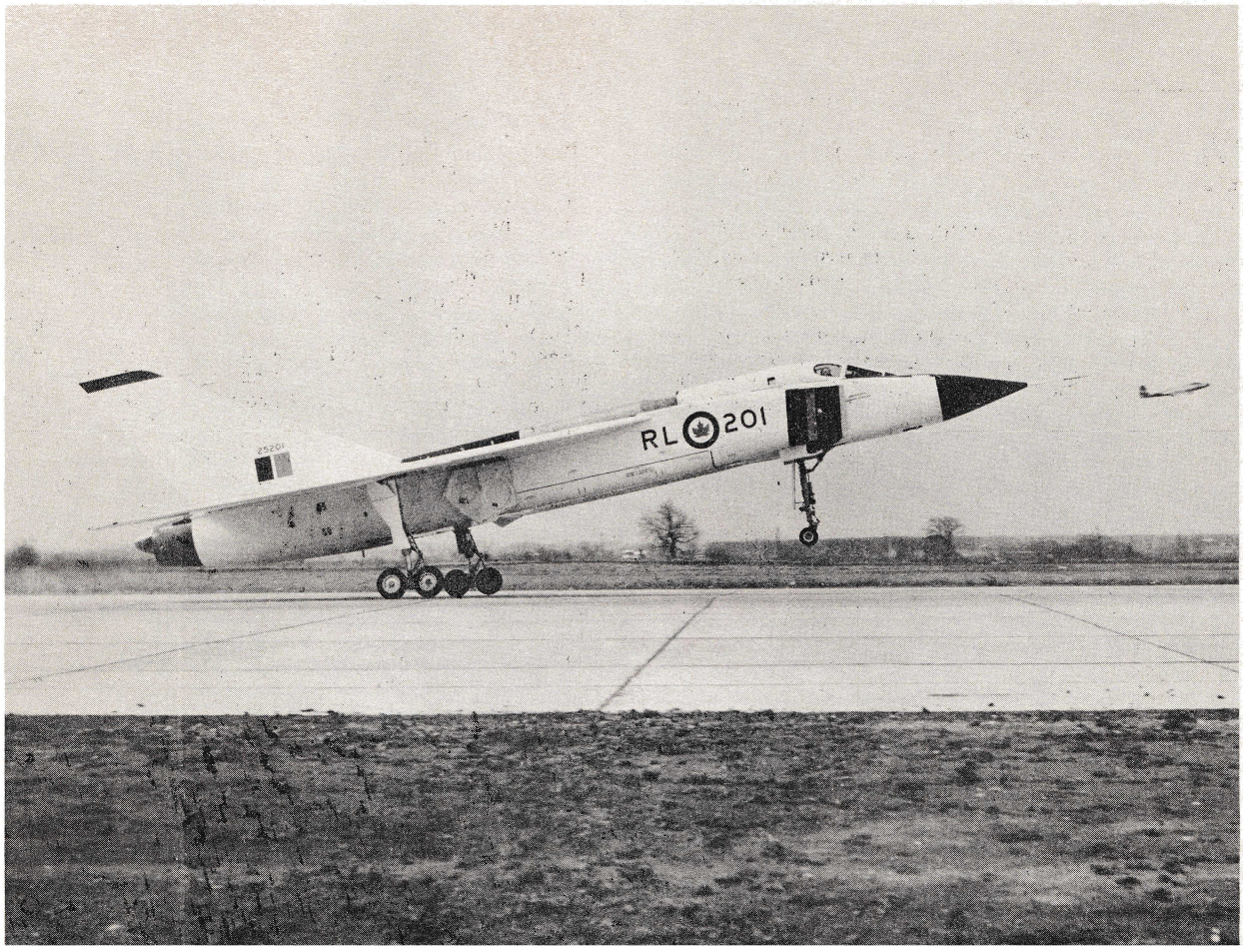
From this moment, approximately 13000 workers were no longer employed. The next day in Toronto's Royal York Hotel, representatives of American companies were hiring our specialists for work in United States industry, and thousands of unemployed were looking for jobs.

The destruction of everything connected with the Arrow followed. The five aircraft which had flown and others on the production line were cut to pieces for scrap. Blueprints, brochures, reports and photographs were all 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 24 September 1958 reported a statement by Lt-Gen. Guy Simmonds: "The day of the airplane is finished as a defence mechanism. It has been replaced by the missile as the primary weapon." Gen. Simmonds 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 February 1959, reported the statement by Air Marshal Roy Slemon, second in command in North America Air Defence: "Regardless of what


RL 201


RL 201

the actual decision is, and it certainly must be a proper one, I will be unable to comment on it."

Reading 19 years later the text of the Prime Minister's announcement of the decision to scrap the Arrow, I have the impression that army and American experts convinced Mr. Diefenbaker that the aircraft was dead as a weapon and only missiles had any 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 afterwards had unlimited range?

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 the Arrow.

The employees of Avro and Orenda were shocked by the Prime Minister's statement: "And frankness demands that I advise that at the 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 ever reached the production stage, and probably even a lower percentage reached operational use. Cancellation of programmes in the initial stages of development or during initial production was quite common, but I had never heard of sudden cancellation without preparations being made to use released manpower and facilities. In England it was generally accepted that the aircraft industry was a national asset, one which helped so much in saving the country in the most difficult times like the Battle of Britain, and that destroying it would be against the national interest.

It appears that 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 used in other countries like England and France, which were working on the design of a supersonic transport, or useful to other industries in Canada where experience of Avro and Orenda companies in electronics, hydraulics and air conditioning manufacturing could have been a tremendous asset.

For the cost of one or two percent of the 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 sense?

With the cancellation of the Arrow, and without any programme for a 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.

Last year saw the publication of a book by John Diefenbaker, called "One Canada". In Volume III of this book a number of pages deal with national defence and the Arrow. I quote from page 35: -

"There is no doubt that from a construction standpoint the Avro Arrow was an impressive aircraft, superior to any other known contemporary all-weather fighter - something all Canadians could be proud of as their product. The Orenda Iroquois engine boasted the highest thrust, the lowest specific weight, the greatest mass flow and the greatest growth potential of all known engines under development. I said at the time it was a tribute to the high standards of technological achievement and development of the Canadian aircraft industry."

But on page 36 Mr. Diefenbaker wrote: -

"And (the Arrow) would be out of date by the time it got into production..."

About the Bomarc he wrote: -

"Our decision to introduce the Bomarc did not work out well. To begin with, the Bomarc was very soon proven to be virtually obsolete even before it was set up."

From the same book we also learn that the proposal by Defence Minister General Pearkes for procurement of the F-101B interceptor aircraft was made during June 1960, just over a year after the Arrow cancellation. The F-104 purchase followed shortly. Canada purchased over 400 fighter class aircraft after cancellation of the Arrow.

This year the government is deciding which type or types of aircraft it will buy to replace the CF-101B, CF-104 and CF-5. And twenty years ago they thought the Arrow was obsolete because it was only an aircraft!

A special report in the Financial Post, dated 19 February of last year, 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, and this was an armament bay. A really big armament pack, sixteen feet long by eight feet wide and three feet deep. It was attached to the aircraft at four points and easily removable. An arrangement like this allowed quick changes in the type of armament (missiles) and a flexible role for the aircraft. For example, long-range reconnaisance or bomber. Internal carriage of armament and fuel did not alter flying characteristics and performance of the aircraft. Somehow on the latest aircraft I cannot see good high-speed performance with all these stores under the wings or fuselage.

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 and 1988 - about thirty 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 twenty years dropped from one billion dollars in 1956 to about 400 million dollars in 1976, and the next graph shows that Canada spends 2.3% of its gross national product on national defence. I think this year the figure is 1.7%. This is the lowest of all NATO countries except Luxemburg.

The Globe and Mail reports the statement on 10 February by the American Chief of Staff General David Jones: "The Soviets are outproducing us in fighter aircraft by a factor of approximately two to one. In 1976 they produced 1 200 new fighter 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 the second. The Arrow was the right aircraft, produced by the right country, at the right time, only our leaders did not realize that not everything can be calculated 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 cannot succeed in anything? I think that if a Canadian is not proud of common achievement and success in Canada and doesn't 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 eastern provinces, and a gentleman from Quebec doesn't care for the rest of Canada,

or that someone from British Columbia sees his better interests in the United States. I think 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 ahead.

This has been my recollection of a very interesting period in Canadian aviation. I do not claim that it is 100% accurate, but that is how I remember it.

QUESTION AND ANSWER SESSION: L. Wilkinson, moder.

Q: Did our speaker ever meet Bill Waterton?

A: Yes, certainly I met Bill Waterton. I was working with him in England. He was chief test pilot and I was chief experimental pilot at Gloster Aircraft. When he went to Canada to fly the CF-100 I took his job with Gloster.

Q: Were there any test flights of the Arrow after the cancellation, with the Iroquois engine?

A: No. The cancellation order was that all work is to stop immediately, and since this was government contract work, the aircraft was not the property of the company, and we couldn't continue with any of the work after cancellation.

Q: What was the maximum speed the Arrow achieved?

A: The maximum speed any of the test aircraft achieved was Mach 1.98, flown by Spud Potocki. The highest I reached was 1.89 on an earlier flight. We must bear in mind that this was not the maximum possible. We were still progressing slowly, recording every step we took, but there was no correct test for speed, as we did not have any priority in reaching maximum speed.

Q: Have you ever missed flying since retirement from test flying?

A: Certainly, yes. But I have accustomed to new conditions and a new way of life.

Q: How close was the Arrow to being an operational aircraft at the time of cancellation?

A: Cancellation took place in February of 1959, and the Arrow was to become operational in the sixties, so parhaps another one and a half or two years.

Q: What was our guest's experience with the approach and landing speeds of the aircraft?

A: The Arrow had quite a high landing speed. As far as I remember, it was of the order of 170 knots across the threshold, 160 at touchdown, but I had hoped we'd lower it quite a lot, through experience and some modification. I think the same would have been done on the Russian supersonic transport, or the Swedish delta-wing fighter. Perhaps by placing an elevator at the front of the aircraft, which allows us to use elevators as flaps whilst in landing configuration. That would reduce the landing run quite a lot. The Swedish requirements were for an 800 metre landing run, which is about 2 000 feet, and they reached it.

Q: Since the Arrow was quite a large aircraft, what was its maneuverability, perhaps as compared with modern day aircraft?

A: What is meant by maneuverability? There is turning maneuverability, rolling maneuverability. Rolling was extremely fast, especially at higher speeds, it was faster than the pilot would have liked to have it. The wingspan was only fifty feet, so the aircraft was very long. Now, turning maneuverability is a very difficult problem to assess on a high-speed aircraft, because it is not the limitation of the aircraft, but its strength and the ability of the pilot to withstand high acceleration for a long period. Turning at Mach 2.0 takes a radius of about ten miles with 5G, if I remember right, so doing a 360^{0} turn at this speed takes quite a long time, so it's actually the ability of the pilot to withstand the high acceleration. Some of the later aircraft have the pilot more in a lying down position rather than sitting, to help him to withstand the force. What the questioner probably has in mind is something like a dogfight, which is very difficult to describe, because there's such high kinetic energy involved. From Mach 2, for example, you can climb without any power some 30 000 feet, or you can convert it into turning or any other kind of maneuver. In older fighters, say the Spitfire, which had optimum maneuvering speed of the order of 160 knots, he had little kinetic energy to be converted into anything.

Q: About how many hours of testing was done on the Arrow up to cancellation?

A: I think about sixty or seventy.

Q: What was the maximum cruise altitude and zoom altitude that was achieved in the aircraft?

A: Cruise altitude, about fifty; zoom altitude - we didn't try. As I mentioned, we had a high priority on testing the actual systems. Our engines at the time were not typical production engines. We were using the American engines, so we didn't spend much time investigating this engine at high altitudes. We knew the actual production engines would be the Iroquois, more powerful, on which we could do full investigation. What we were trying to do on the first five aircraft flying with the Pratt and Whitney engines was to get all basic information. I didn't mention this before, but the total number of aircraft intended for experimental work was about fifteen. These aircraft were intended after testing to go back to service, because they all were built to the same production drawings. I see that some of you are surprised at such a high number. There were about 120 Meteors engaged in experimental flying. Now, that was not all for the Meteor development, I must admit, since Meteors were used for engine development, or rocket development, for brake development, for all sorts of tests. The pace at which we were going was so fast that every day we were finding requirements for new knowledge which made new testing necessary. That is what I mean by going from Mach 0.87 to Mach 2 plus, because Mach 2 was only a specification; we knew we could go much faster, specially with Iroquois engines. The only limitations actually were those of the structure of the aircraft, which was temperature limitation. But the number of tests required to prove the aircraft is really colossal, and that's why we decided from the start to use as high a number of test aircraft as possible to reduce the time before introducing the aircraft into service.

Q: Would our guest like to comment on American influence on the Canadian government to cancel the aircraft?

A: American influence on Canadian government? I don't know whether there was any influence. My own personal impression is simply that our government had no experience. Take, for example, the case of our government saying that we cannot sell the Arrow: that we have failed to win any contracts for it, or that it became too expensive because development costs are too high. Take, for example, the aircraft the Canadian Air Force is trying to buy now. There is only one that has never been flown, but all the others have been flown for four, five or up to seven years. You cannot sell the aircraft before or soon after first flight; you have to prove that the aircraft is good. At the same time, the Prime Minister sent his General Pearkes to sell the aircraft. So he goes to his American counterpart, and the industry, and tells them, look, we've got this Arrow, we're not sure it's any good, we've had a bit of trouble with the development programme, and everyone says it's too expensive... will you buy it?

So, if that is the approach of a salesman, of course the Americans will have a good laugh and say no, we don't want to buy it, but we can sell you anything you like, ready to go.

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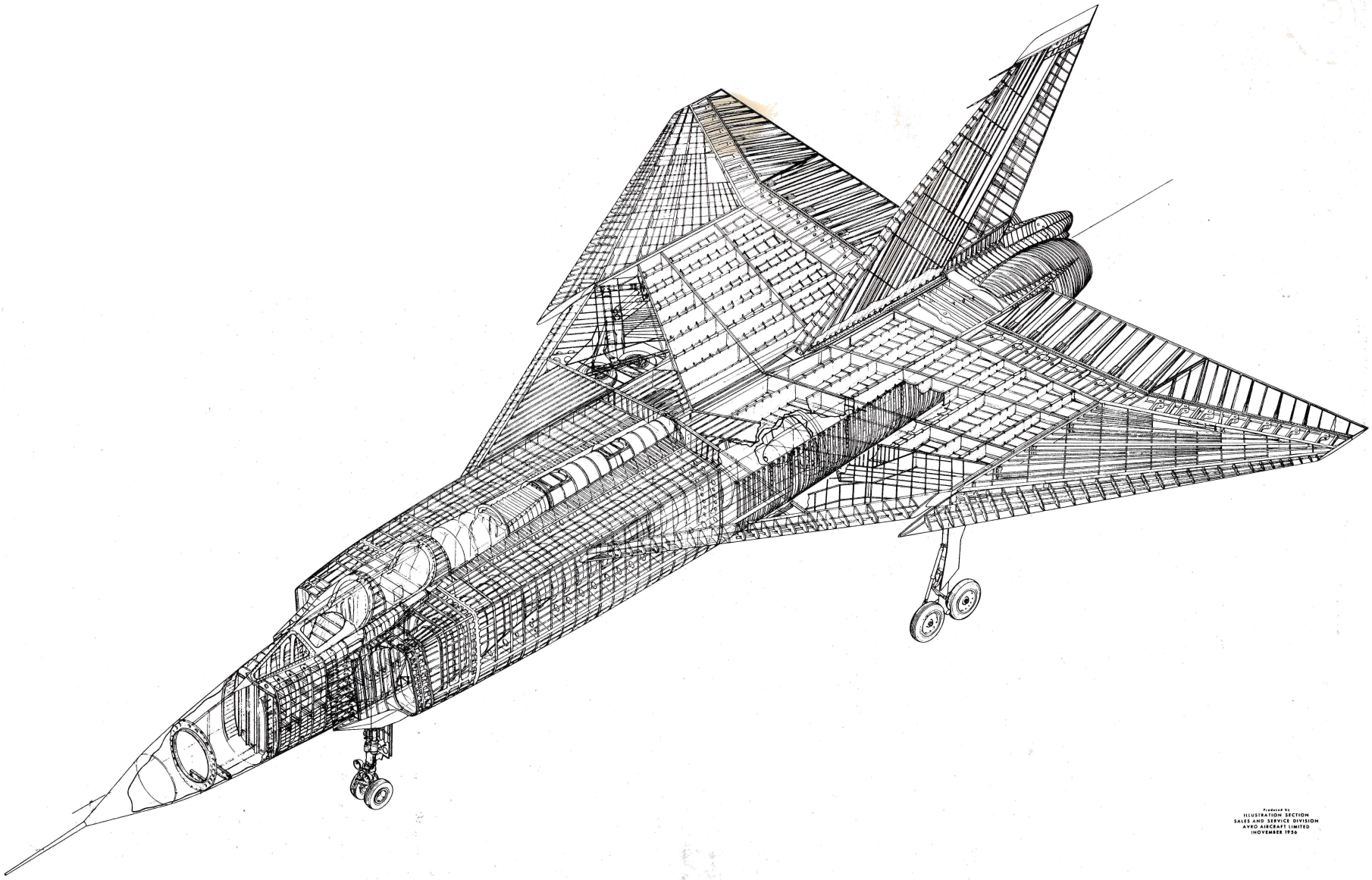

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