

A native of Saskatoon, Jack Woodman was the only RCAF pilot-and one of only four pilots-to fly the Avro CF-105 Arrow. With more than 60 different types of aircraft in his logbook, he probably holds a record of sorts for the longest spin. At about 118,000 ft. in an F-104, the airplane pitched up and spun for between 60,000 and 70,000 ft. before he was able to get it under control. He is currently Director of Flying Operations at Lockheed-California Corp. Palmdale, Calif. The article below is an abridged version of his paper "Flying The Avro Arrow," presented at the Canadian Aeronautics and Space Institute symposium at Winnipeg in

It has been more than 19 years since the Arrow program was cancelled. The Avro Arrow is still, however, a subject of great interest among Canadian aviators, and the program is still being talked about. I'm sure that many people are still wondering whether the decision to cancel the Arrow program was the right decision. The Bomarc missile, which was purchased in lieu of producing the Arrow, turned out to be probably the biggest flop in missile history. The F-101, which the RCAF later received, was only half the airplane the

CF-105 would have been. Most of Canada's high-performance design talent migrated to the U.K. and the U.S. and apart from the fact that the Canadian aerospace industry suffered a major setback, it was perhaps a "swell" decision.

Personally, I thought it was a poor decision. However, I'm not here to discuss politics, but rather, I would like to describe for you as best I can remember and from the limited material available, the design of the Arrow, the flight test program, handling and performance qualities.

The go-ahead for the design and development of the Arrow was first authorized by the Canadian Government in July of 1953 and was assigned the project No. CF-105.

Preliminary design was complete the summer of 1954; the first engine-runs Dec. 4, 1957; first taxi trials Christmas Eve, 1957; and the first flight March 25, 1958.

Jan Zurakowski, Project Pilot and Chief Development Pilot for A. V. Roe, made the first flight, which lasted 35 minutes. Zurakowski, the best test pilot I've ever known, reported good flying qualities, no surprises, no trouble, and made the general comment, "It han-

dled very nicely." John Plante, Executive vice-president and general manager, said, "The first flight on any aircraft is a tremendous achievement, but we've got a lot of work to do yet." It was a proud moment in Canadian aviation.

Unfortunately, less than one year later, on Feb. 20, 1959, the Arrow program was cancelled. The Canadian government elected to go with the Bomarc missle rather than to develop and produce the Arrow. Five airplanes had been built and flown; the 6th, and the first to have a production Orenda engine, was on the line and ready to go. The aircraft, the reports, and the paperwork were all destroyed.

Approximately 68 hours of flight time had been accumulated, and 95% of the flight envelope partially explored. However, the capability and potential of the aircraft and its weapons system was never realized. When it was all over and done with, only four pilots could say they had flown the Avro Arrow—Jan Zurakowski, Spud Potocki, Pete Cope, and myself. (One observer, on one flight, flew in the backseat).

Aircraft Configuration

The Avro Arrow Mk. 1 was a twin-engine, two-seat, delta-winged, all-

Twenty years after it was scrapped, the Avro CF 105 Arrow still holds excitement among Canadians in aviation. Here, the only RCAF pilot to fly the Arrow tells what it was like.

weather interceptor designed specifically to meet the peculiar Canadian defense requirements. There were a number of relatively unconventional features on the Arrow, and aerodynamically the CF-105, was, I believe, a considerable advancement over contemporary aircraft. The Arrow program was a very ambitious project for A. V. Roe and for the RCAF, but seemingly well within reach and completely attainable. Some of the design features are worth mentioning, as detailed in the following descriptions.

Design Features

The crew consisted of a pilot and a radar operator. The advantage of a two-seat airplane as compared to a single-seat airplane lies in the complexity of the fire control system, even though the system was intended to be entirely automatic.

The choice of two engines was a combination of circumstances, with the main advantage being reduced attrition. Perhaps the main factor, however, was the very large weapons package required as payload and the large amount of fuel required to meet the range requirements. In the early design of the airplane, the range requirements pretty well sized the airplane, and at that time there was just no single engine large enough to provide the required power. The Arrow Mk. I was powered by two Pratt and Whitney J75-P3 engines, which produced 18,500 lbs. of thrust at sea level, with afterburner. **Delta Wing**

The choice of a delta wing design versus a straight or sweptback wing was, I believe, a compromise to achieve structural and aeroelastic efficiency

with a very thin wing and at the same time to achieve the large internal fuel capacity required for the specified range. The structural advantages of the delta design made achievement of this thin wing section possible. (CF-105 thickness/chord radio was 3.5%; CF-100 Mk. 1 was 10%).

Some characteristics of a delta wing include:

- No stall—There is no well-defined stall for a tailless delta and this is perhaps the outstanding feature. It permits flying the airplane to much lower speeds compared to straight or sweptback wings. Minimum speed is usually determined by sink rate and/or minimum control.
- Ground effect—Since ground effect is a function of chord length, not wing span, the effect with a delta wing can be very pronounced. This simplifies the flare and landing problem. Landing the CF-105 was quite straightforward.
- Light wing loading—CF-105 wing area was 1,225 sq. ft., and at normal combat weight, wing loading was approximately 50 lbs. per sq. ft. Good manoeuvrability at high altitude, high speed, and also structurally strong.
- Attitude—The Delta wing will have a higher angle of attack for any given CL, which means an increase in pitch attitude and possibly flying on the backside of the power-required curve during approach to landing. Attitude was the limiting factor with the CF-105 during landing; handling qualities remained good throughout.

Analysis showed that, due to a short elevator arm, high elevator angle would be required to trim at high altitude, which would create excessive trim drag. To compensate for this, approximately 3/8 negative camber was built into the wing, which had the effect of building in elevator angle without the excessive control surface drag.

The CF-105 had a leading edge notch and a leading edge extension about midspan on the wing. The purpose of the notch and the extension was to control the spanwise flow of the boundary layer air, characteristic of all sweptwing aircraft, not just deltas. This is necessary to eliminate early flow separation, stalling of the wingtips, and the aerodynamic center shifting forward and giving pitchup, which is embarrassing to any pilot. The notch is similar to a wing fence, but it produces its desired effects by airflow rather than by a physical barrier, and it was Avro's opinion that the effects of the notch were present over the entire speed range of the aircraft rather than just a portion of it. Also, the notch was expected to increase drag by a smaller amount than a

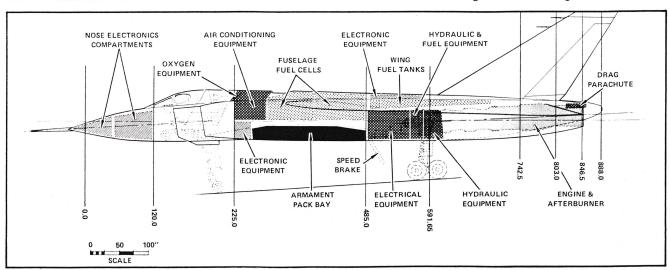
The leading edge of the Arrow wing was drooped approximately 8° inboard and 4° outboard. This was done to increase the manoeuvre margins and the buffet boundary by preventing leading edge breakaway at high angles of attack. Determination of $C_{\rm L.\,MAX}$ was never accomplished in flight test; however, wind tunnel results showed that at Mach 0.92, the $C_{\rm L.}$ was increased from 0.26 to 0.41 due to leading edge droop.

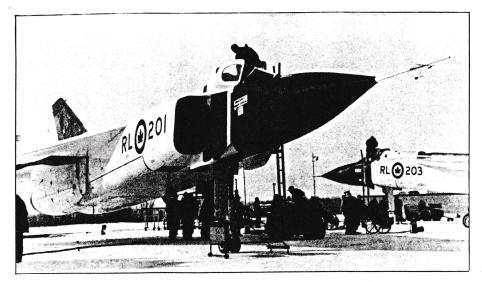
Another peculiarity of the CF-105 wing was 4° anhedral. This was on the airplane strictly to reduce the length of the landing gear, and had no appreciable aerodynamic effect or significance.

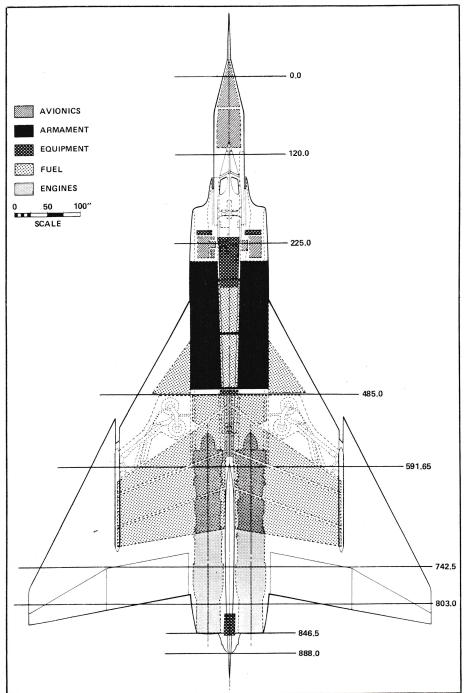
A high wing arrangement was adopted because of the flexibility this permitted. For example, this allowed a relatively simple engine installation. Also, any changes in engines or armament could be made without affecting the basic wing structure. This is not always the case with an integrated wing/fuselage structure.

A great deal of theoretical work was done on the application of area rule to the CF-105, and during the early design stages certain changes were incorpo-

Flight Limitations—Arrow Mk. I Max Takeoff Weight Normal Combat Weight Max Landing Weight Max Speed Max Altitude G-limits Landing Gear Escape System—Max Speed Min Speed Max Angle of Attack	
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Arrows No. 1 and 3 being readied for flight. Men at the cockpit give an indication of the size of the aircraft.

rated. For example, the radar nose was sharpened, the intake lips thinned down, cross section area of the fuse-lage reduced below the canopy, and an extension fairing was added at the rear of the fuselage.

Engine Intake

The CF-105 air intake was a fixed geometry intake. Intake gills immediately adjacent to the compressor inlet opened automatically at Mach 0.5 and allowed air to bypass the engine for cooling purposes and to alleviate spillage at high Mach numbers. It is interesting to note the similarity between the Arrow inlet and the McDonell F-4 inlet.

The arrangement of the intakes consisted basically of the following:

- A boundary layer bleed that diverted air in the boundary layer over the top and bottom of the wing, as well as air being taken into the heat exchangers in the air-conditioning system.
- An intake ramp used to create an oblique shock wave at supersonic speeds in order to achieve optimum pressure recovery characteristics inside the intake and, combined with the normal standing shock, to prevent inlet instability and inlet "unstart" over the Mach number range.

The angle of the intake ramp was 12°. Perforations were installed on the face of the ramp to prevent "intake buzz," caused by the interaction between the inlet shock and the boundary layer from the ramp.

Structures

The structure of the CF-105 was relatively conventional. The outer wing consisted of multispar, boxbeam, heavily tapered skins and ribs running to the main spars. The outer wing was bolted to the inner wing by a peripheral joint covered by a fairing. The inner wing consisted of a main torsion box containing spars, ribs, and machined skins.

The fuselage was designed basically around the two engines, with the cockpit in between the intakes. The engines were suspended from the inner wing. Materials used were basically aluminum and magnesium alloys, although titanium was used extensively in the area of the jet pipe, where low weight and high strength were required at temperatures up to 800°F.

Avro manufacturing capability included a big metal-to-metal autoclave, a special heat-treat furnace, a giant skin mill, heavy machinery equipment, and a 15,000-ton rubber pad forming press, which, at the time, was the largest of its kind in the world.

The fuselage, wings, vertical stabilizer, and control surfaces were all of metal construction. The tandem bogey main wheels were attached to the inner wing main torquebox and retracted inboard and forward. The nosewheel also retracted forward. The flying control surfaces were fully powered by two independent hydraulic systems. Speedbrakes were fitted below the fuselage, and a drag chute was installed in the aft

end of the fuselage. Space in the radar nose and armament bay was utilized for test equipment and instrumentation.

Systems

The aircraft systems (the fuel system, hydraulic system, electrical system, pneumatic system, etc.) were all relatively conventional except, perhaps, for the landing gear and the flying controls system.

The tricycle landing gear consisted of a forward retracting nose gear with dual wheels, and main gear with two-wheeled bogies, which retracted inboard and forward into the wing.

Cockpit control was by means of a lever in the shape of a wheel, located on the left-hand forward panel, and it was operated by a simple up or down motion.

Emergency lowering of the landing gear was by a 5,000-psi nitrogen bottle, which, when activated, released the door and gear uplocks, and the gear then fell in a normal manner by gravity, aided by air loads.

The problem with the CF-105 landing gear was one of stowage. Because of the high, thin wing the gear was relatively long. In order to stow the gear, it had to be shortened and twisted as it retracted. On June 11, on the 11th flight of the first airplane, the gear failed to extend completely, even though cockpit indicators showed it down and locked. The landing was made with the left main gear cocked approximately 30° to one side. In other words, it had not fully untwisted. The landing roll was about 4,000 ft., and, of course, with the port leg twisted it pulled the aircraft to one side. As the aircraft left the runway and came in contact with soft ground, the undercarriage snapped. The aircraft came to rest on its right gear and left wingtip.

Because of the excellent photographic coverage, the cause of the accident was quickly determined. Avro had the airplane flying again approximately four months later, and flight procedure from that time was to have a chase-plane check gear extension prior to landing. Zurakowski was the pilot, and I know that if he had only had some indication of a problem, the accident would never have occurred.

The CF-105 flying control system was a fully powered, irreversible, artificial feel control system. There were three modes of operation: a normal mode, an automatic mode, and an emergency mode. The automatic mode was not installed in the early aircraft.

Two independent hydraulic systems provided the muscle, each with two engine driven pumps. The supply was 4,000 psi. Also, a ram air turbine was to have been installed on later aircraft for use in the event of a two-engine flameout.

In the normal mode, a damping system provided stability augmentation for all three axes, and co-ordinated rudder movement with movement of the ailerons and elevators. Artificial feel was provided by an electrical system in such a way that stick force required was made to feel proportional to the

amount of g's pulled. Stick force per g was constant, irrespective of speed or altitude.

When the pilot exerted a force on the control column to move the elevators, a force transducer on the control column transmitted electrical signals to a series of servos, which converted the electrical signals into mechanical movement by means of hydraulic pressure. The electrical output at the transducer was directly proportional to the force exerted at the grip. The control column would move as the force was exerted, as with a conventional flying control system, but it was not moved directly by the pilot. Movement of the control column followed the positioning of the elevators. The response of the system was instantaneous, and it therefore appeared as if the control column were moved by the pilot.

In the emergency mode, the force transducer was taken out of the loop. The control column was linked by cable directly to the hydraulic actuators, which controlled the elevators. Artificial feel was provided by a spring-loaded assembly along with a bob-weight, which induced loads on the control column and made control column movement progressively heavy as g's were applied.

Operation of the ailerons and the rudder by means of electrical signals, or by cables, was very similar to operation of the elevators. Components in the systems differed slightly, but from the pilot's point of view, the systems operated in a similar manner. The damping system was duplicated in vaw. however, as this was the critical axis and of major importance to the safety of the airplane in the high-speed range. The airplane in the lateral-directional axis was naturally unstable. It was designed that way, by necessity, to meet performance guarantees specified by the RCAF.

The flying control system was anything but developed at the time the program was cancelled, and if I remember correctly, it had No. 1 priority in the flight test program. The airplane, at certain speeds and altitudes, flew as well as any airplane I've ever flown; at other points control was very sensitive and the airplane difficult to fly accurately. However, I know it was just a matter of optimizing the controls, the damping system, and the feel throughout the complete flight envelope. And it would have been accomplished.

I know the control system sounds sophisticated and perhaps overly complicated, and maybe it was for its time. But the Arrow flight control system was very similar to the systems being used now in today's most advanced aircraft. If the automatic mode had been installed, we would have had what is known today as Control Wheel Steering (CWS), i.e., flying the airplane through an autopilot. The Arrow control system was the same as a "fly-by-wire" system except for the mechanical linkage provided in the emergency mode.

I can't help but feel that if Avro had been permitted to develop the Arrow, both Avro and Canada would have been recognized as leaders in the field of high-performance airplanes.

Cockpit

The cockpit was generally comfortable and well arranged. It was a bit small, and with a pressure suit some of the controls and switches on the side consoles were difficult to see or operate. There was only 2 or 3 ins. of clearance between the canopy and the pilot's helmet, and I remember hitting the canopy with my helmet on several occasions with normal head movement and look-around.

Entry and exit to the cockpit was by means of a vertical ladder, nine or 10 steps high, hooked over the engine intake ramp. From the ladder, you stepped to the top of the engine intake, over the canopy, and down into the cockpit. This was a little awkward. Also, I think it would have been a source of trouble in squadron service, with people stepping on the side railing and air-conditioning ducts with dirty or snow-covered boots. Generally, however, I think the cockpit was quite comfortable.

The parachute harness and the seat harness were combined, and strapping in was relatively simple. Leg restraints were used to pull and hold pilots' legs back against the front of the seat pan during emergency ejection.

A Martin-Baker C.5 automatic ejection seat was used, which provided an escape envelope from ground level up.

The Arrow had a V-shaped windshield and vision splitter. This is not, in my opinion, the best kind of windshield to fly behind, but it was obviously satisfactory, and Avro did a good job with forward visibility.

Flight test program

The flight test program was scheduled as an eight-phase program. Basically, the first series of tests were to evaluate the general handling qualities of the aircraft, to evaluate the flying control system and damping system, to check instrumentation and telemetry techniques, and to check safety under adverse conditions.

The initial series of flights entailed pre-production testing and development, using the first five aircraft with the J.75 engines. This was the Arrow Mk I

The Arrow Mk. II started with the 6th airplane, with production Orenda engines. Phases I through III were to have involved contractor testing and development, and phases IV through VIII were slated for Air Force testing and evaluation.

Obviously, only a portion of the initial Phase I pre-production testing was accomplished; however, some significant milestones were reached:

- First two flights were familiarization flights.
- On the third flight, the aircraft flew supersonically (M 1.1-M 1.2).
- On the seventh flight, the aircraft flew to Mach 1.5 (1,000 mph) at 50,000 ft.
- Maximum speed attained was Mach 1.97-1.98.
 - Four pilots were checked out.
 According to my records, the five air-

craft flew 64 flights for a total of 68 hours and 45 minutes. The breakdown by aircraft is as follows:

First Flight Date	Flights	Hours
25201—Mar. 25, 1958	24	25:05
25202—Aug. 1, 1958	22	23:40
25203-Sept. 22, 1958	11	12:20
25204—Oct. 27, 1958	6	7:00
25205—Jan. 11, 1959	1	0:40
	64	68:45

On Feb. 7, 1959, aircraft No. 1 and No. 4 both flew. This was the last day any of the Arrow aircraft left the ground. As I mentioned, Zurakowski made the first flight; he also did most of the early flying.

When Zura retired, Potocki took over as Chief Development Pilot, and at the end of the program was high man in total flying time. I was fortunate enough to have six flights and, as fate would have it, the only military pilot to fly the airplane.

Flying with Don Rogers and the Avro team was an honor for me, and I thoroughly enjoyed the four years I spent at Avro. I mentioned Zurakowski being the best test pilot I have ever known; the rest of the team, and all the Avro troops, were of the same caliber.

The one complaint I had with the company's operation was the lack of detailed flight test plan. My friend Ken Owen (now chief of airworthiness at DoT) and I tried for over a year to get a schedule of flights and tests to be performed, but were unsuccessful. This is not to say that the people running the program did not know where they were going or what had to be done, but they apparently did not believe in writing it down. Ken and I did our best to convince them that we understood flight test and realized the only thing consistent was that it was subject to change. But our efforts were in vain; they refused to write a program. I didn't understand it in 1958, and I don't understand it today.

Data Acquisition

The Arrow data acquisition and handling system was composed of an airborne multichannel recorder (magnetic tape), phono panel, oscillograph, an airborne radio telemetry link, a mobile telemetry receiving station, and a mobile data reduction unit. The aircraft armament bay, which was a removable self-contained unit, was used to house all of the airborne instrumentation. For visual monitoring of flight conditions on the ground, a special "operations" room was set up, which contained recording oscillographs that gave instantaneous visual records of data during actual flight. Personnel in the room were in constant radio contact with the pilot by means of the conventional radio link, so instructions and/or comments could be exchanged at any time.

The instrumentation used during the Arrow program was the same as instrumentation being used in today's flight test programs—refined a little today, but basically the same. The system was a constant source of trouble during the Arrow program, however. During the first series of flights, the system was plagued with a number of problems that

Performance—Arrow Mk. II

The performance specifications for the Arrow Mk. II under ICAO standard atmospheric conditions were as follows: **Weights**

weights	
Normal takeoff weight	62 431 lbs
Combat weight	53 796 lbs
Design landing weight	47 743 lhe
Wing loading at takeoff weight	50.9 lbs/sa ft
Speeds (Sea Level)	
Maximum thrust (TAS)	700 kts
Military thrust TAS	665 kts
Max thrust—50,000 ft., combat wt.	Mach 2 0
Ceiling	
Combat ceiling at combat weight	60 500 ft
Rate of Climb	
(Steady State—S.L.—Combat Wt)	
Max thrust at M 0.92	44 500 fpm
Mil thrust at 527 kts.	20,300 fpm
At 50,000 ft with A/B	10.700 fpm
	pini

were probably due to the thousands of wires and connections running to the instrument pack. But, as I remember, these problems were never really resolved, and many a flight was delayed because of this system. Chase-aircraft, either a CF-100 or F-86 Sabre, were used on almost every flight.

There is not much I can add to the performance picture. As I mentioned. approximately 95% of the flight envelope was investigated, and while the Mk. I Arrow never did quite reach max speed of Mach 2.0, there is no reason to believe that the production aircraft with Iroquois engines would not have reached Mach 2.0 quite easily. The Iroquois engine had approximately 30% more thrust than the J.79, and the airplane would have weighed approximately 5,000 lbs. less. I believe the Arrow Mk. II had sufficient performance capability to set a world speed and altitude record, which was held at that time by the United States. The first Mk. Il Arrow was scheduled to fly at the end of February, and I believe it would have easily met all performance guarantees.

As I mentioned earlier, the Arrow, at certain speeds and altitudes, flew as well as any airplane I have ever flown; at other points control was very sensitive and the aircraft difficult to fly.

Reading from some of my old flight reports, on my first flight I reported that at low and high indicated airspeeds the airplane behaved reasonably well, the controls being effective, with good response, and the aircraft demonstrated positive stability. However, due to the sensitivity of the controls the aircraft was difficult to fly accurately. At high Mach numbers, I reported the transition from subsonic to supersonic speed to be very smooth, compressibility effects negligible, and the sensitive control problem experienced at lower speeds and altitudes eliminated. The aircraft, at supersonic speeds, was pleasant and easy to fly. During approach and landing, the handling characteristics were considered good; approach speed was 190 kts., touchdown was at 165 kts., drag chute was deployed at 155 kts., and the aircraft rolled the full length of the runway. Attitude during approach was approximately 10°, with good forward visibility.

On my second flight, I reported that the general handling characteristics of the Arrow Mk. I were much improved. The yaw damper was now performing quite reliably, although turn co-ordination was questionable in some areas. The roll damper was not optimized as yet, and longitudinal control was sensitive at high IAS.

On my 6th and last flight, I reported longitudinal control to be positive with good response, and breakout force and stick gradients to be very good. Lateral control was good, forces and gradients very good, and the erratic control in the rolling plane, encountered on the last flight, no longer there. Directionally, slip and skid were held to a minimum. At no time during the flight was there more than 1° of sideslip, and the problem of turn co-ordination appeared to be eliminated at this point. Final approach to landing was at 175 kts. and a glideslope; attitude was approximately 12°, touchdown was at 160 kts... and the landing roll was estimated at 6,000 to 6,500 ft., with little or no brak-

To me, it appears obvious that excellent progress was being made in the development of the Arrow.

Comments made by some of the other pilots who flew the Arrow include:

- "The nosewheel can be lifted by very gentle movement of the stick at just over 120 knots."
- "Unstick speed is about 170 knots with an attitude of about 11°."
- "Acceleration is rapid, with negligible correction required and no tendency toward swing."
- "Typical touchdown speed is a little over 165 knots."
- "There was no indication of stalling at maximum angle of attack at 15°."
- "Stability steadily improved with speed."
- "Change of trim was negligible except in the transonic region, where small changes of trim were required."
- "In turns, stick force was moderate to light, but always positive, with no tendency to pitch up or lighten."
 - "In sideslip, the aircraft was a little

(Continued on page 44)

Air Mail

WHERE ARE THE FIGURES

I am beginning to tire of your avionics editor, Mr. (David) Underwood, and if Aviation Electric Ltd. is to continue spending money in your magazine, I would strongly suggest that he start writing based on fact and discontinue using statements such as "while it's difficult to come up with precise applesto-apples comparisons of total sales figures, there's really no question who the world leaders are. Collins and King, in that order." (Avionics, April 1978)

On what basis does Mr. Underwood make the statement "there's really no question" while simultaneously admitting that no valid sales statistics are available? Such statements are, in my opinion, irresponsible reporting.

If your avionics editor is using Canadian sales figures as the criteria for inferring what worldwide figures may be, then perhaps you would be kind enough to forward copies of these statistics to AEL as we are currently planning to carry out an expensive and time-consuming survey to produce the Canadian statistics which your avionics editor may already have. As a customer of your magazine, I am sure you would not want us to spend our money unnecessarily.

C. G. Garbutt, Vice-president, marketing, Aviation Electric Ltd., Montreal

David Underwood replies:

The major difficulty in an apples-toapples comparison is the Bendix (who AEL represents in Canada) and Collins corporate policy against releasing sales figures. King makes no bones about it—\$42 million in 1977.

The question then is, did Bendix or Collins sell more comparable avionics products than King in 1977? To get the answer, one asks a lot of well-informed people in the avionics game inside and outside Canada—and including, I must add, Bendix people—for their assessments. A similar exercise, in fact, to that Mr. Garbutt is planning. He has correctly quoted my findings.

But figures, shmigures. As August's Avionics column notes, Bendix would make liars out of statisticians in a couple of years when it states selling its newly-announced ARINC product line. Indeed, after attending a recent Bendix/AEL briefing, I'd say that there's really no question that these products will revolutionize today's concepts of reliability and maintainability. At least, that's my opinion based on what well-informed people, i.e. Bendix engineers, told me. But again, this opinion is entirely unsupported by fact.

Flying the Arrow

(Continued from page 37)

touchy without the damper, but excellent with the damper engaged."

Summary

In closing, I would just like to say that the handling and performance characteristics of the Avro Arrow were shaping up very nicely. There were many problems still to be resolved at the time of cancellation, but from where I sat the Arrow was performing as predicted and was meeting all guarantees.

The decision to cancel the Arrow program was, in my opinion, very poorly founded. Nothing has happened since 1959 to support that decision as being correct. In fact, just the opposite happened.

Several months before the cancellation announcement, there was a lot of bad publicity in Toronto newspapers about the Arrow. It was like an anti-Arrow campaign was being waged. Retired Army officers and self-proclaimed aviation experts, and others, were implying that the day of the manned interceptor was over. They said missiles would be the first line of defence, and the Arrow would be obsolete before it could enter squadron service.

Ironically, not too long after the program was cancelled, an announcement had to be made concerning the decision to scrap the Bomarc missile program due to obsolescence. The Bomarc just never got off the launching pad, and the Canadian Government had been "led down the garden path." Ground-to-air missiles can be effective weapons, and a combination of missiles and manned aircraft is probably a good way to go, but one certainly does not replace the other.

The decision to scrap the Arrow program could not logically have been based on money, because since the cancellation, the RCAF has purchased at least 400 new aircraft, it not more. This includes the F-101, the F-104, the F-5, and the present-day evaluation of the F-14 and F-15 as a replacement fighter for use in the 1980s, which run about 15 to 20 million dollars per copy. This new manned interceptor is intended for the 1980s, approximately 30 years after the Arrow was cancelled, and the idea of the manned interceptor declared obsolete.

Cancelling the program was one thing, but to make matters worse, everything was destroyed—all the aircraft, the records, and all the work that was accomplished, almost as if to hide all the evidence. I think one of the aircraft, at least, should have been assigned to the National Aeronautical establishment and kept as a research vehicle. Also, I'm sure other aircraft manufacturers could have benefitted from Avro's experience—makers of the Concorde, for example.

Cancelling the Arrow program denied A. V. Roe, and Canada, the opportunity of developing their technological expertise and to be world competitors in the field for high-performance aircraft.

Intercom

(Continued from page 4)

PETE FERRON, who jaunts around North America in Collins Radio's A36 Bonanza promoting the company's avionics, laid ruler to Jeppesen VFR Area Navigation planning chart and drew a straight line between Toronto and Montreal/Dorval.

He jotted down the mileage—275 nautical—made a few other notes and picked up the 'phone to file an IFR flight plan.

"... route of flight, 090, twenty miles, Stirling; zero zero zero, fifteen miles, Massena; Montreal/Dorval."

In other words, on our direct route to Montreal, we would pass the 090° radial of Stirling Vortac 20 nm from the station, and the 000° radial of Massena VOR at 15 nm.

"We have a preferred routing," the ATC girl said.

"I don't want the preferred route," replied Ferron, and continued filing the plan.

A short while later, while I taxied the Bonanza, Ferron called Clearance Delivery. Clearance responded immediately.

"ATC clears November Seven Eight Charlie Romeo to the Montreal airport via Victor Ninety-Eight Massena, Victor Two Oh Three . . ." which was the preferred routing.

So much for our attempt to fly RNAV Direct to Montreal under IFR and save 14 miles.

We both knew, though, that the request likely wouldn't be approved. The Canadian ATC system is not set up to handle other than on-airways IFR in the low level airspace. And it's doubtful if RNAV routes will appear here in the next decade.

So the one advantage of RNAV is lost to Canadian IFR pilots, but it still can be used as a back-up to non-precision IFR approaches.

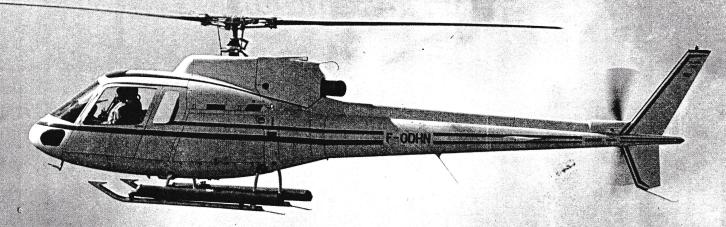
To demonstrate Collins' ANS-351 RNAV, we took the Bonanza to Kitchener. What we did was "move" the Toronto VOR to the Kitchener NDB, and "move" the Ash VOR to the Kitchener airport. That was done by dialing into the RNAV computer the bearing and distance from Toronto to the NDB, and from the Ash to the airport itself. With the Toronto VOR, Waypoint 1, hooked into the No. 1 Nav system which drove the track bar on the HSI, it was simply a case of flying the 136° "radial" by keeping the track bar centred, and monitoring the DME which steadily counted down the distance from the NDB. And when I let the airplane stray from the inbound course, I had the OBS on the No. 1 Nov system pointing the way to the airport, to where we had "moved" the Ash VOR.

Signal strength remained right down to the Minimum Descent Altitude and, in fact, gave me better indications than the ADF. Dead over the runway, heading 136°, the track bar on the HSI was centred, but the ADF needle was about $2\frac{1}{2}$ ° off.



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