Avro NEWSMAGAZINE

THE ARROW STORY

SPECIAL EDITION PUBLISHED BY AVRO AIRCRAFT LIMITED SUMMER, 1958

FROM CONCEPT TO FLIGHT TEST

J. L. PLANT, President and General Manager, AVRO AIRCRAFT LIMITED.

Avro NEWSMAGAZINE

Editor's Note: The following pages comprise re-printing of former Avro Newsmagazine issues dealing with the introduction of the Avro Arrow.

TABLE OF CONTENTS

Editor .... Jim McLean

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From the Office of

J. L. PLANT

There is certainly no need for me to remind you of the sense of pride felt by all of us at Avro when the Arrow flew for the first time.

It was a proud moment.

Many Canadian are contributing in some direct or indirect degree to the development of the Arrow and we all have a right to be proud of this airplane. The Arrow ranks with the most advanced military airplanes in the world, and we believe, on the basis of what we know, that it is more advanced than any similar type anywhere.

It is with pleasure then, that I append to my congratulations and thanks to all personnel for the successful Arrow flight, the following special congratulatory notes from among the many messages received:

To Fred T. Smye, Executive Vice President, Aeronautical Division, A. V. Roe Canada Ltd., from the Hon. George Pearkes, V.C., Minister of National Defence.

"THE FIRST TEST FLIGHT OF THE CF-105 IS A GREAT SUCCESS FOR CANADIAN INDUSTRIAL SKILLS AND A MILESTONE IN OUR AVIATION HISTORY. I KNOW THIS COULD ONLY HAVE BEEN ACHIEVED BY THE TEAMWORK OF ALL AVRO EMPLOYEES. WELL DONE AND BEST WISHES FOR FUTURE DEVELOPMENTS."

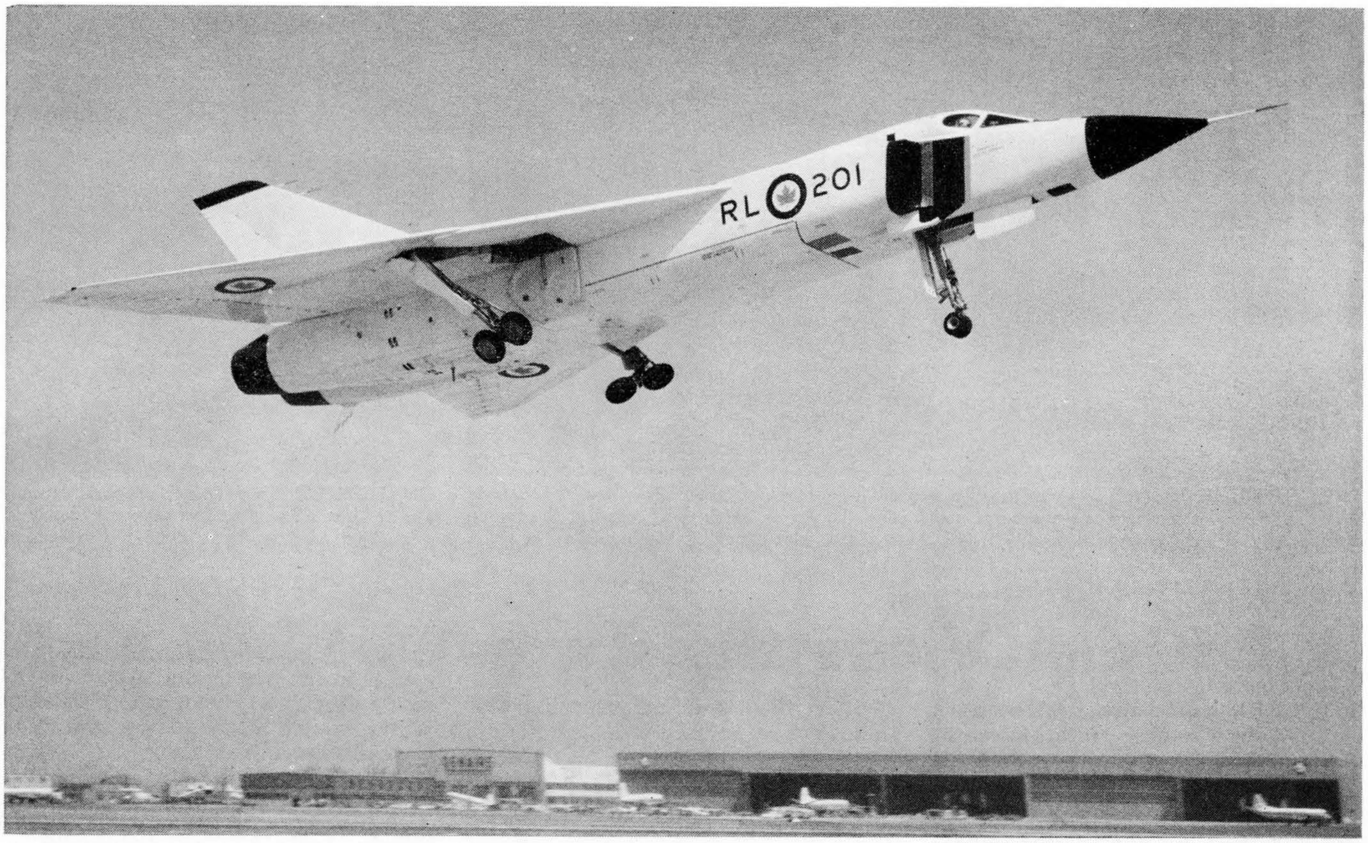
To Fred T. Smye from Sir Roy Dobson, Chairman of the Board, A. V. Roe Canada Ltd.:

"MY HEARTIEST CONGRATULATIONS ON SUCCESSFUL FIRST FLIGHT PROVING ONCE AGAIN AVRO COMPETENCE. ALL HERE SEND YOU BEST WISHES FOR FUTURE."

To J. L. Plant from A/M Hugh Campbell, Chief of the Air Staff, RCAF

"THE AIR COUNCIL JOINS ME IN SENDING OUR HEARTIEST CONGRATULATIONS ON THE SUCCESSFUL FLIGHT OF THE AVRO ARROW. THE FIRST FLIGHT MARKS A SIGNIFICANT STEP FORWARD IN CANADIAN INDUSTRY AND AVIATION."

President and General Manager.



March 25, 1958

First Arrow Takes Off On Initial Test Flight

Canadian Aviation History Made In 35 Minutes

by Jim McLean
Editor, Avro Newsmagazine

AT 9:49 a.m. on March 25, an Avro CF-100 with an Orenda Sabre trailing it, circled low over the button end of Runway 32 at Malton Airport. Suddenly, the CF-100 straightened out and swept along the east side of the runway. The Sabre took up a course on the west side.

This was the signal that Canada was entering the supersonic era of flight. On the runway, below, engines responded to throttle and powered the Avro Arrow toward its first take-off.

Some 3,000 feet along the runway, the Arrow lifted effortlessly from the ground and climbed gracefully to the north at a controlled low speed and rate of climb.

A routine radio check from the Toronto Tower officially recorded the historic event:

"Avro 201 off at 9:51 and cleared to company tower."

Avro's Chief Development Pilot, Jan Zurakowski acknowledged the call and continued climbing northward while the chase airplanes took up their respective positions. 'Spud' Potocki, Avro experimental test pilot, flew the CF-100. In the rear cockpit, Hugh MacKechnie of Photographic, unlimbered his assortment of still and movie cameras loaded with black and white and color film and began taking pictures.

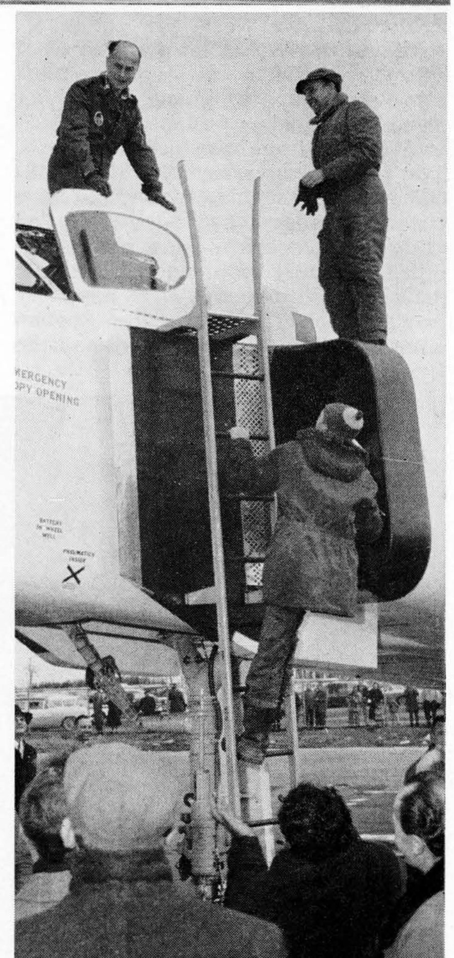
Further back in the Sabre, F/L Jack Woodman, RCAF test pilot fitted a movie camera to a special adapter on his hard helmet and prepared to close up if MacKechnie's equipment developed trouble.

The trio flew over the Avro plant several times at different altitudes, exchanging procedure patter by radio and verbally reporting the Arrow's progress for a tape recording in Avro's tower monitor. Then the Arrow began letting down in what appeared to be a fairly tight circuit, approached Runway 32 and landed. The drag chute developed, and the big delta slowed to nearly a full stop before jettisoning it.

The flight had lasted 35 minutes. The Arrow taxied back to the run-up base, and Zura shut down the engines.

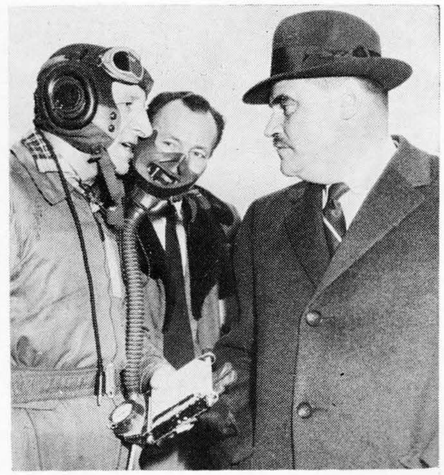
The first flight of Phase 1 of the Arrow Flight Test Program had been successfully completed.

Just 35 minutes . . . and Canadian aviation history was written.



AT MALTON where 10,000 hands proclaimed him hero of the day, Jan Zurakowski emerges from the Arrow after first flight. Ray Hopper, line chief, was first up ladder to greet Zura.

PART OF HUGE CROWD of Avroites who poured from the Avro facilities to see the historic first flight, can be seen under the nose of and behind the Arrow which was parked at the run-up base after the first landing. Nose of CF-100 chase plane, which took air-to-air photos, at right.



CHASE PILOT, Spud Potocki, reports informally to Avro's President and General Manager, J. L. Plant, on how Arrow appeared to handle.

From FLIGHT Magazine—

A Britisher Views the Arrow

UNDER the heading, "Arrow — A World Leading Interceptor by Avro Aircraft", a leading article in Flight magazine of the UK described the aircraft as "the biggest, most powerful and potentially the fastest fighter that the world has yet seen".

The writer, W. T. Gunston, technical editor, referred to the Arrow roll-out as "a significant ceremony". He went on to say:

"We in Britain have nothing like it. Two years ago we curtailed the development of a machine which would have begun to approach it—the so-called "thin-wing Javelin"— and have since relied implicitly on a superb electronic defence environment and relatively small weapons such as the English Electric P.1B and Thunderbird and the Bristol Bloodhound.

"Even the USA", Mr. Gunston continued, "has nothing like the Arrow; yet in that country the development of manned interceptors is by no means dead. North American Aviation hold a development contract from the US Air Force in respect of Weapons System 202A, which enjoys a development priority equalled by only one other USAF aeroplane. The vehicle for this weapon system will be the F-108, a chemical-fuel aircraft intended to reach at least Mach 5 (a scarcely credible figure".

"Of Inestimable Value"

Mr. Gunston described the Arrow as not only the "weapon which can meet the future defence requirements of the RCAF but it is also the only aeroplane of any type in the British Commonwealth which can fly at more than twice the speed of sound; moreover, it can hold its maximum speed indefinitely. Such aeroplanes are going to be of inestimable value, and one this year is worth several next year.

"Considered solely as a weapon system, the chief raison d'être of the Arrow is to be found in the enormous extent of the area which it is designed to defend. Including her numerous water areas Canada covers no less than 3,737,923 square miles, and is thus much larger than Europe or the USA. During the past five years the electronic defence systems of North America have improved out of all recognition, and there exists today a formidable barrier of long-range radars and fighter bases all controlled from a unified HQ in the State of Colorado, USA. Yet this "infrastructure" is of no value unless the means exist to intercept and destroy any raiding bomber which might be encountered.

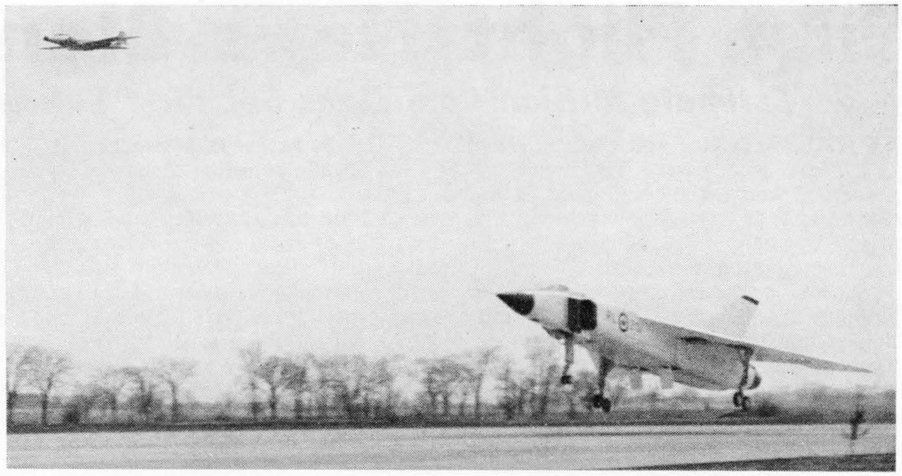
"Nothing at present available can do this, unless one is prepared to finance the cost of not merely dozens but hundreds of bases for such devices as Bloodhound, Bomarc and Nike Hercules. It is a job which calls for a big, long-range, piloted aeroplane, with a flashing performance and all the tools of the interceptor's trade.

"It is fitting that the mighty task of producing such a weapon should fall to Avro Aircraft, since that youthful company was responsible for Canada's first home-defence interceptor (it was also the first all-Canadian aeroplane and the Dominion's first jet aeroplane."

Mr. Gunston went on to describe the CF-100 as "a tremendous achievement that has done much to instil into Canadians a long-overdue appreciation of their ability to design and build advanced aircraft fully comparable with those of America, Britain or any other country. This self-confidence must be regarded as a pre-requisite to the successful development of the CF-100's successor."

SHOULDERED BY JUBILANT AVROITES on successful completion of the first flight in Phase I of the Arrow's Flight Test Program, Jan Zurakowski received ovation from assembled crowd. This was the only time during the whole day that Zura appeared uncertain as to what might happen next.

WARM CONGRATULATIONS are extended to Zura from Harry Beffort, Production Shops Manager, a key man in the Arrow's construction.



ESCORTING ARROW on its maiden flight, the CF-100 flown by Spud Potocki, is seen upper left in this unusual photo which has caught the Arrow airborne just a few feet above the runway. For take-off, Arrow RL-201 used only about 3,000 ft. of Runway 32, recently extended to 11,000 ft.

From AVIATION WEEK Magazine—

An American Views the Arrow

WHEN the Arrow was first rolled out on Oct. 4th, 1957, some highly complimentary language was used to describe the airplane by writers all around the world. Among these was James S. Butz of Aviation Week, a trade magazine of recognized authority in the United States. Mr. Butz presented a knowledgeable opinion of the Arrow's position in the state of the art, which said in part:

"Avro's CF-105 Arrow has given Canada a serious contender for the top military aircraft of the next several years.

"The Arrow's power, weight and general design leave little doubt of its performance potential. Important features of the present version of the CF-105 include:

- Thrust of approximately 60,000 lb. with Orenda Iroquois engines and afterburning.
- Maximum takeoff weight of about 60,000 lb.
- Area-ruled fuselage.
- Very thin wing with conical cambered leading edges and blunt trailing edges.

"The Arrow was designed specifically as a long-range interceptor which would set new standards for combat ceiling and maneuverability at altitude. The aircraft's chances of meeting these specifications and becoming a truly outstanding fighter are intimately related to its powerplant.

"Primary requirement for pushing effective high altitude operation higher is an outstanding thrust-to-weight ratio for both aircraft and engine. (Engine thrust rather than wing lift is the main support of today's fighters at very high altitudes. Thrust holds them in turns and other maneuvers without loss of altitude.) If the engine thrust-to-weight ratio is an improvement over existing types, the aircraft can usually be built to show a similar improvement. The main burden on the aircraft is that it must remain stable and flyable at the new altitudes and speed that the improved thrust-weight ratio will allow it to reach.

"Both the CF-105 and its Orenda Iroquois powerplants are approximately four years old and each is about to begin flight test after extensive test programmes in facilities in the U.S. as well as Canada. As a precautionary measure their flight testing will be accomplished separately rather than as a unit. The Arrow will use J75 engines during its first test phases and the Iroquois will be flown in a B-47 test bed.

"Tremendous Rate of Climb"

"The very high thrust-to-weight ratios of the aircraft and the engine which will aid high altitude, high speed maneuverability will also give the Arrow impressive performance in other areas. Its maximum speed should be well over Mach 2 if comparisons with existing fighters can be used as an indication. Since aerodynamic heating problems begin between Mach 2 and 3, the Arrow's top speed will probably be limited by structural heating rather than by a lack of power.

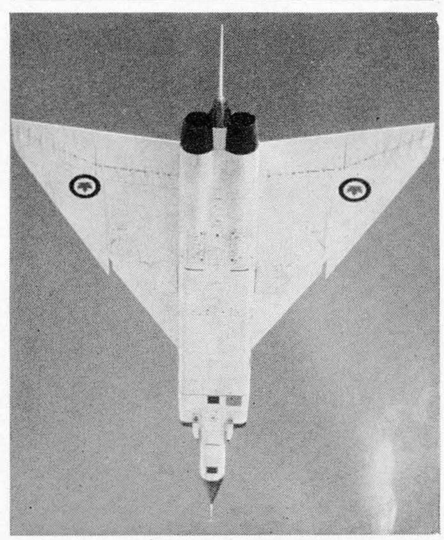
"The rate of climb of the CF-105 should be tremendous at all weights. Even at maximum takeoff weight the Arrow has a thrust-to-weight ratio of about one, which is greater than any existing aircraft except a VTOL.

"As far as ceiling is concerned, Fred T. Smye, president of Avro, has stated that the Arrow will be able to intercept and destroy aircraft flying at 75,000 ft. There was no explanation as to whether the Arrow would reach this altitude in a zoom climb, or whether the Arrow actually had to reach 75,000 ft. for its missile armament to destroy the hostile aircraft, but it does give some indication of the Arrow's altitude capability.

"In the design of the Arrow, the Canadians state that they have tried to make the best possible use of their association with two foreign aircraft industries. They maintain intimate contact with British and American work, especially with projects that are similar to their own. For instance, delta-wing flight test and experimental work at Convair and in England have aided Avro materially.

"J. C. Floyd, Avro vice-president, engineering, who has technical responsibility for the Arrow, is strong in his appreciation and praise for the kind of assistance Avro has received from NACA, the Air Force and Navy as well as some U.S. companies. Other Avro officers and Canadian government officials took the opportunity of the Arrow unveiling to make similar acknowledgements of U.S. help and co-operation.

"However, the exchange of information is anything but one-sided. Some of the most important Canadian contributions so far have been in metallurgy and aircraft and engine structural design and fabrication techniques."



LOOKING LIKE THE ARROW which inspired its name, Avro's new missile-firing bomber destroyer was snapped at this unusual angle from the rear cockpit of the CF-100 chase plane.

First Flight News Blankets World

Estimate Million Canadians See First Takeoff Same Day On TV

By Arthur H. Stewart
Public Relations Manager

WHILE Avroites and their families last week were reviewing together, at home, the excitement of the first flight of the Arrow, they were joined by many millions of well-wishers throughout the Western World.

Within two hours of the take-off on Tuesday morning, more than half a million people in the Toronto area alone, read or heard about the first flight through their favorite newspaper and, or, radio station. Before Avroites went to bed that same night, it is estimated that coverage in the combined Oshawa-Toronto-Hamilton area was well past the million mark.

What about the rest of Canada?

Well, by bedtime on the day of the first flight, the story had been flashed across the continent, from Newfoundland to B.C., by the Canadian newspaper wire services with total coverage exceeding 10 million newspaper readers: in addition, the story had been carried during that day and evening by national radio news services into an estimated million Canadian homes.

Then, in graphic recapitulation of the story spread by the radio and newspaper world, there was the impact of television on more than one million Canadians, as estimated by the CBC-TV. It can be assumed, of course, that there was audience duplication between newspapers, radio and television. But, regardless, at least 10 million Canadians knew about the Arrow's take-off into the supersonic era of flight before they went to bed last Tuesday night.

What of our neighbours to the South? Through the same media as in Canada—wirephotos, news wire services, radio and TV—the story of the Arrow's first flight was flashed from Malton to Toronto to New York and on across the USA to be picked up by individual newspapers, radio and television stations.

What of the rest of the world? Here, the figures climb astronomically.

Perhaps it's time to take a look at a rundown of the system used by Avro's PR in getting out the story of the flight to the Free World. In this way, a mental picture of millions of people learning of the Arrow's historic first flight takes on a better perspective.

PRESS CONFERENCE was held in Avro offices after the first flight debriefing. The happy group shown facing the press above are, from left: Jim Floyd, Vice-President Engineering; J. L. Plant, President and General Manager; Zura; Duke Riggs, Vice-President Manufacturing and Spud Potocki, pilot of Avro's chase plane which followed Arrow at distances of from 30 to 150 ft.

Planning and Liaison

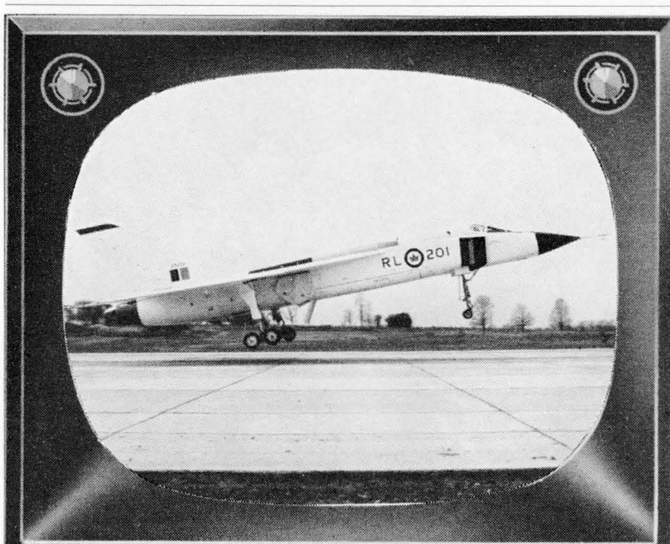
Months of planning and programming by Public Relations with world-wide news media and representative news writers preceded the first flight. More than 2,000 letters, cables and press enquiries had been processed by PR since the turn of the new year.

Liaison with the CBC-TV in the weeks immediately preceding the take-off had resulted in a movie distribution system being organized with the major international TV agencies of the Free World.

Similarly, liaison with the Canadian Press News Service head office in Toronto automatically established a world-wide distribution of the story to newspapers and radio stations through the very nature of the international news service organization.

Briefly, material provided by Avro Public Relations to the Canadian Press news service and augmented by their own on-the-spot representative, was processed and distributed by CP across Canada into the offices of sister organizations in the United States. These include: Associated Press, United Press and International News Service—and through them, material was distribu-

BELOW at left is the Arrow as it appeared on National TV News the same day. At right is how Zura appeared on TV that same evening being interviewed by CBC Newsman Joe Gibson.



ted across the USA and—as with the Canadian Press—across the seas to Europe and Asia.

Similarly, photographs of the Arrow taking off, landing and in flight were taken and processed by Avro and rushed to the Canadian Press head office in Toronto and through their wire service, were distributed to the leading daily newspapers in Canada, down into the USA and across the seas to the UK for world-wide distribution.

In addition, movie film produced by Avro, and processed the same afternoon, was picked up by the CBC-TV organization to augment their own take-off footage and distributed across the world. As a CBC official remarked: "The TV coverage of the Avro Arrow serviced every nation in the world ex-

AVRO PHOTOGRAPHIC CREWS shown above at briefing, recorded publicity and engineering stills and movies of first flight. Sitting, left to right are: Lou Wise (supervisor), Peter Brown, Cy Beard, Harold Roberts, George Laidlaw, Granville Stuart and Jack Hurst. Standing, from left are: Al Betts, Bill McDowell, Fred Hopkinson, Russ Thompson, Ron Northcott, Stu Barefoot, Hugh MacKechnie, Cliff Heckel (Orenda), Ron Nunney, Len Goodenough (Orenda), and Verne Morse, PR Photographer.

RIGHT—Jim Hornick, well-known newswriter on Toronto's morning newspaper, the Globe & Mail, is seen interviewing Zura after the flight.

BELOW LEFT—Zura and Spud Potocki arrange through A. H. Stewart, Public Relations Manager, (left), to tape record an interview requested by radio station CHML in Hamilton.

BELOW RIGHT — Radio news commentator Gilmour of radio station CFRB, Toronto, is seen at left making tape recording of interview with Zura and Spud Potocki, supervised by Avro's Public Relations Manager, Arthur H. Stewart.

TO PHOTOGRAPH ARROW from the rear cockpit of the CF-100 chase plane, Hugh MacKechnie of Photographic, left, had to carry movie and still cameras and magazines and slides of color as well as black and white film. He shows modified Speed Graphic to Spud Potocki.

HEAVILY-INSTRUMENTED ARROW transmitted signals to Telemetry Van, above, where complex electronic equipment makes engineering analysis of performance possible while aircraft is still airborne. Operators shown are: Bill Moore, Ray Gibson, Al Maddock and John Lockyer.

cepting those behind the iron curtain."

And in addition to supplying background and spot news material for newspaper, radio and TV coverage, Avro produced more than 1,000 photographs in less than 24 hours, of the many aspects of the first flight for immediate, specific publicity usage as organized in the months preceding the first flight.

Also, original negatives of the more outstanding pictures were airmailed on the day of the flight to key news agency points in the USA, UK and the Continent for their respective distribution to clients. Photos also went to internationally-read aviation 'trade' magazines in Canada, the US and UK for their exclusive use.

Additional Media

In addition to media mentioned, there is the vast audience of the movie theatre that was serviced during the flight by screen news photographers. This adds many more tens of thousands to the total audience so far classified.

Why such extensive News coverage? Well . . . it has been said that "bad news travels fast" and has a big impact on arrival. Why not try this out with some **good** news? And what better news than that Western defence against possible aggression is assured of a phenomenally strong arm in the not-too-distant future through the Avro Arrow bomber destroyer. The press unanimously agreed that this was News which rated top treatment.

FIRST RCAF ARROW PILOT, F/L Jack Woodman, second from left, appears pleased with his initial flight recently in the big delta. Air Force personnel based at Avro were on hand for a verbal report on his impressions of the Arrow. From left, above are: F/L Reg Kersey, RCAF Acceptance Pilot; F/L Jack Woodman; S/L Gordon Patterson, CEPE; S/L Ken Owen, RCAF TSD Avro; and S/L Bob Young, RCAF TSD Avro.

"Bright Herald"

World opinion of the Arrow's introduction? It follows along the lines of the words of the editorial department of the Toronto Telegram that stated: "The Arrow is a tremendous production achievement. Aside from war and the Arrow's function of intercepting enemy aircraft and, as well, delivering the assault of nuclear and other weapons, the new aircraft is a bright herald of faster, long-range peaceful flight. Men like Jan Zurakowski, the test pilot, and the complex planning and production organization behind the Arrow, are combining to extend the frontiers of mankind's travels."

Coast-to-Coast on U.S. TV

Last Fall, you may recall, the Dave Garroway Show, with a U.S. and Canadian audience listed in the millions, did a live broadcast from Toronto that included references to the preliminaries to the rollout of the Arrow. Cameras panned across the closed hangar doors at the end of Bay 1 and the commentator remarked: "Behind these doors is developing a tremendous achievement in world aviation; but it is top secret".

On Wednesday morning following the Arrow's first flight, the New York announcer of the Garroway Show recalled this incident and then commented: "And now the doors have opened and this is what happened yesterday in Canada". The Garroway audience then saw the first flight of the Arrow.

Where did they get the film? From the CBS, via the CBC, via Avro PR, via Avro Photographic Department, from the back seat of a CF-100 over Malton.

AGAINST A BACKDROP of cumulus cloud high over Malton, the Arrow I displays its delta planform during a recent routine test flight.

Arrow Exceeds 1,000 MPH — RCAF

Jan Zurakowski Flies Arrow At Mach 1.5 On Seventh Flight

AS Avroites began punching out and heading for home last Friday, the clear blue sky over Malton was being interlaced by white, thread-like vapor trails from three high-flying jets. Although no aircraft were visible to the naked eye, many homebound workers paused to watch the flight-path patterns develop because they knew that one of them was plotting the course of the delta-winged Arrow flown by Jan Zurakowski.

It was the Arrow's seventh flight since it first became airborne on March 25th, and it was its second flight of the day. Word had spread throughout the plant that a high-speed run was on the flight test program that afternoon.

Before 5:00 p.m., the Arrow had twice outrun its two chase planes—a CF-100 flown by Spud Potocki and an Orenda Sabre with F/L Jack Woodman at the controls. The vapor trails recorded the circular patterns made by the chase planes as they turned to join up with the Arrow each time.

Just After Five

Then the Arrow headed west on a long curving course. The chase planes peeled away and circled some miles apart. Just after 5 o'clock, a vapor trail became visible, in the western sky. As if drawn by a ruler, the telltale white string of machine-made cloud cut across the blue sky. And it cut across fast!

There was no doubt among the watchers as to what was making the contrail.

"Zura's really got'er opened up today," one Avroite was heard to say as the Arrow sped overhead.

The chase planes took up parallel courses in a token effort to follow the big delta. But the contrast in speed at which their vapor trails developed only served to accentuate the supersonic run of the Arrow.

Out of sight of the watchers on the ground the three planes joined up again, flew back over Malton in formation at about 2,000 feet, broke away and landed each in turn.

RCAF Announcement

After debriefing, W/C Gerrie Waterman, O.C. of the RCAF Technical Services Detachment at Avro, made a phone call to AFHQ in Ottawa. In less than an hour, the following message was speeding across the Canadian Press News Service wires to some 10 million Canadians who get their news via newspapers, radio or television.

"Air Force Headquarters announced that the RCAF Arrow, designed and built by Avro Aircraft Limited, achieved a level flight speed over 1½ times the speed of sound today at an altitude of 50,000 feet.

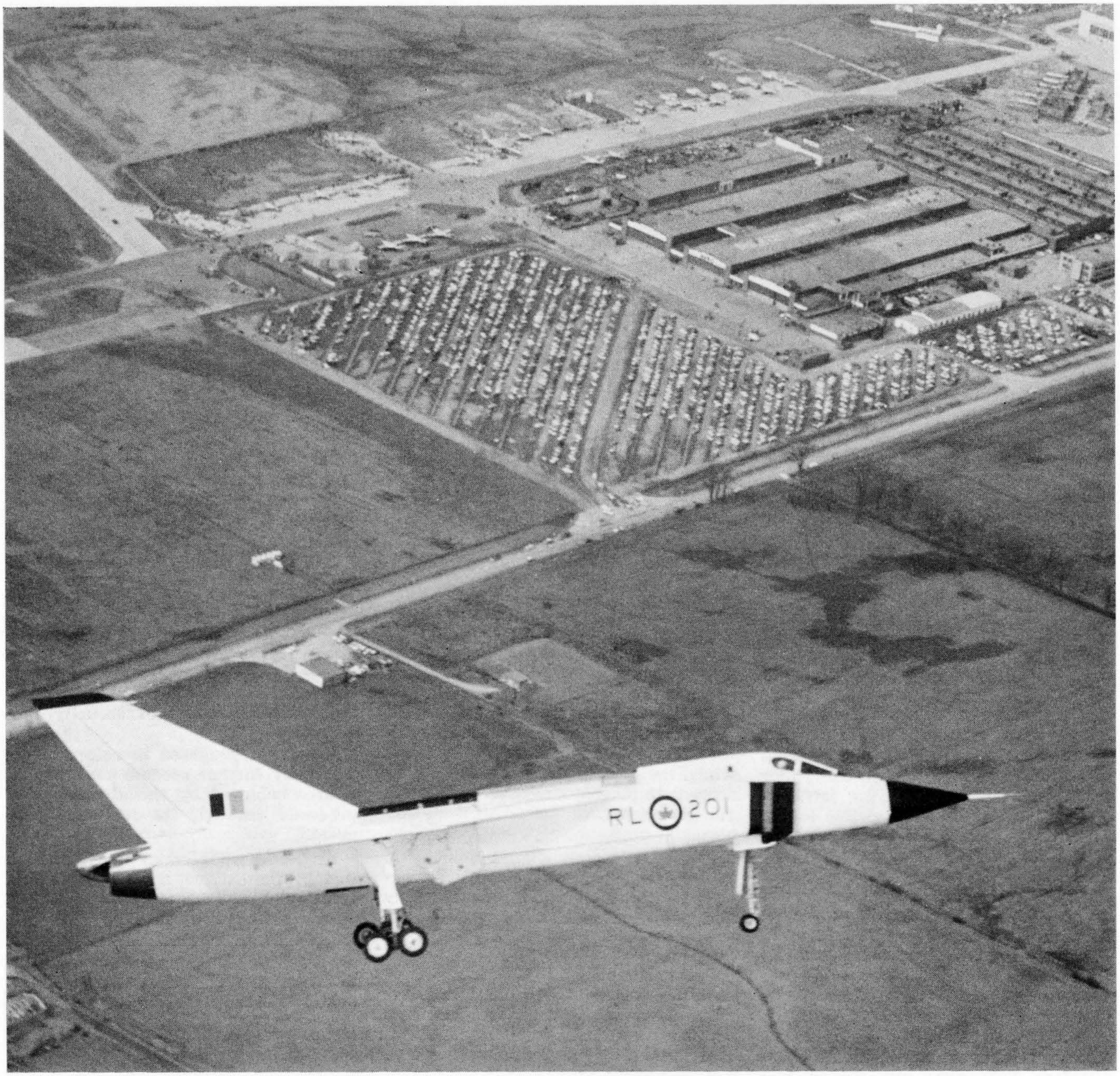
"The speed is equivalent to 1,000 miles per hour. This prototype version of the Arrow is powered with interim engines while later versions will be powered with lighter, more powerful Iroquois engines, designed and built by Orenda Engines Limited.

"Because it is less than one month since the Arrow's first flight and because of the aircraft's high order of complexity, weight and size, the RCAF considers the flight to be a significant achievement. Full details of the Arrow's performance capabilities cannot be released because of security reasons.

"It is not proposed therefore to release any further specific performance figures achieved by the aircraft as it proceeds through its full test program."

An RCAF spokesman added that although the Arrow had made several supersonic runs during previous flights, this was the best yet.

THE LINE CREW—The boys who give the Arrow its final pre-flight preparations give Zura a heartfelt cheer after the flight. From left are: Arnold Banks, Bill Seggie, Johnnie Straboc, John Salmon, Zura, and Bob Levitt.



Completing its first flight on March 25th, the supersonic Arrow is shown circling over the Avro plant at Malton, prior to landing.

Each Move Experiment On Arrow's First Flight

THE first flight of the Arrow on Tuesday, March 25th, triggered Phase I of the big delta's flight test program. It lasted 35 minutes, and was in the nature of a familiarization flight during which, Chief Experimental Pilot Jan Zurakowski "got the feel" of the aircraft by putting it through some elementary manoeuvers.

This is normal procedure for any pilot taking over the controls of an unfamiliar airplane. No two types of airplanes "feel" exactly the same or respond to control movements in precisely the same way. Flying characteristics, idiosyncrasies and limitations of proven airplanes have been established, and can be introduced to a pilot, new to the type, in pre-flight briefings. Shop talk among flying people can help fill in where instruction manuals may not be too explicit. Even so, familiarization flights on proven types are as normal as ham and eggs.

With an untried and unproven airplane, familiarization flights demand a master's touch. There is no room in the cockpit for inexperience or brashness. Wind tunnels, test rigs, electronic simulators and engineering opinion notwithstanding, once a new type of airplane is in the air for the first time, the flight becomes a voyage of discovery for the test pilot—every movement of the controls becomes an experiment. In one sense it can compare to learning how to fly all over again. There is no bible of experience for the type from which the pilot can draw. He will be, in fact, the first author of a new bible.

Such then were the circumstances which governed Zurakowski as he lifted the first Arrow from Runway 32. His mission was to become familiar with, and obtain a pilot's assessment of Canada's first supersonic interceptor.

To do this, he took off, climbed to 5,000 ft., levelled off and raised the undercarriage.

He continued to 10,000 ft., with the

chase planes watching each move, he made some gentle turns and let-downs, first with the gear up, then with it down in order to get the feel of the Arrow on approach to landing. During this time, mechanisms were checked and instrument readings noted. He then let down, approached the runway and landed.

The very significant first flight signalled the start of a detailed development program which will culminate in the most effective defensive weapon system in the history of Canada.

This, in brief, is the background of the first flight of the Arrow I in its airworthiness and equipment-functioning flight test program.

It doesn't even begin to touch on the strain and effort and, in many instances, selfless dedication by Avro personnel which made the first flight a successful historical episode in the introduction of Supersonic Flight in Canada. As the man says. "That's another story".

U.S.-Based CF-100's Test Sparrow Missiles

WELCOME TO POINT MUGU is extended to Avro test pilots Lorne Ursel and Stan Haswell by Capt. H. G. Corvi, U.S. Marine Corps Missile Project Officer, left, and Capt. J. C. Alderman, U.S. Navy, USNAMTC Base Commander.

A team of Avro Aircraft and RCAF personnel, with two CF-100 Mk 5 interceptors is based at the U.S. Naval Air Missile Test Centre, Point Mugu, California, to carry out test firings of the Sparrow 2 air-to-air guided missile.

The extensive facilities of the U.S. Navy Base, and a number of Sparrow 2 missiles have been made available to the Canadian team, which is expected to remain there for about six months or more. The test firings will enable the Canadian personnel to familiarize themselves with the Missile, which has been announced as the intended weapon for the supersonic Arrow, bomber destroyer.

They will also serve to test fire-control and auxiliary equipment. The information and experience gained will be of great value when the RCAF starts its own test firing program of Sparrow 2s at its weapons range at Cold Lake, Alberta, at a later date.

Capsule Comparisons Show Complexity Of Avro Arrow

Some conception of the major problems which were met and overcome in the design and manufacture of the Arrow can be obtained from the following:

Wiring in the Arrow extends 11 miles; there are enough tubes to take care of 200 TV sets. There are 800 separate relays, fuses, switches, terminals and other pieces of electrical hardware in the aircraft.

At 1200 mph, air friction raises the temperature of an aircraft's skin by 300°F. Even at high altitudes with the outside air temperature at around 50°F. below zero, the skin temperature is still 40°F. above boiling point of water.

At a speed of 1200 miles an hour, at high altitudes, the perspex canopy enclosing the pilot and radar-navigator would start to blow out like bubble gum — because of high temperature caused by skin friction, plus the fact that the inside of the canopy is pressurized. This was overcome by installing tempered glass windshields about an inch thick.

Air conditioning system in the Arrow must be capable of handling temperature changes of 100°F. a minute. The refrigeration capacity of the system would be equivalent to 50 domestic room air conditioners and could produce as much as 23 tons of ice per day. The system could also change the air in a room 20 ft. by 12 ft. with a 10 ft. ceiling 10 times per minute.

There are 13,000 parts in the CF-100. In the Avro Arrow there are 38,000.

Some 17,000 engineering drawings were released for the Arrow 1.

On servicing alone, an Avro-RCAF maintenance group had to design some 200 pieces of equipment. These include the engine starter truck which is itself a gas turbine engine mounted on a jeep. The power-and-air-conditioning truck must maintain a constant flow of air at 55°F. to the weapons, electronic and other sensitive equipment under all ground temperature conditions.

To achieve its supersonic speeds, the Arrow uses about twice as much power as that required to drive the Queen Mary. **This power is almost sufficient to lift the aircraft vertically off the ground.**

Though the Arrow is a fighter, it had to be designed with an armament bay about as large as the bomb bay of a Boeing B-29 bomber.

During design, literally millions of calculations were made by mathematicians working with the latest computing equipment.

The hundreds of items of mechanical hydraulic, electrical and electronic equipment in the Arrow are all required to operate in a severe high-temperature, high altitude environment with the utmost reliability.

Some 650 outside suppliers were established for the present Arrow program. As the program progressed, over 5,000 people were employed by companies to manufacture Arrow parts and tools.

October 4, 1957

Minister of Defence Triggers Arrow Rollout

Hon. George R. Pearkes, V.C., Publicly Unveils Big Delta Interceptor

"I NOW have pleasure in unveiling the Avro Arrow—Canada's first supersonic aircraft—a symbol of a new era for Canada in the air." With these words, Hon. George R. Pearkes, VC, Minister of National Defence triggered the mechanism which drew back the curtain to publicly unveil for the first time Avro's highly-classified delta-wing interceptor at Malton Airport.

About 12,000 people viewed the roll-out. These included representatives of Military, Government and Industry from NATO countries together with as many Avroites as could possibly be spared from their work for the period of the ceremony.

In his address to the large assembly, the Defence Minister said:

"Fifty years ago a great Canadian pioneer, John A. D. McCurdy, who is with us on the platform today, flew the Silver Dart, the first aircraft in Canada, in fact it was the first heavier-than-air plane to fly in the British Commonwealth. History recognizes that event as the beginning of Canada's air age.

Significant Event

"This event today marks another milestone—the production of the first Canadian supersonic airplane. I am sure that the historian of tomorrow will regard this event as being equally significant in the annals of Canadian aviation.

"The supersonic era of flight is just beginning. Many of today's aircraft are regularly breaking the sound barrier, but this is done at the extreme peak of their performance. Supersonic flight is still not a routine matter. Present aircraft travel at these exceptionally fast speeds for a relatively short period of time.

Hon. G. R. Pearkes, V.C., Minister of Defence.

"The Avro Arrow, however, has been designed from the outset to operate supersonically throughout as much of its mission as is deemed necessary. It will be as equally at home at one side of the sound barrier as on the other. It will be a truly supersonic aircraft.

"It is difficult for the layman to appreciate the magnitude and complexities of the problems of the last four years culminating in this first phase of the Arrow project. Four years ago the Air Force and the industry set out together on a voyage into the unknown. All the technical difficulties which have been solved thus far have represented pioneering work in aerodynamics, metallurgy, mechanics and electronics and in all the related arts and sciences which form part of our aeronautical industry. Thus far progress has been commendably rapid.

"We are, of course, only part way along the road and no-one would be so foolish as to suggest that the job is complete by any means.

Effective Deterrent

"Four years of designing, testing, tooling and production problems lie behind. Many months of further tests, trials, complex development and modification lie ahead before this aircraft can be considered operationally acceptable. I understand it will be some years yet before this supersonic aircraft with its missile and guidance systems will be available for operational use. We are looking forward to this time.

"It is important to appreciate the significance of proper timing in the introduction of weapons under today's conditions. Our weapons must not only be designed to be better than those of unfriendly nations, they must be ready in time to counteract those weapons should the need arise. If either the timing is wrong or the quality is wrong, we fail to maintain the proper balance of power in our goal towards presenting the most effective deterrent.

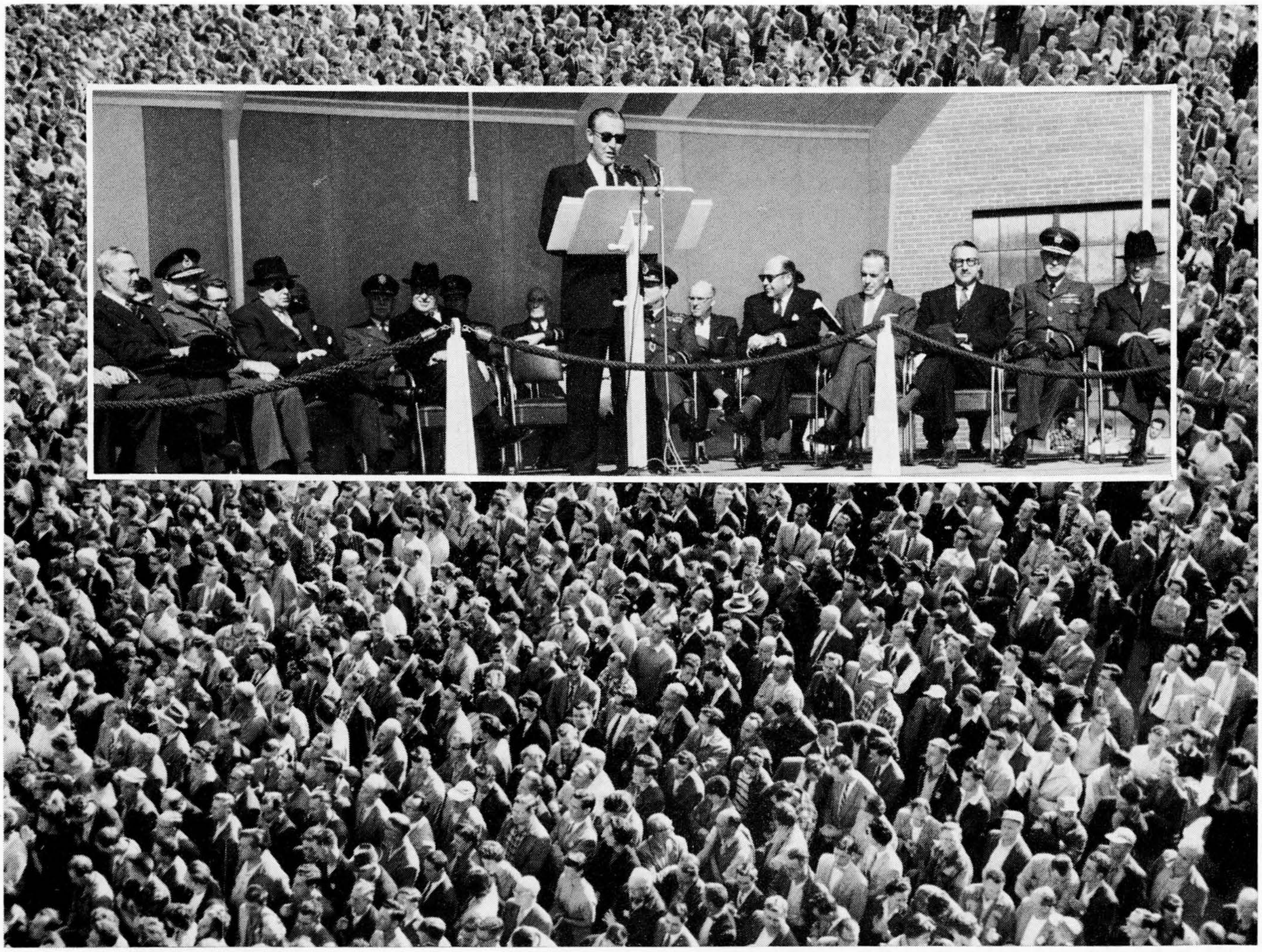
"I would like to recognize the great number of Canadians in our industry who have contributed and will continue to contribute towards this project. I would also like to thank the personnel of those American agencies who have helped so materially in the aircraft's development. As the Chief of Staff said, the development of the Arrow has been an outstanding piece of co-operation between the Service and industrial agencies on an international level.

Views On Missiles

"Much has been said of late about the coming missile age and there have been suggestions from well-intentioned people that the era of the manned aeroplane is over and that we should not be wasting our time and energy producing an aircraft of the performance, complexity and cost of the Avro Arrow. They suggest that we should put our faith in missiles and launch straight into the era of push-button war. I do not feel that missile and manned aircraft have, as yet, reached the point where they should be considered as competitive.

"They will, in fact, become complementary. Each can do things which the other cannot do, and for some years come both will be required in the inventory of any nation seeking to maintain an adequate "deterrent" to war. However, the aircraft has this one great advantage over the missile. It can bring the judgment of a man into the battle and closer to the target where human judgment, combined with

FIRST OFF THE PRODUCTION LINE—To the strains of the Air Force March Past played by the RCAF band, Canada's first supersonic airplane rolled out in front of the big special curtain. Avro Arrow's thin wing and unique intake ramps are clearly evident in the view.



FRED T. SMYE, Executive Vice President, Aeronautical Division, A. V. Roe Canada Ltd., addresses the 12,000 people gathered for the ceremony. With him on the platform can be seen left to right: Dr. Adam Zimmerman, Chairman, Defence Research Board; Gen. Charles Foulkes, Chief of Staff, Canadian Army; Sir Roy Dobson, Chairman of the Board, A. V. Roe Canada Ltd.; Gen. Leon W. Johnson, USAF, U.S. Representative, NATO Standing Committee; Hon. G. R. Pearkes, VC, Minister of National Defence; A/V/M L. E. Wray, AOC, Air Defence Command, RCAF; Hon. J. A. D. McCurdy, first Canadian pilot; A/M H. L. Campbell, Chief of Air Staff, RCAF; W. R. McLachlan, Executive Vice President, Administration and Co-ordination, A. V. Roe Canada, Ltd.; Crawford Gordon, President and General Manager, A. V. Roe Canada Ltd.; Frank R. Miller, Deputy Minister of National Defence; W. H. Huck, Assistant Deputy Minister, DDP; A/V/M M. M. Hendricks, Air Member for Technical Services, RCAF; and A/M W. A. Curtis, Vice-Chairman of the Board, A. V. Roe Canada Ltd. Most Avro employees saw ceremony.

the technology of the aircraft, will provide the most sophisticated and effective defence that human ingenuity can devise.

"The aircraft now being produced in the various countries of our NATO alliance may or may not be the last of the manned interceptors. With the rapid strides being made in the fields of science and engineering, it would be unwise to attempt to forecast the future in this respect. However, I feel sure that if these aircraft continue their development with the same promise as they have in the past, there is no doubt in my mind that they will be a necessary requirement to the arsenal of the West for many years to come.

"In closing, I would like once again to commend the efforts of those who have contributed thus far to the development and production of this airplane. Through your efforts you are making a direct contribution to the defence of the free nations of the world and so to the well-being of us all."

PRESENT AT MALTON for the Arrow rollout ceremony included: Sir Roy Dobson, Chairman of the Board, A. V. Roe Canada Ltd., (left); Hon J. A. D. McCurdy, former Lieutenant Governor of Nova Scotia and the first man to fly in Canada, (centre); and Crawford Gordon, President and General Manager, A. V. Roe Canada Ltd. Golden Anniversary of McCurdy flight is in 1959.

October 4, 1957

Chief Of Air Staff Outlines New Arrow's Role In Defence

A/M Hugh Campbell Defines Arrow Weapon System

THAT the supersonic Avro Arrow has been developed to be included as a key component of a complex, and elaborate, North American air defence system was emphasized by Air Marshal Hugh L. Campbell, Chief of Air Staff, Royal Canadian Air Force, at the Arrow rollout ceremony. Speaking on behalf of the RCAF, A/M Campbell outlined briefly the future continental defence program and how the manned, supersonic interceptor is definitely an important part of it when he said:

"I am very grateful for this opportunity to participate in today's ceremony. It marks significant progress in the field of aviation. In particular the Arrow development is a forward step in the field of Canadian military aviation.

"Suffice to say the planned performance of this aircraft is such that it can effectively meet and deal with any likely bomber threat to this continent over the next decade.

"We in the Air Force look upon this aircraft as one component of a complex and elaborate air defence system covering in the first instance the whole of the North American continent, extending from Labrador to Hudson Bay to the Queen Charlotte Islands.

"It is broader and wider than this continent. We are a member of a NATO alliance which comprises 15 nations. These nations, including Canada, have joined together in common defence and for the mutual protection of one another.

"Its basic aim is to provide security for all its members. All have a common concept for defence.

"It is Canada's belief that not only do we now have a greater collective strength for defence, but more important still, we are in a better position to deter aggression, that is a better position to convince a would-be aggressor that war does not pay.

"The air defence frontiers of this alliance extend from Alaska to Norway, to Germany, to Greece and Turkey, a perimeter distance of some 7,800 miles. The North American air defence system is a part of this overall air defence system of the NATO member.

Air Defence System

"An air defence system comprises aircraft and missiles—the ground environment of radar, whose mission it is to detect the enemy and to guide the path of our interceptors—it comprises the communication links which tie together the radar sites, the command posts, the airfields and the missiles bases — it also includes the command structure which controls and exercises 'the judgment' to fight the battle. All these many components, human, machine, organizational and technical are a part of—and play an important role within any system.

"Allied Command Europe now have and are in the process of building and expanding to; a new and more powerful air defence system in their territory, extending from Norway to Turkey. We, as you are now aware, have an air defence system in North America. When they are all finished and linked together as one, covering the perimeter that I mentioned—from Alaska to Turkey—I think you will

A/M H. L. Campbell, Chief of Air Staff, RCAF.

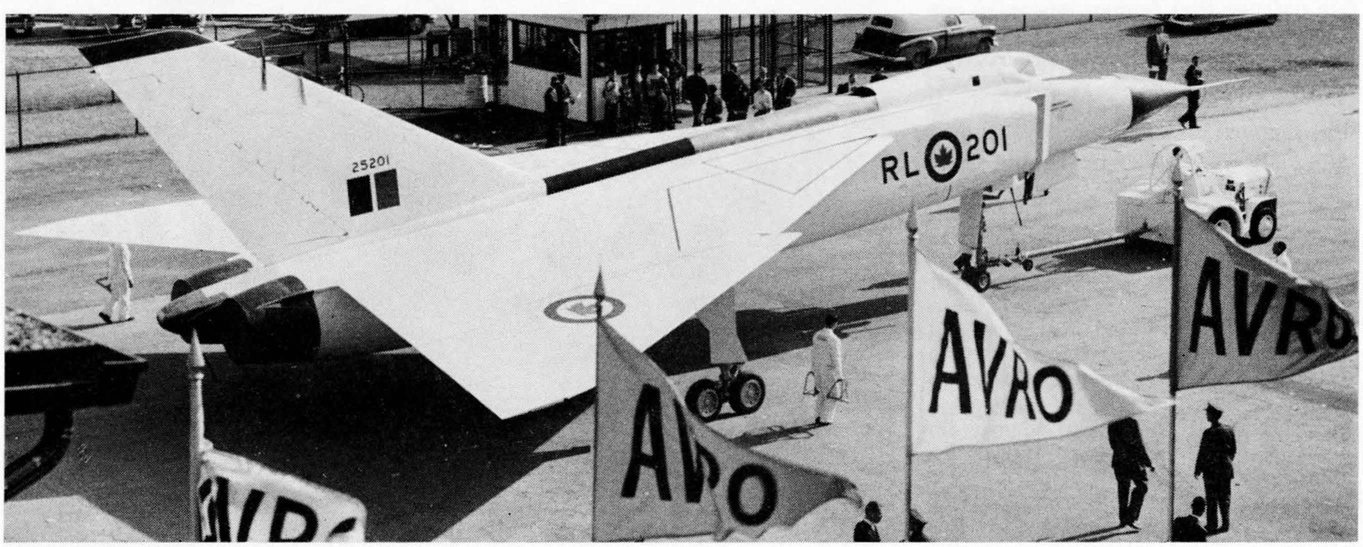
agree with me that it will make a great contribution to our deterrent to aggression.

This is the aim and objective of the military forces of NATO members. It is the aim and objective of the Royal Canadian Air Force—that is, to deter aggression and prevent war.

"The Arrow—including its missiles, flight trial and fire control systems—we believe will become a very important component of this complex system. It has been designed to make a real contribution to the overall defence of North America.

"Because this aircraft—the Avro Arrow—is a twin-engine, two-place machine—and because it will embody what will be the most modern equipment in the airborne interception and fire control fields — it should have an inherent flexibility in operations and promising future development potential. For these reasons we look to it to fill a great need in the air defence system in the years to come.

"I would like to pass on the thanks



OFF TO FLIGHT TEST for a detailed pre-flight program. The graceful delta, its size very much apparent in the above picture, is seen being towed to Flight Test. This was the finale of a ceremony that went off without a hitch, earned the plaudits of those present, and received world-wide news coverage through a variety of media. Newsmen and photographers had been briefed the previous evening without having seen the Arrow.

October 4, 1957

Sees Arrow One Of World's Most Advanced Interceptors

Fred T. Smye Addresses Rollout Crowd Of 12,000

THE supersonic era of powered flight in Canada was ushered in at Malton, with the first public viewing of the supersonic Avro Arrow.

Termed by President Fred T. Smye, "one of the most advanced combat aircraft in the world", the big delta winged aircraft rolled out of Bay 1 in the presence of a representative gathering of Military, Government, and Industry, together with as many Avro-ites as could possibly be spared from their work for the period of the ceremony.

In his address, Mr. Smye said in part:

"The Avro Arrow is a twin engine, long range, day and night supersonic interceptor. It has a crew of two. It is a big, versatile aircraft. The loaded weight of the Arrow is in the order of 30 tons.

"Primary armament of the aircraft is to be air-to-air guided missiles, installed in a detachable armament bay in the fuselage. The versatility provided by this armament bay will enable the aircraft to perform other roles.

"The aircraft will be equipped with one of the most advanced integrated electronics systems, which will combine the navigation and operation of the aircraft with its fire control system.

"The Arrow is designed to operate from existing runways.

"I believe it can be said that the Arrow is one of the most advanced combat aircraft in the world. It has been designed to meet the particular requirements of the RCAF for the defence of Canada.

Production Aircraft

"I wish to emphasize that this aircraft is by no means a hand-made prototype. On the contrary, it has been produced from very complete production tooling. This policy has been followed so that when the aircraft development has been completed, we will be able to move into the production phase without undue delay. Furthermore, an aircraft of the complexity and preciseness of the Arrow requires extensive tooling to ensure accuracy of manufacture.

"Whereas the Arrow is an Avro product, and whereas we are responsible for the overall design and manufacture of the aircraft, we could be considered, let us say, as the captain of a team of hundreds of suppliers and sub-contractors who, together with us, did this job.

"There are many companies who have made outstanding technical contributions in the design, development and manufacture of all types of equipment and material for the aircraft. To them I wish to express our deep appreciation and gratitude. The first aeroplane which you will see to-day, and the next few development aircraft will be powered with the Pratt & Whitney J75 engine. However, the ultimate engine to power the balance of the development aircraft, and all the production aircraft, is the recently unveiled Iroquois, designed by our associate company, Orenda Engines Limited.

More Coming

"As we have been creating the Arrow, they have been creating the Iroquois. This engine too represents a milestone in Canadian industrial accomplishment, and it is the thrust of this engine on which the very advanced performance of the Arrow will depend.

"Behind this first aircraft there are other development aircraft in various stages of completion, and all of which will be subjected to an extensive and time-consuming flight test and development programme. We know that, like all other aircraft of this type, where one is constantly probing the unknown, we will encounter many problems and setbacks—and it will not be until this exhaustive testing is successfully concluded and until the development phase of the programme has been accomplished, that it will be able to see service in the squadrons of the Royal Canadian Air Force."

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of the Royal Canadian Air Force to those who have contributed to the development of the Arrow, to those who have worked so hard to see it take shape.

"To you Mr. Smye, the executive, and all the employees of Avro, you have our sincere appreciation. I would also like to endorse your remarks and pay tribute to the vast number of Canadians everywhere throughout the industrial complex of this nation who have contributed and will continue to contribute towards this project.

United States Aid

"There are some 38,000 parts in this aircraft and over 650 companies in Canada have been engaged in their manufacture. In support also of this very considerable industrial complex has been the Government organizations—the Department of Defence Production, the Defence Research Board, the National Research Council, the National Aeronautical Establishment, and others.

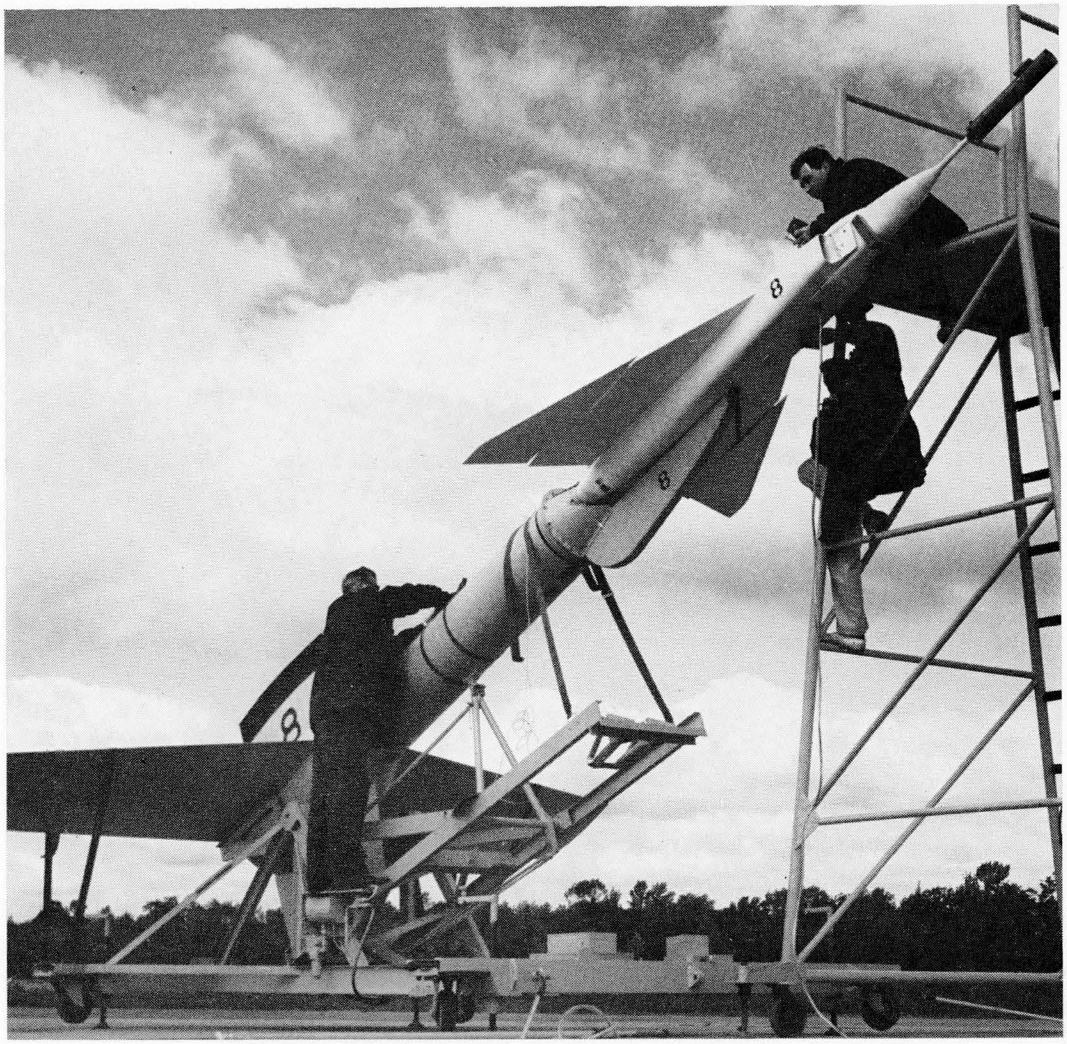
"I should also like to mention, as Mr. Smye has done, that a significant factor in this development has been the material interest and help received from the United States Air Force and the United States Navy, and from various American aeronautical research facilities. Special wind tunnels at Cornell University and at the NACA establishments in Langley Field and Cleveland have been made available to this Canadian project.

"The development of the Arrow has been an outstanding piece of co-operation between service and industrial agencies on an international level. In acknowledging the assistance given by American agencies, I can but express the hope that the ultimate development of the Arrow will be the success that we expect it to be and that it will be accepted by them as a significant contribution to the defence of North America."

AMONG THE GUESTS OF HONOR at the ceremony were Maj. Gen. K. Berquist, Assistant Deputy Chief of Staff—Operations, USAF; A/V/M L. E. Wray, AOC, Air Defence Command, RCAF; and Gen. Leon Johnson, USAF. Trade press reports high American interest in Arrow.

The First Avro Arrow About To Land At Malton Airport, Escorted By CF-100 Mark 5 Chase Plane, During Early Test Flight

Here Is How Avro Aircraft Engineering And Production Teams Turned Out Canada's First Supersonic Jet Interceptor



Large-scale Free-Flight Models were used in early development stages of the Arrow, to gather aerodynamic data. A model is seen here being readied on its launching rig with a Nike rocket booster in firing position.

Engineers Key Arrow's Design To Long, Useful Service Life

by Harry Wilby

CANADA'S first supersonic jet aircraft rolled from the end of Avro Aircraft's assembly line today—a little more than four years after the CF-105 proposal was first submitted to the Royal Canadian Air Force.

In addition to rolling out in much better than average time, this Canadian-designed, twin-engine, delta-wing interceptor was completely fabricated and assembled with production tooling and methods—the first time that such a prototype has appeared in the history of Canadian aviation.

The unveiling ceremonies today culminate what began some six years ago as the germ of an idea in the minds of a small group of creative engineers headed by J. C. Floyd, now Vice-President Engineering. Although the supersonic delta concept was not new, these people felt it was possible for Canada, through the engineering and production facilities of Avro Aircraft, to design and produce in quantity, an advanced aircraft type to meet the threat of future developments of potential enemy bombers.

Delta Planform Chosen

The initial step in the undertaking which produced the first Arrow took place in September 1951. At that time the company submitted to the RCAF a brochure containing three proposals for an advanced supersonic fighter. One of these was a delta wing design for an all-weather interceptor, powered by two Sapphire 4 engines, and manned by a crew of two.

As a result of these proposals, an operational requirement for an "All-Weather Interceptor" was received from the RCAF the following March. Basically, this requirement was for an internally-armed aircraft capable of intercepting and destroying a supersonic, enemy bomber at very high altitudes.

The delta planform version was chosen for further development. This was because it offered the best compromise between a thin wing section—required for supersonic flight—and sufficient physical depth in the wing root section to house the undercarriage plus the large amount of fuel that was required for such a mission. The engineers calculated that the delta also gave an efficient and relatively light structure with good general control at transonic speeds.

Increased Reliability

Both single and twin engine aircraft were considered in the design studies that followed. Company engineers felt that the twin engine version would have a marked increase in performance because it had twice the thrust, but did not need double the fuselage frontal area to accommodate the engines. Two engines would also give increased reliability.

Economic considerations led to the inclusion of "flexibility of tactical use" in the design to give it a long and useful life through continued development. In doing this it was necessary to ensure that this flexibility did not jeopardize the calculated performance of the aircraft, or its ability to meet the RCAF's specification requirements.

In June 1952 Avro issued brochures to the RCAF on "Designs to Interceptor Requirements" under the designation of C104/1 and C104/2. Both proposals were of delta planform, the C104/1 with single engine, and the larger, heavier, C104/2 with twin engines. Each aircraft carried a crew of two, with provision for missiles and rockets.

Engines under consideration for both proposals were the Curtiss-Wright J67, the Bristol Olympus 3, and the Avro TR9. Electronic fire control systems were included in the designs.

National Aeronautical Establishment analysis of the C104/1 and C104/2 proposals was received in October of that year. NAE found the C104/2 design had many desirable features but considered the proposed aircraft too heavy. It recommended that further studies be made on this configuration. In addition, changes were made at this time to the RCAF requirements for the all-weather fighter concept. These primarily called for an increase in the aircraft's operational altitude.

Go Ahead . . .

The C104 proposal was, as a result, redesigned, and the new configuration was established as the C105. To meet th aerodynamic requirements the new proposal maintained the delta planform and was twin-engined, but its weight was reduced while the overall size was kept as small as possible. Avro submitted the C105 proposal to the RCAF in June 1953.

In less than one month the "Go-Ahead" was received from the government authorizing a design study of the C105 to meet the RCAF requirements.

First step in the design study was to adapt the new concept to Rolls Royce RB106 engines which were then in an advanced stage of development. From that point things progressed rapidly and the first tests of the wind tunnel development program were run in September 1953—only two months after the "gun was fired".

To date, Arrow wind tunnel models have been tested from low speed to twice the speed of sound. Facilities used included NAE (Ottawa) for low and high speed testing, Cornell Aeronautical Laboratories (Buffalo) for transonic tests, NACA (Langley Field, Virginia) for supersonic tests, and NACA Lewis Laboratory (Cleveland) for air intake tests. Seventeen models, ranging from 1/80th to 1/6th scale were used at one or the other of these facilities, to obtain necessary structural and aerodynamic data.

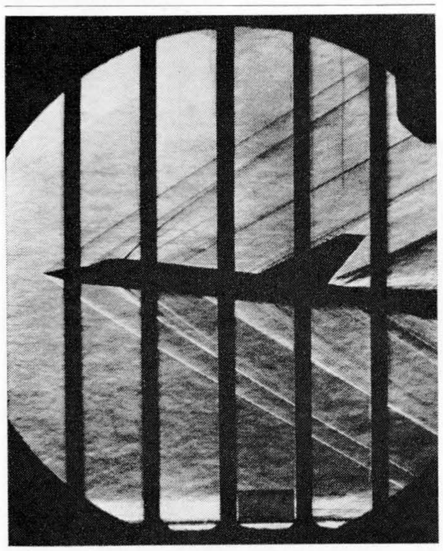
Wind tunnel limitations caused Avro engineers to explore further techniques for obtaining important aerodynamic data. These consisted mainly of a lengthy program of firing large scale free-flight models, with rocket-propelled boosters to supersonic speeds—to simulating flight of the full scale aircraft at

Here are the four men who co-ordinated the efforts of all phases of Engineering which went into creating the Arrow. From left: R. N. Lindley, Chief Engineer; J. C. Floyd, Vice-President Engineering; Guest Hake, now Quality Control and Inspection Manager who was Avro Project Designer at the time of the Arrow introduction; and Jim Chamberlain, Chief of Technical Design.

altitude. The models were instrumented to measure performance and stability and to transmit the information back to a ground station.

Aerodynamics Tests

Eleven free-flight models were fired between December, 1954 and January, 1957—nine at the CARDE range at Point Petre, Ontario, and two at the NACA range in Virginia. All rocket launchings and booster separations were successful and the firing program was completed satisfactorily. In nearly every test, complete performance records were obtained.



Early Wind Tunnel models produced data which led to refinements in the external shape.

During 1954, when preliminary design was completed, the RCAF adopted the CF-105 designation for the aircraft. Initial proposals, design studies and tests which led to establishing the basic configuration of the CF-105, resulted mainly from the efforts of the Preliminary Design Office, under the direction of Jim Chamberlin, who is now Chief of Technical Design.

Later in 1954, powerplant problems arose which required major changes in the proposed program. The Rolls Royce RB106 engines which were incorporated in the design, would not be available in time for the CF-105, and were replaced by two Curtiss-Wright J67 engines. Then, in early 1955, the U.S. Air Force disclosed that the J67 also would be too late to meet the Avro schedule. At this point, the program now in effect was laid on—the installation of Pratt & Whitney J75s as an interim measure, and Orenda PS13s (Iroquois) when they become available. Although the Iroquois development was well advanced, and its specifications more than met Avro's requirements, the combination of an untried engine and an untried airframe was considered not practical on an aircraft development flight test program.

Use "Area Rule"

A great deal of theoretical work on the application of the "Area Rule" was carried out on the CF-105 project. This is essentially a method of refining the fuselage shape to give the so-called "Coke-Bottle" effect for the purpose of reducing supersonic drag of the aircraft.

Both the RAF and USAF were kept constantly informed of the progress of the Canadian project, and contributed significant encouragement by their concurrence in the soundness of the concept.

From the time the basic configuration was established, to the end of 1956, up to 460 engineers, technicians and draftsmen worked on the design and development of the CF-105 structure and systems. Under the general direction and guidance of Bob Lindley, Chief Engineer, and the co-ordinating efforts of Guest Hake, Project De-

Avro's Computer Capacity was greatly increased with the addition, last year, of the IBM 704 electronic data processing machine shown above. Latest and most powerful digital computer available to industry, Avro's 704 is the only one outside the U.S. Staff of over 30 keep machine busy.

signer, a multitude of problems in each of the various fields of engineering were resolved.

An engineering mock-up of the complete aircraft was built to provide a three dimensional check on installation clearances and general accessibility. Construction was mainly of wood with some metal formers. At first, a rough mock-up of the J67 was installed to check clearances around the engines. However, the later decision to install J75s required numerous changes to the engine bay structure. RCAF evaluation of the mock-up took place in February last year, and included assessment of a metal mock-up of the armament pack under consideration at that time.

Mock-up Conversion

To demonstrate pilot visibility while taxiing and cockpit lighting techniques, a special mock-up of the front cockpit was mounted on a truck to stimulate the actual height and attitude of the cockpit during ground manoeuvering. This mock-up was later modified to include the radar nose and the trials were repeated.

Early in 1956 work got under way to change the engine bay section of the mock-up to accommodate the Iroquois engine and to iron out primary installation problems. Associated ground handling equipment was also built at that time.

Later in the year, conversion of the remainder of the engineering mock-up from CF-105 Mk 1 to CF-105 Mk 2 configuration began. Timing of the rebuild was based on the need to obtain RCAF evaluation results in time to incorporate any necessary changes in the Mk 2 engineering release. A number of ground support equipment mock-ups were also built for design appraisal.

The CF-105 was officially designated the Avro Arrow in early 1957, and the two versions of the aircraft were designated Arrow I and Arrow 2.

Aerodynamically, the Arrow was entertaining a new realm of science. Performance, stability and control problems were difficult to evaluate, and data had to be obtained to establish air loads on the wing, fin, canopy and control surfaces. In this respect, wind tunnel results proved and supplemented theories in overcoming some of these problems. Improvements in longitudinal stability, buffet characteristics, subsonic drag and directional stability for example were a direct result of wind tunnel testing.

Computer Capacity

Analog computing equipment was installed to accelerate the solution of dynamic and stress problems. The company also obtained a new electronic digital computer of great speed and capacity to accommodate its accelerated research and development program in supersonic aircraft. This was the IBM 704 electronic data processing machine—the latest and most powerful digital computer designed for scientific applications, now available to industry. The giant computer is equivalent in calculating and problem-solving power of 3000 tireless, perfectly organized and trained engineers. A staff of thirty mathematicians, technicians and operators is involved at the present time in feeding problems to the 704, analyzing results, and keeping the machine in operation. Avro's 704 is the only one installed outside the United States.

The Arrow structure is designed to provide a high wing, delta planform, all metal aircraft. Although the air loads had been determined by the Aerodynamics Department, it was impossible to know at that time what effect manoeuverability would have on the structure. For this reason a large number of stressing cases had to be investigated. Supersonic aircraft are virtually flying pressure vessels, and the problem was further complicated by the need to keep weight to a minimum. Supersonic aircraft also involve problems which previously could be ignored. Two such problems which required extensive investigation by the Stress Department were structure weakening caused by heat and sound.

In simple terms the heat problem is caused by friction between the air and the aircraft skin. Temperatures attained while flying at supersonic speeds are high enough to weaken structure —the higher the speed, the more the heat, bigger the problem.

There are two main types of detrimental sound—jet engine and aerodynamic. These can cause skin panels to fracture and rivets to loosen, again weakening structure. Sonic structural tests are being carried out constantly, and will continue, until they have run long enough to indicate satisfactory panel life.

Proper ground support equipment plays an important role in the operational effectiveness of any modern military aircraft. Since most existing equipment could not be used for Arrow servicing requirements it was essential to ensure adequate maintenance facilities were available.

Ground Handling

A joint Avro-RCAF Maintenance Engineering Group was formed, and to date has designed some 200 pieces of equipment. Problems to be overcome in this field were as great in their own way as those in the aircraft itself. This is self-evident when one realizes for example that the engine starter truck is a jeep-mounted gas turbine, and the power-and-air-conditioning truck must maintain a constant air flow at 55°F to the weapons, electronic and other sensitive equipment, under all ground temperature conditions.

Arrow development presented some problems that were not even dreamed of when the CF-100 was designed. At supersonic speeds, for instance, air loads on the control surfaces are extremely high, and the pilot must be provided with considerable amplification of his physical strength. In fact, control mechanisms are installed on the Arrow which are sufficiently powerful to lift the equivalent of six elephants standing on the elevators.

Electronics

Modern military aircraft require elaborate electrical and electronic systems. In the Arrow there are some eleven miles of wiring and enough vacuum tubes to equip about two hundred television sets except for picture tubes.

Tremendous power is needed to fly an aircraft at supersonic speeds, and the Arrow uses about twice as much power as that required to drive the Queen Mary. To develop this power, the engines consume fuel at the rate of more than a quarter of a ton per minute. Much of this power is dissipated in air friction at these very high speeds, and air friction raises the aircraft temperature to such a degree that the air conditioning required to protect the crew and the vital equipment is sufficient to produce 23 tons of ice a day.

The complex structural requirements, and the desire to keep construction as simple as possible made extensive research necessary in this field. A vast amount of development has been done in the field of metal-to-metal bonding which eliminates much of the time-consuming and difficult processes of conventional riveting and fastening. In order that metal bonding can be used successfully, it must be sufficiently strong, reasonably easy to use, and must have sufficient heat resistance to be unaffected at temperatures experienced by an aircraft flying at supersonic speeds.

Production Prototype

While bonding of aluminum alloys imposed no great problem, considerable experimental work was required with magnesium alloys. A process has been developed by Avro metallurgists which has proven very satisfactory under tests, and is used in many parts of the aircraft.

Until recently, high-performance aircraft was not committed to production until after flight testing of one or more prototypes. Normally quite a number of changes are necessary before the aircraft can go into production. The Arrow program is unusual in Canada in that even the first flying model has been built on production tooling. This time-saving approach made it essential to prove the basic soundness of the structural and system concepts by exhaustive testing prior to the actual build of the aircraft. This procedure subjects nearly all components to test equivalent to the most severe and varied conditions expected.

All the aircraft systems, too, must undergo the most rigorous tests to ensure the high safety standard and efficient component operation demanded.

The fuel system for instance, has been set up in every detail on an elaborate test rig which simulates its operation and allows it to be tested in any position that the aircraft may assume. Fuel system test program includes investigations of the pressure system, refueling and de-fueling, simulated flight sequences and emergency operation.

Stress Analysis

The difficult task of analyzing the structure of the Arrow imposed many unique problems on the stress engineers. The complexity of the Arrow's structure demanded the use of the most advanced analysis methods and techniques available.

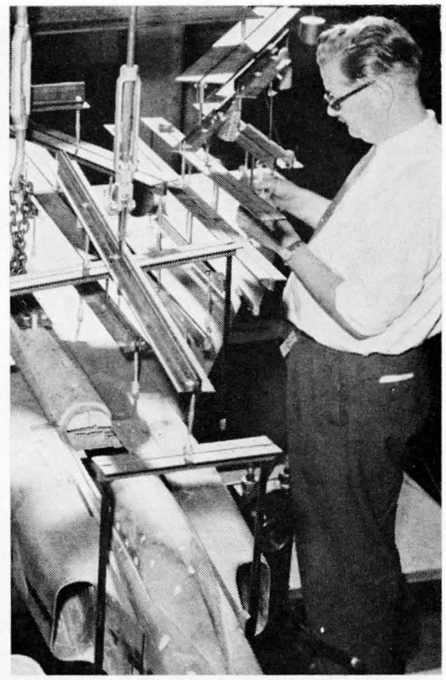
A novel technique used in the stress analysis program involved the use of plastic models. These models had to be constructed with great care so that the structure would have the required degree of similarity to the actual aircraft. They were then placed in test rigs which were capable of producing loads on the models comparable to the predicted flight loads. After intensive testing, the deflections and stresses which were produced showed that the methods being used for analytical studies were valid.

Ancillary Equipment

The hundreds of items of mechanical, hydraulic, electrical and electronic equipment in the Arrow are all required to operate in a severe high-temperature, high-altitude environment with the utmost reliability. Equipment which would perform under these conditions simply did not exist when the Arrow design got under way. It was therefore necessary for Avro to specify the special performance necessary for each one of these devices to do its job, and to assess the proposals of equipment manufacturers throughout the continent to determine their capability to develop the items. Avro then maintained close engineering contact with all these sources while the units which had to meet the Arrow's stringent requirements were being designed, built, tested and delivered.

In modern military terms, an aircraft like the Arrow becomes the central component of a "Weapon System". Besides the basic aircraft, this Weapon System must include a complete, compatible air and ground environment, starting with the support and maintenance equipment at RCAF bases, through the ground radar and communication facilities, up to and including the airborne electronic system and weapons.

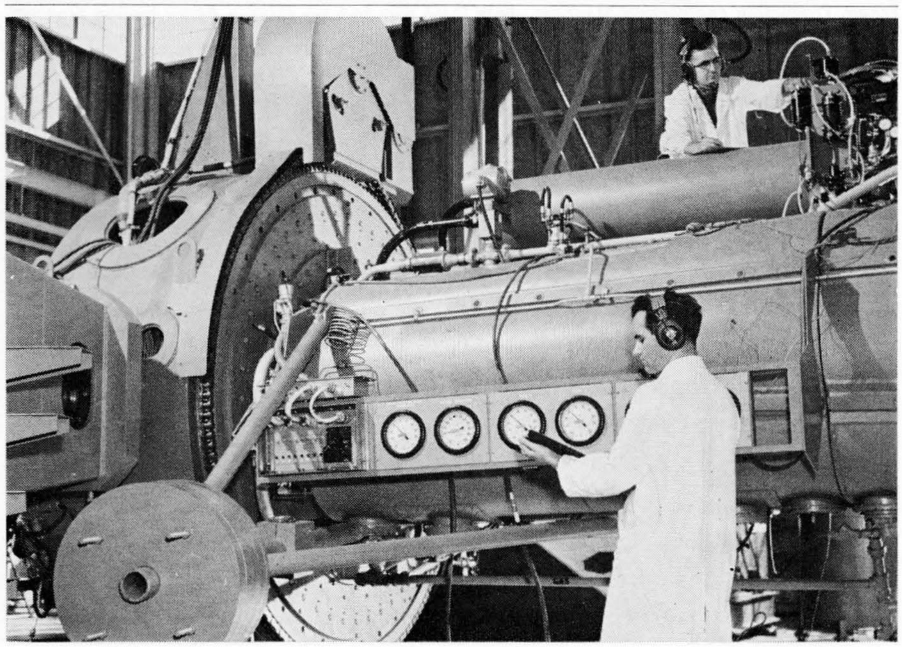
As the Arrow program progressed, it soon became evident that no existing combination of electronic equipment met the RCAF's operational requirements and the Arrow's environmental needs. After evaluating several proposals, the RCAF selected RCA as the electronic system contractor, with the task of developing this most essential component of the Arrow weapon system.



Structure of a free-flight model is tested at key points, with strain gauges to measure deflection. Ready for flight, models were heavily instrumented to transmit data to engineers.

RCA and RCA's associate contractor, Minneapolis-Honeywell, along with their Canadian affiliates, plunged into the task of creating the advanced specialized electronic system for automatic flight, weapon fire control, communication and navigation which has been designated the "Astra I" system.

It is now some four and a half years since the design started. This is considered better than average for the time required to design and build present day high performance aircraft.



Integral fuel tanks are a feature of the Arrow. Extensive checking of the entire fuel system is continually going on in this specially-built test facility. Prevention of leakage is imperative.

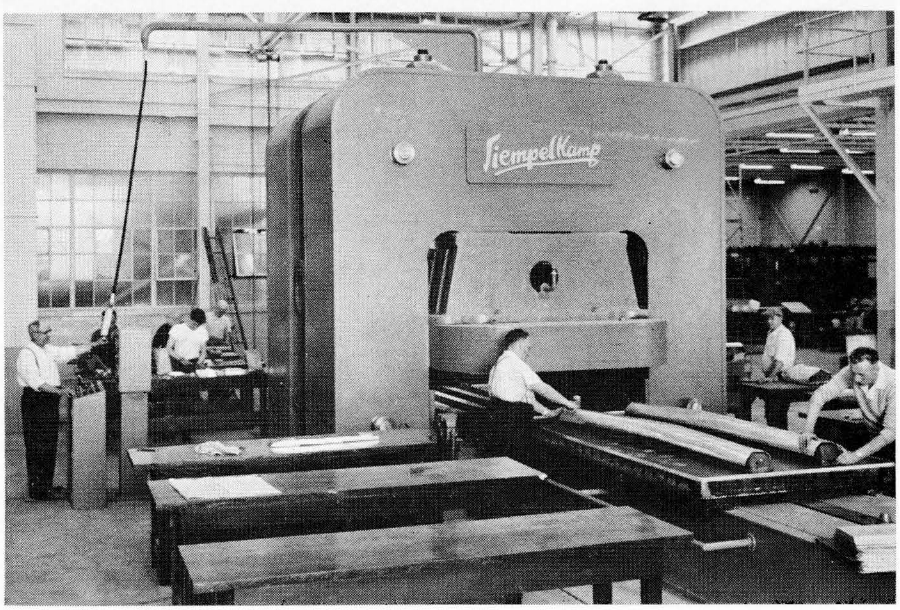
Departure From Conventional Key To Arrow Tooling Program

By Ron Drake

IN order to produce economically the advanced aircraft which rolled from the assembly line today, a complete departure from conventional tooling and methods used in previous programs became essential in some phases of manufacturing. Primary basis for all these departures in both tooling and methods was the necessity to attain an extremely high degree of accuracy in all fabrication operations in order to ensure successful supersonic performance of the completed Arrow. The new departures also provided for interchangeability of all components and parts from the first airplane.

Some idea of the scope of the task facing the tooling and methods people, and the increased complexity of the Arrow compared to the familiar CF-100 may be seen in the fact that there is nearly three times as many manufactured parts in the Arrow.

Avro's Vice-President Manufacturing, W. H. "Duke" Riggs, (left), was Production Shops Manager during the period of pre-flight preparation, in the Avro program. With him here is E. B. "Ted" Bragg, Production Engineering Manager. Both these men had key roles in Arrow tooling program.



Largest rubber forming press in North America was installed for Arrow production. Able to form parts easily from heavier materials than previous needs, the pressure capacity is 15,000 tons.

These changes began with the development of the Glass Cloth Process in which Engineering designs are made directly onto glass cloth to integrate tooling and part manufacturing techniques in the Production stages. The use of glass cloth was decided upon since it is a stable media and may be contact printed directly on the tool material, or paper prints made as required. Its use precluded the need for re-layout at the detail design and tool build stages.

Drawn Full Scale

As soon as the envelope of the aircraft was defined, full scale layouts of these master lines were drawn on glass cloth: These master lines were reproduced on to glass cloth for the purpose of filling in the actual structural details in the area concerned. This is called the assembly glass cloth. In addition to the master lines and the assembly glass cloth, dimensional geometry drawings for interchangeability hard points were also supplied by Engineering.

In order to provide a basic source of control for the accurate manufacture of details that are in contact with the air-frame envelope, master models were built.

Tooling Master

To construct the master model of a component, the master lines glass cloths were contact printed on to light alloy sheets cut to profile, and mounted on a suitable frame. After splining in to ensure accuracy of profile, the spaces between the templates were plastered in to present the finished model. This model is now the tooling master which establishes the shape of the component and the shape and size of the various skin panels. All detail parts adjacent to the outside contour of the structure, and therefore control the aircraft shape, must have their tooling related directly to this model.

Through this process the Production Engineering Department derived a direct contact relationship between the Engineering information and the tools and parts.

To ensure accuracy and to eliminate hand finishing, in the forming of metal parts from heavier materials, a great deal more pressure was required for rubber forming technique. This resulted in the procurement of the 15,000 tons Siempel Kamp Rubber Forming Press, the largest of its kind in North America. The installation of this huge hydraulic Press started in March, 1955 and operations commenced to meet Arrow production requirements in months later. Operation of the press is controlled electronically.

Early in the design stage of the Arrow it was determined that integrally-stiffened skins and completely-machined structural members were necessary to meet design requirements which specified one-piece wing panels for integral fuel storage tanks. Because of this specialized equipment such as the electronically-controlled Skin Mill was procured to machine these parts from solid billets of specially-alloyed rolled plate material. The stationary working surface of this complex machine is 28 feet long and the whole thing weighs 100 tons.

Travelling Cutter

Raw material is held in place by vacuum pressure. The cutter head moves over the material remotely guided by a tracer which follows a template and mills finished skins have integral stiffeners.

Together with the large skin mill other smaller mills were required, including special variable angle contour cutting mills. These are used to machine spars and other structural members from solid pieces of material. A special saw was designed and built by Avro in order to meet cutting capacity for materials up to three inches thick and 20 feet long. In addition special ultra sonic test equipment was needed to properly inspect large pieces of material to locate any imperfections before machining operations started.

A new hot air heat treat furnace was installed which provided adequate space for the processing of the many large pieces of material required for Arrow part manufacturing. Immediately below the hot air circulating furnace, which is mounted on legs, is a 20-foot-long quench bath. This set-up means a minimum of time is spent in the transfer of material from the furnace to the quench.

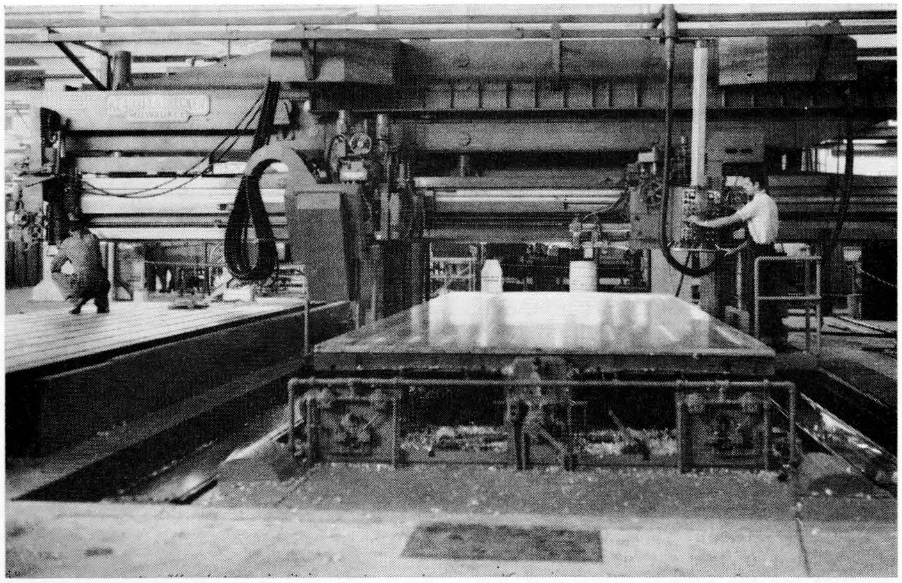
New Techniques

To meet strength specifications where parts were joined together with metal bonding technique, an autoclave pressure chamber was installed. Where metal bonding of materials is used on the Arrow it gives a high degree of adhesive strength as well as a weight-saving factor due to the elimination of rivets and other dowel-type fasteners.

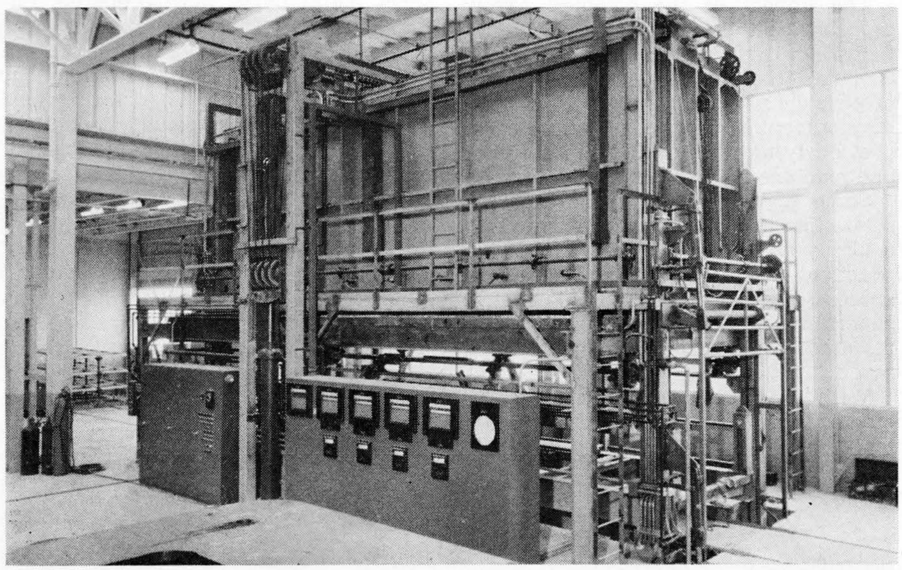
Due to the weight of many of the Arrow components, and the accuracy required in their assembly, a final assembly fixture was provided so that all of the large components could be brought together accurately at one stage.

Methods to establish working flexibility of assembly jigs were developed along with standardization of jig fixtures where possible which added to a more efficient tooling program.

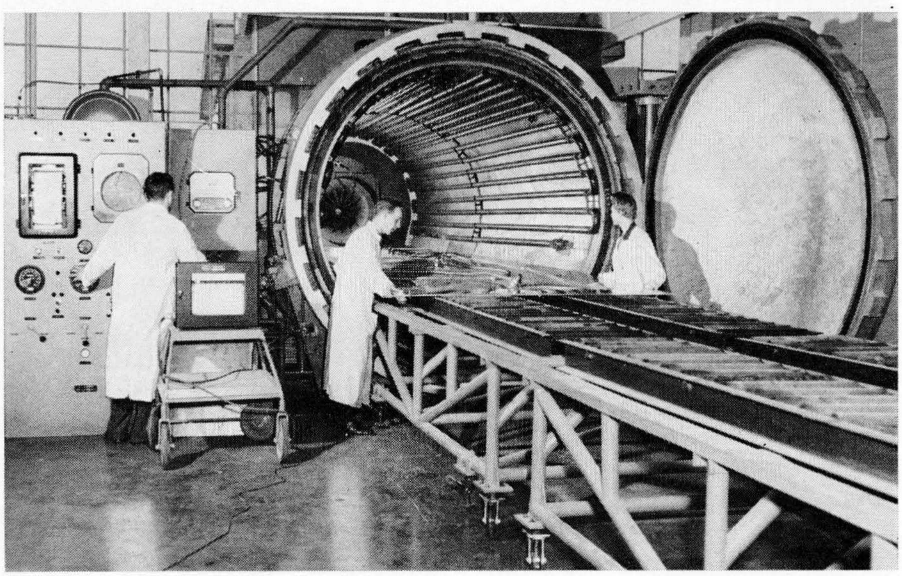
"I do not feel that missiles and manned aircraft have, as yet, reached the point where they should be considered as competitive. They will, in fact, become complementary. Each can do things which the other cannot do, and for some years to come, both will be required in the inventory of any nation seeking to maintain an adequate 'deterrent' to war".
—Hon. George R. Pearkes, Canada's Minister of National Defence.



Avro's big electronically-controlled skin mill was installed to machine integrally-stiffened wing skin panels from solid billets of specially-alloyed rolled plate material. Cutter travels over work.



Large hot-air-circulation Heat Treat furnace was needed to accommodate large pieces of material. It is mounted on legs directly above a 20-foot long quench bath into which treated material goes.



Extensive use of metal bonding in the Arrow resulted in Avro acquiring this huge Autoclave pressure chamber which uses heat and increased pressure to give required adhesive strength.

Establish Low Manhour Record With First Production Arrow

By Fred Lawrence

UNVEILING the Avro Arrow at today's ceremony culminates many months of intensive effort on the part of all departments in the company's manufacturing division. In conjunction with the Engineering Division, they have transcribed a calculated theory into a machine which Allied Air Power experts have publicly recognized as an extremely advanced type of airplane.

With full realization of the important role that this airplane will be required to perform, the manufacturing policy from the start has been predicated on producing the best possible product for the purpose intended, consistent with efficient tooling and fabricating methods.

The impact of the complex Arrow program on the facilities of the Manufacturing Division has been unique in Canada, from both the point of view of physical plant requirements, and the development of new, and in some cases previously untried, production methods and machines.

Some highlights of this impact are related here in an attempt to show how a highly skilled labour force, following practical and efficient methods, has successfully produced Canada's first supersonic jet interceptor which was released today from the production stage.

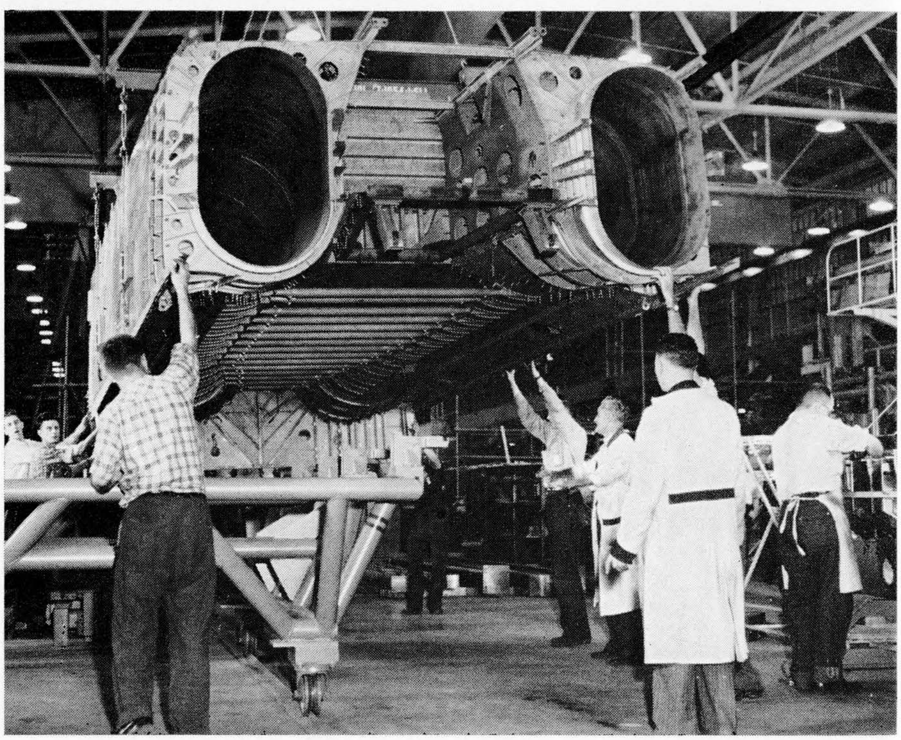
With the release of preliminary Engineering information on the Arrow, the Industrial Engineering Department swung into action preparing Manufacturing's master schedule. This key undertaking provided the exact dates on which each phase of the Arrow manufacturing program would be completed, thus providing an uninterrupted flow of parts and assemblies into the finished aircraft. Preparation of such a complex schedule demanded a very precise analysis of manpower, machine and facility capacities—particularly when no comparative records of a similar production performance at Avro existed at this stage.

From Paper to Hardware

From the completed master schedule, detailed programs for machine and sheet metal parts were prepared, followed in turn by sub-assembly and major assembly schedules. Again from the master schedule, came man hour requirements, which when transcribed into numbers of personnel, permitted the smooth, pre-planned release of manpower from the CF-100 program to the expanding Arrow production line in accordance with a company policy of maintaining a continuous level of employment during the changeover.

Evidence of the successful preplanning of the Arrow program, is reflected today in the completed aircraft which was fabricated and assembled in less than two and one half years from the date of the first design release. In addition, the first Arrow's man-hours-per-pound ratio is approximately 80 per cent of projects of similar size and complexity throughout the aviation industry in North America.

Rupert Cashmore, Assistant Production Shops Manager, (left), discusses assembly operation problems with Harry Befort, Production Shops Manager, during production of first Arrow.



Fuselage Centre Section — the key section — for Arrow number one is seen being lowered on to its marry-up handling trolley for transfer to the main assembly jig for inner wing installation.

Industrial Engineering was responsible also for instigating cost control procedures to ensure that all phases of the program were completed in line with allocated funds. Where shortages of tooling or production facilities made it necessary to sub-contract the building of parts, the same economic control was exercised on the parts produced by sub-contractors as was applied to Avro-manufactured items.

Throughout all tooling and fabricating stages, a time study analysis was maintained over each operation so that established records of performance and capacity are now available for future production.

More Space - New Equipment

To Plant Engineering fell the task of providing additional floor space requirements, as well as the installation and maintenance of the new equipment required.

Over 176,000 sq. ft. of additional floor space was provided for the Arrow program, including space for the new 15,000-ton rubber forming press; the Canefco heat treat furnace, and test facilities for the Engineering Division. In addition, much of the existing floor area required special preparation to accommodate a variety of new equipment. As a matter of fact, large sections of the plant were shifted completely to allow best space utilization of the new equipment. The former Process Room in Bay 2 for instance was moved in order to accommodate the big new skin mill and heavy machining facilities.

Calculated additional power requirements resulted in the construction of two new sub-stations with a total additional output of 3,000 kw's.

To Plant Engineering fell the task of providing these additional floor space requirements, as well as the installation and maintenance of the new equipment required.

Still another responsibility of the Plant Engineering department was the design and installation of portable and static fixtures in the assembly areas, providing work areas which are, in some cases, three storeys high.

Sound Control

As the program progressed, intensive investigations were made into the most practical means of sound control, the necessary ground testing of the Arrow's powerplant. This research resulted in the present flight line installation of the largest sound control units of their type in the world. Each twin-cell unit weighs some fifty tons.

The increase in requirements for water, light, heat and power have increased Avro's plant utilities services to the point where they can now meet a demand equivalent to a community the size of Brampton.

Closely following this large increase of plant and equipment facilities came a streamlined program of house-keeping and maintenance which has contributed significantly to the efficiency of this complex production program.

Outside Suppliers

With the release of design information from the Engineering Division the Procurement Department began negotiations which resulted in over 650 outside suppliers established for the present Arrow program. A very important aspect of Avro's procurement policy was the development of Canadian sources of supply where possible. As a result of this policy many of the sub-contractors had to expand their facilities, purchase new equipment and increase employment in order to economically meet the complex supply wherever possible. As a re-part requirements of the airplane. In all cases company procurement personnel provided technical assistance through liaison with the Avro design and production departments.

Coast to Coast

In the supply of bought-out equipment, negotiations were carried on with firms in almost every part of the continent. Some parts and equipment that had been considered standard throughout the industry had to be redesigned, and in some instances, made of new materials to meet the close-tolerance demands of this supersonic aircraft.

As the program progressed, over 5,000 people were found to be employed outside Avro in the manufacture of Arrow parts and tools. Extensive liaison on the part of Procurement personnel was needed in order that these parts and tools met the efficient schedule and cost requirements of Avro production.

Increased floor areas were provided in the Stores section to meet the heavy demands of the new program. In the handling and storage of materials and equipment, stringent methods were exercised to avoid even the slightest damage that could affect their use on production.

The Production Engineering department provided the key link between the Engineering Division and all Production sections. In addition to planning the work sequence of each part, and the design and manufacture of tools, this department was responsible for ensuring that these production tools and methods resulted in parts being finished to a high degree of accuracy.

The fact that the Arrow is an extremely advanced type of airplane means that extreme accuracy in surface smoothness is mandatory. In addition to provide the most efficient use of the airplane in service, a high degree of interchangeability of parts and components was required right from the first airplane which came off the line today.

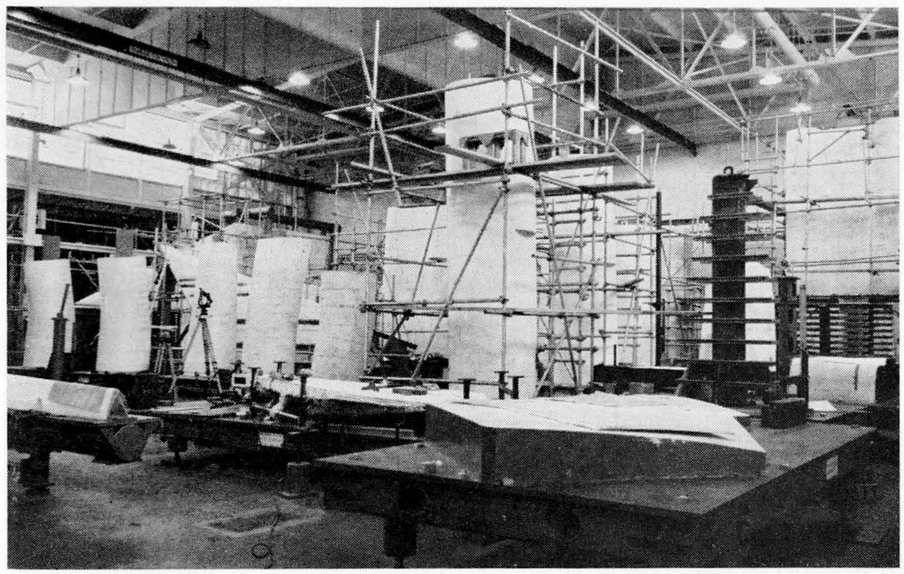
Efficient Handling

These two factors made necessary the master model program for outside envelope control, and the interchangeability tooling program to establish efficient service handling from the beginning.

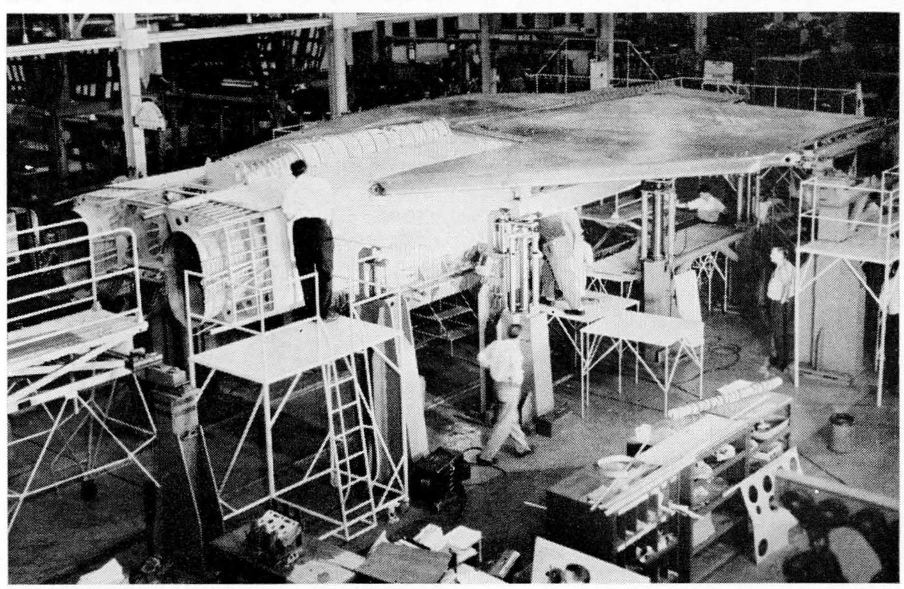
Extensive use of glass cloth was introduced early in the manufacturing program to more accurately transfer Engineering information to tooling and manufacturing stages.

Milling of wing skins and large machined parts from solid billets of metal provided a tremendous integral increase in the Arrow's structural strength. Besides reducing the design and manufacturing times required, this method eliminated tolerance difficulties inherent in the matching of numerous parts.

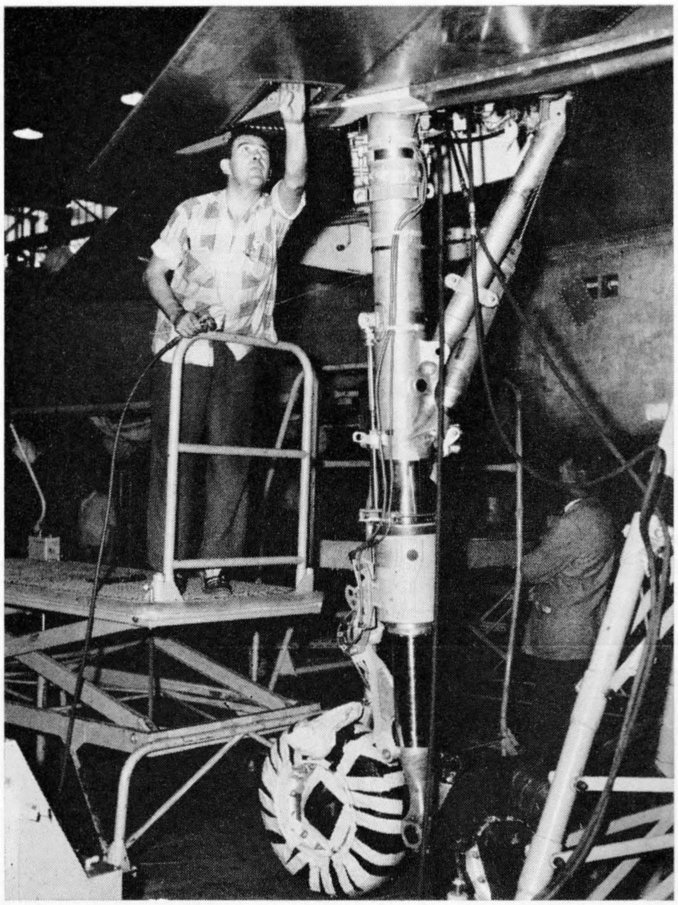
Departures from existing methods



Master models of all skinned sections of the Arrow — basic forming tools for contour accuracy.



Initial stages of final assembly—skin is rivetted on centre section; inner wings are installed.



Sam Gray is shown at work on an inspection panel on the port outer wing. Detail of Arrow's bogey landing gear can be seen plainly above.

Assembly progress is continually checked against drawings. Here in its jig is the front fuselage section showing both cockpits and engine air intakes.

of manufacture became almost common. In the field of metal bonding, Production Engineering developed a stronger and lighter method of joining metal to metal. New materials such as titanium provided key parts with greater heat resistance properties. Magnesium was employed for weight saving purposes.

With the master schedule as a working basis, the Production Control department's task was to schedule release of orders to the many fabricating areas, to expedite production of the parts according to priority sequence and to ensure the supply of finished parts to the assembly areas through the appropriate finished parts stores.

This procedure required exacting control, particularly since the release of these Arrow orders had to be scheduled along with those of the CF100's production, spares and modification programs. Close attention was also the byword in shop loading procedures so that work orders were released consistent with current machine and manpower capacity.

The Progress section played an important part with their follow-up procedures in expediting parts out of the shop and into their finished part stores. Where interruptions occurred in the production flow, the Progress section had to instigate schedule recovery action.

Throughout all stages, from the time the order was placed in the shop until its reception in the finished part store, a day to day reporting system was maintained so that the location and stage of completion of each part was readily available. From these records managment was given a permanently accurate picture of production in relation to scheduled completions.

Bottlenecks

As the final assembly stage was reached, the inevitable "bottlenecks" sprung up, many requiring re-design and re-work processes. Much of the credit is due the Production Control department for getting these snags overcome rapidly through their efforts in providing smooth inter-departmental liaison when fast remedial action was required.

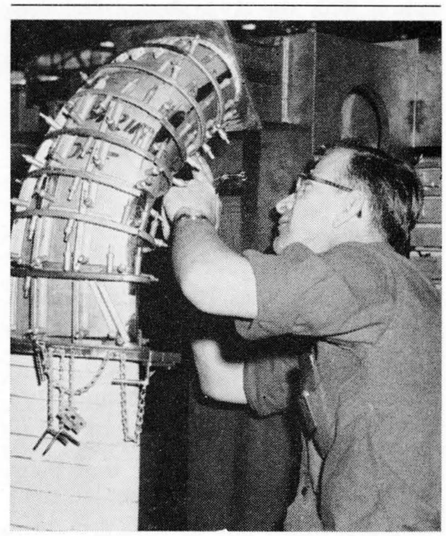
From the raw material to the finished part, and assembly of these parts and equipment into the aircraft unveiled today was the responsibility of the Production Shops Department.

Using over 1½ million square feet of floor space, comprising the sheet metal, machine and assembly areas, the thousands of production shop personnel have made and assembled some 38,000 parts in the first Avro Arrow.

Impact of Arrow

It was a gigantic task while still maintaining scheduled production on all phases of the CF-100 program.

The greatest impact of the Arrow program on the production shops was the extensive increase in both quantity and complexity of parts, along with familiarization in the use of new materials and equipment. Difficult machining and forming operations became the rule rather than the exception, and the fact that the first Avro Arrow is a production aircraft represents an outstanding departure from previous programs involving a series of prototype aircraft.



John Wilson of sub-assembly, is seen above fabricating a stainless steel heat exchanger duct.

New Inspection Techniques Applied By Quality Control

By Joe King

A PROJECT such as the Arrow, can owe much of its successful completion to first rate team work and individual enthusiasm of all people concerned with it. These qualities were fully exploited by each man in Quality Control and Inspection, regardless of his position in the scheme of things.

Quality Control joined in right from the start of the Arrow manufacturing program and there is very little of the preparatory work that they were not concerned with. Back in October of 1954 a group under Norman Turrall became responsible for checking all Arrow drawings before their release to the Shops. His instructions read: "It will be the responsibility of Quality Control to ensure that a part made to the limits of the production drawing or loft will in no way depart from the requirements of the Engineering and Quality Control Departments, the requirements of specifications in force, and the requirements of the RCAF."

Some 38,000 Parts

By June of 1957, a total of some 38,000 drawn or lofted parts had been checked and passed through the section, plus some 14,000 parts which had been reworked or re-designed. Competent checking of drawings resulted in a smoother flow of work through the shops with an accompanying reduced number of hold-ups and queries. One result of this group's work is that a complete breakdown of inspection stages has been available to men on the floor in time for each component, installation, or marry-up sequence. A very important phase of Quality Control operations concerns the Arrow's interchangeability program. Tool designs are routinely checked off for correctness of interchangeability features. When a "first off" part is rejected in the Machine Shop an investigation of the tooling is made to offset the possibility of unnecessary repetition of set ups and tool re-works.

Interchangeability

With interchangeability designed into the Arrow, Quality Control has played an important part in its successful application.

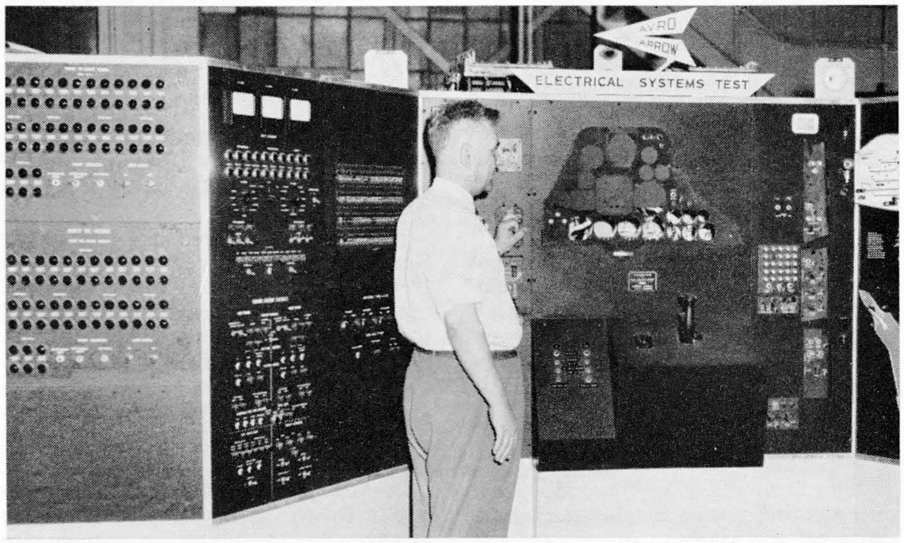
Maurice Cobb, Chairman of the Company Interchangeability Committee, reported in October of 1954 that a start has been made on the Interchangeability Report. That first report of a few pages is today a volume of more than two hundred pages. To Quality Tool Inspection and others this report is "the bible" since it details fully the tool features to be inspected so that acceptable interchangeable parts and components can be produced by the manufacturing division.

Besides compiling the Interchangeability Report, Maurice Cobb is responsible for devising, setting-up and guiding the Quality Control functions so far mentioned. He also superintends Quality Tool Inspection.

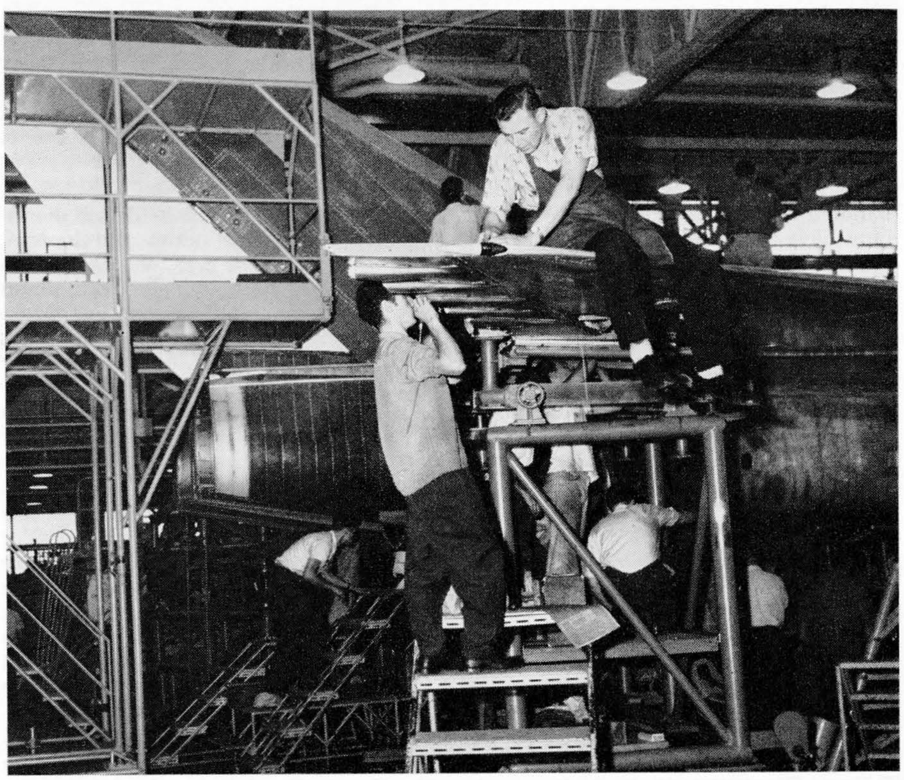
Consider the significance of the Arrow wing sections going together in the marry-up jig and later in the wing final assembly jig, and again later when the fuselage components and the complete wing went together. These marry-ups indicated a terrifically high degree of jig and jig reference accuracy. It speaks well of Quality Tool Inspection, that so few snags showed up and that components went together with the ease they did.

This group under John Trollope passed off the first Arrow jig reference in February, 1955, and the first assembly jig 12 days later. Since then some 235 tools have been passed and 331 jig references, and these include the largest assembly jigs now in the plant.

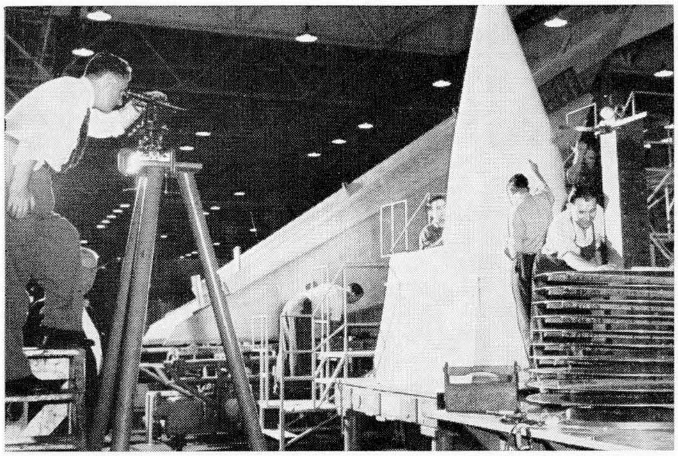
The main concern of Quality Tool Inspection is interchangeability tool-



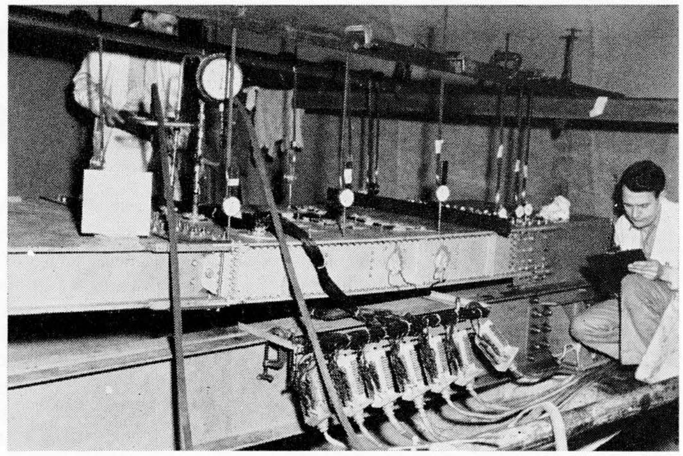
Arrow electrical system test rig simulates exactly the complete electrical system in the aircraft. Any production electrical component can be easily checked for serviceability in the test rig.



Quality Control inspectors okay each step of the complex Arrow assembly. Here, final adjustments are made to the starboard wingtip by Wally Grandey, left, and Bill Osborn of assembly.



Transit is used to line up correct aerofoil forms of master models to horizontal and vertical datum lines. Work on these specially-fabricated tools began in mid-1954. Metal formers with plastic and plaster filler form tools.



Static testing of wing structure being conducted by the Structural Test department. Dial test indicators are being used, along with strain gauges, to measure deflection of wing section under simulated flight loads.

ing. However, in June of last year they took over the proving of sheet metal press form and stretch forming tools and since then have cleared through some 10,000 tools.

Quality Tool Inspection also look after tools which produce classified "complex" machined parts and a variety of other tools which by arrangement with the RCAF can be used as checking media to ensure correctness of the part produced.

Inspection Innovations

Using innovations on inspection, such as accepting profile machined ribs and spars off the machine set-up, and machined castings for canopies and windscreens off the production tooling, has played a big part in speeding production to the point it is today. At the same time it has meant headaches for many.

Take, for instance, Gordon (Andy) Anderson in Receiving Inspection, who has found his section loaded with many parts which were larger than anything handled before. In many cases Andy's men have had problems in discovering what to inspect the parts with. For example, no surface table of sufficient accuracy was available, so it was necessary to have a 30-foot table re-surfaced to an accuracy of plus and minus .0008 in. A custom made universal angle computor had to be obtained because existing and available equipment was not large enough for Avro's purpose.

Pioneering . . .

Evidently the cockpit canopy castings have presented the biggest difficulties, these involved many hours of hand layout both before machining and after. These castings are made from a magnesium alloy not previously used on this continent and this caused Receiving Inspection to get involved pretty deeply in the pioneering work.

Dave Couperthwaite and his men in Machine Shop Inspection had to contend with similar problems, but primarily with machined skins and profiled structural parts such as ribs, spars and formers.

Machined skins produced by the big Kearney and Trecker receive some twelve or more separate inspection operations, and to carry out some of these it was necessary to purchase a "Vidigage" thickness measuring machine which has the appearance of a 21-in. TV and will give accurate checks of thickness at any point regardless of the size of skin.

In areas where other parts have to be bonded to the skins, inspection have to carry out "waviness" checks on the skin surface and tolerances here are as close as plus and minus .002 in.

New Materials

In Details Inspection, Horace Riley found a lot of new problems when Arrow production commenced. It must be remembered that this first Arrow is a production aircraft and that there is no prototype other than mock-ups.

New materials used in detail manufacture such as titanium and inconel, and the extended use of magnesium alloys and high tensile aluminum alloys posed unique inspection problems. New conditions and tolerances needed to be reckoned with. Some material was found to "grow" after heat treatment, others would stretch during forming to a much greater degree than less strong materials.

Increased use, in the Arrow, of details produced by stretch forming has brought about different concepts of inspection and different locations for carrying it out. Some forty parts were produced by stretching for the CF-100. In the case of the Arrow the number is near 2,000 and each had to be inspected to find out where, and what percentage of stretch took place.

Some idea of how the Arrow program progressed can be symbolized by the Centre Fuselage section of the aircraft. It is the largest of the Fuselage components and the main assembly jig for this was handed over to production in October of 1956. The first component was cleared by Inspection in February of this year and there were some thirty-six inspection stages to be carried out while the component was in the jig.

Other than main assembly jigs, work is produced in large numbers of other jigs. In each case, a rigid first-off inspection had to be performed to prove the tool. The Engine Bay alone used thirty-four jigs other than that for the main assembly.

Some of the new inspectional features encountered on final assembly include the optical alignment set-up used in the final jig and the introducing of a refrigerant gas into the wing tank areas whereby leaks are found with a "snifter" detector.

It is an unusual thing for assembly inspectors to carry plug gauges but that had to be done with the first Arrow. The structural strength necessary is such that bolt holes at joints must be right to the close limits called for by Engineering.

Bought-out Items

Geoff Hughes is in charge of electronic installations inspection and has been responsible for the testing and inspection of all equipment for the first Arrow, this includes items of hydraulic and pneumatic equipment as well as electronic. Some 1,300 items of bought-out equipment go into each Arrow.

The four-man team appointed by Fred T. Smye, President and General Manager, to spearhead the drive to get this first Arrow out on schedule, includes Cyril Meilton from Inspection. Cyril who is Inspection Superintendent of the Details and Assembly Shops has, like other team members, been living with the job since the aircraft began to take shape in the final assembly jig. It has been his responsibility to make the major decisions on inspection matters cropping up.

Test Pilots Aid Development From Early In Design Stage

By Don Rogers

IN the development cycle of a new aircraft, the contribution of the test pilot does not reach a peak until the first flight of the prototype. This does not mean, however, that he merely stands by during the period of design and manufacture waiting for the signal to start flying.

His personal attention to details of the aircraft begins during the early design stages. It concerns such items as controls, hydraulics, electrical and fuel systems, emergency provisions, cockpit layout, and extends to a detailed study of expected control characteristics, aircraft response rates, aerodynamic damping and stability throughout the complete range of airspeed and altitude.

Highly Advanced Concept

This type of detailed study and the ability to understand and discuss the various technical aspects with designers and engineers is particularly important in the case of an aircraft such as the Arrow which is planned to meet a highly advanced concept.

One area in which co-operation of pilot and engineer may be of significant mutual benefit is in the design of the flight simulator. This device is an electronic brain, of the Analogue Computer variety, connected to a mock-up of the cockpit and controls. Into this rig the engineer feeds his very best estimates of aircraft flight characteristics and control responses. When the experienced test pilot "flies" the simulator, he benefits by deriving some familiarity with what to expect of the aircraft he will be flying and simultaneously, he can assist the design staff by reporting any conditions of flight during which the simulator does not behave in the way he would wish the actual aircraft to fly. This presents an opportunity to make alterations or adjustments in the controls before the aircraft flies for the first time.

Cockpit Layout

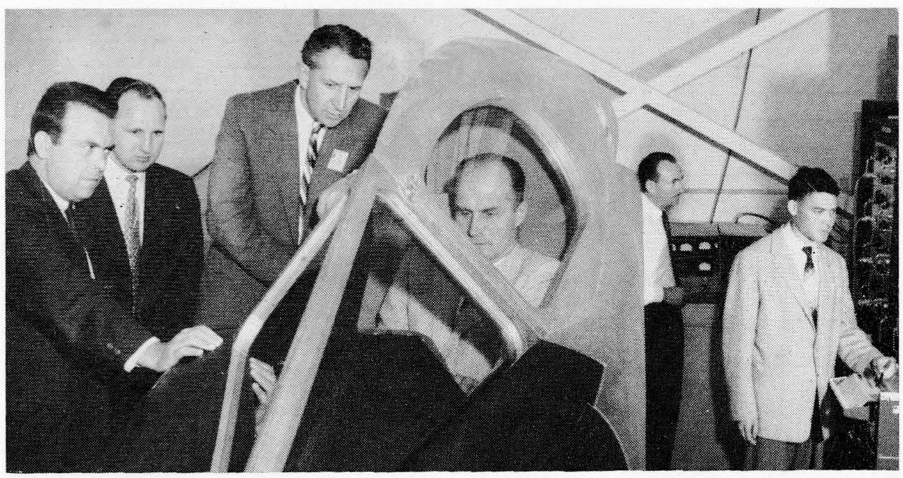
Another area which receives great attention by the test pilot is the arrangement of all controls, instruments and switches in the cockpit. He works very closely with the designers and human factors engineers in an attempt to arrive at the optimum lay-out with a minimum of compromise.

That this effort has been successful in the case of the Arrow is confirmed by the many favourable comments volunteered by other experienced military pilots who have had an opportunity to assess the mock-up. One of the most encouraging statements was that made by General Joseph Caldara, of the Office of the Director of Flight Safety, USAF, following an official visit to the plant, after which he stated that the Arrow's cockpit layout is the best he had seen.

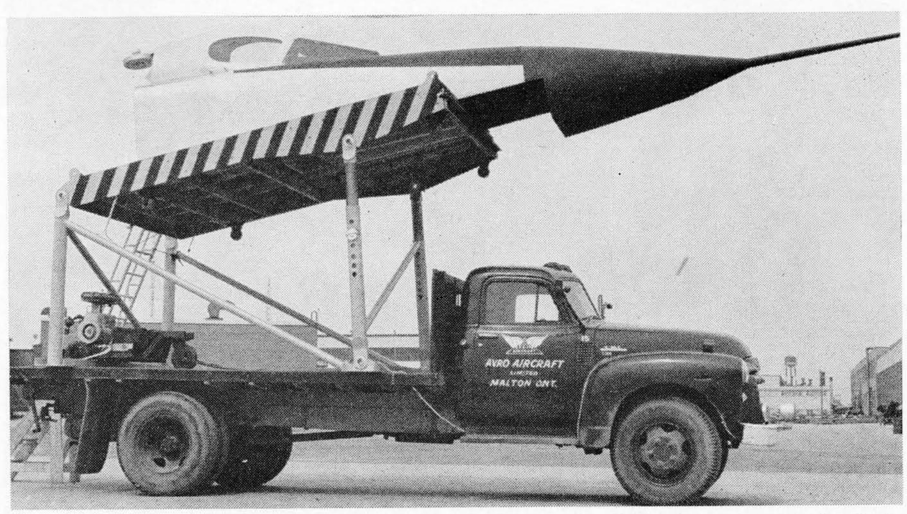
Members of Avro's Experimental Test Pilot staff have, as part of their preparations for preliminary flight tests of the Arrow, spent some time at the Convair test facility at Palmdale, California. There they have flown experimental and production version of the F-12 single-engine, delta-wing interceptor now being produced for the U.S. Air Force.

Now that the Arrow is completed and is unveiled for the first time, it will be moved from the production bays to the flight test hangar in preparation for its initial flight. The test pilots experience a strong feeling of pride in the achievement of the Engineering and Manufacturing divisions, and of anticipation for the opportunity to launch the Arrow on its flight program. They are eager to commence that portion of the development which is implied by the professional title: Experimental Test Pilot.

CHASE PILOT in the Orenda Sabre during initial flight testing of the Arrow was F/L Jack Woodman of the RCAF. He is shown here in the cockpit of the Sabre wearing a hard helmet fitted with a special adapter for holding, aiming and operating a small movie camera.



Experimental Test Pilots Jan Zurakowski, in cockpit, and 'Spud' Potocki, third from left, aid analogue computing specialists in analysing flight control responses in a special Arrow simulator. Analogue Supervisor Stan Kwiatkowski, left, and members of his staff watch for results.



Mock-up of the cockpit was mounted on a truck at actual height and taxiing attitude of the Arrow in order to check pilot visibility under actual daylight and night operating conditions.

Selling New Aircraft Design Delicate Merchandising Job

By Roy Linegar

THE sale of an aircraft design is perhaps the most delicate and complicated of all modern merchandising operations. Everything is "on paper", and there is little to sell that is more tangible than a promising concept, expressed in a design study. It is the design study which forms the basis for the formal proposal submitted to the prospective customer.

In introducing the Avro proposal to the RCAF, Avro's Sales and Service Division became the primary link between the company and customer. It has maintained this role, from the outset to negotiate a proposal such as the Arrow, for a government approval as a defence weapon, a company must be in a position to satisfy the requirements, not of a single customer, but of many government agencies.

Set Out Details

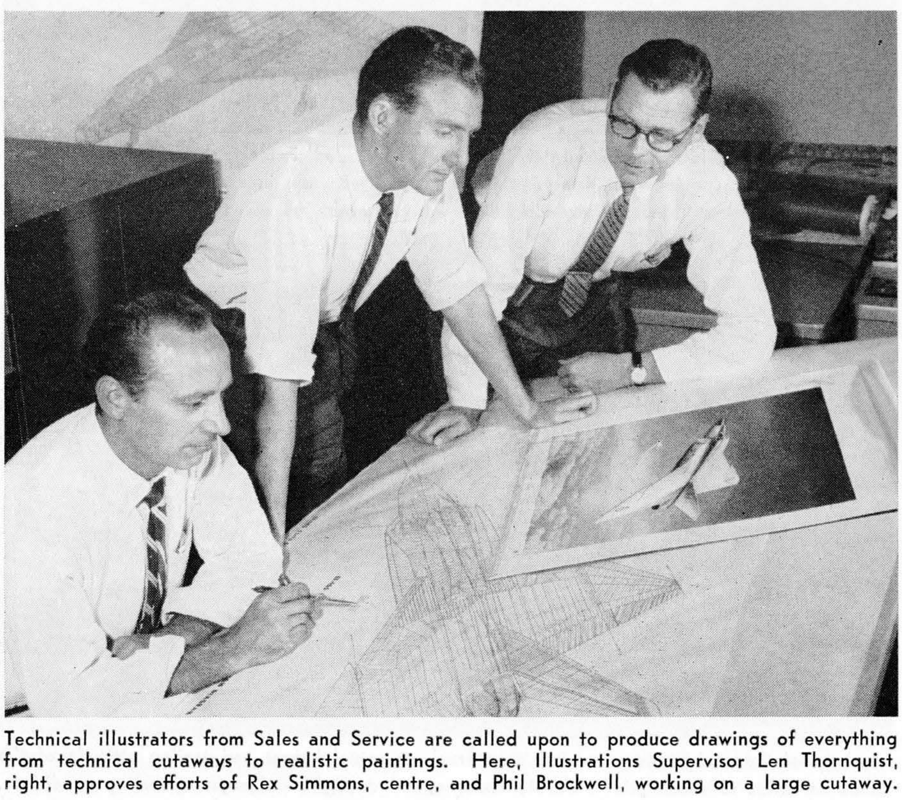
Avro's Sales and Contracts Administration departments had an early hand in preparing and vetting the overall Arrow proposals and submitting them to the RCAF, DDP, and other government offices. The proposals set out details of the work to be performed, plus the time and cost involved.

To present these proposals, a series of informative brochures was prepared by the Technical Writing section, which contained anticipated performance and operational characteristcs of the aircraft, supplemented by numerous illustrations and detailed drawings produced by the Division's illustrating section.

Following acceptance of the Arrow proposal, the Contracts Administration began the complex and lengthy task of negotiating a firm contract. This was based on the scope of the work, the standard of workmanship required, the materials to be used and the aircraft performance to be achieved.

To implement the contract requirements the Contracts Administration department issued sales orders to all departments concerned, and undertook responsibility for contractual negotiations with all sub-contractors concerned in the Arrow program.

After RCAF engineering approval of the proposal for the Arrow was received, the detail design got underway. Simultaneously, the preparing of maintenance instructions was begun by the Technical Writing section. Such technical literature is vital to efficient aircraft operation and maintenance. The staff of technical writers preparing the text maintains close liaison with all other departments within the company to ensure that published information is accurate and comprehensive.


Technical illustrators from Sales and Service are called upon to produce drawings of everything from technical cutaways to realistic paintings. Here, Illustrations Supervisor Len Thornquist, right, approves efforts of Rex Simmons, centre, and Phil Brockwell, working on a large cutaway.

Working in close co-operation with the Writing section is the Illustrating section which prepared a wide variety of art work required both for illustrating the maintenance instructions and for the various reports, charts and film titling for motion pictures which made up the sales literature.

The Publications Production section processes all text and illustrations for offset platemaking. It also arranges for printing and distribution of all literature published by the Division.

Analysis of the servicing requirements of the Arrow's systems and components has gone forward step by step with completion of design. All publications are constantly being revised and brought up to date by the writing section so that complete up-to-date descriptive and servicing instructions are available immediately.

Training Aids

To familiarize RCAF technicians with the new aircraft's costly and complex equipment, the company is designing training aids to be used for the instruction of ground and air crews. The Service Department, acting in an advisory capacity on the design of these aids, will furnish instructors and instructional manuals for such training courses in the near future.

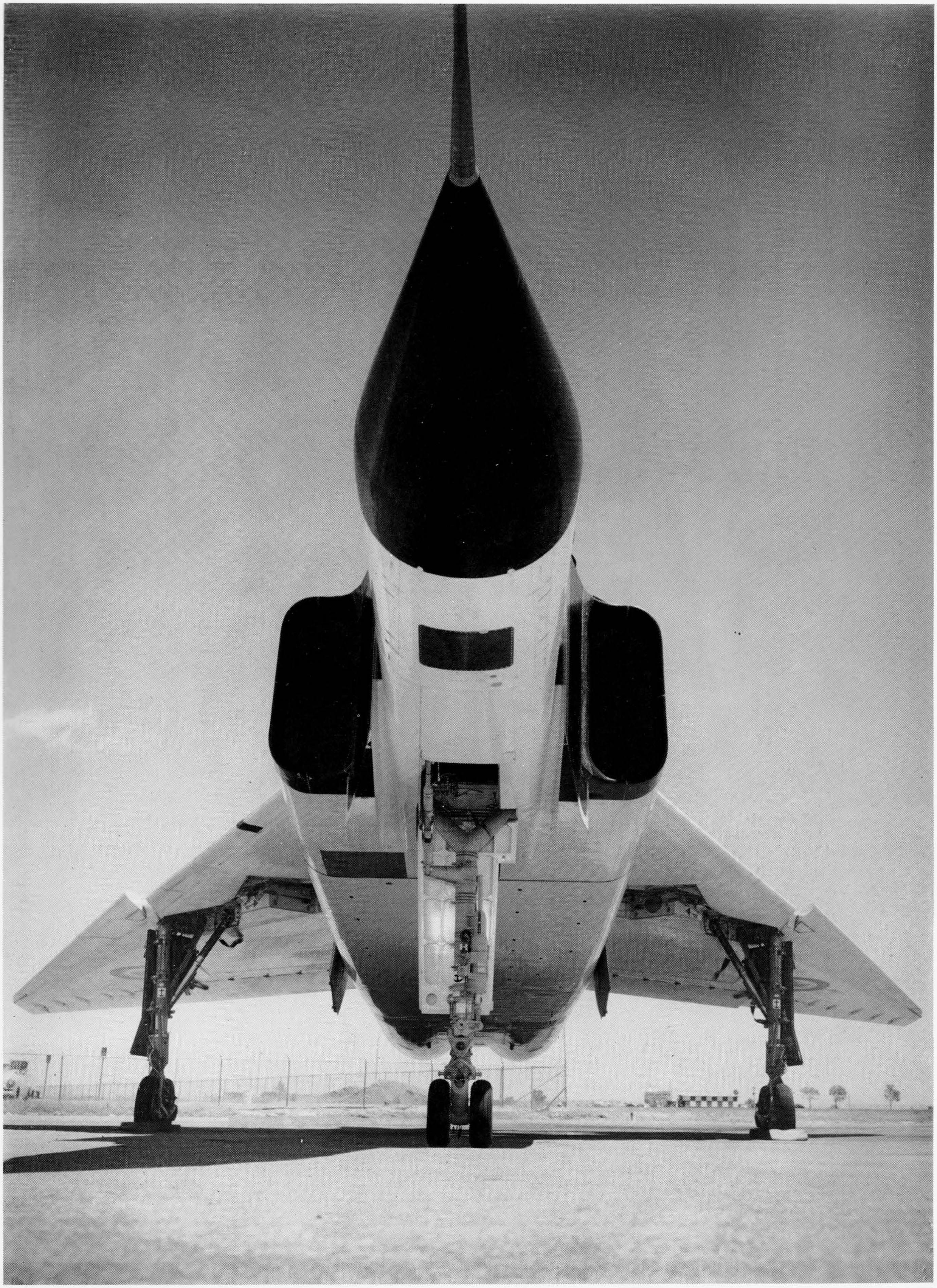
Since the Arrow program involves all divisions of the company plus a host of sub-contractors, a practical assessment of overall progress is made regularly on all significant aspects of the ARROW program.

These reports are prepared by Publications from facts and figures assembled by the various divisions responsible. These are invariably supplemented by documentary motion pictures which record various phases of the program. The movies are prepared by the Photographic Department in co-operation with the Writing Section.

Supply of Spares

The Parts Department of Sales and Service maintains the supply of adequate spares to the customer. From an early design stage, this department, in close co-operation with the RCAF has been analyzing Arrow provisioning requirements. Each part of the aircraft is reviewed and the service life of parts under various operating conditions assessed. When all factors have been studied, the necessary quantity of spare parts is ordered by the RCAF, either from Avro or from the component manufacturer.

All Company spares are prepared for transit by the Parts Department. They are scientifically packed to ensure arrival undamaged at their destination, and to remain servicable during their shelf life under any climatic conditions.



"The Arrow development is a forward step in . . . Canadian military aviation."—Air Marshal H. L. Campbell

▲ The Avro Arrow is shown in flight during test manoeuvres over Ontario.

The Arrow weapon system is a bomber-destroyer having supersonic mission capabilities. ▼

The Avro Arrow is as big as a World War II bomber yet took off on its first flight in only 3,000 feet of the 11,000 foot runway at Malton. ▼

AN ARROW IN THE SKY

Since its first flight on March 25th, the Avro Arrow has been meeting the vigorous demands of its extensive flight test program. Proceeding according to plan, the Arrow flew faster than sound on its third flight, and more than 1,000 miles per hour on its seventh flight.

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