OCTOBER 4, 1957
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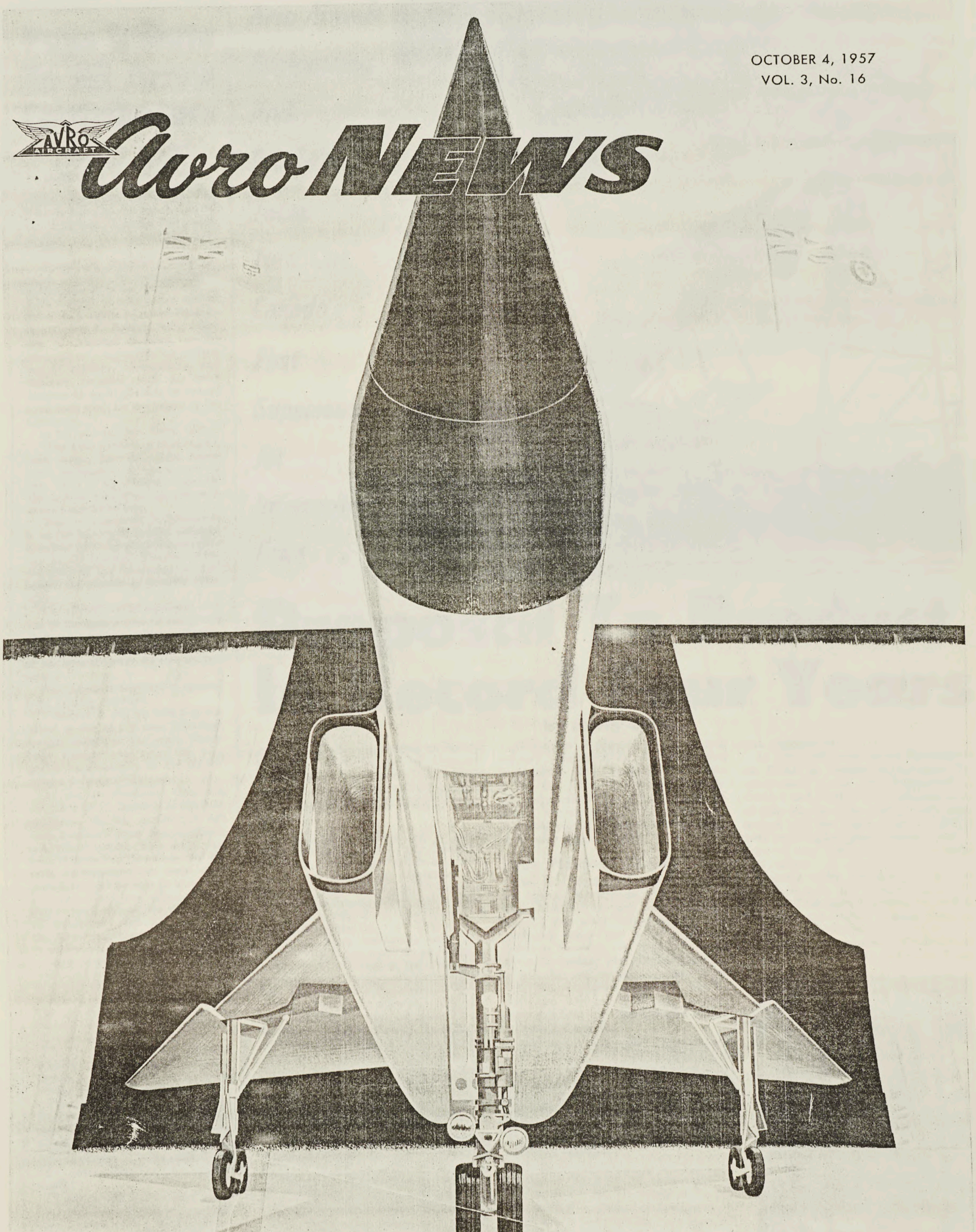
# Avro NEWS



## ARROW ROLLS OUT TO-DAY

# Pays Tribute To All Arrow Contributors

**Fred T. Smye, President And General Manager, Addresses Big Gathering**

The supersonic era of powered flight in Canada was ushered in today 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 on a signal from the Honourable George R. Pearkes, V.C., Minister of National Defence, in the presence of a representative gathering of Military, Government, and Industry, together with as many Avroites as could possibly be spared from their work for the period of the ceremony.

In his address, Mr. Smye said:

"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.

"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.

"This ceremony today is one of great significance to all of us at Avro and, we would like to think, to the Canadian aviation industry. The Arrow represents years of extremely hard work by our engineers, technicians, and craftsmen.

"It is the result of constant probing into new and unknown technical areas to meet the ever-advancing requirements.

"We feel that this airplane represents a substantial technical achievement — that it demonstrates the capability of Canadian technology, and represents a substantial Canadian contribution to the western world.

"I cannot help but say how proud I am of the employees of Avro who have created what I think will become known as a great airplane.

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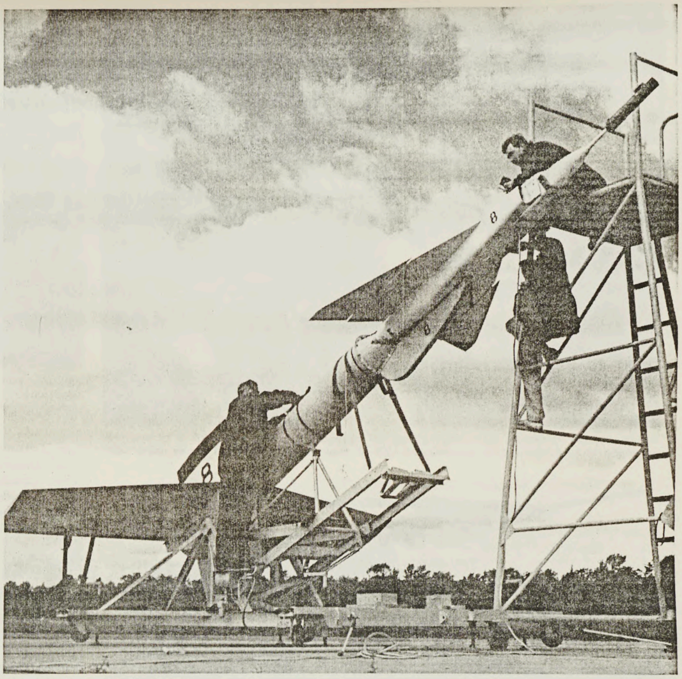
*Avro Aircraft Engineering And Production Teams Turn Out Canada's First Supersonic Jet Interceptor From . . .*



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.

# Proposal To Product In Record Four Years

**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 engineer- 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.

## All-Weather Interceptor

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.

## Delta Planform Chosen

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.

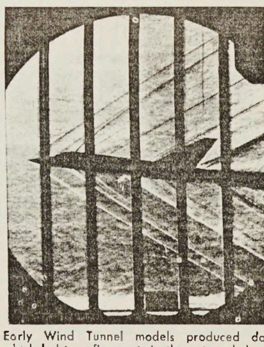
Both single and twin engine aircraft were considered in the design studies that followed. Company engineers felt that the twin engine version would have a marked increase in performance because it had twice the thrust, but did not need double the fuselage frontal area to accommodate the engines. Two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

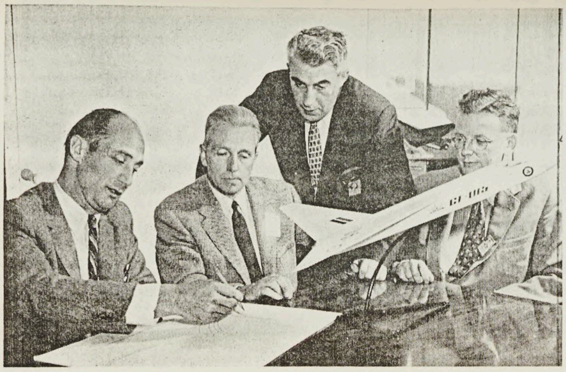
In June 1952 Avro issued brochures to the RCAF on "Designs to Interceptor Requirements" under the designation of C104/1 and C104/2. Both proposals were of delta planform, the C104/1 with single engine, and the larger, heavier, C104/2 with twin engines. Each aircraft carried a crew of two, with provision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

Engines under consideration for both proposals were the Curtiss-Wright J67, the Bristol Olympus 3, and the Avro TR 9. Electronic fire control systems were included in the designs.

National Aeronautical Establishment analysis of the C104/1 and C104/2 pro-



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



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, Arrow Project Designer; and Jim Chamberlin, Chief of Technical Design.

posals 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 the 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".

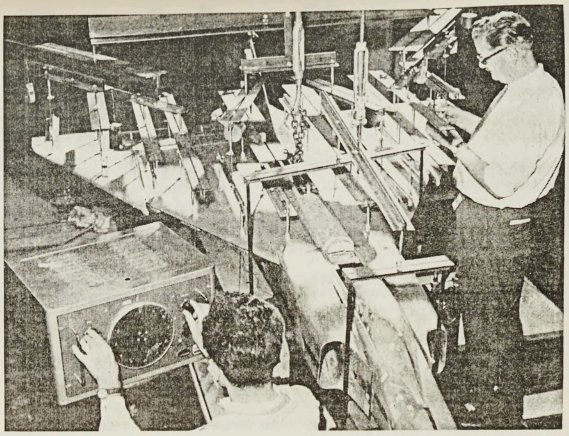
To date, Arrow wind tunnel models have been tested from low speed to twice the speed of sound. Facilities used included NAE (Ottawa) for low and high speed testing, Cornell Aeronautical Laboratories (Buffalo) for transonic tests, NACA (Langley Field, Virginia) for supersonic tests, and NACA Lewis Laboratory (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 altitude. The models were instrumented to measure performance and stability and to transmit the information back to a ground station.

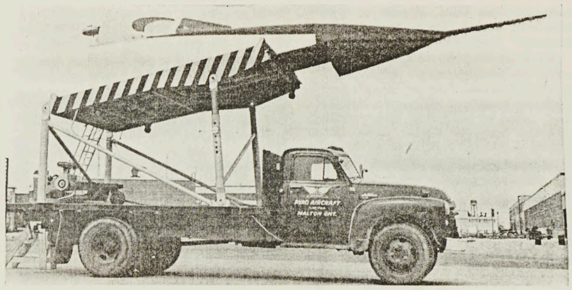
## Aerodynamics Tests

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.

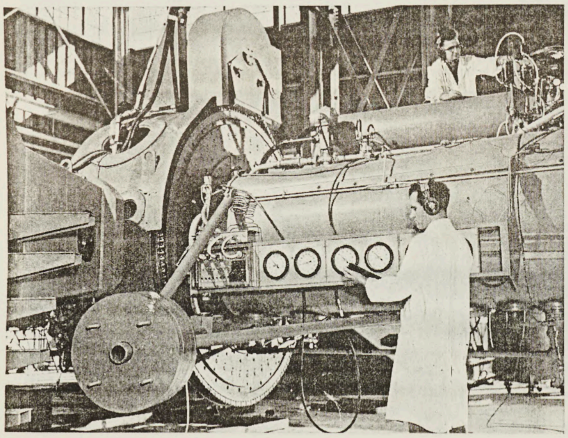
During 1954, when preliminary design was completed, the RCAF adopted the CF-105 designation for the aircraft. Initial proposals, design studies and tests which led to establishing the basic configuration of the CF-105, resulted mainly from the efforts of the Preliminary Design Office, under the direction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



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



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.



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.

## Powerplant Changes

Later in 1954, powerplant problems arose which required major changes in the proposed program. The Rolls Royce RB 106 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.

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 Designer, 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.

## Pilot Visibility

To demonstrate pilot visibility while taxiing and cockpit lighting techniques, a special mock-up of the front cockpit was mounted on a truck to simulate 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

(*Continued on Page 10, Col. 1*)

# Precision Keynotes All Arrow Tooling

**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.

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 airframe envelope, master models were built. built.

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

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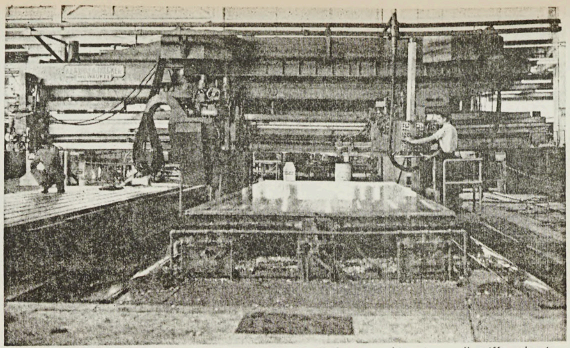
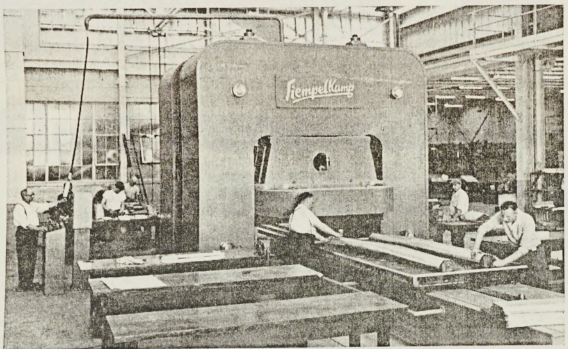
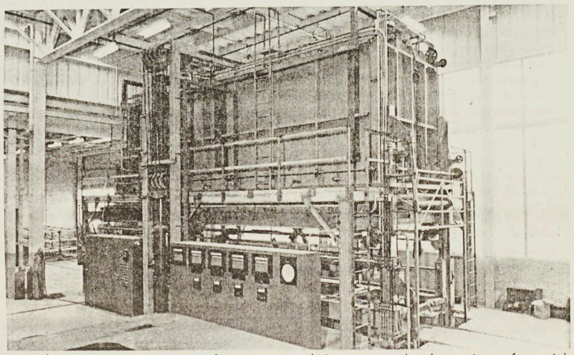


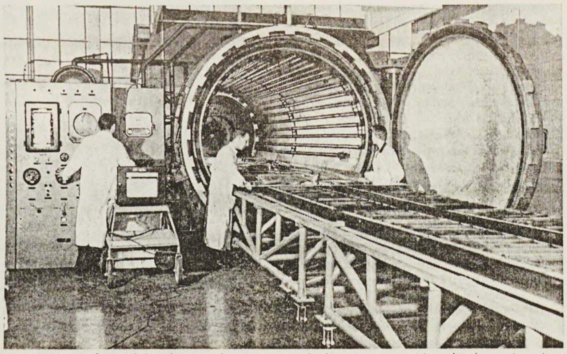
Avro's big electronically-controlled skin mill was installed to machine integrally-stiffened wing skin panels from solid billets of specially-alloyed rolled plate material. Cutter travels over work.



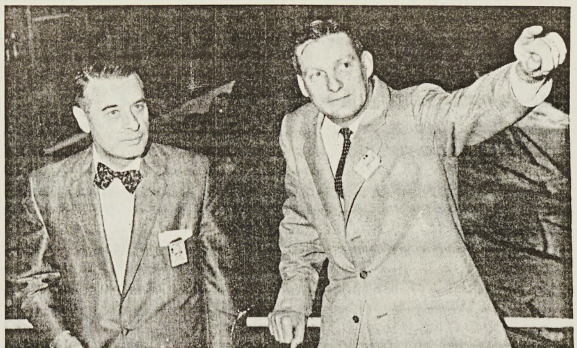

Largest rubber forming press in North America was installed for Arrow production. Able to form parts easily from heavier materials than previous needs, the pressure capacity is 15,000 tons.



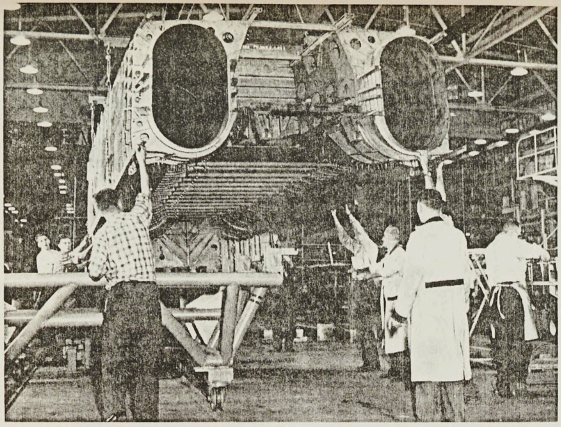
Large hot-air-circulation Heat Treat furnace was needed to accommodate large pieces of material. It is mounted on legs directly above a 20-foot long quench bath into which material goes.



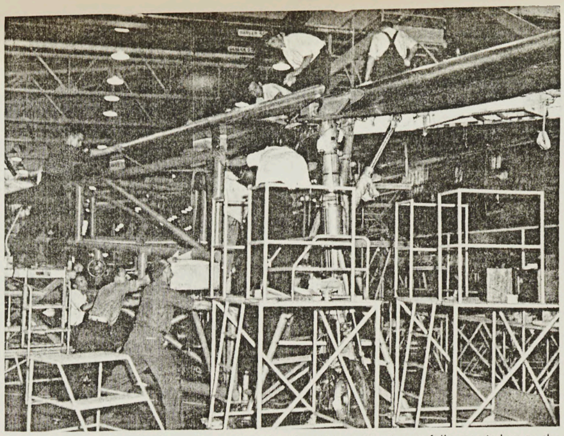
Extensive use of metal bonding in the Arrow resulted in Avro acquiring this huge Autoclave pressure chamber which uses heat and increased pressure to give required adhesive strength.



Key men in the Arrow tooling program were Harvey R. Smith, Vice-President Manufacturing, left, and Harold Young, Production Engineering Manager, seen viewing progress of the new aircraft.



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.



Completing the delta planform, the starboard outer wing section is carefully married-up to the inner wing which houses a landing gear unit equipped with two wheels, tandem mounted.

# First Production Arrow Sets Low Manhour Record

**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.

Harry Beffort, left, special co-ordinator, Arrow assembly operations, discusses Arrow's progress with Duke Riggs, Production Shop Manager.

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 pre-planning 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% of projects of similar size and complexity throughout the aviation industry in North America.

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.

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

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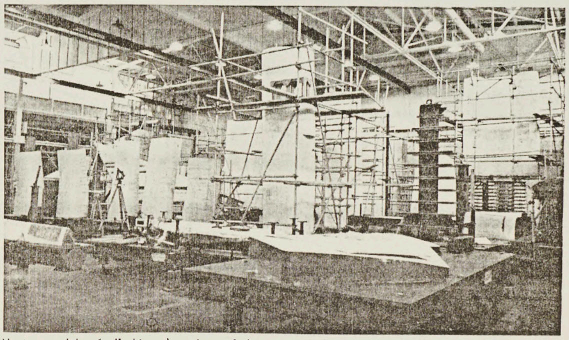
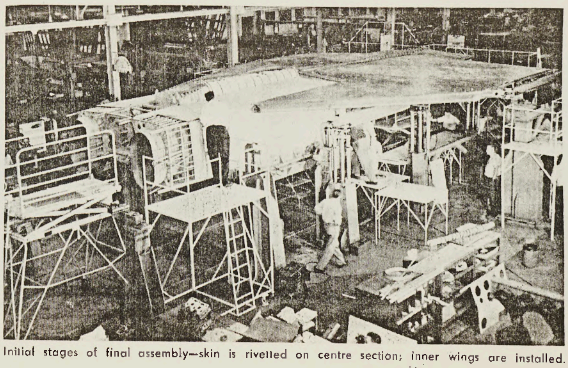
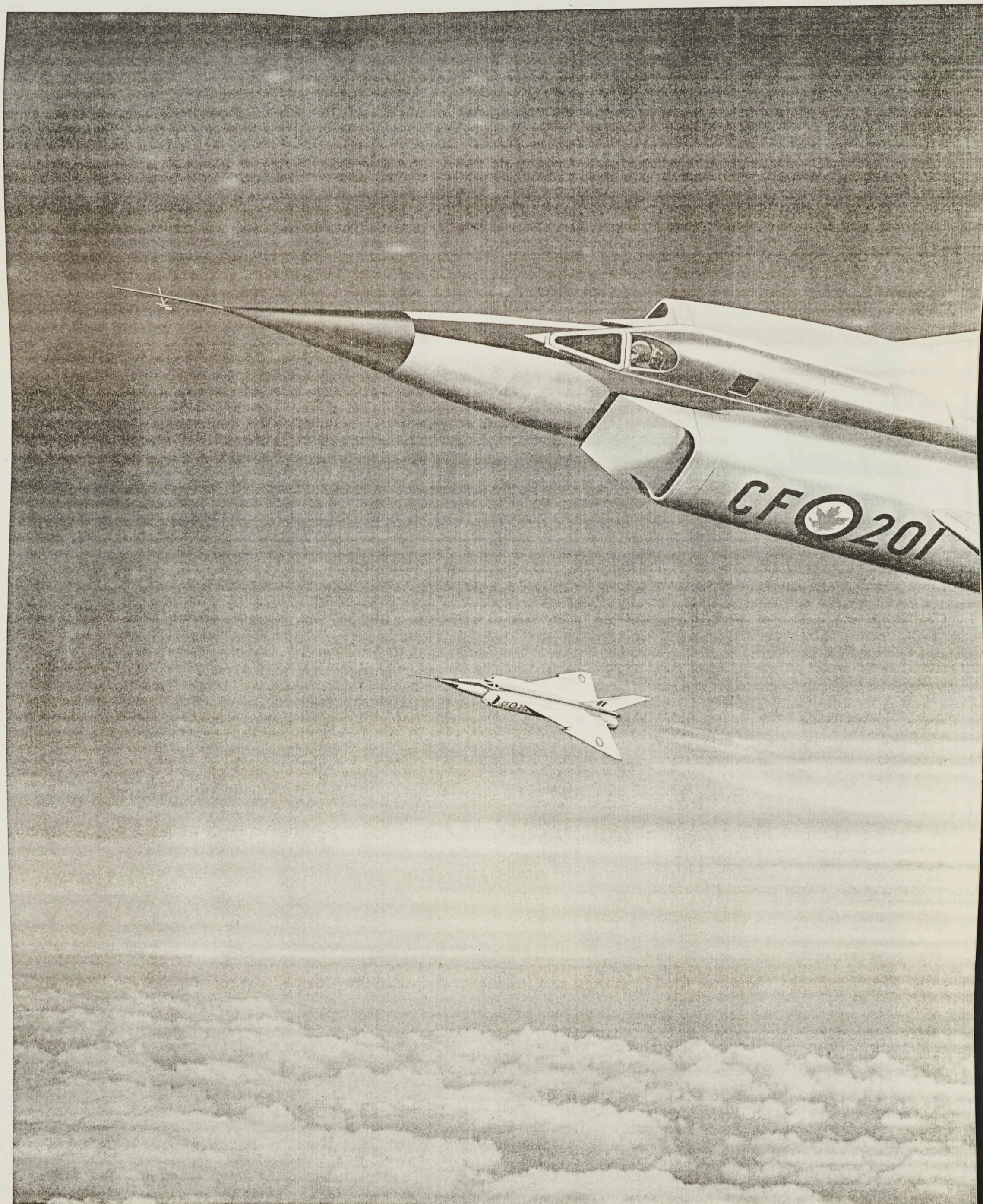


Master models of all skinned sections of the Arrow — basic forming tools for contour accuracy.



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

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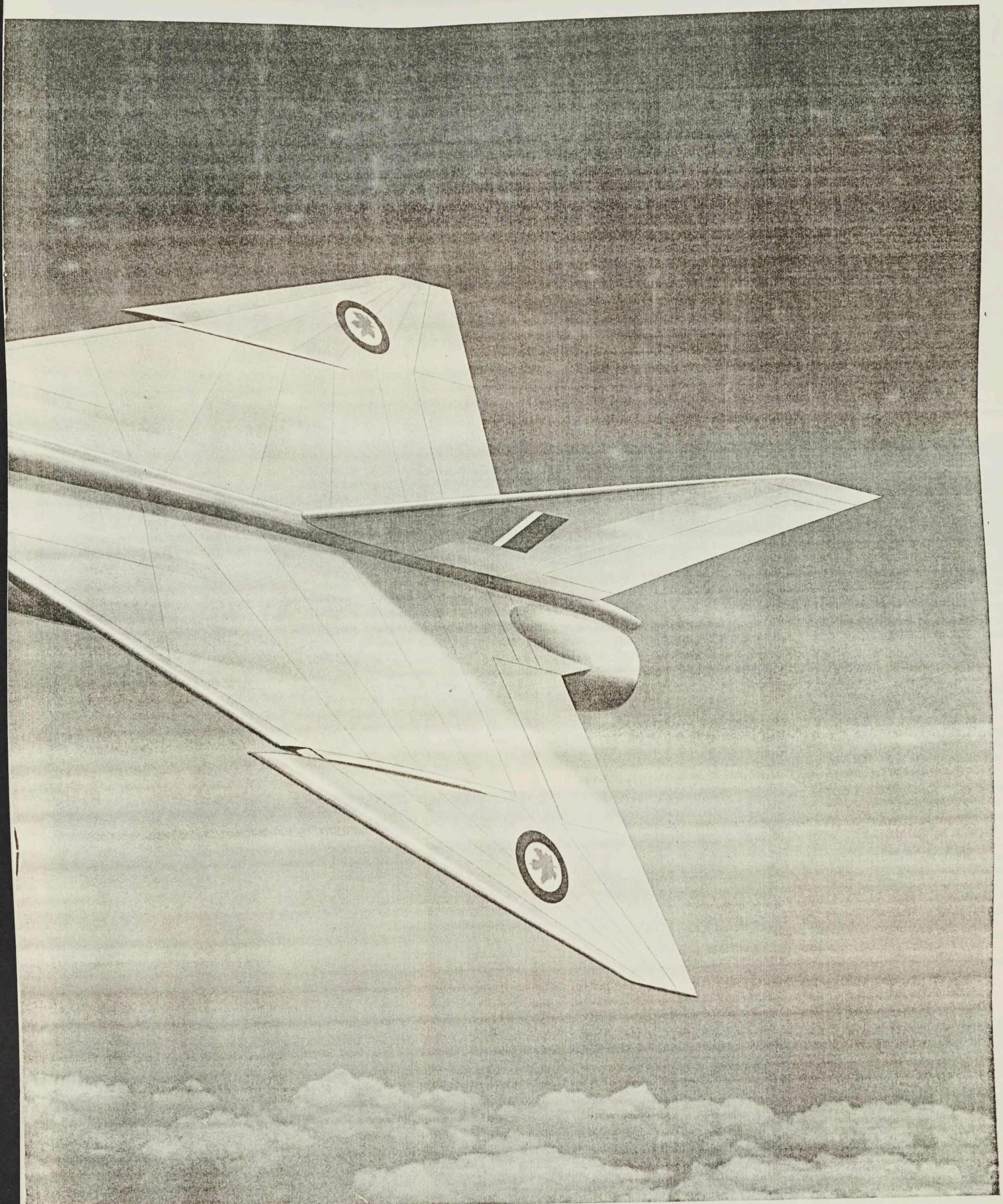
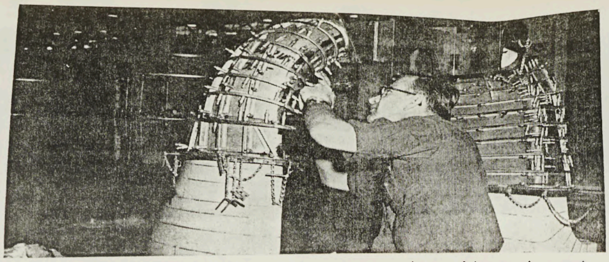
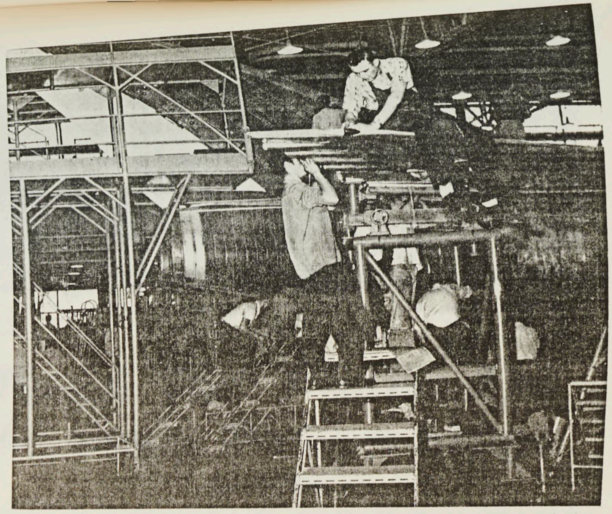


Drawn by Rex Simmons, Avro News Staff Artist

*RROW I*



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



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 Osbarn of assembly.

# Quality Control Gains New Inspection Skills

**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 R.C.A.F."

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 re worked 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 it 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 had been made on the Interchangeability Report. That first report of a few pages is today a volume of more than two hundred pages today. 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 tooling. 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 Innavotions

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 playing 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,

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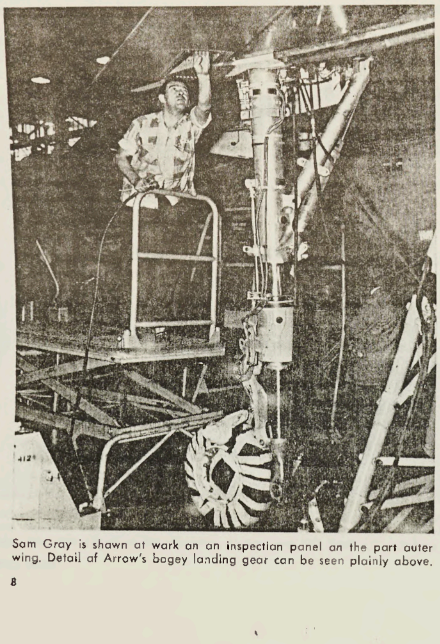
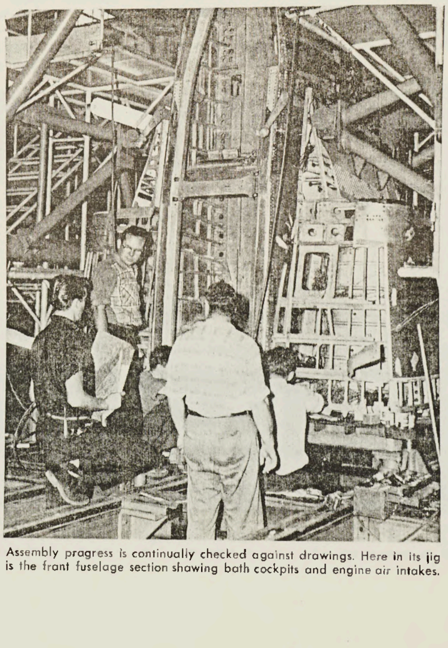


Sam Gray is shown at work on an inspection panel on the part outer wing. Detail of Arrow's bogey landing gear can be seen plainly above.



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

# Selling New Designs Requires Specialists

**by Roy Linegor**

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 characteristics 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 subcontractors 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.

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 rec-

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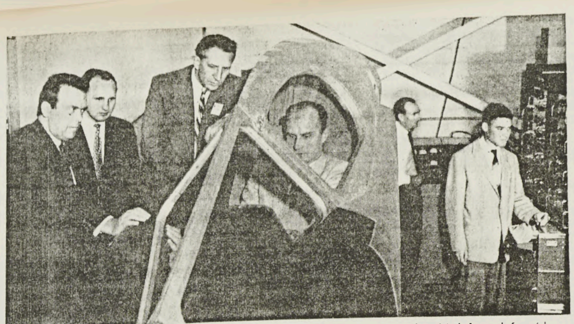

Experimental Test Pilots Jan Zurokowski, in cockpit, and 'Spud' Potocki, third from left, aid analogue computing specialists in analysing flight control responses in a special Arrow simulator. Analogue Supervisor Stan Kwiatkowski, left, and members of his staff watch for results.

# Need Test Pilots' Aid At Early 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.

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 of performance capabilities.

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 pilot must take the aircraft into the air 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

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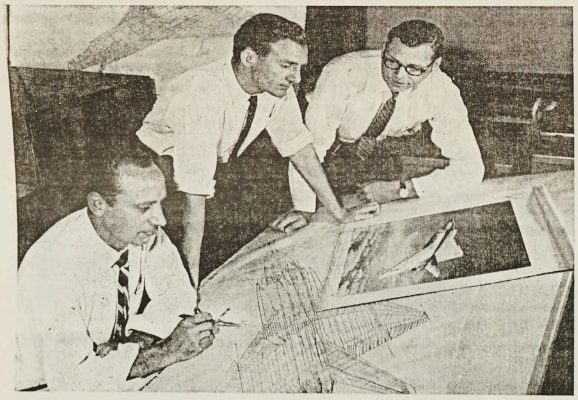
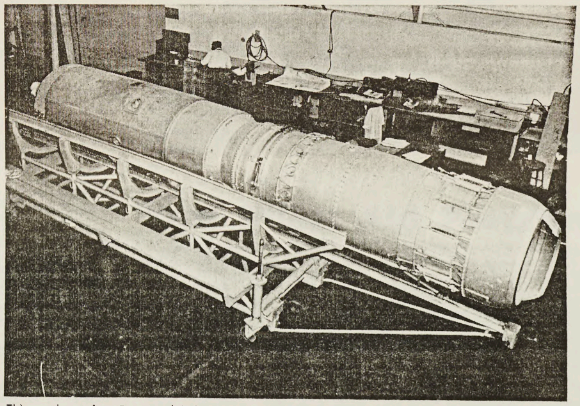
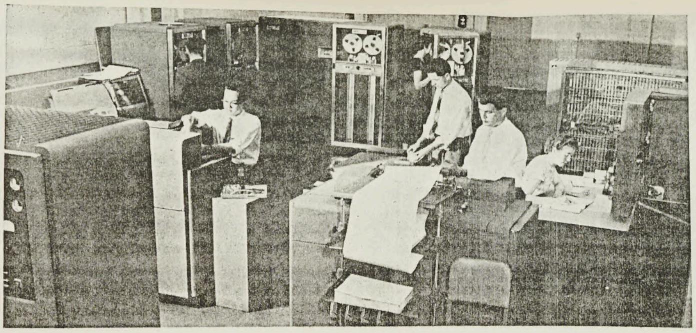


Technical illustrators from Sales and Service are called upon to produce drawings of everything from technical cutaways to realistic paintings. Here, Illustrations Supervisor Len Thornquist, right, approves efforts of Rex Simmons, centre, and Phil Brackwell, working on a large cutaway.



This mockup of a Pratt and Whitney J75 jet engine was used in the design of the Arrow's engine bays in order to accommodate it. Shown above cradled in its handling dolly, the mock-up is now used to aid in the development of field service techniques for engine changes.



Avro's Computer Capacity was greatly increased with the addition, this 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.

# From Concept To Completion In Record Four Years

(*Continued from Page 3, Col. 4*)
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 1 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 to 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 manoeuvrability 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.

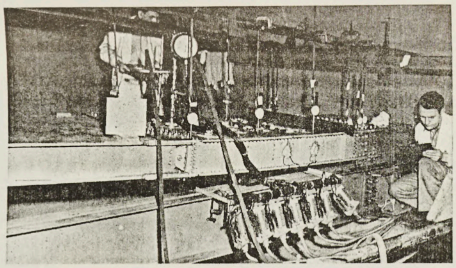
In simple terms the heat problem is caused by friction between the air and the aircraft skin. Temperatures attained while flying at supersonic speeds are high enough to weaken structure—the higher the speed, the more the heat, bigger the problem.

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.*



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.

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 were 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 of the Arrow.

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.

## Ancilary 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. All this is essential for a supersonic interceptor to perform its specified task.

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.

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.

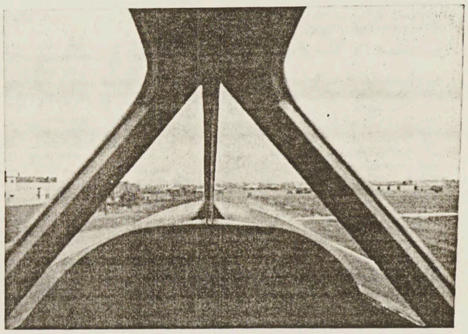
## What Next?

To date, approximately 17,000 different drawings have been released for the Arrow 1 and Engineering has formed a liaison team, which is on call twenty-four hours a day, to ensure that any drawing query or problem which may arise is immediately dealt with.

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

The Arrow is a fighter aircraft, yet its armament bay is as large as the bomb bay of some World War II bombers and the power of its two Iroquois engines is almost sufficient to lift the aircraft vertically off the ground!

With the Arrow 1 engineering complete, the Engineering Division is looking toward future development of the aircraft. It is a flexible, versatile, aircraft and with development it can have a greatly extended future. The present Arrow is on the threshold of the heat barrier, popularly called the Thermal Thicket, and studies are now under way as to how to adapt the aircraft for even higher speeds



Pilots' view from the cockpit of the Arrow shows excellent visibility despite slight nose-up attitude while taxiing. Photo was taken from mobile cockpit mock-up.

# Test Pilots Aid Program

(*Continued from Page 9, Col. 4*)
by General Joseph Caldara, of the Office of the Director of Flight Safety, U.S.A.F., 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.

# Low Manhour Record Set By First Arrow

(*Continued from Page 4, Col. 4*)
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 subcontractors 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.

### New Methods

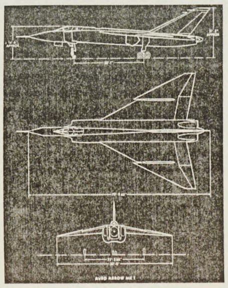
Departures from existing methods of manufacture became almost common. In the field of metal bonding, Production Engineering developed a stronger and lighter method of joining metal to metal. New materials such as titanium provided key parts with greater heat resistence properties. Magnesium was employed 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 part 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 management was given a permanently accurate picture of production in relation to scheduled completions.



### Bottlenecks

As the final assembly stage was reached, the inevitable 'bottlenecks' spring 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.

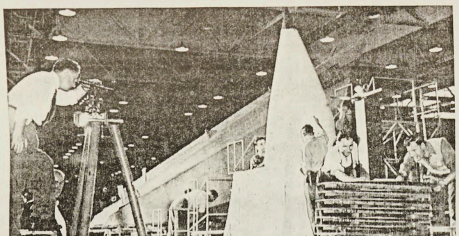
From the raw material to the finished part, and assembly of these parts and equipment into the aircraft unveiled today was the responsibility of the Production Shops Department.

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 into the first Avro Arrow.

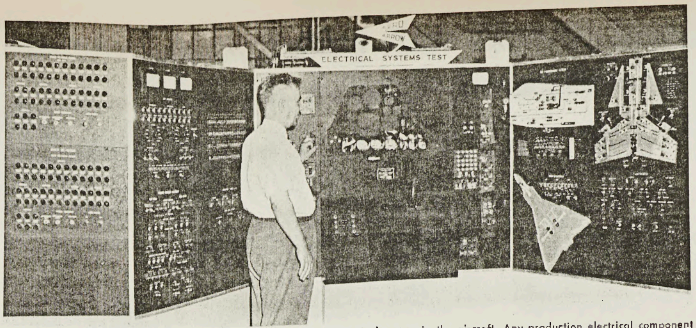
It was a gigantic task while still maintaining scheduled production on all phases of the CF-100 program.

### Impact Of Arrow

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.



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 July, 1954.




Arrow electrical system testrig simulates exactly the complete electrical system in the aircraft. Any production electrical component can be checked for serviceability in this rig. Ed Moore of systems test, is seen proving an electrical fitting for the first Arrow.

# Quality Control Uses Improved Techniques

(*Continued from Page 8, Col. 4*)
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.

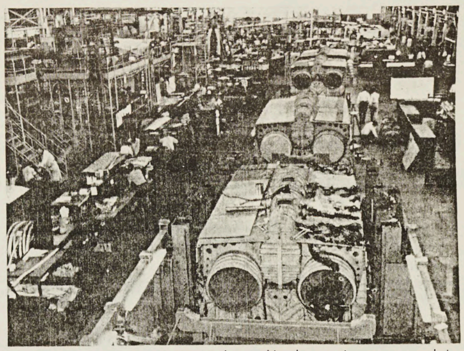
Some of the new inspectional features encountered on final assembly include the optical alignment set-up used in the final jig and the introducing of a refrigerant gas into the wing tank areas whereby leaks are found with a 'snifter' detector.

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.

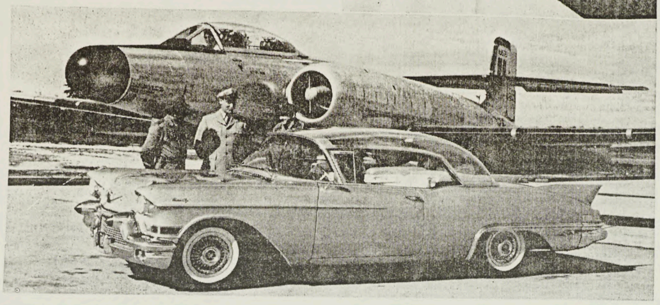


This general view of the Arrow Final Assembly shows major components being assembled for subsequent release to the final assembly marry-up in the background.

**Designed And Built By Avro . . .**

## Queen's Royal-Visit Car Has Clear Plastic Top

The car to be used by Her Majesty, Queen Elizabeth II and Prince Phillip during the Royal Visit to Ottawa and Washington, which begins October 12, is shown here with its newly-built clear plexiglass top installed. Designed, built and installed by Avro, the moulded top is a radical departure from similar designs used in the past. A small group in Avro Preliminary Design Office under Waclaw Czerwinski designed the top which was built by the Experimental Department. The top is being modelled at right by Joan Lukanchoff of Experimental and S/L Don Pettite, 428 Squadron RCAF. Below, Avro chauffeur, Grant Sleep, with F/L Art Rowe, left, and S/L Pettite, right admire the installation by a CF-100 on Avro's flight line.



# Pays Tribute To Arrow Contributors Who Made Today's Rollout Possible

*(Continued from Page 2, Col. 1)*

"In this connection I would like to pay tribute to my colleagues, Mr. J. C. Floyd, Vice-President of Engineering, and Mr. H. R. Smith, Vice-President of Manufacturing, who have headed up their teams so admirably.

"I would also like to pay tribute to the Canadian government agencies with whom we have worked so closely, and who have made such great contributions to this project. In particular, of course, I refer to the Royal Canadian Air Force, and to its staff of able technicians and engineers.

"I would also like to make mention of the National Research Council, who have assisted in many technical areas, and particularly in the use of their wind tunnel and other test facilities.

### DDP Helpful Partner

"The Department of Defence Production has also been a most helpful partner in this undertaking, and is ever ready to assist with our problems which arise in the sphere of their responsibility.

"The Defence Research Board has likewise contributed its assistance in advice on technical problems, and greatly assisted the very important free flight model test programme which was carried out at one of their facilities.

"We also wish to say 'thank you' to the United States Air Force and to the National Advisory Committee on Aeronautics for the co-operation and assistance which they have always been so free in offering.

### Subcontractors

"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 J.75 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.

"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.

"At the close of this ceremony, the aircraft will be taken to the flight test hanger for flight preparation, which will involve exhaustive testing and the installation of extensive, specialized instrumentation. The flight date of the aircraft will depend on the problems which will have to be dealt with during this phase of the programme and, consequently, it is difficult to foretell. We are hopeful, however, that the aircraft will make its first flight before the end of the year.

### Flight Test Program

"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 th 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.

"The CF100, which is currently in production for the Royal Canadian Air Force and the Belgian Air Force, was created, designed, developed and produced here at Malton. We like to feel that that aircraft has played an important role in the defence of our country and has contributed to NATO. It is our fervent hope that, in due course, the Arrow will make the same contribution in the supersonic era in service with the Royal Canadian Air Force and with the air forces of other allied countries.

"In closing, I would like to again thank the Royal Canadian Air Force and the Government of Canada for affording us the opportunity of designing both of these aircraft, and for entrusting to us this responsibility, of which we are so deeply conscious."

# Precision Keynotes All Arrow Tooling

*(Continued from Page 4, Col. 4)*

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.

To meet strength specifications where parts were joined together with the 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.

# Selling New Aircraft Design Is Delicate Merchandizing

*(Continued from Page 9 Col. 2)*

ord various phases of the program. The movies are prepared by the Photographic Department in co-operation with the Writing Section.

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 serviceable during their shelf life under any climatic conditions.

### About The Cover

Cover design on this issue was drawn by Ed Dyke of the Illustrating Section, Sales and Service. Whereas the perspective of the cover picture may appear exaggerated to the layman, it is, in fact, an optically accurate view from immediately under the pointed nose of the Arrow.

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