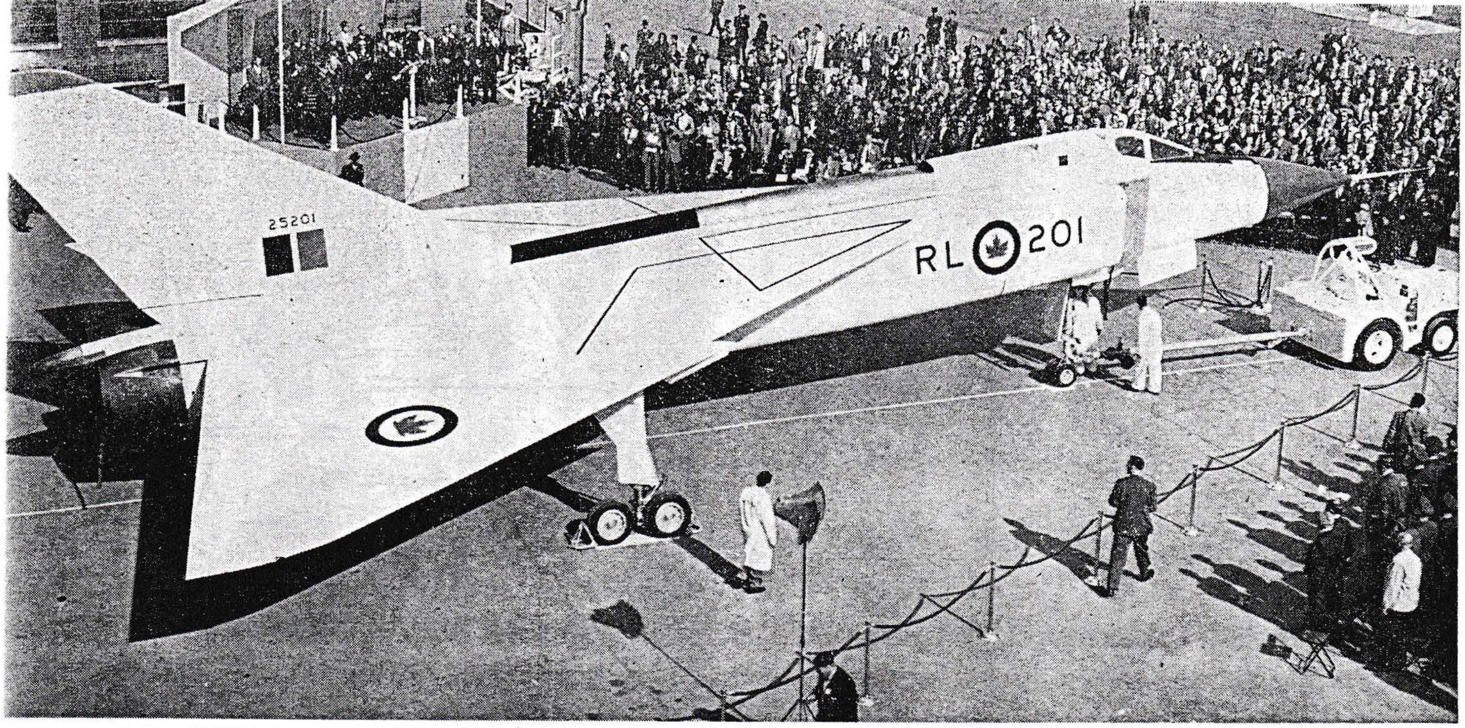


AVRO CF-105 Arrow, Canada's newest two-place, twin-engine, long-range interceptor, is shown during rollout.

CF-105 Displays Advanced Engineering

By J. S. Butz, Jr.

Toronto—Avro CF-105 Arrow has given Canada a serious contender for the top military aircraft of the next several years. The large, decidedly advanced delta-wing fighter was rolled out of the Malton plant a few days ago and flight tests are scheduled to begin before the end of December.

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:

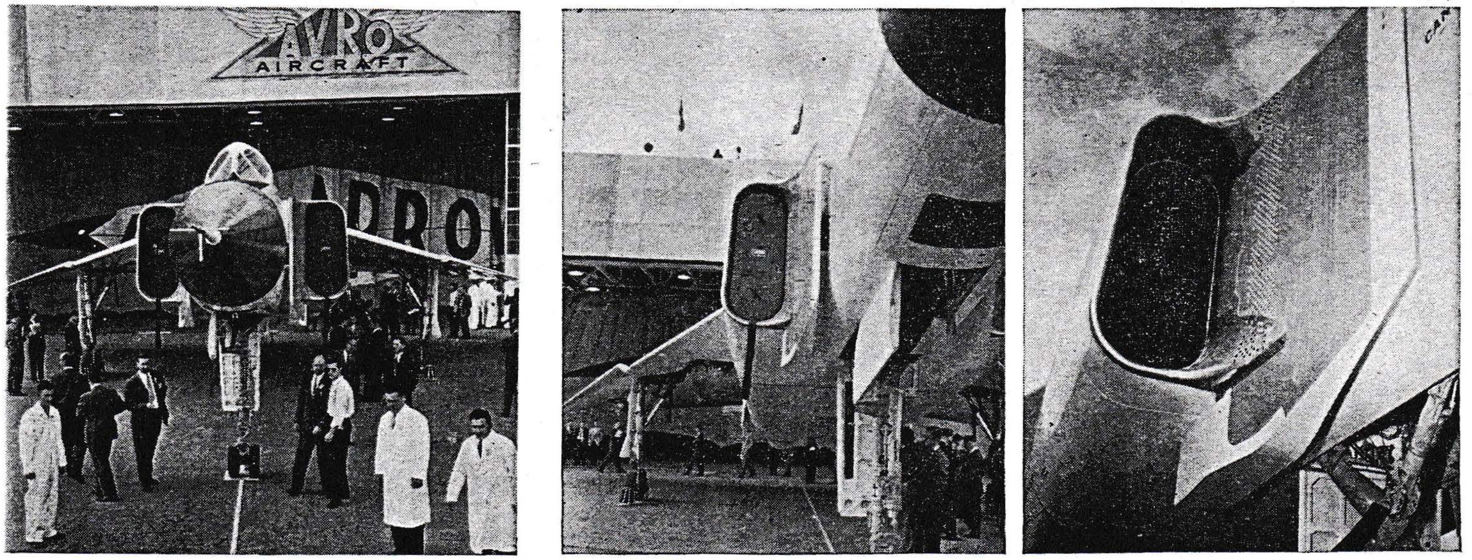
- **Thrust** of approximately 60,000 lb. with Orenda Iroquois engines and afterburning.
- **Maximum** takeoff weight of about 60,000 lb.
- **Area-ruled** fuselage.
- **Very thin** wing with conical cambered leading edges and blunt trailing edges.

Designed for Altitude

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



ARROW'S engine air inlets have fixed ramps and wide boundary layer bleeds. Duct operation is kept efficient at supersonic speeds by bleeding air through perforations on ramps (right photo). This is an alternate solution to the variable geometry duct.

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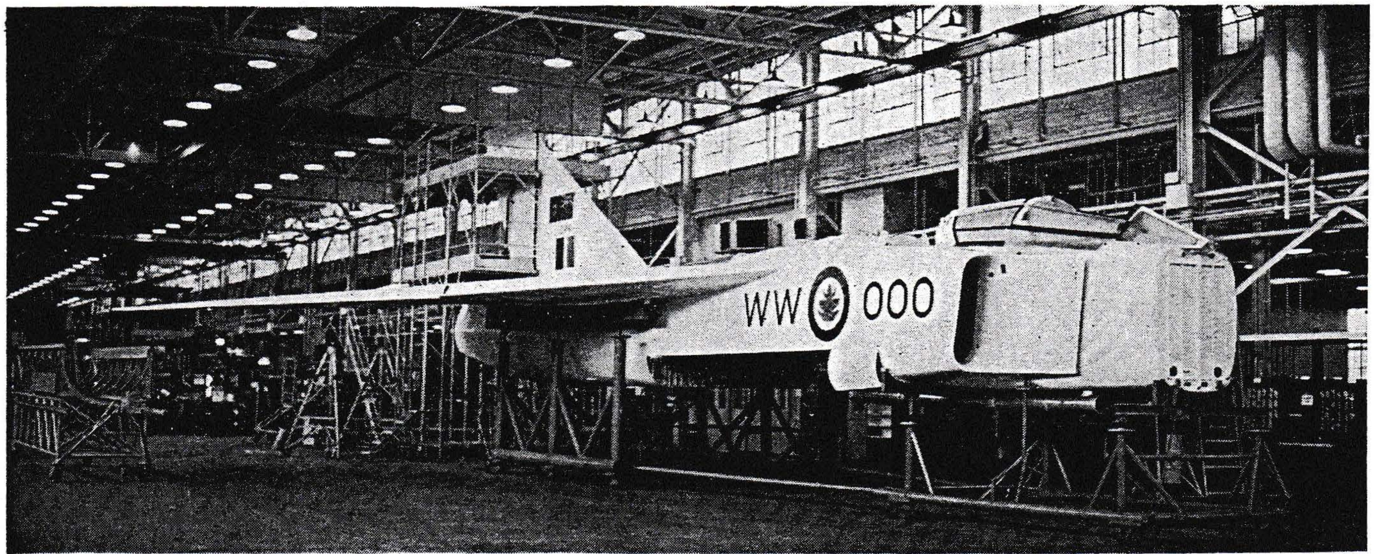


SECOND flight-test CF-105 is in its mating jig. Jig is part of production tooling used in manufacture of all CF-105s.

In Rollout

begin flight test after extensive test programs 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.

Iroquois Saves Weight

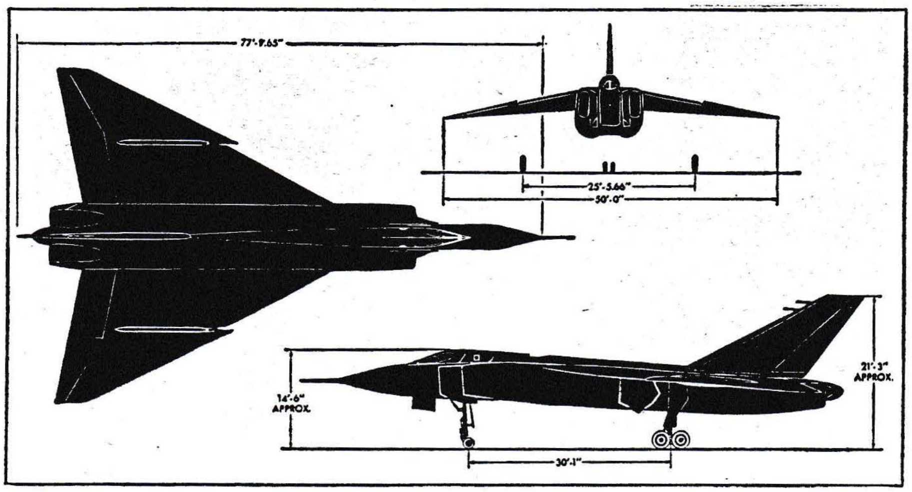
The Iroquois has had extensive ground running under sea level and altitude conditions and has been licensed for production in the U.S. by Curtiss-Wright. The engine uses the most modern design practice in saving weight and it produces around 23,000 lb. of thrust for 4,500 lb. of engine weight.

Afterburning thrust is in the neighborhood of 30,000 lb.

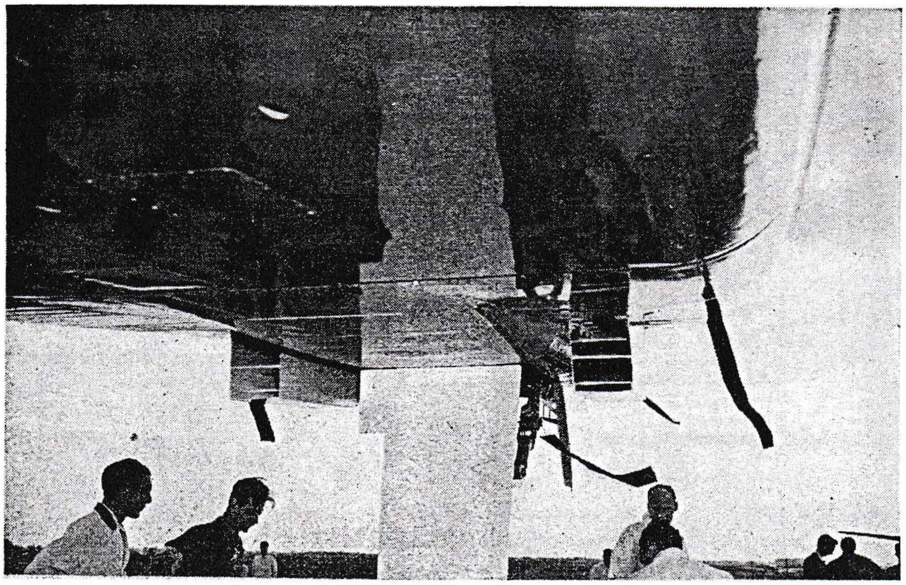
The very high thrust-to-weight ratios of the aircraft and the engine which will aid high altitude, high speed maneuverability will also give the Arrow impressive performance in other areas. Its maximum speed should be well over Mach 2 if comparisons with existing fighters can be used as an indication. 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



ARROW is a large aircraft. For comparison, B-58 has 55-ft. span and is 95 ft. long. F-102A is 68 ft. long with a 38-ft. wingspan.



LOWER rear portion of inlet ramps (above) are dumps for some of duct bleed air.

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 the 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 cooperation.

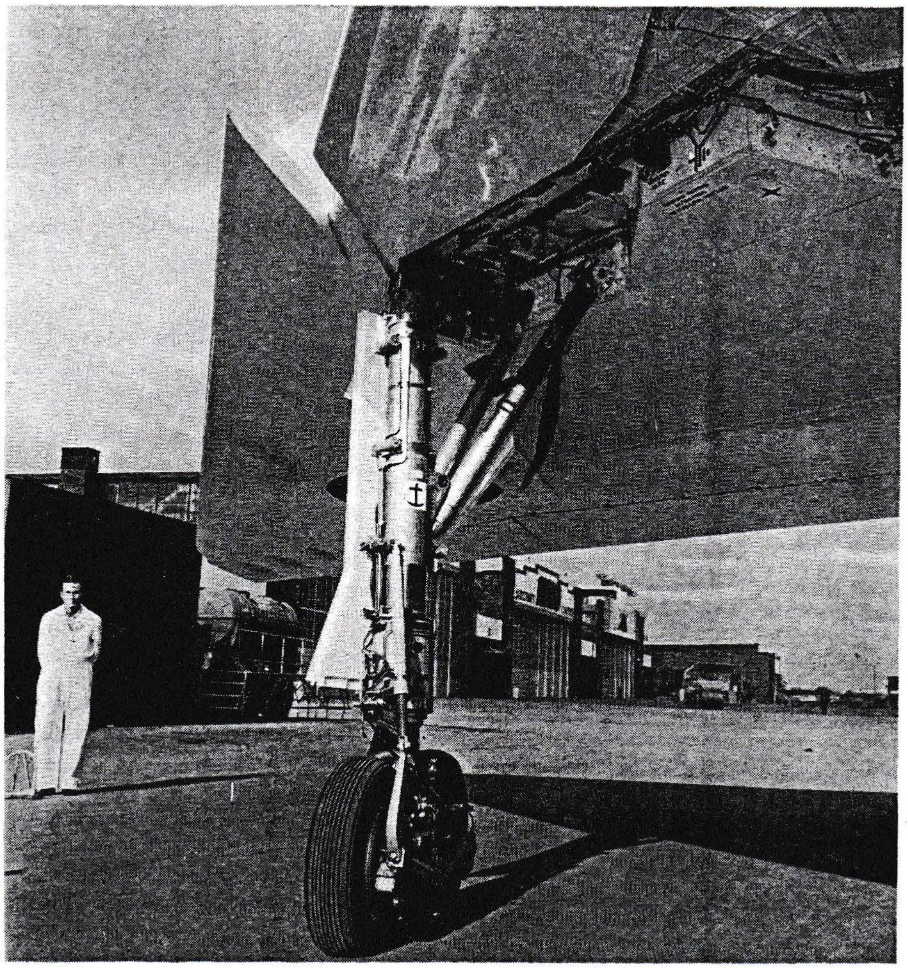
However, the exchange of information is anything but one-sided. Some of the most important Canadian contributions so far have been in metallurgy and aircraft and engine structural design and fabrication techniques.

Aerodynamic Testing

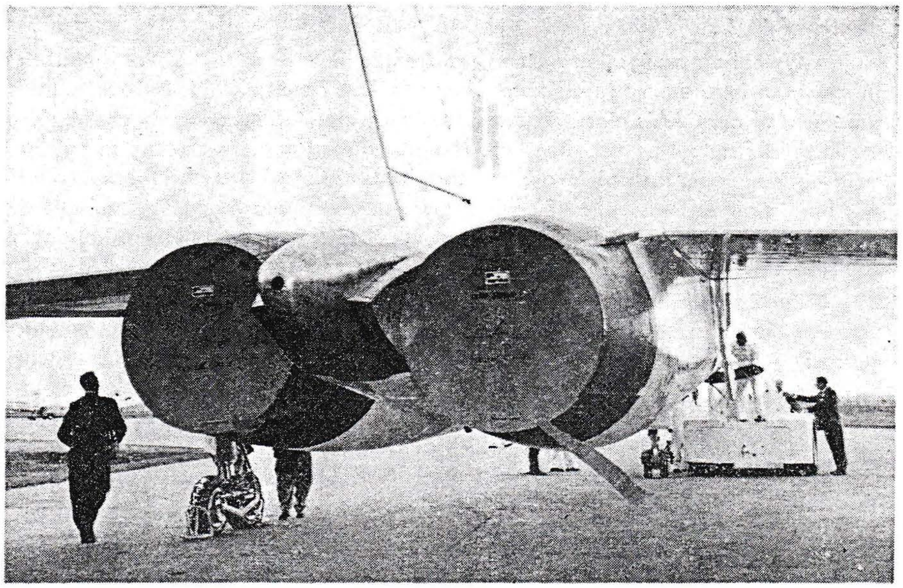
Aerodynamic development of the Arrow design began about four years ago. Wind tunnel tests have been conducted at the National Aeronautical Establishment in Ottawa, in NACA tunnels at Langley Field and Cleveland and at the Cornell Aeronautical Laboratory. Thirteen free-flight rocket models have been fired to supplement the wind tunnel data which went to Mach 2. Eleven of the rocket models were launched over Lake Ontario and the other two in Virginia. All attempted launchings were successful, a small record.

The wing planform resulting from all of this experimentation is a sharply swept delta shape with the trailing edges also slightly swept. Blunt trailing edges make the wide chord control surfaces along the trailing edge more effective and reduce wing drag slightly at very high speed.

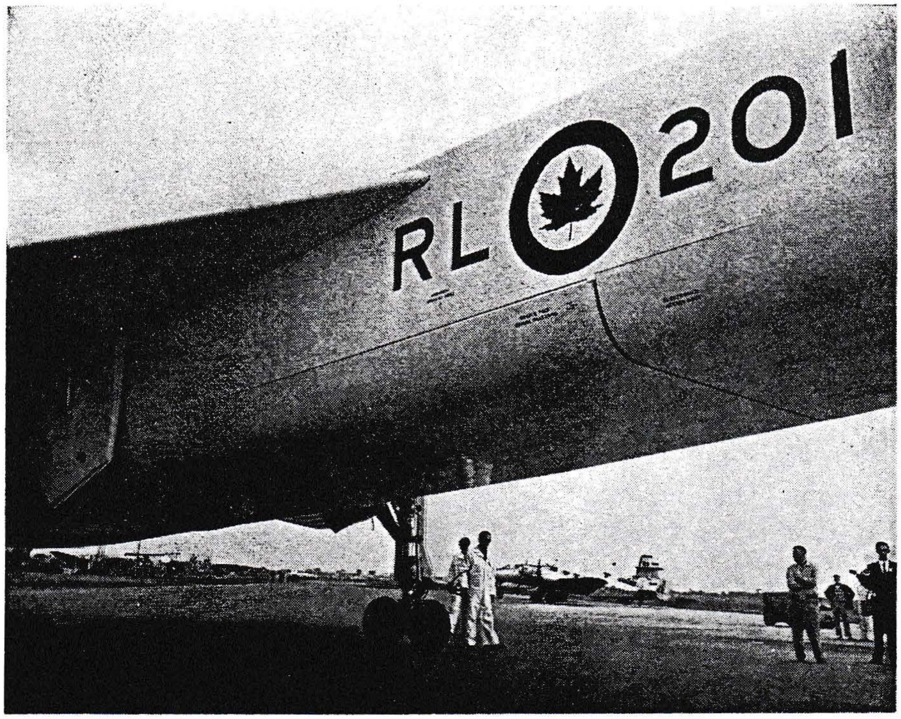
Leading edge extensions are used on the outer half of the semi-span. These extensions, as well as the leading edge of the inboard wing sections, have conical camber to help improve lift distribution and induced drag. Flow conditions at the wing tips, which are



WIDE CUT in the wing leading edge just inboard of the leading edge extension creates an aerodynamic fence. Air moving into the cut is forced straight back over the wing, restricting spanwise flow over the outboard wing sections. Long landing gear on the CF-105 was designed and built by Dowty, a pioneer company in the use of very high tensile strength (around 250,000 psi.) in production gear. High precision forging techniques and new production machining methods had to be developed to use the high strength materials.



ARROW has unusual afterbody fairing between afterburner exits to cut base drag. Fairing and some of the after portions of the engines are covered with high temperature materials and not painted. Fairing would be ideal location for auxiliary rocket engine for climb and acceleration, but Avro officials say that performance in these areas is so great that this would probably never be considered.



LARGE WEAPON BAY on the Arrow begins just under the RCAF roundel and runs aft to the landing gear door. The complete bay is removable to cut rearming time to a minimum. The bay carries air-to-air missiles with internal guidance.

normally somewhat unstable on a delta wing, are improved by the leading edge extensions.

They give the outboard wing section a smaller thickness ratio.

A sort of aerodynamic wing fence is also used to improve tip conditions by alleviating the strong spanwise flow on a wing like the Arrow's. A wide notch has been cut in the wing leading edge just inboard of the leading edge extension. This notch ends in a low wide ramp which extends back over the wing. The ramp is raised an inch or so above the wing well back on the chord. The air which passes into this notch and up on the ramp moves straight back over the wing. It combines with the spanwise flow and gives the flow over the outboard wing section a new direction.

Area Rule Discernible

The Arrow is area-ruled, although it is not as readily discernible as it is on some aircraft. Avro worked closely with NACA at Langley Field on the area distribution for the Arrow. It has evidently been achieved with a minimum structural penalty as the fuselage has relatively straight sides without a pinched waist.

Engine air linlets on the CF-105 appear to have fixed geometry which is somewhat unusual for an aircraft with a top speed of Mach 2 or better. Each inlet is approximately rectangular-shaped and perpendicular to the free stream air. Large, apparently fixed, ramps are located ahead of each inlet. There is a wide gap between each ramp and the fuselage which serves as a boundary layer bleed.

At supersonic speed, the ramp creates a strong oblique shock wave in front of the inlet which slows the air entering the duct and raises its pressure. This oblique shock would strike the outside lip of the inlet for best balance of pressure recovery and duct drag. If the angle of the oblique shock is not great enough, and it stands out in front of the inlet, air spills out around the duct lips and creates a heavy drag.

Shock Angle

The angle of the oblique shock varies with Mach number and the position of the ramp. If the ramp is fixed, the shock angle will be correct at only one Mach number. Many supersonic aircraft have variable position ramps or some kind of variable geometry so that their inlets may operate at maximum efficiency over a wide speed range. The penalty of variable geometry is added weight and the necessity of having a sensitive servo system to match duct geometry with Mach number so that the oblique shock will be properly located at all supersonic speeds.

The Avro approach apparently seems to reject the weight and complexity of variable ramps. Instead its fixed ramp has a wide band of perforations just ahead of the inlet. There is a bleed duct behind the perforations leading farther back on the aircraft. This duct provides an alternate path for the air so that when the oblique shock is not positioned properly the air does not spill around the lip. The air is carried aboard the aircraft and taken aft through the duct to a negative pressure area and dumped.

This type of inlet probably is not as efficient as one with variable geometry but if the aircraft spends a large part of its supersonic time in one fairly wide Mach number range, the weight savings of the fixed ramp would be very desirable. The Iroquois engine has been designed for maximum efficiency in supersonic flight at some expense in subsonic performance (AW July 29, p. 26).

Canopy Drag Reduction

Another interesting feature of the aircraft is what appears to be a large exhaust opening just after the crew's tandem compartment.

The bulge of the crew's canopy fairs back to a rather large spine which runs back to the vertical tail. The spine helps reduce the drag of the canopy as well as serving as a conduit for wires, controls, etc. The large exhaust port is on the back of the canopy just above the spine. Air exhausting here from the air conditioning or some other internal system would further tend to reduce the canopy drag by lowering its base pressure.

Armament on the CF-105 is presently intended to be all guided missile.

The Sparrow II is planned for production in Canada but the exact status of this program is cloudy at present. The Arrow's missiles are carried internally in a very large removable container. The length and width of the container is such that it would just fit into a B-29 bomb bay although it is not as deep.

The electronic system for the Arrow is a specially designed unit which combines automatic flight, weapon fire control, communication and navigation functions. The system is named Astra I and RCA in the U. S. is the prime contractor.

Guidance of the Arrow and its armament is divided into three phases:

- Full ground control toward general area of target.
- Mid-course phase when aircraft search radar is also in operation.
- Terminal phase when the aircraft radar is locked on the target and the missile is launched.

The whole operation may be monitored by ground control and, if any part of the aircraft's system goes out, ground control can take over, although its accuracy is below that of the airborne unit because of its great distance from the combat area.

Avro is tooled up for production of the Arrow. The first aircraft which was just rolled out was constructed on this tooling. At least five more fuselages were visible in the factory during the unveiling of this first aircraft.

Construction of the Arrow is characterized by a large quantity of metal-to-metal bonding to reduce the weight and labor involved in riveting, and some other methods of joining metal. Magnesium as well as aluminum is bonded in quantity on the Avro Arrow, and the Canadian Government decided to have a formal roll-out of the first Arrow and let everyone get a good look at the airplane so that they could go about preparing for the first flight in peace. Security regulations had forced Avro to do much of this type of work on the CF-100 behind screens and at night to keep anyone passing down the public highways near the plant from photographing the plane.

The decision to forego the security inconvenience was deemed a wise one but the timing of the rollout was quite unfortunate. It happened to occur on the same date that the Russians launched their first satellite. The Arrow was pushed from its place in the news, even in Canada.

NAA to Develop Hi-Temp Power Generator System

New airborne power-generator system, capable of withstanding prolonged temperatures of 600 deg. F, will be developed by North American Aviation under Air Force contract which calls for a four year program.

John Maxian, Jr., chief electrical engineer, will direct the program, with John Pierro as electrical project engineer. Program is not aimed at any specific plane but is designed for the benefit of the Air Force and the industry.

Work will be performed at the Los Angeles division and will be monitored by the Aeronautical Accessories Laboratory of the Air Research and Development Command's Wright Air Development Center. NAA will be responsible for managing the development and integration of the system into finished form, with much of the detail work being done by subcontractors under its supervision.

Boeing Jet-Thrust Plant Ready for Shakedown Test

Boeing Airplane Co. will begin initial shakedown testing of its new $300,000 sound suppressor-thrust reverser test facility at Renton, Wash., this week. Facility consists of two engine ground run-up silencers or tube-like steel chambers measuring 45 ft. long by 12 ft. diameter. First tests will be in the nature of an instrumentation and facility shakedown prior to commencing testing on the actual suppressor-reverser units developed by Boeing for installation on its 707 commercial jetliners.

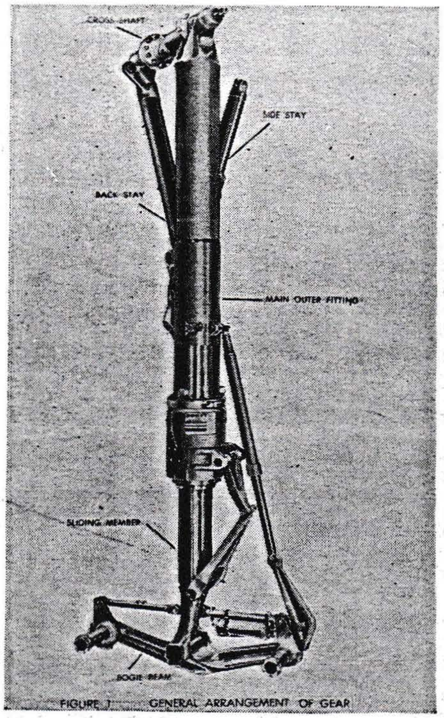
for eventual inclusion should be worth the effort.

- Development of a rocket vehicle capable of mass production for approximately $100.

General specifications of the rocket envisioned by SRI indicate it would be about 4 to 6 in. in diameter, 6 to 8 ft. long and have an impulse of 8,000 to 10,000 lb.-sec.

It would carry a payload weighing approximately 12 lb., including nose cone and ejection mechanism, to 160,000 ft. with maximum accelerations held to 25 to 30G.

While SRI pointed out that eventually the most desirable system would include a rocket motor case which could be fragmented, burned or pulverized to eliminate public hazard, the study recommended a present alternative of a network of remote stations which, while in areas where danger is minimized, could provide adequate coverage of continental U. S. Network stations all



CF-105 Main Landing Gear

Main landing gear for Avro's delta wing supersonic interceptor, the CF-105, features a single-wheel, tandem axle to permit stowage in a very thin wing box. The relatively long undercarriage is required by the delta wing configuration of the aircraft. In order to stow it within the space available, the gear has to be shortened 8½ in. during retraction by a special linkage. Design of the wing structure made it necessary to provide a skew axis for the pivot shaft which in turn necessitated twisting of the landing gear strut during retraction. The undercarriage is made of ultra high tensile steel with a strength level of 260,000 psi.

October 21, 1957 75 cents

AVIATION WEEK

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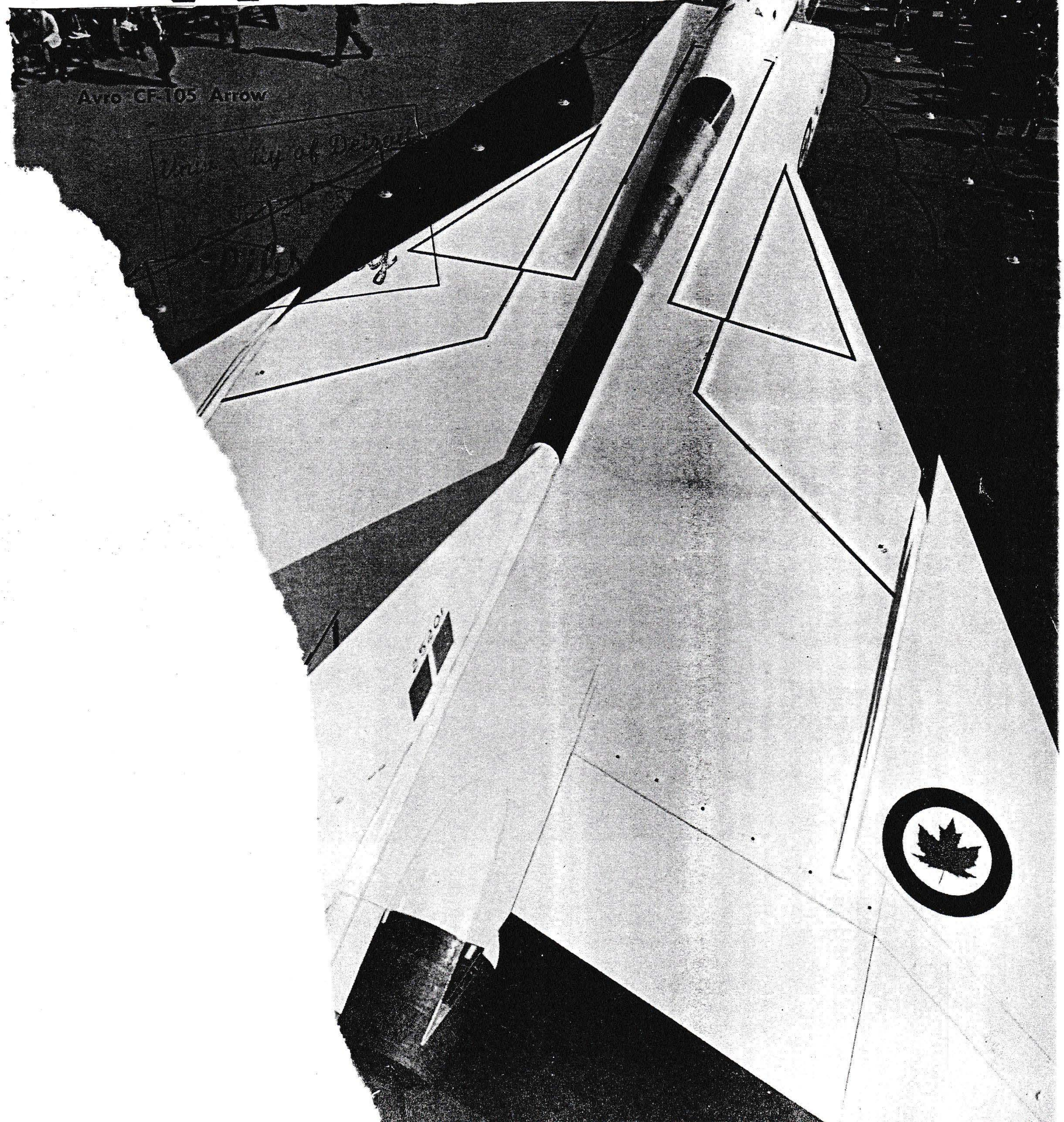

Avro CF-105 Arrow