

ON FINAL. Precisely matched sub-assemblies take on manned missile lines as CF-104 rolls at Canadair.

Building a Manned Missile

CF104 Starfighter is an exacting, unforgiving piece of engineering.

Canadair and subcontractors have met the challenge.

By Ernie Hemphill

How much of a challenge does production of the CF-104 Super Starfighter represent to the Canadian industry? And how are Canada's aircraft and system manufacturers progressing in meeting the challenge?

"We're building a missile and fitting it out so a man can ride along and work in it."

That's the assessment of veteran aircraft builder Basil Daniels, Superintendent of CF-104 production at Canadair Ltd., Montreal.

"The whole concept of this program is new. On the basis of my experience, nothing quite like this has previously been built in Canada."

Has Canadian industry been able to respond to the challenge?

"The record speaks for itself," Daniels declares. "We haven't missed a single production schedule on the project—that includes our sub-contract commitments to Lockheed Aircraft."

And nothing has been returned as unsatisfactory.

"To the contrary," Daniels continues, "we get the impression Canadian workmanship is in many respects considered superior to that achieved by other production sources."

Tolerances Crucial

Crux of potential difficulties on Super Starfighter production, according to Daniels, is the tolerances which have to be achieved on the final product. They are, to paraphrase his description, missile precise.

"On programs we have had here in the past," Daniels explains, "we have worked to tolerances of fractions of an inch over a wing area or section of fuselage."

"On the CF-104, the specification calls for us to hold to tolerances of 10 and in some instances five thousandths over as much as a 12 ft. area."

"This, we realized from the start, required a whole new approach."

In effect, it made the Super Starfighter an aircraft on which it would be impossible to correct an error or make do with a little adjustment. Everything, to the smallest component, had to be right from the start.

The key to success? Quality control!

Rigid, uncompromising quality control exercised back through to the lowliest sub-contractor supplying what might normally be considered the most inconsequential sub-component.

As the man in charge of over-all quality control on the CF-104 ex-

plains it, there appears to be no such thing as an inconsequential sub-component on the Super Starfighter.

"In effect," says Harry McKeown, "we had to set our sights on establishing a level of quality control which would permit us to turn out aircraft components within tolerances which we had previously associated with the production of tooling."

"Another major area of departure on this program," McKeown continues, "is the fact that the prime responsibility for engineering lies with Lockheed. We didn't design this aircraft, they did. They are the people who have guaranteed that it will perform in the manner specified."

"We, of course, have a function in engineering since we are doing the actual production, but we don't have the prime responsibility to the customer in this regard."

"The potential problems here arise from any differences which may exist between our engineering standards and those of Lockheed. We have to reconcile the two. Where no final engineering specification was laid down, we had to negotiate with Lockheed to show that our method was satisfactory and would result in a product that would perform to specification or better."

This arrangement differs from other programs. On the F-86 Sabre, for example, the Canadian government purchased the complete package, including engineering, so that the Canadian contractor, in that instance also Canadair, had full responsibility for engineering. On the Super Starfighter, Lockheed has to answer for performance and therefore exercises final engineering control.

From the physical production point of view, the Super Starfighter program involved a change from the manufacture of a large number of light, comparatively simple components to the turning out of a small number of heavy, complex pieces.

This meant, says McKeown, much more precise tooling than had been required in the past.

"With the light pieces," he elaborates, "it was always possible to push things around a little and make a fit. Not so with the larger, heavy components of the CF-104. Here there is a minimum of forgiveness—and we have to reflect this in the standards we set for quality control."

The aerodynamic envelope within which the Super Starfighter is designed to operate is such that there

is no margin for straying from the precise specification on configuration.

"On less advanced aircraft, with lower performance, we could accept a degree of mismatch on components. They didn't disturb the flight envelope. Not so with the Super Starfighter. Here there are critical areas on which there can be no mismatch," McKeown explains.

This is a reference to the strict limitation on deviation from the designed symmetry of the airframe, particularly with regard to aerodynamic surfaces. Once again, McKeown's comparison was with the F-86 Sabre project.

"On the Sabre it was possible to follow conventional processes in building and checking out major parts of the airframe. Our method of manufacture of wings, for example, was to hand build masters and then establish structural jigs set to the masters. Our experience was that the product of the jig would be satisfactory as long as the jig retained its set to the master."

Not so the CF-104. The basic procedure is similar, but here it is necessary to do a precise quality control check on critical airframe parts as they come off the line. This is the only certain guarantee the specification is being met so far as aerodynamic symmetry is concerned.

To meet the rigid standards on the final product, Canadair found it prudent to insist on manufacturing tolerances below those established by engineering specifications for some key components.

No "Sick Bay"

The approach has paid off.

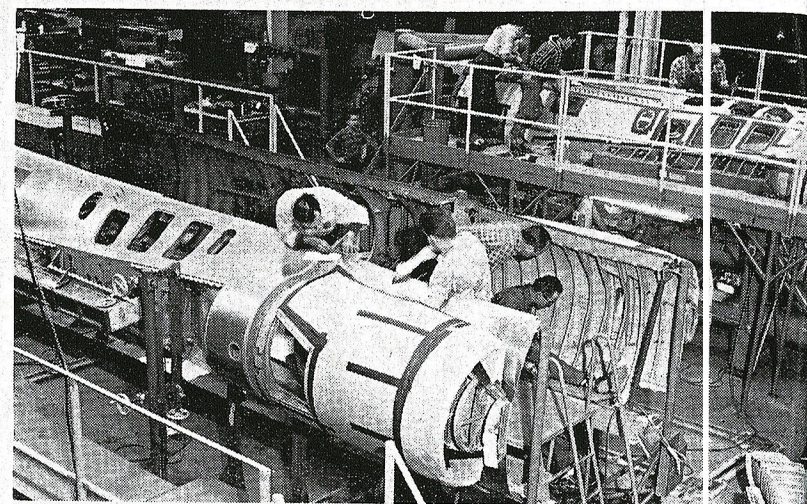
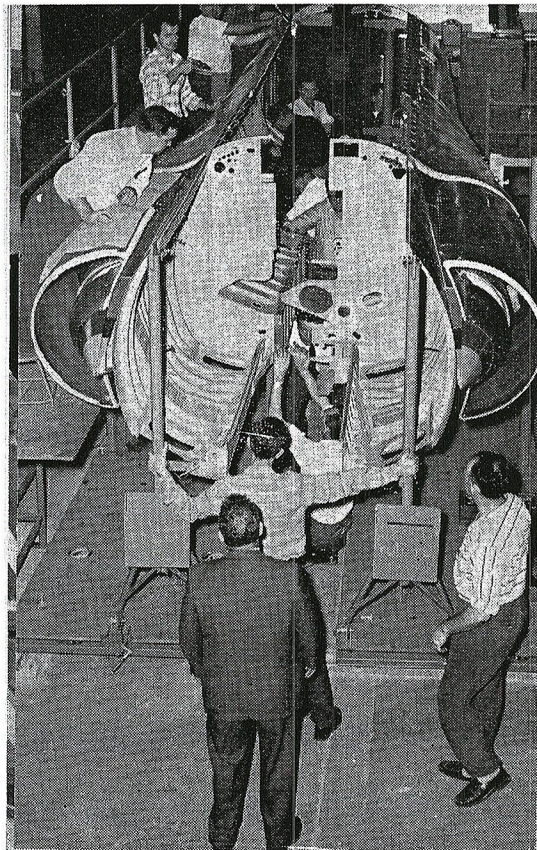
CF-104 wings and other airframe parts come off production jigs at Canadair well within specified tolerances. So far it has been possible to avoid the "wing sick bays" and "twisting to shape" processes which the company's production planners had been told they should anticipate in meeting specifications on the CF-104 airframe.

As Production Superintendent Daniels puts it: "Our decision was to iron out any problems we might have in the production phase itself. With a schedule to meet, we didn't want to have to waste time trying to correct mistakes after a part came off the production line."

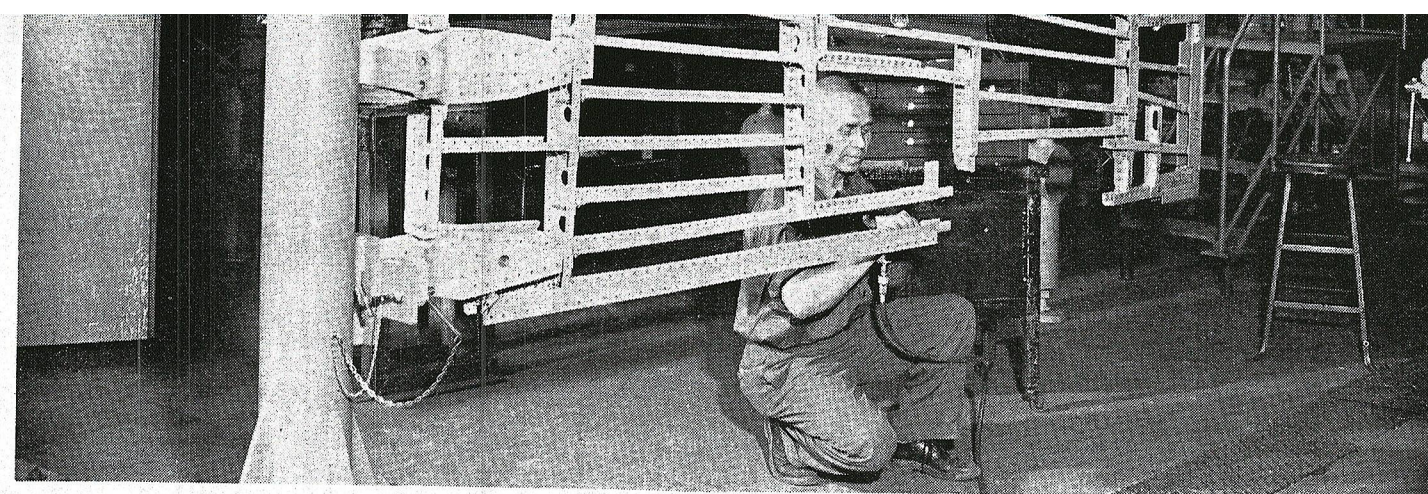
"Tightening up on manufacturing tolerances proved to be the answer."

Or at least an important part of the answer.

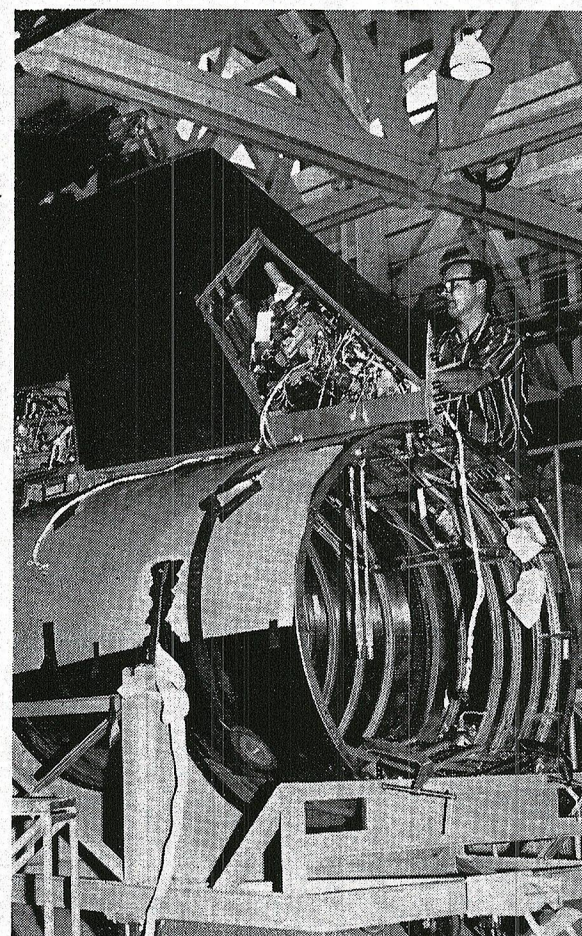
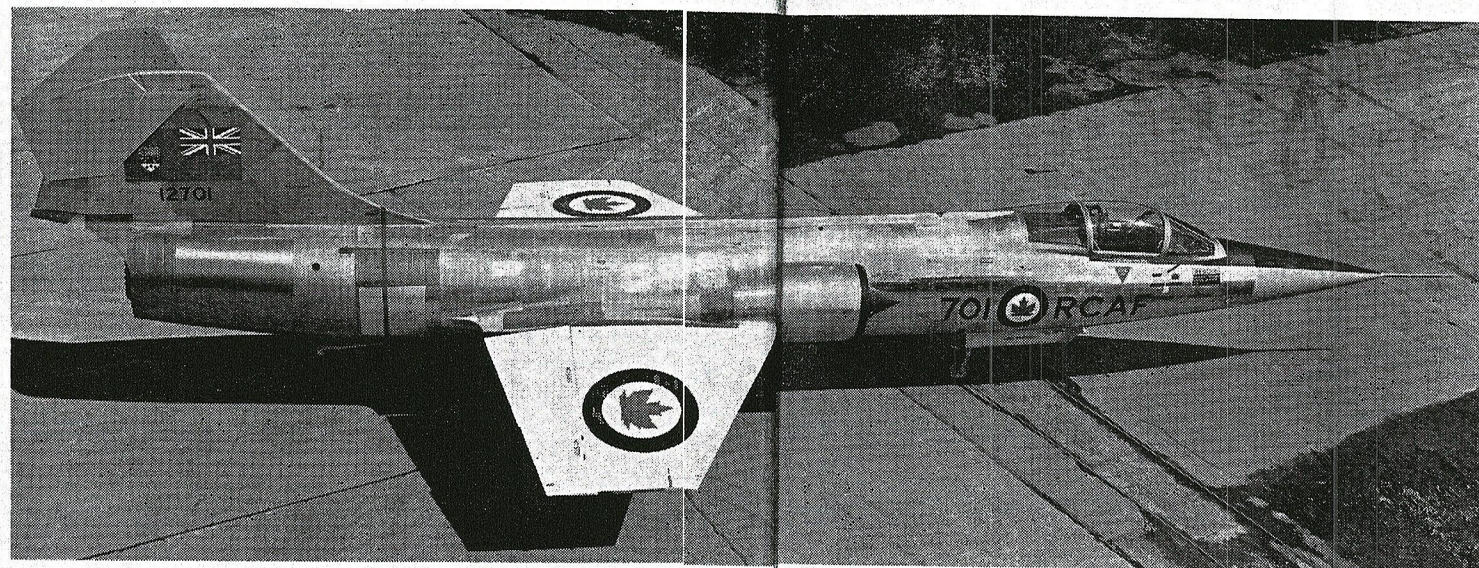
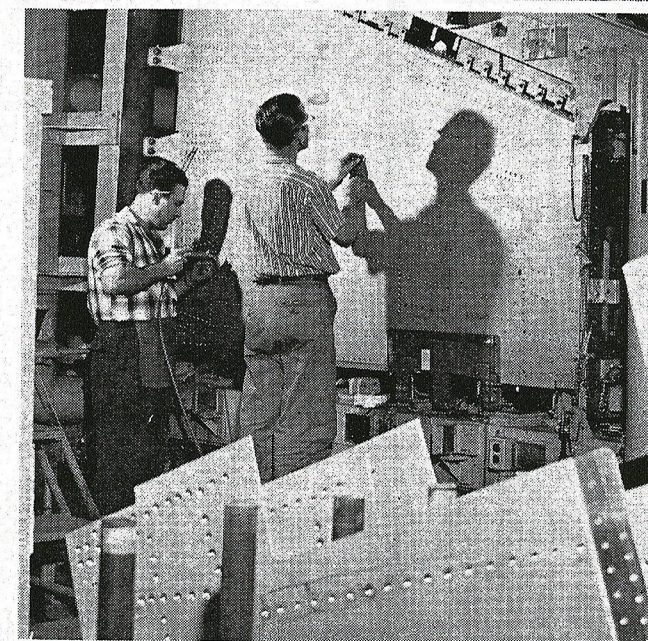
Just as vital was recognition that production of an advanced weapon



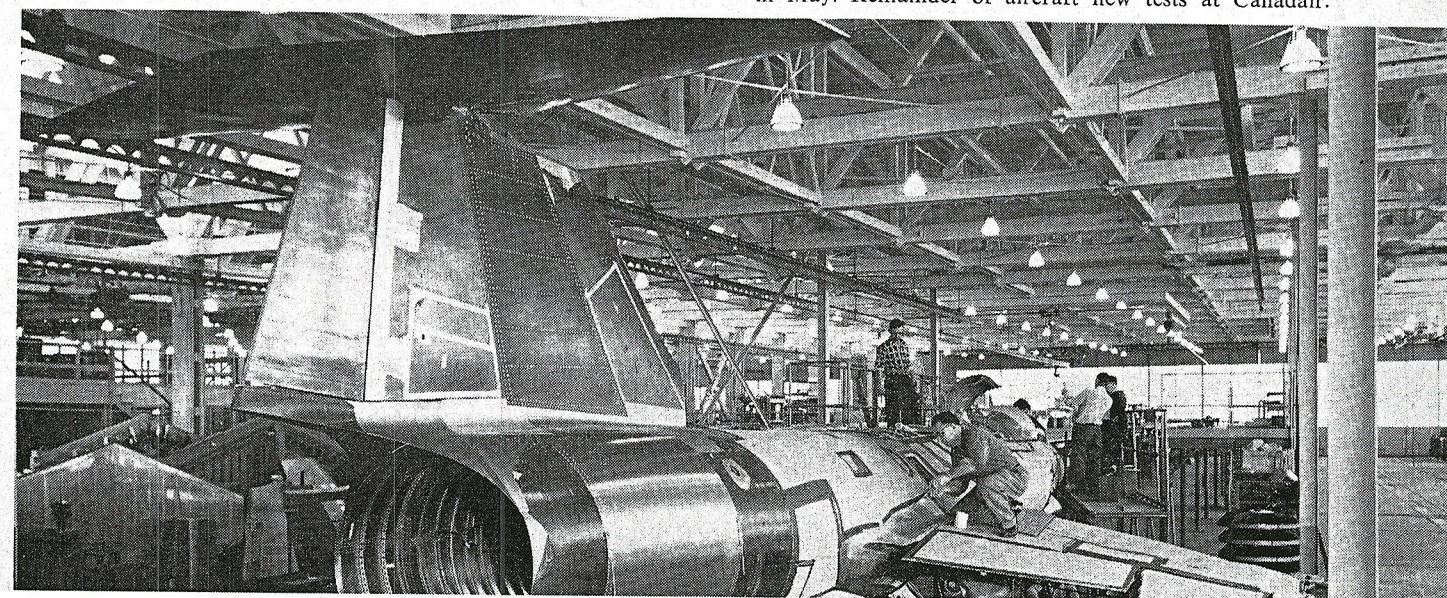
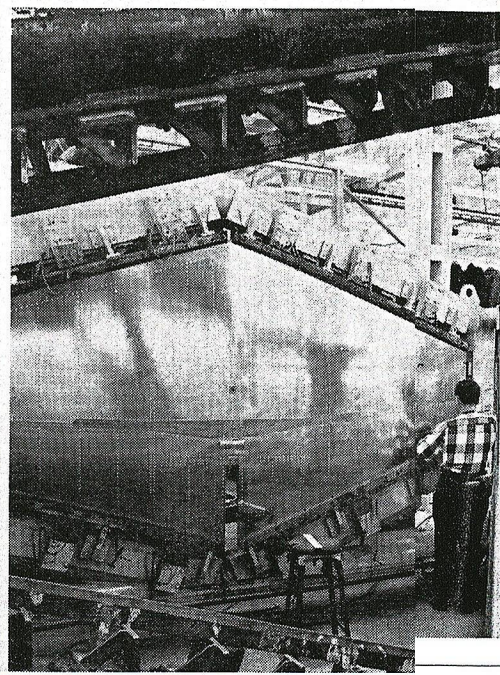
CENTRE FUSELAGE. Building vertical halves (above) permits work to proceed simultaneously on both sides of structure. Halves brought together (left) prior to installation in mating jig. Obviously, perfect fit is essential.



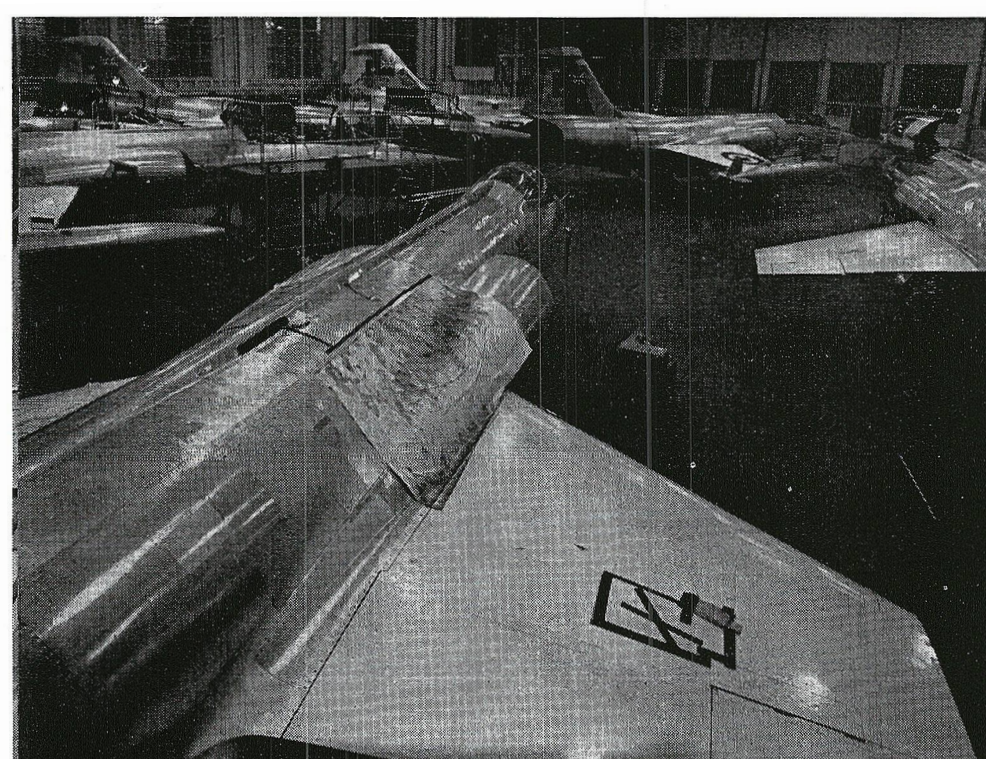
WING STRUCTURE. Forgings at root end and large number of spanwise stringers (above) in the missile-like CF-104 wing. Wing skins (right) are tapered, locally machined down on inner surfaces. Jig member size shows accuracy needed.



TAIL UNIT. Complete unit (left) with hydraulic actuators for horizontal and vertical stabilizers in view. Empty jig (right) frames assembly jigs for aircraft's horizontal stabilizer.



FINAL ASSEMBLY. Tail unit and wings attached, CF-104 nears completion. Short wings, 21 ft. 11 ins. tip to tip, evident in view below. First, second aircraft built at Canadair were airlifted to California for first flight in May. Remainder of aircraft flew tests at Canadair.



READYING FOR FLIGHT. With production in full swing, Super Starfighters for the RCAF are given final check in pre-flight before moving out for tests at Canadair.

system such as the Super Starfighter required a level of production skills and precise workmanship beyond any that had been necessary for previous programs.

On the basis of past experience, there was every confidence Canadair employees and those of sub-contractors could do the jobs required, and at the levels of skill that would be necessary. But to be on the safe side, and to impress workers with the critical nature of the work they were undertaking, Canadair launched a comprehensive training and requalification program.

As McKeown puts it: "We had not had any trouble with our level of skills on earlier programs. We wanted to maintain that record for this program. The way the program has moved along so far indicates we have been successful."

System Complexity

The basic production phase of Canadair's Super Starfighter program was, of course, only the first hurdle.

"What we have here," McKeown explains, "is a fully automatic weapons system, with all the problems on integration of complex sub-systems which that term implies."

"There are in effect seven separate systems on the CF-104, each of which must be tied into the other for cross reference and display of information or activation of a precise control. From this point of view too, we decided that we had to take a completely new approach to this program."

The first step was to gather all available information from others

working in the same area. Canadair teams visited a number of companies in the U. S. where advanced projects are under way.

"These were the people," says McKeown, "who were pushing the state of the art the same as we were. We wanted to know what their problems had been and how they had solved them."

The welcome was cordial and co-operation complete. Canadair's assessment:

- In many instances companies had underestimated the level of skills and training required for various phases of the production and building program;

- It was also evident the quantity and quality of test equipment necessary to prove out systems and establish complete integration had not been fully appreciated;

- There had been a vast underestimation of the requirement for technical service representation from system sub-contractors and vendors.

Canadair moved swiftly to cover areas of possible difficulty.

The company's employee training and requalification program was stepped up.

A vast expansion of facilities for testing out the various systems which are part of the CF-104 was undertaken and specification was laid down for a tape type, automatic digital computer which would permit full test of the complete Super Starfighter weapons system.

Suppliers were cautioned of a possible heavy demand for technical representation and asked to provide

additional personnel where necessary..

The verdict to date:

Canadian industry, as represented by Canadair's direct sub-contractors for airframe parts and components and by the vendors and suppliers of the various aircraft systems, has shown itself capable and competent on the advanced production techniques the Super Starfighter calls up.

As one Canadair spokesman put it: "There is a lot at stake here. Not only for us, but for the whole Canadian aircraft industry."

"This aircraft, or versions of it, is being built in a number of other countries. The products of our program are going to be going into service not only with the RCAF but with the air forces of a number of our allies. In many instances, Canadian-built Super Starfighters will be operating side by side with those built in other countries."

"We want the Canadian aircraft to stand out as a reliable, well built product of a capable industry. We have a good record on the basis of our past production. We want to enhance that record on this program."

Production so far has been well up to the quality sought and expected. With the Canadian program rolling along well in advance of production in other countries, Super Starfighter airframe and system components have been in demand to fill some of the lags which have developed in other programs. So far, the Canadian products have shown themselves to be eminently acceptable.

Widely Subcontracted

"On this program," Director of Manufacturing Administration W. H. Meacher points out, "We have done as much sub-contracting as we have ever done. We estimate that upward of 40 percent of what this company undertook to build on the CF-104 airframe has been sub-contracted in Canada."

"And this sub-contracting involves much larger items than we have let out on previous programs. These are items which called for machined part assemblies rather than sheet metal work. Our sub-contractors were faced with all the problems we ourselves had on meeting close tolerances for sophisticated components."

"In general they have come through for us. The fact that we have been able to maintain our production schedules indicates the response we have had."

On the Super Starfighter program, Canada's aviation industry has shown itself equal to the challenge of today's advanced weapons systems. No one expected anything less.