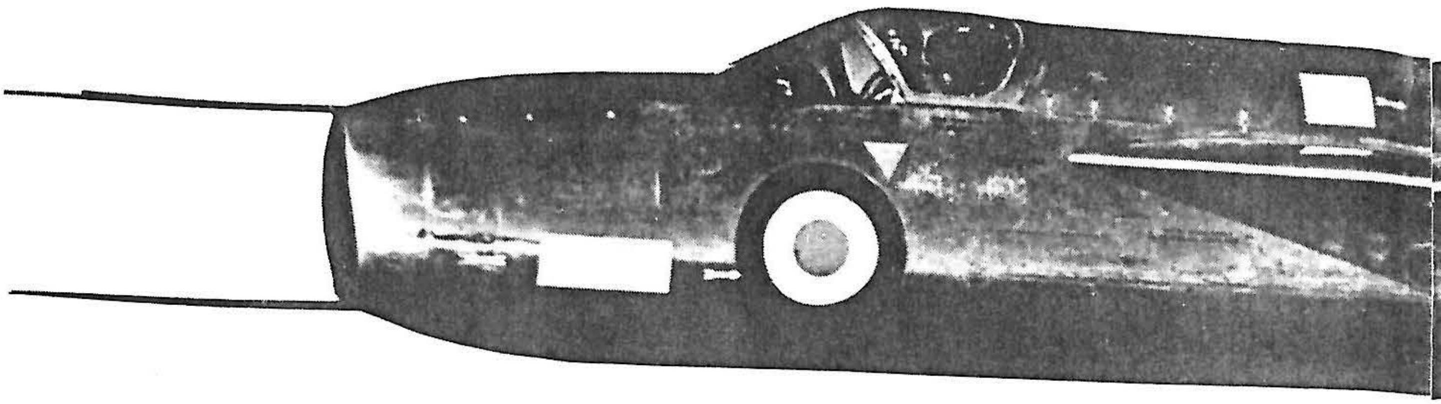
Development of modern aircraft like the English Electric P-1 supersonic interceptor is speeded by means of schemes which by-pass the old prototype stage, and are known variously as the "Development Batch" scheme, or the "Craigie-Cooke" scheme. Under these plans, the aircraft under development is ordered in small quantity (20, in the case of the P-1) during the design stage.



The Proving Process

By GROUP CAPTAIN H. R. FOOTTIT

"A long period of testing and development is necessary to see whether the aircraft will be satisfactory as a fighting weapon."

—Lord Alexander of Tunis

JUNE 25, 1950. On this memorable date, the rumble of tank treads echoed around the world. For the uneasy peace of the cold war had been broken. Now the tide of the Soviet equipped forces of North Korea swept over the 38th parallel and engulfed their southern neighbors. In about a month's time, the United Nation's forces were clinging to a slender beach-head, the Pusan perimeter.

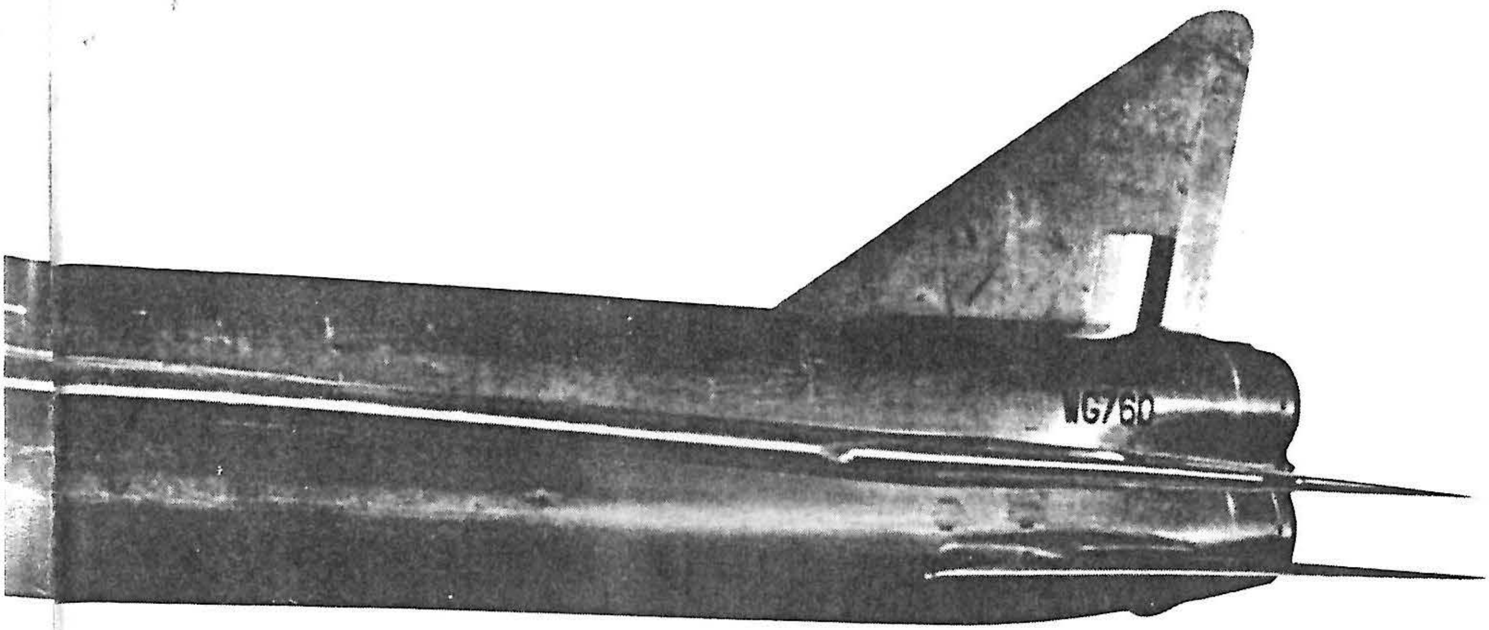
On the other side of the world, the Korean war was soon to cause another crisis. With the signing of the peace treaty that silenced the Lancasters and Spitfires of World War II, the British government had decided "not to take a major step forward in the re-equipment of the Royal Navy and the Royal Air Force with new front line aircraft until about 1957." But the Korean Reds had turned the tables. War was upon the world again. And the British were to learn the stern lesson that modern air power cannot be quickly created from an airplane development policy that limits new aircraft to one or two prototypes for trials. True as this prototype proving process was before Hitler kindled World War II in the late 1930's—and the British had ample proof from the successful development of their Spitfire fighter by such a scheme—it just did not work in the early 1950's.

Overwhelming: In the decade between the start of the Second World War and the Korean crisis, the complexity of modern air power had progressed by leaps and bounds. To try and develop a complex fighter, a large airliner, or a big bomber using only one or two prototype models, in this day and age, is a hopeless proposition. It takes too long. As the Honorable Ralph Campney, Minister of National Defence, reported to Parliament last year, referring to the Avro CF-105 supersonic fighter that is being designed and built for the RCAF, "A number of pre-production models are being ordered for comprehensive tests and development. This will ensure a sound operational configuration prior to full production and should reduce considerably the overall time from design to production of aircraft for squadron use."

The old prototype proving process, that preceded the modern pre-production method that Mr. Campney referred to, has been described by General H. H. Arnold, former Chief of the U.S. Army Air Forces. In the old days, the military minds pinned down the specification requirements, and then held a design competition. From the numerous proposals submitted the Air Force selected the one that came closest to their requirement. They then let a contract for *one* experimental plane for test. As General Arnold said in his book *Winged Warfare,* "It will require, for the simplest type, the single seat fighter, at least six months to build this experimental plane. For the heavy bomber or multi-engine fighter, from nine months to a year will generally elapse."

So about one year later the Air Force took delivery of its single prototype plane for preliminary flight tests. If the trials were successful, within another year a further contract would be negotiated for as many as 13 pre-production planes for service trials. The first one of these should be delivered to the USAAF's flight test section for a thorough wringing out, with simulated combat missions, which usually added up to some 150 flying hours. If the aircraft withstood this ordeal then a production contract was signed. Soon large numbers of the new fighter, bomber, transport or trainer would flow into the operational squadrons. And another milestone would pass in the build-up of modern military air power.

Rude Awakening: But the coming of World War II quickly blasted this leisurely proving process to pieces. Mustangs, Thunderbolts and Liberators were required in a hurry. For German



aircraft production was well advanced, and Hitler's Stukas and Messerschmitts were boring through the Allied air space almost at will. Allied production lines began to churn out existing types. And new airplanes, or major modifications to existing ones, were ordered into quantity production right from the drawing boards.

This new process of ordering new models in the thousands, before the first airplane had flown, caused a number of headaches. Military and civil test pilots flew the early aircraft literally around the clock struggling to "debug" the type before the production process disgorged hundreds of useless aircraft from the end of the line. Engineers worked overtime on corrective modifications. Drop hammers sounded far into the night. And finally "modification center" became a new term in the language of production. For it was found that it was easier to let the production line flow, and wheel the new bomber or fighter into a modification line to correct any deficiencies, rather than try and do the corrections in the flight test hangar or on the production factory floor.

But all this was a costly business. So at the end of the war the fist of the government's Treasury Board tightened on the taxpayer's tithe. The result was that air forces, generally, tended to go back to their pre-war proving process for new airplanes by ordering a few prototypes. However, a change in the airplanes themselves had occurred. They had become exceedingly complex gadgets that demanded a lot of test flying to get them to operate efficiently. And no one seemed to realize it.

Bits and Pieces: Ian Rankin, Manager of the Garrett Manufacturing Corporation of Canada, and representative for the AiResearch divisions of the Garrett Corporation—who make air conditioning and other equipment for many Canadian aircraft—pointed out to me recently, "Many people do not appreciate the fact that an aircraft is composed of many pieces of highly developed equipment—more than ever before. And the operation of each piece of this equipment is just as important to the efficient functioning of the airplane as the airframe and engine."

bits and pieces

RANKIN'S words are right. The cost of a complete aircraft today can easily break down into as little as half for the airframe and engine, and the rest for the installed equipment. In the early war years the airframe and engine accounted for 80 to 90%. So it is readily apparent that we have added far more functioning items that must be attuned together to make fully operational aircraft. The only way that this can be done is by building up flying hours. In other words, the complete airplane, with all its installed equipment, must pass through a proving process of air trials. There is no substitute or short cut for this extensive flying, correcting, and reflying process if we want to ensure efficient, functioning airplanes before they go forth into civil or military service use.

In February of last year the British Minister of Defence and the Minister of Supply tabled, before the House of Commons, a "White Paper" to answer the rising tide of dissatisfaction that was welling up over Britain's air power. The story they told of the new British fighters, the Hunter and the Swift, is typical of the postwar development quandary. The U.K. had formed her air force re-equipment policy so that only a few new airplanes of advanced designs would be built. In this way they hoped to go back to their prewar policy of developing and proving a few prototypes, before ordering large scale production.

Under a Handicap: Then came the Korean war. Hundreds of what were later to be called the Hunter and the Swift had to be contracted for. As the White Paper explains: "The decisions of 1950-51 to order many hundreds of these aircraft meant that while development was still in a very early stage, tooling up and other preparations were rapidly pushed ahead for production of swept wing aircraft with a large number of new features, such as axial flow engines power controls, heavier armament, and other more complicated equipment. All these had to be introduced and developed together. They had to be tested concurrently. Modifications to one feature often meant modifications to many others. *This had to be done under the handicap*

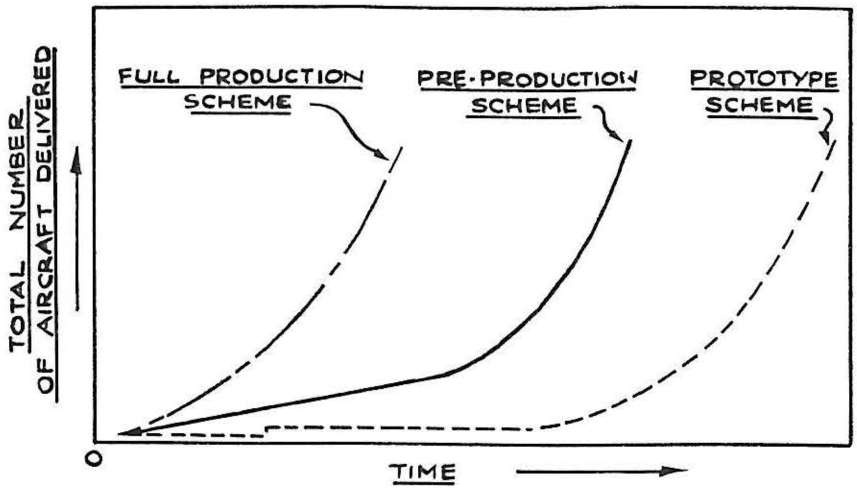


FIGURE 1
DEVELOPMENT – PRODUCTION PROCEDURES

that only a few prototypes had been ordered."

The Hunter and Swift programs went through the two extremes of this proving process. In the early stages there was the minimum cost, long time, few prototypes scheme that was the standard in the late 1930s: later on the high cost, short time, "order from the drawing board into production" scheme of World War II was essentially adopted. In this day of uneasy peace, this "age of peril" as President Eisenhower has called it, neither of these systems is really workable. In the first it takes far too long to develop our air power; in the second it takes far too much money. So in the last few years Britain, Canada, and the U.S. have adopted a mid-way house. This new process is variously called the Development Batch scheme in the U.K. and the Craigie-Cooke scheme in the U.S. In both cases the basic principles are the same.

Figure 1 shows the pre-war prototype scheme, the wartime full production system, and the new preproduction Craigie-Cooke or Development Batch scheme. In essence the modern procedure involves letting a preproduction contract for some 15 to 50 airplanes before the first one has flown. These initial aircraft are ordered from production type tooling, as compared to the prewar hand built pototypes. However, the rate of production is held at a low level for a period of 1½ to 2 years. During this time all airplanes built are funnelled into intensive test programs to determine their deficiencies. At some point during this proving process, and while vital modifications are still being incorporated on the low rate production line, the decision is made for all-out production. And in due course stepped up production begins.

No Cure-All: It should be clear that this new preproduction scheme will not eliminate all the difficulties connected with the two previous development procedures that it strives to replace. But it certainly can reduce the frequency and the magnitude of the problems. Enough development airplanes should be available for testing within a reasonable time without unreasonable costs. Yet there will always be some new airplanes that vary from this basic concept as long as the art of aircraft design keeps penetrating beyond the frontiers of engineering knowledge.

Once these preproduction run airplanes start flowing from the factory, the proving process comes into play. A typical framework for the phased testing of these early planes is shown in Figure 2. The number of flying hours required to complete such a test program will vary widely with the type of aircraft, and the type of problems that arise during the development. For a simple airplane, such as a trainer or small transport, 500 flying hours, or even less, may be all that is necessary. For a large aircraft, such as a transport, or a complex airplane, such as a fighter, anywhere from 1,000 to 3,000, or more, flying hours may be required. In any case, it is readily apparent that a number of test airplanes are necessary, since the average company usually finds it difficult to get in many more than 5 flying hours per aircraft per month during these early days.

Outside of the direct value of this proving process, there are a number of useful by-products that stem from this system. For example, with early planning and partial production tooling the aircraft manufacturer is able to maintain better continuity to his engineering and production efforts: the final product, when delivered to the squadron

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PHASE	TESTED BY	TYPE OF TEST
1	Contractor	Airworthiness and functioning of equipment
2	Customer	Preliminary performance and handling trials
3	Contractor	Tests on aircraft modified to correct design deficiencies
4	Customer	Full performance and handling trials
5	Customer	Hot and cold weather tests
6	Customer	Intensive flying to prove reliability
7	Customer	Suitability on typical operational missions

FIGURE 2
TYPICAL FLIGHT TEST PROGRAM

Turning on to final—we were a little far out due to the strong wind—the Twin Bonanza was easy to drive down the slot to the runway. Approach speed was 90 mph. The "book" recommends an approach speed of between 80 and 90 mph depending on weather conditions and all-up weight. During the round-out to land, drift was kicked off by rudder, and the airplane settled firmly enough on its mainwheels. By using standard "trike" technique, holding the nosewheel off until elevator control was nearly lost, the landing roll was remarkably short. We stopped within 500 feet—and that without the use of brakes.

Into the Air: We set the airplane up for minimum run take-off by lowering flaps to the fully-down position—30 degrees. Winding the power up to maximum on both engines whilst standing on the brakes is the recommended ploy. Releasing the brakes, our Twin Bonanza leaped away like a startled antelope. Easing the nosewheel off at 60 mph, further back pressure on the stick lifted the whole airplane off at 65 mph accompanied by the intermittent hoot of the stall warning device, heard through the cockpit loudspeaker at a speed 5% above stall. By maintaining this airspeed, the resulting angle of climb was steep, and an estimation put us at 50 feet altitude after a forward run of only 900 feet.

Thereafter, we tried two flap-less take-offs, and the distance covered before unstick was more normal.

Beechcraft quote an increase in lift of 31% when flaps are fully lowered.

Creditwise, the Twin Bonanza is exceptional for short take-off and landing performance. Cruise conditions at altitude give a TAS of 197 mph and a 1100-mile range at maximum all-up weight. It has a high degree of pilot and passenger comfort. Power and airframe handling are straightforward in all conditions of flight. All in all, the C50 is a very workmanlike and happily uncomplicated airplane.

After an hour's very pleasant flying, we returned to the Toronto Island Airport, and reluctantly parted with the Twin Bonanza.

PROVING PROCESS

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or air line, has a better chance of being technically up to date, reliable, operationally effective, and therefore better able to complete its assigned mission: with this longer test program and a number of test airplanes, there is a better chance of getting more operational and maintenance training, and more spare parts, consumption data for better logistics support. In a word, there is a better "balance" to the whole development process than ever before.

Human Element: Yet in spite of this, we must never forget that all we have established is a framework for airplane development—a process for proving our air power in reasonable time at reasonable cost. K. Irbitis, of the Preliminary Design Section at Canadair Ltd., feels, however, that the question of personnel cannot be neglected. Says he, "The startling difference in development time for a certain type of aircraft, between the U.S.S.R. and the U.S., is proportional to the efficiencies of their design and development teams." Since the Russians appear to develop airplanes much quicker, he particularly emphasises having "creative minded companies, established predominantly by men with vision." He goes on to say, "Based on my personal experience, I can tell that in the U.S.S.R. most of the companies are established and led by experienced aircraft designers."

So the proving process we have established will only be as good as the manpower we have to support it. Moreover, in these days of peace, uneasy though they are, there is always a tendency in democratic nations to try and cut the costs of aircraft development to the very bone. So unless we are careful we will tend to drift back to the pre-war prototype system, only because it costs less. Then the "long period of testing and development", that Lord Alexander mentioned to the House of Lords, will become infinite and our new air power obsolete in the process.

The best guiding principle that I have come across in this respect is a statement by the well known Lockheed test pilot Tony Levier in his book *Pilot*: "I have always said, *and I suppose most people realize it but forget it,* that when you are dealing with experimental (military) airplanes you are dealing with something that can mean an awful lot to the security of our country . . ."