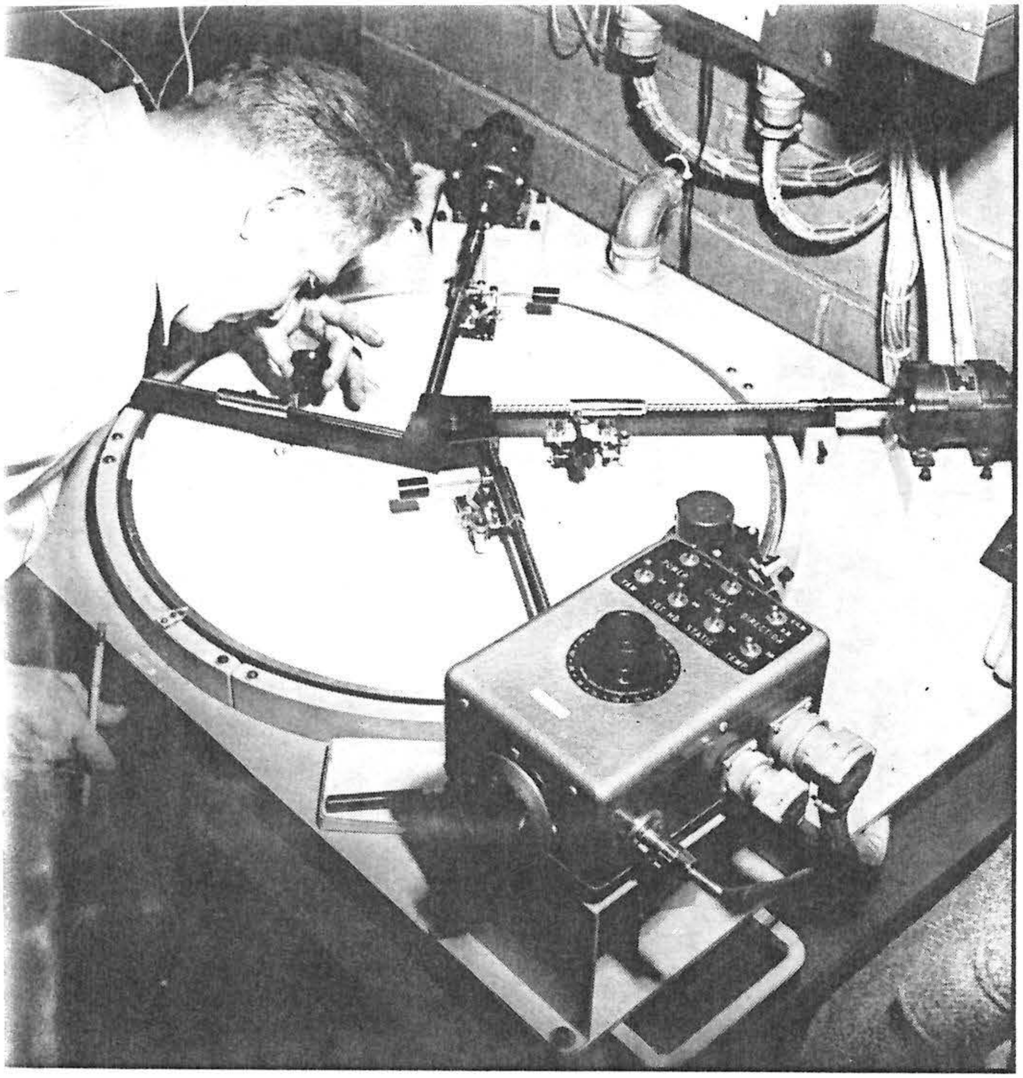


Using aids like this recording traverser (left) at the Nobel, Ont., gas turbine test establishment of Orenda Engines Ltd., Canadian engineers are able to compress into hours, work that would take weeks by other means.

Our Strategic Pool of Engineers

By GROUP CAPTAIN H. R. FOOTTIT

"Science, engineering, and industry have had as great, if not greater, part in shaping the destiny and form of this country than have statesmanship and political philosophies."

Rt. Hon. C. D. Howe (1952)

NO SOONER had James Cook dropped the Resolution's anchor in the calm coastal waters off Vancouver Island, than the ship was swarming with Indians. To our aboriginal forefathers of 1778 the topsails of such a European windjammer meant one thing—metal. Their thirst for this precious commodity was almost insatiable. "Whole suits of clothes were stripped of every (metal) button; bureaus of their furniture, and copper kettles, tin cannisters, candlesticks and the like went into the wreck." From this stockpile the Resolution's crew bartered copper, brass, and iron for sea otter furs. And from the copper, brass and iron came the trinkets, pans and knives that had become a vital necessity to the Indian's daily life.

From this typical seed, nurtured with European know-how, has grown the vast Canadian manufacturing industry of today. Woven into this industrial fabric are the large airplane and engine design teams, at such companies as Avro Aircraft, Orenda Engines, and deHavilland of Canada. Though we may regard them as mere necessities to enable us to design our own equipment to suit our peculiar Canadian requirements, they are much more than that.

Technical Reservoir: For these teams form a strategic pool of engineers — a technical reservoir from which we can siphon off experienced engineers to expand the aviation industry in time of war. If we loose the large design teams in the large companies, by reverting to straight production runs of U.S. or British designs, then we loose a large part of our capacity for a swift production build up. And to loose such a capacity may be dangerous, in the flash fire of modern atomic war.

Today, we in Canada stand on a threshold. Since the last gun sounded in World War II, to now, we have planted our aircraft design industry and nursed it to the budding stage. Now we must have the confidence and fortitude, through the years, to bring it to full bloom. And as the time passes, the design part of the industry must be expanded with our expanding economy. Although a decade has passed since the first RCAF specifications went out for the design of CF-100 Canuck and the Orenda engine, industrial maturity, in so complicated a design field as aircraft and their equipment, is merely in its swaddling clothes.

Though we may have a tendency to sit back and feel that we have finished our engineering wall against adversity, history warns us that we would be hiding our heads in the sand. In the adventurous days of Queen Elizabeth the First, England began her industrial growth that parallels the growth of Canada some 400 years later. At that time (1558) Sir William Cecil, Secretary of State, and Sir Thomas Gresham, Elizabeth's Financial Advisor, poured long hours under the candle light hatching various plans for making England self sufficient in armament manufacture. For the dawn of the Rennaisance Era had left the country trailing far behind the continent in technical skills.

German Know-how: To start the ball rolling, Englishman George Evelyn was given a monopoly for the production of gunpowder. In 1561 a contract was let with the Germans to produce saltpetre in England. Englishmen were sent to Germany to learn secretly the art of making "the mills and engines for forging and drawing". With these, and many other monopolies, licenses, and contracts, the energetic English laid the foundation for an armament empire that was to prove its worth on such a dire days as the one when the Spanish Armada made a landfall on the shores of the homeland.

But technical skills, either on the drawing board or in the shop, are not pieced together overnight. It took the English some 50 years to catch up and master the design and manufacture of cannon. In fact it was not until the close of Elizabeth's reign that Raleigh was able to complain that English cannons were so good that they were being smuggled to her continental enemies: "Heretofore one ship of her Majesty's was able to beat ten Spaniards, but now, by reason of our own ordnance, we are hardly matched one to one."

And in the new brass making industry British historian Rowse reports, ". . . . English brass, for a century more, was inferior to foreign, so long does it take to build up traditional skill."

Long Term: The build up of a large pool of engineering talent, particularly in the aeronautical field, is also a time consuming job, with real results arriving in decades, not in days or years. For the days of the quickly trained engineer, that could do his job with the aid of an all-embracing handbook, are rapidly receding. As former Dean Kenneth F. Tupper, of the University of Toronto explained in his inaugural address in 1949: "Man's conquest of the air brought the engineer a very exacting task." And he goes on to point out that . . . "No longer can the engineer expect to get by with merely the ability to read the handbook. He should be able to write the handbook."

What we have been able to accomplish in Canada in the design of the Otter, the Beaver, the CF-100 Canuck, the Orenda engine, and other pieces of aeronautical equipment, in the first ten years from the real start of the design industry in 1945, has been with the aid of senior and experienced engineers that we have been able to cull from England, the U.S., Poland, France and many other countries. True, Canadians have played their part. But the basic know-how, that has made our gigantic expansion possible, has been fed in by the top level engineers who landed on our shores.

With this crutch we have been able to cut considerably the years necessary to reach design maturity. With this aid we have been able to slice a large branch from the half century of aircraft engineering experience of our western world neighbors, and graft it to our own budding industry. And now that we have built up these large engineering teams we must maintain them—designing, drafting, calculating, planning. For these teams, if war breaks out again, will be splintered off to build up the air power we need for survival.

Necessary Spark: It was adequately proven in World War II, and it is even more true today, the efficient production cannot get going in a wide swath of industry, unless we provide the engineers to spark the effort. And this means production of a proven airplane, engine, or component, that has already passed through the development stage.

Sorting through statistics on the production of 86 different types of airplanes, from fighters to large bombers, that had been rolled out in Engand, the U.S., Japan, and Germany during World War II, P. J. Stanley of Britain came to the conclusion that the size of the aircraft, the magnitude of the program, and the monthly production rate were inconsequential criteria. In other words, the time taken from the day the first airplane was pushed off the production line, until the factory was grinding them out at the peak rate for which the tooling had been planned, did not depend on these factors.

The detail design of the particular airplane, however, did make a difference to this time. And the managerial and *technical* efficiency of the men sitting in the front office, in the planning departments, and leaning over drawing boards and desks littered with blueprints and graphs, did make a difference.

Engineering Pool: Thus we must maintain our strategic pool of experienced engineers at large companies. Then by draining them off to our automobile plants, refrigerator manufacturers, and our smaller aircraft and accessory companies, and others, we will have some hope of getting the weapons of war in the 12 to 18 months that Stanley found was the average time from first airplane to peak production output (Figure 1).

Even in countries that have a large hard core of seasoned aeronautical engineers there is considerable variation from this average. Our neighbour to the south, for example, has a world wide reputation for her skill at firing up the production boiler in times of stress. Yet the worst U.S.

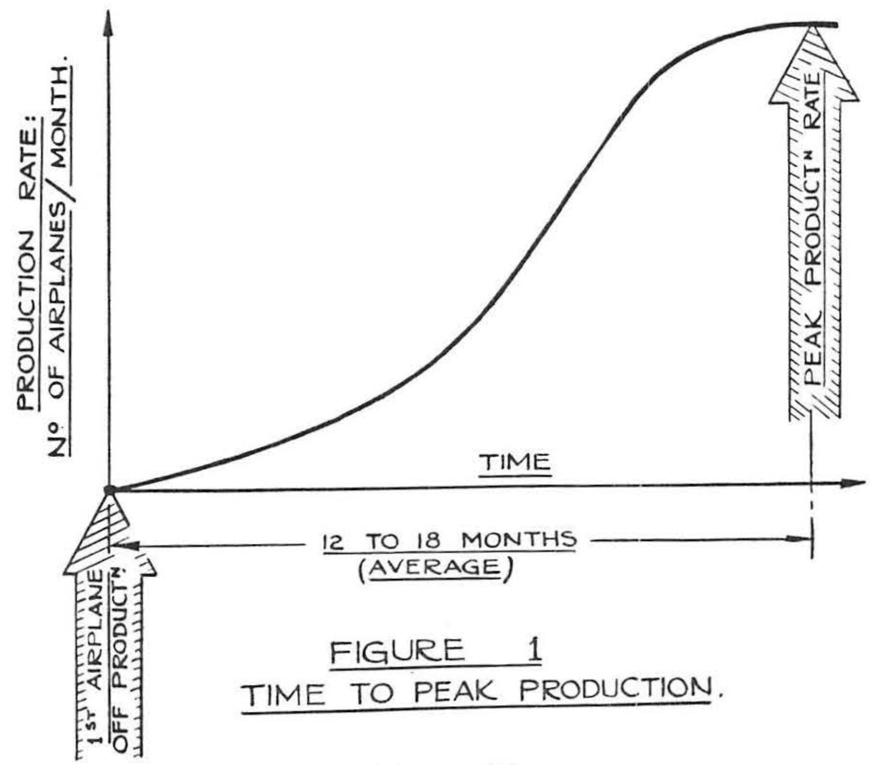
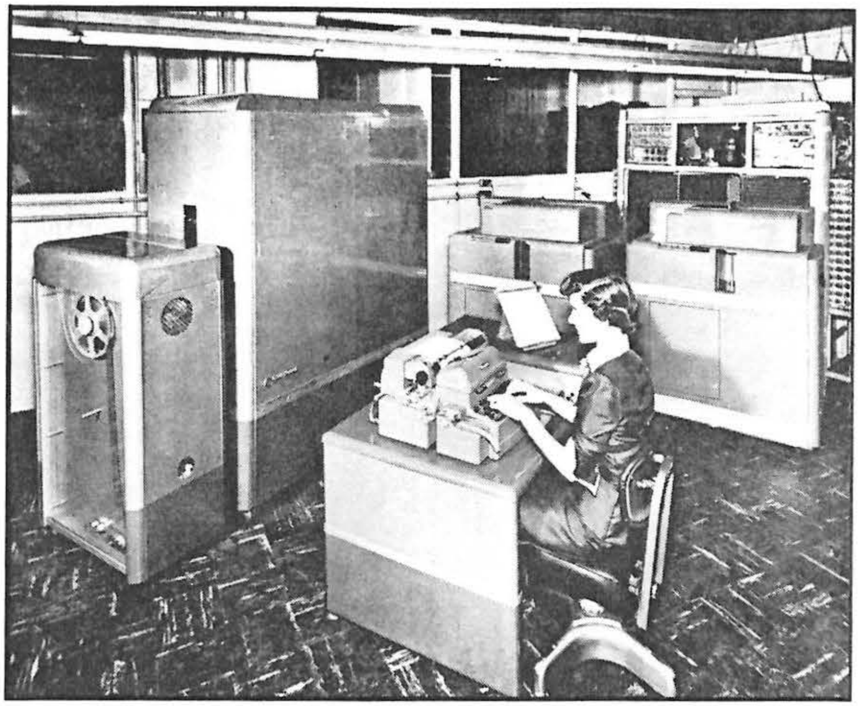


FIGURE 1
TIME TO PEAK PRODUCTION.



ELECTRONIC COMPUTERS conserve engineering manpower by saving thousands of engineering manhours in the solution of complex problems. However, such computers require skilled professional personnel to operate them.

aircraft production facility of World War II took three and one half times as long to build up production to the peak rate, as compared to her best. Even the U.S. did not have the experienced aeronautical arsenal to support her air power expansion.

With this variation in mind we in Canada cannot afford to be complacent about our engineering reservoir. We must plan on expanding our strategic pool of engineers with our expanding industrial front. In this way the sluice gates can be opened, when the guns start firing, to inundate every ounce of industrial strength that we can muster, in the shortest possible time.

Difficult Task: Unfortunately in infancy, it is not easy to carry out such an expansion. Take the current case of MacDonald Brothers Aircraft Limited. Here is a traditionally Canadian company housed on the outskirts of Stevenson Field, Winnipeg. At present the company is turning out precision sheet metal components for the Orenda engine. It is also busily engaged in converting Beechcraft and Mustang overhaul and modification facilities to those for Mitchell and Canuck airplanes, as well as doing some commercial work.

To carry out these projects the engineering department boasts a modest 38 employees, including 12 engineers, 6 technicians, and 10 draftsmen.

When the Bristol Aeroplane Company of Canada took over the plant last year their well known executive, W. S. Haggett, moved into the manager's office. Slowly plans began to shape up for an entry into the helicopter field. Says W. S. Haggett, "Our future plans in this venture are based on the assumption that the basic design, aerodynamics and performance of the helicopter will be done by Bristol, England. However, just to change the design to North American standards, and work out modifications to suit the customer, we consider that we will have to triple our present engineering department."

Under Haggett's direction the plans are not due to mature for another year and a half or more. This time lag meshes with the overall scheme, and, more important, it gives the company a chance to get together the necessary engineering staff. In the somewhat specialized art of helicopter engineering this is a useful breather. "We have," he reports, "recently taken steps to visit the Canadian universities to offer coming engineering graduates a free round trip to Bristol, England. While there they would spend some 2 to 3 years in the Helicopter Engineering section. They would be under no obligation whatsoever. But we hope that after that time they would return to MacDonald Brothers to help us in our new and expanding helicopter organization."

Sound Approach: With the resistance of British and U.S. industry stiffening against past pilfering of their aeronautical brain power, this is a common sense and generous approach to the problem of engineering expansion in Canada. Undoubtedly, it will be one that many Canadian manufacturers will have to follow if we are to extend our baseline of engineering talent.

While this scheme is satisfactory for a peacetime build up, it points a warning finger to the future. In wartime we would not have enough time to carry through such a prodigious training program. Thus, we must have the key manpower readily available in sufficient numbers to get production moving with all the speed and efficiency that the dilution of skilled engineering talent with unskilled will allow.

But what is this dilution factor? How much would our small aircraft companies, and others, be expected to grow when the dark clouds of war break over the horizon? C. C. Young, Chief Aeronautical Engineer for Northwest Industries Limited of Edmonton, has done some serious thinking about this wartime expansion. It is obviously impossible to definitely pin down what a company with a small peacetime engineering staff might do in case of war. However, Young considers, as a rough estimate, "If our company were to remain in the fields of installations, modifications, and sub-contract manufacture, our total engineering staff would swell to some 300 to keep pace with a total employee roster of 4,000 to 5,000."

At present the Northwest Industries' engineering staff adds up to 24, including 4 engineers, and 13 draftsmen.

Wartime Expansion: Thus a tenfold-plus engineering expansion is a reasonably good estimate of what the small Canadian airplane company could expect in a time of hostilities. Now add to this the expansion that would have to take place through the equipment manufacture and consumer

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of the universal power plant are almost behind us and much more effort will be required in the installation of the power plant in the aircraft than has ever been provided before. The matching of the engine inlet and exhaust portions with the aircraft and the cooling of the nacelle will all require special attention for optimum performance over the ever increasing range of operating conditions.

Contol Complexity: The control system of the future aircraft power plant will become more and more complex in its operational requirements. It will have to control the engine fuel flow for the various aircraft speeds, altitudes and temperatures; it will have to guard against engine rotor overspeed, against over-pressurization of the combustion chamber, against over-heating of the turbine and it will have to control the fuel flow to the afterburner. It probably will be integrated with parts of the aircraft control system to control such variables as aircraft speed since the pilot will be too busy flying and navigating to have time for such items.

In the design of such engine accessories, therefore, it becomes increasingly important that the philosophy of design simplicity be applied to the utmost in the execution of each mechanical function to avoid hopeless confusion in the overall result. When you visualize the maze of equipment, practically covering the outside of the average turbojet, including the Orenda, you can well understand that, if simplicity is not the preliminary design keynote, this hopeless confusion could well develop as extra equipment is added—and it usually is—during the lifetime of the power plant. These accessory details such as valves, pipe fittings, filters, solenoids, control levers and other are the very items that keep aircraft grounded, perhaps because they seem relatively unimpotant and generally do not receive the same careful study as the major units such as discs and shafts. These tremendous trifles, as they may be named, must assume the same importance as the so-called major parts since grounded aircraft are very poor weapons of defence or profit-making vehicles.

Material Considerations: You have realized no doubt, that materials will play a very important part in the design of future engines, even more than they did in the past. There are ever increasing numbers, each with its own particular properties, and the designer must familiarize himself with them as they are developed, since materials well utilized in a sound mechanical configuration can make a good aerodynamic design a useful power plant.

The importance of the power plant will increase with aircraft speed since it will become the most profitable place in which to expend our efforts in the search for optimum aircraft performance. Abe Silverstein, Associate Director, Lewis Flight Propulsion Laboratory, NACA, showed recently before the IAS, that the engine and fuel weight increases from 25% of the gross weight of a hypotheical aircraft designed to fly at Mach .5, to 40% at Mach 1, and to over 60% at Mach 1.5. This is by no means the full story, but it indicates a definite trend and emphasizes the need for an increased effort on the part of the mechanical designer in practicing the philosophy of simplicity.

Remember that complexity is the easy solution, and simplicity takes a little longer, but every part eliminated is one that can not cause trouble.

ENGINEERS

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goods industry, on the engineering side, and it becomes apparent that our nucleus of aeronautical engineers can be no small helping on the industrial plate.

To estimate this engineering dilution factor, and thus get to grips with the details of our strategic pool of engineers, by reducing it to numbers and plotting its probable growth through the years as we build up our industrial strength, is a governmental job that must be tackled. Then the design and development of airplanes, engines, and equipment can be fed to the growing infant in the proper proportions to maintain its health, nurse it to maturity, and keep it in full grown fighting trim.

This development and pooling of our engineering brain power is a vital part of what the great strategist Admiral Mahan meant when he said, "It behoves countries whose people, like all free peoples, object to paying for large military establishments, *to see to it that they are at least strong enough to gain the time* to turn the spirit and capacity of their subjects into the new activities which war calls for."

In this age of split second atomic war we must be strong enough to "gain the time." And one of our vital bulwarks in this endeavour will be our reservoir of experienced aeronautical engineering man-power. Let us guard it well. For it may have even a greater part to play "in shaping the destiny and form of this country" in the turbulent days to come.