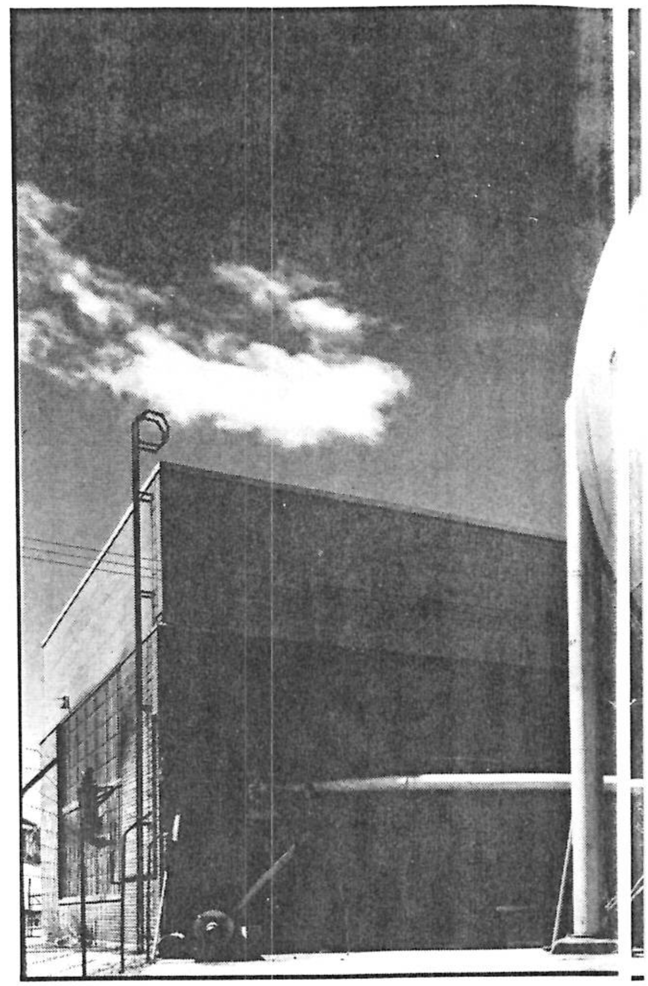
FOUNDATION FOR AIR POWER



By

GROUP CAPTAIN H. R. FOOTTIT

"The mistakes of years cannot be remedied in hours."
Sir Winston Churchill.

IT WAS EARLY in the rainswept winter of 1941 when Sir Winston was pondering these thoughts. For Yugoslavia, a key factor in the Balkan powder keg, was wavering from the line of strict neutrality, to the side of the Rome-Berlin axis. Then, in the first light of March 27th, Yugoslavian officers and men, loyal to the cause of the Allies, seized the Belgrade government. News of the coup flashed to Germany. "Operation Punishment" was immediately ordered.

Within ten days German bombers screamed over the Yugoslav capital at tree-top height. Wave followed wave for three searing days. In the end, with no significant air power for their own defence, the Yugoslavs went down to defeat. And seventeen thousand citizens lay dead in the streets or buried under the rubble that once was a city.

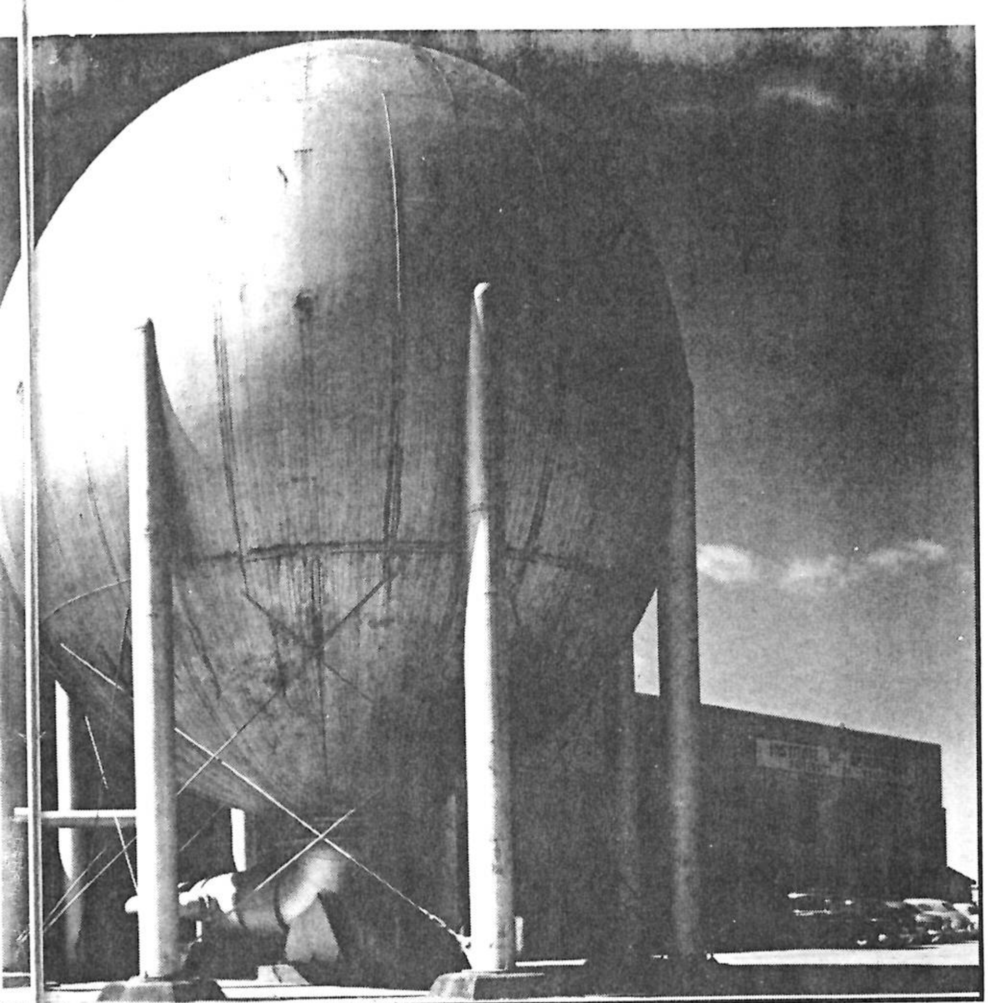
Minor Exercise: To the Nazis, "Operation Punishment" was merely a minor exercise in the use of the air power that they had carefully built, in the pre-war years, from a solid foundation of aeronautical research and development. Anyone who has roamed through the 1945 remains of wind tunnels, research laboratories, vast design offices and flight test establishments, could not fail to be impressed. The methodical Germans were well aware that the strength of their early air power depended on this structure. And if the Nazis had tended to this foundation as the war dragged on, their air power roof would never have collapsed with the resounding thud that it finally did.

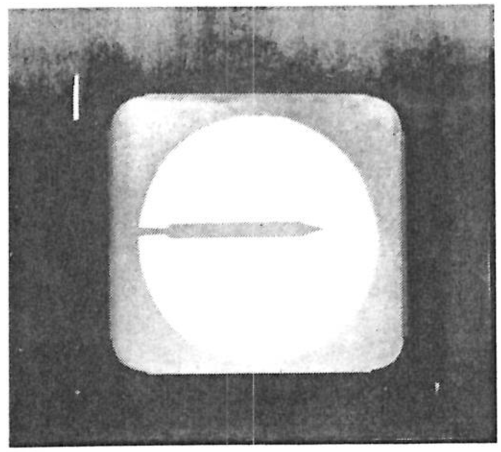
For the research and development foundation for air power must be carefully cast and carefully cared for. It cannot be continually remolded, by see-saw changes in basic policy, nor continually built askew, by concentrating on one small phase of air power. It must be built block by block on a straight and even surface, with aeronautical research supplying the building material, and aeronautical development selecting and laying the foundation.

It is only from such a firm foundation that future air power can be built to benefit us in peace and preserve us in war. And air power so constructed is more than just a squadron of CF-100 fighters zooming over Comox. Air power is, according to the former Marshal of the RAF, Lord Tedder, "Air forces, civil transport, air bases, communications for control and direction, radar and radio facilities, aircraft and engine industries, . . ." In other words, everything that contributes to the wonder of flight.

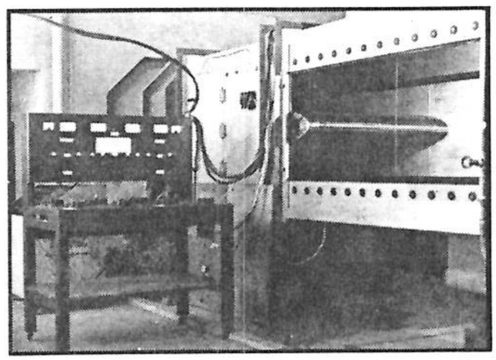
Wellsprings of Knowledge: When we see and live with these end-products of research and development, we tend to forget that they took root from such facilities as our National Aeronautical Establishment, National Research Council, and laboratories of the Defence Research Board. Day after day, with little fanfare or reward, engineers and technicians cluster around a maze of instruments as a wind tunnel whirrs nearby, or a jet engine on a test stand screams and flashes in the night. Figures are tabulated, graphs are plotted, reports are written, in endless flow.

At the other end of this pipeline, engineers and designers at such fac-





Air power for the future is based on a foundation made up of such facilities as the University of Toronto's Institute of Aerophysics (L) and the NRC's icing tunnel (below). Above is a model in the working section of a supersonic wind tunnel at the U. of T.'s Institute of Aerophysics.



tories as Avro, Orenda Engines, and Canadair ponder over the results. Data is matched with significant information from the U.S. National Advisory Committee for Aeronautics, or the U.K.'s Royal Aircraft Establishment. A curve is plotted. A line is drawn. And the design of a new fighter, bomber or transport begins to take shape. The thrill of piecing together the technical jigsaw has been best brought home by Orville Wright: "Wilbur and I did not take nearly so much pride in the fact that we were the first to fly as we did in the fact that we were the first to have the scientific data from which a flying machine could be built."

Aeronautical research data, however, can cover a vast field of possible scientific investigation. In order to limit the field, and concentrate our efforts for maximum results in minimum time, the development policy that leads to the final product must be definitely defined and clearly consistent. Yet such a policy must allow some breadth of vision. Can you imagine how much basic aeronautical knowledge the British Navy might have had early in this century if the First Lord of the Admiralty had taken a broad outlook on the Wright Brothers' patents four years *after* the Kittyhawk flight? When offered the patents, the First Lord wrote: "I regret to have to tell you, after careful consideration of my Board, that the Admiralty while thanking you for so kindly bringing the proposals to their notice, are of the opinion that they would not be of any practical value to the Naval Service."

Classics of Their Kind Or what would have happened to the U.S. Army Air Corps during World War II if the U.S. Navy hadn't fostered and fed the research and development background for the air cooled engine? Just before the war the USAF, with great fanfare, decided on an inconsistent move. The future of air power, they divined, was linked with the liquid cooled engine, and all work on the air cooled variety slowed to a halt.

Or where would the Western World have been in the Korean conflict if the British hadn't finally, and with much reluctance, taken a broad view and sponsored the research and development that Sir Frank Whittle poured into the jet engine.

Or where the British might have been today, in the field of supersonic flight, if the government hadn't swung from the beaten development track. As Parliament read in the White Paper tabled early this year, "The decision was taken in 1946 that, in the light of the limited knowledge then available, the risks of attempting supersonic flight in manned aircraft were unacceptably great and that our research into the problems involved should be conducted in the first place by the means of air launched models." The paper then goes on to explain, "It is easy to be wise after the event, but it is clear now that this decision seriously delayed the progress of aeronautical research in the U.K."

Question & Answer: It may be easy to be wise after the event, but the question is, "How can we avoid these faltering mis-steps, in which the history of aeronautical research and development abounds?" I think that part of the answer lies in some psychological research that was done by Donald Walker and a team from the

University of Chicago a few years ago. The group set out to probe the creative thinking, mental flexibility, resourcefulness, and ability to concentrate, of a number of chemists and mathematicians of Nobel Prize calibre. To the team's amazement only 22% of these distinguished scientists showed real creativeness and originality, even with a generous interpretation of the results. But some 60% had great flexibility of minds.

Walker finally concludes that a teamed effort will produce results quicker and cheaper than any solitary genius. In a group, one mind challenges another, inspires another, and results flow with less time lost and less mis-directed experimenting.

Applied to future airplane programs, this means that research and development policies must be thoroughly debated by the best aeronautical brains of the country, with cool and objective direction. This does not mean, however, that the aeronautical hierarchy of a government should pass judgement without bringing in the people that are responsible for carrying through the development work — the aircraft, engine, and equipment design teams that are the backbone of the industry.

Probing the Future: For every company worthy of its name, in this enlightened day, is forever probing into the future. It is giving free rein to what J. C. Floyd, Vice-President of Engineering for Avro Aircraft, calls, "The natural inquisitiveness of engineers." The good design team always has its "backroom boys." These are the ones that not only dig into the research data and see what appears possible in the future, but they prod the military and civil operators to enquire how they intend to use this air power of the future. In other words, they are not mere designers of airplanes, but designers with all its ramifications. And the job of the airplane operator is to strengthen this link between research and development, and the future, by putting all his operating experience into the alloying pot. These design teams, then, must be given a full hearing where future policies are up for debate.

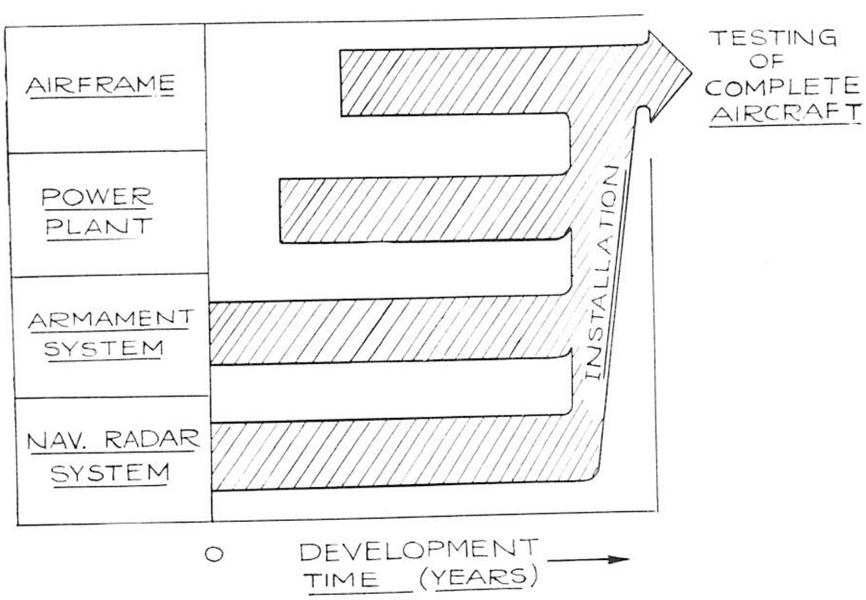


FIGURE 1: DEVELOPMENT PHASING.

In my opinion most of the false steps of the past can be laid at the doorstep of passionate prejudices played to the full by a few closed minds behind closed doors. However, there is another powerful force that affects the future, which we have inherited from the age of enlightenment in the 16th century — the Doctrine of Order. At that time it was discovered that all things appeared to progress in an orderly fashion. And research and development is no abstainer from this orderly march.

Always an Alternate: This is what J. C. Floyd calls the "development ladder." Speaking from his experience in the design of the Canadian civil "Jetliner", and a variety of fighter models for the RCAF, Floyd considers that "Airplane development is like climbing a ladder leaning against a wall. You take one step at a time, steady yourself, and then take the next." However, he is quick to point out that you do not confine yourself to just one ladder.

"There is always one main and strong ladder of development, that has built into it the best research and development information available at the time. But you do not hesitate to start other ladders, climb them a ways, test them for strength, and see whether some new or radical idea really holds up. Some ladders may collapse after a few steps. But others may go on so that, in the end, you may even abandon the ladder you thought earlier was the best bet and continue the climb on the ladder with a more solid structure."

Floyd goes on to point out that even the sidelines that fail, always produce something that strengthens your main climb of endeavour. No development is unproductive, in the absolute sense.

The basic concept, then, is to have an avenue of orderly development, broadened by side-road investigations carried through to logical conclusions. With this outlook could anyone arrive at such decisions as the Royal Navy's turn down of the Wrights' airplane in 1907; or the USAAF's or British failure to sponsor various engine developments; or the Ministry of Supply's dogmatic approach to the supersonic flight era?

Time & Money: While this covers the broad approach to sign postings, as much as humanly possible (this dense and baffling veil of the unknown, as Churchill called it) there are time and money factors that, in the broad field of air power, must always be weighed.

Obviously a country cannot pour unlimited funds into every possible research and development project. This is where judgment must enter the equation. And this is where the team approach of psychologist Walker can again play a part. The great American scientist, Vannevar Bush, in his book, *Modern Arms and Free Men*, laid down the ground rules for assessing such ventures; "In the field of complex mechanics, inventions are a dime a dozen. The question of whether a device will come into being depends on three things: first, whether there is a practical use for it that warrants its development and manufacturing costs; second, whether the laws of physics applying to the elements available for use in its design allow the

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indexing of automatic production machinery. Copies from Ferguson Machine & Tool Co., Roller Gear Div., P.O. Box 191, St. Louis 21, Mo.

• **Die Steel:** Detailed information on "Ottawa 60", a new die steel specifically developed to deep draw and form stainless steel, is available in a technical data sheet obtainable on request from the Advertising Department, Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 22, Pa.

• **Wet Blasting:** "How to Cut Die and Mold Finishing Time 50% to 94%" is the title of a new bulletin just published by American Wheelabrator & Equipment Corp., 1005 S. Byrkit St., Mishawaka, Indiana. This four-page folder shows the application of wet blasting as done in the company's Liquamatte machines to such cleaning and finishing work as is met in the manufacture and maintenance of forming dies and molds.

• **Hardness Tester:** Gries Industries Bulletin No. A-12 describes new Wolpert-Gries machine for standard Rockwell Hardness tests. Copies from Gries Industries Inc., Testing Div., Beechwood Av. at Second St., New Rochelle 6, N.Y.

• **Brinell Tester:** New four-page illustrated folder describing King portable Brinell Hardness Tester that makes standard Brinell tests and can be used as a bench tester or taken to the job and used in any position, anywhere, has recently been published by Andrew King, 67 E. Lancaster Ave., Ardmore, Pa.

ELECTRONICS COOLING

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The possibility of isolating temperature sensitive components from sources of heat might also include the application of thermal barriers such as plastic foam or aluminum foil. Design of circuit layouts to group heat generators together for simplicity of cooling and to derive maximum efficiency from the cooling air must be kept in mind. The circuit engineer should be aware of these factors at all times so that circuit design may be kept less dependent on the length of lead, or, that the length of lead will permit some latitude in the final layout and packaging phases, thus allowing for advantageous component locations.

By attending to some of the points discussed here, the need for refrigerator cooling of weapons systems and aircraft electronics may, at least, be avoided for some time to come, and with the responsibility for cooling perhaps difficult to allocate as either wholly electronic or wholly aeronautical, the fact that 95% of the energy supplied by the aircraft power plant to electronics apparatus is wasted as heat, it might possibly be safe to say that attention by electronics engineers to their share of the cooling problem is important.

AIR POWER

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attainment of the needed ranges, sensitivities, or the like; and third, whether the pertinent art of manufacture has advanced sufficiently to allow a useful embodiment to be built successfully."

Time Variation: After a team has used this approach to sift out the proper avenues of research and development then the time factor must be inserted into the deliberations. Unfortunately, the research and development phasing, in such a broad and complex field as aeronautical equipment, can be markedly variable. For example, the development of the armament and navigation systems for a typical bomber must be started before the development of the airframe and engine, as illustrated in Figure 1.

And to make matters worse, the time phasing or the ground elements of an air defence or air offense system, may be in a completely different time scale relative to the airplane itself.

The only answer, of course, is to have a master plan spotted into the future "a long, long way ahead". In this plan all the elements that fit together to form that part of air power must be assembled. The research and development jobs must be timed to allow the proper production of useable components to fit the master schedule. In this way the research and development foundation grows at an even, steady rate. But such a plan is no easy task, as witnessed by the present difficulties being experienced by the United Kingdom.

Diagnostician: Sir Roy Fedden, well known British engine designer and, more recently, aircraft advisor to NATO, has been probing the aircraft research, development, and production policies as tabled in the British House of Commons. He has found that there is no single cause for the British lack of up-to-date air power, but a complex intertwining of a number of factors, among them a vacillating policy on research and development that "must have been heartbreaking to our technicians."

The key point, however, is planning. Says Sir Roy, in the *Daily Telegraph*, "To my mind the truth is that immediately after the war there was a sad lack of vision and realistic long term planning in both the industry and official circles. I submit that it was this, more than anything else, which caused us to slip back, and which has resulted in the disturbing situation in which we find ourselves today."

Thus ten years may elapse before the real results, or the lack of them, begin to show in the state of a nation's air power. Ten years before a poor plan and a vacillating policy rends huge cracks in the research and development foundation for air power. Since we in Canada are also in this research and development business we can well pay heed to the bitter experiences of our Western World neighbours. For, what Sir Winston Churchill said of political procedures is also true in research and development. "The mistakes of years cannot be remedied in hours."

TWIN PIONEER

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be expected for slow flying at high incidence. The complete unit, tailplane, three fins and control surfaces, is assembled as a whole and mounted on the fuselage by four bolts. The tailplane is fixed, but both halves of the elevator incorporate trimming tabs. The tailplane and the fins are of simple metal-covered construction, each with two spars.

The control surfaces have simple spars, D torsion-box leading edges and the minimum of ribs with a 28 swg skin stiffened by chordwise swages. All the controls are fitted with adjustable mass balances. The rudders have aerodynamic horn balances, while the elevator has inset hinges.

The landing gear is of the tail-wheel type because this makes the use of maximum incidence both easier and safer. The technique used with most slotted and flapped high-wing monoplanes — including the Prestwick Pioneer — is to rumble in at a high angle of attack and cut the throttle when the tail wheel touches. Likewise, the tail wheel is often the last to leave the ground.

The Twin Pioneer has low-pressure