FROM ALL QUARTERS . . .

in cost. We can forge finished precision blades as cheaply as rough forging, thus eliminating a costly process. In today's jet engines there are well over 1,000 blades, usually made of aluminium or steel. Now that titanium is coming widely into use because of its great strength and low weight we believe we have made a development of the greatest significance.

"Mr. C. J. Luby, president of the company [Canadian Steel Improvement], has now cabled me the news that we have just received an order from a major U.S. manufacturer for a quantity of titanium blades. Other orders are also in the offing. This indicates that we have established a clear technical lead in this field.

"While our process remains secret, I can say that it protects the metal from problems normally associated with titanium during forging and heat treatment. One of the great barriers to the economic use of this new strategic metal has been its chemical affinity for hydrogen and oxygen. Hydrogen "pick-up" causes it to become brittle, thereby lowering its fatigue life, and oxygen causes a scale to form on the surface. The metal is also liable to distortion when forging thin sections. Our process has completely eliminated all these difficulties.

"These Canadian Steel Improvement discoveries in processing of titanium are largely the result of work done for the sister company, Orenda Engines, Ltd., in the development of a new supersonic engine which is to succeed the Orenda turbojet currently in production. . . ."

TEST FLYING TODAY

—explained to Young Listeners by Roland Beamont

W/C. Beamont, whose lecture to young guests of the Royal Aeronautical Society is reported here.

AT this season it is customary for the Royal Aeronautical Society to present what is known as a "Young People's Lecture." It would be difficult to say whether the subject or the lecturer was the main reason for the packed attendance at this year's event, held on the afternoon of January 5th; for the young people—mainly boys of an average age of 14-15—heard a talk on *Test Flying—Current Problems and Techniques,* given by W/C. Roland Beamont, who is manager (flight operations) and chief test pilot to the English Electric Co., Ltd.

We should have thought some of the references—to such esoteric matters as design envelopes and flutter boundaries—to be a little above the heads of such a youthful audience: but there was never a single fidget, and the questions afterwards displayed plenty of insight.

W/C. Beamont began by saying that, from the test pilot's point of view, the great strides in aircraft performance design since the war years had not, contrary to common belief, brought with them many completely new problems. Rather had they changed the emphasis of problems which had existed in the days of high-performance propeller-driven aircraft, and they had made necessary the employment of some new techniques.

Possibly the most significant change in flight-testing conditions in recent years had been the introduction of fully powered flying controls to high-performance aircraft. At a stroke this had changed the pilot's problem in the early qualitative assessment of an aircraft from one of a relatively hit-or-miss type of development programme on aerodynamically balanced manually-operated controls (in which he had to attempt to distinguish, from changes in hinge moment under varying flight conditions, the effects of local changes to balance surfaces) to the relatively more simple programme of assessing powered control circuits in terms of friction, backlash, spring rate, the desirable proportions of "Q" feel, and, of course, effectiveness.

In the early flight stages, the pilot was no longer presented with the possibility of over-balance on controls, leading to reversal of feel or stability; and, in fact, a large proportion of the control characteristics could be set up and proved to the pilot's satisfaction on a ground rig before the first flight of the prototype. This method had two main advantages. Firstly, the full engineering layout of the powered control system could be proved on the ground before it was committed to flight in the prototype; secondly, a large proportion of pilot criticisms—such as excessive friction, poor self-centering, lumpiness and, of course, maximum force for full deflection—could be cleared in the test section without the added embarrassment of having an aeroplane attached to them at the time.

The second noticeable improvement which had occurred in flight testing techniques in the past three or four years had been the increased use of instrumentation. By the employment of trace recorders, detailed information on control angles and forces, rate of roll, pitch and yaw, vibration, pressure plotting and longitudinal and normal acceleration could be obtained at will. Instead of wasting flying time in searching for defects or for the cause of known defects by laborious trial-and-error methods, the pilot had only to make accurate observations of flight characteristics for these characteristics to be identified on the trace recorders concerned, and for the necessary information to be supplied to the design department to enable modification action to be taken.

"At one time," continued W/C. Beamont, "there was much discussion on the subject of whether instrumentation and telemetering would eventually replace the test pilot; but, as a result of experience of the limitations of 'little black boxes' I have it on the authority of a very distinguished chief engineer that it is unlikely that instrumentation will ever replace qualitative assessment by the test pilot. After all, these aeroplanes have eventually to be flown by a man, and, although the human machine is almost infinitely adaptable, there are some limits to what the poor chap can do. Only another human being can say what those limits are."

One result of the great advances that had been made in the development of flight test instrumentation had been the introduction of new techniques in flutter investigation. In the past it had been the not-very-happy lot of the test pilot to fly new machines at progressively faster speeds until their whole design envelope had been filled out, knowing that flutter might develop unexpectedly at any time, and merely hoping that it would not. The only relieving feature was that, as time went by, the flutter experts became able to predict more closely the possible flutter boundaries; and, if they turned out to be right, the pilot could always throttle back, pull the nose up, open the airbrakes or do anything else he could think of to lose speed in a hurry, hoping that nothing would fall off in the meantime. There had in fact been a great many accidents and incidents of structural failure caused by flutter.

Recently the science of flutter calculation had advanced very rapidly, and it now seemed possible to predict characteristics with quite reasonable accuracy. Additionally, by the use of vibration trace recorders with pick-ups at various significant points on the structure, records of vibration and damping could be obtained from the first flight on a prototype onwards, so that the closest check could be kept on any signs of serious deterioration as speeds and Mach numbers were increased.

In further efforts to provide detailed information on damping characteristics at a safe margin below the estimated critical flutter speeds, techniques had been developed for the exciting of wing-tips, tailplane tips, etc., at their natural frequency by artificial means. When the structures were vibrated in this way the approach of a flutter condition could be detected if the subsequent damping of the vibration was getting worse. Vibrographs then recorded the damping, or lack of damping if the condition were near the critical flutter speed. At least, that was the theory.

In practice these systems worked very well in giving confirmatory evidence of damping characteristics; and, of course, if the vibrograph was running at the time, in recording the frequency and amplitude of divergent oscillation. But as a safeguard against the inadvertent encountering of flutter in flight they had not so far proved very satisfactory, because flutter incidents had been encountered when increasing from one excitation stage to the next. However, it was now thought that the associated instrumentation requirements were better understood and would probably be applied with better effect on future occasions.

"Lest an impression should be gained that all the modern aids and conveniences to flight testing leave little element of the unexpected," continued W/C. Beamont, "mention should perhaps be made of an incident which occurred to us recently. When we were approaching the final stages of a progressive flutter investigation the cockpit canopy disappeared with a loud noise and circumstances became noticeably draughty for a few minutes—this