The Royal Aircraft Establishment during World War II
some personal reminiscences

Hugh Warren
Royal Aircraft Establishment 1940 - 1978

Summary

This paper was presented as the 4th Cody Lecture to the Farnborough Branch of the Royal Aeronautical Society on 14 December 2004. It records the personal reminiscences of a scientist at the Royal Aircraft Establishment during the second World War, mainly in Aerodynamics Department.

1. Introduction

It is an honour to be asked to give the Cody Memorial Lecture. When I was approached and asked whether I would talk about the work of the Royal Aircraft Establishment during the wartime years, as I was one of the few remaining persons from that time, I replied that I was only a very junior person then. Security and the ‘need to know’ prevented anyone from being aware of the big picture of what was going on, except in one’s own narrow area.

What I could talk about is what I did during the War, and perhaps make a few personal observations. So my talk has been entitled “The Royal Aircraft Establishment during World War II – some personal reminiscences”.

I intend to talk about my activities as a scientist, then say something about the working environment, and then the social life, and I shall conclude by giving my opinion on the standing of the Royal Aircraft Establishment.

2. Personal activities as a scientist

I was called up in May 1939 under the Military Training Act 1939 – the first call-up in the United Kingdom in peacetime. The advent of war in September led to the Act being superseded by the National Service (Armed Forces) Act 1939.

Note by the Editor

This paper formed the fourth Cody Lecture, presented to the Farnborough Branch of the Royal Aeronautical Society on 14th December 2004. Copies of the lecture were subsequently deposited with the National Aerospace Library and the Farnborough Air Sciences Trust, but not formally published.

Hugh Warren died in February 2007. This paper is published without having been reviewed, as finalised by Hugh Warren in 2005.
At my interview, the Interview Board decided to send me to Farnborough ‘to work in the wind tunnels’ as a reserved occupation.

At the Royal Aircraft Establishment I was directed to the Aerodynamics Department, then called BA Department. The Head of BA Department, Dr G. P. Douglas, asked his assistant, ‘Pop’ Finn, “Where shall we put this man Warren?” Pop replied “He is a mathematician from Trinity College Cambridge, who got a first in Part II of the Mathematical Tripos, and who then went on to take Part III – an identical progression to Laurie Fox, except that Warren is possibly better than Fox, because Warren got a distinction in Part III”. Fox was one of Douglas’s well-thought-of scientific officers. So Douglas decided to start Warren off under Fox, in what was then called the Performance Section.

In the Performance Section I was introduced to many aspects of the work that the Section did. One of the tasks was to evaluate new designs of aircraft. The first such that I was shown how to do the calculations for working out, from a three-view general arrangement drawing, the drag of the aircraft, the position of the neutral point, which is related to its longitudinal stability, the values of the so-called derivatives $l_v$ and $n_v$, which are related to its lateral stability, and its projected take-off and landing distances. This was all good training, and exciting work to be doing.

G. P. Douglas – Head of BA Department

The F4/40 was eventually given the name Welkin. It first flew in 1942. Seventy-seven aircraft were built, but most went into storage, and were subsequently broken up. The task for which the aircraft had been specified – high altitude fighting – did not materialise.

Another task that came my way was to look into various proposals that were made to improve the performance of existing aircraft.
One such was to assess the effect on the performance of the Hurricane of fitting drop tanks in order to increase range, so that Hurricanes could accompany bombers on bombing missions. This necessitated adding the effects of the drag and weight of the drop tanks to the calculations which had long past been done on the basic Hurricane.

Here I learned a lot from Laurie Fox. “If you have done some calculations in an untidy form on the back of an already-used piece of paper, don’t throw the paper away. Give the job a number, and file the paper away in a file with an index. Because, as sure as fate, in six months time someone may ask you the same question, or a related one. It will save you having to do a lot of the same calculations again.”

How right Fox was. In six months time I was asked to assess the effect on the performance of the Hurricane if, instead of fitting drop tanks, the Hurricane was made to tow a jettisonable rider-plane.

In August 1940 bombs were dropped on the Royal Aircraft Establishment, killing, I believe, a member of the Local Defence Volunteers, the forerunner of the Home Guard, a body which played such an important part in winning the War, as anyone who has seen its postwar portrayal, ‘Dad’s Army’, will realise!

A result of this bombing of the Royal Aircraft Establishment was that dispersal became the order of the day. Parts of the Establishment which were not tied to facilities, like the wind tunnels, should be dispersed. So in October the Head of Aerodynamics Department, theoretical workers, and the Performance Section, were moved out of the main factory area to the requisitioned Old Rectory in Rectory Road.

Telephone in all rooms, and a small exchange, were quickly installed, but initially no telephone exchange operator. So, as the junior boy, I had to double up as telephone exchange operator as I did my work in the Performance Section.
One more intellectual outcome of the move to the Old Rectory was that the Department’s leading theoretical aerodynamicist, Brian Squire, who of course was one of those now out at the Old Rectory, was told that he now had a Cambridge mathematician in the room next to him, whom he might like to make use of. Squire had been working on the design of aerofoils to give prescribed pressure distributions, with the aim of delaying the onset of transition from laminar flow to turbulent flow, and also of avoiding shock wave formation at high speeds, both of which should lead to aerofoils which should have reduced drag.

Squire knew, although of course I didn’t, that jet aircraft were coming in. So Squire gave me the task of adapting his two-dimensional small perturbation theory of aerofoils to the axisymmetric case of jet engine nacelles. This work provided me with the opportunity to use some of my mathematics, which was most satisfying. I found that I had to acquaint myself with Bessel functions, about which I was pretty ignorant. But, as with many things at the Royal Aircraft Establishment, there was an expert on Bessel functions whom Squire put me on to, and of whom I made great use.

Although an interesting mathematical exercise for me, small perturbation theory in the axisymmetric case turned out to be far less powerful than in the analogous two-dimensional case for aerofoils.

After about a year in Performance Section I was moved to Frances Bradfield’s Wind Tunnels Section. So I moved back into the Factory proper, and left the Old Rectory.

The wind tunnels were a facility for testing models of designs of new aircraft. One of the first tasks to be given to me was to do the wind tunnel tests on the Shetland, a boat seaplane to replace the Sunderland. Miss Bradfield always appointed a senior person to oversee a newcomer to the tunnels. For me, it was Handel Davies. “You have written your report, I hope” said Handel. “I have not done the tests yet!” I replied. Then Handel explained that Miss Bradfield always insisted that one at least drafted one’s report before going into the tunnel, as a way of ensuring that one would make all the necessary measurements whilst one was in the tunnel, for there would be no going back!
It was during these tests that the air raid warning sirens sounded. The drill was that we should shut the tunnel down, gather up one’s papers, and go into the safe shelter beneath the return circuit of the wind tunnel. This we did, and we sat working out our results so far. After over an hour we had not heard anything: we had run out of work to do, and we wondered whether we had missed the all-clear. So I went up to ground level where an air raid warden – they were all rather like Bill Pertwee in Dad’s Army – came up to me and said “What have you come up from out of down in under for?” I said “You can’t end a sentence with eight prepositions”. Miss Bradfield was very hot on not ending sentences with prepositions. It had him: there was no answer.

The other main task was in helping to sort out problems that the Royal Air Force was having in service. One such problem concerned the Halifax. We were asked whether there was any aerodynamic reason why, proportionally, more Halifaxes were being lost over the target than Lancasters. We put models of both aircraft in the wind tunnel, and checked their stability up to large angles of yaw. We found that the Halifax became laterally unstable at large angles of yaw, the Lancaster not so. So more Halifaxes were probably not being shot down, but, in their evasive action, the pilots were probably yawing them to far larger angles than they had been designed for. The solution to the problem, which Handley Page proposed, and which we checked out, was to fit fins of larger area. We believe that this led to a reduction in Halifax losses.
After two and a half years in the Wind Tunnels I was moved to the Seaplane Tank Section to take charge of the work on ditching. Many of our aircraft, returning from raids over enemy territory, often damaged or short of fuel, had had to make a forced alighting on water, which was called ditching. So in 1941 the Royal Aircraft Establishment was asked whether it could do any work to advise how best to put landplanes down on water; in other words, how best to ditch. Forty-seven Hudsons had been lost at sea without trace.

The task was given to Don MacPhail in the Seaplane Tank Section, but his moving on to the Section working on the planned National Aeronautical Establishment at Bedford was why I had been drafted in.

MacPhail had found that some work had been done before the War on the ditching of landplanes by investigating the alighting of model landplanes on water in the Seaplane Tank. The results were unsatisfactory, and the report on them concluded that, if such work was contemplated again, then it would be better to catapult dynamic models on to water in free flight.

As with so many things, successful work depended greatly on the contributions of assistant staff and industrials, as I had found when in the Wind Tunnels. Clearly, accurately-made dynamic models in balsa wood would be required which, besides being to scale in dimensions, would have to be scaled in weight too. Our industrial craftsmen could do this. MacPhail had decided that the three main parameters that required investigation were the speed, the flight path angle on striking the water, and the angle of attack. MacPhail gave the job of designing some apparatus to catapult dynamic models onto water to his Assistant, W. D. Tye.

Tye soon found some suitable water – an open area on the spray pond of the then-being-built High Speed Wind Tunnel.

Tye decided to attach the models to a carriage, which would be catapulted down an inclined track towards the water. The catapult was powered by the fall of a heavy weight attached to the carriage by a rope and pulley system. By relying on gravity, we did not suffer from power cuts as the wind tunnel people often did!
Ditching tank catapult

The model was held in the carriage by detents, which rotated out of the way, allowing the model to be released, by the acceleration of the carriage acting on the inertia of the heads of the detents.

When the model was released to fly down on to the water, the carriage was halted by an ingenious pair of brakes, one a friction brake and one a piece of bungee. The bungee was tuned to provide slightly more than 50% of the braking effort, so that, once the carriage had been brought to rest, the bungee was just able to pull the carriage slowly out of the friction brake. The carriage was now ready for pulling back for the next launch.

This cleverly thought-out piece of apparatus worked every time for over five years, and was a tribute to W. D. Tye's concept and design.
The people who made most use of the results of ditching tests were the authors of Pilot’s Notes at Hullavington. When the squadrons reported that they were losing a lot of aircrew in ditching of the Fortress, Hullavington replied that the R.A.E. tests showed that the Fortress should be a good ditcher. Since the R.A.E. tests had been qualitatively right in the past, Hullavington suggested that perhaps the squadrons should look to their ditching drill. This they did, and it led to the record rescue of 118 aircrew out of 121 in one day’s Fortress operations.

The most significant contribution that the Royal Aircraft Establishment was able to make on ditching was in regard to the Mustang fighter. Ditching tests showed that, upon hitting the water, the Mustang invariably dived beneath the surface. The Spitfire and Hurricane behaved in a similar way due, no doubt, to their underslung radiators, but on the Mustang the dive was more vicious. The authors of Pilot’s Notes considered that this merited making a short film, to be shown to Mustang pilots, in order to impress upon them that in no circumstances should they attempt to ditch a Mustang.

Towards the end of the War the Ministry of Aircraft Production had set up the Brabazon Committee to consider what commercial aircraft would be required in a postwar world. Naturally the performance of such aircraft was the prime consideration, but the safety aspects were considered too. Amongst other things the wartime experience on ditching was sought to conjecture how the various commercial designs might behave if forced to alight on water. I was just getting stuck in to this work, when I made a move to Controlled Weapons Department.

With the cessation of hostilities in 1945 great changes took place in the Royal Aircraft Establishment, as in everywhere else. A new department, called Controlled Weapons Department, was set up to deal with the problems of pilotless air missiles. Germany had
introduced such missiles towards the end of the War. There was the V1, the so-called
doodlebug, and the V2, or ballistic rocket. Such controlled missiles would clearly feature
alongside manned aircraft in future warfare. This was the raison d’être for the formation of
Controlled Weapons Department. It was soon to be combined with the also newly-formed
Guided Projectile Department at Westcott to yield what was for many years the Guided
Weapons Department of the Royal Aircraft Establishment.

I joined Controlled Weapons Department in 1946. One of the tasks which I was given was to
look into the increase in range of V2-like ballistic rockets which might be achievable with
rockets of greater specific impulse (related to exhaust velocity) and through introducing staged
rocketry. For the purpose in mind – the bombing of distant targets – there was obviously no
need to consider ranges greater than the semi-circumference of the Earth. My report showed
that, with modest payloads, a two-stage rocket could achieve this range with only a small
increase in specific impulse. For heavier payloads, either a very heavy two-stage rocket or,
better, a three-stage rocket, would be required.

What has made this work of mine in 1946 particularly significant for me is that my grandson,
in 1999, was given, as a project by his university mathematics supervisor, the task of finding
what specific impulse, and how many stages of rocket, would be required to put satellites into
orbit. Naturally, the mathematics of what I had done, and of what he was asked to do, are the
same. It was just that the objects were different: my work stopped when the range reached the
semi-circumference of the Earth, after which the missile would go into orbit, which is where
my grandson started. Grandfather and grandson were pleased to find that they agreed on the
mathematics of the two problems!

3. Working environment

The working environment at the R.A.E. has to be set against the progress of the War.

The War started in September 1939 with Hitler’s invasion of Poland, which was overrun in six
weeks, with Stalin coming in from the east following the Molotov-Ribbentrop pact. The next
six months were known as the Phoney War because nothing much happened. Then, in April
1940, Hitler overran Denmark and Norway, and in May 1940 he overran the Netherlands,
Belgium and Luxembourg. June 1940 saw the Dunkirk evacuation, the fall of France, the fall
of Chamberlain, and the emergence of Churchill as Prime Minister, who immediately formed a
Coalition Government, with Attlee, the Labour leader, as Deputy Prime Minister and Sinclair,
the Liberal leader, in the Cabinet too as Air Minister. The R.A.E. came under the Air Ministry.
But Churchill made many far-sighted appointments. He brought in Bevin, the leader of the
TUC, as Minister of Labour; Morrison, the Leader of the LCC, as Home Secretary; and
Beaverbrook, the newspaper tycoon, to head a new ministry called the Ministry of Aircraft
Production, under which the R.A.E. then came.

The summer of 1940 saw the Battle of Britain, the winter of 1940-41 saw the mis-named Blitz.
In June 1941 Hitler invaded the USSR, and in December 1941 Japan entered the war at Pearl
Harbor, thereby bringing in the USA.
During 1942 there was retreat in all theatres – North Africa, USSR and the Pacific. But December 1942 saw El Alamein, Stalingrad and the Solomon Islands, and from then on it was advance in all theatres, culminating in D-day in June 1944 and then VE-day in May 1945.

The coming of Lord Beaverbrook and the Ministry of Aircraft Production had an immediate effect on the R.A.E. Overnight the Establishment changed from 9 to 5 working (9 to 1 on Saturdays) to a seven-day week. This was later reduced to a six-day week for staff, but the Establishment continued to work seven days. These new regulations were applied very sensibly. For example, many single persons such as I occasionally sought to take our day off one week on the Saturday and the next week on the Sunday, thereby getting two days together when it was possible to go to our distant homes. There were quite a few young staff from Belfast. Their ploy was to work seven days one week and then to add a ‘day-in-lieu’ to a Saturday and Sunday, thereby getting three days together, when it then became practical to go home to Northern Ireland.

Christmas Day 1940 was just like any other working day. The R.A.E. was working, but again sense prevailed, and it was mainly the single staff who were in on that day: we let the married ones have that day off with their families. Their appreciation was made manifest when at about 3.30pm on Christmas Day Brian Squire, one of the ones with a family, came in to the Old Rectory, where Beaumont Thomas and I were working, with some Christmas cake for us. Such little gestures are never forgotten.

Of course staff were allowed time off to go to the doctor or dentist, but the system reacted when they found that staff were asking for time off to go to the hairdresser. It was worked out that less time would be lost if the R.A.E. had its own resident hairdresser, so a bookable appointment scheme was set up through Personnel Department. So instead of being absent from one’s job for about an hour, absence was reduced to just over fifteen minutes. The argument was made that as one’s hair grew in factory time, it was right that it should be cut in factory time!

When I joined the R.A.E. it was very much an Oxbridge Establishment. Men like Arnold Hall, Morien Morgan, Alec Young and my first boss Laurie Fox, were all from Cambridge. Brian Squire and my intermediate boss under Fox, Eric Priestly, were from Oxford. I, from Cambridge, joined at the same time as John Nivison, who was from Oxford. In 1941 Tony Anscombe, from Cambridge, joined, but two of the new intake that year were Henry Becker, who sadly was later killed, and John Allen. They were from Northampton Polytechnic!

In 1942 Miss Bradfield called me in. “They must really be scraping the bottom of the barrel now. None of this year’s intake is Oxbridge: they must all be going into the Armed Forces. But worse: there is not an aerodynamicist amongst them. All that they can let Dr. Douglas have is a civil engineer. Douglas has asked me to assess whether we should take him. You start in the tunnel on Monday. Have him with you and see what you make of him. And try to teach him some aerodynamics!”

I duly tried, explaining about trailing vortices, downwash and the stall. Then I said “You probably measure things in cubic yards, etc. In aerodynamics we work much more with
coefficients – lift coefficient, drag coefficient, etc.” And I brought in \( \frac{1}{2} p V^2 \) and mentioned Bernoulli’s equation.

Miss Bradfield subsequently asked me “What do you make of him?” “Well, he seemed bright enough, he seemed to understand what I told him, he would fit in. I would say that if it is a question of getting him or getting no one this year, then take him.” (I had noted a point in his favour – he played rugby.) So he was taken on. He was an acquisition. He had soon overtaken me, and went on to higher things, and is now Sir John Charnley.

Besides the British persons who joined the R.A.E. during the War, there was also a flow of people from the occupied countries, who the powers that be judged could best serve the cause by coming to the R.A.E. There were many Poles, but also Czechs, Hungarians, Croats and a Palestinian. With their different backgrounds they enriched the R.A.E.; and most were keen. Once he had settled in, Frank Holoubek, a Czech, asked of his new colleagues, Ron Atkinson and Richard Starkey, “What do I have to do to become one of the boys?” “Drink beer and play rugby.” “I can drink beer, but what is this rugby?” “There is a match on Saturday, and we are a man short: come and find out.” Frank would never be a Gareth Edwards, but he was great fun in the Clubhouse after the match.

In the summer of 1945, German scientists began to appear at the R.A.E. Initially they were prisoners of war, and were housed in a suitably big house in Surrey. We were told who was there, and what their specialism was, and we could ask the army to bring any one of them to the R.A.E. for interrogation if we felt that he might have some knowledge that could be of interest to us.

After a month or so the scientists were taken back to Germany and freed. With the chaotic situation in Germany under occupation their former establishments had difficulty in finding funds to re-employ them. In the British sector the occupying power helped out by recruiting certain of the scientists to write monographs on agreed subjects under contract.

After this phase, again because of the employment situation in Germany, Britain offered contracts for a six month period to certain of the German scientists to work at the R.A.E. with the pay of about a senior scientific assistant, which was of course less than they were worth, but was more than they would be able to earn in Germany.

They were called “German Scientists”, but were subject to restrictions. One was that, as enemy aliens, they must not be in a position where they would have to give orders to Brits. These restrictions irked some of the Germans, and Busemann, for one, did not renew his contract when it expired, and went to seek opportunities in America. Schlichting went back to Germany to help get aeronautics going at Braunschweig when the Allied Powers allowed some autonomy again in aeronautical establishments.

Eventually the concept of German scientists under contract was ended, partly because of the restrictions, and partly because of Union objection to the Ministry’s getting labour on the cheap. The scientists were told that if they wished to continue at the R.A.E., they would have to seek British nationality, and go before the Civil Service Commission. As we know, a number did. There was little difficulty in their being assimilated. The War had not been
between British scientists and German scientists. And so many of the Germans were very musical, and in this, and other ways, they enriched our society.

As regards the effect of the end of the War on the British personnel, most of those scientists who had joined the Royal Aircraft Establishment before the War were, of course, established civil servants, who could continue their career in the scientific civil service if they wished. But the War had seen a great influx of scientific staff, who were classified as unestablished. Some of those who had been posted to the RAE during the War were glad when they were demobbed: they had other careers which they wished to pursue. Some, however, wished to pursue a career in the scientific civil service. They were told that they would have to seek establishment by the Civil Service Commission, under what was called the Reconstruction.

My own position was that I had been doing a job for over six years which I had found that I liked. So it was relatively easy to decide that a career in the scientific civil service was the option that I should seek. I was successful in getting established.

Some were not successful, and others had no clear idea of what they wanted to do. Some of these went into industry. I subsequently met one such who had gone to an aircraft firm, where he was now Assistant Chief Aerodynamicist, and earning more than I was. He had clearly fallen on his feet. Others had gone into the then expanding university system, and some into jobs unconnected with aeronautics.

4. Social life

Being at the Royal Aircraft Establishment in wartime was not a case of all work and no play. There was play, but because play had to be fitted in, one tended to enjoy it all the more.

As boffins, who had been conscripted and posted to the R.A.E. in reserved occupations, employees of the R.A.E. were extended many perks by the army in nearby Aldershot. One of these perks was that we could visit Aldershot’s Garrison Theatre, where quite excellent shows were put on by the Entertainment National Services Association (ENSA). I remember seeing Noël Coward, with his full west-end cast, which he had brought down, in ‘Blithe Spirit’, upon production of one’s R.A.E. pass (not being in uniform as soldiers were) and payment of the admission fee of threepence (just over one penny of current money)!

The Royal Aircraft Establishment had a wide range of clubs and societies – as many, I felt, as I had experienced when at university, which was one reason why the move from university to research establishment was so smooth.

The clubs which I tended to have most to do with were the Rugby Club, the Dramatic Society and the Tennis Club. The main characteristic that we exhibited in the Rugby Club was keenness. Many of the sides that the Rugby Club played against were army sides in the Aldershot area. Because of travelling restrictions, we travelled to their grounds by bicycle.

We did somehow manage transport when we played RAF Medmenham. Dennis Mallinson did not turn up at the appointed meeting place, so the fourteen had to set off without him. Having
The Dramatic Society took advantage of the lawn and shrubbed garden at the Old Rectory Outstation to stage a play in the evenings of the summer months. They put on Twelfth Night in 1941, As You Like It in 1942, and The Winter’s Tale in 1943. There was plenty of space behind the shrubs to conceal all the off-stage necessities. D-day in 1944, and VE-day in 1945, put an end to this summer enterprise. The Society also put on a first-rate show each winter, usually in Farnborough Town Hall, of which “The Importance of being Earnest” was probably the most memorable.

But as light entertainment for ourselves mainly, the Society would periodically have an evening of One Act Plays in Cove Labour Hall. These were completely unrehearsed. Those participating came on stage reading their part from a copy of the play. The evenings were a riot, with many errors in the acting being made. What was good was that our Deputy Director, W. G. A. Perring, used to participate, often not knowing when the play started whether he would turn out to be the villain, or a rejected lover.

The Tennis Club was a social club as much as a tennis club. With four courts, only sixteen persons could be playing at any one time. So there were always many persons milling around off-court, waiting for their turn to go on. Others turned up just for the social contact. On one occasion a Wellington, fitted with a degaussing ring, which was used to bring up magnetic mines, flew over. Molly Rye-Williams, who had worked at the RAE before the War, and who still liked to know what was going on there, asked “What is that aeroplane?” Conscious of the secrecy regulations no one liked to answer, but Brian Squire, looking up, saved the situation by saying “Oh, I think that it’s a circus aeroplane!” Molly did not explore her curiosity further.
5. The standing of the R.A.E.

I should like to conclude by giving my assessment of the part that the Aerodynamics Department of the Royal Aircraft Establishment has played in the development and application of aerodynamics.

I remember Frances Bradfield telling me that by the 1930s the Establishment had a very strong aerodynamics department. “Hermann Glauert, who had been one of the “Chudleigh” group of eminent scientists who had worked at the Royal Aircraft Factory during World War I, was its leading theoretical aerodynamicist, and Head of Aerodynamics Department.” Glauert had laid the foundations of practical aerodynamics with his book “The Elements of Aerofoil and Airscrew Theory”, in which he explained, amongst other things, how the vortices trailing from a wing give rise to what is now called vortex drag.

Miss Bradfield went on “George Douglas, a first-rate engineer, was Head of Wind Tunnels. And I, Frances Bradfield, was his tame mathematician, whose job it was to be a sort of internuncio between Glauert and Douglas.

Then, in 1934, Glauert was tragically killed in an accident near Norris Bridge. Douglas moved up to be Head of Department, but he was not the world-renowned figure that Glauert had been. I moved up to be Head of Wind Tunnels, but, not being an engineer, I insisted on having Charles Callen as my supporting engineer, in order to ensure that what we did in the wind tunnels was sound engineering-wise.”
But Aerodynamics Department had suffered a setback: it was not what it was before Glauert was killed.

In the course of time Glauert’s mantle of being the Establishment’s leading theoretical aerodynamicist fell upon Brian Squire. In the 1930s work was being directed to designing wings for low drag. It was known that the drag of aerofoils depended upon where the onset of transition from laminar to turbulent flow occurred, and upon whether shock waves were formed. Both these matters were known to depend upon the pressure distribution over the aerofoil, and it was known what types of pressure distribution were favourable.

Many mathematicians, from Joukowski onwards, had developed ways of working out the pressure distribution on aerofoils, but Squire developed the theory of small perturbations to solve the inverse problem of finding the shape of an aerofoil that would yield a given pressure distribution. Squire, and his colleague Alec Young, then developed a method of calculating the drag of such aerofoils. Squire left the RAE in 1952, and died in 1961.

After the War, one of Germany’s aeronautical scientists who elected to stay on at the Royal Aircraft Establishment was Dietrich Küchemann, upon whom the mantle of leading theoretical aerodynamicist now fell. Küchemann became Head of Aerodynamics Department in 1966. Now whereas Squire had looked into the problem of wing section, or two-dimensional aerofoil, design, Küchemann led the way into the problem of wing planform design. Germany, it must be said, had appreciated, more than it had been appreciated in the United Kingdom, the advantages that could be attained by the use of sweepback.

Küchemann, naturally, appreciated the advantages that sweepback brought to high subsonic and supersonic flight, but he also foresaw the changed, and advantageous, flow patterns that wings of very high sweepback would have at low, landing, speeds.
All these developments in wing planform design reached a zenith in the design of the wing for the Concorde, the World’s first supersonic airliner.

In my opinion, it was the inspiration of these three great theoretical aerodynamicists – Glauert, Squire and Küchemann – that enabled the Royal Aircraft Establishment to attain a position as one of the major aeronautical research establishments in the World during its roughly sixty years existence.

Acknowledgements

The following photographs are courtesy of Royal Aeronautical Society (National Aerospace Library)
G. P. Douglas; Westland Welkin I; Hawker Hurricane IIC; Short Shetland; Handley Page Halifax I; Handley Page Halifax B.VI; North American Mustang; Hermann Glauert; Alec Young; Dietrich Küchmann.

The following photographs are courtesy of the Farnborough Air Sciences Trust
Bomb damage 13 August 1940; Brian Squire; Frances Bradfield; Ditching model under construction; Ditching tank catapult; Ditching test 1951; The Rugby Club; The Amateur Dramatic Society.

Crown Copyright
Extract from Pilot’s Notes

The Journal of Aeronautical History thanks Hugh Warren’s sons Crispin and David for permission to publish this paper.
C. H. E. (Hugh) Warren
1918 - 2007

Read Mathematics at Trinity College, Cambridge; got a Distinction in Part III.

Summer 1939 Vacation student, RAE, not doing anything very much

On graduation, summer 1940, directed to RAE Aerodynamics Department as a reserved occupation

1940   Performance Section
1941   Wind Tunnels Section
1944   Seaplane Tank – ditching
1945   Controlled Weapons Department

Aerodynamics Department, High Speed Section
Structures Department, Head of Flutter, Vibration and Noise Division

Retired 1979

December 2004, gave the Cody Lecture to the Farnborough Branch of the Royal Aeronautical Society.

Died February 2007.