his way back to London. It was late in the day when he arrived and he was quite worried about a dinner appointment in London that evening which he did not want to miss. So we rearranged the demonstration flight to take place along a line from Martlesham to London, so that we could drop him off at North Weald at the conclusion of the test. This was an RAF Station on the outskirts of London; his Rolls Royce was sent ahead to meet him there.

For some reason which I have forgotten, our target was a Wellington of 'B Per T' flight, flown by Flight Lieutenant Slee—an old friend of the radar boys. I think he was already scheduled to do an altitude test that day, so it was decided that we might as well use him as a target. It is of some historical interest that this aircraft was the prototype Wellington undergoing its final acceptance tests. On this particular afternoon it was loaded down with bags of lead shot to 50 per cent over its design maximum weight. Later that afternoon, when we were close enough to have a good look at it, I was amazed. The air was relatively smooth, but from close astern that Wellington looked as if it were made of rubber. The wing tips flexed up and down three or four feet and the fuselage snaked about like a giant fish in a fish bowl. It was a fascinating sight and was the best example of aero-elasticity I have ever observed. Ever since, I have been very partial to aircraft which bend and flex their way through turbulence—as distinct from those which are rigid bodies and drive through without bending. I have an instinctive feeling that if anything is going to break in rough air, it is much more likely to happen to a rigid structure, rather than the one which bends and adjusts itself to the prevailing air currents.

Since the Wellington was carrying such a heavy load, it would take a long time to reach 15000feet so Slee took off early. We undertook to find him by radar somewhere between Martlesham and London. We gave him 20 or 30 minutes start and then followed in the Battle. Hetty Hyde was the pilot and his two passengers, a very portly Lindemann and myself, were squeezed onto the wooden plank across the back seat—the same plank which we had used for Stuffy Dowding, the Commander-in-Chief of Fighter Command, and for Winston Churchill only a few weeks before. We made a normal take-off but were hardly off the ground before it became obvious that something was badly wrong. Masses of black smoke started to pour out of the engine and boiling oil came streaming back over the cockpit. Hetty Hyde said: 'Christ' and snapped back his copkpit cover. The thought shot through my mind: could we ride it out or would we have to jump for it? In the rear cockpit were two seat-type parachutes, but they were on the floor and it would have taken Houdini himself to get into them.

Hetty made reassuring noises from the front 'I think we can make it.' He throttled back and as he did so the smoke subsided but the oil kept coming. With his head out of the cockpit, he did a very sedate circuit and, after what seemed an eternity, we made a smooth landing. The engine was still smoking furiously but the worst was clearly over and the fire-engine which drew alongside as we came to rest did not have to unwind the hoses. I have to say that Lindemann—an old Farnborough pilot from World War I—took all this in his stride. There was simply no panic and no visible reaction to speak about.

I climbed out on the wing and scrambled up to the front cockpit. Hetty's face and shoulders were covered in hot engine oil but otherwise he was unshaken. A quick check showed that someone had left the filler cap off the oil tank and practically all the oil had been pumped out; it had streamed out of the cowling and over the exhaust stubs and it was this which had caused all the smoke. It was a miracle the oil did not ignite. Lesser souls would have quit right there, but both Lindemann and Hetty Hyde were prepared to have another go. After a quick mop down and a refill with oil, Hetty restarted the engine. It seemed to be quite healthy and there was no more smoke, so we prepared for another take-off. This time, everything went well and it was not long before we caught up with the Wellington. We finished by giving Lindemann a very effective demonstration of radar interception and at the end of a long and rather eventful afternoon we headed for North Weald as planned. As we were on the final approach, Lindemann's Rolls Royce came through the Station gates to meet him. The timing could not have been better.

We expected that Lindemann would be impressed, at least with the technical part of the demonstration, but it was not so. He seemed to be in his usual mood of finding fault with everything and did not have a single positive suggestion to make. I wrote later '. . . he seemed rather peeved about the whole thing, and generally gave the impression it was a bit of a fraud'. When he got back to London, he gave us a poor report. Of all the distinguished people to whom we demonstrated airborne radar, Lindemann was the only one who was unimpressed. For reasons best known to himself, he continued to deprecate British radar, at least in its defensive role, for most of the war. Strangely enough, only when it was realised that radar might play an important role in the bombing of Germany did he become enthusiastic about its potential. But that is another story.

Air-Interception Trials in the Blenheim Aircraft

Following the Air Ministry decision to adopt the Benheim as a night fighter, we converted from Battles and began an intensive series of flight trials using the Blenheims K7033 and K7034 as night fighter and target respectively. Compared with the Battle, the Blenheim was a spacious aircraft in which it was relatively easy to install the gear. There was also no difficulty with the elevation aerials, but for the first time we ran into a nagging problem with the azimuth aerials. On the Battle we had used stub antennae on either side of the fuselage. This was a clean configuration which gave a very satisfactory azimuth pattern. However, compared with the Battle, the nose of the Blenheim was short and stubby, the skin was riddled with perspex windows and there were two huge radial engines, one on either side. It was difficult to find a location for the azimuth aerials which provided smooth overlapping beams and Wood, Chalky White and Mills spent a great deal of time swinging the aircraft on the compass base checking aerial patterns. They finally achieved a satisfactory pattern, but it was by no means as straightforward as it had been on the smooth profile provided by the Battle.

It was already July 1939 and things were rapidly coming to a head in Europe. Up to that time, little thought had been given to producing airborne radars in any quantity. Towards the end of 1938, anticipating a demand for production of airborne equipment at some future date, Watson Watt had placed a preliminary order for six airborne transmitters and six receivers with Metro-Vickers and A C Cossor Ltd respectively. These were the contractors already working on construction of the chain air-warning system and they were chosen simply because they had already established procedures for operating under the strict security arrangements which were then called for. They were asked to come to Bawdsey, obtain samples of our airborne equipment or a specification of requirements and to manufacture copies.

Our air-interception transmitter now used British equivalents of the original Western Electric 4304s and our best model was built into the leading edge of the rather thick wing of the Battle K9208. We had a spare ready to install in case of trouble and the Vickers representative asked for it as a model. We were reluctant to part with it as it was our only spare and demands on us were getting heavy. So, we gave him a full specification complete with sketches and photographs. However, he persisted and asked for at least something to take back to Manchester which he could run in the laboratory and obtain a pulsed transmission to measure against. In response to his plea, we gave him an old laboratory transmitter built on a wooden frame; we had once used it in the Ansons but it had long since been discarded. It worked tolerably well, but we made it clear that this was not the design to be copied.

Meanwhile, we gave Cossor a complete run-down on the receiver and specified the sensitivity, band width, output parameters, weight and so on. Once again, we could not let them have a model as we still literally had only the one receiver with the original EMI 45 Mc/s chassis as IF amplifier. They went away confident that they could deliver the equivalent and we were presented with their first six models a few months later. They were a complete failure. They did not come within a factor of ten of the required sensitivity and there was no obvious way of improving them. Furthermore, their weight was astronomical—they weighed more than our complete system up to that time. It was with some regret that we sent them back; we could have used several more receivers at that time. We heard no more from Cossor as potential manufacturers of airborne receivers, but I doubt whether they were much concerned; they were already fully loaded with orders for receivers for the main air-warning system and for Army radars. We did not receive any sample transmitters from Metro-Vickers at that time, but there was a later development concerning this particular company.

Something clearly had to be done about receivers. EMI would have been an obvious choice of contractors, but we were under some kind of restraint not to talk to them. Quite by chance in April or May of 1939, I heard some encouraging news from Edward Appleton, my old Professor at King's College and now the Jacksonian Professor of Physics at Cambridge. He told me that the Pye Radio Company, still hoping there would be a television industry in Britain, had set up a production line for 45 Mc/s TRF chassis and had actually made a trial run. I went hot-foot to Cambridge to see B J Edwards, the Technical Director of Pye Radio, and was rewarded with a remarkable sight—he had scores of TRF chassis of just the type we were looking for.

These used a new valve with an octal base which had not yet appeared on the market. It was the EF 50, a valve which was destined to play almost as important a part in the radar war as the magnetron itself. We were told that the EF 50 was manufactured by Mullard and we were assured that it was in good supply. However, when the Germans started to go through the Low Country in May 1940, a terrible thing happened. It was suddenly discovered that Mullard had in fact run into serious difficulty manufacturing the valve base and that, although the valves we were now depending on bore the Mullard label, all of them came from Philips at Eindhoven. Under circumstances which matched the Zeebrugge raid of World War I, a destroyer was dispatched post-haste to The Hague and, virtually under the German guns, something like 25000 complete EF 50s together with no fewer than 250000 valve bases were brought out from Holland.

Using these bases, Mullard was able to commence manufacture of EF 50s in Britain and the situation was saved. It happened that those valve bases from Holland had nine pins, not eight, and from that time onward the EF 50 was assembled on a nine pin base, not the original octal base. I took a few samples of the Pye chassis back to Bawdsey and we quickly verified that here was a product significantly better than our old EMI chassis; it was also smaller and lighter. Touch and his men quickly put a 200 Mc/s mixer in front and we were in business. B J Edwards did likewise in Cambridge and we were very nearly ready to go into limited production on airborne receivers. In addition to their expertise on receivers, the Pye Radio Company had also embarked on the production of a type of cathode-ray tube suitable for airborne radar. I passed all this information on to Watson Watt at the Air Ministry.

It was now the end of July 1939. We were satisfied that the new installation in the Blenhiem was behaving well and we looked forward to orders being placed for a few prototype models of both air-interception and sea-search radar. Up to that time, six was the number contemplated. What actually happened came as a considerable shock. With virtually no prior notice, we were told at the beginning of August that orders were being placed with Metro-Vickers for 30 transmitters and power supplies, and with Pye Radio for 30 receivers and that these not only had to be manufactured but fitted to 30 squadron aircraft in 30 days—literally by 1 September. This was barely a month after our demonstration to Stuffy Dowding, so the decision making had been rapid, but it bore little relation to the resources available to carry it out.

The setting of unrealistic and unattainable targets was something which plagued radar production until the end of the war. Whether this is the right way to proceed with technological warfare is open to grave doubt. Certainly, if the enemy makes an unexpected move or comes up with an unexpected technical development, a quick and intelligent response is called for. But in conducting long-term plans of the kind required in a national air defence system, there is no substitute for proper foresight. Tizard is the outstanding example of a man who worked out what was likely to happen many years before the event and saw to it that the right steps were taken. Unfortunately, Tizard was not in an executive position in the events now being described.

The original orders for six sets from Metro-Vickers and Cossor were not for complete airborne systems, but for transmitters and receivers only. We ourselves had to fit them together, supply the cables, fittings, and the innumerable bits and pieces which make up a complete system. We managed to persuade the Air Ministry to include in the Pye contract most of the switch-gear, power supplies, control panels and the rest of the components which made a complete assembly. But

there were no racks, no brackets, and no cable runs—nothing with which to install the completed equipment in an aircraft. Neither were there any shake tests, altitude tests nor acceptance tests, except of the most rudimentary kind. So much for the primitive conditions under which we worked and for the pious hopes of completing all this in 30 days.

We had another worry. The Ansons and Battles we had used so far, although slow and hardly up to their German equivalents, were wonderfully safe aircraft and ideal for experimental work. The Blenheims were a different matter. They did not come from the Bristol Aircraft Company which designed and built them in the first place but from the shadow factories which had just come into being. I have no wish to malign the dedicated and hard-working people who were doing their best for the country well before war was declared, but the Blenheims delivered to us were not as well built as they might have been. The factories were working under the same kind of pressures which were placed on us and the manufacturers were seldom given enough time to get the bugs out of the product. We were getting the first run of aircraft coming off the assembly lines and minor faults were obvious. Rows of rivets were often missing, the marriage of engine and airframe was not the best and after one or two flights one became apprehensive about what other faults might lie hidden under the skin of those aircraft.

Trouble was inevitable. The K7033 was returning to base one afternoon, trundling along in clear weather at 15000 feet over the tranquil Suffolk countryside, suddenly, the port engine gave a tremendous roar, the revs went up to an astronomical figure—and the propeller flew off. It sailed away into the distance, climbing sedately in an upward direction until it went out of sight. The pilot cut the engine and barely saved it from self-destruction. The Blenheim could fly reasonably well on one engine and there was plenty of height so it got back to Martlesham without further problems. The hydraulics were still operating, the wheels and flaps went down and the crew made a safe landing. It was subsequently found that a tooth had broken off the propeller reduction gear and jammed in the gear casing. It had cut its way into the propeller shaft and sheared it off like a parting tool on a high-speed lathe.

A new engine was installed and the K7033 was back in business, but we joked among ourselves that as the K7034 was the next number in sequence, it might soon perform in the same way. Sure enough, a few weeks later when the K7034 was acting as target, it suffered the same fate, except that this time the starboard propeller was lost. On returning to base, the crew found they had no hydraulics and could not get the wheels or the flaps down. They made a comparatively safe belly landing but the aircraft was a write-off. It was replaced by another Blenheim numbered K7044. The numbers were disconcertingly close.

In less than 24 hours there was an amusing sequel to this last episode. The propeller from the K7033 was never recovered. It must be lying at the bottom of a Suffolk creek or stream to this day. But the day after the K7034 incident, an irate farmer showed up at Martlesham Heath with a very bent propeller in the back of his truck. He told a highly coloured story of how he had heard a whirring noise in the sky. He looked up and saw a propeller coming down rotating at high speed. It then chased him around his home paddock and very nearly decapitated him. Next, it ploughed its way through both his chicken pens and his pigsties, where it caused terrible slaughter. He produced several carcasses to lend weight to his story. I do not know the end of the tale, but the Air Ministry employs legal wallahs to assess how much compensation is paid in such cases; I feel sure that a proper balance was finally struck between how much of it was fact and how much fiction.

Before any of the production sets arrived, Blenheims started to be delivered to 'D' flight, flown in by ferry pilots from factories in the Midlands. When they arrived we had another shock. They were not even the same model as the Blenheims previously sent to us—they were the so-called long-nose version. This meant that many of the fittings and cables we had prepared had to be modified. What was to prove even more of a problem was that the whole azimuth aerial layout had to be changed. This meant more uncertainty and several more weeks' work by Chalky White and Mills, measuring polar diagrams on the compass pad.

Meanwhile, the magnitude of the task we had been presented with bore down on us. If my count is correct, the total staff of the airborne group was just 23 people, including my faithful typist, Betty Holding, and the cleaning man. There were six or eight scientific staff, a corresponding number of technical and assistant staff and positively no one qualified to do aircraft fitting. There was no lack of people at Bawdsey by this time; the total staff was several hundred people, but in spite of the pressure being placed on the airborne group, the number of skilled hands available for airborne work was ludicrously small.

Meanwhile, transmitters and receivers started to arrive from Metro-Vickers and Pye respectively. To our dismay, there was a slip-up at Metro-Vickers. Instead of copying the 1939 transmitter which we had specified, they had copied the 1937 model—the wooden version which their engineer had taken away with him several months earlier to act as a laboratory test piece. When we protested, we were told that

during a visit to their Manchester factory Watson Watt had read them his lecture on putting up with third best and insisted that they produce the model which they had working on the laboratory bench, not the one we had specified. With only days to spare, we had no alternative but to go ahead and use them.

The incoming models were assembled at Bawdsey and tested against our standard target, the Trimley water tower. Due mostly to the improvement in gain coming from the Pye receiver, the range performance was excellent. The complete assemblies were then taken to Martlesham for installation in the Blenheims, which were now parked in a long line on the aerodrome. This was no neat production line under cover, it was strictly installation among the daisies and the dandelions, completely exposed to the wind and the weather. It was a case of all hands to the pumps, and every one of us pitched into installing units, running them up on the ground and then flight-testing them. We were helped enormously in the installation task by five civilian fitters who were drafted in from Farnborough under the supervision of a friendly foreman, whose name I seem to remember was 'Charlie'. These proved to be pearls without price and they soon carried the main load of actually fitting our airborne radars to the aircraft. However, it was obvious that starting from nothing on 1 August, we would never complete 30 installations by the end of the month.

The completed aircraft were to go to 25 Squadron at Northolt, who knew nothing about operating the equipment they would shortly be presented with. So in addition to the fitting programme, we hastily set up a schoolroom in a wooden hut alongside 'D' flight at Martlesham. The radar sets would be operated by rear gunners of 25 Squadron and eight or ten of them, together with several pilots, came up from Northolt to be shown the equipment and to receive some elementary instruction on what radar and air-interception was all about—all in the course of a week or ten days. The first Blenheim was delivered to the squadron in mid-August and, thanks to prodigious efforts, five more were delivered by the end of the month. By any standards, this must be regarded as a minor miracle. Hanbury Brown went with them to give further instruction to pilots and crew and to help with maintenance. This was a monumental task which in normal times would have called for a whole team to accomplish, but we could only spare one man and Hanbury was the only one with the necessary experience. One of these Blenheims was the only radar-equipped night fighter to be in the air over London on the first night of the war, with a civilian—Hanbury Brown—in the back seat as radar operator.

As already explained, the maximum range of an air-interception radar set on metre waves was limited by the height of the aircraft above