February/March 2015
Issue No. 153

Radio Bygones

ISSN 0956-974X

The Daventry Experiment: The Birth Of British Radar

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The Daventry Experiment: The Birth Of British Radar

by Brian Austin, G0GSF

If one learns one's history from the television, especially from what I believe are known as 'infotainment' programmes, then there is a distinct likelihood that some facts will either go awry or will be 'altered' in the interests of some other (presumably more lofty) artistic objective. And so it was with the recent BBC showing of the story of radar in Britain. Called *Castles in the Sky* it might just as easily have been called 'Pie in the Sky'.

So, in an attempt to correct some of the fallacies, falsehoods and even downright disingenuous assertions that occurred throughout that 'remarkable human drama', as the BBC billed it, this article will tell a rather different story, including that of the people most directly involved in it.

The Bomber Will Always Get Through

These now famous words are often quoted, especially when talk turns to the origins of radar in Britain. They were spoken by Stanley Baldwin, a three-time Prime Minister, who was then serving as Lord President of the Council in the national (coalition) government of Ramsay MacDonald. It was 1932. Baldwin was making a rather prophetic speech in the House of Commons in which he foresaw the approaching calamity of a resurgent Germany. Adolf Hitler, though only to become German Chancellor the following year, was already a massively looming danger and his Luftwaffe was soon to come into being. Already, the signs were ominous: German pilots had begun training in secret, in defiance of the terms of the Treaty of Versailles, while the German aircraft industry was manufacturing modern machines under the guise of developing civil aircraft. None of this could be entirely hidden and Baldwin, amongst others, had seen its implications.

There were many within the Air Ministry, particularly, who were especially concerned about Britain's vulnerability to attack from the air and even more concerned about its ability to defend itself against an airborne armada. To try to assess the risks, a major air defence exercise was held in 1934. It turned out to be a catastrophe with both the Air Ministry buildings themselves, as well as the Houses of Parliament, being 'destroyed' in a mock air raid. The defending fighter aircraft had been left floundering. As a result, all sorts of what we would now call 'early warning systems' were examined. Many were almost laughably ineffective, while some of the suggested schemes proved rich feeding grounds for charlatans and others who saw an opportunity to line their pockets at the government's expense.

The 'Death Ray'

Many suggested schemes and ideas were examined; some even got as far as being tested. One claim which attracted the attention of the press, as well as reaching the ears of the Air Ministry, was a mysterious device evidently capable of producing what was called a 'death ray'. It was said that such a ray could disable a motor cycle engine at a distance, as well as explode gunpowder and it could even shoot down aeroplanes! However, no convincing demonstrations followed even though some in the press, as well as a few well-heeled entrepreneurs, were highly enthusiastic about this new weapon. Some within the Air Ministry followed all those stories with a degree of interest but also with a large slice of scepticism and, in an attempt to produce experimental evidence to back up the claims, the Ministry offered £1,000 to the first person who could kill a sheep by such a ray at a distance of 100 yards. No one ever claimed the money [1].

But there was within the Air Ministry one man who had taken a very particular interest in all aspects of air defence and he was most perturbed by the ineffectiveness of all the somewhat more mundane methods of detecting and possibly even destroying enemy

A P Rowe of the Air Ministry

H E Wimperis, the Air Ministry's Director of Scientific Research

Sir Henry Tizard, chairman of the committee that bore his name

Sir Robert Watson-Watt, the father of British radar

Arnold 'Skip' Wilkins, the man who proved it could be done

aircraft. He was A P Rowe, a physicist with a 1st class honours degree from the Royal College of Science, University of London. After studying all the Air Ministry's files on the subject, Rowe wrote a memorandum to his immediate boss, H E Wimperis, then Director of Scientific Research at the Air Ministry. Wimperis, too, had been a student at the Royal College of Science before completing an engineering degree at Cambridge and he acted immediately on reading Rowe's far from reassuring summary of those files.

Britain was essentially defenceless against attack from the air and immediate scientific action was needed to address the problem. And to answer, once and for all, the persistent claims from some quarters about this 'death ray' Wimperis approached a physiologist, the Nobel Prize winner, Professor A V Hill at University College London, in order to get his views on the feasibility of such a weapon. Hill told him what thermal effects might disable a pilot, but how they might be achieved by using electromagnetic (EM) waves would require specialist study. To investigate this and all other related matters further, Wimperis established a committee. It was charged with examining all scientific aspects of air defence. The committee would be chaired by Henry Tizard FRS, the Rector of Imperial College and an Oxford-educated chemist with a distinguished record in aeronautical research during the First World War. Hill was appointed as its first member. Soon he was joined by Professor P M S Blackett, a highly-regarded physicist from Cambridge who was subsequently to win the Nobel Prize. Thus the Committee for the Scientific Survey of Air Defence (CSSAD) came into being with Wimperis himself completing its numbers. This group of scientists under their distinguished chairman has, ever since, been known as the Tizard Committee. Its secretary was A P Rowe [2].

To provide the expert advice about there being any likelihood of generating a death ray Wimperis then turned, on 18th January 1935, to the superintendent of the Radio Research Station (RRS), which was then part of the National Physical Laboratory, based at Ditton Park, Slough. Robert Watson Watt (whose name acquired a hyphen after his knighthood in 1942) obtained a degree in electrical engineering (with special emphasis on physics as applied to wireless telegraphy) from the University of Dundee in 1914. During the First World War he worked on radio direction finding methods to track thunderstorms and so provide warning of their presence to aircraft. This work was initially done under the auspices of the Meteorological Department of the Royal Aircraft Establishment. In 1927 it was amalgamated with the direction finding research at the National Physical Laboratory and the new organisation became the Radio Research Station with Watson-Watt as its superintendent.

It was while he was at Slough that Watson-Watt became an expert in the use of the recently developed cathode ray tube as well as in the antenna techniques required for direction finding by radio. In addition, following the original work of the Americans, Breit and Tuve, who used pulses of electromagnetic energy to investigate the ionosphere, Watson-Watt soon became very familiar with this pulse technique for making accurate measurements of distance as well. It was while he was making his own investigation, in 1926, of the electrically charged layers above the earth that he coined the term 'ionosphere' to describe them. Thus Watson-Watt was undoubtedly the man to advise the Air Ministry on practical matters to do with radio waves. When he was called upon he responded immediately and his enthusiasm for a challenge was both palpable and infectious [3].

Watson-Watt and Wilkins

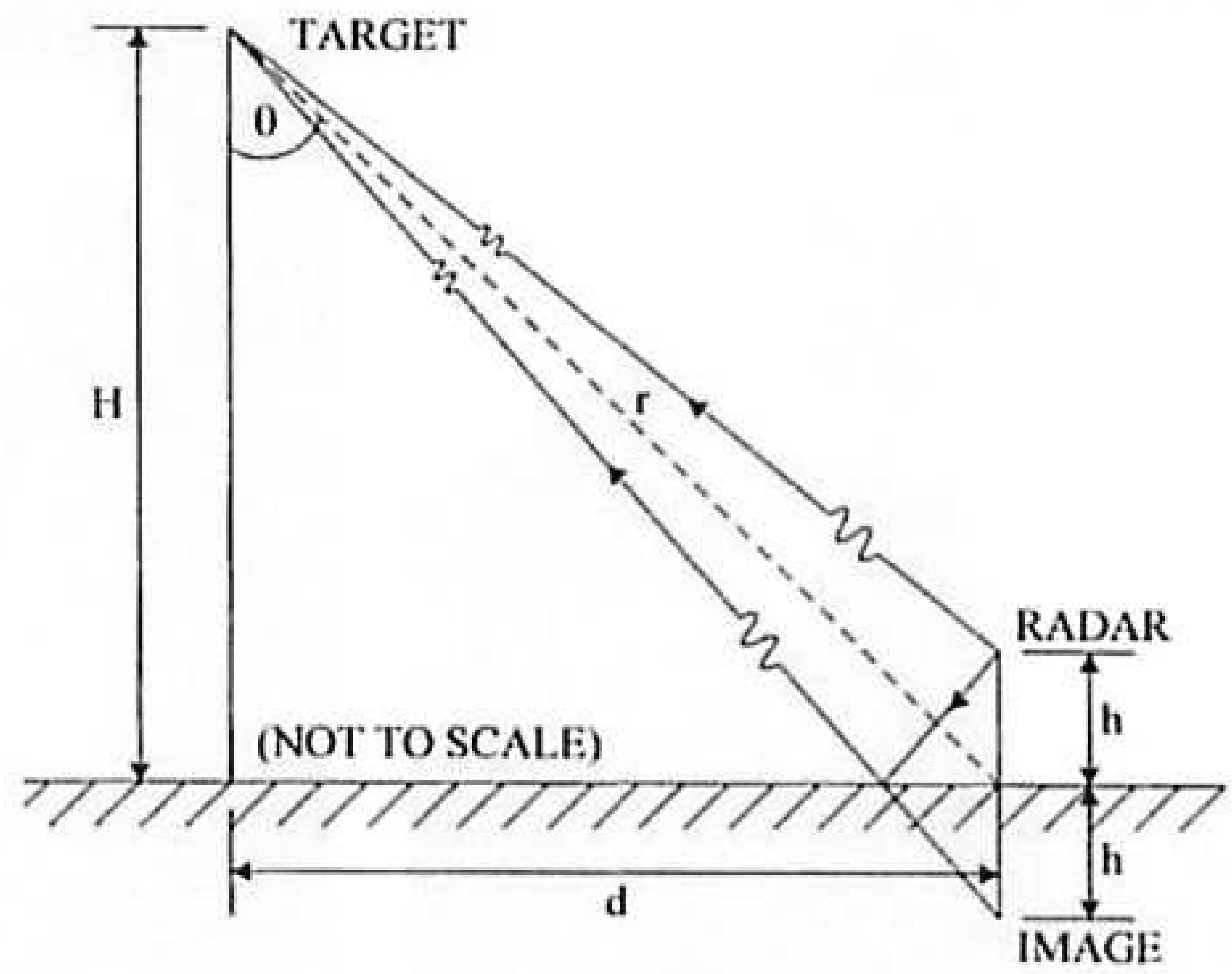
As soon as it was put to him, Watson-Watt dismissed on technical grounds the possibility of a death ray. But he agreed to have his colleague Arnold Wilkins do the calculations to show, definitively, how much power would be required to have any measurable effect on either a pilot or an aircraft flying at a distance of 5km and a height of 1km from a radio transmitting antenna. As Wilkins remembered it, he found a note on his desk from Watson-Watt, written on a torn-out leaf from a desk calendar, asking him to calculate the amount of HF power needed to raise the temperature of eight pints of water from 98 degrees Fahrenheit to 105 degrees. It didn't take Wilkins long to realise that the eight pints of water was approximately the amount of blood in a typical human being, and the fact that he was a kilometre above the ground at the time suggested he must be in an aeroplane, perhaps its pilot.

Wilkins's mathematics very quickly revealed that many gigawatts would be needed to bring about such an increase in body temperature, and even to achieve that one had to make all sorts of completely impractical assumptions. The power would have to be accurately focused on the pilot, which clearly had implications for the antenna, bearing in mind that the targeted aircraft was moving pretty rapidly. In addition, most modern aircraft were metal-skinned so the pilot (and the aircraft's engine) would, for the most part, be shielded from any electromagnetic waves. Furthermore, if an antenna with an extremely high gain were used, so that the actual transmitter power could be reduced in proportion, the power required would still be unachievably large, by almost any standards, let alone those applying in 1935. And then there was the matter of the operators of this apparatus on the ground. Any side lobes of radiation from the antenna would almost certainly place them in an even more risky situation than that encountered by the pilot many thousands of metres away.

And so the death ray could be forgotten about. Tizard's Committee was made aware of this in the first of Watson-Watt's famous memoranda which was delivered on 28th January 1935, just ten days after the request from Wimperis to Watson-Watt for advice on the matter [2,4]. However, as soon as Watson-Watt had seen Wilkins's calculations ruling out the feasibility of the death ray he asked him if there was anything else they could do to assist the Air Ministry. There certainly was. But who was Arnold Wilkins?

Arnold 'Skip' Wilkins was born in 1907. He was a physicist with a BSc degree from Manchester and an MSc from Cambridge. He joined the National Physical Laboratory in 1931 and was based at the Radio Research Station in Slough where he specialised in making measurements of the ionosphere as part of the laboratory's radio propagation research programme. In January 1935, when he was asked to comment on the 'death ray', he was a Scientific Officer with a wealth of experience in the art and science of radio engineering.

Fig. 1. Diagrammatic view of a ground-based transmitter and its airborne target



In answer to Watson-Watt's question (posed above) Wilkins mentioned that he had been told by Post Office engineers that they had experienced disturbances to their VHF communications systems when aircraft flew nearby. This phenomenon, he suggested, might be useful for detecting aircraft in flight. Watson-Watt then asked Wilkins to calculate the strength, on the ground, of any energy that might be reflected by an aircraft at some height and distance from a ground-based transmitter.

Watson-Watt's own recollection of this most important request, in his 1957 autobiography *Three Steps to Victory*, differs somewhat from Wilkins's but that fascinating and at times almost embarrassingly grandiose book, written in the ultra-verbose style of 'the best salesman I have ever met', according to one of his later radar colleagues [5], should not be regarded as the last word in historical accuracy.

Fantasy Becomes Radar

Having disposed of the possibility of disabling either a pilot or his aircraft by means of electromagnetic waves, Wilkins set out to calculate how feasible it might be to detect an aircraft by those same means. Having discussed the matter with Watson-Watt, Wilkins began by using the fact that the wings of a typical bomber were about 75 feet (or roughly 25 metres) long. His next assumption was the crucial one because it determined the frequency of the ground-based transmitter. If the wing behaved as a resonant antenna – in other words it was a half-wavelength dipole – then the transmitter must operate at a wavelength of about 50m or a frequency of around 6MHz [6].

Together they agreed to consider the case where the bomber was assumed to be flying at an altitude of 6km and at a distance of 6km from the horizontally polarised transmitting antenna on the ground. From this it is a simple matter to determine the angle at which the ground-based antenna must radiate its energy in order to 'illuminate' the target. Based on these assumptions Wilkins set to and worked out the various field strengths, currents, power densities and whatever else were needed to answer Watson-Watt's prophetic question. It should be made clear at this stage that the method Wilkins used to do this, and the equations he must have formulated, were never published; only the answers were. They are to be found in the famous memorandum that Watson-Watt sent to the Tizard Committee on 27th February 1935. This remarkable document, always known as the Watson-Watt Memorandum, is published in full in both his autobiography [7] as well as in Appendix D of reference [2].

A Mathematical Model

In 1993, while recovering from a bout of 'flu, I became intrigued by Arnold Wilkins's numerical results and wondered whether I could derive them myself by using fairly straight-forward antenna theory. I set up what we call a mathematical model where the aircraft was represented simply by a horizontal half-wavelength dipole 25m in length. Using the Wilkins model the aircraft (dipole) was assumed to be flying at an altitude of 6,000 metres and the ground range from the transmitting antenna (a halfwave dipole) was also 6km. Any antenna above the ground is always assumed to have an image within the ground at a depth equal to the height of the antenna. This follows the same principle that applies in optics and is well-known whenever we look in a mirror and see our image as far behind the mirror as we are in front of it. The ray diagram in **Figure 1** illustrates the situation.

It should be noted from this diagram that not one but two 'rays' representing the electric field actually strike the target. The first is the direct ray E_d while the second is the reflected ray E_r caused by the incident field striking the ground and then rebounding into space after having its phase changed by 180 degrees. This happens when the horizontally polarised field strikes the ground. It has to satisfy what are called the boundary conditions which always exist when two different media (in this case air and ground) meet.

It clearly helps in the analysis to show the image antenna within the ground with this reflected ray coming directly from it. The required elevation angle of this incident energy is easily shown, from the geometry, to be equal to 45 degrees. Now, in order to produce the maximum intensity of electric field at that angle requires the transmitting antenna to be at the correct height above the ground. We can find that height by using the theory of an array of antennas – for that is what we have: the antenna and its image simply constitute a simple two-element array.

For those interested in how all this is done, the detailed mathematics can be found in my paper published in 1999 [8].

The Numbers

So, what did the sums show? It turns out that to radiate its strongest signal in the direction of the aircraft the antenna needs to be 17.7m high at a wavelength of 50m. Wilkins said 18m, so we agree within acceptable limits of engineering accuracy. Then, from the geometry shown in the figure, the 'slant range' r between the radar antenna and the target aircraft is

$$r=\sqrt{6^2+6^2}=8.5\text{km}$$

With that result and another mathematical relationship from antenna theory, the maximum field strength at the target can be shown to be

$$E_t=120I_m/r$$

where I_m is the current at the centre of the transmitting antenna. Thus we find that for every amp flowing in that antenna, the total field at the target is

$$E_t=\frac{120}{8.5\times10^3}=14.1\text{mV/m}$$

which agrees with Wilkins's result of 'about 14mV/m'.

Now, if the target is to reflect the energy contained within the EM wave there needs to be current induced into it. The question is how much current would be induced by this field into the wings of the aircraft, assuming them to be highly conducting and parallel to that electric field in space? As we saw above, Watson-Watt and Wilkins assumed that their target would be a typical modern German bomber of metal-skinned construction and 'well-bonded throughout' [6]. Therefore, we can safely assume that all losses will be minimal and that the resistance of the wings is due almost entirely to its radiation resistance, or about 73ohms, being a resonant half-wave dipole. Conventional antenna theory, involving the effective aperture or capture area of an antenna, yields the expression for that induced current, I_w. It turns out to be

$$I_w=\frac{E_t\lambda}{\pi}\sqrt{\frac{G_r}{480R_{rad}}}$$

and substituting the numerical values of $E_t = 0.0141$, $\lambda = 50$, $R_{rad} = 73$ and G_r (the gain of a half-wave dipole) as 1.64, the induced current is 1.54mA for every amp of current flowing in the transmitting antenna on the ground. Once again this agrees with Wilkins's quoted value of 'about 1.5 milliamperes per ampere in the sending aerial' [2,7].

The next calculation is perhaps the most crucial one. It determined whether the target aircraft would reflect sufficient energy to be detectable on the ground. Since it is assumed to be lossless, the aircraft wing simply re-radiates all the energy incident upon it. When Wilkins made his calculations in 1935 the concept of what we call 'radar cross-section' or RCS was, obviously, unknown. So he used the current induced in the wing of the aircraft to find how much power the target dipole would re-radiate, just as if it behaved as a transmitting antenna. I adopted the same approach to see what the field strength would be back on the ground at the position of the transmitting antenna. In his memorandum Watson-Watt said that the 'reflected field returned to the vicinity of the sending aerial would be about 20 microvolts per metre per ampere in sending aerial'. The equation for determining the electric field back on the ground turns out to be

$$E_g=\frac{E_t\lambda}{\pi r}\sqrt{\frac{30G_r}{R_{rad}}}$$

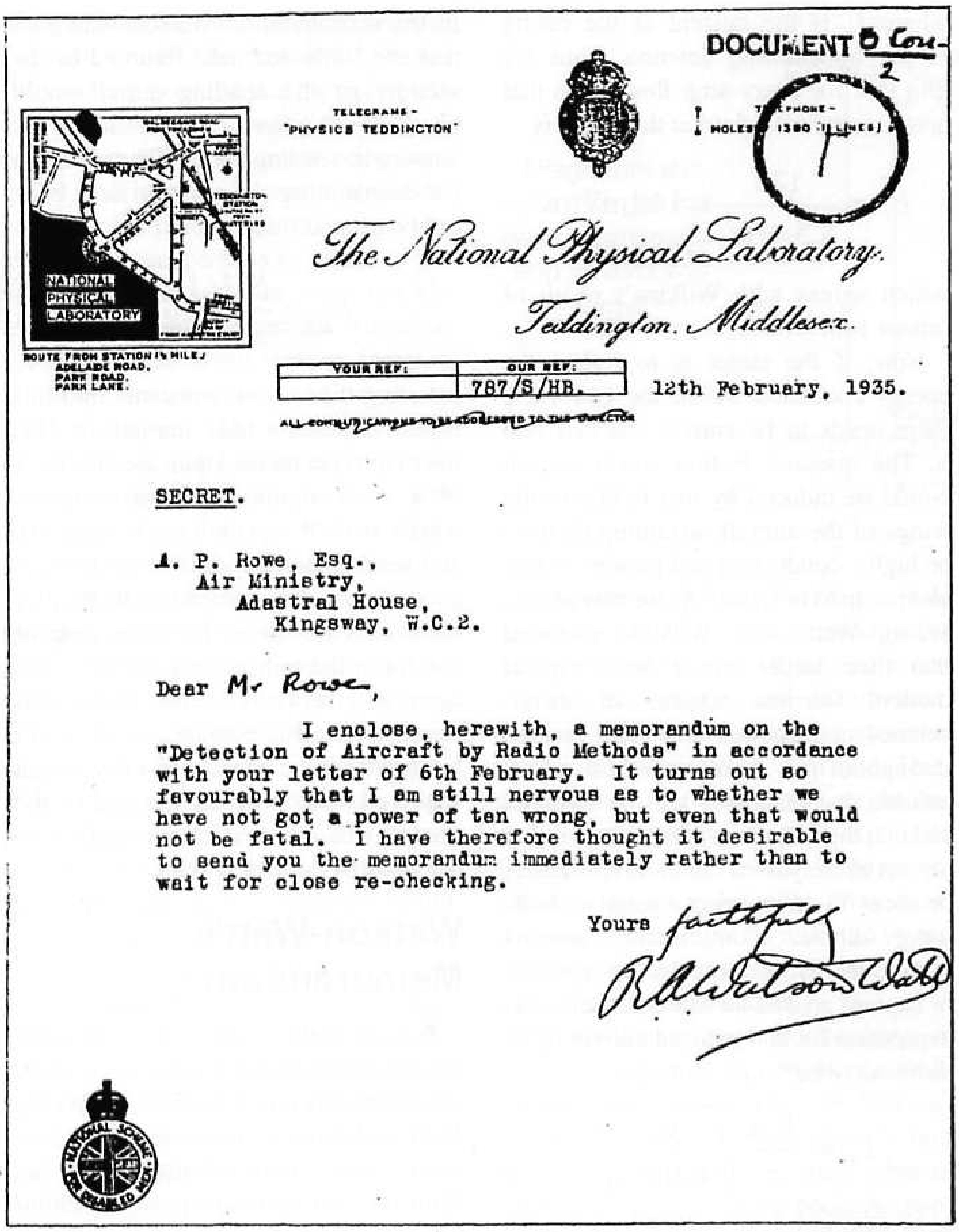
Inserting the various constants into this equation yields a field strength of 21.6 microvolts per metre. I then used the RCS of a short-circuited half-wave dipole, which is 0.86 square wavelengths [9], and recalculated the field strength back on the ground. It turned out to be 21.7 microvolts per metre for every amp of current in the transmitting antenna. The agreement between the two methods is almost exact. But perhaps one shouldn't be surprised: the concept of RCS, which was well-understood by the end of the war, was based on a similar analysis to that used by Arnold Wilkins.

Watson-Watt's Memorandum

Watson-Watt, in his second memorandum to the Tizard Committee, submitted in draft form on 12th February 1935 and in its final version some two weeks later, duly informed the Air Ministry that common practice within the shortwave broadcasting world at that time was to drive currents of around 15A into their transmitting antennas, this would yield a value at the ground 'of the order of a tenth of a millivolt per metre' and indeed it would. Since field strengths of that magnitude were well within the receiving capability of equipment then in service he concluded that it would certainly be possible to detect an aircraft by means of suitable apparatus on the ground [6,7].

We must remember that, at this stage, this entirely new technology had no name. Only some time later would Watson-Watt call it RDF (which itself had no meaning at all, incidentally) and then finally, in 1940, the American term RADAR – a clever palindrome meaning radio detection and ranging – would be universally adopted.

That famous Memorandum contained very much more than just the outcome of Arnold Wilkins's calculations, as significant as they were. It described, for example, how, by transmitting a series of brief pulses of energy, all


DOCUMENT

TELEGRAMS - "PHYSICS TEDDINGTON"

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ROUTE FROM STATION (¼ MILE)
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	787/S/HB.

12th February, 1935.

ALL COMMUNICATIONS TO BE ADDRESSED TO THE DIRECTOR

SECRET.

A. P. Rowe, Esq.,
Air Ministry,
Adastral House,
Kingsway, W.C.2.

Dear Mr Rowe,

I enclose, herewith, a memorandum on the "Detection of Aircraft by Radio Methods" in accordance with your letter of 6th February. It turns out so favourably that I am still nervous as to whether we have not got a power of ten wrong, but even that would not be fatal. I have therefore thought it desirable to send you the memorandum immediately rather than to wait for close re-checking.

Yours faithfully
R A Watson Watt

The letter from Watson-Watt that accompanied his famous memorandum

equally spaced in time, it would be possible to measure, on the cathode ray tube screen, the range of the target aircraft. Such methods were already well-known and much used at Slough in the research on the ionosphere that had started as early as 1931.

The Memorandum then went on to describe how, by positioning a 'line of senders over a long front', it would be possible to provide a continuous tracking capability covering a large area. This was, in essence, the Chain Home system that was soon to save the country during the Battle of Britain. Watson-Watt then described how the height of an aircraft could be determined by using well-established procedures worked out at Slough many years before as part of the RRS research activity in tracking and following thunderstorms by the radio-frequency emissions produced by lightning. He also emphasized how important the cathode ray tube (CRT) would be in this process and pointed out that his team was exceptionally well-versed in its use. In fact they acquired, from the United States, the very first CRT to arrive in England as early as 1922 [3].

Watson-Watt also considered likely problems that might be caused by ionospheric reflections, since the 6MHz frequency range chosen fell within that part of the HF spectrum where the ionosphere was a very strong reflector of EM energy. To mitigate this he said that a move to a higher frequency (or shorter wavelength), such as 10m, might well be preferable because ionospheric reflection was far less likely up there. But the constraint against doing that immediately was the unavailability of suitable high-power valves for use in the transmitter. Finally, he even described how 'friendly' aircraft would be able to identify themselves when they were illuminated by British radars. This involved fitting all the RAF's aircraft with a 'keyed resonating array'. This crucial comment, though only made in the Memorandum's penultimate paragraph, was actually the first proposal of what subsequently became a vitally important weapon in the British radar armoury: Identification Friend or Foe, or IFF as it was to be called.

Dowding's Decision

Having read the Watson-Watt Memorandum and absorbed its highly significant conclusions, the Tizard Committee instructed Wimperis to ask Air Marshal Dowding, the RAF's Air Member for Research and Development, for £10,000 (around £600,000 in today's money) to immediately commence full-blown experiments. But Dowding, though much impressed with what had been told to him, first requested a demonstration to prove that theory and practice actually agreed with one another. He stipulated that it should take place with the absolute minimum of delay and gave Wimperis the authority to arrange for a suitable 'target' aircraft to be used for the trial [4].

Initially, Watson-Watt thought that the ionospheric-sounding equipment at Slough could be modified to produce both the required amount of transmitter power as well as the short pulses of energy needed to detect a target some tens of miles distant. However, Wilkins

Air Chief Marshal Sir Hugh 'Stuffy' Dowding convinced him that this would not only prove difficult to do in the time available, but that it was not even necessary in the first instance. All that was needed was a transmitter, operating on the right wavelength, which produced sufficient power that could be received back on the ground after being reflected by the aircraft. And from his previous involvement with the BBC, when conducting propagation experiments, Wilkins knew that the shortwave transmitter at Daventry would be ideal for this purpose.

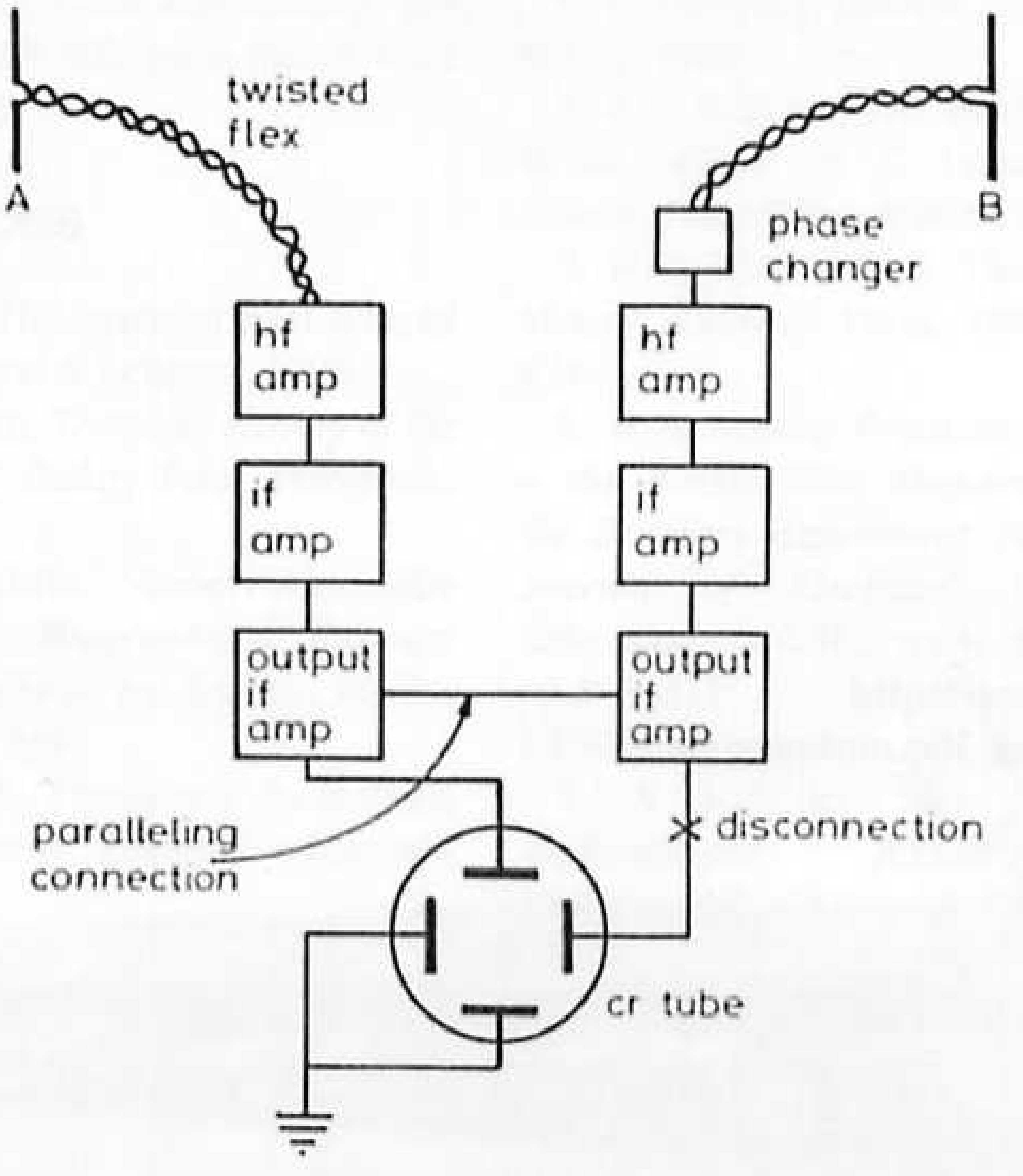


Fig.2. A block diagram of the equipment used at Daventry

The Experiment At Daventry

The Daventry transmitter (callsign GSA) of the BBC's Empire Service operated in the 49 metre band and generated about 10kW of power. The antenna produced a fairly broad beam radiating in a south-easterly direction. It was Wilkins's intention to have a metal-skinned aircraft, of the correct wingspan, fly along the axis of the beam while the Daventry transmitter produced an unmodulated carrier. This would require coordination with the BBC but since the group at Slough knew their technical colleagues at the BBC very well this should not be a problem.

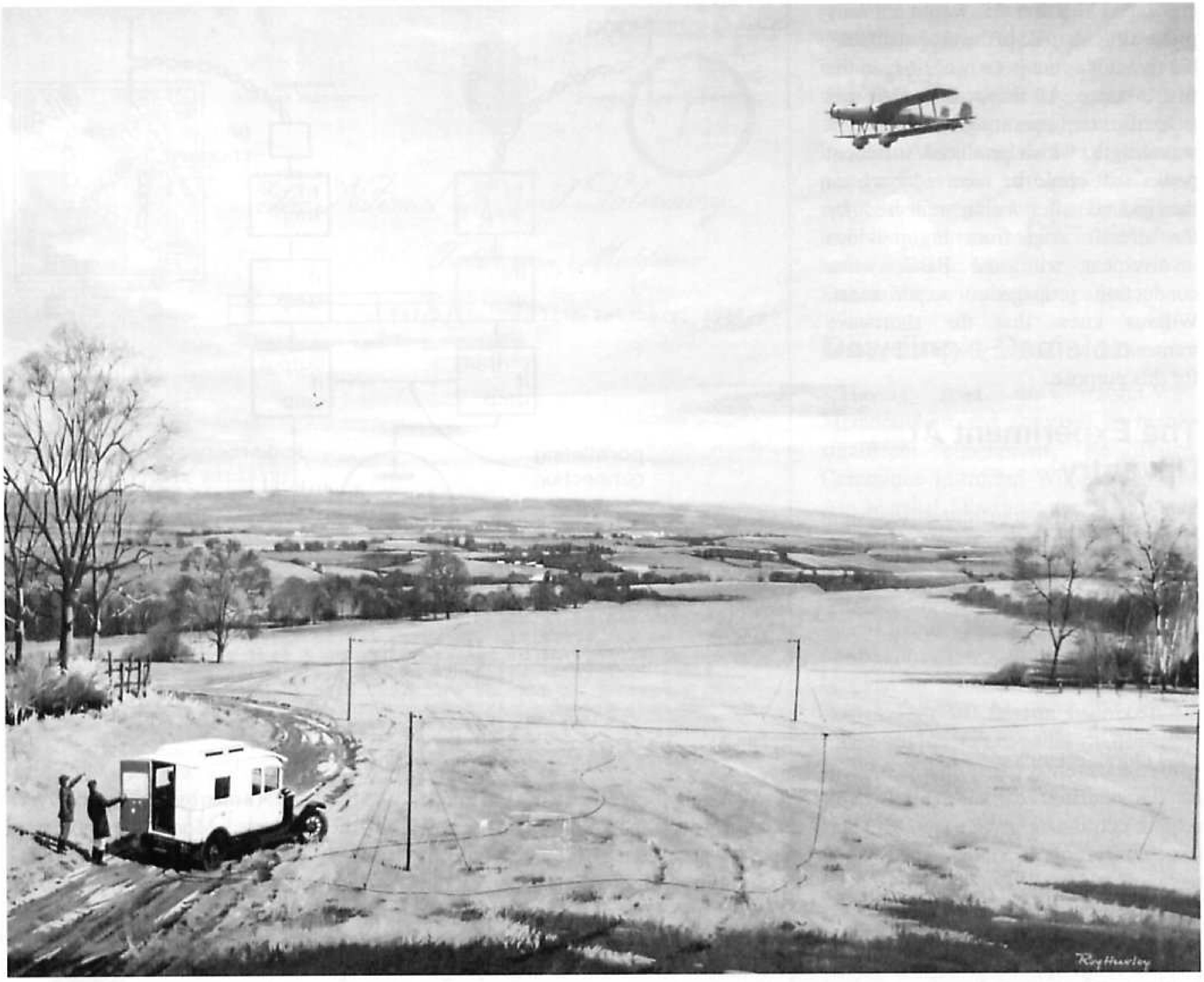
Wilkins immediately set to work. He planned to set up, at a distance of some six or seven miles from the Daventry transmitter, two horizontal parallel half-wave dipole antennas around 100 feet apart and aligned at right angles to the main beam from the BBC transmitter. To detect the reflected signal from an aircraft flying along that beam while discriminating against the ground wave, he planned to use a well-tried and tested phase-shifter of his own design to cause a 180 degree phase-shift in one of those antenna feedlines (**Figure 2**). After the two signals had been individually amplified and shifted to the IF in their respective receive paths, they would be combined, and being in anti-phase would cancel, leaving just a stationary dot on the CRT screen. By ensuring that the amplitudes of the signals in those separate receive paths were carefully balanced this nulling process would be perfect. However, the passage of an aircraft overhead would lead to a reflected ray which would cause a deflection on the CRT screen. And this is what they hoped to see when the test took place.

It duly did on 26th February 1935. An RAF Heyford bomber had been assigned by the Royal Aircraft Establishment at Farnborough for this task. It was piloted by Flight Lieutenant R S Blucke, flight commander of the Wireless and Electrical Flight [4]. The plan was to fly to Daventry where, on arrival, Blucke would fire a Verey light to indicate his presence. He would then follow a particular course that would take him along the transmitted beam from the BBC transmitter at an altitude of 6,000 feet. After executing an about turn over some designated marker he would fly back to Daventry while losing altitude to around 1,000 feet. After firing another Verey light he would then head for home.

Blucke and his observer, a Mr W T Davies who was responsible for the installation of new radio equipment in the RAE's test aircraft, duly took off shortly before 9 a.m. on the morning of the 26th. Though encountering a stronger headwind than expected and having a few problems with the map, Blucke duly made a number of passes over the area, each time reversing his course as required. On his return to Farnborough he considered the flight to have been completely uneventful and promptly forgot about it. Only later did he learn of its significance in the annals of radar [4].

On the ground, not far from the village of Weedon, Watson-Watt and A P Rowe from the Air Ministry had joined Wilkins and the driver (a man by the name of Dyer) of the converted Morris ex-ambulance that served as the RRS's rather grandly-named travelling laboratory. Together, the night before, Wilkins and Dyer had erected the two parallel antennas in a co-operative farmer's field. Wilkins then set about balancing the two receivers in the vehicle, but this task was somewhat impeded because he had forgotten to take with them any form of battery-powered light and the lamp in the old ambulance had long-since ceased to function. So, by the light of numerous matches he managed to complete the task, but had just five minutes before the BBC transmission closed down for the night, to check that the phase shifter did its job and that the direct signal could be nulled satisfactorily.

The Heyford bomber number K6902 used in the Daventry experiment



The Daventry test site as painted by Roy Huxley using a little artistic licence in the direction of the aircraft

Air Vice-Marshal R S Blucke some years after the test flight

When Blucke's aircraft appeared the next morning it was initially well to the east of the agreed flight path and no indication of its presence appeared on the CRT screen. However, on its next pass, now closer to the observers, there were definite variations on the CRT screen – a 'rhythmic beating' Wilkins described it – with good beats continuing as the aircraft flew off to the south. This happened again on the following run and Wilkins and Watson-Watt estimated that they were able to observe the Heyford over a distance of about eight miles.

Neither Watson-Watt nor Rowe who, with Wilkins, had witnessed the fluctuations on the cathode ray tube (Dyer, who was not party to the secret, having been dispatched to a remote corner of the field!) showed any elation when it was over. They duly said their good-byes and left immediately for London. Wilkins, likewise, was unemotional but he admitted later that, inwardly, he had felt highly elated and not a little relieved that his calculations had been shown, essentially, to be correct [6].

This remarkable event, in a farmer's field, using a make-shift collection of equipment, put together in a minimum amount of time, was the precursor of radar in Britain. Much remained to be done before Watson-Watt's eventual radar system, of which he can justifiably be called the father, came into being. But the Daventry experiment was the beginning of it all.

Conclusion

Despite what makers of 'docu-dramas' would have us believe, there was no class war being fought between the men from the Air Ministry and their scientific colleagues in Slough. And neither were Watson-Watt and Arnold Wilkins a pair of hyperactive and highly-strung prima donnas. In addition, the BBC transmitter at Daventry did not suddenly deviate from its usual mode of amplitude modulation to generate a stream of pulses, nor did the receiving apparatus in the RSS's converted ambulance explode at the completion of the Daventry experiment. Such deviations from the facts (plus many others) were clearly chosen for dramatic effect which, presumably, is more important to some than preserving the historical record.

What was achieved by those extremely talented and dedicated men at Slough, and by those who were soon to join them at Orfordness and then at Bawdsey Manor, will go down in history as one of the landmark events in British science and engineering, but presumably dull television had it been told as it really was.

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RB

Feedback...

...where you can air your views

Letters should be original and not copied to or from other publications. The views expressed here are not necessarily those of the Editor

Navy Receiver

I was pleased to see in *RB152* an article by Ben Nock. Ben can always be depended upon to deliver interesting articles about interesting receivers. I was delighted to find he had written about a receiver whose details I had long been on the look out for, the little Naval regenerative TRF receiver.

Ben expresses surprise on a seemingly rather obsolete design still being made in 1941. However, there is more to this than technical simplicity. The Germans also were using regenerative TRF receivers, one example being the remarkable TORN Eb. beautifully made with two RF stages and die-cast coil turret. Although they all had advanced superhets, navies were cautious about using them because of the possibility of the local oscillators radiating sufficient signal for the enemy to being able to use direction finding to locate ships.

One solution the Americans employed was by careful design of superhets. The Scott communications receiver used in Liberty Ships had elaborate filtering and screening, even to the extent of building the input RF stage into its own box.

Let's not underestimate the simple regenerative TRF. Anyone who has used well made examples will vouch for their surprising performance, especially with CW transmissions. Sensitivity is such that atmospheric noise level is the limiting factor. (By the way, I suggest that to restore audio gain Ben could use the substitute output transformer primary as an audio choke, coupled to high impedance headphones via a 0.25μF capacitor.)

By a strange coincidence, the very evening that I read Ben's article I discovered that the little TRF was not confined to ship board use. I had recorded a Northern Ireland BBC *Battle of the Atlantic* documentary which included a description of a Naval operations bunker. In the playback, a brief shot showed radio operators in action. It was brief, but long enough for me to note an interesting detail. Each position had in the top left corner one of Ben's receivers painted black rather than blue. A photograph of the TV screen is attached.

Finally, Ben notes a confusion found in some early circuit diagrams. In his example a grid leak value reads as 2 ohms rather than 2 megohms. Other resistors are listed on the diagram with a suffix that looks like a cursive w. The explanation is that the upper case omega was used for megohms, the lower case omega for ohms.

Peter Lankshear, via email

F.G. Rayer Designs

I was fascinated by Stef Niewiadomski's fine exposition of the writings of F.G. Rayer in *Radio Bygones* 149 and 150, as I have built many of FGR's designs over the years. Looking through my collection of *Practical Wireless*, which goes further back than Stef's, I have found the following article in the issue for March 1943, pages 139 & 140: *A Two-valve Shortwave Receiver* by F.G. Rayer. I do not claim that this is his earliest publication as my collection, like Stef's, is incomplete, so maybe some other collector of *PW* who has issues going further back than ours could find an even earlier contribution of his?

Jim Jobe, M0JBJ, via email