CHELMSFORD

NEWS AND VIEWS

Marconi
Radar Systems

RADAR HISTORY SPECIAL EDITION

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CHELMSFORD NEWS AND VIEWS
Marconi Radar Systems

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THE DAVENTRY

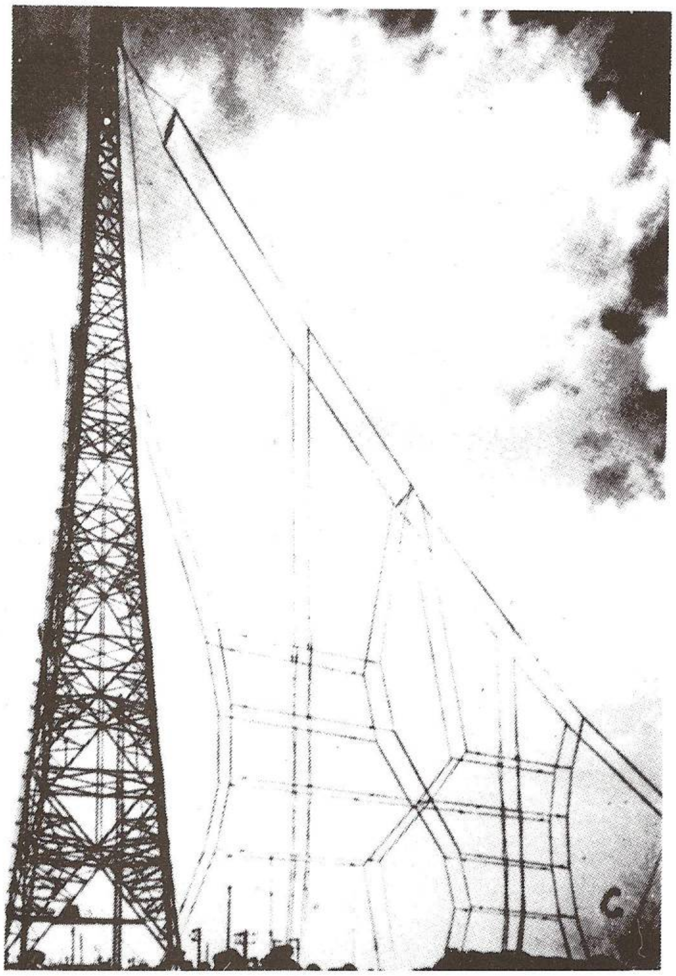


FIG. 1. B.B.C. DAVENTRY S.W. BEAM TRANSMITTING STATION.

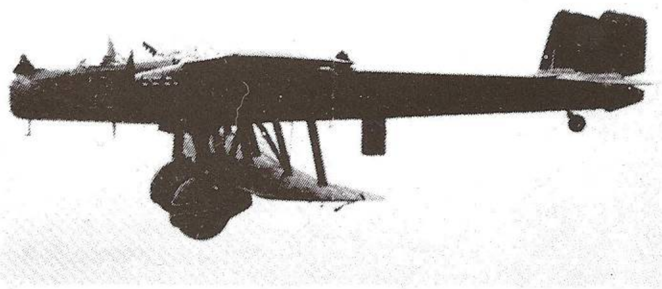


FIG. 2. THE "HEYFORD" BOMBER.

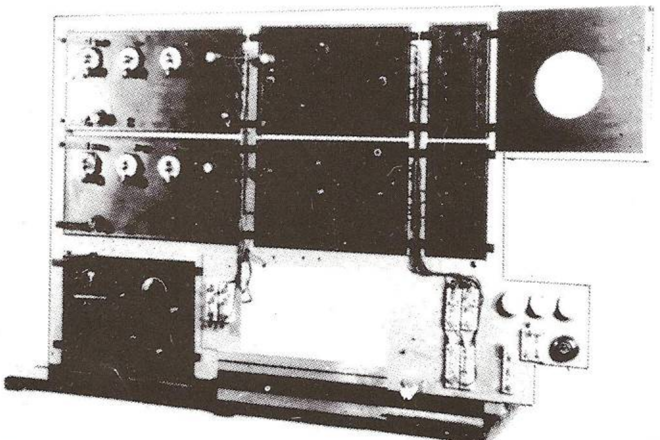


FIG 3. THE ACTUAL RECEIVER USED IN THE EXPERIMENT SHOWING C.R.T.

THE "DAVENTRY EXPERIMENT"

by Bruce Neale

A brief account of the celebrated experiment which provided the basis of an air defence system that saved Britain from the heel of Nazi tyranny and, post war, initiated a multi-million pound electronic industry.

FIFTY YEARS AGO, on the 26th February, 1935, a simple experiment in a field near Daventry conclusively demonstrated that aircraft could be detected by 'wireless'. With the rapid build up of offensive forces in Germany, this was a glimmer of hope for a country whose only early warning of air attack was a huge concrete acoustic mirror on Romney Marshes.

The experiment arose directly from a theoretical study to resolve, once and for all, the feasibility of the so-called Death Ray. Ever since the Great War, crank 'scientists' had been claiming to have invented a Death Ray. In the early thirties, the Air Ministry publicly offered £1,000 to anyone who could kill a sheep at a range of 100 feet by such a ray. Needless to say, the sheep continued to 'safely graze' and nobody claimed the £1,000.

Briefly, the simple answer to the question posed by Robert Watson-Watt: "How much R.F. power should be radiated to raise the temperature of eight pints of water from 95 degrees F to 105 degrees F at a distance of 5Km and at a height of 1Km?" was: "Too much — far beyond our present technology!"

(The reader should have little difficulty in appreciating the connotation of this unusual request!)

However, taking account of the 'fourth power law' and an average size bomber, a few basic calculations showed that enough power might be generated to DETECT aircraft by re-radiation, rather than actually causing damage.

It is surprising, with hindsight, that in view of the number of people claimed to have 'invented' Radar from 1900 onwards, (Tesla, Hulsmeyer, Marconi, Breit and Tuve, etc.), nobody had ever bothered to make these few fundamental calculations!

To test the theory — it looked too good to be true — Watson-Watt and his colleague Arnold Wilkins 'borrowed' the powerful BBC short-wave beam station at Daventry, transmitting on a wavelength of 49 metres at a power of 10kW. (See Fig. 1.) The beam was approximately 30 degrees wide and vertically inclined 10 degrees.

The plan was to fly a Heyford bomber, (See Fig. 2), up and down the beam using the radiated power as an "illuminator" and attempting to measure the amount of power reflected from it at different ranges. This measurement was to be made by an antenna placed some distance from the transmitter, in a field near Weedon, and connected to a sensitive receiver (See Fig. 3), using a cathode ray tube as an indicator. The cathode ray tube (CRT) in 1935 was considered to be what we now call High-Tech and was a very rare and expensive device!

Clearly the direct radiation, even off-beam, would have saturated the sensitive receiver had not special precautions been taken to cancel it. The method adopted was very simple and effective: instead of a single antenna (A centre-fed, horizontal, half-wave dipole slung between two poles) two were used, one approximately half-wave behind the other along a line drawn through the transmitter, their outputs being combined in a cunning arrangement which allowed the phase of the two signals to be combined in anti-phase thus effectively cancelling the direct radiation. (See Fig. 4.)

The Receiver, CRT, Batteries, etc., were contained within a small Morris Commercial van euphemistically called the Travelling Laboratory. (See Fig. 5.)

The output of the receiver was connected to the Y plates of the CRT and the phase adjusted to cancel the direct signal and then slightly offset to leave a small residual deflection. This was done to give a reference signal and to provide continuous monitoring of the transmission, showing that all was well.

The Heyford, piloted by Flt. Lt. Blucke, then flew at 6,000 feet along the beam, navigating by dead-reckoning, whilst the observers on the ground (Robert Watson-Watt, Arnold Wilkins and A. P. Rowe) measured the signal on the CRT as it 'beat' in and out of phase with the reference signal.

The results were immediate and conclusive, the Heyford giving measurable signals at ranges exceeding 8 miles, confirming the optimistic forecast of the experimenters. Watson-Watt was so impressed by the results that he remarked: "Great Britain has once more become an island!"

This demonstration has since been hailed as the most convincing ever staged. It should be noted that the Travelling Laboratory set out for Daventry at midday on February 25th with a driver and Arnold Wilkins, arriving in the afternoon. The antennae and receiving equipment was then set up in a muddy field near Weedon and tested by the late evening. Watson-Watt and A. P. Rowe arrived in the morning of February 26th, observed the demonstration and returned to London in the afternoon. Imagine that timescale today!

EXPERIMENT

The whole exercise was immediately classified MOST SECRET and £10,000 instantly allocated to set up, with the highest priority, an experimental station at Orford Ness. In an incredibly short time the station was designed, installed, tested, modified and re-tested. Ranges of 17 miles increasing to 30 then 40 miles were achieved. There were many triumphs and many disappointments but the viability of the system was proved beyond doubt. As stated, all this work was classified Most Secret and, in order to mislead, the system was initially christened "R.D.F." short for Radio Direction Finding a conventional technique which had been in use for many years.

The "Committee for the Scientific Survey of Air Defence", (commonly known as the Tizard Committee) that was responsible for co-ordination of all Air Defence matters, presented a massive proposal to the Cabinet and Treasury to erect a defensive early warning screen consisting of RDF stations (later to become known as 'CH') approximately 20 miles apart along the East Coast with absolute priority. Without hestitation, this proposal was accepted and millions of pounds voted for immediate use; it was an act of faith for which we must be eternally grateful.

The writer has since had the pleasure and privilege of discussing this famous experiment with Arnold Wilkins and he has sent a sketch of the layout as he recalls it. (See Fig. 6.) He says it was all very matter-of-fact at the time and reminded me that it was fifty years ago. Even now, I don't think he fully appreciates the full significance of this historic event!

For reference, the participators in the 1935 event were:–

Robert Watson-Watt, Superintendent D.S.I.R., Slough.

A. P. Rowe, Secretary to Harry Wimperis, Director of Scientific Research.

Arnold F. Wilkins, Technical Assistant to Watson-Watt.

Dyer, Driver of the Travelling Laboratory and General Handyman.

Fl. Lt. Blucke R.A.F. pilot (later to become famous in tracking down the German 'Knickebein' Beams).

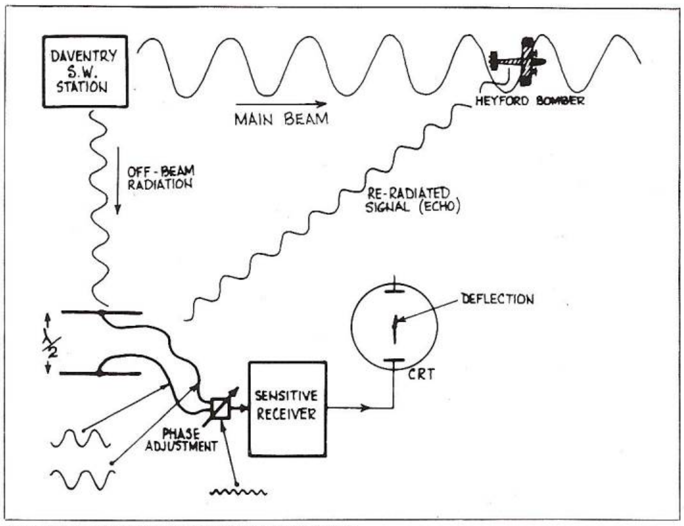


FIG 4. DIAGRAM SHOWING PHASING ARRANGEMENT.

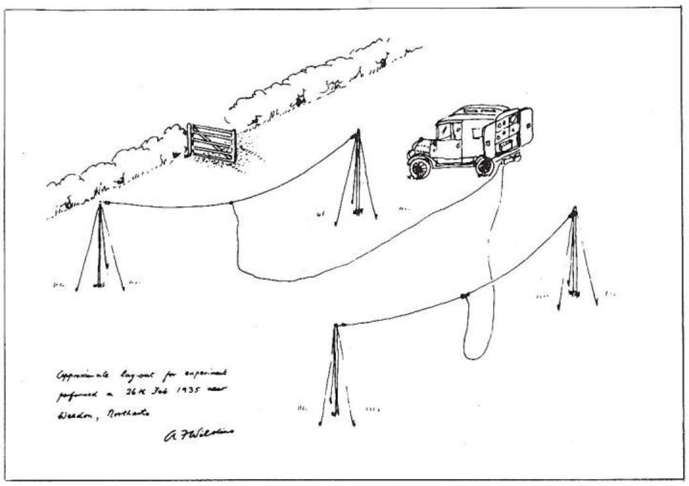


FIG 6. SKETCH BY ARNOLD WILKINS, MADE RECENTLY, SHOWING THE EQUIPMENT IN THE FIELD NEAR WEEDON.

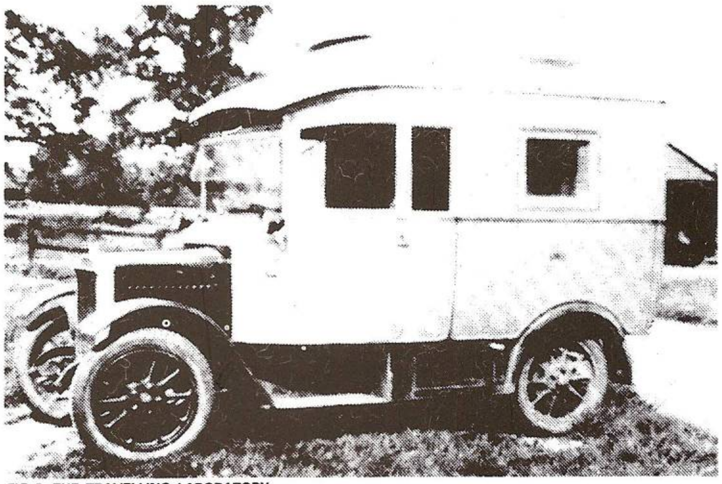
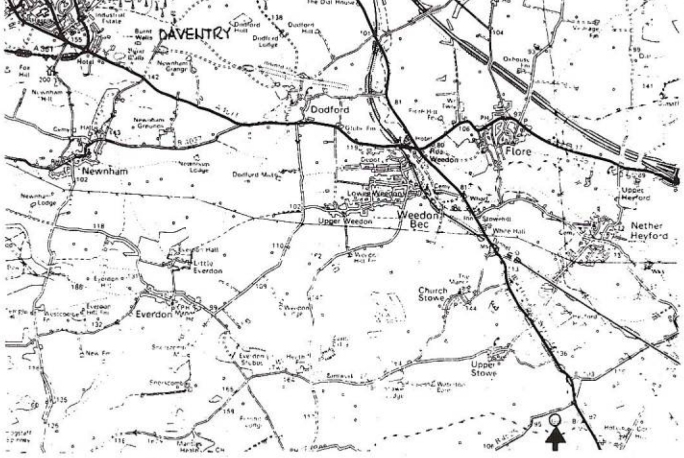


FIG 5. THE TRAVELLING LABORATORY.



Memorandum from Sir Henry Tizard to R. Watson-Watt. 20th September, 1936 or 1937).

TO SAY that I was disappointed on Thursday is to put it very mildly. As you put it yourself, you have to face the fact that very little progress in achievement has been made for a year. I am surprised that you encouraged — indeed proposed — the September exercises.

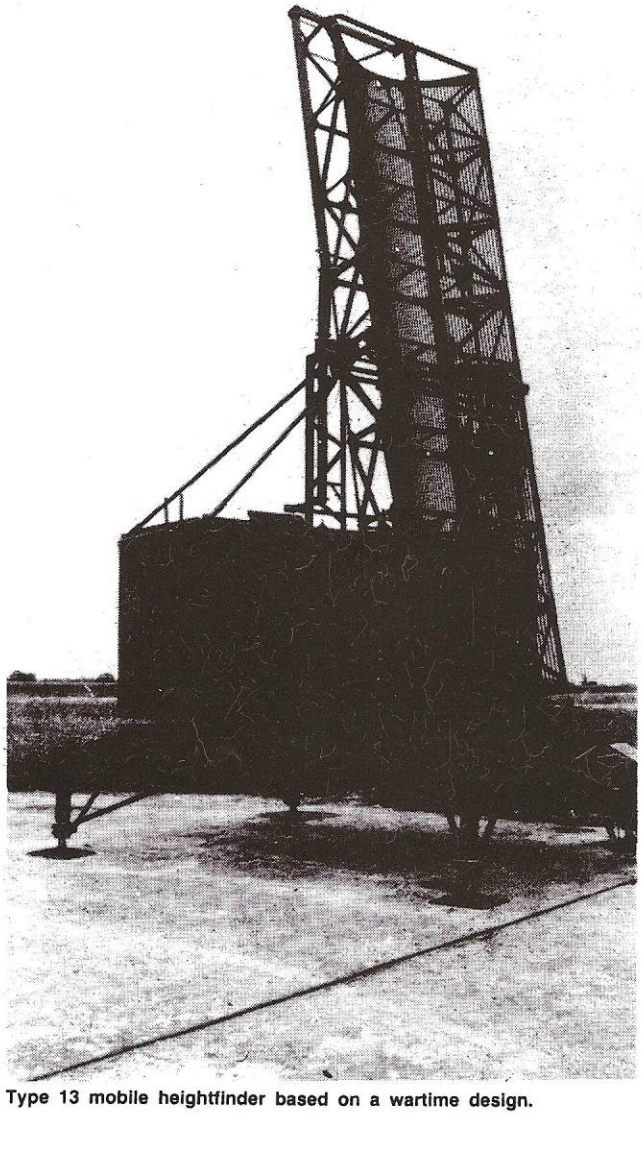
Unless very different results are obtained soon I shall have to dissuade the Air Ministry from putting up other stations. The Secretary of State must have got a very bad impression. What particularly disturbs me is that there seems to have been a lack of good judgement on your part. You have had good results in the past, but there has been little effort to ensure that those results are repeatable, before going on to get better results. Although the transmitter was blamed for Thursday's fiasco it seemed to me that you had no evidence for this.

Surely it is not difficult to get a sufficiently accurate measure of the energy emitted on the right wave-length on every occasion when the transmitter is operated? If so, I don't understand why this was not done long ago. Also why you should court failure by running your valves at full power when you can only get a mile or so extra range by doing so, is beyond my comprehension. I think that it is of the utmost importance that you should find the real reason for these irregular results as soon as possible

I am sorry to write like this, but it will not help you if I conceal my feelings. A great deal depends on your work.

EARLY DAYS OF RADAR

'Their aircraft were blind in comparison with the RAF'



Type 13 mobile heightfinder based on a wartime design.

THE STORY of radar is a very remarkable story indeed. While it is nonsensical to state that any one invention won the war, there is absolutely no doubt that without radar things would have been very different and the Battle of Britain could well have been lost — and with it the war.

The main asset of radar in those times was its effective integration with the ground to air communication network, for without this combined system, the RAF fighters would have had to maintain 24 hours standing patrols — and with the limited number of planes available, this just wasn't on, and very many more enemy planes would have got through without being intercepted. As it was, we only just made it!

The story really starts in the early 1930's, with Stanley Baldwin's sobering statement, 'The bomber will always get through!' This, of course, was a political phrase, but there was a good degree of truth to it.

In 1934, a large-scale exercise was held to test the defences of Great Britain — the results being, to say the least, alarming.

Mock raids were carried out on London, with the Air Ministry, the Houses of Parliament and Buckingham Palace being especially picked out. In spite of the fact that the targets and the routes of the bombers were known in advance, well over half of the bombers reached their targets with little or no opposition. In the opinion of the umpires, the Houses of Parliament, the Air Ministry and other key establishments were eliminated.

It appeared very much as if Mr. Baldwin was right.

Mr. Churchill summed up the vulnerability of the capital city in one succinct phrase — 'London, the greatest target in the world. A kind of tremendous fat cow tied up to attract the beasts of prey.'

THE TIZARD COMMITTEE

At this time, the only early warning devices available were acoustic, the largest of them being a tremendous concrete acoustic mirror 200 feet long and 25 feet high, with an arrangement of sensitive microphones at its focus, built on Romney Marshes. The best range ever achieved was 15 miles — and this under perfect conditions. There was no range information, very inaccurate bearings and no height — and the sound mirror was useless on a windy day.

In an urgent attempt to tackle this formidable problem, a special committee of scientific experts, free from 'red-tape' procedure, was set up under the leadership of Sir Henry Tizard. The terms of reference for this committee were 'To see how the latest advances in science and technology could assist in the defence of the United Kingdom'.

The committee was named 'The Committee for the Scientific Survey of Air Defence', commonly known as 'The Tizard Committee'. It consisted of Sir Henry Tizard, Professor P. M. S. Blackett, Henry Wimperis and A.P. Rowe, the later acting as secretary. The committee was to report to, and advise, the Government.

It was this committee, under the powerful and imaginative leadership of Sir Henry Tizard, which ultimately acted as midwife to the birth of radar in Great Britain.

But first the committee had to examine a wide range of proposals, including death rays, infra-red devices, supersonic devices, aerial mines on balloons — and similar wide-ranging and far-fetched ideas. (Crank scientists were continually inventing so called 'death rays' and attempting to peddle their ideas to the Ministry).

CALCULATIONS

To settle once and for all the feasibility of such a device, Sir Henry enlisted the aid of Robert Watson-Watt, an experimental scientist working on atmospheric research at the D.S.I.R. establishment at Slough. The question put to Watson-Watt was this: "How much radio energy is required to raise the temperature of 1cc of blood by 1°C at a range of X miles?'

After a few simple calculations, it became clear that the required energy was astronomically high, way above anything available at the time, disposing at one stroke of any hope of such a device.

Meanwhile, it appeared to Robert Watson-Watt, well immersed in calculations, that perhaps enough radio energy could be generated and propogated to 'illuminate' a metal object of the dimensions of an aircraft, to enable the reflected energy to be detected by a specially sensitive receiver. In other words, to detect the radio echo.

This looked a much more promising approach and detailed calculations were quickly done, Watson-Watt worrying all the time whether he had dropped a nought! The results were good — almost too good to be true!

This work was summarised in a classic memorandum by Watson-Watt entitled: 'The Detection and Location of Aircraft by Radio Methods'. It was a masterpiece of clarity and reasoning, offering more than a glimmer of hope, a straw that was eagerly grasped. With astonishing speed — one of the remarkable things about the development of radar was the astonishing way in which Government departments actually got things done! — a simple experiment was set up to test the feasibility of the idea.

EXPERIMENT

The BBC short-wave beam transmitter at Daventry was used to 'illuminate' an aircraft (a Heyford bomber) flying down the beam from Kettering, starting at 6,000 feet and dropping to 1,000 feet. Close by, Watson-Watt and his small team had set up a receiving aerial and a sensitive receiver using the Y deflection plates of the then rare instrument the cathode ray tube, to detect the presence of any reflected energy (or echo) from the aircraft.

The direct radiation from the nearby powerful transmitter, which would have saturated the sensitive receiver, was suppressed by a cunning phase cancelling technique. No attempt to measure bearing or range was to be made. The experiment was simply to establish whether the radio echo could be detected.

The results were immediate and impressive. Signals returned from the aircraft were clearly detected at a range that confirmed the calculations — in a word, it worked! At the successful outcome of the experiment, Watson-Watt turned to A. P. Rowe and said: "Britain has become an island again".

All this took place in 1935. The original apparatus used in the historic experiment can be seen in the Science Museum at South Kensington.

Armed with this encouraging result, Sir Henry Tizard made a powerful assault on the Treasury for funds — and, supported by Professor Lindemann and Air Marshal Hugh (Stuffy) Dowding, the Air Member for Research and Development — obtained the princely sum of £10,000 to set up an experimental station at Orford Ness on the Suffolk coast.

So great was the enthusiasm of Robert Watson-Watt and his small team, that within weeks of the go-ahead, an embryo system had been worked out and with the aid of string and sealing wax (plus gallons of the local bitter), the first primitive British radar station was built and ready for test.

Ranges of 17 miles, increasing to 30 and then 40 miles, were achieved. There were many disappointments and failures, especially when demonstrating to the 'top-brass', but by the end of the year, the vexed problem of bearing (D/F) had been most elegantly solved and the viability of the system proved beyond doubt.

All of this work was, of course, of a highly secret nature and in order to mislead, the system was christened 'R.D.F.' which stood for 'Radio Direction Finding'.

The Tizard committee now presented to the Cabinet a massive proposal to erect a defensive R.D.F. screen, consisting of stations every 20 miles, around the coast of Britain, with initial priorities for South East England.

With remarkably little hesitation, this proposal was accepted and millions of pounds were voted for immediate use: it was indeed an 'act of faith' for which we must be eternally grateful.

While the stations were being built, the experimental work was moved to Bawdsey Manor, a few miles south of Orford Ness and across the estuary from Felixstowe. The team was built up and significant improvements achieved: ranges increased to 150 miles; a means of heightfinding, and very much improved reliability of equipment.

UTILISATION

It was all very well having a large number of R.D.F. stations — called C.H. or Chain Home — but how could this mass of plots and information be best utilised? As early as 1936, the Royal Air Force recognised the need for an operational organisation to match this powerful warning tool. To this end, an extensive exercise was set up using all operationally available aircraft, for many weeks acting as 'enemy bombers' and 'defending fighters'.

Plots of bomber tracks were taken from the operational R.D.F. stations and fighters were directed to intercept (by V.H.F.) from the ground — a revolutionary idea for those days!

It soon became apparent that the mass of information available from the R.D.F. stations, some of it ambiguous or inaccurate, had to be processed or filtered in some way. This was solved by setting up a filter room, to which a number of R.D.F. stations passed plots over secure telephone lines to W.A.A.F. operators, one for each station, who plotted the course of the attacking bombers by means of plaques. It was the filter officer's job to assess the true position of the aircraft from the data available and decide whether it was hostile or friendly.

At the end of the exercise, a successful operational procedure had been worked out, which served as a sound basis for the conduct of the Battle of Britain yet to come.

PRIMITIVE?

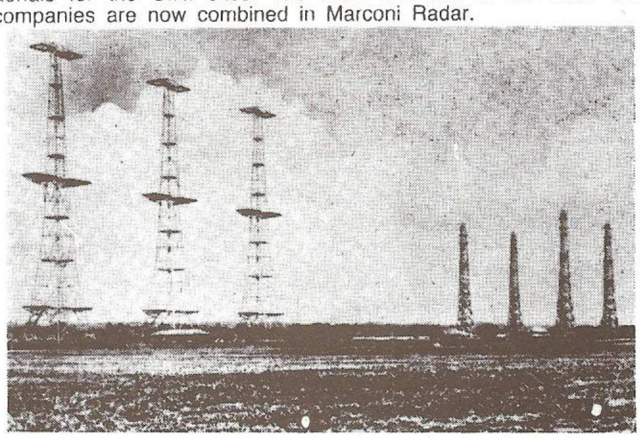
As an addendum to this story, mention must be made of work on radar by scientists abroad. While not widely known at the time, several other countries were experimenting with radar, including America, France and Germany.

In Germany, considerable progress had been made, indeed they had experimented with radio detection as early as 1934. By 1937, a gun ranging radar had been fitted to the battleship Graf Spee, and in July, 1938, the Germans had a radar called 'Freya' in action.

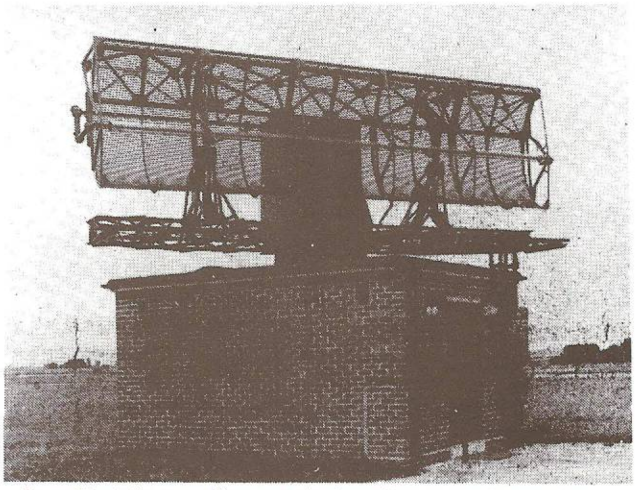
By 1939, their 'Wurzburg' A.A. radar was available, a 50cm band equipment using a parabolic dish aerial. In fact, when they captured a British mobile radar in France in 1940, they dismissed it as primitive . . .

As stated earlier, however, it was in the actual co-ordination of the various elements of the defensive system where the British were so advanced. The Germans had nothing so sophisticated as our combined radar/fighter systems. Their aircraft were 'blind' in comparison with the RAF fighters.

Another feature of interest to Marconi people in particular is the actual firms involved in the manufacture of the early radar equipment. Those mainly involved were Cossor, Pye, B.T.H., Metro-Vic and Marconi's Wireless Telegraph Company, the Marconi company producing the aerials for the C.H. sites. The radar interests of the latter three companies are now combined in Marconi Radar.



C.H. — 'Chain Home' radar station. Transmit tower in the foreground receive at the back.



Type 14 static surveillance radar based on a wartime design.

OBOE hit right note

by
Bruce
Neale

Target for tonight: Essen 1943 background.

MUCH has been written about the German wartime navigational 'beams':- "Knickebein', X Gerät, Y Gerät. What is not generally known is that the British, always reluctant 'heroes', had a precision, blind-bombing system in operation from 1942 until the end of the war that was far superior to anything the Germans had achieved.

THE PROBLEM

Air navigation at the beginning of WW2 was primitive to say the least; relying on the stars, dead-reckoning, visual sitings and some elementary radio aids. Analysis of 'bombing effectiveness' over the first two years of the war makes depressing reading; for example, less than 10% of all bombs dropped on the Ruhr fell within a five mile radius of the aiming point and probably less than 50% within 25 miles, many on the wrong target! Because of the industrial haze that normally enshrouds the Ruhr Valley, Essen, the armament centre of Germany, including the giant Krupps Works, emerged virtually unscathed despite the regular attention of Bomber Command.

In the early war years, bombing was considered by Churchill to be the only practical way of striking back hard at Germany, land invasion being out of the question at that time. However, without an effective means of all-weather night-and-day target location, plus precision bomb aiming, the enormous expenditure in lives and hardware would be in vain.

THE SOLUTION

In 1942-3, thanks to the timely emergence of three groups of elegant hardware, plus the courage, skill and dedication of the airmen, the bombing offensive against Germany assumed a new and devastating role and Bomber Command became the most potent instrument of war ever conceived up to that time.

Whatever its armchair critics — and there are many of them — say today with the benefit of hindsight — (an exact science) — Bomber Command was the major contri-

'OBOE' RADAR ON OFFENSIV

Along with 'Ultra' and 'Project Manhattan', Oboe was one of the best kept secrets of World War II. Even today, some forty years on, particular operational aspects of the system are still shrouded in mystery.

The inaccuracy of our all-weather bombing, especially at night, had been recognised for some time; something had to be done.

Oboe was the brainchild of Alec Reeves, the PCM wizard of Standard Telephones and Cables Ltd, who along with Frank Jones of TRE, developed an idea from the back of an envelope to a potent instrument of war. The basic principle of Oboe is really very simple, it was the inspired engineering and operational concept that was the key to its success.

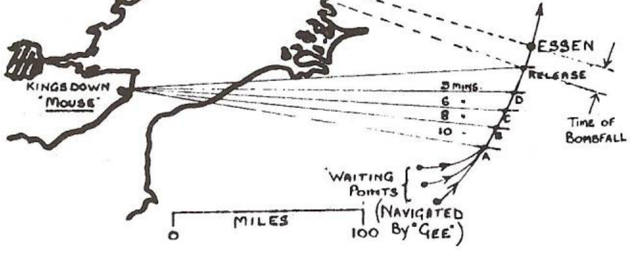
HOW IT WORKS (See Fig. 1)

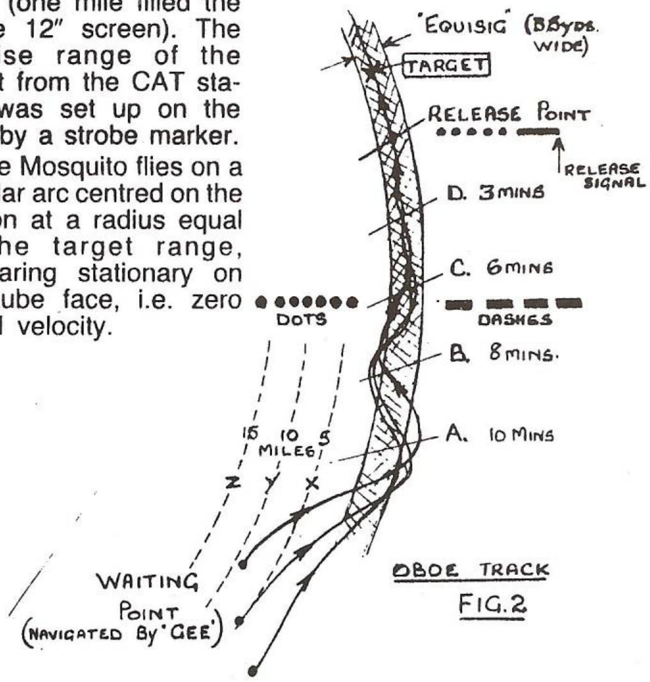
The range of a target, say the Krupps armaments works in Essen, measured from two widely spaced ground stations in the U.K., was derived from pre-war ordnance survey maps and aerial photographs to an accuracy of plus or minus 17 yards! A remarkable feat of cartography and Intelligence. One ground station, code named "CAT", controlled the track of the marker aircraft (usually a Mosquito flying at 30,000 plus feet) by interrogating an on-board transponder not unlike SSR of today.

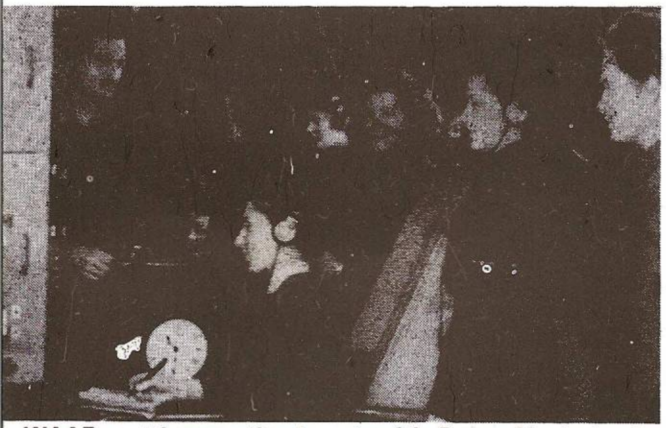
The returned pulse was displayed on a CRT with a delayed, magnified time-base (one mile filled the whole 12" screen). The precise range of the target from the CAT station was set up on the tube by a strobe marker.

The Mosquito flies on a circular arc centred on the station at a radius equal to the target range, appearing stationary on the tube face, i.e. zero radial velocity.

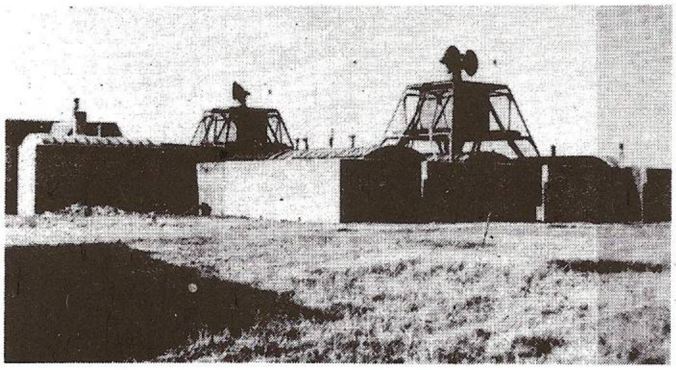
The purpose of the CAT was to keep the returned pulse exactly in line with the target marker strobe by automatically signalling 'dots' or 'dashes'; dots if the Mosquito range was less than the target range, dashes if it was greater. The dots and dashes merged into a continuous or 'equi-signal' note when the Mosquito range and target







. WAAFs setting up the target with Bruce Neale in the



OBOE — quiet but deadly! (Winterton IV).

butor to the ultimate defeat of Germany.

The major groups of hardware were:-

1. **Radar Navigational Aids:** GEE (7K) OBOE (9K) H_2S
2. **Aircraft:** Mosquito, Lancaster
3. **Target Indicators (Precision Ballistics):** Ground Markers, Sky Markers.

plus, on the operational side, the formation of the Pathfinder Force, an elite, specialised group of aircrew and ground staff under the powerful leadership of Air Vice Marshal Don Bennett.

Oboe was a target marking system, ground controlled from the U.K. It had a minimum theoretical error (assuming that all other error contributions, viz: Met, ballistics, target data, were zero) of ± 17 yards when the target indicator was dropped from a height of over 32,000 feet out to a range of over 250 miles from the U.K. ground stations; the range limit being just beyond the ground station radar horizon.

The target indicators laid by Oboe Mosquitoes achieved consistent accuracies of between 50 and 100 yards and, in many cases, were within 30 yards of the aiming point, in 10/10ths cloud, enabling the 'heavies' to follow up with 4,000 lb. 'Cookies', 12,000 lb. 'Tallboys' and 22,000 lb. 'Grand Slams' with deadly consequences.

The next issue of "News and Views" will attempt to describe the inner workings of this truly remarkable system.

THE
E!

range coincided, i.e. it was precisely on track.

The dot/dash signal was transmitted automatically by width-modulation of the primary interrogating pulse.

The sensitivity of the system was such that a deviation of plus or minus 17 yards from the circular arc would cause either dashes or dots to be sent, thereby enabling the pilot to steer along an 'invisible' track some 35 yards wide in the sky above the target; there was no beam as such (See Fig. 2).

The other ground station code named MOUSE, signalled the Mosquito as it passed a number of 'milestones' along the arc until it reached the release point — the intersection of the Cat and Mouse ranges — when the bomb release signal (five dots and a dash) was given automatically. Like the Cat station, the target range was set by a strobe on a CRT with a delayed, magnified time base. Unlike the Cat, the returned pulse moved along the trace as the Mosquito approached the target region.

The precise release point along the arc was influenced by many factors, eg., Time of bombfall, trail distance (a function of bomb ballistics and airspeed), meteorological data, the velocity and heading of the Mosquito just prior to release plus instrumental corrections (See Fig. 3).

These were taken into account by the Mouse computer (aptly named the Micestro!) the release point being continuously and automatically corrected to ensure that the predicted impact point of the bomb (or Target Indicator) was within the target zone.

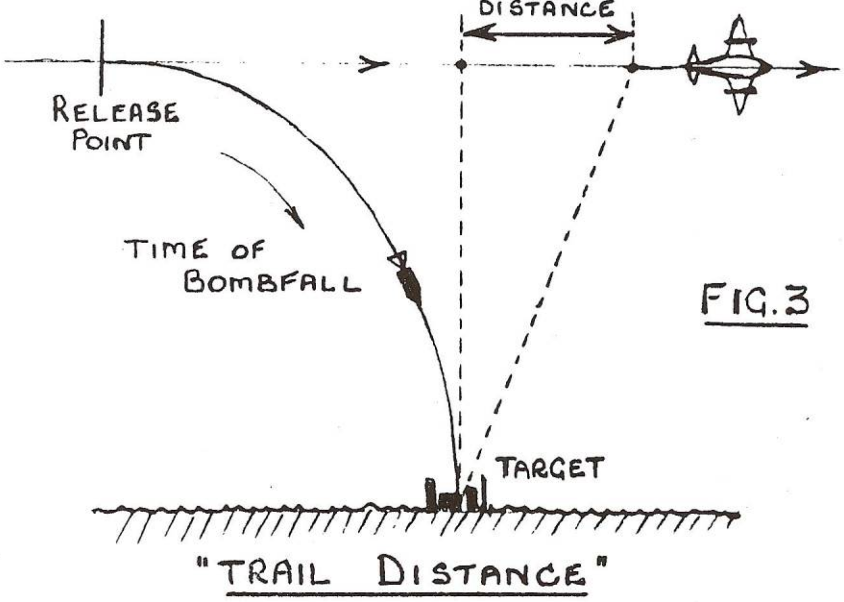
There were several Oboe stations (Type 9000) around the East and South Coast of England (from Cleadon in Durham to Sennen in Cornwall) any of which could be nominated to perform a Cat or Mouse function depending on the target location.

Early stations (Mk. I) used modified CHL equipment working on 200 MHz using pulse space modulation for signalling.

Later stations (Mk. III) worked in S band and used pulse width modulation as already stated.

Early Oboe suffered from two limitations: (1) its range was limited to just beyond the Radar horizon, about 250 miles and each pair of ground stations could only handle one Mosquito every fifteen minutes.

The next issue of 'News and Views' will describe the ingenious way in which these limitations were overcome and the vital part Oboe played in the destruction of V1 and V2 supply dumps together with the support of the D Day landings.



OBOE part 3

by Bruce Neale

"I expect the British to be advanced but frankly I never thought they would get so far ahead. I did hope that even if we were behind we could at least be in the same race."
Hermann Göering, May 1943.

In the last issue, two limitations of Oboe were considered, viz (a) the inability of the system to control more than four target marking Mosquitoes per hour and (b) the limited operational range imposed by the Earth's curvature (Radar Horizon).

Delta approach

The first problem was elegantly solved by using multiple interlaced P.R.F.'s enabling 10 control channels to be worked simultaneously through a single Magnetron transmitter. The PRF's in the range 100 to 200 p.p.s. were selected by precision filters in the aircraft's transponder. It will be recalled that each aircraft was required to follow a circular track (the radius of which is the range of the target from the CAT ground station) for some 15 minutes before the bomb release signal was given (see Issue 6 part II Fig: 2). A new type of approach to the target was evolved whereby the aircraft's radial velocity as seen from the ground station, in addition to its range. was fed into the 'Micestro' computer. Provided the aircraft heading derived from the velocity component was correct at the point of release, there was an infinite number of approach tracks to the target and a skilled pilot could enter a track from any angle. The dot — equisignal — dash signal to the pilot enabled him to steer along any chosen track by keeping his 'heading' correct (Fig 1). An experienced pilot could pick up a track and be correctly positioned at the bomb release point in about 3 minutes allowing a maximum of 20 sorties per hour per pair of ground stations. In fact, for operational reasons, the best ever achieved was, I believe, 10 sorties per hour. This technique was known as the 'Delta' or 'Exponential' approach.'

One weakness of early Oboe was the requirement for the aircraft to fly a fixed circular track thereby giving the German defences the opportunity of predicting its course thus making it vulnerable to attack. The Delta track, on the other hand, was unpredictable and confused the defences. The speed and operational height of the Oboe Mosquito were important factors in its survivability.

REPEATER TECHNIQUE

The problem of range limitation due to the Earth's curvature (about 250 miles) was a more difficult nut to crack. It was partially solved by the use of repeater aircraft flying a racetrack pattern (Fig 2) one for the MOUSE and one for the CAT. The aircraft, usually Mosquitoes, were flown at maximum height, around 32,000 ft and kept 'on-station' by 'Gee' (Type: 7000). Ranges of 600 miles plus were theoretically possible, putting Berlin well within Oboe range. The big problem was not technical but operational; as can be imagined, it required a considerable amount of planning and it exposed the repeater aircraft to attack; they were sitting ducks.

The war in Europe ended before the operational advantages of these new techniques could be fully exploited.

D Day

Oboe played a vital part in the support of D Day landings both during the run-up phase, knocking out radar and coast watching stations, airfields, gun emplacements and troop concentrations, and the subsequent landings by precision pattern bombing of enemy forces just ahead of the advancing Allied armies.

Oboe stations such as Hawkshill Down, Kingsdown (Kent) Winterton and Scratby (Norfolk) worked round the clock, target marking and precision bombing designated key targets. The success rates or 'copes' as they were called, were in the region of 90 per cent, a cope being defined as an impact within 'x' feet of the aiming point where 'x' depended on the type of operation. Mobile versions of Oboe (Type 9000, Mk II) were deployed behind the Allied lines to support the advance thus bringing a large area of Germany within Oboe range. The siting, operational and organisational problems were prodigious as can well be imagined.

V1, V2 and V3

The part played by Oboe in the destruction of V1, V2 and V3 launching and supply dumps in the Pas de Calais area was decisive in minimising the impact of Hitler's 'Grand Slam' of vengeance weapons. The terrifying V3 site at Mimoyeques never did become operational.

Precision reconnaissance photographs pin-pointed V1 and V2 sites and these were translated into target ranges from both CAT and MOUSE stations (with incredible accuracy) The reconnaissance was followed up within hours by oboe Mosquitoes dropping 'Cookies' (4,000 lb bombs) which literally pulverised the site (see photograph in issue 4 of 'News and Views').

IN ANSWER TO YOUR QUERIES

FOLLOWING the publication of part 2 of the OBOE story in issue six of News and Views, several people asked just what was meant by the 'trail-distance' diagram. To alleviate their puzzled minds, Bruce has put together the following description:

TIME OF BOMBFALL

Both bomb and aircraft have the same initial horizontal velocity at the moment of release, but the bomb is then retarded by air drag so that, in still air, the point of impact will lie directly behind the aircraft by a distance known as the *trail distance*. This is given by H tan λ (Fig 1) where h is the height of the aircraft and λ is the trail angle The trail angle is a function only of airspeed and type of bomb.

In the presence of a cross wind the aircraft crabs along its track and as the trail distance lies along the reciprocal of the direction of course or heading, drawn through the position of the aircraft at the moment of release, the track of the aircraft must be offset to the side of the track from which the wind is blowing, by a distance EF = d sin *d* where *d* is the angle of drift (Fig 2).

The component of trail distance EC parallel to the track is then d cos *d*.

The time taken for the bomb to fall (t.b.f.) is a function only of height, airspeed and type of bomb.

It is clear that the time taken for the bomb to fall is equal to the time the aircraft takes to fly from

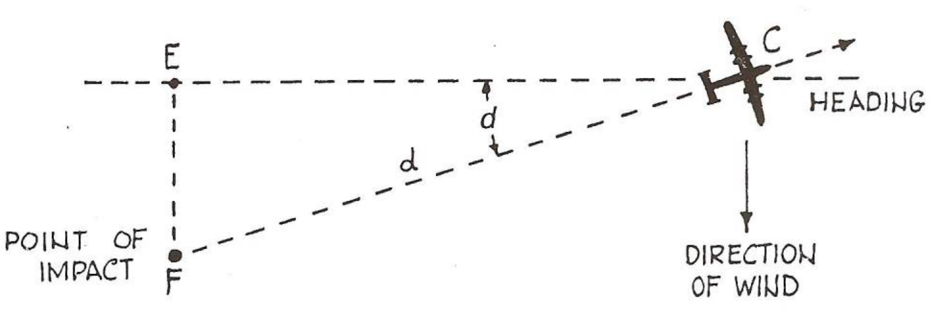
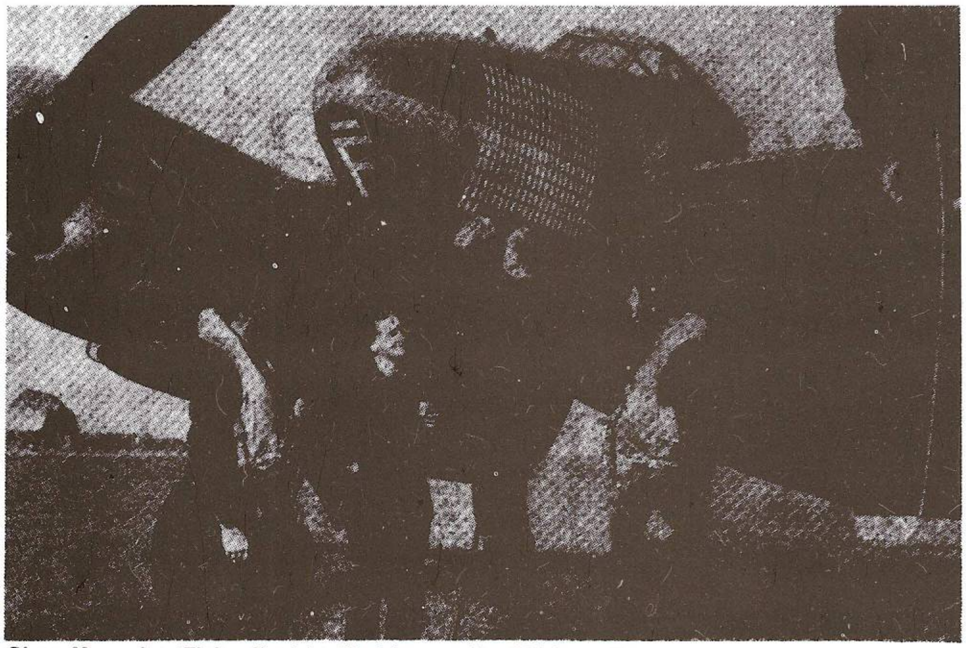


Fig 2. Illustrating allowance required for cross wind.

Mercy Mission

If the destruction of these sites was Oboe's only success, it would all have been worthwhile in terms of the lives saved from the flying bomb. As it was, Oboe (along with H2S, Gee, G.H.) played a decisive part in the total bomber offensive against Germany. But one must never forget the courage, skill and dedication of the pilots and navigators of the Pathfinder Force and, of course, the superlative qualities of the ubiquitous Mosquito!

It is not generally known that towards the end of the war in Europe, food 'bombs' were dropped on Holland for the starving Dutch people in the Hague and other towns. By pre-arrangement with the Dutch Resistance, a site was chosen well away from the German security forces for a 'drop.' The precise aiming point was signalled to London and the CAT/MOUSE ranges calculated. At a pre-arranged time Oboe Mosquitoes carrying food canisters (with good ballistics!) set out to rendezvous with the Resistance and the cannisters were dropped to within 30 yards of the aiming point where eager hands rapidly distributed their contents.

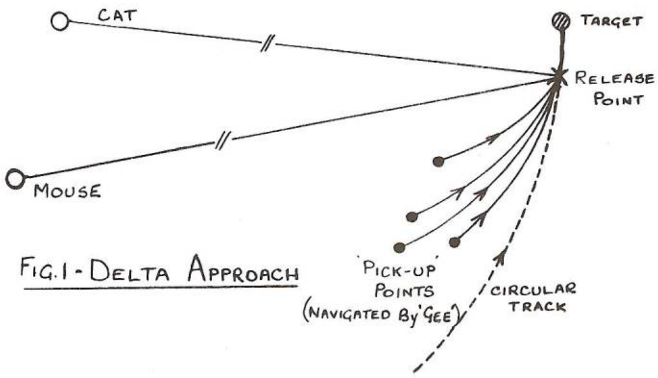


Oboe Mosquito 'F' for Freddy. Marking up the 204th sortie!

Postscript

In 1976, the author was in the Hague and had the good fortune to meet a Professor Eric Goldbohm who was a member of the Dutch Resistance and was present at the receiving end of one of these operations. He remarked on the fantastic accuracy of the 'drop'; in fact, he was very nearly clobbered by one of the cannisters. He said how truly grateful the Dutch people were and bought me a pint!

B. T. Neale



A to C (Fig 1) and is therefore equal to $v_g \times$ t.b.f. where v_g is the ground speed.

In practice the value of *d* and d are evaluated from a knowledge of the meteorological-forecast wind, direction of track and prearranged height, airspeed and type of bomb. The two components of trail, EF and EC, are allowed for in the setting-up of the target range at the appropriate ground stations. v_g is measured at the releasing ground station by an electronic circuit called the *Micestro.*

(Derived from: Frank Jones notes)

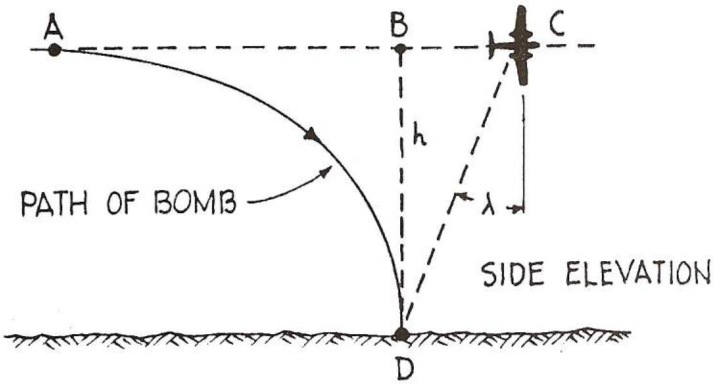
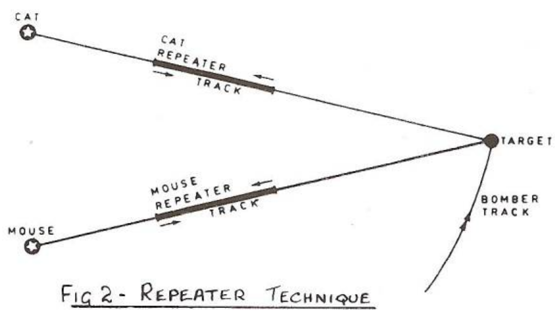


Fig 1. Effect of air-drag on fall of bomb.



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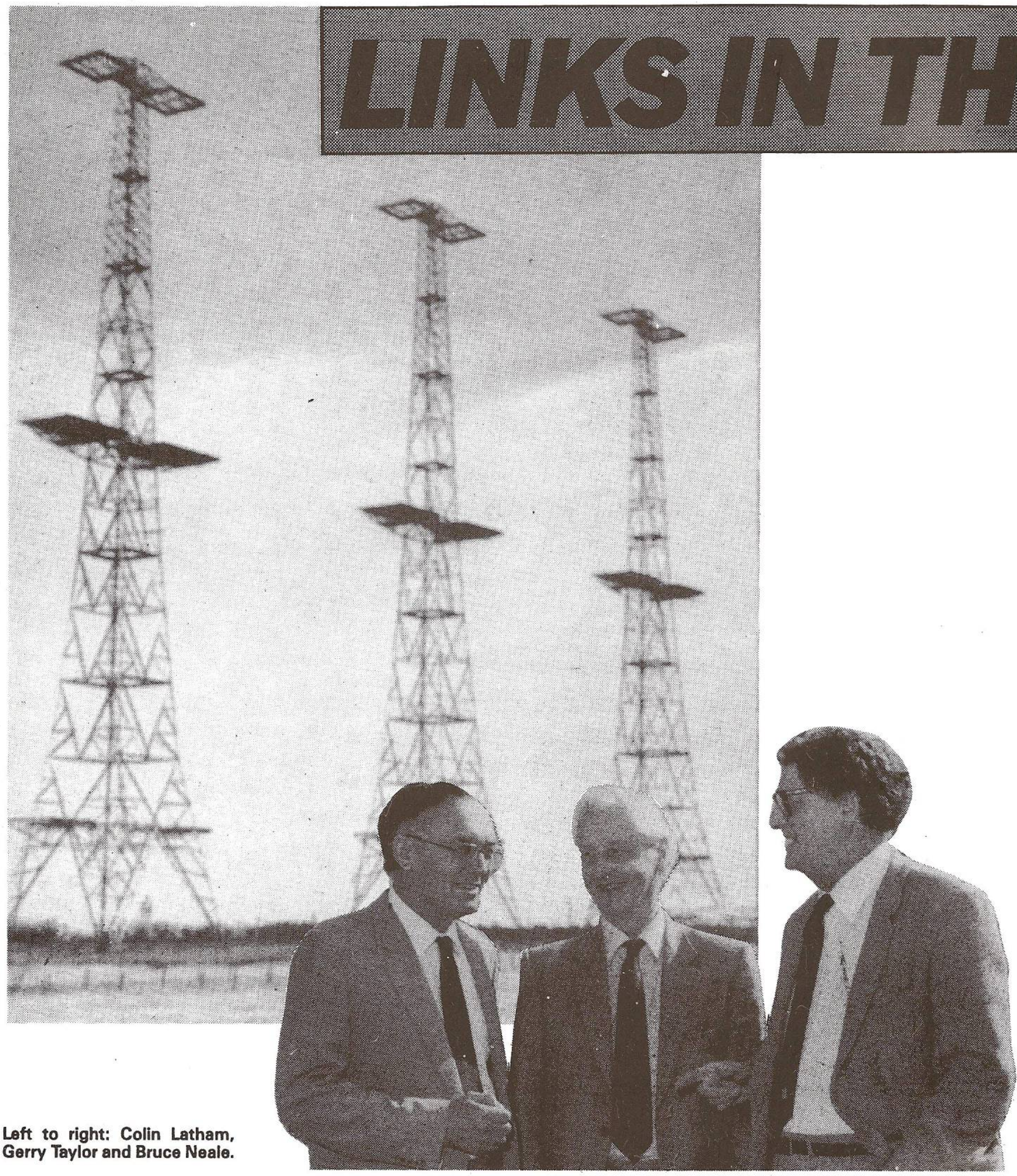

Left to right: Colin Latham, Gerry Taylor and Bruce Neale.

Veterans of World War Two, Colin Latham, Bruce Neale and Gerry Taylor, all served in the RAF and were all involved in Chain Home, the British radar network that changed the course of the war and, to a large extent, influenced the course of their lives.

CHAIN

COLIN LATHAM

'But it's only 46° Farenheit in the classroom! Why should my dad pay school fees *and* feed me so's I give off enough heat to raise the temperature?'

The church school headmaster to whom 13-year-old Colin Latham addressed his question, responded by asking that Colin be educated elsewhere — just another incident in a short, inglorious academic career that started when he was seven, a delay caused by illness, and finished somewhat abruptly seven years later, due to a loathing of school.

At 14, then, Colin was free to devote himself to his all-absorbing passion — wireless. For the next four years, he worked by day in a radio shop and during the evenings at classes.

At 18, his knowledge was sound enough to enable him to become a laboratory assistant at the RAE, Farnborough: his foot was set on the bottom rung of the professional ladder that he was to scale so successfully in the years to come.

Bombing forced the lab to move in 1941 and, unable to get to the new site, Colin joined the RAF, where, because of his knowledge of wireless, he was categorized a Tradesman Group I.

'What do you want to do, bloody wireless or bloody radio?' roared the Warrant Officer.

'I was a bit puzzled,' admits Colin, 'I'd never thought there was any difference. But I didn't want to appear ignorant, so I opted for radio, because it sounded more up-to-date.'

It later transpired that neither the W.O. nor most other people knew the difference: a case of the powers-that-be deliberately fogging the issue so that 'radio's' true identity should remain under wraps.

On the training course, it was swiftly revealed that Colin had opted for the relatively new, advanced technique of radio direction finding, later to be known as radar.

Colin spent most of the war in Training Command as an instructor, and became a specialist in the G and GH ground-based systems that directed bomber aircraft onto target and back to base.

After the war, having worked for a year developing amplifiers for a film company, he fell again under the radar spell and accepted an invitation to join the Air Ministry as a civilian instructor.

'It was a case of back to Yatesbury, where I'd spent much of the war, but this time I was initiating Signals Officers from other countries into the mysteries of radar.'

Hard-up and ready for a change, he left the Ministry in 1950 and went to India to teach the Indian officers.

Industry finally got its hands on Colin in 1953. For ten years, he applied himself to radar development at Marconi. There followed a three-year stint at Vickers, working on linear accelerators.

'I came back to Marconi in 1966, and since then I've worn a number of hats — engineering manager at Leicester, where I later doubled as site manager and development manager; manager of the then new Military and Airspace Division (UK) at Writtle Road and now, assistant divisional manager of Airspace Control Division.

'For the last ten years, I've also been giving talks on Marconi at RAF stations — some 15 or so, up and down the country — and I've succeeded in recruiting a number of RAF officers into the Company.'

Earlier this year Colin made his debut on the air. Essex Radio put out a programme on February 12 to commemorate the 50th anniversary of the Watson Watt demonstration of radar.

Colin was the sacrificial lamb. Totally unrehearsed, he sat in the studio and answered the hundred-and-one questions fired at him by the interviewer. The result was a masterly and fluent resumé of the history of radar.

'Over the last year or so, I've visited and established links with various universities and colleges where the Company has sponsored students. As I shall be moving to North Wales when I retire at Christmas, I hope I may be able to strengthen my links with the University of Bangor, where, by the way, the newly appointed Professor of Electronic and Electrical Engineering also comes from Essex.

'No, I shall not be "taking things up" when I retire. I detest dancing and cards and social functions but I hope to have time to pursue such interests as music and literature. And if all else fails, I can fall back on my love of radio — or is it wireless?'

GERRY TAYLOR

'Early in the war,' said Gerry, 'I joined the Home Guard. Communication was by lamp, electric, signalling, daylight, which meant by Boer War Morse lamp. If you couldn't find water for the batteries, you made it! Armament was a pike, later replaced by a World War One rifle.

'Knowing that I'd soon be called up, and believing that if something's unavoidable it's best to volunteer, I left the HG and joined the RAF.'

That was in 1940. He emerged from his trade test a Group One Tradesman, and was advised to take up wireless rather than radio. Like Colin Latham, he wondered where the difference lay.

'On the square bashing course, I remember being stripped to the waist, exercising in the snow outside the Winter Gardens in Morecambe, when Max Miller drove up for rehearsal in a Rolls and a fur coat. He was the only one laughing.'

Surviving the bread and margarine of the Morecambe landladies, and being called pregnant parrots by instructors under orders not to use bad language, Gerry and his mates finished as top squad.

After an equipment course at Cranwell, spent learning about antique radio sets, LAC Taylor was posted to a night fighter squadron to look after v.h.f. ground/air communication equipment.

'VHF was very new and was better understood by civilian amateurs than by the RAF, who were used to 1929 stuff.

'My next station was terrific. WAAFs appeared on my horizon for the first time; a house party atmosphere prevailed; pyjamas could be worn at breakfast, provided they weren't coloured; sports gear took the place of uniform in the evenings.

'But it was the equipment and the techical people that really opened my eyes.

'I'd fetched up at the heart of something I'd only heard rumours about — radio direction finding, or radar as we now know it. And this was one of the first mobile night interception stations — Type 8.'

Pretty soon, Gerry decided that wireless had been a bad choice. He applied to remuster, and the right answers to four technical questions saw him into 'radio'.

There followed an almost frenetic series of postings — in all, he notched up 36 stations in 5½ years: an idyllic period in a CHL station in South Wales; introspective months of isolation in the gale-torn Faroes, with airborne radar that sat on the ground and fooled the Germans into thinking that the invasion of Europe might be through Norway; days spent in a Martello tower in Essex; a spell maintaining an oscillator unit in a biscuit tin installed in an autogyro; a short stint in the Outer Hebrides, where he was banished after telling no less a person than the editor of *The Aeroplane* that he spent his time mending officers' bicycles.

In 1944, the RAF acceeded to his request to go on a millimetric radar course. His newly acquired knowledge took him into France, Germany, Belgium and Australia, delayed his demob for six months and profoundly affected the rest of the his life.

'In Civvy Street, I knew exactly what I wanted to do. I was lucky enough to get a place at Cambridge and then, with a shaky third under my belt, I presented myself at Marconi. There, on the strength of my knowledge of 10cm radar, I got the only vacancy in the Company, and that was in Services Equipment Division.'

● continued

Gerry Taylor

• **continued**

Starting in Sales, Gerry soon switched to the technical side. 'At one time, I helped develop a display, using components bought on my expense account from a radio shop in New Street. All Company items were being channelled into the super-priority VAST & ROTOR project.'

Gerry was in the senior delivery team at the births of 50cm radar and the concept of system engineering and product planning.

He recalls an early post-war period spent at Baddow, where eccentricity ran amok.

'No one wore neck ties, ancient cars were *de rigueur*, and the chief brain, T.L. Eckersley, was so preoccupied with higher things that you'd find him standing in the loo, deep in thought, having forgotten why he was there.'

Gerry's present job as systems marketing manager gives him the opportunity to pursue his conviction that only by assiduous product planning can the Company be sure of developing equipments that the customer will buy.

Soon he will retire. 'There's no question of wondering how I shall fill my time. I suffer from a big garden and two lively grandchildren — all needing attention.

'I may do some writing, and one day, my wife and I may up sticks and head for Wales or Devon. I've enjoyed product planning: I've no doubt I shall enjoy retirement planning just as much.'

BRUCE NEALE

Bruce Neale's association with radar started in 1940 when, aged 19, he joined the RAF and was sent to the Orkneys. There, without training, he helped to install, calibrate and operate Britain's most northerly Chain Home station.

Within a few months, he was posted to the Middle East, and for the next three years served on radar stations in Aden, Egypt and, finally, on the site of the Pharos Lighthouse at Alexandria — one of the Seven Wonders of the Ancient World.

'In Aden', recalls Bruce, 'we were under constant surveillance by the Italians. The day the RDF went operational, without test or trial, an agitated native bearer reported an enemy aircraft overhead.

'The RDF had seen nothing! A *Gladiator* was scrambled, vectored on a course indicated by the bearer, and made a perfect interception.

'The Savoia Marchetti 79 was shot down, and the success attributed to the new, magic RDF. But honesty prevailed. The station log recorded, "18.30 hours native bearer Ali Mohammed reports hostile aircraft overhead."

'We found the SM 79 floating in the Gulf. It was made of wood and stuffed with Italian Generals. They were highly indignant that we'd shot them down, as they were only on reconnaissance!

'There may not have been any bombs on board, but there was a crate of Chianti in danger of sinking. We rescued it and, together with the Generals, passed a happy evening toasting Winston Churchill, Benito Mussolini and King George VI — war seemed a long way away.'

Back in the UK in 1943, Bruce spent the remaining war years on new radar developments, including measures to deal with V1 flying bombs, and OBOE, the blind precision bombing system that contributed so much to the successful demolition of the Krupps Armament Works and the V1 and V2 launch sites, and to the triumph of the D-day landings.

Demobbed in 1946, Warrant Officer Neale joined forces with an ex-Aden colleague and band leader Geraldo to set up a professional sound recording studio in New Bond Street.

As Chief Engineer, Bruce designed all the high quality, hand-made equipment, which was used by HMV, Decca, NBC, BBC, Radio Luxembourg and many other organisations.

He worked alongside such artists at Bing Crosby, the Goons, Mantovani (whose 'singing strings' owed much to the recording equipment), Orson Welles and Nat King Cole, to name but a few.

'Once, when I was working with Tommy Beecham, a phone call came through for him. "Sir Malcolm Sargeant would like a word with you, Sir Thomas," I said. Sargeant had only recently been knighted. "Sir Malcolm Sargeant?" replied Tommy B, "I thought he'd only been doctored." '

After developing a high fidelity magnetic tape recorder, which was taken up by EMI and developed as the BTR/1, Bruce succumbed in 1952 to the siren radar and joined Marconi which has acquired a multi-million pound contract to design, manufacture and install stations around the UK coast — code-named ROTOR.

There followed over 30 years of deep involvement with all the major radar developments.

'We had our moments of internecine warfare. I remember the proving test flights of the Bawdsey prototype Type 7, when the first detection range performance fell short of spec.

'Doc Eastwood, who'd been responsible for the antenna and feeder systems, proceeded to dissect the transmitter, for which Ellis-Robinson had been responsible, hoping to prove that it was either on the wrong frequency or the output measurements were over-optimistic.

'Meanwhile, E-R was crawling all over the antenna array, making crude measurements by 'spark gap', hoping to prove that the power wasn't reaching the radiating elements. It was a sight that had to be seen to be believed.

"'In fact, neither transmitter nor antenna was seriously at fault. We simply hadn't appreciated the critical dependence of the "effective target echoing area" on the flying "attitude" of the aircraft.'

Colleagues have said of Bruce that he is an outstanding design engineer, that all the Marconi radars that have been giving super service for decades bear his stamp, that he goes direct to the root of the problem, that he makes things happen, and that he has a king-size sense of humour.

These qualities are still on tap for Marconi Radar, because although he retired earlier this year, Bruce comes to Writtle Road twice a week in a consultative capacity.

These articles were first published in the 1980's. The author of most of them, Bruce Neale died on the 7th March 1990. It is with fond memories that Marconi Radar has reproduced them in this form as a mark of respect for this astute engineer, manager and fanatical radar historian.

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