PART 3 - RADAR

Chapter 11 - Beginnings of 'Radiolocation'

Marconi in 1922 foreshadowed the reception of reflections when ships were in radio beams, p 13 of biography of Marconi. It was later common knowledge that aircraft caused flutter fading while passing near a SW receiving station and that in a DF system, when the goniometer was adjusted to give a complete zero, the passage of an aircraft nearby brought-up the signal again. But no one seems to have made before 1935 any quantitative estimates of what ranges might be possible with the receiver, not near the aircraft, but back at the transmitter. Scientists failing to be 'numerate'; what a non-event to have to record. And such a simple calculation; A F Wilkins did it later for Watson-Watt in half an hour!

However, the detection and ranging of ships was seen to be a possibility by Signal School in 1928 when L S B Alder filed with the Captain, J S C Salmond, Provisional Specification No 6433/28 of 1.3.28, relating to "methods and means for the employment of reflection, scattering, or re-radiation of wireless waves by objects as a means of detecting the presence of such objects and of determining the positions, directions or distances of such objects . . . The invention may also be used as an aid to navigation or for detecting the approach of enemy craft by observations at known positions of the reflection or re-radiation of wireless waves by an approaching ship or aircraft . . . The waves emitted are interrupted periodically or modulated in one of a number of known ways." The method described in the text was actually frequency modulation up and back in an approximately linear manner - a copy of the specification is in Archives 14. Mr Horton, head of radar from Nov 1937 onwards and Chief Scientist from Oct '45-Apr '51, later said of the patent (JRNSS p 192 1947): "It gives convincingly and lucidly the fundamental principles on which the various types of radar have been developed. Nevertheless nothing was done about that patent and it lapsed: it fell on very unfertile soil. The Establishment failed to see the significance of radar and as late as 1937 it was a matter of great difficulty to get workshop and drawing office effort to put on it. The reason was always the same - other and more obvious demands took priority. The user had had no previous experience of radar on which to base his sense of value." In mitigation it must be said that Dr A B Wood in 1935 when Deputy Supt of ARL with all his experience of Asdics since 1915 said: "Previous to visiting the research station at Orfordness (Watson-Watt's NPL Radio Dept Extension for RDF work from 13.5.35) I would have prophesied that radio location

of aircraft by echo was unlikely to succeed. But, of course, the asdic detection of submarines also seemed unlikely to succeed when it was first proposed in 1915." 'The invention all admired, so easy it seemed once found, which yet unfound most would have thought impossible,' (Milton).

The possibilities of long range detection by radio waves were however appreciated in 1931 by two members of the SEE Woolwich, W A S Butement and P E Pollard.* "Pollard and I" wrote Butement "discussed the possibility of detecting ships for the improvement of coastal defence batteries. We considered that the greatly-increased sensitivity of receivers at that time made it possible to detect very weak signals and that enough energy would be reflected from a ship to allow detection, if a powerful transmitter were available. To conserve power and to give an indication of bearing at least good enough to allow a searchlight to be "put on", we would need to use a beam of radio waves and hence, to keep the aerial system compact, a very high frequency. We therefore set out to develope a transmitter operating at some power on the highest frequency we though then practicable. We chose a wavelength of 50 centimetres. For our source of power we contemplated the use of the Barkhausen and Kurz principle (first used in 1921) in which a high voltage is applied to the grid of a triode while the anode is kept at a low voltage. We contemplated using the Fizeau method of measuring range. Fizeau many years earlier had used pulses of light of equal mark/space ratio, and so arranged a system of rotating shutters that his reception could be blocked at various discrete shutter speeds because the light reflected back from a mirror arrived after the shutter had moved from "open" to "closed"." We planned to apply this principle of equal mark/space pulses for the range measurement."

"We wrote a very brief note to the Royal Engineer and Signals Board, but were informed that "there was no War Office requirement" for such equipment. We were, however, allowed to work in our own spare time in the evenings, and to draw from the general stores such apparatus as could be found there."

Butement and Pollard then constructed a pulsed radio transmitter with which it was possible to measure range. "In due course we got the apparatus working . . and found at once that we could obtain reflections from the base of a mast in the centre of the Establishment compound on Woolwich Common. This was perhaps nine inches in diameter. We then set up an ordinary sheet of galvanised corrugated roofing iron, measuring about six feet by two feet, as a target and were delighted to be able to detect this at a range of 100 yards or more.

* Ref 38 p 165.

"We then informed the War Office of our experiments, inviting them to witness a demonstration. We were again informed that "there was no War Office requirement". We persisted, as we felt justified in doing; we then were able only to state it as our opinion that the range of scaled-up equipment on a ship would be enough to justify its adoption. Details of our work were sent to other establishments, but it is impossible to say on any evidence available to me that it had any direct bearing upon the radar work which started four years later as a result of the efforts of Watson-Watt, Wilkins and others." Watson-Watt says p 164: "The Butement-Pollard proposal of 1931 was disclosed to the Admiralty and while DSD expressed interest the DSR had considerable doubts as to the practicability of the system from the scientific aspect." Seven years later Butement was at the AM Bawdsey Research Station, set up in 1936 after Orfordness, working on coast-defence radar, but this time there was a requirement! It was to provide a sufficiently accurate indication of bearing to enable a searchlight to be put on its target. From this work sprang fire-control radars, first the Army's GL (gun-laying) set on $3\frac{1}{2}$ m, then Signal School's important systems on 50 cm and afterwards 10 cm and 3 cm systems.

The Tizard Committee. In 1934 official interest in air defence was strong and the Secretary for Air (Cunliffe-Lister, later Lord Swinton) set up the Committee for the Scientific Study of Air Defence. The DSR Air Ministry, H E Wimperis, who had originally proposed it, was the only member in government service: the other members were Henry T Tizard the Chairman of the Aeronautical Research Committee, a physical-chemist formerly in the RFC and much concerned after the war with airplane performance studies at the AM Establishment at Martlesham Heath, Professors A V Hill and P M S Blackett and A P Rowe, of the DSR's staff, as secretary. Professor F A Lindemann (later Lord Cherwell) was added shortly afterwards. The committee held its first meeting on 28.1.35 and towards the end of it Wimperis said that Mr R A Watson-Watt of the Radio Division of the NPL had just prepared at his request a memorandum on the uses of short wave em radiation for defence purposes. This was basically on the (negative) possibilities of a 'death-ray'; but since Wimperis and Rowe from their initial studies knew that the problem of air defence "was largely one of the detection of enemy aircraft" Watson-Watt had added an appendix 'Detection and Location of Aircraft by Radio Methods' actually dated 27.2.35 (reproduced at the end of Pt 1 of the Cabinet Office History, 'Archives 12'). The famous demonstration of detecting a metal aircraft at 8 miles range when it was in the 'beam' of one of the BBC's SW (50 m) transmitters at Daventry had taken place the day before! Watson-Watt's

paper had shown that at 10 miles the reflected energy was 10,000 times stronger than the minimum required for detection and thus indicated a possible range of 100 miles. After that the deluge.

A meeting of the committee took place on 18 March 1935, with Admiralty representatives only, which the DSR C S Wright, Dr A B Wood and Signal School's chief scientist Mr G Shearing attended, a. to obtain information on means for detecting and locating aircraft through cloud and fog, b. Naval AA gunnery and prediction methods used therewith.

Strangely no mention was made of AM work or Watson-Watt's epoch-making paper of three weeks before. Mr Shearing's minutes* state: "the committee appeared to place no reliance on acoustics or infra-red, and they consider the only possible method is one which involves the use of a source of energy independently of the plane eg ultra-high frequency. We referred to the experience of the Post Office in 1931 who, transmitting on 5 metres from Dollis Hill to Colney Heath, noticed interference effects (beats) when an aeroplane was 2½ miles away at a height of 200 ft."

Back at SS Mr Shearing wrote: "The following is suggested as a possible first experiment which would not involve a large amount of experimental work. Using the 1½ m homing beacon, point the beacon to sea and with a ship eg "Sardonyx" close in, attempt to get re-radiation off the ship with a parabolic reflector ashore, screened from the transmitter: the effect with distance to be observed. If a result is attained then the effect of a plane flying over to be observed." So SS was not far behind after all; but there is no record of this experiment being done. But Orfordness was visited in July '35 after the first demonstration to the Tizard Committee there on 15.6.35, when an aircraft was followed to 17 miles. A very important result of this visit was that SS were asked to provide special silica valves:-

> "Signal School to produce six experimental silica valves, on the lines of the NT41 modified as required for the voltage conditions" (5000 volts, but worked up to 12000 as W-W records on p 165 of 'Three Steps to Victory'), "of these, two to be ready by 1.9.35 and four by 1 October. Also two NT41A experimental valves to be supplied immediately." These were for 4-8 m trials: for 25-50 m trials:- "Two NT41s to be supplied. Also consideration to be given in Signal School to possible change to NT34s as regards improved filament emission. Three exp valves to be made up for test by November 1935."

* ASWE File FI/79.

Then on 13.8.35 DSD to SS:-

"The Controller has decided that Signal School should start work as soon as possible on the Naval application of the detection and location of aircraft by wireless methods, work on the production of transmitting apparatus being begun at once. To enable this work to be carried out without interfering with other commitments Treasury approval is being sought for an increase in SS staff of one Scientific Officer and one Assistant II.

As regards the receiving gear permission is being sought for an SS Officer to visit Slough and Orfordness for about six weeks."

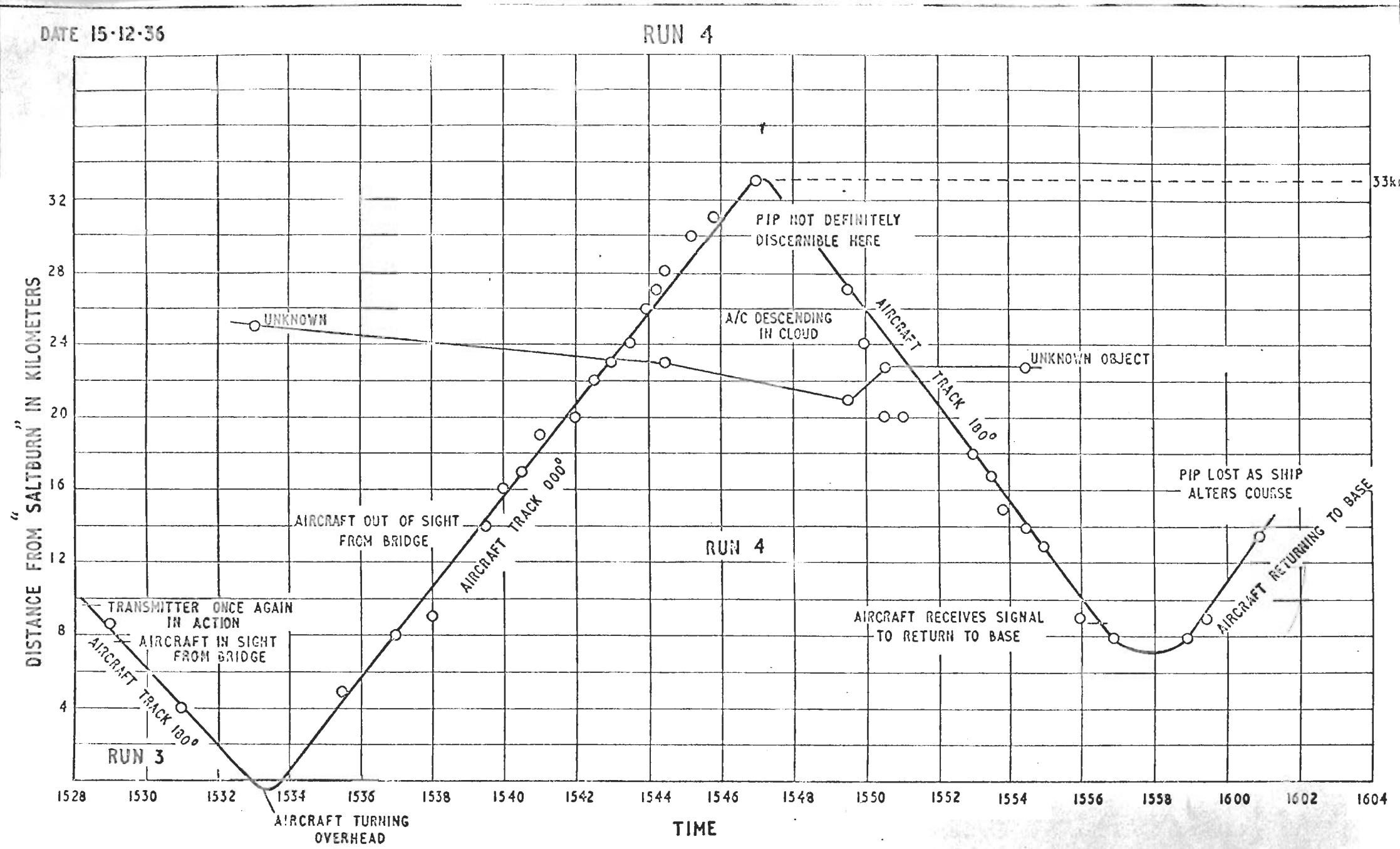
E M Gollin and W P Anderson were eventually recruited in December '35, and R A Yeo went to Orfordness on 2.9.35, and returned 9 October. An Admiralty meeting on 11 October recommended carrying out work at SS and proposed further additions of staff (C F Bareford joined June, A W Ross September and H M Bristow November '36). On 30.12.35 CE7149/35 approved the proposals for work at Signal School, the provision of a hut for experiments near the sea, later erected at Eastney Fort East in the Marine Barracks, and increase of staff of 3 SOs and 2 Assistants, in addition to the two staff already approved; and additional laboratory and workshop space in SS. The tentative requirements were stated to be:-

Aircraft: Warning of approach 60 miles, precise location 10.

Ships: Warning 10 miles, precise location 5.

Signal School were to begin work to develop the apparatus on 1½ m, and to explore bands both longer and shorter. "Initial experiments to be directed towards detection of surface craft." The WT set was named 79X on 17.10.35. Installation of apparatus in the hut at Eastney began on 14.7.36: Yeo and Anderson had taken the SS receiver to Orford for trial on 16.3.36. By 1.10.36 it was reported that an experimental transmitter (based on Type 7DX: illustrated in Fig 2 of QR for 30.9.28) and receiver had been built on 4 m and trials carried out. The stage had been reached when it was possible to transmit without paralysing the receiver. Aircraft had been detected but not below 500 ft and no ships. Range could be obtained but not direction or elevation. On 1½ m apparatus was in hand, but trials had not yet been carried out.

Although not definitely directed to 79X, work had been carried out by other staff on cm waves "which might be useful when applied to detection problems". Financial provision in 1936 was proposed as a transfer from Shore Stations, or by adding £5000 to the Contingency Fund. In November the Board approved the transfer of £5000 to DSD for provision of Type 79X.


DATE 15-12-36
RUN 4
"DISTANCE FROM SALTBURN" IN KILOMETERS
32
28
24
20
16
12
8
4
33k
PIP NOT DEFINITELY DISCERNIBLE HERE
UNKNOWN
A/C DESCENDING IN CLOUD
AIRCRAFT TRACK 180°
UNKNOWN OBJECT
PIP LOST AS SHIP ALTERS COURSE
AIRCRAFT OUT OF SIGHT FROM BRIDGE
AIRCRAFT TRACK 000°
RUN 4
AIRCRAFT RETURNING TO BASE
TRANSMITTER ONCE AGAIN IN ACTION
AIRCRAFT IN SIGHT FROM BRIDGE
AIRCRAFT RECEIVES SIGNAL TO RETURN TO BASE
AIRCRAFT TRACK 180°
RUN 3
AIRCRAFT TURNING OVERHEAD
1528
1530
1532
1534
1536
1538
1540
1542
1544
1546
1548
1550
1552
1554
1556
1558
1600
1602
1604
TIME

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