CHAPTER 12 - RDF 1936-1941

In 1936 permission was obtained to set up an extension of SS at Eastney Fort East. The Commandant, Royal Marines, soon expressed the hope that the unsightly tubular structures acting as masts would be regarded as temporary: but they were not moved, further south, until 1939 to make room for the permanent 100 foot masts, and not finally removed until 1943! The first brick building was erected in 1936 and until 1939, with a wooden hut, was all we had. In 39/40 other buildings were added to give 10,000 sq ft of lab space with 7000 of roof space.*

1936 was a year of experiment with little material progress, but by December a second 4 m transmitter and receiver had been constructed and installed in HMS "Saltburn", the Navigation School's sloop. Trials were made on 15.12.36. "Saltburn" was stopped 7 miles SE of Nab Tower with the ship's head due east; an aircraft flew at 5000 ft due north from over "Saltburn". It was followed out to 33 km and back from 27 km. "The set is ready for the proposed demonstration for the controller. On the way to the trial position it is possible that the following were observed:- Nab Tower at 9 km, "Curacoa" at 7 km, grid power lines at 20 km." A photograph of an A-scan trace is in the file FI/79, with plots of the aircrafts position versus time for the 4 runs. The transmitting and receiving aerials, single horizontal dipoles, were suspended in line between the 2 masts at about 75 ft height and approximately 50 ft apart.

Rotating dipole arrays with 2 dipoles one above the other (no 'sense' therefore) were to be installed by 31.5.37, one on each mast. Trials with these were done in July on a navigation school cruise to Guernsey and then Harwich (R A Yeo and W P Anderson). Mr Anderson wrote (manuscript notes preserved in the file quoted):-

> "As the aerials and the fitting of the receiving bench were not completed until a few hours before the ship sailed it was not possible to obtain a complete check on the apparatus before leaving Portsmouth. At sea it was found to be very difficult to tune the receiver and to check its correct working in the absence of any objects capable of giving an echo. Eventually however by the end of the second day (8 July) reflections from various fixed objects were observed up to a distance of 8 miles." (Appropriately enough the first echo seen was of Dartmouth at 5 miles.) A Tuned RF receiver (H M Bristow 30.11.36) was substituted for the superhet later in the trials period.
>
> During the trials carried out with RAF aircraft the maximum range was about 8 miles. There is no reason to suppose however that the ranges obtained during the December trials (16 miles) cannot be repeated after further work."

*J D S Rawlinson 'History of Naval Radar 1935-44' in 'Archives 13'.

D. DRG. Nº 16368L.

H.M. SIGNAL SCHOOL,
R.M. BARRACKS,
PORTSMOUTH.
SEPTEMBER 1937.

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X.3.3. A.E. H.S. [illegible]
X.3.4. J.F. [illegible], G.I.E.E.

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D.45. C.O. BAVERSTOCK.
D.46. W. CROFTON.
D.47. T.E. BOND.
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R.1. G.S. AYTRILL

The maximum range in aircraft by Oct '37 from Eastney was 35 miles. A larger ship to give a more stable platform and more allowable top weight was required and a cruiser was therefore indicated. HMS "Dunedin" was talked about in '38 but apparently this was not actually proceeded with.

"There is no doubt that the staff of 1 SSO, 3 SO or JSO and 3 Assistants is inadequate to enable the various aspects of R and D on 79X to be adequately followed, especially bearing in mind the fact that one of the JSOs has been permanently attached to Bawdsey", DSD and DSR informed the Controller on 28.10.37 "It is proposed by internal arrangement to relieve one of the PSOs in Signal School of some of his less important duties in order that he may devote close attention to the supervision of the 79X experiments." Thus Mr Horton became head of the radar group with the tally RO, from being X4 head of DF, about Nov '37. The exp Cdr from 15.12.37 was Cdr Basil R Willett (Capt Jan '40). Mr Brendrett at about the same time went to be assistant DSR and Dr A B Wood to MDD**. This was the first real change of organisation since 1920, the organisation in Sept 1937 being shown on the chart facing. Dr A A Symonds (5.9.28) became R1 at Eastney, J F Coales (21.10.29) R3 (later R2), with E M Gollin and C F Bareford, on the CM wave work, and A W Ross (28.9.36) R3.1 at Nutbourne.* The application officer for Type 79 A8, later B3, was Cdr The Hon H M A Cecil OBE, well remembered by the author for musical moments on the wardroom piano in "Rodney" and "Carlisle".

By Mar '38 it had been decided to change to 7 m to gain a considerable increase of transmitter power; and the aerial arrays had 2 reflector dipoles added. At this date Bawdsey were in a position to give a demonstration of the detection of ships from aircraft. On 25.3.38 at a meeting under ACNS the following order of priority of development was agreed:-

(a) Long distance warning of approach of aircraft from ships, with fair indication of direction, 50 miles at 5000 ft.

(b) Rangetaking of ships from a ship for purposes of low-angle fire with 1^{o} accuracy to 20,000 yds.

(c) Continuous short-range ranging on a/c, up to 5 miles, and in elevation and bearing with sufficient accuracy for AA control and searchlight purposes.

Following this meeting an Admiralty letter of 17.5.38 directed that 2 sets were to be fitted in the Home Fleet as soon as possible; copies of 79X to be known as 79 BX (actually not so, but 79Y when in HMSs "Sheffield" and "Nelson") had been begun in SS in anticipation of approval. DSD also minuted in SD 0345 of 31.5.38: "the AM, and the War Office also, are almost entirely dependent at the present time on SS for R and D of silica valves. At present the NT57 is only giving a life of about 100 hours as compared with at least 1000 for WT use.

* See app 2 at end of this chapter for a summary of the position at 22.2.38.
** To be Chief Scientist, Mine Design Dept, "Vernon" in Oct '37. See his "From BIR to RNSS" (1915-64) in the Memorial Issue of the JRNSS July '65.

Unless the valve section is enabled to extend the life and meet the demands, increasing every day in volume and complexity, which are being put upon it, there is a very real and grave risk that the whole RDF defence system, on which such high hopes are placed, may be brought to a virtual standstill in the moment of greatest urgency."

There was a sudden and very large demand for silica valves in Sept '38, when the Munich crisis made it imperative to keep the Thames Estuary Chain in continuous operation (39). This chain of 5 stations watched Mr Chamberlain's plane flying to Munich, and a continuous 24-hour watch for strange aircraft was started. £2M had been spent on the system. Signal School in May '38 was asking for finance, for purchase of special apparatus or development by approved firms, of only £15,000. High priority was to be given to Dockyard work on mechanical design associated with the mounting of the 2 aerial pedestals plus masts and, at ARL, the production of remote control apparatus for the rotation of the aerials. The proposals made by DSD in May '38 were readily approved: the wartime expansion had begun. The R group personnel at mid '38 was about 10 officers: in July '39, 3 SSOs, 11 SOs, 9 Assistants, 6 lab assistants plus about 28 designers and draughtsmen and 45 mechanics. Eleven more SOs, 9 Assistants and 6 lab assistants were asked for, and a total of 60 mechanics.

In parallel with the 4 m work in '37 a second group was working on 23 cm (E M Gollin, C F Bareford). Ranges were up to 3 miles on "Sardonyx" from Southsea Castle. Two 6 ft parabolic aerials were in use (6° beam) with a split-anode magnetron as the transmitter and a similar, quenched, oscillator as the receiver. J F Coales and H C Calpine had begun work on 50 cm in 1938 in conjunction with the GEC Research Labs, Wembley (E C S Megaw and C Chilton) initially for communications. A half-kilowatt pulse was obtained using 2 Western Electric 316A valves. The receiver had a noise factor of about 25 dB. At about this time the advent of polythene insulation gave much lower loss cables at 600 MHz, so that the transmitter and receiver could be fitted in an office below the associated gunnery director, initially that for the Mk II pom-pom, which only had to carry the twin yagi aerials (R V Alred) with their hemi-cylindrical reflectors.

Air to Surface Vessel (ASV) During the summer of 1937 E G Bowen, an original member of the Bawdsey team, demonstrated detection of ships from aircraft. Strong signals were obtained at 5 miles from "Rodney" and the aircraft carrier "Courageous" using 1½ m. The next major step was the use of the overlapping beam technique ('split') for homing onto a ship. Aerials were mechanically switched and the resulting signals were applied to a single crt giving both range and right-left

(39) See 'Science at War', Crowther and Whiddington, HMSO 1947; Fig 1 shows the growth of chain coverage from Sept '35 to Sept '41.

indications, 'butterfly' wings either side of the vertical range trace. This 'display' was characteristic of all subsequent versions of ASV operating on metre wavelengths. Admiral Doenity would one day say in a speech at Weimar during the decline of the U-boat war, 1943 - "The enemy has deprived the U-boat of its essential feature the element of surprise, by means of radar. With these methods he has conquered the U-boat menace. The scientists who have created radar have been called the saviours of their country. It was not superior strategy or tactics which gave success, but superiority in scientific research."*

Accurate Range and Bearing The first gunnery application of radar following the work of Butiment and Pollard at Bawdsey was the Army GL set, on 85 MHz. This used air-cooled copper anode valves in the transmitter (GEC E960, following the valves used in mobile television transmitters) of 40 kW pulse power. The feature of the set was the greatly expanded fast trace on the CRT with means for accurately shifting the zero off the tube, based on a very large size precision linear potentiometer with many tappings, until the echo was in the centre of the tube, thus giving much enhanced range accuracy of ± 25 yds. A GL Mk I set was fitted in HMS Carlisle (Type 280X) in late '39 and underwent accuracy trials at Malta in early 1940 (O L Ratsey, G E F Fertel). This ranging system was adopted for the next 7 m set, Type 279, first fitted in "Curacoa" in early 1940.** The maximum range on aircraft (10,000 ft) was about 65 nm.

Mowing the grass In 1938 green trace CRTs were in use so that the receiver noise on the trace of 79X was very like grass both in form and colour. The improvement in receivers at this time in respect of signal to noise ratio was considerable so that the noise was less relatively to a given echo. (H E Hogben 11.7.27, J Croney 2.10.39). The words of a US naval officer on first seeing this are memorable:- "You have mown the grass."

RDF in the Fleet

The two 79Ys, the first operational RDF sets, underwent trials in Sept '38 ("Sheffield") and Jan '39 ("Rodney"). The results with 79Y were good. The power output was 15-20 kW only but in Oct '38 "Sheffield" reported detection ranges on aircraft of 30 nm at 3000 ft, 48 at 7000, and 53 at 10,000 ft. A third improved set type 79Z was put in hand in June and was fitted by Sept '39 in "Curlew", a cruiser specially adapted as an AA ship: 30 more 79Zs were to be fitted. Their

*Ref 39 p 69; 38 pp 54-61.

**ASWE Monograph M333 A W Ross 29.5.1940 "Report on Trials of 279".

characteristics were as follows:-

The peak pulse output was 70 kW with a pulse length variable between 8 and 30 microseconds; this greatly increased power was due to the use of the new thoriated filament MT57T silica valves.

The echoes were shown on a range-amplitude display (A scan) with a scale calibrated in miles.

Bearing accuracy on a maximum was 5°, but rather better by taking the mean of the 2 zeros on each side of the maximum. The aerials, one at each masthead, had 4 dipole elements, 2 driven in parallel with 2 reflectors, the feeders being open-wire with the last section flexible to give 400° of rotation. The single-aerial version, with the first diode-switch, was Type 79B.

The switched-beam or "split-beam" technique, (Butement) whereby continuous and accurate following of the target could be made was evolved in about May 1939 and gave bearing accuracy enhanced by nearly 2 orders of magnitude over a rotatable "modified Adcock" system (null in broad polar diagram).

"While following the target, a boat which left Harwich every evening for Denmark", said Butement, "we were delighted to observe that while following the target on the radar the bearing was always 'between the masts'. A few quick sums showed that we had a probable error in bearing measurements of 10 minutes of arc, which was adequate to control gunfire without the use of searchlights at all.

There was a very interesting sequel to this experiment which occurred on 20.6.39. Winston Churchill arrived to inspect the Establishment: he was then a member of the Air Defence Research Sub Committee and so took an especial interest in our coastal defence apparatus. We had a flying boat as target and at 25 miles, farther out than usual. I adjusted the radar bearing until we were on target as indicated by the radar. "If you will look out through the peephole you will see the target on the cross wire, Sir". He looked, paused and exclaimed "I can't see a ——— thing." The naval aide looked, and I swung slightly right and left. The Commander promptly said, "No wonder you couldn't see it, Sir, the aircraft was obscured by the hair-line." (The aircraft was at greater range, remember). Churchill looked again, and I repeated the bracketing. "Marvellous" he exclaimed. Churchill "measured" the aerial array holding his hands before him as one might measure a fish. "We must have this on HM Ships. I will see to it." Next day Admiral Somerville arrived to view the equipment."*

Surface Warning Equipment. The main purpose of rdf up to mid 1940 had been air warning, but the value of detection of surface vessels had not been forgotten, and a new set to replace type 279 was planned in late '39 for this purpose. Accuracy in bearing required the use of beam-split, and since 2 arrays were

*Hartcup, loc cit ref 38, p 105.

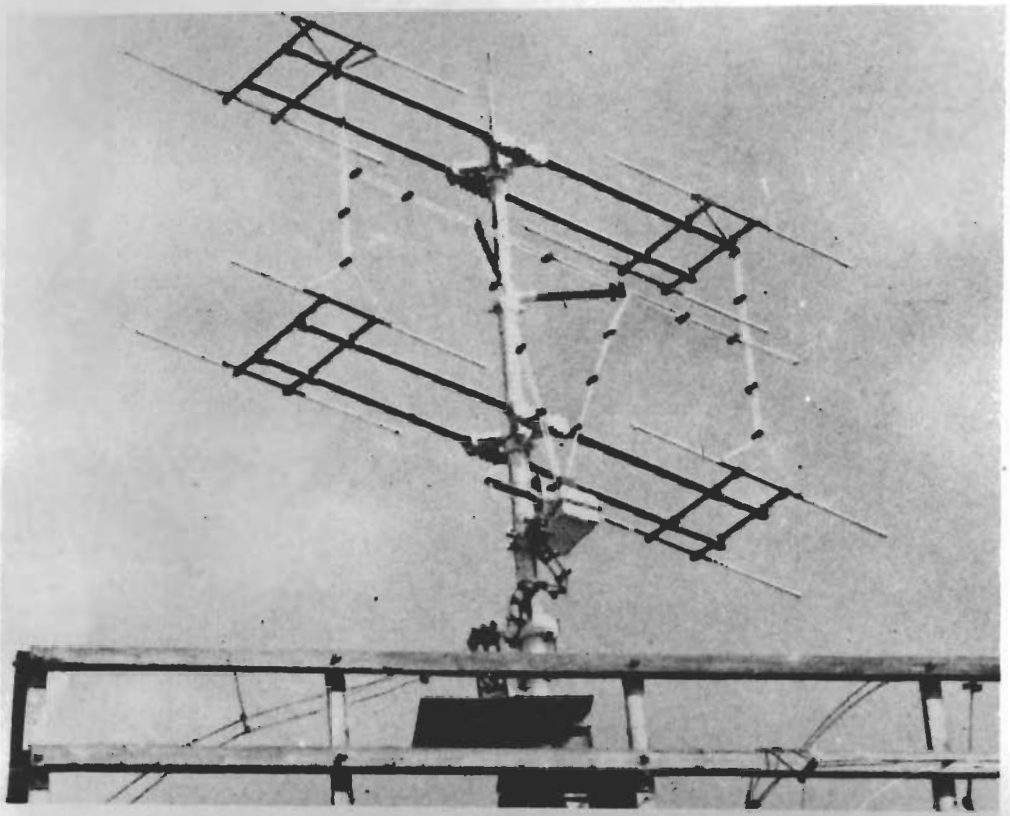

Figure 2. Type 281 aerial

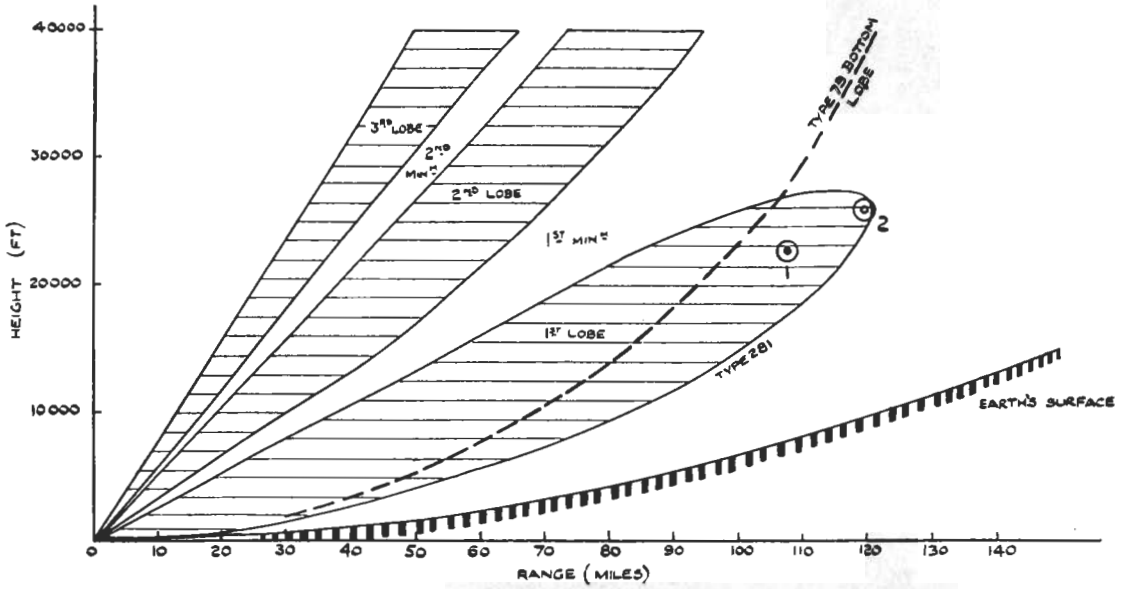

Fig. 3. Type 281—coverage diagram

necessary side by side in the receiving aerial to switch the beam, they had to be half the size, andthe frequency doubled therefore to 90 MHz. The new high power Surface and Air Warning set was Type 281, first fitted in "Dido" in Sept 1940. Its aerial is shown in Fig 2 facing. The transmitting aerial was fed symmetrically and thereby gave increased gain over 279. A bearing accuracy of ±½ degree was obtained. The lobed vertical coverage diagram shown in Fig 3, was a well-known feature of the early metre-wave sets, whereby some indication of height of the target aircraft could be obtained by noting at what ranges the echo went through a minimum. Thousands of hours must have been spent by radar officers at sea checking their vertical diagrams and determining height by this method, as part of the early warning procedure. The 15 micro-sec transmitter power of the 281 was 350 kW for warning (pulse) and 1 MW for ranging on short pulse, 2-3 micro-sec. This was the first time a megawatt pulse had been achieved. For a description of the transmitter and of the ranging techniques see the papers in the Radiolocation Convention Proceedings of the IEE (40). A feature of the modulator was the use of a thyratron with a discharge-line to generate a long 'rectangular' pulse (O L Ratsey) anda'pulse' transformer (D F Gibbs), with a 2-mil Rhometal tape core, to reverse the negative pulse to drive the silica series modulator valves. This was a major step in modulation techniques, which later became almost universally used for magnetrons.

The beam-switching reduced the gain of the receiving aerial by about 6 dB compared with the transmitting aerial and aircraft could fly over the top of the first lobe of 281. So, when the 600 MHz sets were introduced for gunnery purposes, the beam-switch on the receiving aerial was removed. The development model 281 was erected at Eastney in July '40 and became part of the chain warning system for a period. After the fall of France in June 1940 aircraft began coming from the north of France. The chain stations did not then extend sufficiently westward and the masts atove Ventnor had not yet been erected, or had been destroyed. So the staff at Eastney manned the set continuously: a hand-wheel controlled the turning of the aerial via M motors, and there was not yet beam-split on the receiving aerial (later designed by H J W Reeves). The first raid on Portsmouth, on 11 July 1940 at about 6 pm, was plotted in from the coast of France and west of the Isle of Wight.

(40) a. Radar Transmitters O L Ratsey JIEE V93 Pt 3A p 247 1946
b. Precision Ranging Equipment C A Laws JIEE p 423
c. A Switched-beam Directive Aerial on 600 MHz R V Alred do p 411
d. Naval Fire Control Radar J F Coales, H C Calpine & D S Watson, do p 349
e. Precision Ranging Systems for Close Range Weapons E W Pout, do p 380
f. High Power Pulsed Transmitters for 3000 MHz. D F Gibbs and B W Lythall p 266
g. Cheese Aerials, O Bunn, p 45.