THE STORY OF RADAR

METROPOLITAN-VICKERS ELECTRICAL CO. LTD
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Signal honour has been done to the British wireless industry. Many industries have received well-earned tributes for their contributions to the war effort, but to no other has been accorded by official Government spokesmen such unstinted praise, couched in such detailed terms, as that given to the radio industry — collectively and as individual firms — for its production of radar equipment. By now everyone knows the decisive part played in the war by that equipment, first in defence and then in offence, but it should be stressed that radar, though radio-like, is a brand-new thing, involving brand-new problems at every stage of design and production. That these problems were successfully solved reflects the highest credit on all the teams that played a part in its evolution. The work of all teams was so closely intermingled that, as Sir Stafford Cripps said at a recent Radio Industry Council celebration, it is impossible, even if we wished, to separate the various contributions. All were partners in a new enterprise, and it shows rare qualities of flexibility of mind in the industrial teams that they were able to adapt themselves to such novel conditions.

It must not be thought that the industrial contribution was restricted to production — mere "nuts and bolts stuff." On the contrary, much fundamental development work was done by industry, and in many cases, only a brief specification or elementary circuit diagram formed the basis of a "development contract", which passed through the successive stages of laboratory investigation, manufacture of development and pre-production models, and finally became a production contract for very large numbers of units.

The official story begins in the era of appeasement ; it was actually early in 1937 that radar secrets were first entrusted to the industry, and contracts placed. The transmitters for the CH (Chain, Home) stations were made the responsibility of Metropolitan-Vickers and the receivers were made by Cossor.

Those two firms thereby became forerunners of the many which were to work for Victory during war ; but it is a matter of interest that they, together with Pye, met the heaviest proportion of wartime demands for R.A.F. ground radar stations of all kinds.

These included not only the various sets in the radiolocation chain but the ground stations associated with "Gee" (the radar navigation system), "Oboe" (the ground-controlled bombing system), and "Gee-H" (another blind-bombing system).

It might also be mentioned here that the earliest experimental models of the airborne radar transmitters were manufactured by Metropolitan-Vickers in 1938.

Many new materials and processes were introduced to the electronics and radio field by the specialised conditions imposed by radar. Pre-eminent amongst these is the plastics material Polythene introduced by Imperial Chemical Industries and used almost universally as an insulating medium for ultra high frequency cables. Special moulding technique had to be evolved for the manufacture of such components as plugs and sockets, aerial insulators, matching units, etc., and several thousand mouldings were produced by Metrovick both at Trafford Park and in one of their dispersal factories.

When radar production first passed into the hands of industry, the chain was of vital importance, and the two contracting firms (Metrovick and Cossors) had to provide separate buildings for assembly and testing in complete secrecy. Two men alone were initiated into the whole story : Dr. J. M. Dodds, of Metrovick, and L. H. Bedford, of Cossors. Their colleagues were told only about the transmitter or the receiver ; never both.

The CH was the first *operational* radar system and led by logical steps which were determined by the war situation to the host of devices which are now available. In July, 1937, twenty stations were authorised to cover the east and south coasts of Great Britain. More were being set up at the beginning of the war, and with the fall of France CH coverage was extended round the south-west and west coast. The design of these stations was a peacetime design, and was very dependent on existing techniques. The wave-length used was 10 to 13 metres and pulses of about 10 to 15 micro-seconds duration were radiated at a recurrence rate of 25 pulses per second. The nominal pulse power was initially 200 kW, but later developments brought it up to about 800 kW. As the transmitter was "marking" only for 250 micro-seconds in each second, the mean power was only one-fifth kW when the pulse power had reached

800 kW. This very small mark/space ratio is characteristic of radar transmitters and explains the very high pulse powers which have been obtained.

Provision of additions to this system and of the coastal defence radar for detecting enemy aircraft sowing magnetic mines were early problems of the war.

A Cambridge professor undertook a hurricane programme for the introduction along the coast of equipment which existed only in a single laboratory model. Metrovick were asked to develop the transmitter, which became known as the CHL, capable of delivering a pulse power of over 100 kW to the aerial system at 1½ metres wavelength. The system operated over a range exceeding 100 miles.

With these developments the radar defences, which were to win the Battle of Britain, were given their final link.

From the Navy's point of view, meanwhile, the outbreak of war had not only given added impetus to the development of new devices but enormously increased the demand for standard sets for communication, and DF, in order that requisitioned vessels could be equipped.

The Admiralty Signal Establishment was rapidly and enormously expanded, partly by drawing technical talent from the very firms which were later to make so great a contribution ; but no expansion could be adequate to permit adherence to the old "slow but sure" routine, and production had to be arranged before laboratory work was finished.

A certain type of set was made for fitting in ships with a type of aerial which produced a narrow beam. To cope with the rolling of the ship, this aerial had to be "stabilised", making it what was at first regarded as a fantastic mechanical contraption. It was, however, successfully put into production by Metropolitan-Vickers, Ferranti, and W. A. Bentley, of Leicester.

The application of a cathode-ray tube to portray in plan the positions of all surface ships relative to each other and to the observer as if on a map of known scale was adapted for naval use by the Gramophone Company, and produced by them, Metropolitan-Vickers and Allen West.

An improved type of this display system has recently been developed for the Admiralty by Metrovick.

It will be appreciated that naval gunnery introduces the special circumstances in which both combatants are always moving freely in two dimensions, and, in the case of air targets, in three dimensions. Targets, too, are relatively small, and it is no use putting the shells close to them ; they must be hits. This calls for extreme accuracy and first-class workmanship in instruments.

The earlier equipments measured range only, albeit more accurately than the range-finder, yet much below the standard science knew could be achieved. Greatly improved devices measuring range, accurate to a few yards, were made from 1941 onwards by the Marconi Company and Metropolitan-Vickers.

On land, the night blitzes were finally mastered by radar ; the problem for the R.A.F. was the ground control in the dark by GCI (Ground Controlled Interception) radar stations of fighters which themselves would carry AI (Air Interception) radar to finish the chase. The Army demanded means for the accurate sighting of AA guns and searchlights by GL (gun-laying) and SLC (Searchlight Control). GCI was a development from CHL (Chain, Home, Low-flying), and the first prototype was shown to the industry during the crucial autumn of 1940. Within two months the first experimental model was ready.

This model was inspected, and at least one of the three firms concerned had its first production model installed at an R.A.F. station within three weeks. It was on the air within another six hours.

In the months during which these stations came into use the night fighters, with the Army's radar-aided searchlights and guns of AA Command co-operating, took steadily increasing toll of the enemy night bombers. In May the Germans lost 144 night bombers, of which our fighters shot down 102. Then they abandoned the raids and turned to the war on Russia.

The radar transmitter used in this system was developed and manufactured by Metrovick.

The ground radar transmitter which directed the Army's defence over our coasts and cities was developed from the earliest days by Metropolitan-Vickers, who received a development and construction contract for the first gun-laying equipment at the beginning of February, 1939, and the first prototype was produced in August, still before the war, with more than 400 completed by November.

On the next "mark", Metropolitan-Vickers — who were bombed on Christmas Eve but immediately continued in a dispersal factory — were engaged.

An indication of the size and complexity of the transmitting equipment is given by the fact that it weighed over a ton, incorporated no fewer than 60 valves, and many highly accurate gears, wormwheels, cams and so on. By May the first prototype model was being field-tested and early in June was undergoing official trials, the first equipment coming off the line in November, 1940.

Parallel with all the defence developments was the first of the airborne radar sets for the offensive, the ASV (air-to-surface-vessel) equipment carried by aircraft to search for shipping. This was followed by an improved version in a series used for finding surfaced U-boats at night. ASV was also adapted for use with the Navy in small ships for the detection of surface shipping and aircraft.

The Aerial System associated with ASV presented many problems in that it had to "scan" the complete horizon continuously, its weight had to be reduced to a minimum for aircraft use, and it had to be capable of handling the very high pulse power obtained from the centimetric radar. The development of this system was carried out by Metrovick.

Then, owing to the desperate struggle at sea, "H2S" sets — which show coastal and other geographical outlines on the cathode-ray tubes in map form — were modified and diverted from their use by Bomber Command into coastal aircraft. This decision was taken in November, 1942, the actual production taking place in the following January and February.

With all these radar developments by no means the limit for industry had been reached. The great series of navigation and bombing aids which were to make possible the shattering of Germany's industry was on the way.

"Gee" enabled bombers to take off, assemble in saturation strength, and navigate constantly until their return, as well as making possible accurate navigation over home territory and sea in all conditions of visibility.

It has been revealed already that from February 1942 onwards more than 2,300 acres of Germany were destroyed in a year, mainly by the use of "Gee" navigation, compared with a total of 400 acres until that system started. By the end of 1943 no fewer than 11,000 airborne "Gee" sets of an improved type — now almost universally used by Transport, Coastal, Bomber and other R.A.F. Commands as well as in naval craft — had been delivered by three big firms which were now working on it in the United Kingdom. The final achievement was a rate of production which enabled Britain to give 2,000 sets a month to her United States allies.

During 1943 the first Mark of "Gee-H", blind-bombing aid akin to "Gee", was developed, and 200 sets delivered in three summer months.

When the battle of the Ruhr started in full blast in 1943 the "Oboe" ground-guided bombing system was introduced, principally for the pathfinders to drop their flares. "Oboe" was produced by Metropolitan-Vickers, Pye, and Standard Telephone and Cables, and developed under TRE direction as a mobile unit in 1944.

Finally, as the world now knows, the bomber was freed from any dependence on ground radar stations. "H2S" had arrived and with it the first direct picture of the unseen earth's surface at night or in cloud.

Work on H2S went on, and within a year of the approach to industry these sets were being turned out.

The eight "boxes" which made up the original installation were developed and crash-produced by several firms who completed the development task hand in glove with TRE between March and December, 1942, and turned out a first order for 50 installations at the same time. By the end of April, 1944, shortly before the invasion of Europe, the total was 3,700. By the end of the European war seven out of every eight Bomber Command aircraft had H2S.

The Metrovick contribution to this project was in the development and production of many thousands of modulators which constituted one of the eight "boxes" mentioned above.

Large numbers of motor alternator sets for supplying power to radar equipment were made for the Air Ministry by Metropolitan-Vickers in their Trafford Park Works, while engine-driven alternators for aircraft were manufactured in their Sheffield factory. Control panels for these and for the Admiralty were also developed by the same firm.

This story of the magnificent achievements of the radio industry, which all the time kept pace on ordinary wireless needs, can of necessity cover only a fraction of the radar devices which have been put into use. Not only are many of them still undivulged, but there are as many others whose uses for height-finding and other purposes cannot be detailed because of their very variety.

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