The Orford Ness Rotating Wireless Navigation Beacon (Black Beacon)

By Barry Searle

1. Background

The 1920's witnessed a huge growth in experimentation and development of radio technology. There was a great interest in broadcast radio, where a large audience could be reached by transmitting signals on the long, medium and short wave frequency bands. The BBC was created in 1922. Maritime radio systems slowly developed firstly using telegraph (Morse code) and then voice services. By the late 1920's valve technology had improved to a point where reasonably high power transmitters were economically possible. Receiver designs, however, were limited by the technology of the day, being quite basic in their capability. During this period there was an increasing need for better navigation systems to improve safety and efficiency of ship and aircraft movements. Government scientists recognised that radio systems had potential in this area and increased funding to stimulate research.

2. The Rotating Beacon concept

In 1928, the Royal Aircraft Establishment (RAE) at Farnborough was working on a system that used two rotating beacon transmitters at known locations. Ships and aircraft would establish their bearing to each station and then could plot their position by triangulation on a chart. The design objectives were that the system should have a useful range, be easy to use and not require specialist receiver equipment.

3. Construction

In early 1929, building work commenced on identical beacons at RAE Farnborough and Orford Ness in order to provide navigation coverage of the English Channel area. The system used a sturdy 3m square wooden aerial frame structure, vertically mounted on an elevated motorised rotating platform. A copper conductor loop and associated large air-spaced tuning capacitor were attached to the rotating frame and connected to the transmitter located below by means of electrical slip rings. The aerial rotated clockwise at a rate once a minute, so that every second of rotation of the aerial corresponded to 6 degrees of bearing change. The transmitter was built on a brick ground floor base, with a two storey octagonal wooden windmill-like structure above to house the aerial and associated equipment. At Orford Ness the Beacon was initially supplied with electrical power from the site central DC generator located near the motor transport workshop. Cables were laid from the generator house, over Stony Ditch, then over the shingle to the beacon, a distance of about half a mile.

4. Design

The system transmitted a 288 kHz (1041m) long wave continuous signal from the rotating square aerial. Aerials of this type transmit a maximum signal strength when a receiver is in line with the aerial frame or plane. It subsequently transmits a near zero 'null' signal when a receiver is positioned at 90 deg to the aerial plane. When the aerial plane is facing north, an amplitude-modulated morse V signal is sent (…-). It then rotates 90 deg to face east and a morse B (-…) signal is sent.

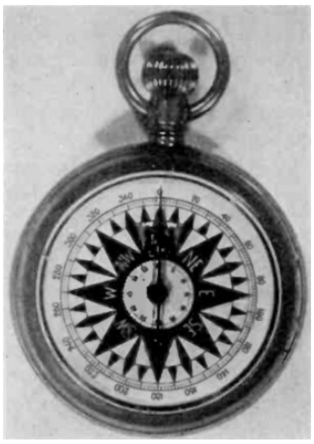
Orford Ness would transmit for 5 minutes, and then Farnborough would transmit for 5 min at the same frequency and so on. The system could be run continuously when sufficient funding was available.

5. How the system worked

A ship out at sea would tune their ordinary receiver to 288 kHz and their signal strength meter would rise and fall as the beacon rotated. A stopwatch was required. When the 'V' code was heard the stopwatch was started. The operator observed the signal strength meter and when the signal fell to its lowest point, the watch was stopped and elapsed time in seconds noted. The number of seconds was multiplied by 6 to calculate the bearing in degrees.

A customised stopwatch with an integral compass rose shown below was produced, based on a 'sports' 30 seconds per revolution product. As before, when hearing the 'V' code, the user started the watch running. When the 'null' was observed the watch was stopped. The bearing could then be read directly from the watch compass rose, thus avoiding the need to calculate the bearing.

Customised Compass Card Stopwatch



Courtesy of NPL
www.npl.co.uk

The operator kept monitoring and recording, with similar results. The operator would then notice a change in the null timing (the transmitters have changed over). Both bearings were then plotted on a chart from both beacons. There would usually only be one intersection, which would be your position. The easterly ‘B’ signal was there to provide a second sanity check reference for ambiguous situations.

Courtesy of NPL
www.npl.co.uk

6. How well did the system perform?

It was simple to use and did not require specialist receiver equipment or training, only a stopwatch and navigation chart. It could be accurate to within 2 degrees, with a practical range of up to 100 miles and, under certain conditions, much further. Performance at night was degraded over longer distances. It was, however, unsophisticated and cumbersome to use and the rapid pace of radio development internationally made the system look increasingly obsolete. In early 1933, a dedicated power house containing a diesel generator was built nearby, which was shared with the newly constructed Bomb Ballistics Building. Continuous operation was costly and funding was shared between the Air Ministry and Trinity House. Use of the beacon system by commercial mariners for navigation steadily declined. The beacon system finally shut down in October 1934 following the withdrawal of funding.

7. Historical reflection

The rotating beacon was in fact the ‘first of the beams’. Orford Ness was used for the initial development of Chain Home Radar in the mid 1930 s and, subsequently, major over-the-horizon experimental radar installations during the Cold War period.

The rotating beacon building and nearby powerhouse have been restored by the National Trust and are now used as an exhibition space and visual observatory. The building is Grade II listed.