

# 'The Beginnings of Directional Radio Techniques for Air Navigation'

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Brian Kendal's paper in this issue of the Journal is an interesting catalogue of most, but not all, of the development of radio aids to air navigation as seen from the technical radio point of view. Its principal omission appears to me to be that no mention has been made of that remarkable German invention called *Die Sonne*, which we renamed 'Consol'. This provided very accurate and long-range navigationally valuable position lines depicted upon special plotting charts. It was a Medium Frequency system transmitted from geographically widely-separated stations (Stavanger, Brest, Santander, Seville, etc.) to obtain excellent 'fixes' which were available to anyone equipped with a simple M/F receiver and the ability to count. [It is hoped that Consol can be dealt with in a forthcoming article on hyperbolic air navigation systems – Ed.]

There is no account given of the difficulties encountered in the development of the external loop. For instance, the 'boffins' at the Royal Aircraft Establishment, Farnborough, vigorously opposed the loop's installation on the grounds of faulty assumptions of the amount of aerodynamic drag which would be involved. Unfortunately, their views prevailed for some considerable time. Then there was the problem of eliminating the interference of static electricity, which builds up in flight. This was cured by fitting static bleeders to the trailing edges of wings. However, the very real difficulties of plotting the position line obtained from a loop at any distance from the source on the ground were completely ignored because of ignorance of the effects of the convergence of meridians. Nobody had heard of curves of equal bearing! It is important not to overlook really important defects of radio aids such as coastal refraction, night effect and the difficulty of calibrating loops for quadrantal error.

The use of the Orfordness beacon, mentioned in Section 4.1, was not invalidated by the movement of the aircraft, since the air navigator was quite familiar with the process of a 'running' fix. The problem arose from the cumbersome nature of the operation.

I am afraid that the paper gives an exaggerated impression that radio navigation aids (beacons, ranges, and D/F systems) gave a complete answer to the needs of air navigation during the war. On the contrary, the widespread introduction of radio ranges in North America in the thirties resulted in the general extinction of the practice of air navigation in that continent, regardless of the fact that radio aids were not universally available and that they could be equally useful to all combatants engaged in a war. In the UK, any such installation of a system of beacons would have provided an attacking bomber with perfect target orientation.

The result of the American dependence upon radio ranges meant that, when their Air Forces arrived in the UK at Prestwick, they had to be lent RAF navigators to get them to their operational bases. I am surprised by the assertion in Section 4.2 that 'several (radio ranges) were also installed in the United Kingdom' during the wartime period. I do not think they would have been approved by a highly sensitive Defence Authority, and I do not recall their introduction, but I may be wrong!

In these circumstances, it can be truly stated that reliance upon radio ranges and

radiocompasses had produced a highly dangerous degree of navigational illiteracy which had to be overcome with much pain and many penalties.

In Section 4.3, a brief description is given of *Knickebein*, which was used by German bombers against UK targets early in the war. Strenuous efforts were made by the RAF to identify this system, and eventually it became possible to bend the beams and also to deduce from their layout which targets were under threat. The system was far from totally effective.

It is, of course, axiomatic that the needs of the user must always be paramount. Unfortunately, each of the radio navigation systems was found to be wanting in one or more aspect. For example, the D/F systems were unable to deliver accurate fixes at any distance from the UK – which was a serious defect in such areas of operation as the South-Western Approaches. As these facilities were used only in times of emergency – under the prevailing conditions of radio silence – they were seldom overloaded. Their failure sprang from the narrow width of their baselines: so-called ‘fixes’ were usually large areas of uncertainty. Similar limitations applied to loop bearings – only more so: the bearings were usually in error by several degrees.

As a matter of history, it is appropriate to conclude with the official doctrine of the Royal Air Force for navigation during the war, involving the use of radio aids. Apart from the practical plotting techniques of determining the actual position line, which, in the case of a loop bearing, is a sector of the applicable curve of equal bearing, there is the added problem of laying-off a bearing from a source not contained on the map or chart in use. Given all these real difficulties, the navigator was given the following warnings:

- (i) All D/F may be subject to enemy interference.
- (ii) The reliability of D/F depends on the distance from station, the height of the aircraft, the kind of intervening country and the prevailing atmospheric conditions.
- (iii) Congestion may occur when asking for D/F bearings or fixes, as only one caller can be handled at a time. When flying conditions are bad and D/F help is in great demand, serious delay may be experienced.
- (iv) When using the aircraft loop, bearings can be obtained at any time without causing congestion; but the reliability of a bearing is always dubious, and at extreme range (300 miles), the plotting of position lines may be complicated. The sense of a D/F bearing should always be checked against the bearing to be expected from general considerations. Remember that a steady course is essential for an accurate loop bearing.
- (v) Good fixes can be obtained only when the baseline between the stations subtends an angle of at least 30 degrees.
- (vi) The failure of the aircraft's W/T, due to a variety of reasons, cuts the navigator off completely from all D/F facilities.

It cannot be too strongly emphasised that D/F is only an aid to air navigation. Used cautiously and always supported by a background of other observations, it can be a valuable asset to assist, but never to replace, DR navigation.

The emphasis was necessary to give the wartime navigator a proper sense of proportion.

It is hoped that these comments do not appear to be too negative, but it is important to keep the record straight.

#### KEY WORDS

1. History.
2. Air navigation.
3. Radio navigation.