'Hyperbolic Airborne Radio Navigation'

from Keith R. Greenaway

Mr Blanchard is to be complimented on his very informative paper on the history of hyperbolic radio navigation aids, (Air Navigation Systems, Chapter 4, Vol. 44, No. 3, September 1991). The opportunity to comment on the paper is much appreciated, as some additional information on the testing of LF Loran appears appropriate at this time.

About 1945, the USAAF expressed an urgent need for a long-range navigation aid for high latitudes. Results from the USA experimental east coast chain operating at 180 kHz showed promise in fulfilling this need. Hence, in late 1945, the USAAF, in cooperation with the RCAF, set up an experimental chain named Musk Calf in western Canada. The master station was located near North Battleford, Sask., the western slave at Dawson Creek, B.C., and the eastern slave at Gimli, Man. Balloons were used to support the aerials and the chain transmitted on 180 kHz.

The project was directed by a 'Combined LF Loran Committee Canada-USA'. A flight test section consisting of USAAF, USN and RCAF personnel was established at Edmonton, Alberta, in March 1946. For the next 4 years the unit, in conjunction with a ground monitoring programme, gathered data on LF Loran signals throughout the northern reaches of the continent and as far north as the geographic pole.

The bandwidth of the airborne receiver was widened to accommodate the longer pulses transmitted at the 180 kHz. Unfortunately, this appeared to increase the problem with precipitation static. The overland coverage was much greater than that of Standard Loran but, at times, ground-skywave interaction made matching signals difficult which was reflected in the accuracy of the fixes. Nevertheless, test results were sufficiently encouraging for the Combined Committee to go ahead with the construction of an Arctic chain in response to a priority stated by the USAF for a navigation aid in the polar region.

The Arctic chain consisted of a master station at Kittigazuit, NWT, a slave station at Skull Cliff just west of Pt. Barrow, Alaska, and another slave at Cambridge Bay, Victoria Island, NWT. It was known as the Beetle Chain. Construction was completed by late 1947 and flight testing commenced during the first half of 1948. Just prior to beginning the flight testing it became evident that attenuation of the ground wave signal was much greater over permafrost and certain types of sea ice than had been predicted. Control stations at Barter Island, Alaska, and Sawmill Bay, NWT, were introduced to assist synchronization.

As the test programme proceeded, it became quite evident that a pulse matching system operating at 180 kHz would not provide the reliability or accuracy needed for navigation in high latitudes. Greater attenuation of the ground wave over permanently frozen ground, problems with ground wave-sky wave interaction, and severe precipitation static interference when flying in cloud or ice crystal haze led to abandoning the project in early 1950.

Although the LF Loran programme failed to meet requirements, knowledge gained from it, coupled with the results of experimentation at lower frequencies, eventually led to the Omega system of today. Additionally, there were many beneficial side-effects which aided the development of polar navigation equipment and techniques, and increased the knowledge of high latitude regions generally.

from S. Ratcliffe

Mr Blanchard's paper on Air Navigation Systems in the September 1991 issue of this *Journal* may give the impression that the Decca Flight Log was the first flight-desk map display to convert hyperbolic coordinates to a fair approximation to lat–long coordinates.

A map display driven from GEE was built at TRE (Telecommunications Research Establishment) and demonstrated to PICAO (Provisional International Civil Aviation Organization) in 1946. The coordinate conversion problem was considerably simplified by representing the hyperbolae in polar coordinates having the master station at the origin. This technique was apparently independently devised by Decca, whose display was undoubtedly better engineered than TRE's experimental model, which made extensive use of Meccano and was unlikely, in that form, to appeal to aviators.

Incidentally, reference 11 in Mr Blanchard's paper should be to Volume 32, No. 1 – not Volume 43, as was printed.

KEY WORDS

1. History. 2. Air navigation. 3. Radio navigation. 4. Hyperbolic systems.

'Navigation: Land, Sea, Air and Space'

Myron Kayton

I want to thank Mr J. E. D. Williams for the historical additions he suggested in his review of my book. *Navigation: Land, Sea, Air and Space* (Vol. 44, p. 283). I especially thank him for his information about the existence of four-course ranges outside the United States in the 1940s and for his information about Mercator's recalculation of the east–west extent of the Mediterranean Sea.

Though I am not a maritime historian, I think my statement that the method of lunar distances was little used at sea is correct because of the complexity of the calculations for the navigators of the time. In future editions, I will distinguish two periods. In the period prior to the chronometer, longitude was measured by dead-reckoning, sometimes indirectly by observing magnetic variation using the pelorus in conjunction with magvar charts such as Halley's. Ships were steered by constant-latitude sailing, requiring only a coarse knowledge of longitude. In the second period, during the transition to chronometers from about 1800 to 1900, Bowditch's simplified calculations of lunar distances were used by educated navigators.

Mr Williams chided me for confining 'navigation' to the measurement of position and velocity. He pointed out that our pre-electronic colleagues used the term for measuring position, conning their ships, and other means of 'conducting a craft from one place to another'. He objected to my 'flouting...the unanimity of centuries'. He should be aware that, among practitioners of electronic navigation, which I have been for 35 years, 'navigation' is universally used for the determination of position/velocity, 'guidance'