THE USE OF TWO RANGE DECCA IN THE CROSS CHANNEL TUNNEL SURVEY

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In March 1962 the Contract Survey Department of Kelvin Hughes was commissioned to carry out a cross Channel survey for Messrs Richard Costain in connection with the proposed immersed twin tube tunnel from England to France. The object of the survey was, primarily, to obtain an accurate profile of the sea-bed along the proposed tunnel route, this to include the location and close investigation of wrecks lying on or near this route. Sea-bed and other investigations were to be carried out simultaneously.

The ingenious method of laying the immersed twin tube tunnel has been much discussed in various technical journals and no further elaboration on this will be attempted in this article. The writer will also assume that the reader is familiar with the use of two range Decca for hydrographic surveying.

The tunnel route was decided upon after a series of preliminary surveys carried out some time previously and was to be a straight line from a point on the English coast, just south of Dover, to Sangatte, south of Calais ; over some twenty nautical miles. The first problem was to decide the method of fixing and, initially, Decca Hi-Fix was considered to be the ideal system for this particular survey. Unfortunately Hi-Fix equipment was not, at that time, available for allocation, therefore the use of the two range Decca system with its longer wave lengths had to be accepted. As the nature of the survey demanded its execution on a relatively large scale, 1/5 000, it was imperative that the system be carefully calibrated with frequent checks during the course of the survey to achieve the highest possible accuracy.

Sites for the slave stations were selected as shown in figure 1 and the electrical centres of these were tied in to the national grid of Great Britain. Reasonable angles of cut were obtained up to a point some two miles off Dover and from there visual fixing methods were used, utilising a theodolite on the top of Shakespeare Cliff (*) and the survey vessel being conned on to the line by radiotelephony.

(*) *I.H.B. Note.* — This cliff is situated near the extremity of the tunnel on the English coast.

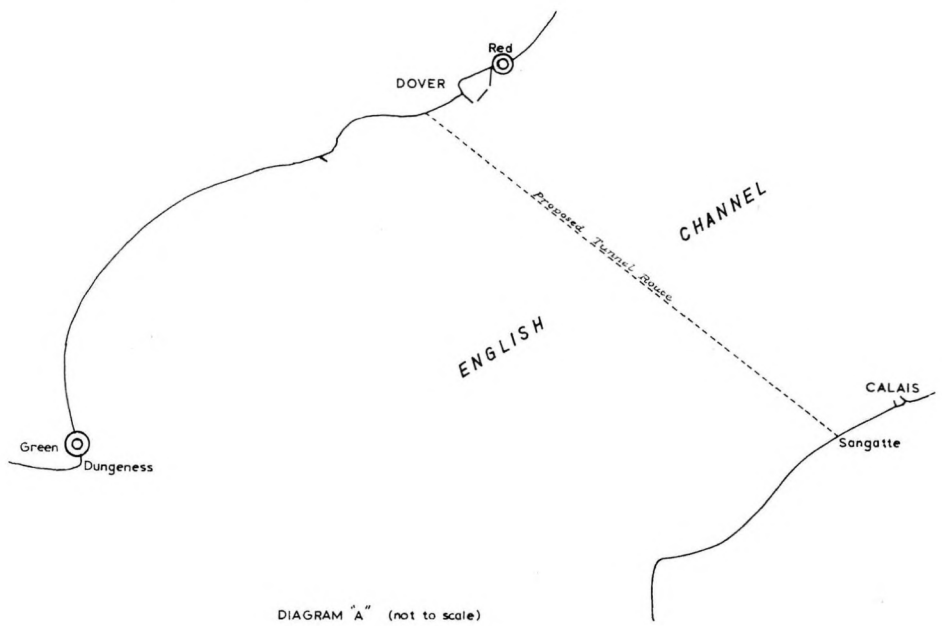

FIG. 1

The construction of the plotting sheet, some thirty feet in length, was greatly facilitated by the use of Admiralty standard circle sheets for the use of which the writer is indebted to the Hydrographic Department of the Admiralty. These sheets, printed on a plastic base, show arcs of circles from a common centre with radii every 2 centimetres up to 1 000 cm and were admirably suited for the task of drawing the two sets of lanes along the tunnel route.

It was decided at the outset to use a velocity of propagation of 299 776 km/sec and to apply phase lag correction to each lane on the plotting sheet according to its distance from the slave. The frequencies were :

Master	171.890	kc/s	(12 *f*)
Red	114.593	kc/s	(8 *f*)
Green	128.9175	kc/s	(9 *f*)

with a basic frequency of 14.3242 kc/s.

Red lane-widths were, therefore, 436.00104 metres and green 290.66651 metres.

Lines to be sounded along the tunnel route were transferred from the plotting sheet to a track plotter chart using a scale of 4 inches to one lane; in point of fact this approximated to the actual scale of the survey. The plotting sheet itself, drawn on Permatrace, was far too long and unwieldy for use on board and, in this respect, the track plotter proved to be indispensable.

All was now ready to commence the initial calibration of each slave to determine locking constant. Particular care had to be exercised here as the green slave had to be sited at a point on the coast some two miles

north of Dungeness where a considerable stretch of sand and shingle is exposed at low water and it was expected that a change of locking constant might occur with the state of the tide. It was therefore necessary to calibrate over a tidal cycle at this station and the following method was adopted to avoid having a number of observers ashore and also to avoid the time and labour required to compute large numbers of intersections.

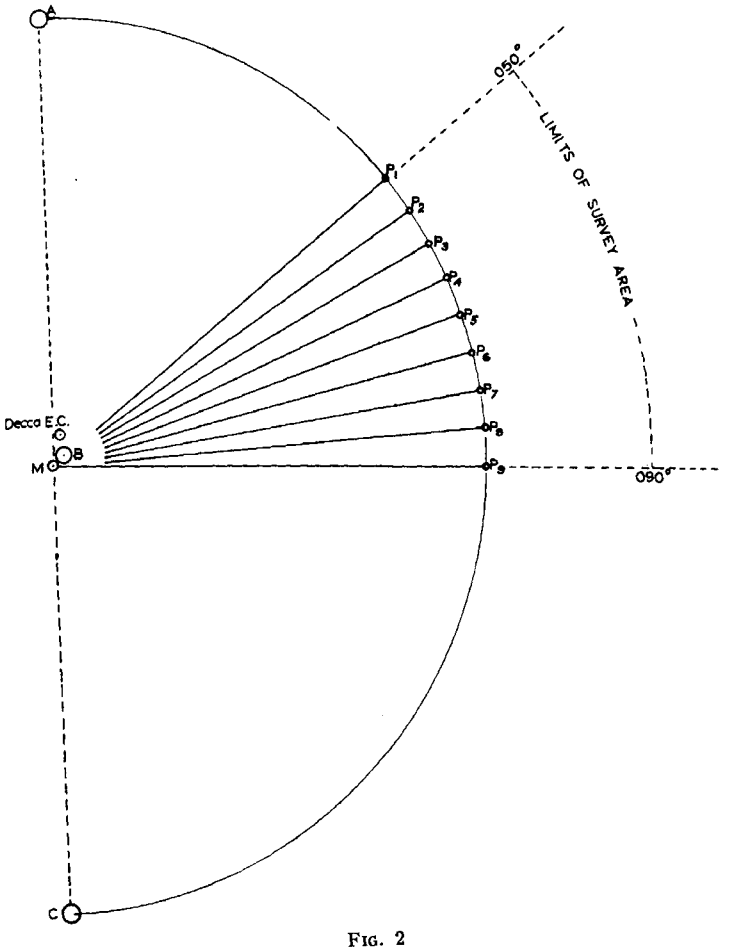

FIG. 2

As shown in figure 2, natural fixing marks were selected either side of the station so as to be almost equidistant from the station. In point of fact, in this case, these marks also subtended an angle of very nearly 180 degrees from the station and so the arc of constant angle of 90 degrees was chosen as shown. The centre of this arc is point M and the coordinates of points P_1 to P_9 were computed along the arc of the circle. From the coordinated points the grid bearings P_1-B, P_1-A, P_2-B, P_2-A, and so on to P_9 were computed and thus the angle between B and A at each point deduced. Grid distances between each of these points and the Decca electrical centre were also computed and a graph constructed showing distance to

the electrical centre against the angle between marks A and B for each of the above points. A reconstruction of the graph is shown in figure 3 and it can be seen in this case that the range of distances differed by only 33 metres over the 40-degree sector of arc. The distances on the graph are converted to lane widths, corrected for phase lag in this case, and, if required, true bearing from green slave can be superimposed over the graph angles shown. Although the construction of this graph involved a certain amount of time and effort, this was done before the survey was due

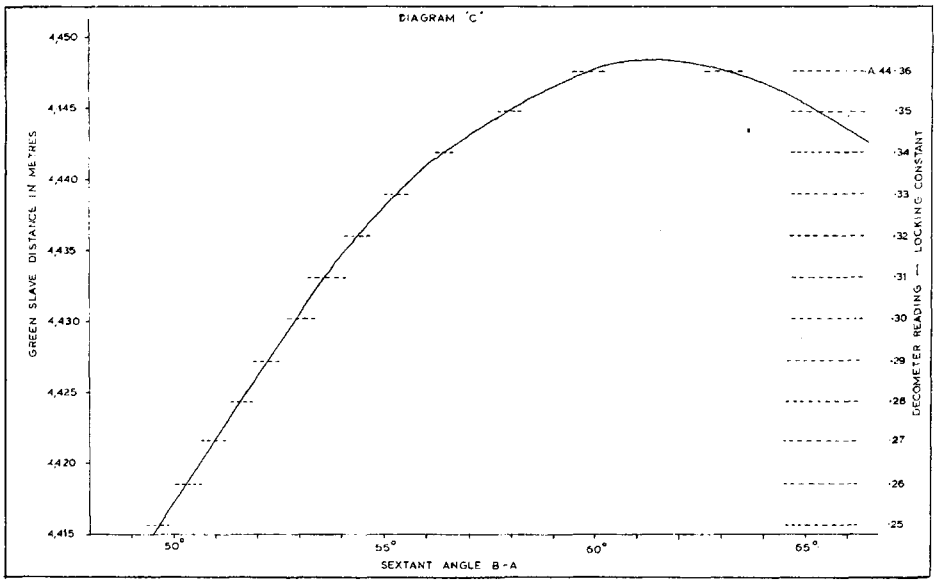

FIG. 3

to commence and saved a considerable amount of labour during the period allocated for calibration. In practice the survey vessel was steered along the arc by sextant with a second angle taking the angle BA at frequent intervals and decometers read at each instant of fixing. By entering the graph with the angle, the distance or correct Decca reading can be extracted. To obtain locking constant subtract the graph reading from the actual decometer reading. Using this method, therefore, 130 fixes were obtained over a 6-hour period and it was found that in practice, locking constant varied neither for bearing nor for change in tidal height. The red slave was calibrated in a like manner. It will be observed that during this calibration the vessel was only some 2 miles from the green slave and therefore well inside the field of induction. However, although the phase lag correction was large because of the short range, it would also have been constant as the distance from the station throughout the calibration was constant, or nearly so. It is considered that, by eliminating a variable phase lag correction, a more accurate locking constant can be determined.

Simultaneously with slave calibrations a base line crossing was carried out midway between red and green slaves, the results of which were as follows :

Decometer distance converted to metres and corrected for phase lag	34 126.6	metres
True distance between stations	34 129.1	metres
Therefore decometer readings	2.5	metres high

This was considered to be more than satisfactory and all was now ready to commence the survey as circle plotting sheets for Decca checks on the French coast had already been prepared. Unfortunately at this juncture an unlisted and powerful transmitter operating somewhere in Europe on the same frequency as our Decca system was causing grave interference, and when operating caused green slave in particular to fluctuate by some 3 to 5 hundredths of a lane. Decca engineers remedied this eventually by increasing the shipborne master transmitting aerial height and increasing the output so as to overcome the signal of the interfering station.

As soon as these modifications had been completed and the weather allowed, the first successful sounding run was made across at a speed of six knots, and steering by track plotter. A series of sextant fixes off the French coast agreed with Decca fixes to within one hundredth of a lane, this in fact was about the error that one could expect with a sextant fix anyway, although observed very carefully with the ship stopped.

The area sounded was 150 feet either side of the centre line of the proposed tunnel route and during the course of the survey three separate wrecks were found by echo sounder to lie within this area. These were later investigated more closely and by repeated runs over them with the echo it was possible to trace an outline on the track plotter of their probable dimensions and orientation.

Conclusions drawn at the completion of this unusual and interesting survey in regard to the use of two range Decca were as follows :

(1) Previous doubts as to the suitability of the system for such a large scale survey were completely dispelled after exhaustive tests although a scale of 1/1 000 can be considered the absolute maximum for an electronic survey aid using this range of frequencies. Even so the guaranteed accuracy of ± 30 feet and probably less was obtained and this compares favourably with other systems in use.

(2) The track plotter was indispensable and indeed without some other form of conning device it would have been impossible to steer a survey vessel so accurately along a given line in these waters.

(3) If time before calibration allows and the positions of the slave stations are known, it is well worth investigating the possibility of using the method of fixing described above. On a suitable stretch of coastline it would indeed be possible to mark the electrical centre of the slave station and erect marks either side and equidistant. In the simplest and ideal case, all three marks would be in line and equidistant, and the survey vessel anywhere along an arc of fixed angle of 90 degrees between the two outer marks would have a constant range from the electrical centre of the slave equal to the radius of the circle. In any event, providing the marks are

equidistant from the slave, the electrical centre will lie on the bisector of the two outer marks and the fixed angle to use can easily be computed. To eliminate the difference in position of the observers and the electrical centre of the shipborne master station it should be the practice to fix with the ship's head both toward and away from the slave station ashore on the same bearing.