# THE DECCA NAVIGATOR IN HYDROGRAPHY

Colonel C. POWELL, New Malden, Surrey.

## INTRODUCTION

Since its inception 10 years ago as a commercial navigational aid, the Decca Navigator radio position-fixing system has been used on a steadily increasing scale as an aid to hydrographic surveying. Much has been written about the system in this role, particularly in publications issued by the International Hydrographic Bureau; the objects of the present paper are to summarize briefly a few examples of Decca-aided surveying and to indicate certain lines of present and future development. It is assumed that the reader is familiar with the form and principles of the system.

## USE OF THE PERMANENT DECCA SERVICE FOR HYDROGRAPHY

*Lyme Bay Survey.*

The shore-based radio transmitting stations which constitute a Decca Navigator Chain exist in the form of permanent installations, and also as mobile stations of very much lighter weight for use in connection with specific survey operations. Where the accuracy is sufficient the permanent Decca coverage forms a continuously-available aid to hydrographic and many other allied activities. An interesting example is described by Captain C. C. Lowry, R.N. (Assistant Hydrographer), in a paper delivered to the 1955 Commonwealth Survey Officers' Conference; not the least interesting aspects of this paper were the emphasis on the relative accuracy or repeatability of the radio aid as its most valuable feature and the manner in which visual observations were combined where necessary with the Decca readings as a check upon the fixed errors — small in relation to navigation requirements but not negligible when surveying — which can exist in the coverage of a shore based chain whose stations are not sited with the primary object of providing high absolute accuracy off-shore.

The survey in question was carried out in Lyme Bay at a scale of 1 :72,000 using the South-West British Chain. The distances from the operational area to the master station and the Red and Purple slave stations were approximately 41, 113 and 53 miles. The area to be sounded lay on the zero extension of the Green baseline and therefore fell within the 35-foot relative accuracy contour of the Red and Purple patterns. Due to the land paths followed by the Purple lanes fairly large systematic erors were expected. The Red paths lay over the sea and here it was expected that the relative and absolute accuracies would be of the same order. Checks by shore fixes were therefore taken where possible in the north-east and north-west sectors and in the centre a floating beacon was fixed by the additional use of taut-wire measuring gear. Red errors, as expected, were negligible but Purple errors varied from 0.16 lanes in the north-east of the area to 0.26 in the north-west. The series of Decca fixes at the beacon, which was taut moored, showed that random erors were small, the differences being possibly due to the slight swing of the beacon. Sounding was carried out steaming along the Red lanes, the Purple being used as cut-offs. This was done because of the reliability of the Red pattern, any uncorrected errors in the Purple only causing a slight displacement of the soundings in the direction of the ship's track and not across it. As a result the whole area was sounded with no gaps, which might have occurred had a ship steered along Purple position lines. A great saving in time and money was achieved by the use of Decca as the weather was poor and also the area lay athwart a main shipping route where the danger of beacons being run down was large.

*Wreck Dispersal.*

Closely allied to hydrographic surveying are several other operations that can be performed in the high-accuracy part of a Decca chain service area with a consequent saving of time and effort. In the paper mentioned above, Captain Lowry referred to the work of sweeping the many hundreds of wrecks left around the coast of Britain after the second world war, of which a large proportion existed in the shallow and restricted waters of the Thames Estuary and along the east coast from the Straits of Dover to the Humber — both areas being covered by the first commercial Decca Chain to be erected. The rapid dispersal of these wrecks after the war called for a major effort by the Hydrographic departments and the Boom Defence and Marine Salvage Divisions of the Admiralty and by Trinity House. Before a wreck could be declared safe and the Trinity House buoy removed, the depths over it had to be checked by a surveying ship; over 450 wrecks have been dispersed and swept since the war and Decca has been used in a large proportion of cases. After location of a wreck by Asdic or echo sounding, its position in terms of Decca co-ordinates are passed to Trinity House who buoy it pending the arrival of a dispersal vessel, which steams up the Decca position line most nearly parallel with the tidal stream using the other pattern as cut-offs. (Trinity House lay all their buoys by this method.) On completion of the dispersal the surveying ship is informed and carries out the final check sweeping; in areas where the geometry of the system is suitable the high degree of « repeatability » given by Decca enables it to be used for the check sweeping with the aid of a very large-scale grid constructed to cover the immediate vicinity of the wreck.

The foregoing examples typify the aid derived from the permanent Decca Navigator service at medium and short ranges. This illustration shows the present European coverage of the system together with that of the Swedish chain now under construction and indicates the considerable scope in European coastal waters for this use of Decca. By inserting crystals of the appropriate frequency it is possible to use Decca receivers of the « Survey » type in conjunction with the permanent chains, thus securing the maximum degree of instrumental accuracy. Another valuable adjunct to the shipborne equipment that can be used with permanent and mobile chains alike is the Track Plotter referred to below.

## USE OF MOBILE CHAINS

***Deployment.***

The first mobile Decca chain to be used for hydrographic work in peace time was deployed by the Danish Navy in Greenland in 1947. This was followed a year later by the Swedish Hydrographic Office's chain in the Baltic. Subsequently mobile chains have been deployed in many different parts of the world including Canada, France, Great Britain, Japan, The Persian Gulf, North Africa and New Guinea with increasing field experience the design of the equipment has been progressively improved and refined, a notable improvement of a practical nature being the reduction in weight of the mobile stations to about one quarter that of the original type. For hydrographic surveying a Decca chain can be sited in two configurations : hyperbolic and two-range. The slave stations are identical in each case, as is the electronic section of the master station equipment, the only difference being a special transmitting aerial system required in the two-range case for the shipborne master station. Two-Range Decca, which confers certain advantages in cases where a survey is being carried out by a single vessel, is described in another paper submitted to this Congress.

*Swedish Hydrographic Chain.*

A striking example of the use of the hyperbolic Decca layout for hydrography is that of the mobile chain already mentioned used by the Royal Swedish Hydrographic Office in the Baltic and the Gulf of Bothnia. It is an axiom that for the advantages of an electronic or any other aid to surveying to be realised in practice a study must be made of its limitations and appropriate corrective measures applied; in the successive sitings of the Swedish mobile chain, each survey has been preceded by a detailed observation of systematic errors in the pattern arising through changes in the effective speed of propagation. With stations sited directly on the coastline these are already small, and by a rigorous checking procedure they can be reduced to an order sufficiently low for the « absolute » accuracy of the system to approach the same order as the « relative ». This is in fact done in the Swedish Hydrographic Office's procedure, detailed contour drawings of the survey area being prepared to show the corections to be applied.

Careful control is also exercised over the stability of the system by means of a shore-based monitor receiver station, this having the additional refinement of a radio link to the two slave stations which passes signals representing the degree of deviation observed at the monitor. The signals cause the necessary phase corrections at the slave station to take place automatically. With the steady evolution of the Decca phase-locking technique, the need for this precaution has diminished and results from recently-deployed chains such as that in New Guinea indicate that the daytime stability is comparable without automatic monitoring to that of the Swedish Chain. By virtue of such measures the Swedish Hydrographic Office has been able to use Decca not only for position-fixing when out of sight of land in coastal surveys, but also for detailed survey work in the inner channels of the archipelago; very large scales have been involved in this work and it has even proved possible, for example in close examination of the shoal of Argos (Swedish Chart No. 113), to carry out the survey at a scale of 1 :2,500 by means of Decca without recourse to buoy-laying. The survey work in the Baltic and in the Gulf of Bothnia has been the subject of close co-operation between the Hydrographic Offices of Sweden and Finland ; the Finnish survey vessel Nautilus has taken part in the Decca pattern-checking surveys already referred to and the chain has been used for subsequent hydrographic work on the Finnish side.

*Dutch New Guinea.*

One of the current operations using the normal hyperbolic configuration is the survey now being carried out by the Royal Netherlands Navy in New Guinea. The initial setting-up of this chain, under the guidance of Mr. J. Th. Verstelle, is an interesting example of the process of establishing a radio position-fixing system in terrain having very limited survey facilities. The process of « trilateration » was employed whereby the inter-station distances are measured by determining the total number of lanes in the patterns. These measurements were in turn closely checked by a specially established local survey network, the results showing that without any detailed knowledge of ground conductivity constants the effects of anomalies in propagation speed could be limited to errors of one part in 10,000 for propagation over land and one part in 40,000 over sea; in both cases these figures proved to be valid up to distances of at least 235 kilometres.

In regard to random errors, analysis of the results obtained during the setting-up and checking period showed that the stability was considerably better than the value of 0.01 lane normally adopted for Decca relative-accuracy contours and it appeared, furthermore, that the instrumental accuracy of phase measurement given by the new series of equipment employed on the New Guinea chain was in the order of one degree. The chain in its present siting covers, in addition to the sea areas to be surveyed, some 70,000 sq. kilometres of land and it will probably be used on a considerable scale for inshore surveys. A point worth noting about the New Guinea survey is the example it provides of a single chain of stations giving both land and sea coverage; that this flexibility of operation is possible at all is due to the use of the long-wave transmissions which suffer negligible attenuation when passing over land.

## DEVELOPMENTS IN THE EQUIPMENT AND TECHNIQUES

### *The Transmitting Stations.*

The mobile transmitting stations and associated receivers used for surveying are described in other publications. The basic principles have remained unchanged during the operational life of the system, although the practical design of the equipment has been considerably improved in detail as already mentioned in connection with the weight of the mobile transmitting stations. The total weight of the units required for three representative types of station is 1245, 2183 and 3086 pounds per station. With the addition of packing, cabling and test gear together with one representative type of generator for the lightweight station and two for the larger stations the respective overall weights per station total approximately 2,500, 5,000 and 9,000 pounds respectively. To these weights must be added those of the necessary domestic equipment, shelter, communication gear and food and fuel supplies, together with such spare parts as are moved forward with the individual stations rather than held at base.

### *The Track Plotter.*

A valuable addition to the Decca survey equipment has been the Track Plotter, an automatic device which plots continuously the output of the two Decometers, through servo mechanisms, on to an « inverse-lattice » chart. The latter is drawn on a projection such that the hyperbolic position lines, or circular in the case of Two-Range Decca, are converted into a rectilinear grid. In the high accuracy parts of the coverage where surveying is generally carried out, the distortion resulting from this projection has not been found to introduce any problems so long as elementary precautions are taken such as the preparation of a distorted compass-rose for use in steering or conning the ship from the plotter. The Track Plotter greatly facilitates cross-lattice navigation, for example when following section lines that do not coincide with either of the Decca position lines; it also proves a complete positional record of the ship's movements and, with the aid of the annotation-marker now incorporated, of events such as the detection of particular underwater features and the firing of seismic « shots ». The continuous record of whole and fractional lane values also provides an insurance against the possibility of lane-loss in the event of an interruption in transmission or reception.

*Lane Identification.*

A facility proposed for future hydrographic-survey chains is that of a limited form of lane identification. Generally speaking, the Decca lanes are of such a width (averaging some 500 metres on the baselines) that the likelihood of lane-loss during actual operation is extremely remote. There are, however, circumstances in which a reduced ambiguity would be valuable, in particular the case where the survey vessel moves during the night to a new location and requires to set up the Decometers before resuming work. The provision of a full lane identification service such as is embodied in all permanent Decca Navigator chains would necessitate a large quantity of extra equipment at the shore stations and a considerably more complex receiver; a compromise is therefore proposed whereby the slave stations would transmit on request, or during a pre-arranged morning period of say half an hour, signals intended specifically for lane identification. These signals would simply take the form of a Green transmission from the Red slave and Red from the Green; by comparing the readings during the special transmissions with those obtained normally, the observer could carry out the so-called vernier lane identification.

The relationship of the Red and Green comparison frequencies, and hence lanewidths, is such that there are exactly four Red lanes for every three Green. Given proper phasing of the two successive patterns, therefore, observation of the two fractional readings will locate the ship within a « vernier » lane which is three times wider than Red. The reduced ambiguity will require a ship using two-range Decca or operating close to a baseline to know her position in the lattice only to half a mile when setting up, the latitude being correspondingly greater in the hyperbolic case by virtue of the lane expansion. Very little extra equipment will be required to provide this limited lane identification service, the only major items being a single « Red » control rack at the Green slave station and *vice versa*. The aerial coils at the slave stations will be fitted with a switch so that they can be retuned to the complementary slave frequency at will.

*Hyperbolic reconnaissance fixing.*

A proposal involving modification of procedure rather than of equipment has been made by Mr. Ian A. Miller of the Canadian Hydrographic Service, in which the two-range and hyperbolic layouts would effectively be combined; in this the survey ship carrying the master station would anchor and would send out launches or helicopters equipped with Decca receivers to carry out a preliminary reconnaissance of shoal areas. A relatively low order of accuracy would be acceptable such that the « master » ship's movement could be neglected and a simple graphical method would be employed of constructing the small scale hyperbolic lattice required. The fact that the two-range receiver at the master vessel would give continuous indication of changes in the baseline length could be used as a source of corrections if necessary.

## FUTURE DEVELOPMENTS

The development of the Decca Navigator as an aid to hydrographic survey has been a process of gradual evolution and learning by field experience. In the immediate future, fresh developments are likely to take the form of improvements in the practical form of the equipment: for example, close attention is being given to the problem of producing a lightweight portable generating set having a reliability, even under prolonged operation in hot climates, comparable with that of the much heavier diesel-powered units in present use. A new piece of electronic equipment shortly to be introduced is a slightly modified master transmitting station designed for two-range operation in severe tropical noise level conditions. Future developments already broadly formulated include a small, low-powered chain intended for short-range use by small craft.

# DECCA FIXING ACCURACY