APPLICATION OF TWO-RANGE DECCA TO HYDROGRAPHIC SURVEY IN CANADA

by Ian A. MILLER
Canadian Hydrographic Service.

The TWO-RANGE DECCA equipment purchased by the Canadian Hydrographic Service is of the lightweight transportable type, with 300- watt transmitters, duplicate control units, and 100- foot light alloy transmitting masts.

The equipment forming the chain consists of three radio transmitting stations, comprising the MASTER, the RED slave, and the PURPLE slave, each radiating non-directional, unmodulated, continuous-wave signals in the frequency band 70 to 130 Kc/s. The comparison frequency within the receivers was 337.120 Kc/s. for the RED slave, and 421.400 Kc/s. for the PURPLE slave.

The MASTER station, which is shipborne, was installed by DECCA engineers on the Canadian Hydrographic Vessel *Kapuskasing*, an ex-algerine class, ocean-escort vessel of 1,084 gross tons. The transmitting equipment was housed below the weather-deck, below and about 20 feet forward of the heel of the specially-constructed transmitting mast. The latter consisted of a 50 foot lattice-type, light alloy, guyed mast with top capacity loading, operating as a vertical radiator, mounted on a base insulator, and fed from a tuning network located at the mast base.

The shipborne receiver, duplicated to ensure continuous operation, and two decometers were conveniently located in the charthouse, forward of and one deck below the navigating bridge. Each receiver had its own 16- foot, plain, vertical, insulated aerial, hoisted on halyards from the forestay. The distance between the transmitting mast and the receiving aerials was approximately 40 metres.

The vessel had adequate deck space to transport the equipment for the two slave stations. The personnel, besides the normal ship's crew, consisted of four hydrographers. In addition, an engineer in charge of equipment, and a station engineer for each slave, field staff from the Decca Company, were included.

On the 24th May the vessel left Halifax, Nova Scotia, for her survey area in the southern part of the Gulf of St. Lawrence. This area extended eastward from the shores of New Brunswick to the Magdalen Islands, and from Prince Edward Island northward to the 48th parallel. By placing the RED slave on the north shore of Prince Edward Island in the vicinity of Cape Tryon, and the PURPLE slave on Amherst Island in the Magdalens Group, the inter-slave baseline was of 76 nautical miles' length, and an uninterrupted seawater path of propagation was secured throughout the greater part of the area. Furthermore, with the slave stations in these vicinities, primary triangulation stations were available for the tie-in, and good geometrical position-line cuts could be obtained.

Later, the proper sites within these areas were carefully chosen, with good holding ground for the mast anchorages, and so that each slave was within 1,000 feet of the waterline, with no local obstructions inducing screening effects. At each

station the equipment was so disposed that the transmitting mast was 250 to 300 feet from the receiving aerials, the latter being hoisted on a 20- foot gantry attached to the equipment shack. Power at each slave was supplied by two diesel generators, rated at 3 KVA, 230 volts A.C., housed in a canvas tent.

On advice from the Decca engineer, it was assumed that the ELECTRICAL CENTRE, the effective centre from which all measurements must be made, was a point midway between the transmitting and receiving aerials at each slave. The positions of these centres were tied by conventional methods to existing primary triangulation stations. At the same time, in each slave locality, two new triangulation stations were established on the shoreline, more than two miles apart, for position determination of the ship when calibrating.

The construction of the shack to house the equipment and personnel, the erection of the mast, the assembly of the equipment and the survey to procure positions took five days for the RED slave, and four days for the PURPLE slave. However, it is considered that the time required to build a station depends on local conditions, and it is felt that in subsequent seasons the experience gained may cut down this time.

When the slave stations were on the air, and the functioning of the whole system checked, calibration was commenced.

First of all the variation of phase with the direction of the ship's head was investigated. This was carried out with respect to each slave, and was accomplished while the vessel was berthed. Care was taken to ensure that there were no obstructions such as large sheds, power lines, electric cranes, etc., in close proximity.

While the vessel was stationary and roughly head-on to, say the RED slave, and with the ship centre against a mark on the jetty face, the decometer readings were recorded at half-minute intervals over a period of one hour, and averaged. Then the vessel was swung through 180 degrees, and with her centre at the same mark on the jetty, another series of readings were taken and averaged. These averages were corrected according to the angle between the actual direction of the ship's head and that of the slave. The half difference of the corrected averages indicated that the EFFECTIVE or ELECTRICAL centre of the vessel with respect to the slave concerned was forward of, or abaft, the ship centre by this amount. Results showed that this centre with respect to the RED slave was 0.001 lane abaft the ship centre, and for the PURPLE slave was 0.010 lane forward of the ship centre.

For determination of the LOCKING CONSTANTS, the vessel was anchored about three miles offshore in the vicinity of the PURPLE slave first. Transits were set up at our two stations, the positions of which had already been established, and a series of observations on the foremast of the ship were taken at agreed intervals, and on agreed signals. At the same instant, the PURPLE decometer was read to hundredths of a lane, and the direction of the ship's head noted.

In all, ten observations were taken, and each angular value used to compute sides from SHIP TO STATIONS in order to ensure that the side values varied roughly in the same proportion as the decometer readings, and so that blunders might be noted and eliminated from the observations. A geodetic position for the ship was computed using average values, and the distance SHIP TO SLAVE was procured by INVERSE SOLUTION.

As the transit intersections were taken on the foremast, the angle contained between the direction of the ship's head and the slave station was noted for each observation in order that the computed distance FOREMAST TO SLAVE might be reduced to the respective electrical centre. Before comparison with the decometer readings, these were freed from the effect of slave induction field by applying corrections taken from BREMMER curves.

This determination of LOCKING CONSTANT was repeated at the RED slave, The computed corrections were then set into the shipborne Decca receivers by offsetting the respective goniometers.

With the calibration completed, lines of soundings were attempted when convenient, the ship steaming from the RED slave area to the PURPLE slave area, checking by visual fix at each end, in order to secure a lane count. In general, this was a test to ensure that were the ship to steam directly along the baseline, the RED and PURPLE decometers would count accurately the respective integral numbers of lanes contained therein.

At the same time, graphs of signal strength at MASTER from SLAVES, and at SLAVES from MASTER, were maintained. From a careful study of these it was seen that in order to achieve an even balance of signal strength over maximum range, it was necessary to extend the transmitting mast at the PURPLE slave by 20 feet, and to extend the receiving aerials at the RED slave by 10 to 15 feet. At the same time certain minor modifications were required at MASTER to boost signal strength.

These alterations and modifications, as expected, caused some change in the LOCKING CONSTANTS, and the latter were redetermined.

When this second series of observations were taken, both decometer readings were recorded whilst anchored in each slave area, so that two values for each LOCKING CONSTANT might be obtained and compared. These new values were used unaltered thereafter, and their determination results were as follows:

Ship anchored at Red slave:		LOCKING CONSTANT
Ship approx. 3 miles from RED.	For RED.....	0.082 lane
Ship approx. 73 miles from PURPLE.	For PURPLE.....	0.676 lane

Ship anchored at Purple slave:		
Ship approx. 73 miles from RED.	For RED.....	0.098 lane
Ship approx. 3 miles from PURPLE.	For PURPLE.....	0.661 lane
	Mean Value for RED.....	0.09 lane
	Mean Value for PURPLE.....	0.67 lane

For computation of LOCKING CONSTANTS, and plotting of sounding fixes, the propagation velocity used was 299,650,000 metres per second, and with this the width of a RED lane was 444.426317 metres, and the width of a PURPLE lane 355.541054 metres.

A polyconic projection of the area, at scale 1:144,000, had been laid down at Hydrographic headquarters in Ottawa prior to departure. As the exact positions of the slaves were unknown at that time, position-line patterns for the TWO-RANGE DECCA had to be prepared in the field. These being concentric circles about the two slave stations, were drawn at radial intervals of ten lanes and described in ink

with the aid of beam compasses on a sheet of good quality transparent plastic covering the projection. Plotting was carried out on the plastic sheet, and carefully pricked through when desired.

In order to simplify the plotting of fixes, tabular values for converting RED and PURPLE decometer readings into inches at scale, were prepared. When fixing on the even ten lane value on the PURPLE decometer for instance, the RED reading would be recorded simultaneously. From the tabular values this RED reading could be quickly converted to inches of projection beyond the next lower ten lane value. The measurement on screw-dividers would be laid down in the direction of the RED slave beyond the RED circle concerned, and swept round until it cut the PURPLE circle. The time taken to plot a sounding fix can be considered to be less than half a minute, with the possibility of human error reduced to a minimum.

Bearing in mind the necessity of securing good geometrical cuts throughout the area of sounding, slave stations were located and change of sites planned accordingly. In this way, plotting on or near the baseline, where the arcs of circles of position are tangential, can be avoided and a high degree of fixing accuracy maintained throughout the survey area.

TWO-RANGE DECCA, providing us with accurate positions for relatively great distances offshore has brought about changes in normal hydrographic survey procedure. In the first instance, the projection used covers a much larger area, and projectional distortion must be evaluated, while the atmospheric distortion of a field sheet of such dimensions is considerable and more variable. It appears to be advantageous to consider these values on a percentage basis.

The application of accurate tide reductions caused some concern, but with the aid of three suitably located gauges, it is considered that sufficiently accurate reductions were obtained.

With the present type of TWO-RANGE DECCA there is no automatic lane identification. It was considered wise therefore to establish readings for all permanent navigation buoys in the area, and to lay special survey buoys where convenient. With these, in the event of loss of lock, for morning lane identification and evening check, the hydrographers could depend upon securely moored buoys which would never leave integral numbers of lanes ambiguous.

Runs over the area were so adjusted that buoy readings could be carried one to the other and checked against visual fixes. In addition, whenever possible buoys were fixed by visual means as a rough check against the Decca pattern.

Having achieved a balance of signal strength, range tests were run whilst sounding, and on one day when the weather and noise level conditions were rather worse than normal, the vessel steamed northwards until the slaves lost lock. The results of this test showed that ranges of 150 miles are possible with this type of equipment.

During this season Decca was used only for fixing offshore soundings in comparatively small-scale charting. In this case, the scale 1 :144,000 was chosen in order that the plotting sheet would be of suitable dimensions, and at the same time include the full range of the equipment. No attempt was made to use the TWO-RANGE DECCA for expansion of the control-point net.

As plotting accuracy may be considered to be 0.004 inches, which at this scale represents 48 feet on the earth's surface, several small corrections inherent

to the Decca system in general could be neglected. Whenever possible, in localities where control points were available, visual fixes were obtained to procure a graphical check on the Decca pattern. Comparisons were highly satisfactory provided the overall seawater path was maintained.

Extensive accuracy tests of this equipment were carried out by the British Admiralty, in conjunction with the Decca Company. We were supplied with a comprehensive report of their findings, for which we were extremely grateful. Our experience with the TWO-RANGE DECCA chain on the *Kapuskasing* certainly justifies their confidence in it.

Our main worries stemmed from noise level conditions which vary with season and locality. In the Gulf of St. Lawrence region trouble with electrical storms was experienced. On two or three occasions, with lightning flashes in close proximity, decometers have lost torque completely, leaping several lanes within seconds. It is our opinion, however, that this minor disturbance is more than compensated for by being able to carry on sounding during days of fog, heavy rain, or foul weather. It was noted also that operation of the ship's W/T equipment caused a definite phase change, and for this reason W/T communication was confined to the hours of darkness. The Company staff assures us that this can be overcome.

It appears that sky-wave effect commences about fifteen minutes before sunset, is a function of distance, and causes an erratic variation of uncertain magnitude within the decometers. For this reason the day's work was so arranged that the ship was in the vicinity of a check-point about sunset, and remained at anchor during the night.

Weather conditions were extremely variable, and on quite a few occasions the equipment on board was subjected to excessive strain and severe vibration while the vessel was pounding and labouring in heavy weather. Slave stations had a severe test also, withstanding high winds and violent rainstorms with no apparent ill-effects.

The vessel maintained an average operational speed of 12.5 knots and during the whole season completed 7,300 miles of sounding in a period of four and a half months. On several occasions 140 to 163 miles were recorded in one day.

The results obtained, the extent of the area accurately sounded, fully eighty-five per cent of which is beyond the limits of visual fixing, is indeed gratifying. In our opinion TWO-RANGE DECCA is an important contribution to the advancement of hydrographic survey methods.