TWO-RANGE DECCA

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Introduction.

The conventional Decca Navigator system is of the type in which pairs of stations generate patterns of hyperbolic position-lines. One station, the master, is common to each pair so that a chain of three stations suffices to provide the two intersecting position-lines required for fixing. Among the advantages of this arrangement are the absence of any limit to the number of users of a single chain and the compactness of the position fixing instrument (the receiver) which can readily be installed in the smallest craft. These two features contribute considerably to the success of Decca as an aid to surveying as well as to navigation.

If, however, it is not required to use more than one ship throughout a given survey operation, a Decca chain can be rearranged in such a way as to introduce certain valuable features not given by the normal layout, together with an enormous increase in the area within which accurate position fixing is possible. The layout is shown in Figure 1 a. The Red and Green slave stations are sited on the coast or a few miles inland some sixty miles apart and the master station is set up on the survey ship itself together with the receiver driving the conventional Red and Green Decometers. The Decometer readings are then a function of the distance from the ship to the corresponding slave stations.

This arrangement, known as « Two-Range Decca », does not supersede the type of layout used on the survey-chains deployed in many parts of the world; but in cases where the single-ship limitation can be accepted, the two-range layout offers the following advantages :

a) Computation of a hyperbolic lattice is avoided, the position lines being circles centred on the two shore stations.

b) The use of only two shore stations simplifies the problems of station survey and maintenance in undeveloped areas.

c) The measurement being unaffected by « lane expansion », the spatial effects of phase errors are relatively small over the whole coverage. The areas covered by the high-accuracy contours are some hundreds of times larger than for the corresponding conventional Decca layout (see figure 1 b).

d) The two-range layout lends itself to siting on a convex coast-line, always a problem with conventional Decca.

The equipment used in the two-range layout is identical with that of a conventional survey-type chain except for the use of a shipborne master transmitting aerial; with the addition of an extra mast and aerial coil for a shore-based master station together with the necessary generators, a chain may be used as a hyperbolic or two-range system at will.

Derivation of method.

The total number of lanes in a Decca pattern is given by the master-slave baseline distance divided by half the wavelength of the comparison frequency. The wavelength of the comparison frequency depends in turn upon the effective speed of propagation of the signals. Assuming that the speed is known, the total lane number is therefore a measure of the master-slave distance. The exact fractional value of the total lane number is found by comparing the readings recorded on the two base-line extensions; the measurement of a line in this way, by placing a Decca master station at one end and a slave at the other, has long been recognised as the basis of a potentially very accurate method of tying-in two triangulation systems across an expanse of sea-water (over which the propagation speed is known within very close limits) and of fixing the position of islands with respect to points on the mainland. Assuming a proper technique and procedure there is no reason why long-line measurements of this type should not ultimately have an accuracy of about ten yards in two hundred miles. Decca may well be used on a considerable scale for over-water trilateration within the next few years and it scores heavily over the secondary-radar method in that no aircraft is required.

Two-range Decca consists simply in placing one of the transmitters in the above arrangement, the master, on the survey vessel together with a receiver; as the master moves, the slave base-line extension value is automatically held constant by the normal functioning of the slave phase control circuits so that, given one initial calibration of the slave equipment, it suffices to read the appropriate Decometer only at the master end of the line — i.e. on the shipborne receiver.

Equipment.

Figure 1 a shows schematically the layout of a Decca chain, deployed as a two-range system. The shore (slave) stations are identical with those of a normal chain and consist essentially of a 300-watt transmitter with two control units and a 100-foot tubular mast aerial. The master station uses a similar transmitter, deriving its input from the normal double control unit, and feeds the shipborne transmitting aerial via a specially-wound aerial coil housed in the standard water-proof case. The latter may be mounted at some convenient point under the approximate centre of the aerial, the other items of equipment being housed under cover. When the master equipment is set up ashore to form a hyperbolic system, it employs a standard aerial coil and 100-foot aerial system provided for this purpose.

The form of the shipborne master transmitting aerial depends upon the design of the individual vessel. A typical arrangement comprises three approximately horizontal top-wires on 12-foot spreaders, the wires being seventy feet in length and at a mean height of about 60 feet above the water-line. The aerial coil is placed under the aerial and is connected thereto by a single down-lead from one end of the central top-wire.

The receiver, of the hydrographic survey type 371 or 373, may be installed in the chart room and can drive two sets of Decometers and a Track Plotter. The latter is equally suitable for two-range or hyperbolic operation. If further repeater Decometers are required a second receiver may be installed; in this case each receiver should have a separate aerial, the latter being of the usual vertical wire type employed with shipborne Decca receivers. « Whip » aerials can be used provided that extreme care is taken to preserve insulation at the aerial base.

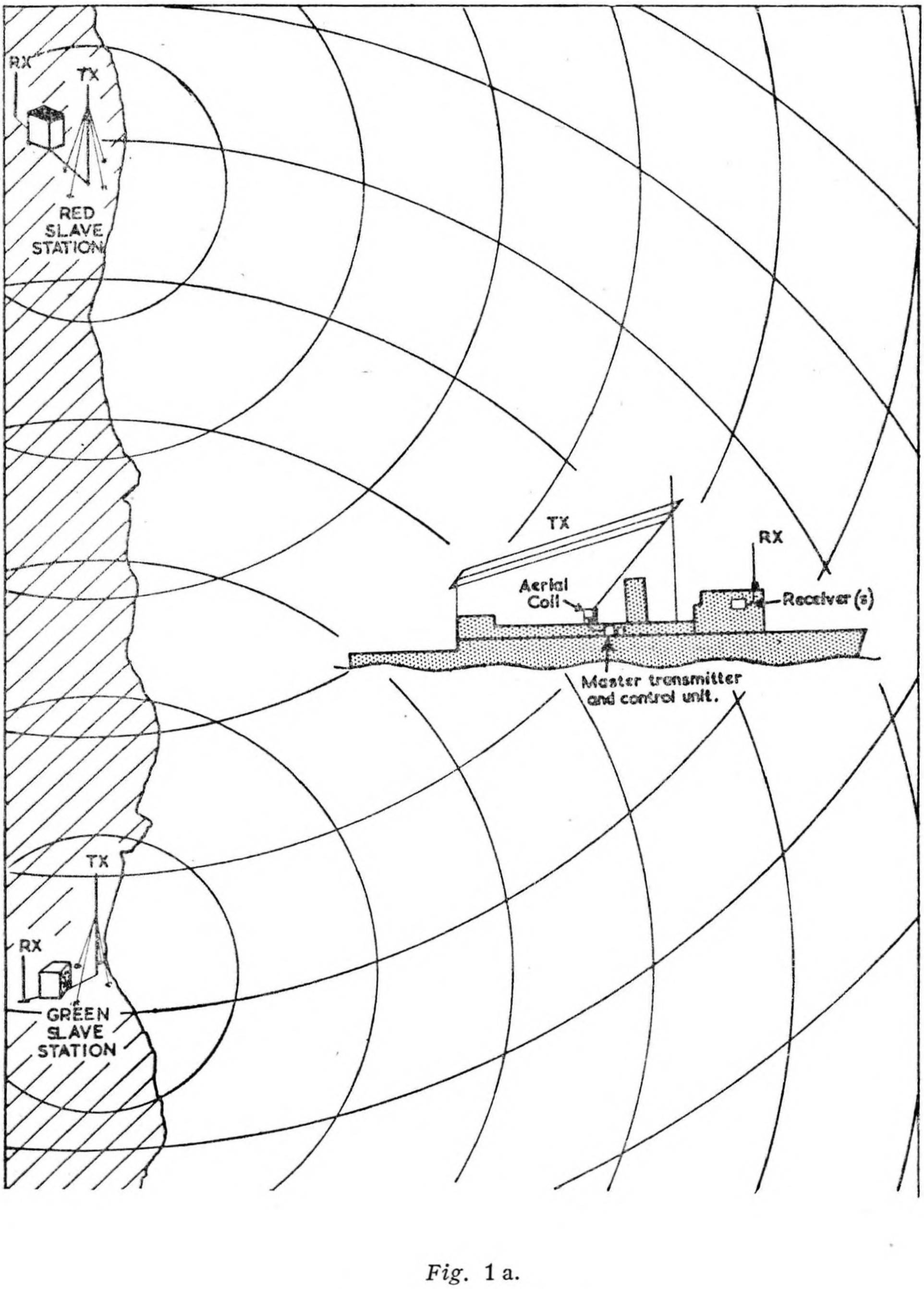

Fig. 1 a.

LAYOUT OF TWO-RANCE DECCA

Schematic layout of Two-Range Decca System showing slave stations ashore and master/receiver aerial installation on the survey vessel. The vertical portion of the master aerial should be not less than 40 feet above the ship's structure.

As in the conventional system the decometers are installed in the chart room, with an extra pair in the instrument room if required.

Range.

It is estimated that a master transmitting aerial of the type outlined above radiates a power of about one watt. With a slave phase control equipment of the latest design and in view of the over-water transmission paths, this would ensure practicable operation at distances of up to a hundred miles from a slave in all parts of the world. In temperate latitudes where atmospheric noise is comparatively low, the working range would be increased and the method is applicable to deep-sea hydrographic work such as that for which the Greenland chain is used.

Accuracy.

The « instrumental » accuracy of two-range Decca may be assumed to be identical with the normal system since the same equipment is used; new sources of error which the method introduces are systematic in character, such as the large fixed displacement which the shipborne Decometers will sustain owing to the proximity of the master aerial to the receiver. Errors of this type can readily be calibrated-out and to this end the establishment of a known point alongside which the ship can make check-observations is regarded as an essential part of the two-range system.

In other respects, considerable advantages are offered by the method. There is no lane expansion since the lines which the system measures are always coincident with the master-slave baselines; for this reason, phase errors originating at the stations or in the receiver give rise to distance errors whose magnitudes are independent of range. This is in marked contrast with the conventional system, in which an error of, say, one hundredth of a lane represents a change of position at the edge of the coverage several times greater than that obtaining close to the base-line.

Figure 1 b shows a typical set of accuracy contours of slave stations sited sixty miles apart. This inter-slave distance is probably a representative one for hydrographic survey by the two-range method. The contours are circles with the inter-slave baseline as a chord. On a straight coastline the high-accuracy region is several hundred times larger in area than the corresponding contour of a conventional chain with 60-mile master-slave baselines sited on the same straight coastline. The large area covered at high accuracy by the two-range method is instanced by the fact that in winter night-time (U.K.) a pair of slave stations one hundred miles apart is calculated to give a 67 % error of fix of only 100 yards at 175 miles from the stations, given sufficient radiated power from the master.

The above considerations apply to errors of the random type. Two-range Decca is susceptible to fixed or « systematic » errors when the ship is so positioned that the transmission paths lie along terrain over which the effective velocity is different from the mean value assumed for the coverage as a whole. The same consideration applies to hyperbolic systems, except that when the latter have a common master station as with a conventional Decca chain, variations in the master path produce systematic errors in both patterns; with the two-range system, the two position lines are related to independent transmission paths. To realize the high accuracy over a wide area that is one of the main features of two-range Decca, the slave stations should be sited as close as possible to the coast in order to ensure that as much of the transmission paths as possible shall lie over the uniform medium of sea water, for all positions of the ship in the coverage.

Stability.

The stability of the phase-locking circuits in the Decca slave station has been raised to a very high order such that after initial warming-up, for which at least one

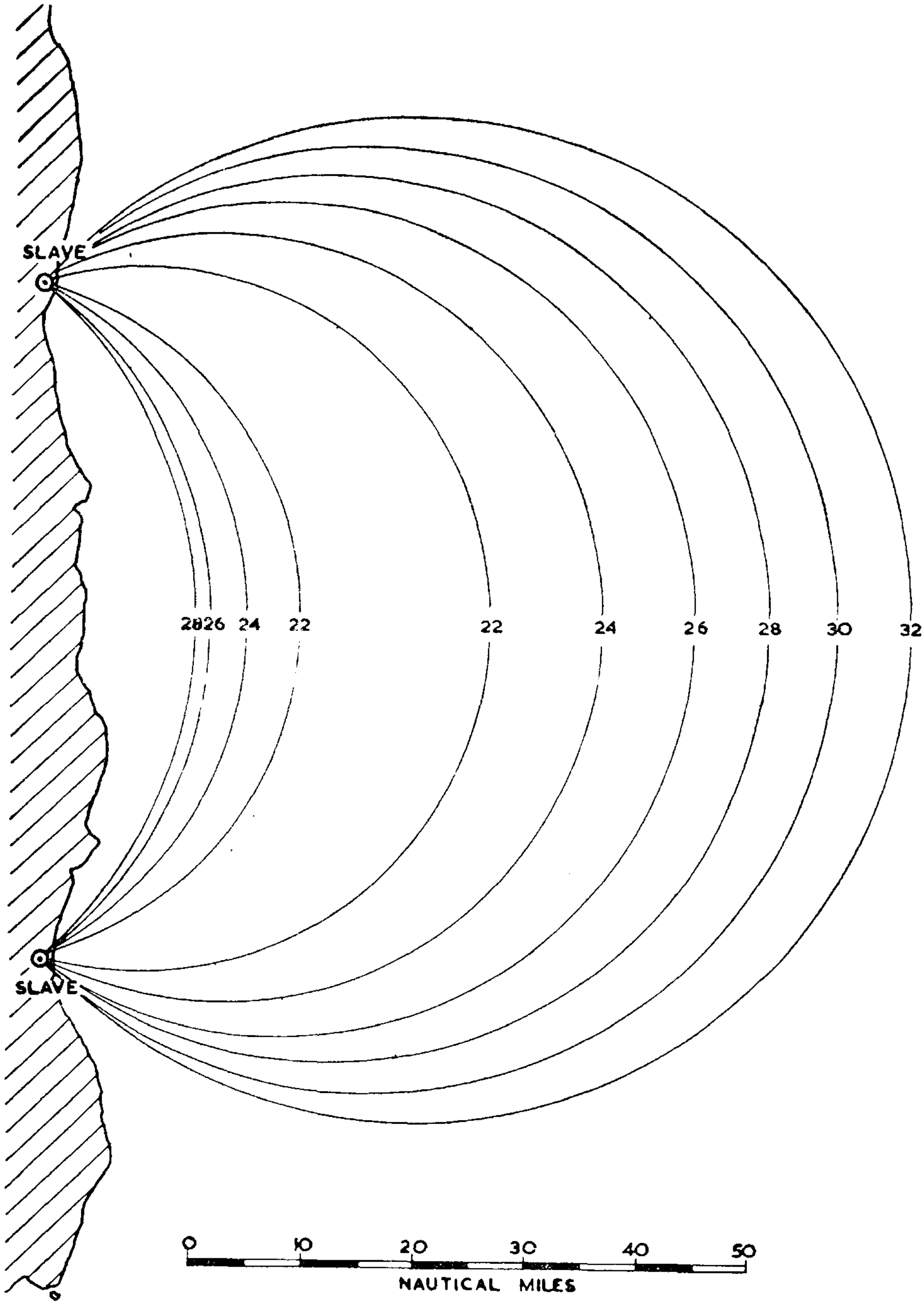

Fig. 1 b.

ACCURACY OF TWO-RANGE DECCA

Contours of Fixing-Accuracy in FEET (67 % probability) for a typical Two-Range Decca layout in daylight operation. The Slave Stations are shown sited on the coast at points 60 miles apart.

The contours are drawn for a Standard Deviation of 0.01 Mean Lanes.

hour should be allowed, a standard deviation of about five thousandths of a lane is common for a whole day's observation at a monitor station. When operating a chain in the two-range layout the monitor station is dispensed with, but two slave control units are employed at each slave station so that one may serve as an independent check on the duty unit and provide a means of « referencing » without interrupting the service.

Calibration.

In a hyperbolic Decca chain, the value of the phase angle between the slave transmission and the master signal received at the slave is pre-set by a manual phase adjustment when initially adjusting the pattern, either in accordance with observations at a known point or to bring the master baseline extension to the conventional zero-value. The former method applies in the two-range working. The slave control equipment has the same primary function as before, namely the maintenance of stable phase locking between slave and master signals, the value of the master/slave phase angle being set-in empirically by placing the ship at a known point and ordering the slave operator to adjust the phasing control until the desired fractional reading is observed at the ship. This process serves to calibrate the whole system and to compensate for the fixed displacement caused by the receiver's proximity to the master transmitter.

The only errors of a systematic character not taken care of by a simple check observation at a known point are small and are those resulting from the displacements between the master and receiver aerials at the ship, and the transmitting and receiving aerials at the slave stations. For most practical purposes, however, it may be assumed that the range indicated by a Decometer will be the distance between the mid-point of the slave installation and a point on the ship which will approximate to the midpoint between transmitting and receiving aerials but which should be determined empirically by calibration with the vessel at various headings.

Units of measurement.

Theoretically it would be possible to mark the scales of the shipborne Decometers in units of distance and read the range directly, but owing to the dependence of range indication upon the exact values of the comparison frequencies (and hence the transmitted frequencies) the Decometers belonging to each chain of the two-range type would have to be calibrated individually. If for any reason the frequencies had to be changed it would be necessary to re-calibrate the Decometers. There is also the fact that a whole lane, or a complete rotation of the Decometer fraction pointer, would represent some inconvenient value such as 481.28 yards and again this value would alter if some small change were made in the assumed velocity figure.

Accordingly the Decometer dials are in practice marked in the standard units of Zones, Lanes and Hundredths and the distance is found from the Decometer readings by reference to a chart marked with the concentric lane patterns, or to a conversion table or slide rule.

Running section lines.

The use of the two-range system for running lines by steering the ship so as to keep one of the Decometers at a constant reading would produce circular section lines centred at one of the slaves. Close to a slave the curvature would be pronounced, but the position lines from the remote Slave would then be of large radius. There would be no difficulty in running straight and parallel section lines by the method based on continuous plotting. The Decca Track Plotter, which draws continuously the track made good, is eminently suitable for use with the two-range method.

Lane integration.

As with the normal Decca survey chains, which do not include Lane Identification, it is necessary to know the whole Lane-Numbers of the point at which the receiver was first switched on and to maintain the receiver in continuous operation thereafter. The effect of the ambiguity is greater than with conventional Decca since there is no Lane expansion to offset it and the receiver is operating « on the base-line » of each pattern where the lanes are narrowest. It is doubtful, however, if this would represent a sufficiently serious disadvantage, under survey conditions as opposed to general navigation, to justify the extra cost and complication involved in a Lane Identification system.

Personnel.

The two-range layout requires fewer operating personnel than the normal Decca chain since the master station is shipborne and can be looked after by personnel having other duties. The master station is extremely simple in operation and needs only to be switched on when required and checked for power output and aerial tuning from time to time. Each of the slave stations requires one competent radio mechanic per watch. A qualified radio engineer should be placed in charge of the Chain as a whole.

Frequencies.

The two-range system is identical with the conventional Decca layout in respect of frequency values and relationships.

Communications.

As with the normal layout, it is convenient to have R/T communication between the shore stations and the ship for general administrative purposes. The reduction of the number of shore stations to two is if obvious value in this connection.