THE BRITISH ADMIRALTY TIDAL PREDICTION FORM

(HD-289 — June 1947)

By Capt. H. BENCKER, *Secretary general I. H. B.*

In " Hydrographic Review " (Vol. XVI, No. 1, May, 1939, page 59), we pointed out the criticism often made concerning the harmonic method of tidal prediction, namely, its excessive length and the irksome calculations, from the navigator's point of view, that must be undertaken when it is desired to group together the various effects of the different constituents to obtain the total of the tidal motion.

According to numerous authors, the practical solution of the problem is to be found in combining equal-period components with an approximation good for a limited duration, say that of one whole day, and making use of this grouping to carry out the prediction either by means of a small machine, of diagrams, or even by calculation.

It is with this in mind that the new practical method of prediction of tidal heights, introduced in 1936 by the Tidal Branch of the British Admiralty Hydrographic Department in collaboration with the Tidal Institute of the University of Liverpool, was conceived; this new method formed the subject of an article given by us in " Hydrographic Review " (Vol. XVII, No. 1, May, 1940, pages 120-130).

During the last few years the B. A. Hydrographic Department has brought to a high degree of perfection its publication : " Admiralty Tide Tables " which to-day offers the most accurate and the most complete document placed at the disposal of mariners for the solution of the basic problem with which they have to cope when it is a question of navigating shallow waters.

In fact, the volumes of this publication for the year 1949 (the 116th edition since 1833), consist of more than 1100 pages giving detailed predictions for 224 standard ports and concordance data for 5170 secondary ports with the harmonic data for 2010 stations.

Some idea of the improvement brought about may be formed by comparing these figures with those of the first tables which simply gave predictions of times of HW for 4 ports in the British Isles in 1833.

Since 1948 British Admiralty " Tide Tables " have been issued in a new form which enables a further improvement and a very great simplification in obtaining predictions at secondary ports by means of the harmonic method, to be introduced by the inclusion in these Tables of a sort of " Calendar " showing for each day of the year the astronomic situation angles. and tidal elements already calculated for the four principal harmonic constituents M_2 S_2 K_1 and O_1; there is also a new arrangement of the Correction Tables to take into account the influence of shallow water (shallow water corrections).

Moreover, since June, 1947, the Hydrographic Department has published a new form (H.D.-289) entitled : " Admiralty Tidal Prediction Form ", containing the instructions, diagrams and graphs necessary for tidal predictions from harmonic constants at secondary ports. using the new data summarised above.

In this new form, the ancient harmonic prediction calculations as developed in Part III of the 1936 " Admiralty Tide Tables ", which might appear too arduous to the mariner but slightly acquainted with the theory of tides, are replaced by the graph method.

By the diagrams and graphs used, publication H.D.-289 materialises so to speak a small portable tide-predicting machine; and to the ease with which it may be used by anyone, even though their previous knowledge of it may have been slight, it adds the special attraction of making the partial result attained stand out at every moment of the procedure—which further increases the interest and satisfaction of the user.

Thus the aims of the Admiralty Committee nominated in 1923 to study a new accurate and practical method of prediction making use of a modified harmonic method, readily understood by the mariner, have now been fully realised.

The object of " Admiralty Tidal Prediction Form H.D.-289 " is to plot for a given day the curve illustrating the tidal level at any moment by means of a previous determination of 24 hourly ordinates made by using a plotting circle on which is superimposed a Height scale traced on transparent " Kodatrace " paper.

The corrected complete curve for a given day having been obtained, all the information necessary for the solution, with reference to such day, of any tidal problem whatever, may be extracted from it : Times and Heights of HW and LW, periods during which height is above a given level, grounding problems, etc.

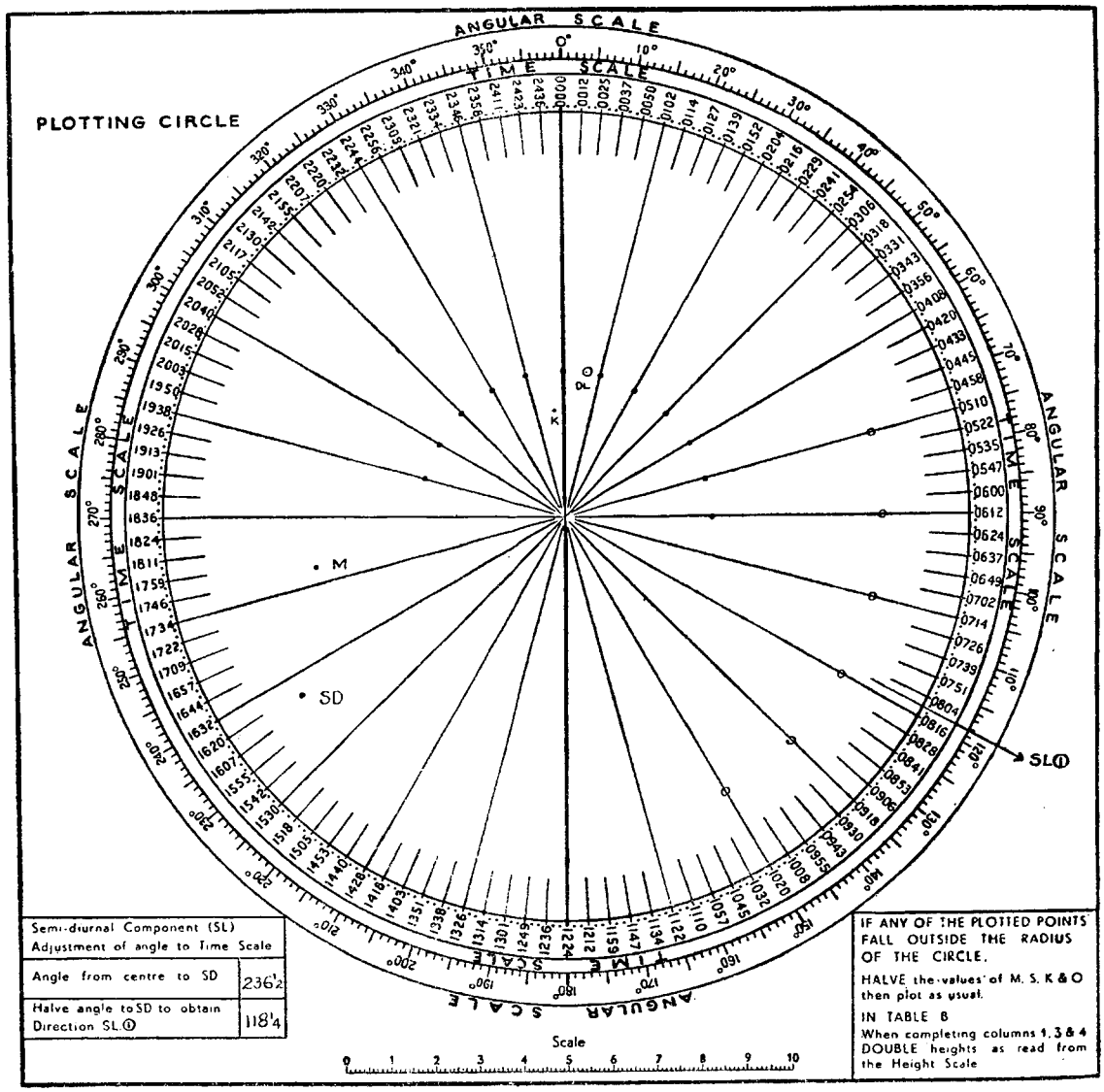

FIG. 1

We shall assume that the few theoretic details necessary to understand the nature of the various elements concerning harmonic constants given in Part II of " Admiralty Tide Tables ", are known. The reader who wishes to refer to it will

consult with great advantage : " Notes on Tidal Prediction from Harmonic Constants " appearing in the Introduction to above-quoted Part II (pages 393 to 400); we regret that lack of space forbids us to give here a translation.

It is known that the phase and phase-lag of the various tidal harmonic components are generally expressed in degrees of arc; they may also be expressed in hours by dividing these degrees of arc by the velocity proper to each constituent.

The originality of " Tidal Prediction Form H.D.-289 " consists in using on the basic diagram a double scale for angles, one in degrees of arc, the other in time, so that this transformation may be rendered automatic. Further, the time-unit selected for the graph and for the record of the corresponding heights in the tabulations, is the luni-hourly interval which has been chosen equal to 1 h. 02 m. mean solar time, thus bringing the duration of the lunar day to be figured at 24 h. 48 m., instead of the theoretical value of 24 h. 50 m.

This artifice allows the plotting circle to be divided in a perfectly symmetrical way, 15° corresponding to 1 h. 02 m., for the sexagesimal system (degree scale = angular scale) as well as for the duodecimal system (time scale).

Figure 1 represents the plotting circle reduced by ½. On its external scale the ½ degree of arc may be read; the division of the internal scale furnishes the approximation of 2 minutes' time.

This plotting circle serves to combine in one the two semi-diurnal components M_2 and S_2, then the two diurnal components K_1 and O_1, after having filled up Table A (fig. 2) of form H.D.-289 in conformity with the printed indications on the tabulation which are self-explanatory.

PLACE DARWIN DATE 5th DECEMBER 1948

TABLE A (data for plotting)	Semidiurnal Constituents				Diurnal Constituents				ML
	M_2		S_2		K_1		O_1		
(1) From A.T.T. part II · g & H of M_2 S_2 K_1 & O_1, Ml	g° 158	H ft 6 6	g° 217	H ft 3·4	g° 348	H ft 1·9	g° 315	H ft 1·1	ft 12·6
(2) From A.T.T. part II, seasonal corr : to Ml From A.T.T. part I, Table VII : Tidal Angles & Factors	101	87	330	·84	007	1·28	085	1·04	corr: — 1·0
(3) From (1)&(2) : add angles,(subtracting 360° if greater than 360°) Multiply H by factor Ml ± seasonal correction.	m 259	M 5·7	ν 187	S 2·9	k 355	K 2·4	o 040	O 1 1	corr: Ml 11·6
(4) From Plotting Circle, semidiurnal HW times	SL ① 0809			SL ② 2033					

FIG. 2

For instance, the combination of the two constituents M_2 and S_2 is accomplished by the method well known in geometry of the composition of the vectors : from the centre of the circle, with dividers set to 5,7 feet, the point M is laid off in the direction 259°; from this point M, with dividers set to 2,9 feet, the point S_2 is laid off in direction 187° obtained by transferring to M, using parallel ruler, from centre of circle.

The point thus marked SD is the extremity of the semi-diurnal resulting vector. The angle from centre to SD (236 ½) is read; halve it (118 ¼) to obtain the direction SL (1) which intersects the time scale at 0809 which is the time of the first semi-diurnal HW of the day; by adding 1224 the time of the second HW of the day is obtained SL (2) = 2033.

The two diurnal components K_1 and O_1 are combined in the same way; the point (.) DL representing the extremity of the resulting vector. It is not necessary here to read off the time of diurnal HW; the latter might be obtained at the extremity of the radius through point DL.

The " Kodatrace " sheet (Height scale) represented on figure 3 (reduced by ½) shows two diagrams which enable the ordinates to be plotted in Table B (fig. 4), to be read off by superimposition on the plotting circle.

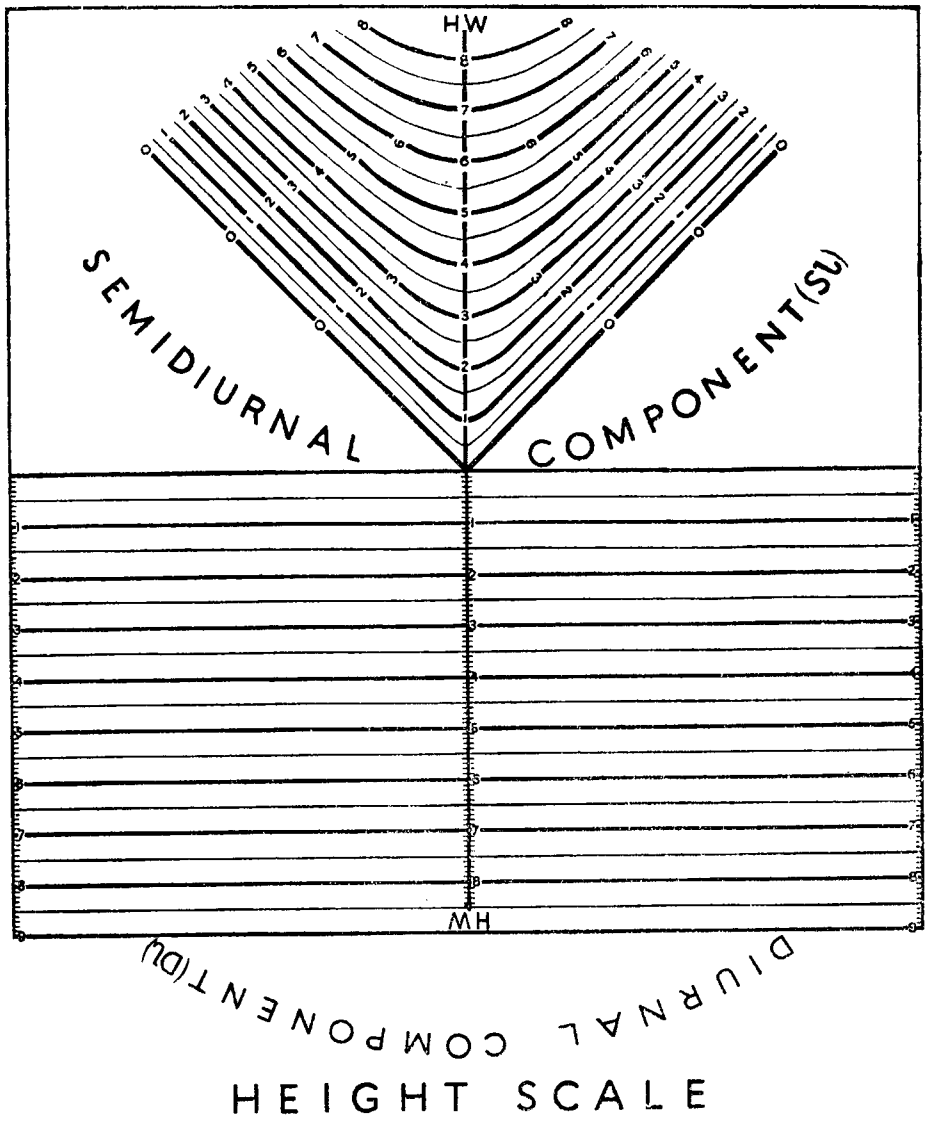

FIG. 3

For the diurnal component the diagram consists of parallel lines numbered from 1 to 8 feet which represent respectively the geometrical loci of the points : $R = 1 \sec \varphi$, $R = 2 \sec \varphi$, $R = 3 \sec \varphi$, ...$R = 8 \sec \varphi$ (fig. 3).

For the semi-diurnal component the diagram gives curves on which appear numbers corresponding to the following equations : $R \cos 2\varphi = 0$, $R \cos 2\varphi = 1$. $R \cos 2\varphi = 2$....., $R \cos 2\varphi = 8$ (fig. 3) which, if desired, permits these curves to be plotted point by point using a table of natural secants.

From the centre by means of the divider the three nearest radial lines on either side of the line SL (1) are executed with radius to SD (6 small circles on figure 1); also, with radius to DL, the six nearest radial lines on either side of (.) DL are marked (12 points on figure 1).

The height scale is then placed over the plotting circle so that their centres coincide and the HW line on scale is aligned to direction showing High Water, for instance SL (1) on the plotting circle.

TABLE B (To predict heights at luni-hourly intervals)

A.M. & P.M. Times			(1)		(2)	A.M.	(3)		P.M.	(4)		(5) A.M	(6) P.M.
			Sign	SI Heights	ML + SI Heights	Time	Sign	DI Heights	Time	Sign	DI Heights	Heights above Chart Datum	
0000	1224	A	−	3·9	7·7	0000	+	3·2	1224	−	3·2	10·9	4·5
0102	1326	B	−	6·3	5·3	0102	+	3·2	1326	−	3·2	8·5	2·1
0204	1428	C	−	7·1	4·5	0204	+	3·0	1428	−	3·0	7·5	1·5
0306	1530	D	−	5·9	5·7	0306	+	2·6	1530	−	2·6	8·3	3·1
0408	1632	E	−	3·2	8·4	0408	+	2·0	1632	−	2·0	10·4	6·4
0510	1734	F	+	0·4	12·0	0510	+	1·3	1734	−	1·3	13·3	10·7
0612	1836	a	+	3·9	15·5	0612	+	0·5	1836	−	0·5	16·0	15·0
0714	1938	b	+	6·3	17·9	0714	−	0·3	1938	+	0·3	17·6	18·2
0816	2040	c	+	7·1	18·7	0816	−	1·2	2040	+	1·2	17·5	19·9
0918	2142	d	+	5·9	17·5	0918	−	1·9	2142	+	1·9	15·6	19·4
1020	2244	e	+	3·2	14·8	1020	−	2·5	2244	+	2·5	12·3	17·3
1122	2346	f	−	0·4	11·2	1122	−	3·0	2346	+	3·0	8·2	14·2

FIG. 4

From the graduations superimposed the heights corresponding to the six small semi-diurnal circles are read and entered with the + sign against the proper time in column 1 of Table B. For the 6 remaining spaces the sign — is entered and the heights : a = A, b = B, etc.

SHALLOW WATER CORRECTIONS TO HARMONIC PREDICTIONS

Corrections in feet at luni-hourly intervals from semi-diurnal (SI) H.W.

No 4440 Darwin SI.HW(1)				Luni-hourly intervals	No. SI.HW(1)		
0729	1035	0117	0423				
+0·6	+0·2	−0·1	+0·2	−6			
+0·3	0	−0·3	+0·3	−5			
+0·2	−0·3	−0·4	+0·5	−4			
+0·2	−0·4	−0·5	+0·6	−3			
+0·1	−0·5	−0·6	+0·5	−2			
+0·2	−0·2	−0·7	+0·3	−1			
+0·8	+0·1	−0·7	+0·2	AT			
+1·1	+0·2	−0·8	+0·1	+1			
+0·7	−0·1	−0·7	−0·2	+2			
+0·2	−0·4	−0·4	−0·3	+3			
+0·3	−0·3	−0·2	−0·2	+4			
+0·6	+0·1	−0·1	0	+5			

FIG. 5

A similar operation is carried out for the 12 dots marking the diurnal tide, the heights for which are entered with the sign + under the corresponding times in columns (3) or (4) of Table B. These columns are then completed by entering signs — for the figures that remain, after having filled up column (2) as indicated. Columns (5) and (6) of Table B are completed making (5) = (2) + (3) and (6) = (2) + (4).

The 24 ordinates at luni-hourly intervals are thus obtained and the curve of the tidal level for the particular day may be plotted.

For some places the Admiralty Tide Tables also furnish height corrections taking into account the influence of shallow water (constituents M_4 and MS_4) : they are given, as, for instance in figure 5, for the various luni-hourly intervals, from specified times of semi-diurnal HW and should be interpolated for the hour SL (1) which has been entered in Table A during the above graphical operations.

Corrections at luni-hourly intervals counted from SL (2) are the same as those counted from SL (1).

Therefore, on the daily graph the ordinates corresponding to times SL (1) and SL (2) will be plotted; height corrections should be applied to the non-corrected curve at proper luni-hourly intervals through SL (1) and SL (2).

Finally, through the new points thus obtained the corrected tidal curve for the day should be plotted.

Changes in level due to meteorological conditions represented in the harmonic method by long-period constituents, are taken account of by means of a seasonal correction to the height of mean level given by the A.T.T. for the first day of each month. The interpolated value of the curve is entered in the proper place in Table A.

H. B.