Mr. Nightingale writes:

I agree with Mr. Sadler that Table II is misleading, for my 14 *selected* pairs of sights below 10 n.m. separation are less accurate than those above 10 n.m. I did not consciously select the less accurate sights.

I give below more detailed figures on the separation of successive position lines and their errors. The total number of position lines obtained from two successive sights was 113.

Total less than 10 n.m. separation—90.
Number with error of 5 n.m. and over—22 or 24·4 per cent.
Number with error of 10 n.m. and over—2 or 2·22 per cent.
Average error—3·24 n.m.
Total of 10 n.m. and over separation—23.
Number with error of 5 n.m. and over—4 or 17·4 per cent.
Number with error of 10 n.m. and over—nil.
Average error—2·64 n.m.

These results show that in fact the successive position lines separated by 10 n.m. and more (the maximum was 28 n.m.) were less liable to large systematic errors by 17·4 per cent to 24·4 per cent and that the mean error was less, 2·64 n.m. against 3·24 n.m.

In reply to Mr. J. B. Parker, the conditions were exactly the same in both cases, in fact as far as was possible all the sights were taken under ideal conditions. No attempt was made to take sights under bumpy conditions.

REFERENCES

1 Willems, R. C. (1951). Low altitude refraction correction. *Navigation, Los Angeles,* 3, 41.
2 Hagger, A. J. (1952). The accuracy of bubble sextant observation. This *Journal,* 5, 380.

Priming and Lagging

from E. E. Mann

The term 'Priming and Lagging' has been defined in two different ways.

The *Admiralty Manual of Navigation* (1922) defines it as occurring when the resultant of the solar and lunar tides arrives before or after the lunar tide would arrive. This is here called definition *A*. The *Admiralty Manual of Tides* (1941) defines it as occurring when the interval between successive diurnal high waters is less or more than the average $24^h\ 50^m$. This is here called definition *B*.

The two phenomena thus defined are distinct. If we take a horizontal line divided into equal parts to represent successive lunar days and for each day plot as ordinate the amount of priming upwards or lagging downwards, as calculated from definition *A*, and join the ends of the ordinates by a curve, we find that normally the tide primes during the week from springs to neaps (that is, Moon in first and third quarters) and lags normally during the week from neaps to springs (that is, Moon in second and fourth quarters). If we plot a similar diagram as calculated from definition *B* we find that normally the tide primes

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during the week in the middle of which spring tides occur and lags during the week in the middle of which neap tides occur. In fact, the ordinates of curve *B* appear to be proportionate to the slope of curve *A*.

A further confusion appears to have arisen. The usual diagram which is drawn to illustrate definition *A* shows the Earth as rotating from west to east; the Sun is stationary, and the Moon slowly rotating also from west to east as its phase changes. During the first quarter of the Moon, the effect of the Sun's tidal pull is to cause the combined resultant high water to lag (in the diagram) behind that caused by the Moon alone and this may be described as a tidal lag during the first and third quarters. It will be seen, however, that the effect of this lag in the diagram is to cause any given spot on the Earth's surface to experience the high water *earlier* in time than it would have done if there had only been a lunar tide and this effect is usually called 'priming' by definition *A*.

These confusions appear to be of long standing.

R. A. Harris of the U.S. Coast and Geodetic Survey uses definition *B* and then, later, definition *A* without apparently noticing the discrepancy.

The *Admiralty Manual of Tides,* as already stated, uses definition *B* but, later, states that priming occurs from springs to neaps which is a characteristic of definition *A*.

Nicholls's Concise Guide uses definition *A* and, as already stated, the *Admiralty Manual of Navigation* uses definition *A*.

It is obvious, that whatever decision is ultimately made on this point by any responsible authority should be widely published so that instructors, examiners and candidates may be in agreement.

Dr. A. T. Doodson (Director of the Liverpool Tidal Institute) comments:

If the times of high water are related to the times of transit of the Moon the 'interval' varies throughout the cycle, taking its mean values at neaps and springs, rising to a maximum somewhere between neaps and springs, and falling to a minimum somewhere between springs and neaps. The diagram of variation (Fig. 1) is like a distorted sine curve. The tidal period from one high water to the next one increases continually but at a varying rate from springs to neaps, and decreases continually from neaps to springs: that is, the tide is coming in more slowly day by day from springs to neaps, and at a faster rate from neaps to springs.

From a consideration of definitions of words and phrases in the *Shorter Oxford English Dictionary* it is evident that it is the last stated facts which have given rise to the terms considered. The word 'lag' means to progress too slowly, and the word 'prime' means to come at a shorter interval. The dictionary gives the original definition as dating from 1833, and defines the lagging of the tides as the retardation taking place from springs to neaps, and the priming of the tides as the acceleration taking place from neaps to springs. There is thus complete consistency between the definitions of words and phrases. With these definitions *Webster's Dictionary* agrees, and it is evident that they have both used original sources. Both dictionaries, however, also mention the phases of the Moon, but it is inaccurate to do so, owing to the age of the tide.

Thus the original (and in my judgment the correct) definitions are that the tide lags from springs to neaps and primes from neaps to springs, it being understood that this lagging or priming refers to the day-by-day changes.

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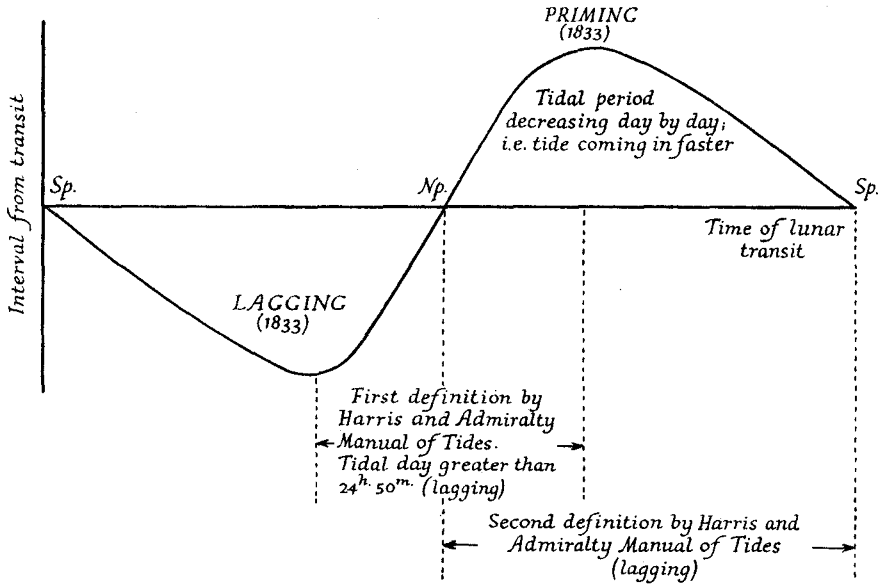

Fig. 1. Diagram showing variation and definitions.

The definitions given in the *Admiralty Manual of Navigation* (1922) and in one statement of the *Admiralty Manual of Tides*, also in the International Hydrographic Bureau's *Hydrographic Dictionary*, are the inverse of the original definitions. Harris's *Manual* is also incorrect and has two conflicting statements.

The simplest method of avoiding confusion would be to drop the terms, for they are never used in modern tidal exposition. The use of other terms and phrases will lead to similar confusion unless they are very lengthy. All the essential facts are given in the first paragraph of these notes.

The Size of Navigation Tables

In his review of *Sight Reduction Tables for Air Navigation* (A.P. 3270) on page 98, Mr. J. B. Parker suggests that navigators might tolerate the disadvantage of tables with large intervals in the arguments. Mr. D. H. Sadler, Superintendent of H.M. Nautical Almanac Office, comments on this suggestion as follows:

Mr. Parker's suggestion is most intriguing. A substantial reduction in bulk would be possible, as the following table of approximate figures shows.

Interpolation for declination, and choice of assumed longitude, would be more difficult; the interpolation table for declination would either have to be larger or, more probably, coarser. The azimuth would have to be interpolated for declination. The actual values taken from the tables would not normally be greatly in error, though at an interval of 3° in declination neglect of second difference in interpolation might give rise to an error of 2′ in the altitude. Errors will, however, arise in plotting:

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