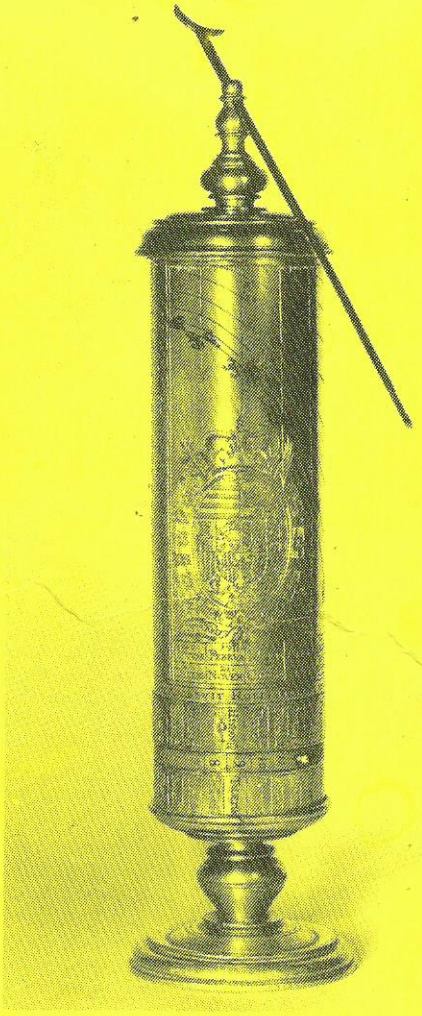
The British Sundial Society



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A TIDAL DIAL

BY DENIS SCHNEIDER (FRANCE)

When the tidal time of an harbour changes each half day, and tidal tables are valid only for a given year, it does not seem likely that a dial can foretell the state of the tide in the furthest harbour as well as the nearest.

It will appear to you, however, as it did to John Marr (BSS *Bulletin* 91.1, page 5, line 26; and 91.2, page 4, line 42 with correction page 27): or as with John Bonar 91.3, page 13, if you read Gordon Taylor's account, and if you don't expect a precision better than one hour in the less favourable cases. Otherwise you had better continue to scan the tidal tables printed in your daily newspaper.

To solve this apparently complex problem, first consider the course of the sun's shadow which delays 2 minutes an hour on the moon clock, which for our present purposes, is to be preferred. It is true that the sun, rising above the horizon, has a more immediate impact on the human race, but it does need another force to raise the surface of the sea. This comes from the moon, so much smaller than the sun, but so much more powerful in its effects through being so near. From the sun, the male star, light and warmth; and from the moon, the female satellite, coolness, with more secretive forces ...

Remember that when the sun and moon clocks are showing the same hour (at New Moon, or as at Full Moon with 12 hours difference, that is to say every 14.25 days [nearly], the time of high tide on this day is termed the "establishment" at a particular port (Port Establishment) and also its "Lunar Situation", (in all exactitude when sizygies arrive precisely locally overhead. The attraction of the oceanic waters is then exercised with maximum effect with the moon on the local meridian or anti-meridian (separated by solar time of 12h 24m) but the full effects are delayed which depends upon the inertia of the body of water affected and the coast configuration.

If the hour hand of your watch turned once in 12h 24m (12h + 12 x 2m), and if the moon's motion was uniform, the watch would indicate at every moment, a near enough indication of tidal hours, but only if you knew the "Port Establishment" of the harbour concerned. The hand would turn a complete revolution in 12 h equal to 12h 24m of the familiar mean solar time. It would be necessary to set the watch to the local time of the harbour, or even better to regulate the watch to Universal Time after having converted the "Port Establishment" of all the harbours in the world of UT, and this would allow an instantaneous knowledge of the state of the tides at any point on the globe (after having eliminated harbours subjected to tidal regimes other than the semi-diurnal lunar one, as for example the Gulf of Mexico or the Indian Ocean). For every horary angle of the moon respectively to the Greenwich Meridian would correspond to high tide in harbours with which the UT values of the Establishment coincided.

Every twelve lunar hours on average, the world system of high tides develops itself in the same sequence, with changes of intensity essentially depending upon, in this sidereal orchestra, the distance of the principal actor (the moon), its declination of Jupiter's and Venus's influence; and above all of the difference of right ascension between moon and sun (depending of course upon the age of the moon). This difference of right ascension reveals the solar component of the tides by changing chiefly the tidal coefficient, but also the tidal hour by advancing it or retarding it a little, these differences add algebraically to zero at New or Full Moon. Therefore it is possible to give mean corrections in accordance with the moon's age when considering "Port Establishments".

Every dial surface with an oriented style is suitable, but only if the shadow is clear enough, and in the case of night observations, only in the second and third quarters of the moon. The occasions where the knowledge of tidal hours was required by dials would be too few if it there were not methods to estimate them almost permanently. Thus to know the moon horary angle each time it is visible, by day and night, it is much better to utilize an optical sight, such as an alidade with holes, turning around an axis parallel to the polar axis and set on an equatorial dial, the noon of which is set to the Greenwich Meridian.

By such means it is possible to know the moon horary angle with sufficient accuracy, even when it is invisible: by day from the sun shadow by subtracting the difference of right ascension between the sun and moon from the sun horary angle, thanks to knowledge of the age of the moon, or from circumpolar stars horary angle (for example the alpha and beta stars of the Great Bear) thanks to the principle of the nocturlabe which converts star time to solar time before estimating the lunar hour by means of the previously described manner. Except with a cloudy sky, essentially, you can therefore estimate where the moon stands on the horary dial.

Soon the moon is not visible, how is it possible to know the age of the moon? In the absence of a calendar, ephemeris, or moon perpetual calendar (ecclesiastic moon, accurate to one or two days), it is still possible to know it to a similar approximation in adding the Epact (bound to Meton's cycle), the day of the month and the correct month lunar key which takes into account the number of days in the months of the year and the alternance of moons having 29 and 30 days difference (average 29½, and substracting 30 if the calculated age exceeds this value:

Month Lunar Key

Jan 0 Feb 1 March 0 April 1 May 2 June 3

July 4 Aug 5 Sept 7 Oct 7 Nov 9 Dec 9

Following this arithmetical exercise, consult Fig. 1a, which will give the mean delay of the moon from the sun for every age of the moon (in setting the New Moon on 12 h). Figure 1a shows the horary angle and age of the moon graduated in the same sense. It is sufficient to subtract the mean delay of the moon from the sun to obtain the lunar hour. This system also allows the knowledge of high tide solar hour of any harbour for each age of the moon by setting the New Moon on the "Port Establishment" E, see Fig. 1b. By setting the age of the moon on the solar hour, ~~the lunar hour~~, the lunar hour lead on the NM may be read, see Fig. 1c.

It is more convenient to find in which part of the horary dial the moon stands by the use of inverse sense graduated discs - Fig. 2. By setting NM on the solar shadow, the lunar hour is read in respect of the age of the moon.

By taking the previous horary discrepancies into account in respect of the "Port Establishment" according to the age of the moon, and having converted all the "Port Establishment" into UT values or the local time of your meridian, a perpetual book of tide-hours may be compiled.

Do not seek to know the tidal coefficient, nevertheless remember that great tides arrive 36 hours after NM and FM, also that these are greater when the moon and sun are in perigee (the mean motion of the moon's perigee is 45° per year, that is to say 5° every 45 days). On the platform of my dial, 75 holes are perforated to allow an advance of 5° every forty-five days, see Fig. 3.

Figure 5 gives an overall view of the complete instrument with integral plumbob and levelling screws in the brass to allow accurate setting of the instrument.

Remember that a number of distant harbours do not obey the lunar semi-diurnal regime and it will be better to

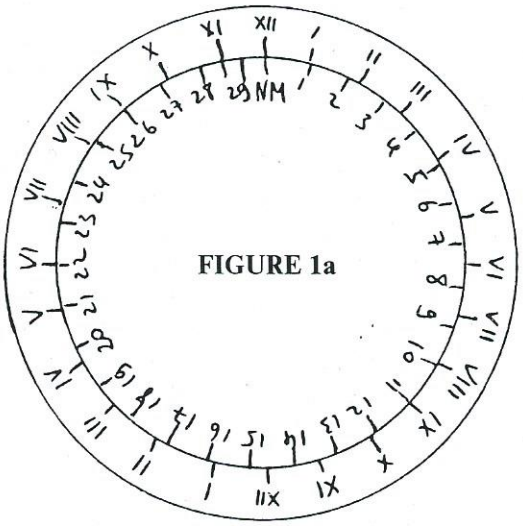

FIGURE 1a

'E' = 2h 30m

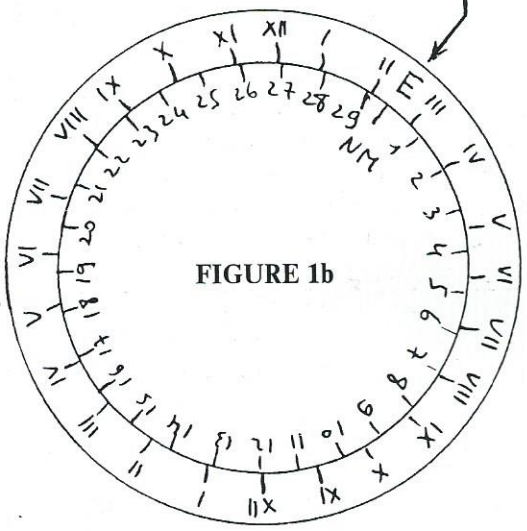

FIGURE 1b

Lunar hour 9h 20m

Solar hour 3h 20m

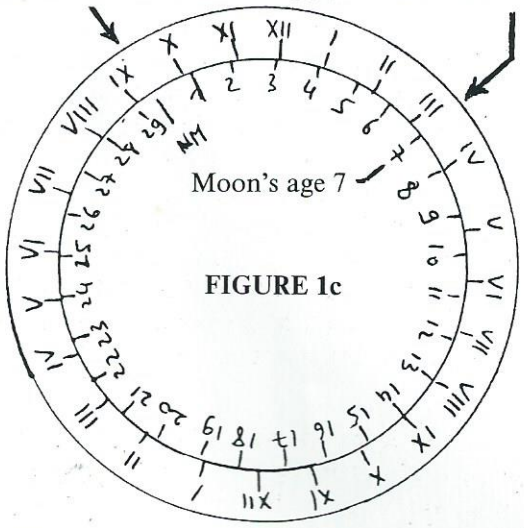

FIGURE 1c

FIGURES 1a - 1c

Lunar hour 1h 30m

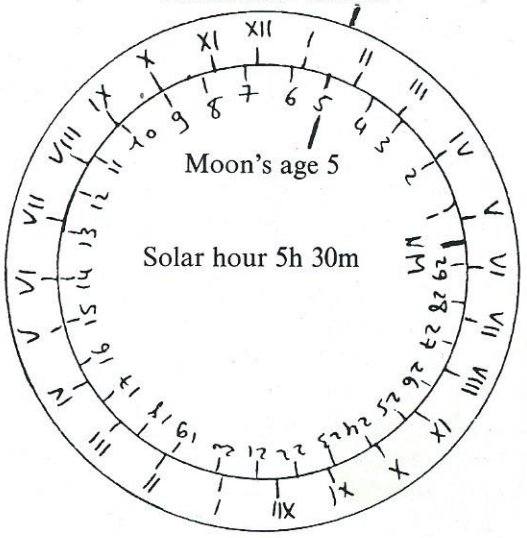

FIGURE 2

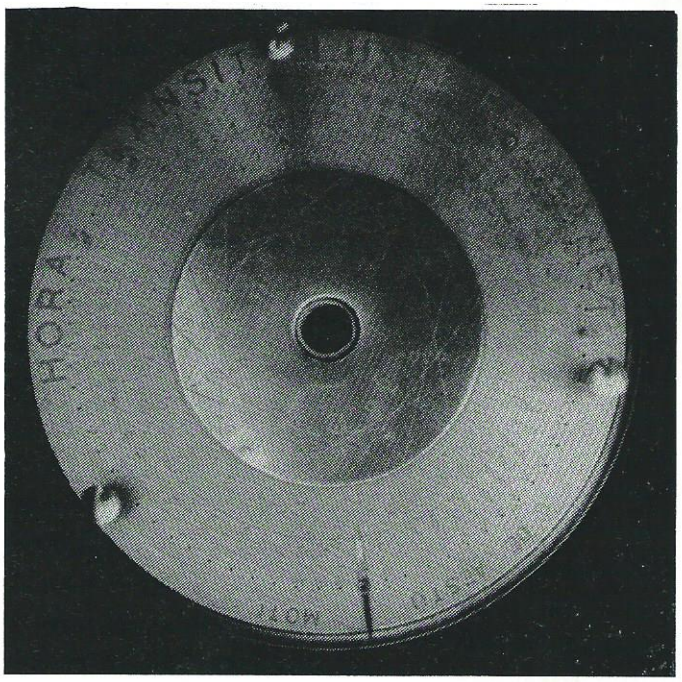

FIGURE 3: The axis of the cylinder is positioned parallel to the axis of the world; on each of its 24 hours graduations are engraved the names of the harbours according to the order of the "E" values converted to U.T. Beneath is the index of the nocturlabe to turn the alidade and the slide to use as the style.

find these out if you intend to maintain a coastal trade in all oceans!

I have never ventured upon this myself, but when I informed the National Hydrographic Service of seeming anomalies revealed by my dial (containing 761 harbours engraved upon it), of harbours in New Zealand, I was surprised to learn by return post that the date of the International Hydrographic Board would be corrected for six harbours of this country. In thanking me, the Principal Engineer confided in me that it was due to typographical errors!

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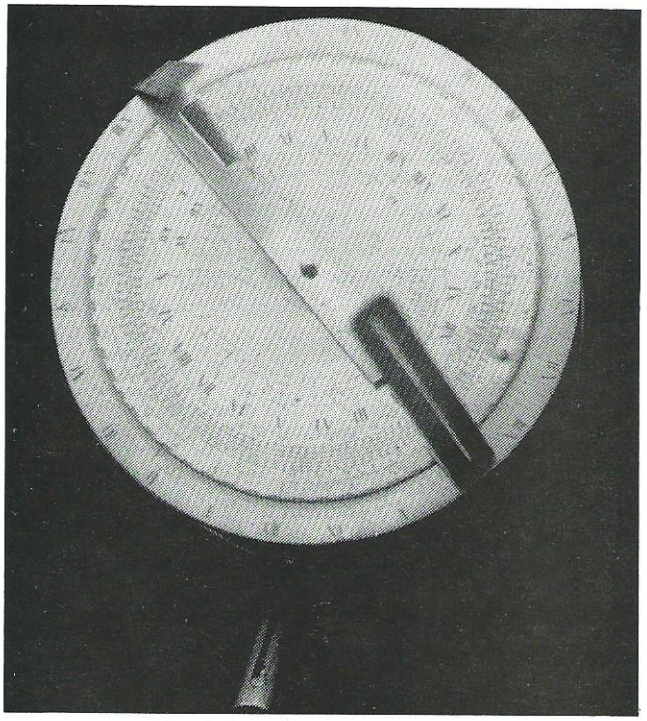

FIGURE 4: Upper face of the cylinder to find moon or sun hour. The inner movable disc (graduated in hours at 15° intervals, and also the age of the moon graduated in the same sense) is used to convert the sun hour into the moon hour. The branches of the alidade are inclined at 61° 30′ = 90° - [23° 27′ + 5° 03′], one may be shortened to permit sighting the moon whatever its declination + or -, one is slotted, the other is pierced by two holes.

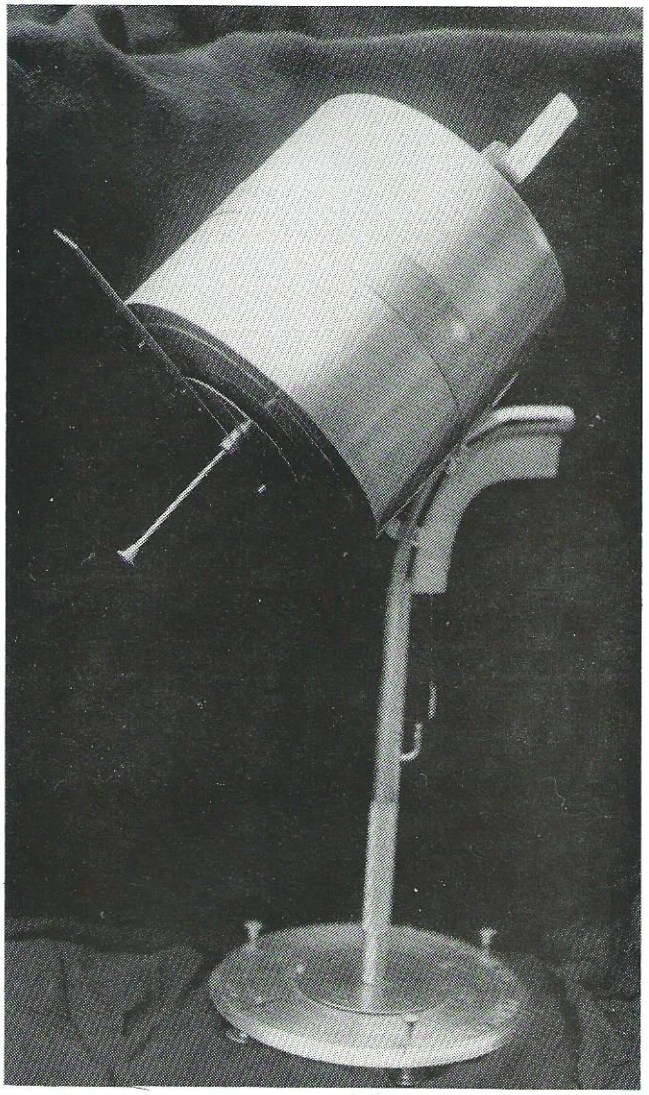

FIGURE 5: The base of the stand has a central movable disc with the 19 Golden Number arranged in 15 points to allow the age of the moon until the year 2199 in conjunction with the mean corrections of the solar components on the fixed disc. Around the periphery are the 72 holes with the dates of the year in steps of 5 days, to allow the advance every period of 45 days of the pointer showing the position of the moon's perigee.