Master (Yachts)

Celestial Navigation

Lesson 3.5

The Marine Chronometer

Note
Knowledge of the relationship between time and longitude is essential; the marine chronometer permits a navigator to determine his longitude by celestial navigation.

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The Marine Chronometer

Invented by John Harrison in 1735 the Marine Chronometer is the essential instrument to allow a navigator to determine *longitude*. A ship's chronometer is always set to indicate Universal Time (UT) (or Greenwich Mean Time (GMT)); other clocks on board will indicate some form of 'local time' to regulate the routine and internal organisational activities on board ship.

The chronometer may be fast or slow of UT but this is of no concern provided that *the exact error is known and applied* to all chronometer readings used for navigational purposes.

Daily rate

The value and reliability of a chronometer depends on the steadiness of its *daily rate* which is the amount by which it gains or loses time during the course of a single day. In consequence, a daily change of one or two seconds is acceptable providing the amount is known and the daily rate is reasonably constant.

Any error which is present can be regularly checked by use of radio time signals. The *Chronometer Error*, together with the details of the *Date, Time, Temperature* and *Average Daily Rate (ADR)*, is then recorded in the Chronometer Log Book; this should be done on a daily basis ideally at the same time each day; a good practice would be to do this just before noon each day. Table 1 shows a typical extract from a Chronometer Log Book.

CHRONOMETER LOG (2017)												
Date UT	Correct UT			Chron. Time			Error		Average Daily Rate	Temp (°C)	Time Signal Source & Remarks	Initials of Observer
	H	M	S	H	M	S	M	S				
17-Jul	11	30	0	11	32	0	2	0		15.0	Portishead	MAR
18-Jul	11	30	0	11	32	1	2	1	+01s	14.6	Portishead	MAR
19-Jul	11	28	30	11	30	32	2	2	+01s	15.8	GPS	DC
21-Jul	11	32	40	11	34	44	2	4	+01s	18.2	GPS	DC
22-Jul	11	33	50	11	35	55	2	5	+01s	17.6	Portishead	DC
24-Jul	11	38	30	11	40	37	2	7	+01s	13.8	GPS	DC
25-Jul	11	45	0	11	47	9	2	9	+02s	20.2	GPS - Rate increased	DC
26-Jul	10	48	10	10	50	21	2	11	+02s	18.6	Portishead	MAR

Table 1 - Chronometer Log Book extract.

The error is termed *Fast of UT* or *Slow of UT* and must be applied to the chronometer reading to obtain the correct UT.

The time of a navigational observation (sight) is always taken from the chronometer. Reference must then be made to the Chronometer Log Book in order to check the *Average Daily Rate* which is then applied to *Chronometer Time* to obtain *Corrected Chronometer Time*.

Average Daily Rate (ADR) can be found using the formula:

$$\textbf{ADR} = \frac{\textbf{(Error on last day observed) - (Error on first day observed)}}{\textbf{(Date of last observation) - (Date of first observation)}}$$

Considering the table of extracts above for the period logged:

$$\text{ADR} = \frac{\text{(Fast) 2m 11s - (Fast) 2m 0s}}{26 - 17} = \frac{11\text{s}}{9\text{d}} = 1.22 \text{ seconds/day } \textit{Gaining}$$

The ADR can be taken to be **1 second per day (Gaining)**.

No attempt should be made to determine the chronometer error closer than 0.5 seconds accuracy. Average daily rates, therefore, are somewhat a more accurate measurement of the chronometer's performance than are daily checks because, in the former method, any daily observational errors are averaged out.

Confirming the 'hours' reading of the chronometer

As the chronometer reads 12 hours (as opposed to 24 hours) it is then necessary to make a simple calculation to convert *Ship Date and Time* into an approximate *Universal Date and Time*. This done, the navigator can then decide if it is necessary to add or subtract 12 hours to the corrected time in order to obtain UT.

The following will help to determine whether the chronometer is reading, for example 0624 UT or 1824 UT:

Longitude East, UT (GMT) Least!

Longitude West, UT (GMT) Best!

where 15° change in longitude represents 1 hour in time.

Example 1
At approximately 1800 hrs on the 23rd December 0000 a ship's chronometer read 02:05:15. The chronometer error was 2m 23s fast of UT and the vessel was keeping Zone Time UT (GMT) + 4 hours. Find the exact UT and date.
Solution

Approximate ship's time (LMT)	23d	1800
Time zone (+04)		-0400
Approximate UT	23d	1400

Therefore chronometer is really reading 14:05:15!

Chron.	23d 02h 05m 15s
+12h	12h 00m 00s
Chron. (24h)	23d 14h 05m 15s
Error (FAST)	-02m 23s
Exact UT	**23d 14h 02m 52s**

Example 2
At approximately 1915 hrs on the 1st April 000 on a ship in position 10° 13' S 91° 15' W the chronometer read 01:19:13. The chronometer error was 2m 50s slow of UT. Find the exact UT and date.

Solution

Approximate ship's time (LMT)	01d	1915
Long. W in time		0605
Approximate UT	02d	0120

Therefore chronometer is really reading 01:19:13 – no need to add 12 hours!

Chron.	01d 01h 19m 13s
Error (SLOW)	+02m 50s
Exact UT	**02d 01h 22m 03s**

Complete the Tutorial Exercise that accompanies this Lesson.