# THE COMPENDIUM

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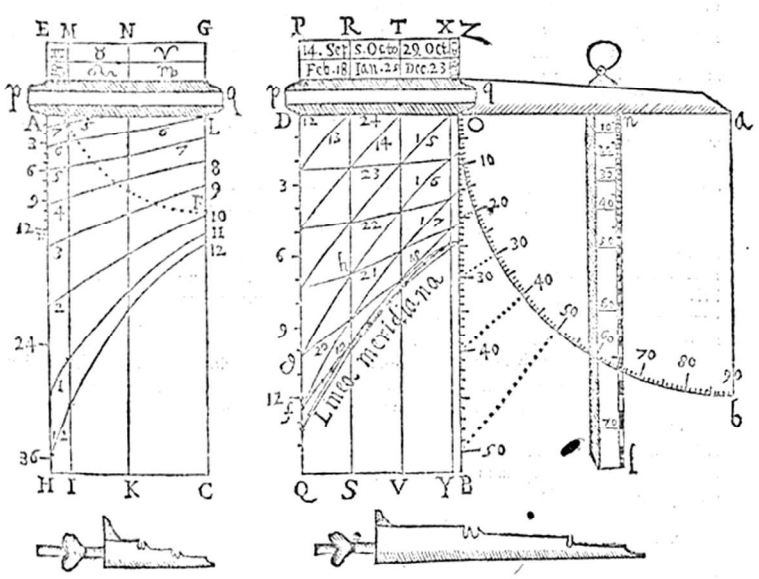


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# AN EQUATION OF TIME CHART WITH TWO-MINUTE INTERVALS AND IMPROVED ACCURACY

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My neighborhood of Ingleside Terraces in San Francisco has an historic horizontal sundial with a 28-foot concrete gnomon and a 34-foot diameter dial, dedicated in 1913. Its plaque had been missing for many years, and its original contents are unknown. I found that I was able to read this sundial and correct to Mean Time within a minute or two accuracy, using cell phone photos for documentation[1]. I wanted a new plaque that would be easy to use and as accurate as possible.

*Ingleside Terraces sundial. Photo: R. Karis.*

Traditional sundial plaques that show the Equation of Time data in tabular form, list the dates three times a month, on the 1st, 10th, and 20th, so that the intervals between the dates vary from 9 days to 12 days. The time adjustments are given to the nearest minute (which

[1] https://www.sfog.us/solar/sundial_accuracy.htm

may be off by 30 seconds from the values provided by NOAA) and the time intervals vary from one minute to six minutes. The chart below is a traditional EOT chart that I created using 2022 data from NOAA[2].

**Traditional Sundial chart**

| date | minutes | date | minutes | date | minutes |
|---|---|---|---|---|---|
| Jan 01 | 3 | May 01 | -3 | Sep 01 | 0 |
| Jan 10 | 7 | May 10 | -4 | Sep 10 | -3 |
| Jan 20 | 11 | May 20 | -3 | Sep 20 | -6 |
| Feb 01 | 14 | Jun 01 | -2 | Oct 01 | -10 |
| Feb 10 | 14 | Jun 10 | -1 | Oct 10 | -14 |
| Feb 20 | 14 | Jun 20 | 1 | Oct 20 | -15 |
| Mar 01 | 12 | Jul 01 | 4 | Nov 01 | -16 |
| Mar 10 | 10 | Jul 10 | 5 | Nov 10 | -16 |
| Mar 20 | 8 | Jul 20 | 6 | Nov 20 | -15 |
| Apr 01 | 4 | Aug 01 | 6 | Dec 01 | -11 |
| Apr 10 | 1 | Aug 10 | 5 | Dec 10 | -7 |
| Apr 20 | -1 | Aug 20 | 4 | Dec 20 | -3 |

Add the indicated number of minutes to sundial time to obtain local clock time. If daylight savings time is in effect, add one hour to the result. Numerical data from: NOAA

**2022**

The data in this chart is for the prime meridian; it is necessary to add a longitude correction at other locations.

To calculate the time adjustment for intermediate dates between the 1st, 10th, and 20th day of the month, one needs to divide the difference in minutes between two dates by the difference in days between the two dates, times the number of days from the previous date to the current date, and add that to the value for the previous date. For example, on September 25, 2022, the calculation would be:

$((-4/11) \times 5) - 6 = -7.8$ minutes, or about −8 minutes correction.

[2] https://gml.noaa.gov/grad/solcalc/

I thought that there should be an easier way. Instead of using standard – but arbitrary – dates (the 1st, 10th and 20th of every month), I developed a chart with data listed in 2-minute intervals, as follows:

**Sundial EOT chart with 2 minute intervals ©**

| date | minutes | date | minutes | date | minutes |
|---|---|---|---|---|---|
| Jan 03 | 4 | May 14 | -4 | Sep 30 | -10 |
| Jan 07 | 6 | Jun 02 | -2 | Oct 07 | -12 |
| Jan 12 | 8 | Jun 13 | 0 | Oct 14 | -14 |
| Jan 17 | 10 | Jun 22 | 2 | Oct 26 | -16 |
| Jan 24 | 12 | Jul 02 | 4 | Nov 12 | -16 |
| Feb 06 | 14 | Jul 15 | 6 | Nov 22 | -14 |
| Feb 17 | 14 | Jul 26 | 7 | Nov 29 | -12 |
| Mar 03 | 12 | Aug 06 | 6 | Dec 04 | -10 |
| Mar 11 | 10 | Aug 18 | 4 | Dec 09 | -8 |
| Mar 18 | 8 | Aug 26 | 2 | Dec 13 | -6 |
| Mar 25 | 6 | Sep 01 | 0 | Dec 17 | -4 |
| Apr 01 | 4 | Sep 07 | -2 | Dec 21 | -2 |
| Apr 08 | 2 | Sep 13 | -4 | Dec 25 | 0 |
| Apr 15 | 0 | Sep 19 | -6 | Dec 29 | 2 |
| Apr 25 | -2 | Sep 24 | -8 | **2022 - 2025** | |

Add the indicated number of minutes to sundial time to obtain local clock time. If daylight savings time is in effect, add one hour to the result.
Two minute intervals, except one minute on July 26.

For further accuracy when using horizontal sundials, correct to the center of the sun by adding one minute in the morning or subtracting one minute in the afternoon[3].

This chart is accurate to the nearest minute. Add longitude correction for your location or generate data from NOAA[2].

Using NOAA data for 2022 to 2025 allowed me to deal with the small cyclic variation of the Equation of Time due to Leap Years.

Initially, I used 2-minute intervals throughout, but that led to a gap of 22 days from July 15 to August 6. Adding an entry with a 1-minute

[3] https://www.sfog.us/solar/sundial_accuracy.htm#Britannica

interval on July 26 improved the accuracy of the chart. This chart has 44 entries compared to 36 entries in the traditional chart. It is relatively easy to calculate the correct adjustment, as you only have to divide the date difference in thirds and then apply a 0, 1, or 2-minute adjustment. A traditional chart with entries three times a month leads to many entries where the correction from the NOAA values is close to half a minute. In my chart, I chose 2-minute intervals that were closest to the NOAA values. Using a traditional chart resulted in 37 days per year for which the variation from the NOAA data is over 30 seconds. According to my chart, there are no days in which the calculated variation from the NOAA numbers is 30 seconds or more, which is a highly statistically significant difference, and enables the chart to always be read to the nearest minute.

A new plaque, with time adjustments for its location in Ingleside Terraces, and with my 2-minute intervals, was recently put in place in the same location as the original plaque[4].

The idea of Equation of Time tables with intervals based on numbers of minutes has been used by others. An impressive review by Kevin Karney is found in the *Displaying … As a Table* section of https://equation-of-time.info/.

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The Ingleside Terraces sundial is #82 in the NASS registry.

A 1-minute video clip about it is to be found on the NASS site at https://sundials.org/index.php/all-things-sundial/old-and-historic-sundials/205-historic-ingleside-sundial.

[4] https://www.sfog.us/solar/sundialsp.htm#IT_Sundial_Plaque