Jens Olsen's astronomical clock (III)

Summary of the clock

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(https://jens-olsen.github.io)

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Jens Olsen's astronomical clock is located inside the Copenhagen city hall (figures 7, 8, and 9).

At some point in the 1930s or early 1940s, the plan was to have the layout of the mechanisms as shown in figure 4. The upper view of that figure shows a mock-up of the clock, and one can see that the dials are almost all at their final place. The main change between the mock-up and the actual clock, on the front side, is that the sky dial was planned to be at the extreme right, and the orrery (planet dial) was above and left of it. In the final clock, these two dials have been swapped, so that the upper dial is now the sky dial. Another change is that the main dial was to show the time on 24 hours, and now only does on 12 hours. And of course, the other very conspicuous change is that the dials are now not located on an opaque panel, but on a structure which makes it possible to see through most of the mechanisms, both from the front and from the back. Such a structure was perhaps what Schwilgué would have done in Strasbourg, if he didn't have to reuse the 16th century case.

This mock-up, by the way, may still exist and, according to Søren Andersen (private communication, August 2022), it may be located at the Adler Planetarium in Chicago. How it came there, if this is true, is not known.

Figure 4 also shows the rear view of the clock and we can see that another important change was made between the mid-1940s design and the final clock, namely that the equations work, which was located at the bottom of the righthand panel (seen from the back), was moved to the center. This was certainly done for matters of symmetry, and also as a consequence of the new transparent case designed by the architect Gunnar Biilmann Petersen. This is probably also why the main driving weight was split in two, and not merely kept on one side of the clock, as in the initial design.

The architect designed a glass case and the frame supporting the works of the clock, and the result is such that the works seem to be floating in the air, and that the connections between the works are very

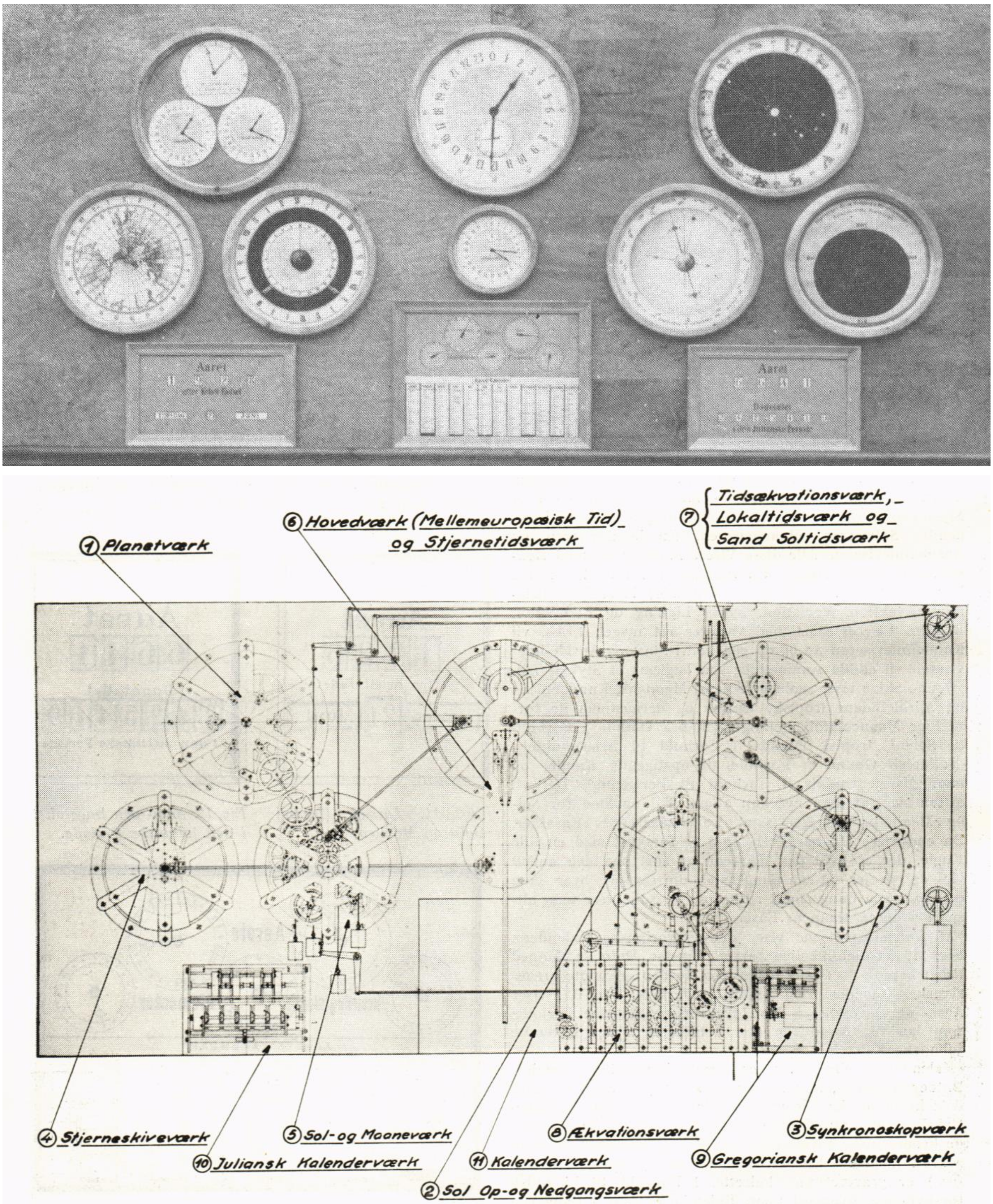

Figure 4: The planned layout of the clock as of 1947 [5, 2]. The left of the bottom view corresponds to the right of the upper view, and conversely.

Figure 5: The architect Gunnar Biilmann Petersen (left) and Otto Mortensen (second from left) in front of Jens Olsen's clock in 1956. (Atuagagdliutit/Grønlandsposten, 22 March 1956, page 9)

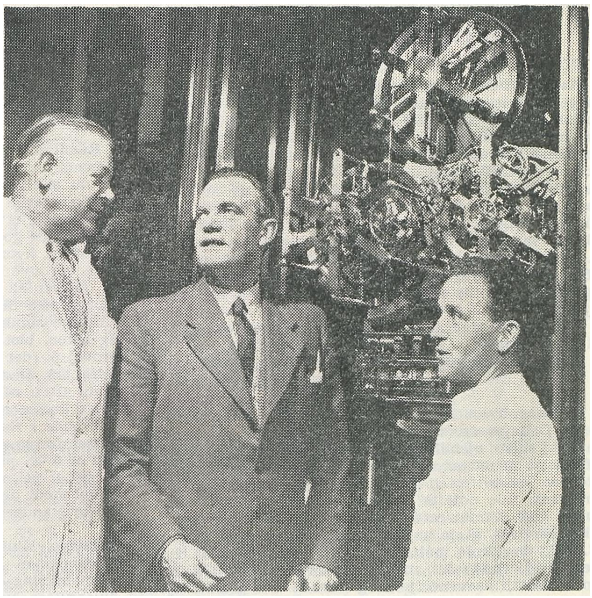

Figure 6: The mechanicians Willy Sørensen, Otto Mortensen and Svend Danielsen. (Den farende Svend, Januar 1956, number 1)

discrete. The case is supported by a granite base sunk in the undersoil.

Figure 10 shows the structure of the clock as it was completed, as seen from the front. There are three main parts. The central part has a large dial (1) showing the civil time, currently without Daylight Savings Time (the time is not changed in the Summer). This dial contains a smaller dial below its center showing the seconds. Another smaller dial (2) shows the sidereal time, and it does also contain a smaller dial for seconds. Below, the dials (3) to (7) are the elements of the ecclesiastical computus, which are useful for the computation of Easter. The same five elements are found on the Strasbourg clock and other older clocks. Below these five dials are twelve openings (8) for the twelve months of the calendar. These openings show the days of the week, the moving feasts related to Easter and the cyclic phases of the Moon.

In the left column, the upper dial (6) is called the triple-dial and shows the equation of time, the mean local time and the true local time. Dial (10) is the "synchronoscope" and shows the time in any place of the world. Dial (11) shows the times of sunrise and sunset. At the bottom, the upper four digits (12a) are those of the year, whereas the lower three indications are the day of the week, the day of the month, and the month (12b).

In the column on the right, the upper dial (13) shows the configuration of the sky, dial (14) shows the motion of the sun and the moon in the plane of the ecliptic, dial (15) shows the mean motions of the planets up to Neptune, and the bottom dial (16) shows the Julian day (16b) and the year (16a) in the Julian period of 7980 years that started in 4713 BC.

Figure 11 is a conceptual map of the works in Olsen's clock. It shows in red the rotary arbor connections. For instance, the main dial has an arbor (t_1) going towards the triple dial, and another one (t_2) going towards the work for the eclipses. These arbors are named $t_1, \ldots, t_6$. The arrows show the directions of the transmissions, that is, which work drives which work. The dashed arrow lines are either transmissions by gears (in the case of t_9 and t_{11}), transmissions by rigid rods (t_7, t_8, t_{10}, and t_{14}), or transmissions by steel strips (t_{12} and t_{13}). These dashed lines only show the directions, but the actual layout is different. For instance, the link from the Gregorian calendar to the computus goes through a vertical rod, reaches a rocker, then moves horizontally towards the left, reaches another rocker, and then goes down with another vertical rod until it can trigger the computus work.

This figure thus shows that everything stems from the main dial, where the escapement is located. A number of uniform motions are produced and are transmitted to the sidereal time dial, to the triple dial (for local time), to the synchronoscope (for the time in all places on Earth), to the sun and moon work (eclipses work), in order to produce the mean motions of the sun and the moon, to the sky dial, and to the planet dial. In addition, although the work for the equations is only advanced every hour, it does also produce a longer quasi-uniform motion which is sent (t_6) to the work for the sunrise and sunset. Some motions are intermittent, this is the case for the work for the equations which is triggered every hour (t_{10}), the Julian and Gregorian counts (t_7 and t_8) which are triggered once a day, and the computus which is triggered once a year (t_{14}). (Strictly speaking, the motions of the entire clock are intermittent, except for the pendulum.) The remaining transmissions t_{12} and t_{13} (which is actually four-fold) are corrections which are used in the work for the eclipses and in the work for sunrise and sunset.

Finally, figure 12 shows a more faithful view of the non-rotary connections on the rear side of the clock. All the works are connected either by direct meshing of gears, or by rotary connections (arbors), or by rods or strips. These are the ones depicted in the figure. All such connections between works transit through rockers which are located in the upper part of the glass case. There are 16 arbors, but 18 sets of rockers, as two of the arbors contain two independent set of rockers. A set of rockers is made of two arms which are spaced away, or (in the case of 13 and 15b) of one arm and a wheel. These rockers are all at the same level, but on the figure they have been depicted at different heights, in order to keep the drawing clear. The arbors numbered 1 to 16, including 11a, 11b, 15a and 15b, must be thought of being at the same level. The red lines are rigid rods, but the blue lines stand for steel strips. In addition, the black vertical lines are the main weight cables. All these connections will be explained in the sequel, but we can for instance see that there is a link from the right going through rocker 16 and left towards rocker 1, in order to trigger the change in the Julian day. Another connection is that in the middle transmitting the correction s to the longitude of the Moon, going through rocker 9, left to rocker 5, and then to a differential gear located below. This will all become clear later, and I will then often refer to this first drawing.

When the clock was built, it was supplied by a ventilating plant which is summarily described by Mortensen. This plant ensured that the hygrometry and temperature remained in some acceptable range. Moreover, within the glass case, the air pressure was slightly greater than outside of it, preventing the entrance of dust. (But the case still needs to be opened for rewinding.) I do not know if the original ventilating plant depicted in Mortensen's book does still exist. Probably not. The pressure is nevertheless somehow kept higher than outside, and this can be felt when putting one's hand on the frame of the case. There are also now (2022) two sensors within the case, perhaps in order to measure the hygrometry.

The maintenance of the clock was initially in the hands of Jens Olsen's coworkers. In 1977-1978, when Søren Andersen became acquainted with the clock, those maintaining it were Svend Danielsen and Keller Petersen. Danielsen had been a coworker on the clock between 1944 and 1955 and had been closely involved in its construction.

At the beginning of the 1990s, it was noticed that many of the clock's astronomical indications were incorrect, and that some parts of the clock were still, or not moving smoothly. The clock was in need of a complete rehaul. Jens Olsen's clock was then restored for a first time between 1995 and 1997 by the clockmaker and restorer Søren Andersen and his team. During this process, a large number of parts were numbered. The clock was again restored by Søren Andersen, Steen Hegner, Jørgen Hegner, Christian Lass and Robin Ravnkilde between 2019 and 2020. Nowadays (2022), the clock is rewound once a week each Wednesday morning. The works that need to be rewound each week are the main work, the Gregorian calendar, the Julian days and years (currently disconnected), the equations' work, and the synchronoscope. In addition, the computus needs to be rewound once a year. The clock is reset at the right time once a week and the drift is recorded in a notebook.

Visiting the clock is currently (2022) free, but at the beginning there was an entrance fee of 1 Krone.

Figure 7: The front side of Olsen's clock with its dials (© Gerhard Huber, May 2011, `https://austria-forum.org`).

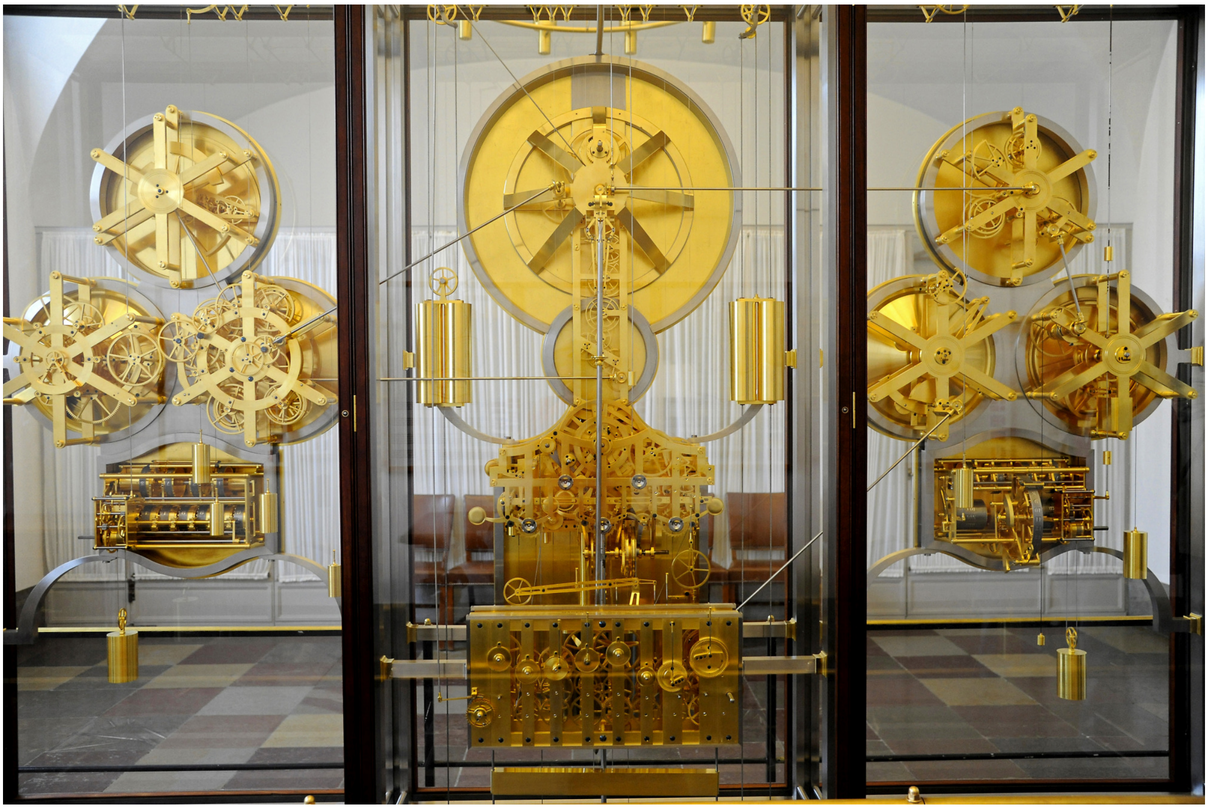

Figure 8: The rear side of Olsen's clock with its mechanisms (© Gerhard Huber, May 2011, `https://austria-forum.org`).

Figure 9: The sides of Olsen's clock (D. Roegel, 2022).

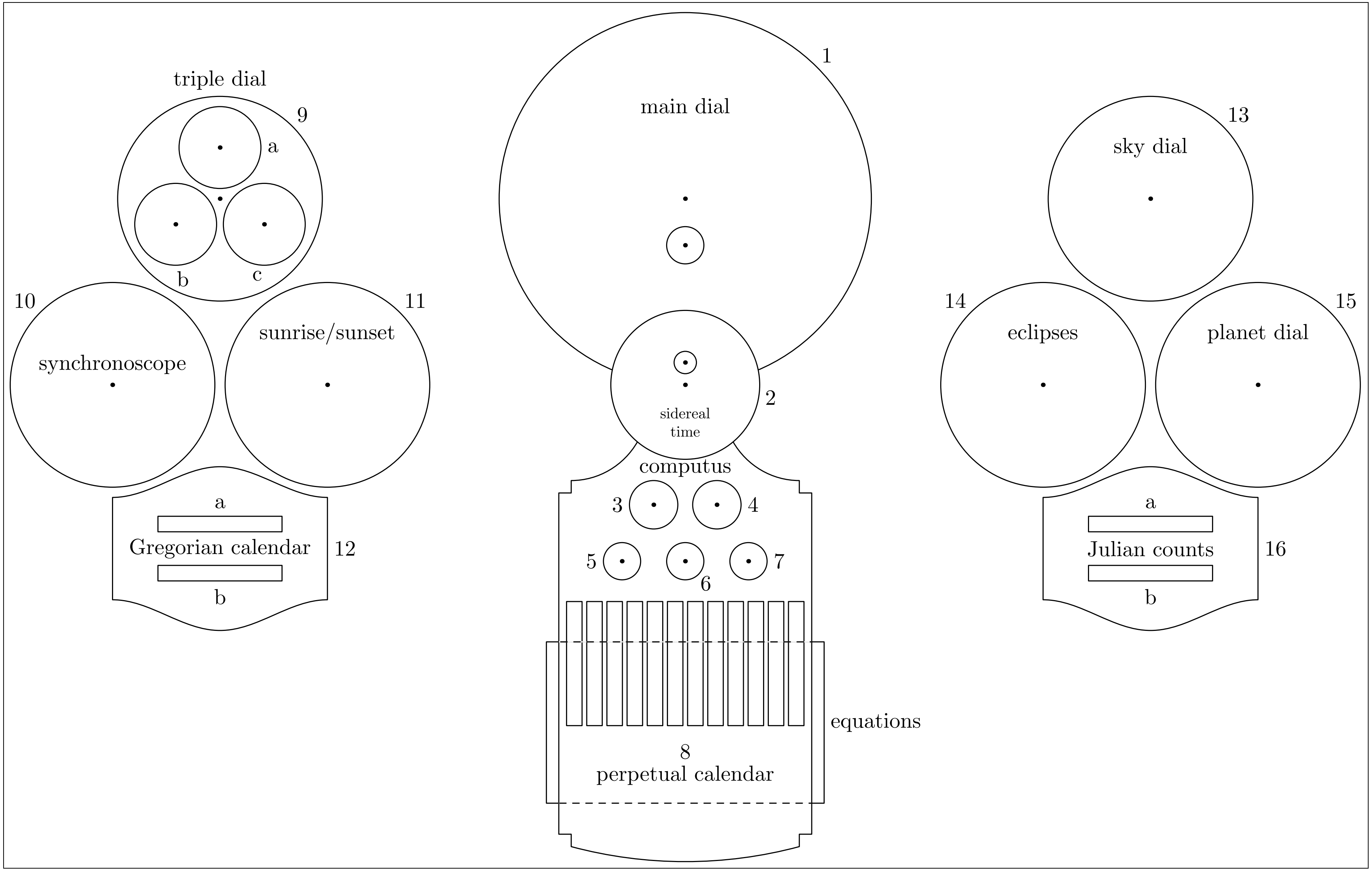

Figure 10: The front side of Olsen's clock with its dials.

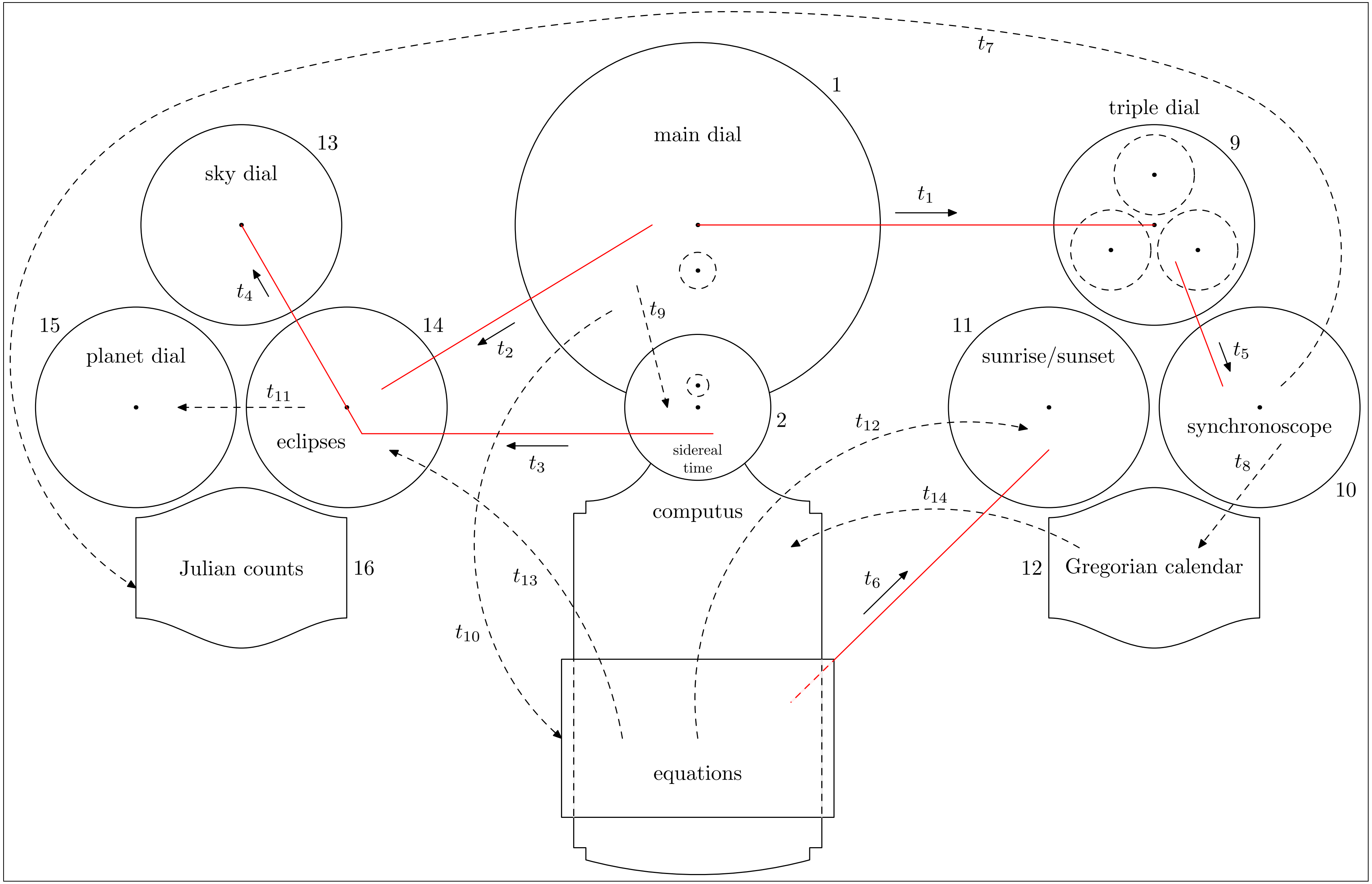

Figure 11: Conceptual map of the connections on the rear side, with the rotary connections in red.

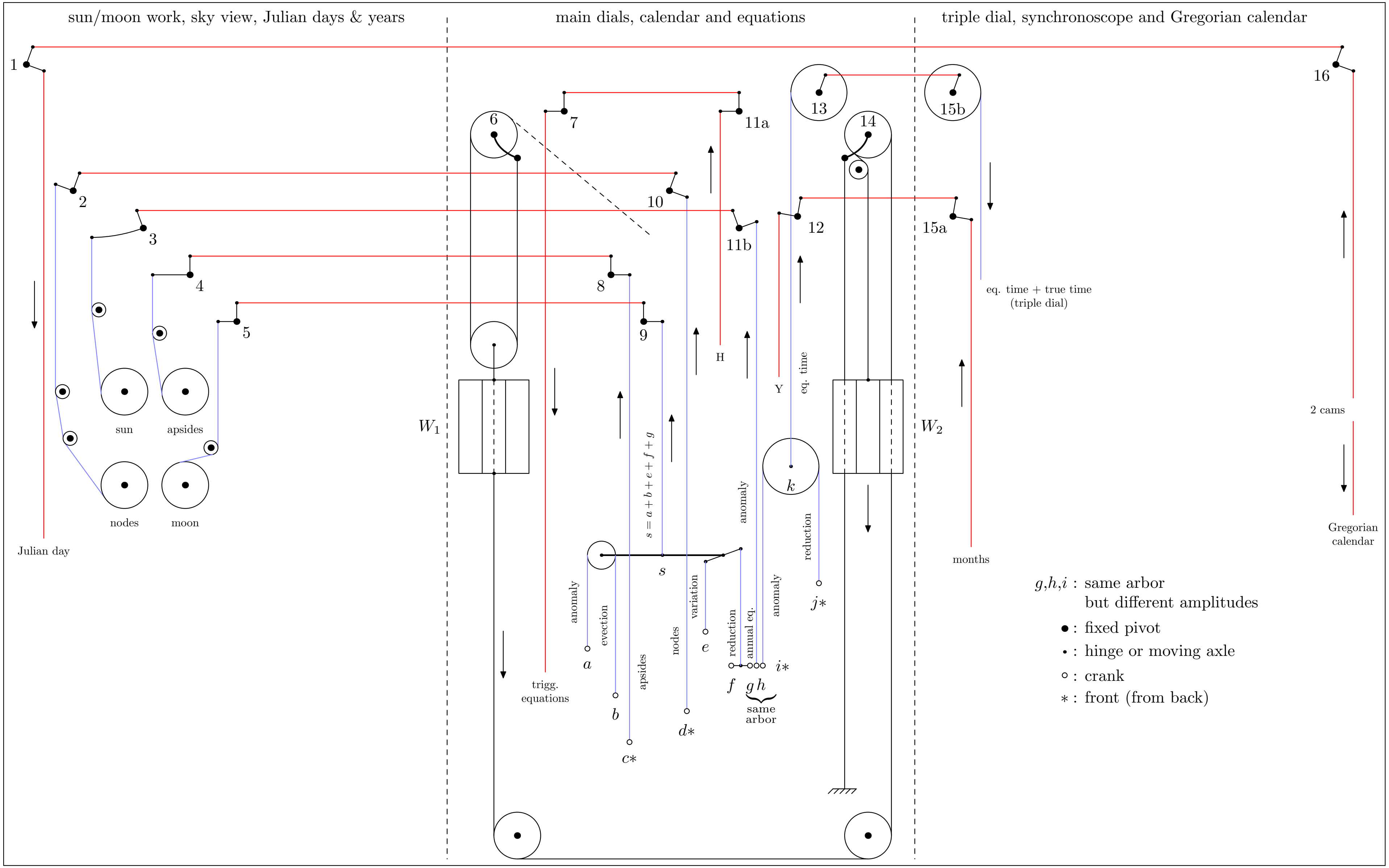

Figure 12: The non-rotary connections on the rear side. The connections to the triple-dial works will be detailed later. Counterweights are not shown.

In the following article, I will describe the heart of the clock.