Chapter 21 **(Oechslin: 2.1)**

Klein's geographic clock in Dresden (1738)

This chapter is a work in progress and is not yet finalized. See the details in the introduction. It can be read independently from the other chapters, but for the notations, the general introduction should be read first. Newer versions will be put online from time to time.

21.1 Introduction

The clock described here was constructed in 1738 by Jan Klein (1684-1762).[1]

This clock was an order of the elector of Saxony Frederick Augustus II (Augustus III of Poland) (1696-1763). The year 1738 is inscribed on the mock pendulum.[2]

The clock is a geographical clock inspired by Johann Baptist Homann (1663-1724)'s design of a geographical clock which was constructed in 1705 by Zacharias Landteck (1670-1740) [4, 14] (figure 21.1).

It is similar to Klein's geographical clock kept in the Clementinum in Prague (Oechslin 2.2) which may be the earlier one.[3] In any case, the Dresden clock has a simpler mechanism than that of Prague which uses three versions of the annual motion, instead of two here. The Dresden clock is topped by the Polish crown.

[1] For biographical information on Klein, see the chapter on the geographic clock in Prague.

[2] For brief descriptions of this clock, see Grötzsch [8], Schardin [19, p. 21], Oechslin [13, p. 38, 49-50], Michal [11, 12], Šolc [21] and Pařízek [16] who dates it around 1760. This clock was also shown at the 1989 Hahn exhibition [25, p. 63-64].

[3] Pelcl also describes Klein's three clocks in Prague, and mentions that a copy of the geographical clock in Prague had to be made for the King August of Poland and is now in Dresden [17, p. 137-141]. Although the Prague geographical clock has been dated around 1753 by Böhm [1], I prefer to follow Engelmann [6] who believes that the Prague clock was made sometime between 1732 and 1737. Maurice, incidentally, claims that Klein must have made a third geographical clock, because Klein's portrait shows a geographical clock which is neither that of Dresden, nor that of Prague [10, v.1, p. 268].

The globe of the clock was made by Pater Sichelbarth, but Schardin writes that he was born in 1690 and died in 1747.[4] I believe that there is a confusion with Pater Ignatius Sichelbarth (1708-1780), a Jesuit who was a painter and went to China around 1745 where he became a mandarin.

Figure 21.1: Johann Baptist Homann's geographical clock (1705).

[4][19, p. 21]

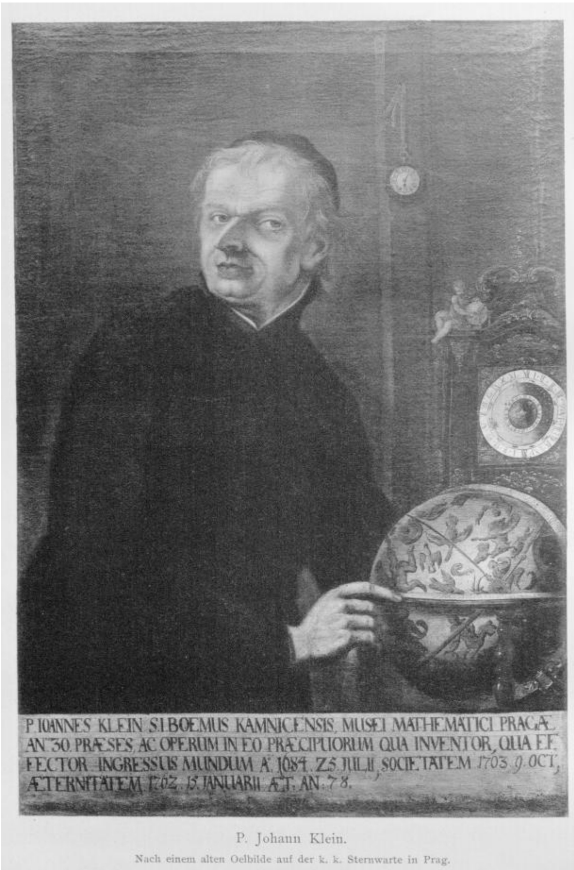

Figure 21.2: Left: Portrait of Jan Klein with his geographic clock from 1753/1754. (source: [1]) Right: portrait in Pelcl's biographical notice [17].

Figure 21.3: Klein's 1738 clock on a 1975 stamp from the DDR.

Although Oechslin describes the gear trains of the clock, I believe that he did not have the opportunity to disassemble the clock. He may have used some unpublished source, or only examined the works from the outside, comparing it with the geographical clock located in Prague.

This clock is a table clock with two sides. The clock is spring-driven with a fusee and regulated by a short pendulum.[5] There are two striking works and six bells. The clock works 8 days. One side shows the time on a 12-hour dial with additional openings for the day of the month, the sunrise and sunset. There is also an aperture for a mock pendulum. The other side shows a fixed the Northern hemisphere, but with a rotating metal shell representing the part of the Earth which is not lit by the Sun. The Sun rotates around the Earth and there is a ring for the ecliptic. For the study of this clock, it is best to first read the description of the geographical clock located in Prague, as it is supplemented by Böhm's drawings [1].

The common arbor to both sides is arbor 2 which makes one turn in one hour. Measured from the time side, we have

$$\mathrm{V}_2^0 = -24 \tag{21.1}$$

$$\mathrm{P}_2^0 = -\frac{1}{24} = -1 \text{ h} \tag{21.2}$$

[5] [5, p. 113]

21.2 The time side of the clock

This side of the clock gets its input from arbor 2 which carries the minute hand. This motion is derived from the going work which is not described by Oechslin.

The motion of arbor 2 is transferred to tube 8 which makes a turn in 12 hours, but the teeth counts are not given by Oechslin. We thus have

$$V_8^0 = -12 \tag{21.3}$$

$$P_8^0 = -\frac{1}{2} = -12 \text{ h} \tag{21.4}$$

The motion of tube 8 is first transferred to arbor 9 which makes a turn in a day, but Oechslin doesn't give the details of the gears:

$$V_9^0 = 1 \tag{21.5}$$

This arbor carries a finger which moves a 31-teeth wheel by one position and this will serve to indicate the day of the month in the lower part of the 12-hour dial, just above the figure VI. The lengths of the months do not seem to be accounted for.

The motion of arbor 9 is used to obtain the motion of arbor 13:

$$V_{13}^0 = V_9^0 \times \left(-\frac{a}{a}\right) \times \left(-\frac{1}{5}\right) \times \left(-\frac{1}{73}\right) = V_9^0 \times \left(-\frac{1}{365}\right) = -\frac{1}{365} \tag{21.6}$$

$$P_{13}^0 = -365 \text{ days} \tag{21.7}$$

This arbor carries a cam and this cam is used to move the hours of sunrise and sunset back and forth. These hours are written on a horizontal slider, with the hour of sunrise on the left and the hours of sunset on the right. The figures on the left part are given in opposite order as the figures on the right, so that when the sunrise is one hour later, the sunset is also given one hour earlier.

21.3 The geographic side of the clock

The geographic side of the clock shows a fixed Northern hemisphere and a moving shell shows which part of the globe is lit, and which one is not, taking into account both the diurnal motion of the Sun, and the inclination of Earth's axis on the ecliptic. Just above the main dial, there is a small dial which can be used to regulate the clock.

The input motion of that side is also arbor 2 which makes one turn clockwise in one hour as seen from the other side:

$$\mathrm{V}_2^0 = -24 \tag{21.8}$$

$$\mathrm{P}_2^0 = -\frac{1}{24} = -1 \text{ h} \tag{21.9}$$

21.3.1 The rotating motion of the shell and the Sun

The arbor 2 carries a 3-pin pinion which meshes with a 72-teeth wheel on tube 3, which is on the central axis of the geographic side. The center of this side is therefore higher than the center of the opposite side which is at the level of arbor 2. Tube 3 has the velocity (measured from the geographic side)

$$\mathrm{V}_3^0 = \mathrm{V}_2^0 \times \frac{3}{72} = \mathrm{V}_2^0 \times \frac{1}{24} = -1 \tag{21.10}$$

This tube makes a turn clockwise in one day and carries the metal shell representing the shadow. This shell is not a hemisphere, but must extend at least $90° + 23.5°$. The clockwise motion is the expected motion, because the apparent motion of the Sun is clockwise.

The shell is also mobile around an horizontal axis (on the drawing, but in fact parallel to the dial), but this axis moves with frame 3. The Sun is at a fixed position on frame 3, at right angle with the horizontal axis of the shell, so that the Sun is always in the middle of the lit part of the Earth.

21.3.2 The motion of the ecliptic and the oscillation of the shell

The ecliptic is represented by a ring located around the Earth and this ring is part of frame 6. The ring is located outside of the Sun (part of frame 3), but inside of the 24-hour dial (frame 4).

The ecliptic ring, or the zodiac, makes a turn clockwise in a sidereal day. This motion is obtained as follows. A finger is located on the frame 4 of the 24-hour dial. When frame 3 rotates, a 5-pointed star on arbor 5 meets this finger and rotates the arbor. This motion is then transferred to the vertical arbor 6 which carries the ecliptic ring. We have

$$V_6^3 = V_4^3 \times \frac{1}{5} \times \left(-\frac{1}{73}\right) = V_4^3 \times \left(-\frac{1}{365}\right) = -V_3^4 \times \left(-\frac{1}{365}\right) \tag{21.11}$$

$$= V_3^0 \times \frac{1}{365} = -\frac{1}{365} \tag{21.12}$$

$$P_6^3 = -365 \text{ days} \tag{21.13}$$

The frame 6 makes a turn clockwise in 365 days.

There is a back and forth motion of the shell between the two solstices. In Winter, the shell covers the North pole, but in Summer the North pole is lit by the Sun. This is done by having a tilted rail on frame 6 and this rail guides the shell, having it oscillate with the period P_6^3.

In the Prague clock (Oechslin 2.2), there is another similar gear train which is used to produce the oscillation of the shell around an axis parallel to the dial, but it is a more complex solution.

21.4 References

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