Essl 290 2021

Lecture 13

Weds: HW 4 due

Select topic for first Research Paper.

Read

Fri:

Returned: HW - review Q3

Q4

Verge + Foliot Clocks

Demo: Model V+F clock.

The verge and foliot clock contains three sections / ingredients

1) an energy source - drives the clock mechanism, turns hands, rings bells.

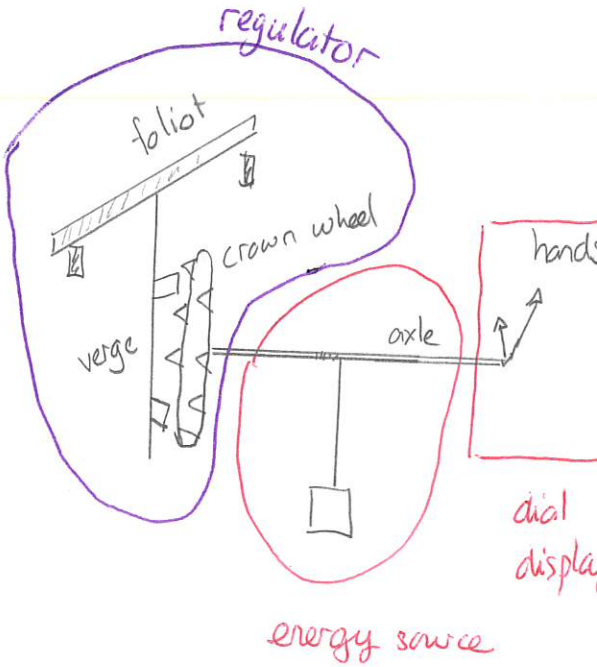
2) a regulator - regulates the motion of the clock by regulating the axle / hands
- controls the delivery of energy to the clock

3) a dial / bell ringer - indicates the passage of time

Every clock since these has had the same components although their construction and operation varies widely.

In a verge and foliot clock, the energy source was usually a suspended mass.

The regulator consists of the entire verge + foliot and crown wheel mechanism.



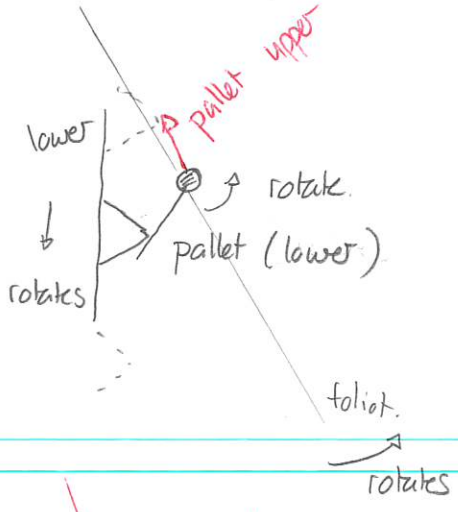
The verge and foliot are an example of an escapement.

Demo: Salisbury Cathedral Clock.

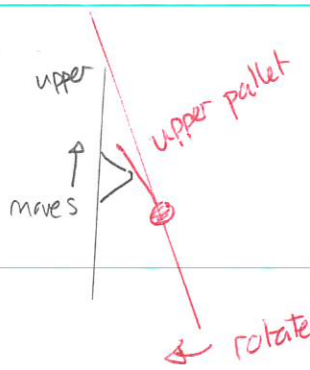
The basic operation of these involves:

1) the suspended mass causes the crown wheel to rotate, and move the hands. In the absence of the escapement the wheel would run interrupted and accelerate.

2) the crown wheel tooth engages a lower pallet, causing the verge + foliot to rotate



3) a different tooth engages the upper pallet, causing the verge + foliot to reverse and rotate in the opposite direction.



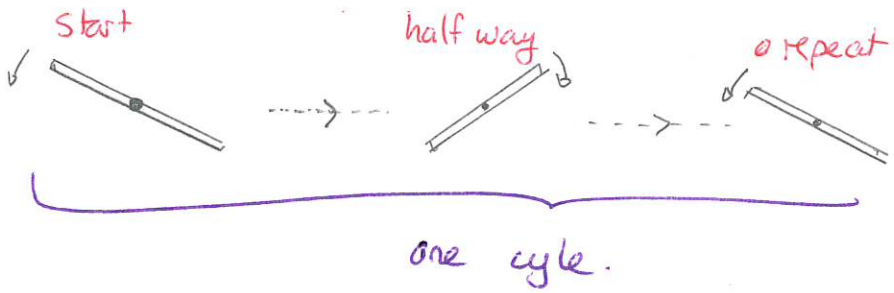
Thus the verge + foliot oscillates back + forth. The rate at which it does this depends on

Demo: Step Kuo animation slowly
Watch an individual lower tooth escape.

Period and frequency in timekeeping

The repetitive motion of the verge and foliot is called oscillatory. There is some standard terminology about such motion from physics and mathematics that will be important for describing any clock.

One cycle of the motion is one cycle of repetition.



The period of oscillation, denoted T, and measured in seconds is

> Period = time to complete one cycle $\equiv T$

The frequency, denoted f, is roughly the number of cycles completed in one second, and is measured in Hertz (Hz). So

> Frequency, $f \approx$ number of cycles in one second

These are always related by

$\text{frequency} = \frac{1}{\text{period}}$	$f = \frac{1}{T}$
$\text{period} = \frac{1}{\text{frequency}}$	$T = \frac{1}{f}$

1 Period and frequency

a) An oscillator (like a foliot or a pendulum) completes 30 cycles per minute. Determine the period and frequency of this oscillator.

b) A simple electronic device is constructed to oscillate with period 2 ms = 0.002 s = 2×10^{-3} s. Determine the frequency of oscillation.

Answers: a) There are 60s in one minute. So the time for one cycle is

$$\frac{60\,s}{30} = 2\,s \quad \Rightarrow \quad \text{Period} = 2\,s$$

Then frequency $= \frac{1}{\text{period}} = \frac{1}{2\,s} = 0.5\,Hz$

frequency = 0.5 Hz

b) $\text{frequency} = \frac{1}{\text{period}}$

$$= \frac{1}{0.002\,s} = 500\,Hz$$

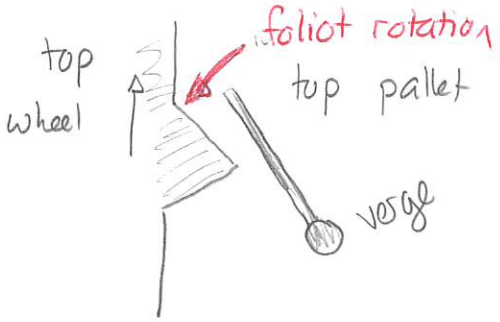
frequency = 500 Hz

Performance of Verge + Foliot Clocks

How well could verge and foliot clocks work? In general the typical accuracy would be about 15 min per day. The issues that limit this would be: Q??

1) friction - always inhibits motion of moving parts.

2) driving the foliot - there is constant interaction between the verge/pallet and the crown wheel. Observing the motion slowly we see that the pallets not only interrupt the crown wheel but briefly cause it to reverse direction.



The rate at which this occurs is determined by the mass placement.

However, there is no natural restoring force in this system and the frequency of oscillation will depend very finely on the design. Any small imperfections that appear during the motion will effectively adjust the frequency and period and therefore lead to timing errors.

Evidently the most accurate V+F clocks were constructed by Bürgi (16-17th century) reaching accuracies of 1 min/day

Q: What other practical issues are there with this clock?

- long mass drop
- stable mounting/environment → not on a ship