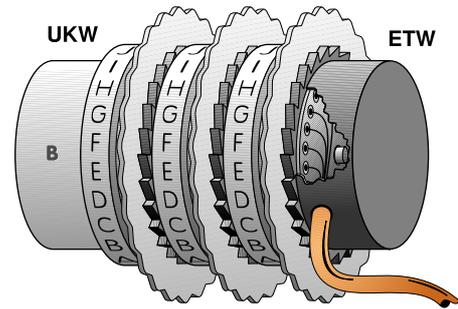
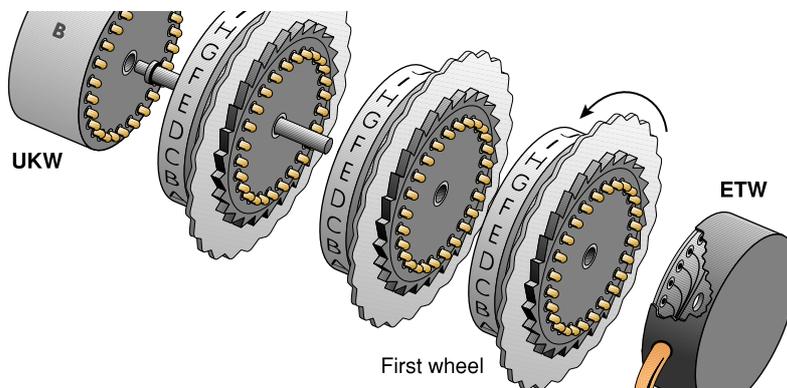


## 6.2 Wheel rotation in more detail

The mechanical part of the Enigma consists of the ETW (Eintrittswalze), 3 or 4 Walze (wheels) and the UKW (Umkehrwalze). The wheels are held in position by a rod, which also allows the wheels to rotate. The ETW contains 26 circular contacts, one for each letter of the alphabet. Each wheel contains 26 flat circular contacts on one side, and 26 spring-loaded contacts on the other side. The UKW contains only 26 spring-loaded contacts. When the wheels are in place and the UKW is engaged, it will look like this:



The UKW can be disengaged by pulling a lever. The rod, containing the 3 (or 4) wheels, can now be removed. Removing the wheels from the rod, clearly shows the spring-loaded contact. The ETW is shown here with part of its body 'removed' so that you can see how the internal wires are connected to the pads.



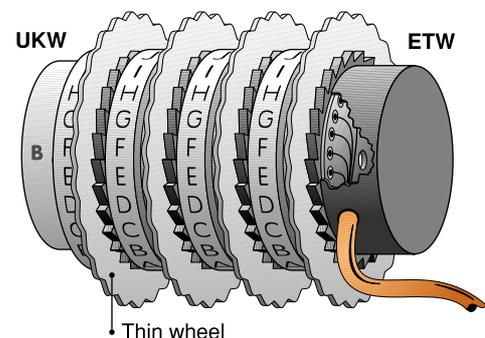
When a key is pressed, the wheels are moved into a new position, **before** the electrical contact is closed.

Pressing a key engages the transport mechanism, causing the first wheel to step by one position in counter clockwise direction (looking from the ETW).

A wheel contains one or more notches that may cause the next wheel to be stepped as well, etc. This is done to ensure a unique coding for each letter pressed, without generating a repeating pattern. The last wheel, just before the UKW, makes the fewest steps and is therefore often called the 'slow wheel'.

Each wheel has 26 positions that we will call A-Z. The index on the wheels is engraved (either as A-Z or 1-26) along the side of the wheel. The wheels are rotated counter clockwise, when viewed from the ETW. If **A** was visible in the window, the letter **B** will be visible next time the wheel is moved. Each wheel has a ring that can be used to rotate the wiring independent from the index. This can be regarded as creating an offset in the opposite direction. The notches are fixed to the index. Therefore the turnover of the next wheel, will always happen at the same letter in the window.

In January 1942, the German Navy introduced the Enigma M4 featuring an extra wheel. The design of the M4 was based on a 'modified' M3, so that existing parts could be used. As the same case was used, the 4 wheels had to be fitted in the space previously used for 3 wheels. This was done by replacing the existing UKW by a much smaller one, which provided space for an extra coding wheel. As the remaining space wasn't sufficient for a standard coding wheel, a **thin** wheel was designed to sit next to the UKW. For this reason the 4th wheel cannot be swapped with the other three wheels. When mounted together, all four wheels and the UKW would fit in the same space as before.



Two variants of the 4th wheel were available, called **Beta** and **Gamma**, one for each UKW (**B** and **C**). The 4th wheel is never moved by any of the other wheels and will stay in place for the duration of the cipher session. It can be set up in 26 positions which, in combination with the UKW, effectively creates 26 different UKWs.