



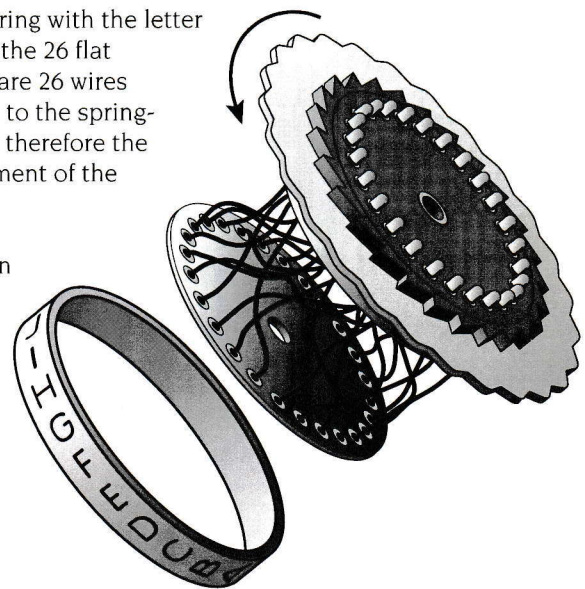
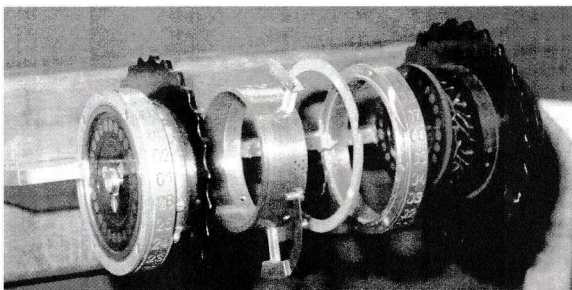
The four wheel Enigma M4, was used exclusively by the U-boat section of the German Navy. In order to be able to exchange messages with other parts of the navy (or indeed other parts of the army), some level of compatibility had to be achieved. The UKW and 4th wheel were therefore wired in such a way that, when set to **A**, the machine would behave as an M3. So an **M4 UKB-B + Beta (set to A) = M3 UKW-B**. Of course the same is true for UKW C and the Gamma wheel. Extra complexity could be added to the M4 by using UKW-B in combination with the Gamma wheel and UKW-C in combination with Beta.

There are various names for the **4th wheel**. We've already called it the **thin wheel**, but it's also called the **Zusatzwalze** or, more commonly, the **Griechenwalze** (as the Greek symbols Beta and Gamma are used).

Most Enigma models are equipped with stepping levers and notches which, under certain circumstances, may cause the middle wheel to step twice on two successive key presses. The Enigma G series however, uses a transport mechanism similar to a gear box and does not suffer from the double stepping behaviour.

This drawing shows the interior of a coding wheel. The ring with the letter index has been removed and the circular plate holding the 26 flat contacts has been disassembled. As you can see there are 26 wires connecting the flat contacts from one side of the wheel to the spring-loaded contacts at the other side. The letter-index, and therefore the contact numbering, goes clockwise, whereas the movement of the wheel during encipherment is counter clockwise.

The image below shows two Enigma wheels. The one on the left is a fully assembled wheel. You can see the 26 flat circular contacts on the left hand side. The wheel on the right is shown in 'exploded view', which means you can see the interior. On the right hand side you can see the inner wiring of the wheel.



**Exploded view of an Enigma wheel**

*Photo by Jerry Proc*

The Heeres Enigma (A models) were supplied with a set of 5 wheels, 3 of which could be used in any particular order. This would give 60 possible combinations ( $5 \times 4 \times 3$ ). There are 17576 possible settings for the Grundstellung ( $26 \times 26 \times 26$ ) and another 17576 settings for the Ringstellung.

The M3 had 3 extra wheels to pick from, so this would give 336 possible combinations ( $8 \times 7 \times 6$ ). The M4 was supplied with two 4th wheels: Beta and Gamma, which would double the number of wheel combinations to 672. In addition to the combinations for Grundstellung and Ringstellung, the 4th wheel can be set to 26 different positions.

On top of that, the Steckerbrett was added, which has even more combinations...