The Fichet F3D High Security Lock Mechanism – An Inside View.

Introduction

Hi, my name is Michael Huebler, I'm a lock collector from Germany, and this is my second paper on interesting locks. When I first learned about this new French lock by Fichet Serrurerie Bâtiment[1] – an ASSA ABLOY Group company – in April 2008, with its impressively huge 3-dimensionally milled keys and most likely again lots of racks and gear wheels inside, I immediately knew that I needed to get and analyze one. They were however hard to find outside France, and it took me more than two years before I got the first one at an acceptable price.

I hope you enjoy reading about the details of this very interesting mechanism as much as I enjoyed disassembling and analyzing the actual lock.

The paper is structured into these main sections:

The outside – Pictures of the lock and its keys 1

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I would be very happy to receive your comments, corrections, or just a short note if you found this paper interesting or helpful. You can contact me at mh@TheOpenSourceLock.org.
The most recent version of this paper is available at http://toool.nl/. Thanks for your interest!

The outside – Pictures of the lock and its keys

Fig. 1: The Fichet F3D monobloc cylinder with two keys (one without plastic covers).

[1] Now ASSA ABLOY Côte Picarde.

The Fichet F3D locks come in the so-called “monobloc” cylinder format, a special format used by Fichet for their door lock mechanisms. The cylinder is 120mm/4.7” long, with a main diameter of 26mm/1.02”. As far as I know, F3D cylinders are only available in this format, i.e. they only fit to these door locks.
I took a picture of an F3D monobloc cylinder next to a standard Euro cylinder for size comparison:

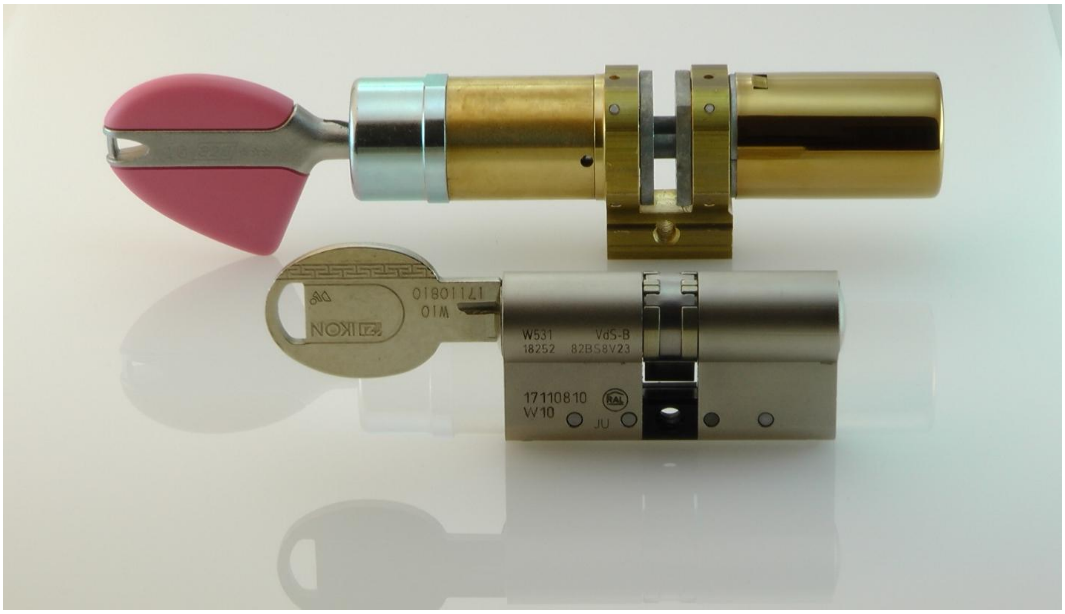

Fig. 2: The Fichet F3D monobloc cylinder and a 30mm/30mm Euro cylinder.

The lock shown here came from a box marked “MONO A F3D 3X DO”. This apparently refers to the MONObloc format, with “3X” meaning a 3 star rating according to the French CNPP’s ‘a2p’ certification scheme, and “DO” referring to the color of the interior side, dorée = golden – another box was marked “CH” and contained a chrome colored lock.

The name “FICHET” is stamped on the interior side, while the exterior side is unmarked:

Fig. 3: Interior side (left) and exterior side (right).

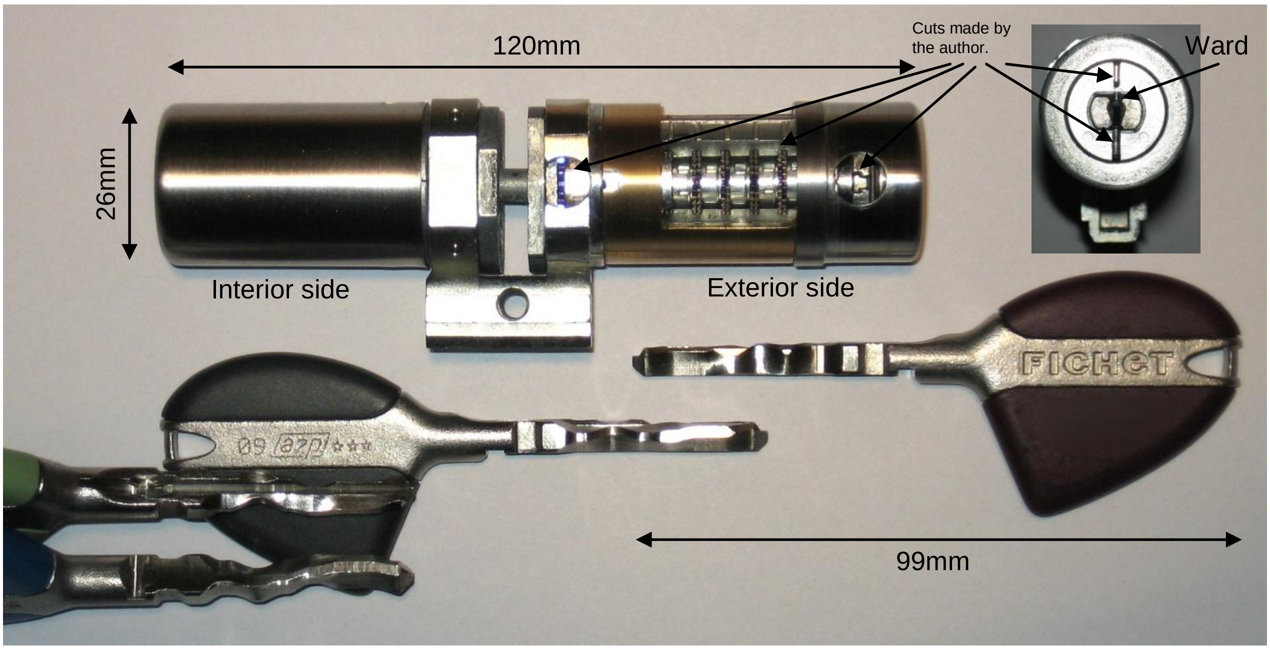

Fig. 4: The Fichet F3D monobloc cylinder with keys.

The exterior housing is made from brass, with a steel alloy front piece. The front piece has a slightly wider ring that can e.g. prevent pulling attacks when mounted in a matching escutcheon. The middle part of the cylinder (cast from steel alloy) holds the interior and exterior parts with 4 drive pins each, and it also holds the rotating center piece that interfaces with the Fichet door lock. The interior part of the cylinder is covered by a thin brass skin.
The keys are huge and have a 3D shape (hence the name F**3D**). They are 99mm/3.9" long and 8.2mm/0.32" thick and have plastic covers that are available in various colors. Fichet seems to also offer custom folding sheaths for these keys.

The inside – How the mechanism works

The F3D is a "pump" or push style mechanism – any key with the correct profile can be inserted into the lock to a certain depth, but only the correct key can be pushed in further to the "authenticated" position. In this last phase of the insertion of a correct key, the authentication phase, parts of the mechanism will engage with the rotating center piece of the cylinder, and the key can then be turned to move the bolts.

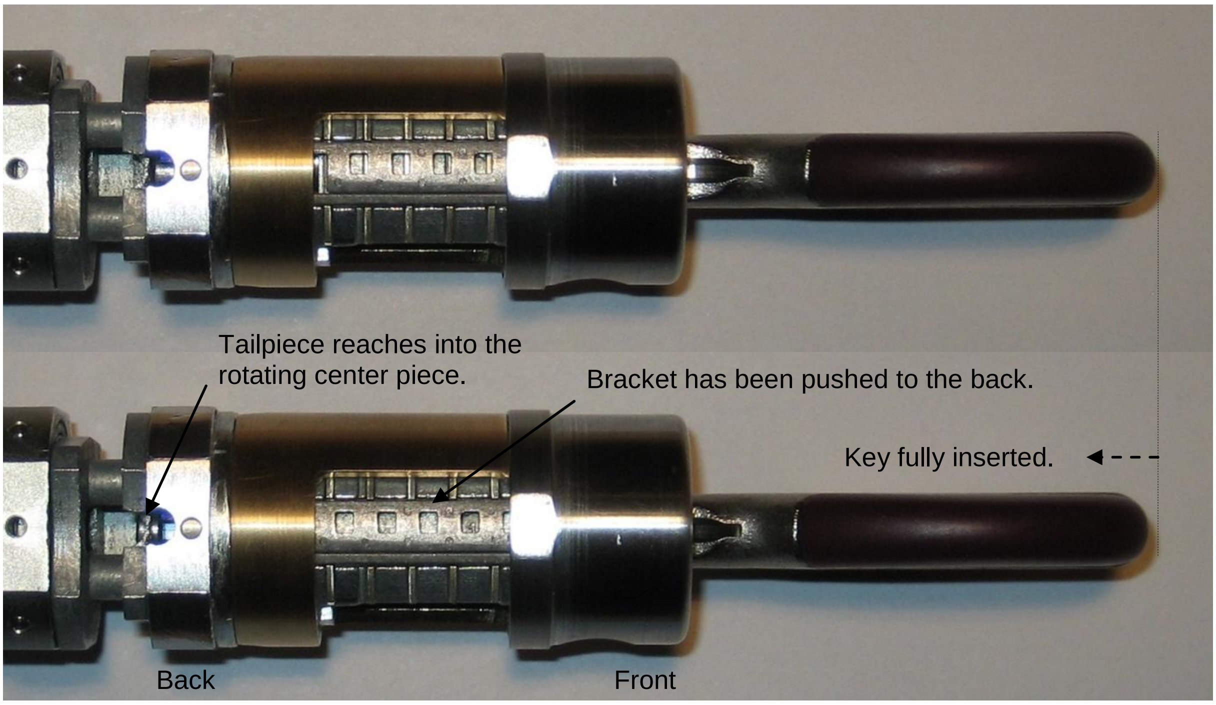

Fig. 5: Correct key partially and fully inserted (authenticated).

In this paper we take a closer look into the exterior side of the monobloc cylinder:

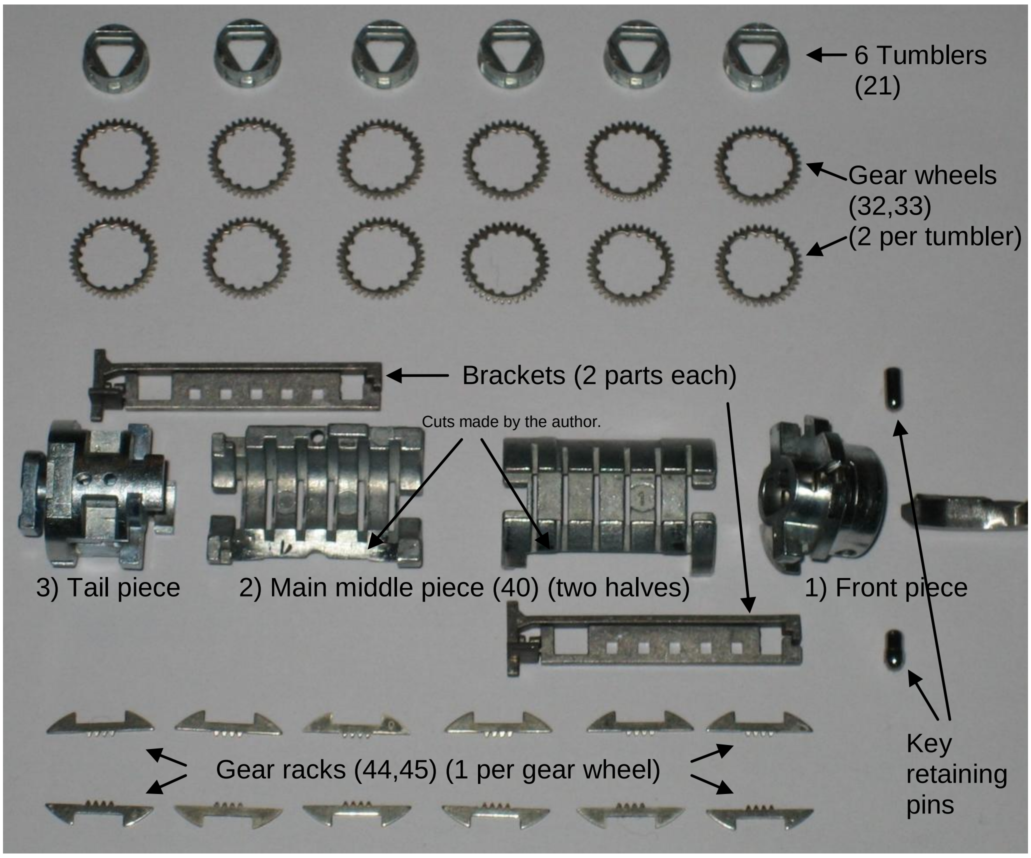

Fig. 6: The parts of the rotor.

The housing contains a rotor, which consists of 1) a steel alloy front piece, 2) the main piece (40)[2] in the middle, assembled from two slightly different cast aluminum alloy halves, and 3) a steel alloy tail piece. The front and tail pieces are held together by two brackets[3] that can slide along the sides of the middle piece. The *whole rotor* can *turn* with the key (but only while the mechanism is in the "authenticated" position). The front piece, the two brackets, and parts of the tail piece can also together *move along its axis*; this "pump" action switches between the blocked and authenticated positions: Pushing these elements towards the back engages the bolts of the door lock and enables rotation (authenticated position), pulling them towards the front again blocks rotation (blocked position) and enables removal of the key.
To prevent a simple destructive attack where the whole rotor is pushed towards the rotating center piece with force, the rotor is held in its position by a steel plate that has predetermined breaking points and could be slightly deformed when forced backwards. In this forced position, the plate still cannot turn, but it will instead permanently block the cylinder.

The authentication of the key is performed by a stack of 6 round tumblers (21) that can rotate and move sideways (laterally) according to the key shape at their position. This stack is held between the front piece of the plug and the moving part of the tail piece, and for positive authentication it needs to move towards the back.

[2] The mechanism is patented in France (Theillet, et al., 2003) – see page 7 for details and links to the patent documents – and several other countries, a world-wide patent was also granted. The numbers mentioned in this paper are consistent with the patent drawings for easier cross-referencing.
[3] The brackets are not yet shown in the first patent (Theillet, et al., 2003). The brackets in this lock are made from two parts, as shown in a later patent (Theillet, 2005b), but don't have a spring or a selective blocking functionality.

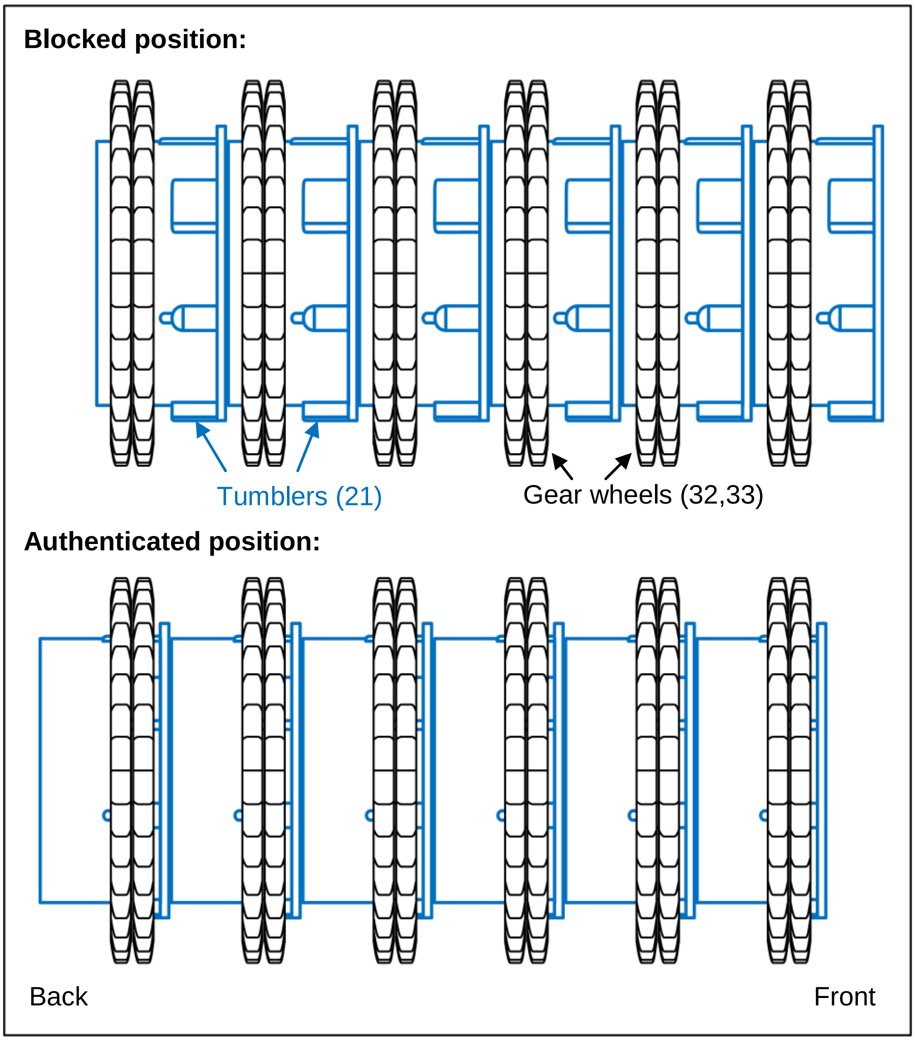

Fig. 7: The stack of tumblers – side view.

Each tumbler has a triangular opening for the key, and like a little puzzle piece, it also has wide and thin protrusions (24,25) along its circumference that need to move into corresponding cutouts (324,334,35) of two steel gear wheels (32,33). If the relative angle of the tumbler vs. the gear wheel is incorrect, the wide protrusions (24) will block against the gear wheel. The cutouts in the gear wheels are spaced in 20° steps, while the 36 teeth are spaced in 10° steps.
For increased manipulation resistance, the protrusions on the tumblers have different shapes: Thin catch protrusions (25) are longer than the wide protrusions (24). Therefore the tumblers cannot turn anymore to the next angle or move laterally to the next position once the mechanism is tensioned.[4]

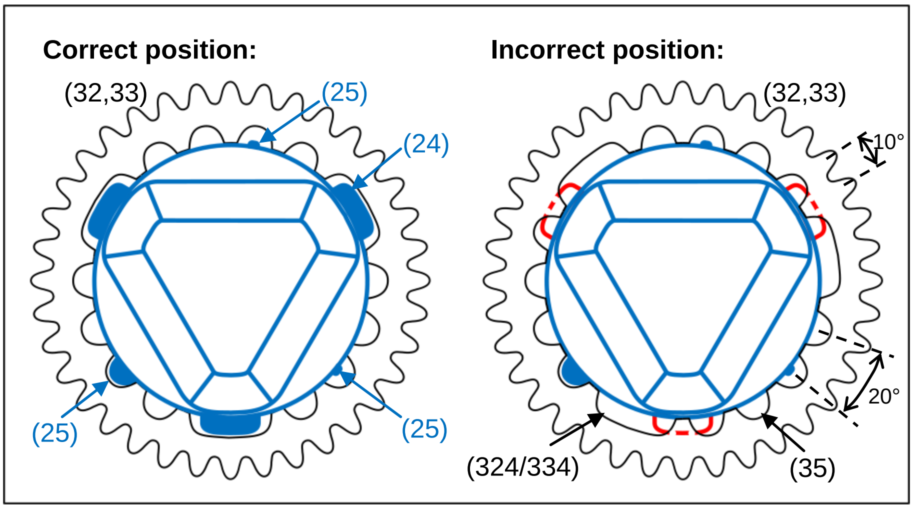

Fig. 8: Tumbler and gear wheel – view from the back.

Because each gear wheel interfaces with a gear rack (44,45) that is fixed in the rotor housing, the gear wheels will turn when moved sideways.

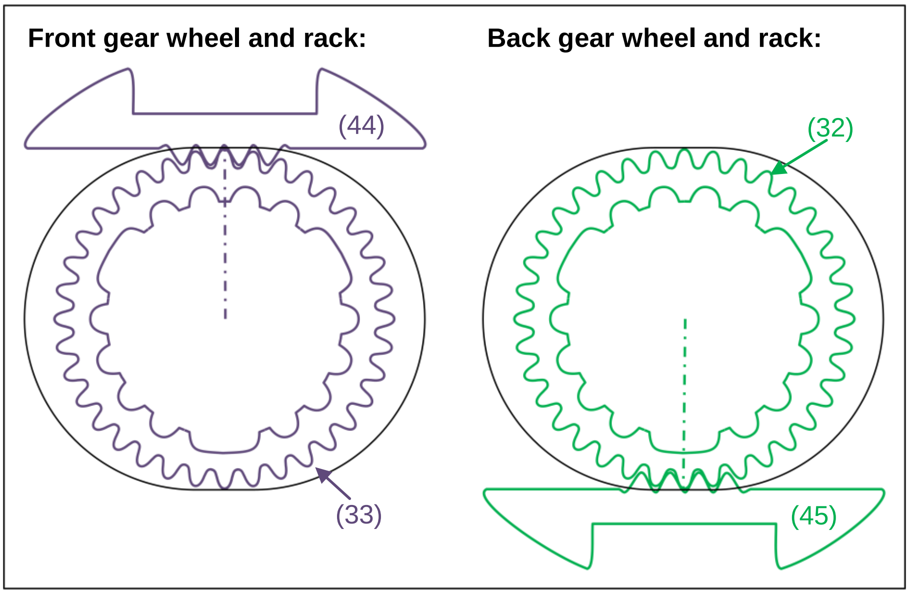

Fig. 9: Gear wheels in the middle (M) position.

The gear wheel (33) in the front interfaces with a gear rack (44) in the upper part of the rotor, therefore moving it to the left will also *turn it clockwise*; while the gear wheel (32) in the back interfaces with a gear rack (45) in the lower part of the rotor, and moving it to the left will *turn it counterclockwise*.

[4] While the two lengths are already explained in the patent, the actual catch protrusions (25) in the lock additionally have different shapes, as shown e.g. in Fig. 7, Fig. 8, and Fig. 11.

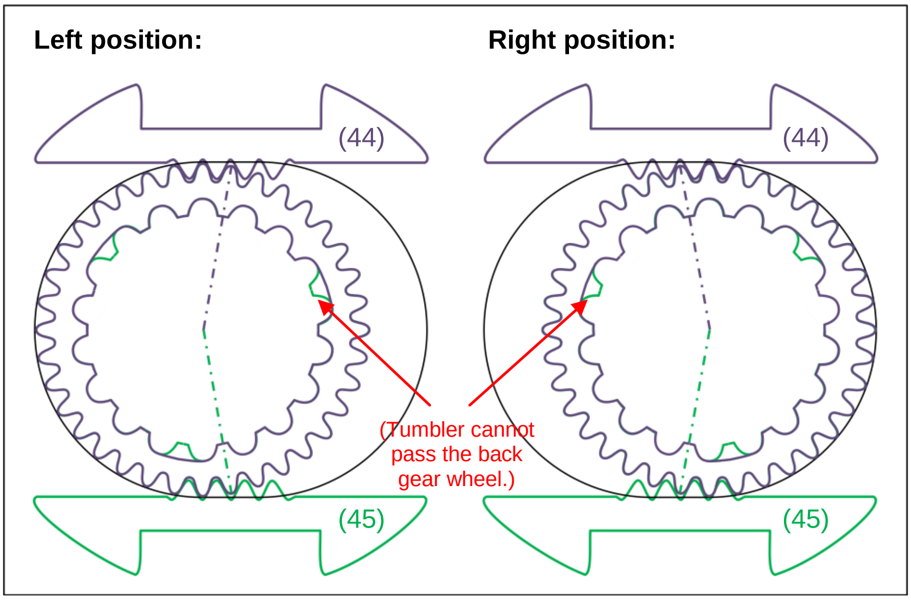

Fig. 10: Gear wheels moved to the left (L) and right (R) positions.

The key can move the tumbler and the two gear wheels to **three different lateral positions: left, middle, or right (L, M, or R)**. Between each of these steps, one gear wheel will turn by +10° and the other one will turn by -10°, yielding a total relative angular displacement of 20°. In the correct position (see Fig. 9), the cutout shapes of both gear wheels overlap, and the tumbler can pass through them (if turned to the correct angle, which we will discuss next). In the two other positions however, the tumbler could only pass through the first gear wheel and would then stop at the second gear wheel – because the protrusions would not meet the cutouts (see Fig. 10).

Moving the tumbler sideways to the correct position was the first necessary step. It can however only pass through the gear wheel cutouts, if the key has also *turned it to the correct angle*.
Looking at the gear wheel / rack setup explained above, the gear wheels can be mounted in 10° steps.
The keys delivered with my lock position the tumblers at +10° and +30°, with an accuracy of about ±3°. Pictures[5] of other keys show also other cuts in 10° steps, so I assume that **seven angles** are used: **-30°, -20°, -10°, 0°, +10°, +20°, and +30° (-3, -2, -1, 0, +1, +2, +3)**.

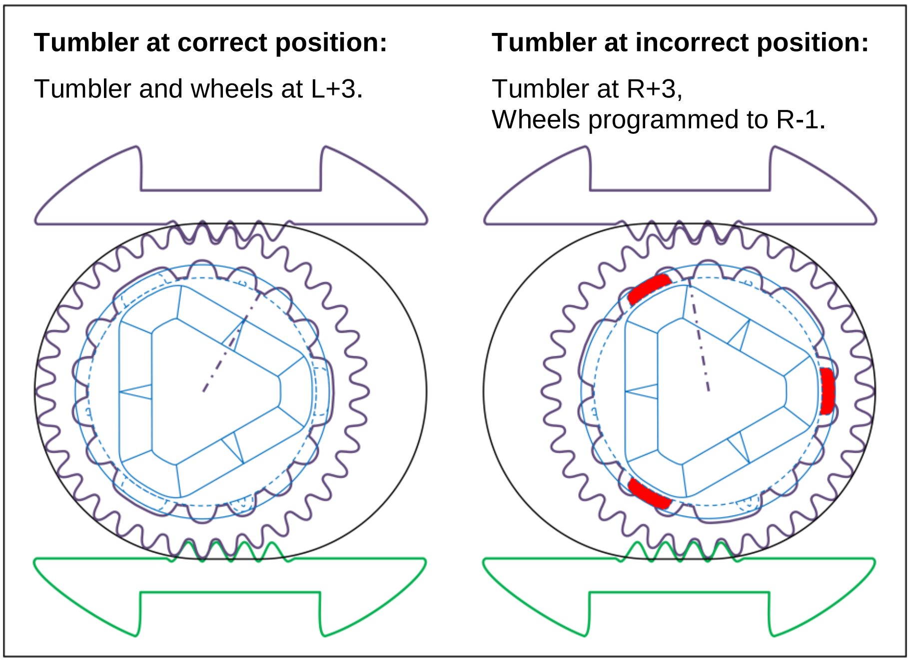

Fig. 11: Correctly and incorrectly positioned tumblers – view from the front.

[5] It should be noted that reading key cuts from pictures is much more difficult with this system than with other conventional designs. Very clear pictures – and for most key codes, more than one perspective – are required for unambiguous identification.

This theoretically allows for (7 angles x 3 lateral positions) ^ 6 tumblers = 21^6 = 85,766,121 code variations, minus codes that violate MACS (maximum adjacent cut specifications). I assume that e.g. L-3 and R+3 are not used next to each other, because the slopes between these cuts would be very steep.
Fichet has stated that there are more than 11 million variations.

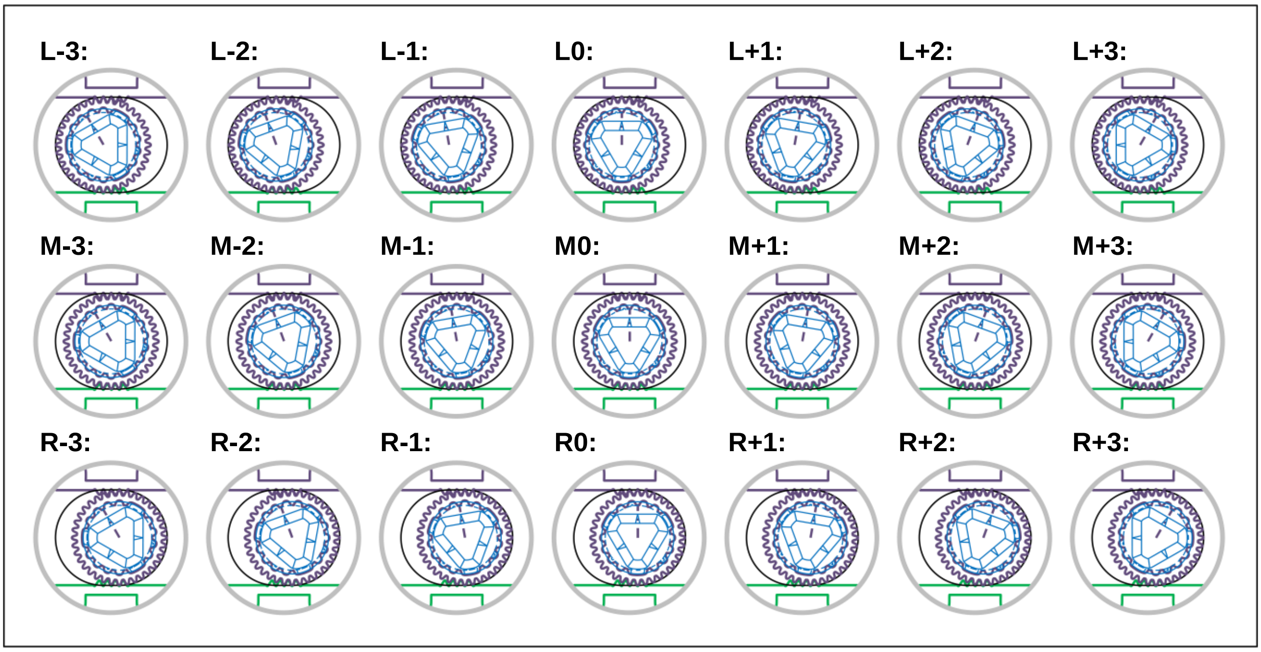

Fig. 12: Twenty-one possible positions for each tumbler.

Like in the Fichet 787, the parts of this lock also do not have variations dependent on the desired key code – instead the code is set during the assembly process by establishing a fixed relation between the gear wheels and the racks. To achieve this, the tumblers are fully inserted into the gear wheels, then the rotor is assembled in the authenticated position, a key is inserted into the rotor – which will set all gear wheels to the desired position – and then the racks are added.

Key details

The keys are milled on a high precision machine at a factory controlled by Fichet. This machine creates six sections where the key moves and turns the tumblers, spaced at 4.5 mm, and appropriate slopes in between. A long groove is milled into the top, to match the ward at the entrance of the keyway. This ward guides the key and ensures that it is always inserted at the right angle and lateral position. On recent keys, the bottom surface of the key is also milled flat.

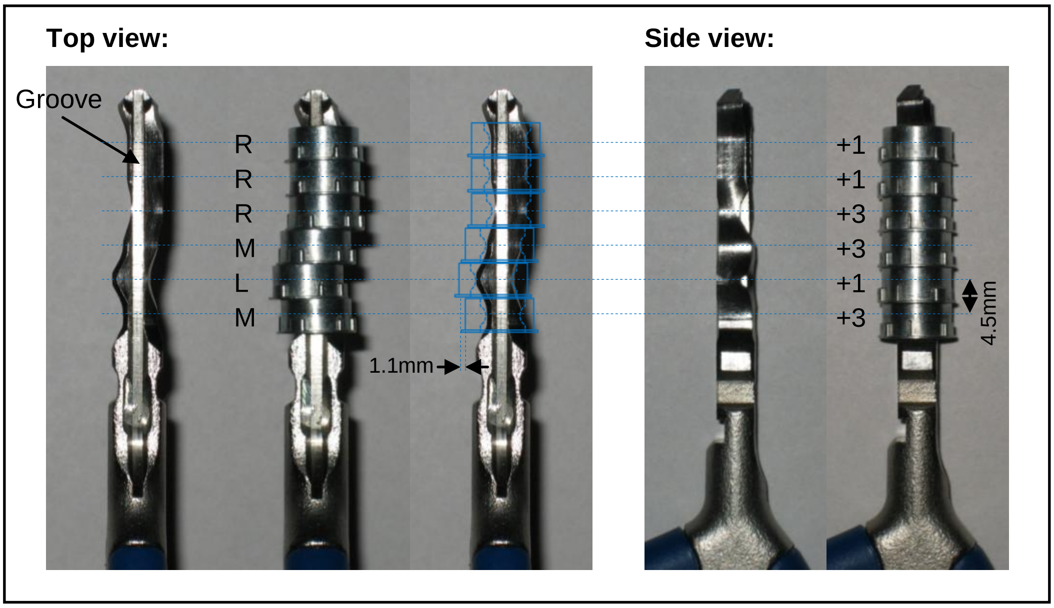

Fig. 13: Key and tumblers – original size.

Fig. 14 shows the possible cuts of the key at the positions where the tumblers are located:

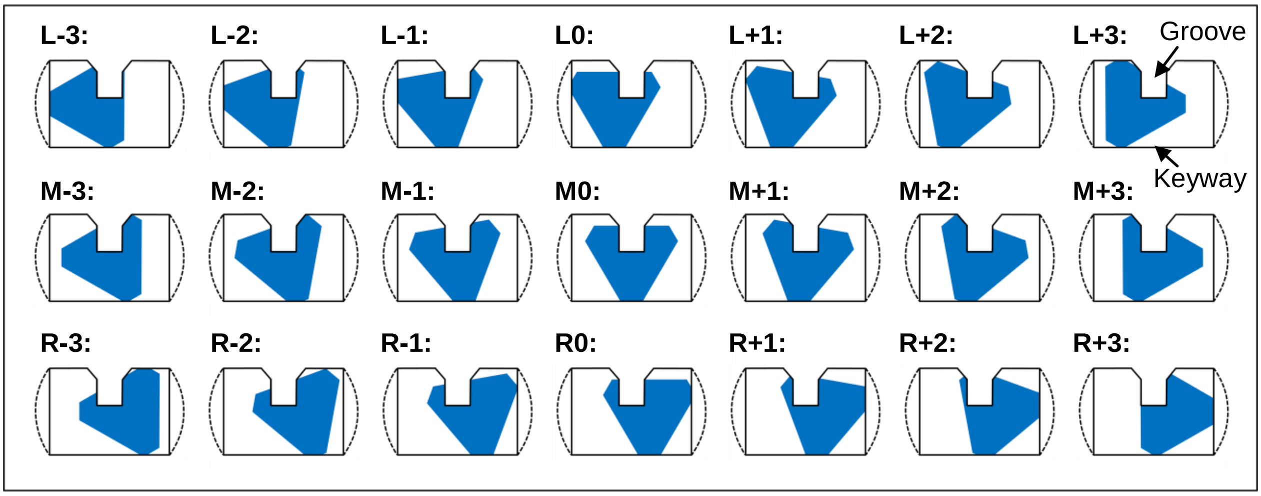

Fig. 14: Twenty-one possible key cuts – cross sections, view from the bow.

Dérouter les cambrioleurs – Additional options

Two years after the first patent, Fichet has filed two more patents:
The first one (Theillet, 2005a) describes an additional security measure in the tail piece of the rotor that blocks rotation if the front part of the cylinder is cut off.
The second new patent (Theillet, 2005b) explains another authentication mechanism that could be used instead of, or in addition to the existing tumbler / gear wheel concept, "to confuse the burglars": Another set of slightly differently shaped gear racks could be added next to the existing racks. They would be movable laterally, so that moving the gear wheels to the L, M, or R position will also move these racks to the left, middle, or right. The racks would have protrusions that would extend into the channel where the brackets move along the rotor. The brackets (35) – made from two parts with a spring in between them – could then have appropriate cutouts and could block on keys with incorrect lateral shapes. This would also increase security against destructive attacks.
These additional security measures have not been implemented in the cylinder discussed above.

Patent references

Theillet, Christophe and Riberolles, Benoît. 2003. *Dispositif de blocage et de déblocage d'un mouvement d'actionnement, notamment pour serrure de sûreté. FR2833638* France, 2003. Prority date: 2001-12-13. Source: http://v3.espacenet.com/publicationDetails/biblio?CC=FR&NR=2833638A1&FT=D.
Theillet, Christophe Laurent. 2005a. *Dispositif de blocage et de déblocage d'un mouvement d'actionnement, notamment pour serrure de sûreté, muni de de moyens de blocage en cas de tronçonnement du barillet. FR2863295* France, 2005a. Prority date: 2003-12-03. Source: http://v3.espacenet.com/publicationDetails/biblio?CC=FR&NR=2863295A1&FT=D.
Theillet, Christophe Laurent. 2005b. *Dispositif de blocage et de déblocage sélectif d'un mouvement d'actionnement, applicable à une serrure de sûreté, à garniture et crémaillère mobile. FR2864134* France, 2005b. Prority date: 2003-12-22. Source: http://v3.espacenet.com/publicationDetails/biblio?CC=FR&NR=2864134A1&FT=D.

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