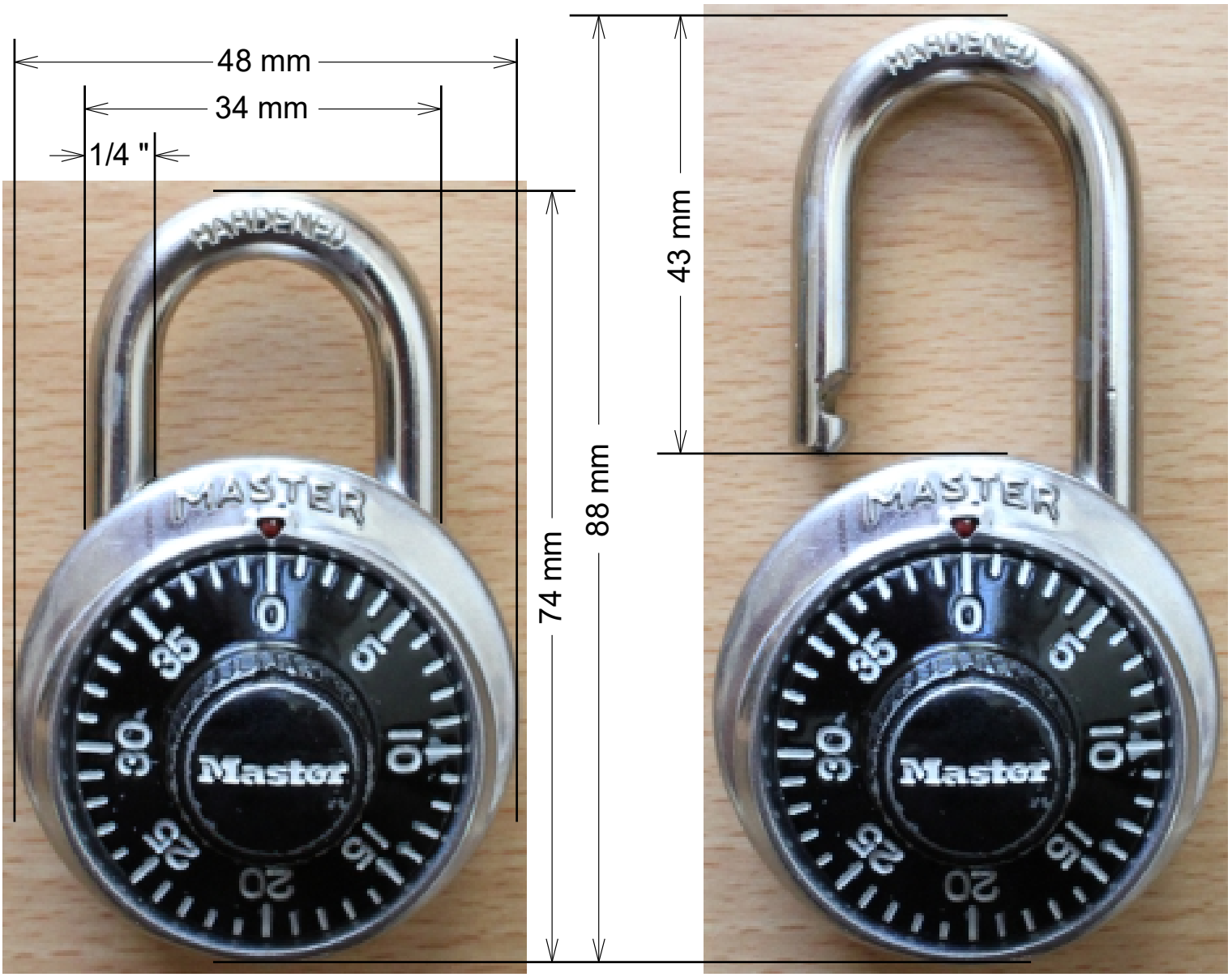
Master Lock's Combination Lock



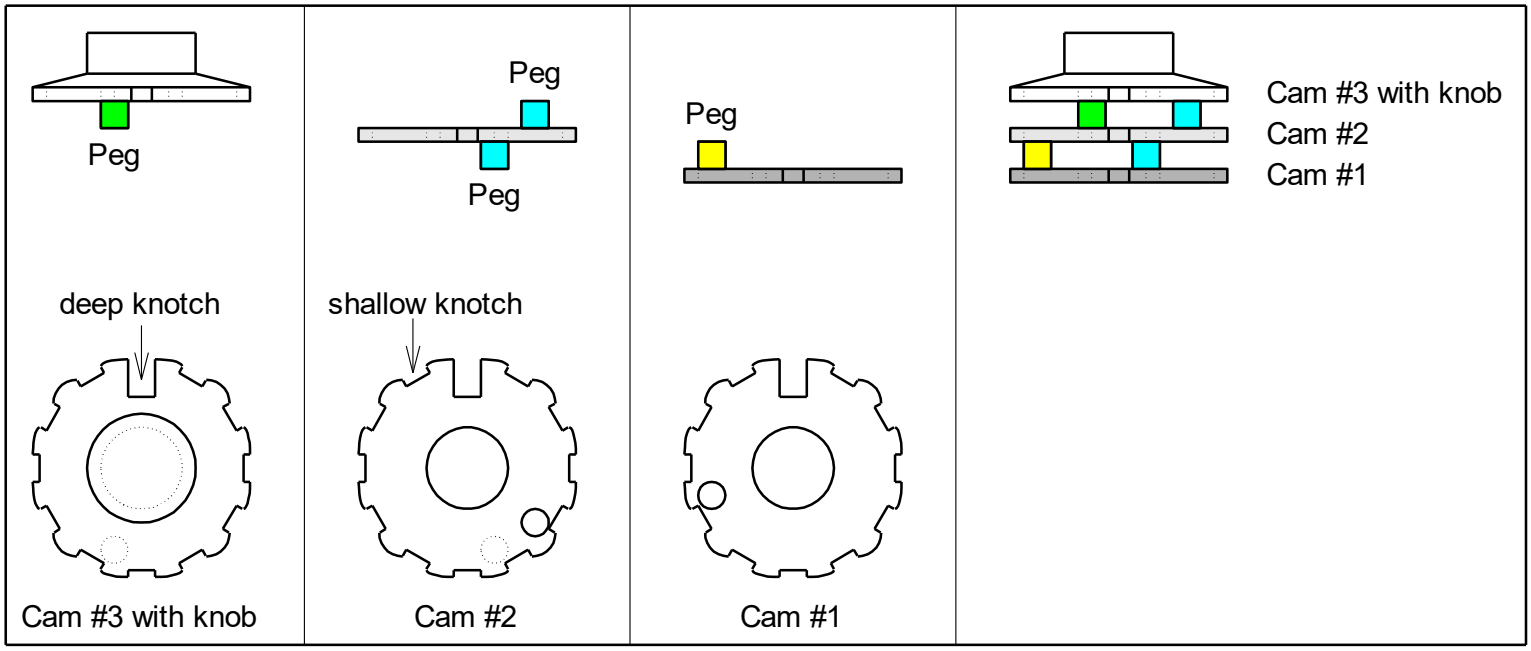
Locked Unlocked

Physical size

In USA, this lock is widely used at lockers at schools and gyms from the young to the old. Most people have seen and actually used it before (without knowing how it works, though).

I introduce the internal lock mechanism proficiently designed by Master Lock company.

First, read a "Step by step instruction" issued by Master Lock.



Facts

Cam #3 is made by metal and adhered on back of a knob.

Numbers from 0 through 39 are carved on the front knob to ease understanding the position.

Cam #2 and Cam #1 are made by plastic and rotate by getting rotation force through mutual contact of pegs.

Cam #3 has one peg to rotate Cam #2 as well as to specify the third unlock number.

Cam #2 has one peg on both side each. One peg on the upper surface gets rotation force from a peg on Cam #3. Another peg on the lower surface of Cam #2 contacts with a peg on Cam #1 and rotates Cam #1.

Cam #1 has one peg on the upper surface. The peg contacts with a lower peg of Cam #2 and gets rotation force.

Each cam has one deep notch to release a shackle latched (unlock) and has eleven shallow notches in order to jumble a decryption trial done by numerous hackers as basic protection scheme of the lock.

The position of the deep and shallow notches is evenly made every 30 degrees (1 deep notch and 11 shallow notches).

The peg can be positioned every 36 degrees (One of 10 different numbers can be programmed by changing one of 10 different peg position as N_PTN[3:0] below where deep notch position is 34).

N_PTN0										**N_PTN1**									
0	4	8	12	16	20	24	28	32	36	1	5	9	13	17	21	25	29	--	37
N_PTN2										**N_PTN3**									
2	6	10	14	18	22	26	30	--	38	3	7	11	15	19	23	27	31	--	39

Hereinafter, numbers from 0 to 39 are taken to normalize the positioning of such peg and shallow notches.
(A) The physical width of both pegs and notches is 2.
(B) A shackle is unlocked when all three deep notches are aligned to 34.

Unlocking procedure of Master Lock's combination lock

Master Lock's combination lock is shipped along with the 3 numbers that specifies the position of Cam #1 (N1), Cam #2 (N2), and Cam #3 (N3).

The position of lower peg on Cam #1 and Cam #2 does not have deep meanings. They are used to move Cam #1 when (b) below. Accordingly, they can be positioned at any places other than the examples.

(1) Initialization
Rotating the knob clockwise more than two full turns initializes the positioning. All pegs are engaged and all Cam #1, #2, and #3 rotate.
(2) Specifying the position of Cam #1
Turning clockwise must stop at N1 to specify the position of Cam #1.
(3) Specifying the position of Cam #2
Turning counterclockwise more than one turn and stop at N2 to specify the position of Cam #2. Cam #1 stays at the previous position.
(4) Specifying the position of Cam #3
Turning clockwise and stop at first appearance of N3 to specify the position of Cam #3. Cam #1 and Cam #2 stay at the previous position. At this moment, the position of the three deep notches match at the position of deep notch and the lock is unlocked by pulling up a shackle.

Appendix

How to find N1 by rotating knob

(1) Pull down a shackle to lock key.
(2) Rotate knob clockwise slowly pulling up the shackle and sense vertical movement of the shackle.
(3) Read the number by turning knob anticlockwise and clockwise on each vertical movement.

Example of the reading result

11 vertical movement are made by 11 shallow notches. It has narrow allowance of 1 (1 - 2, 5 – 6, 8 – 9, 11 – 12, 15 – 16, 18 – 19, 25 – 26, 28 – 29, 31 – 32, 35 – 36, 38 – 39).

Another vertical movement which has wide allowance of 2 (21 – 23) is made by a deep notch. N1 is 22 which is central number of 21 and 23.

Possible "N1 – N2 – N3" combination when deep notch receptor on lock is placed at position 34

N1	0									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	10									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	20									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	30									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	1									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

N1	11									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

N1	21									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

N1	31									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

N1	2									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	12									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	22									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	32									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	3									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

N1	13									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

N1	23									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

N1	33									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

N1	4									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	14									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	24									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	34									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	5									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

N1	15									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

N1	25									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

N1	35									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

N1	6									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	16									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	26									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	36									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	7									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

N1	17									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

N1	27									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

N1	37									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

N1	8									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	18									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	28									
N2	2	6	10	14	18	22	26	30	34	38
N3	0	4	8	12	16	20	24	28	32	36

N1	38									
N2	0	4	8	12	16	20	24	28	32	36
N3	2	6	10	14	18	22	26	30	34	38

N1	9									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

N1	19									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

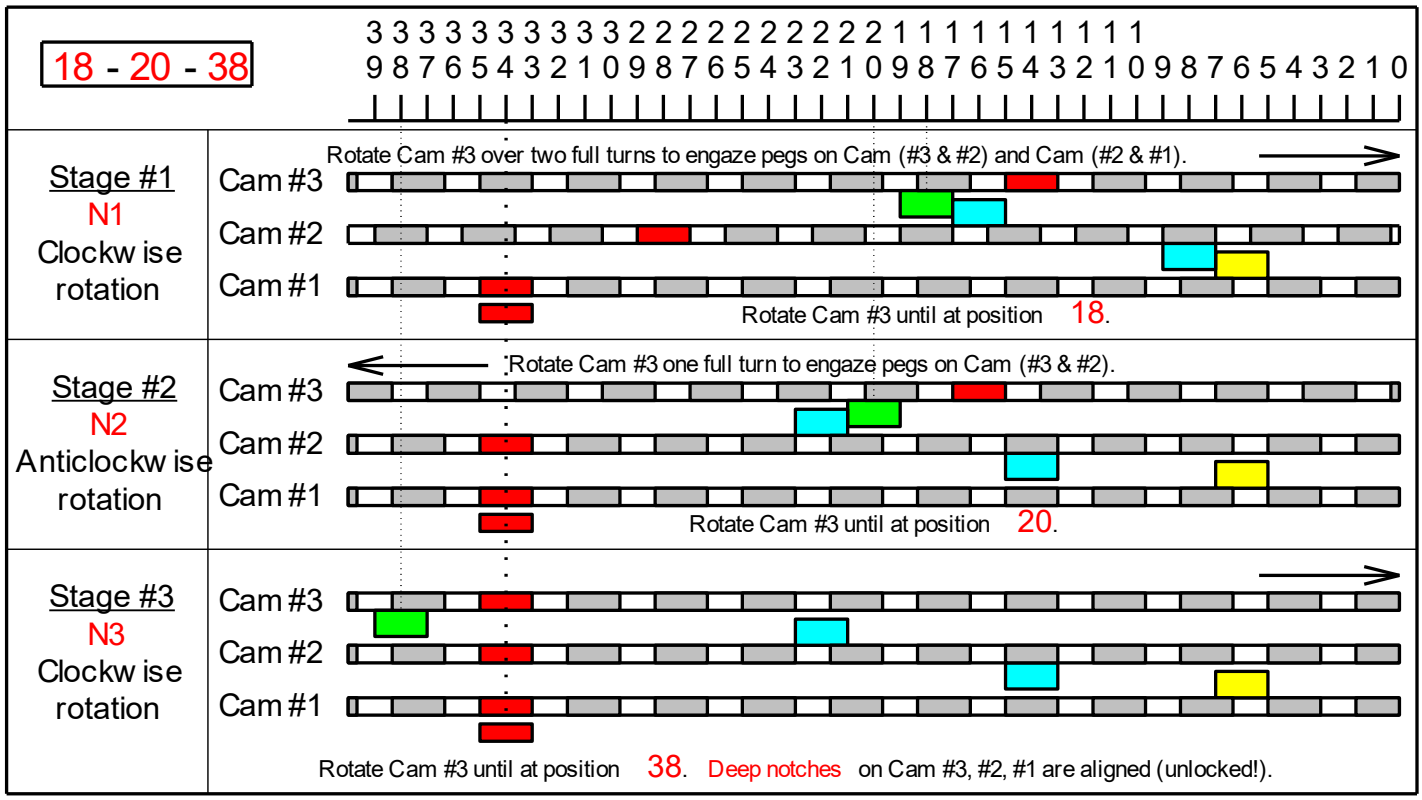
N1	29									
N2	3	7	11	15	19	23	27	31	--	39
N3	1	5	9	13	17	21	25	29	--	37

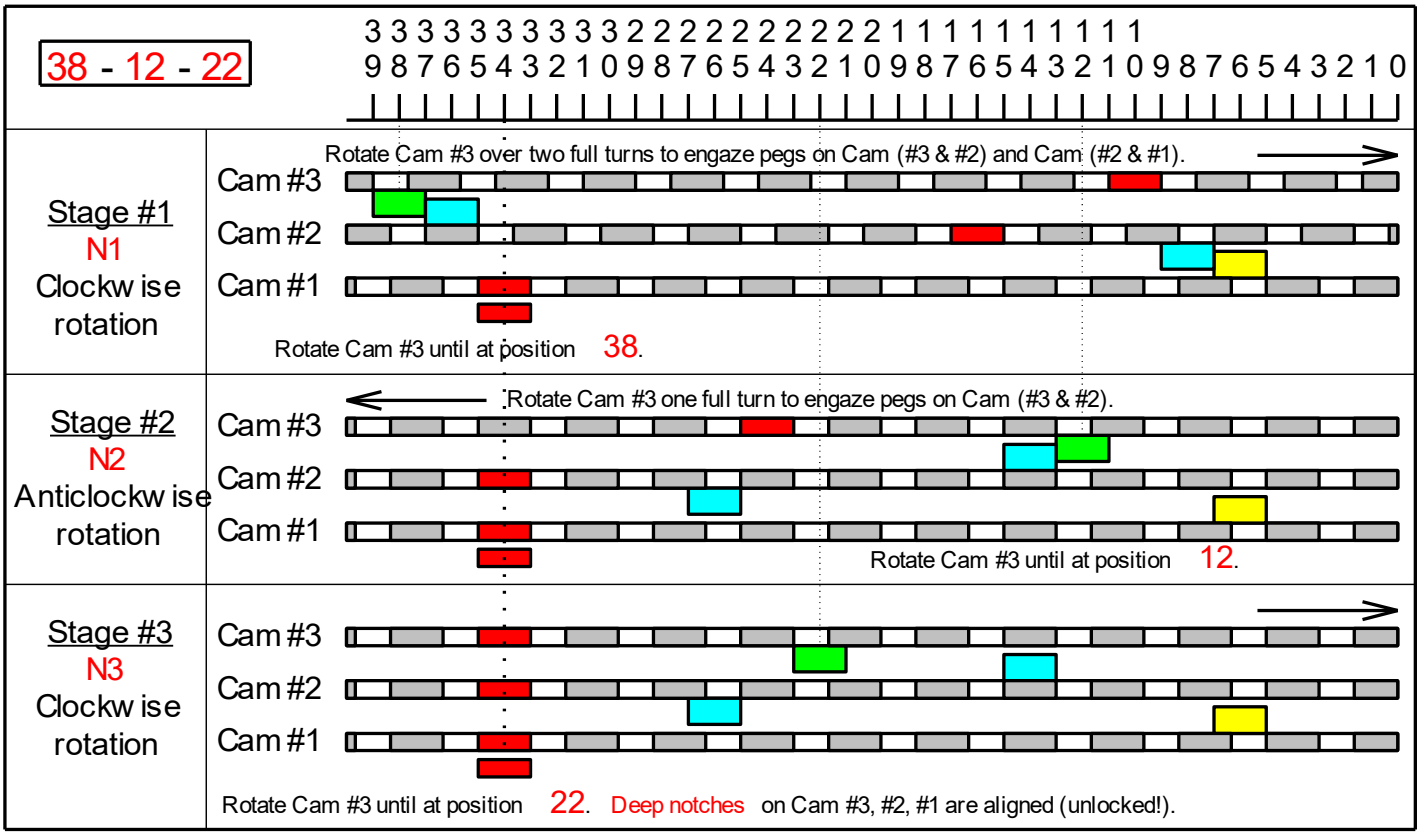
N1	39									
N2	1	5	9	13	17	21	25	29	--	37
N3	3	7	11	15	19	23	27	31	--	39

See concrete examples of "18 – 20 – 38", "38 – 12 – 22", and "8 – 30 – 16" below.

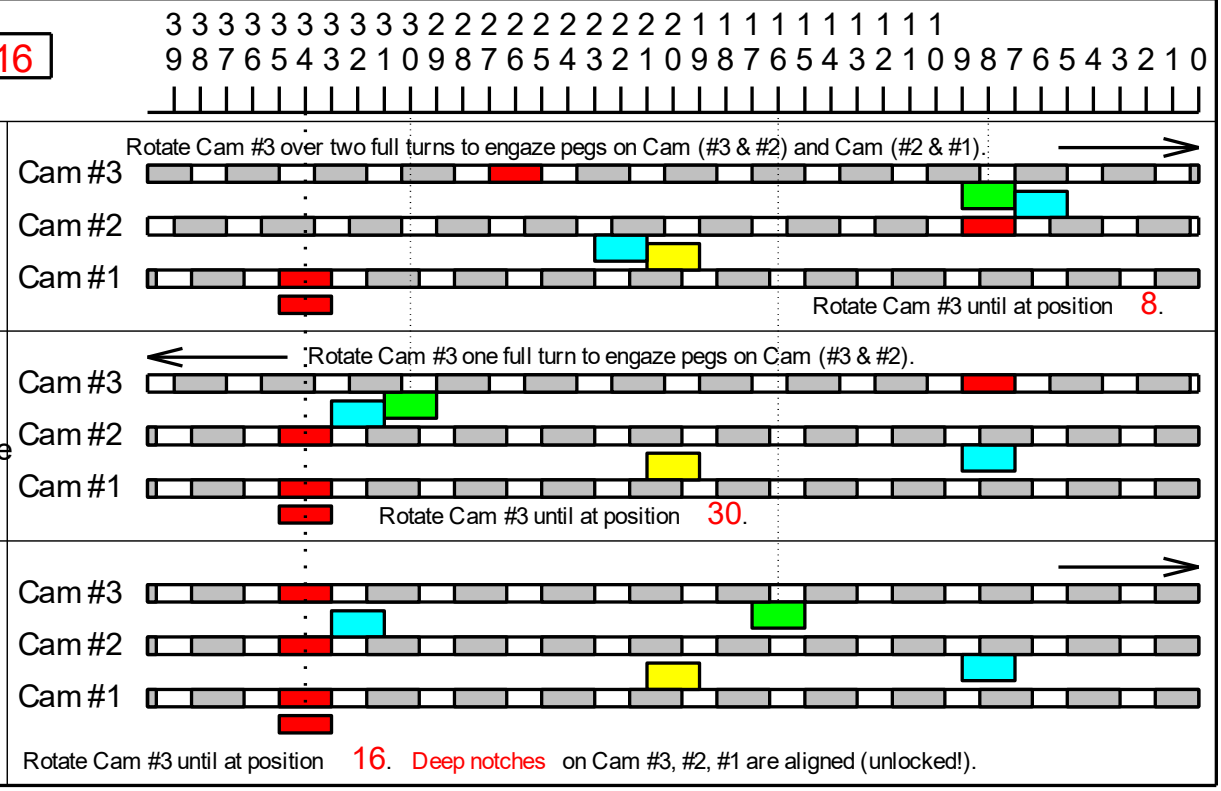
Concrete examples of unlock procedure and internal three cams' movement

Notch	Color	Peg	Color
Deep notch	Red	Cam #3 peg	Green
Shallow notch	Gray	Cam #2 pegs	Blue
		Cam #1 peg	Yellow





8 - 30 - 16


3 3 3 3 3 3 3 3 3 3 2 2 2 2 2 2 2 2 2 1 1 1 1 1 1 1 1 1
9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0 9 8 7 6 5 4 3 2 1 0
Stage #1
N1
Clockw ise rotation
Rotate Cam #3 over two full turns to engaze pegs on Cam (#3 & #2) and Cam (#2 & #1).
Cam #3
Cam #2
Cam #1
Rotate Cam #3 until at position 8.
Stage #2
N2
Anticlockw ise rotation
Rotate Cam #3 one full turn to engaze pegs on Cam (#3 & #2).
Cam #3
Cam #2
Cam #1
Rotate Cam #3 until at position 30.
Stage #3
N3
Clockw ise rotation
Cam #3
Cam #2
Cam #1
Rotate Cam #3 until at position 16. Deep notches on Cam #3, #2, #1 are aligned (unlocked!).