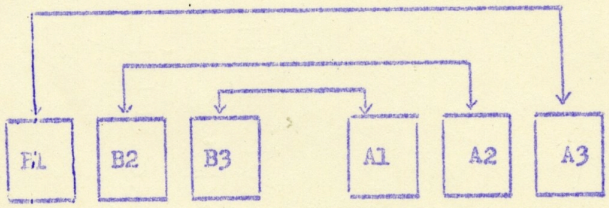
CALCULATION OF THE PERIOD WITH DEVICE 39

1. Drive law :



a. Number of divisions of the pin wheels A1,2,3
A1 = 23, A2 = 25, A3 = 27

b. Number of divisions of the cipher wheels B1,2,3
B1 = 26, B2 = 26, B3 = 26

c. Pin wheels A1,2,3 with their effective pins affect the course of cipher wheels B1,2,3.

d. According to their divisions pins (t) on the pin wheels can be brought into an effective or ineffective position. That pin position is termed effective which checks the course of the cipher wheel.

e. If all pins on pin wheel A1,2,3 are in the ineffective position then pin wheels A1,2,3 and cipher wheels B1,2,3 take one step each time a key is pressed.

f. The number of effective pins is to be determined by the following formula: the number of divisions of the pin wheel less the number of effective pins must be prime to the number of divisions of the cipher wheel.

Number of effective pins = (tA - n) ≠ tB.

g. The total period is the product of the number of divisions of A1, A2, A3, B1, B2, B3. It breaks up into partial periods if the factors are not prime to one another. The sum of the partial periods is equal to the product of the divisions of all the wheels.

In the present case 26^2 partial periods (B2 x B3) of the length A1 x A2 x A3 x B1 = 23 x 25 x 27 x 26 = 403676 steps are derived.

The following example [in miniature] is intended to illustrate the computation.

Terms: A = pin wheels (t1,2,3)

B = cipher wheels (t4,5,6)

f = steps B4,5,6

t = number of divisions of A1,2,3 or B1,2,3

U = revolutions of A or B

n = number of effective pins on A

F = period

Ziffer = A1,2,3, B4,5,6

h = braking of the course of B4,5,6

A1 = 5, A2 = 7, A3 = 9, B4 = 4, B5 = 4, B6 = 4.

a. Periods without effective pins on the pin wheels:

A1 = 5 steps

A2 = 7 steps

A3 = 9 steps

B4 = 4 steps

B5 = 4 steps

B6 = 4 steps

b. Pin setting (effective pins)

A1) At1 - n $\neq$ Bt4 = 5 - 2 = 3 $\neq$ 4 (2 effective pins)

A2) At2 - n $\neq$ Bt5 = 7 - 4 = 3 $\neq$ 4 (4 effective pins)

A3) At3 - n $\neq$ Bt6 = 9 - 6 = 3 $\neq$ 4 (6 effective pins)

c. Periods: A1B4 = t1 x t4 = 5 x 4 = 20 steps.

A1 12345123451234512345
o o o o o o o o o o effective pins
B4 abbccdaabbccddaabccdd = 20 steps

A2 12345671234567123456712345 67
ooo o ooo o ooo o ooo o effective pins
B5 aaaabbcdddddaabccccddabbbbccd = 28 steps

A3 123456789123456789123456789123456789
o o oo ooo o oo ooo o oo ooo o oo oo effective pins
B6 aabbccccddddaabbbccccddaaabbbbccdddaa 36 steps

d. Period A1,2,3 = t1 x t2 x t3 = 5 x 7 x 9 = 315 steps

e. Revolutions of a pin wheel during the course of the period of A1,2,3 (315 steps).

$$\frac{F}{At1} = \frac{UA1}{} = \frac{315}{5} = 63UA1, \quad \frac{315}{7} = 45UA2, \quad \frac{315}{9} = 35UA3$$

Hence A1 makes 63 revolutions, A2 makes 45 and A3 makes 35.

f. Number of effective pin functions (brakings of the cipher wheels B4,5,6) within the course of one period of A1,2,3.

A1: h1 = U1 x n1A = 63 x 2 = 126 steps

A2: h2 = U2 x n2A = 45 x 4 = 180 steps

A3: h3 = U3 x n3A = 35 x 6 = 210 steps

g. Number of steps of cipher wheels B4,5,6.

B1: f1 = F-h1 = 315 - 126 = 189 steps

B2: f2 = F-h2 = 315 - 180 = 135 steps

B3: f3 = F-h3 = 315 - 120 = 105 steps

h. Number of revolutions of the cipher wheels within one period of A1,2,3.

B4: $B4U = \frac{f1}{Bt} = \frac{189}{4}$ = 47 1/4 revolutions

B5: $B5U = \frac{f2}{Bt} = \frac{135}{4}$ = 33 3/4 revolutions

B6: $B6U = \frac{f3}{Bt} = \frac{105}{4}$ = 26 1/4 revolutions

1. The period A1,2,3, B4,5,6 is found from the product of the t's.

Nevertheless the period of A1,2,3 B4,5,6 has only run out when all drive wheels and cipher wheels have completed full revolutions at the same time. With 315 steps this is only satisfied for A1,2,3. Wheels B1,2,3 have, as shown in paragraph h, made 1/4, 3/4, and 1/4 too many revolutions. The period A1,2,3 must therefore be run through several times before all six wheels reach the initial position simultaneously.

In running through the periods A1,2,3 the following steps are made.

Full Periods of A1,2,3	Steps	= Cipher Wheel Revolutions		
1	315	B4 47-1/4,	B5 33-3/4,	B6 26-1/4
2	630	B4 94-1/2,	B5 67-1/2,	B6 52-1/2
3	945	B4 141-3/4,	B5 101-1/4,	B6 78-3/4
4	1260	B4 180,	B5 135,	B6 105

The period A1.2.3 B4.5.6 yields, therefore:

F = A1 x A2 x A3 x B4 x B5 x B6 = 5 x 7 x 9 x 4 = 1260 steps

k. In the preceeding example each cipher wheel has 4 positions. With 3 cipher wheels there are therefore 4^3 effectively different positions, that means 4 x 4 x 4 = 64 positions. The pin wheels A1,2,3 have 5 x 7 x 9 = 315 effectively different positions. The runs 1-4 shown in paragraph i had as a result that each of the 315 positions of the pin wheels A1,2,3 came into connection in each case with only 4 of the 64 possibilities of the cipher wheel.

E. g. The position of the pin wheels 1, 1, 1 only occurs in connection with the cipher wheel positions aaa, bcb, cbc, ddd. 4 of the 64 possibilities always occur together so that there are $\frac{64}{4}$ = 16 periods with a lenth of 1260 steps. This number 16 comes from the product B5 x B6 = 4 x 4 = 16. The breaking down of the period given by the product of all 6 wheels into 16 partial periods is the consequence of the equal number of divisions on B4,5,6.

A1 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5

B4 a b b c c d a a b b c d d a a b c c d d a b b c c d a a b b c d d a a

A2 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7

B5 a a a a b b c d d d d a a b c c c c d d a b b b b c c d a a a a b b c

A3 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 (23)

B6 a a b b c c c d d d d a a b b b c c c c d d a a a b b b b c c d d d a

1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5

b c c d d a b b c c d a a b b c d d d a a b c c d d a b b c c d a a b b

1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7

d d d d a a b c c c c d d a b b b b c c d a a a a b b c d d d d a a b

9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 (23)

a a a b b c c c d d d d a a b b b c c c c d d a a a b b b b c c d d d

1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5

c d d a a b c c d d a b b c c d a a b b c d d a a b c c d d a b b c c

1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7

c c c c d d a b b b b c c d a a a a b b c d d d d a a b c c c c d d a

8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 (24)

a a a a b b c c c d d d d a a b b b c c c c d d a a a b b b b c c d d

1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5

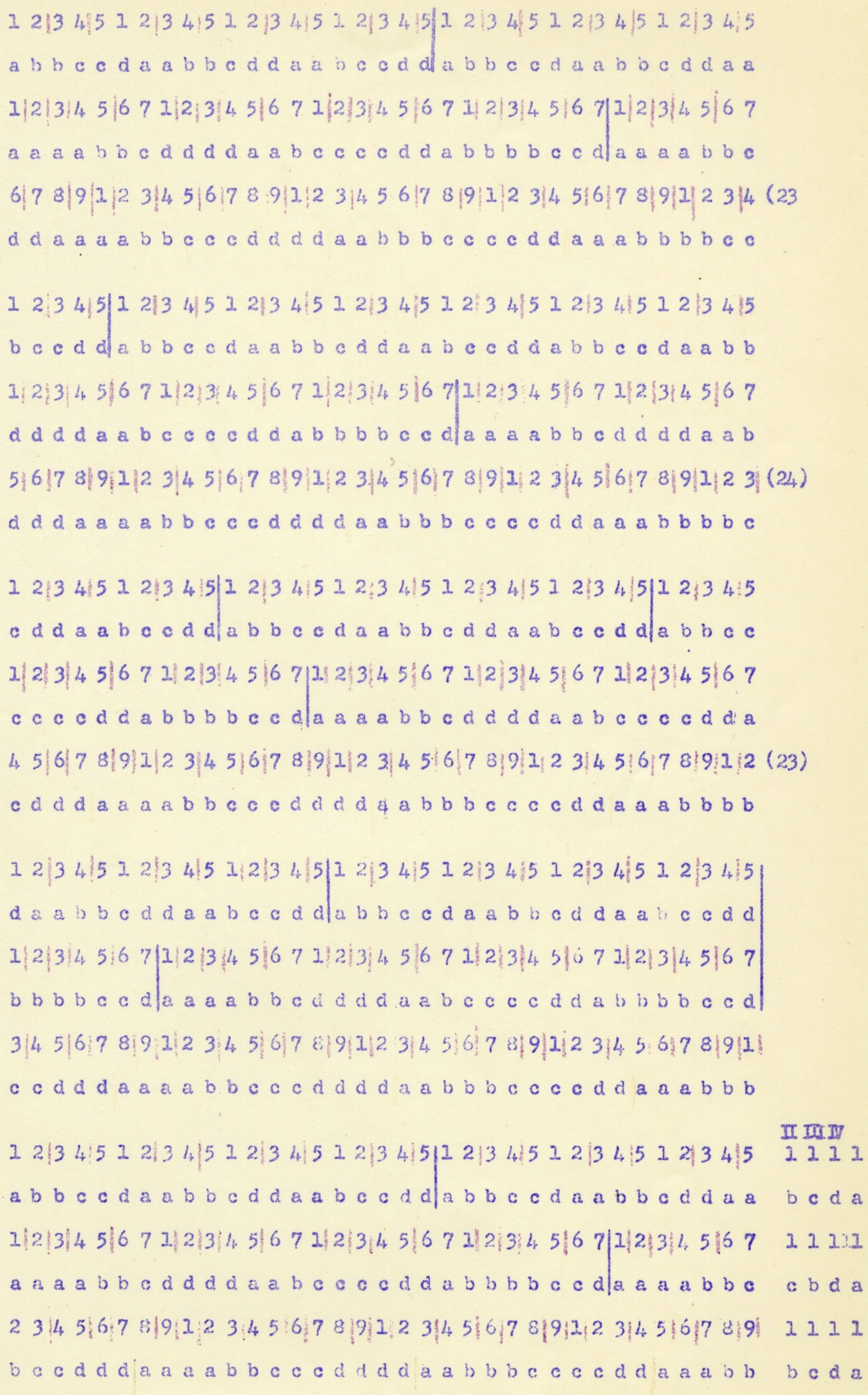
d a a b b c d d a a b c c d d a b b c c d a a b b c d d a a b c c d d

1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7

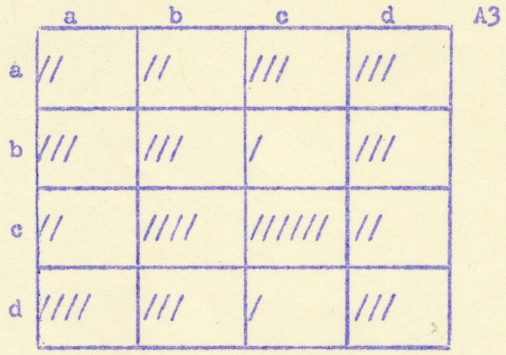
b b b b c c d a a a a b b c d d d d a a b c c c c d d a b b b b c c d

7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9 1 2 3 4 5 (23)

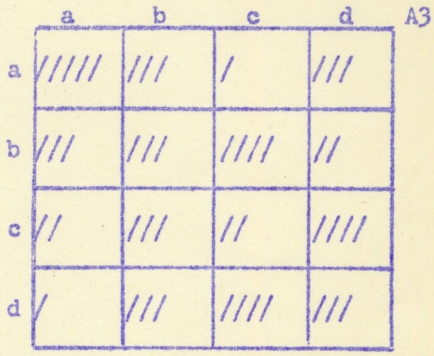
d a a a a b b c c c d d d d a a b b b c c c c d d a a a b b b b c c d



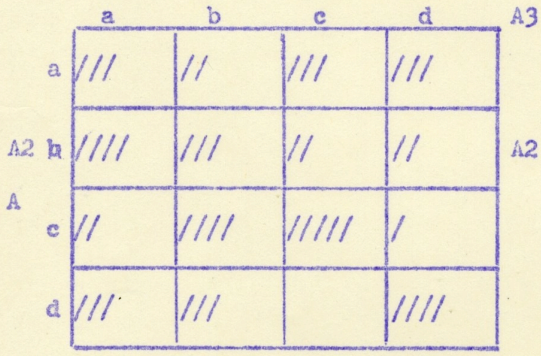
A1 a



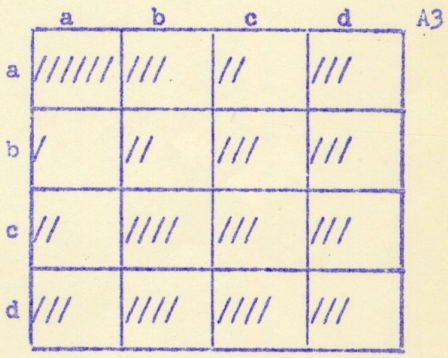
A1 b



A1 c



A1 d



Run of 180 steps