automatic slide rule

for engineers & scientists

1660 IWAMATIC

Instruction manual

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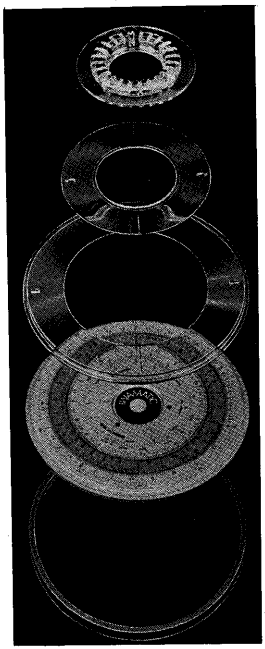


The IWAMATIC needs no maintenance. The scales are protected against wear and dirt by the transparent cursor shields. If, after long use, some dust collects under the transparent cursor shield rings, this can easily be removed by wiping with a soft dry cloth or chamois.

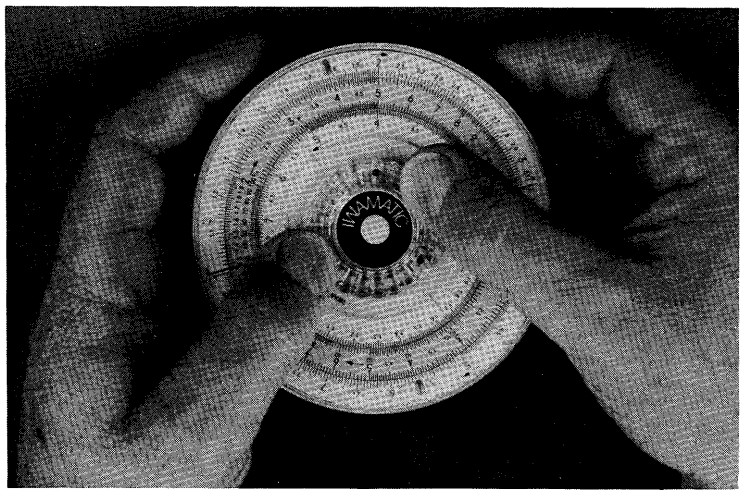
The operating knob ① and the elastic outer ring ⑤ are first removed by pulling them vertically upwards. The two transparent cursor rings ② and ③ can then be removed.

To assemble, the rings ② and ③ are first replaced and then the operating knob ① is pushed back into place, making sure that the three pins are correctly inserted. The outer ring ⑤ is then easily pushed over the face of the slide rule to fit around the rim.

How to operate the IWAMATIC

The IWAMATIC is held with both hands as illustrated so that the operating knob and the cursor rings can be manipulated easily with both thumbs.

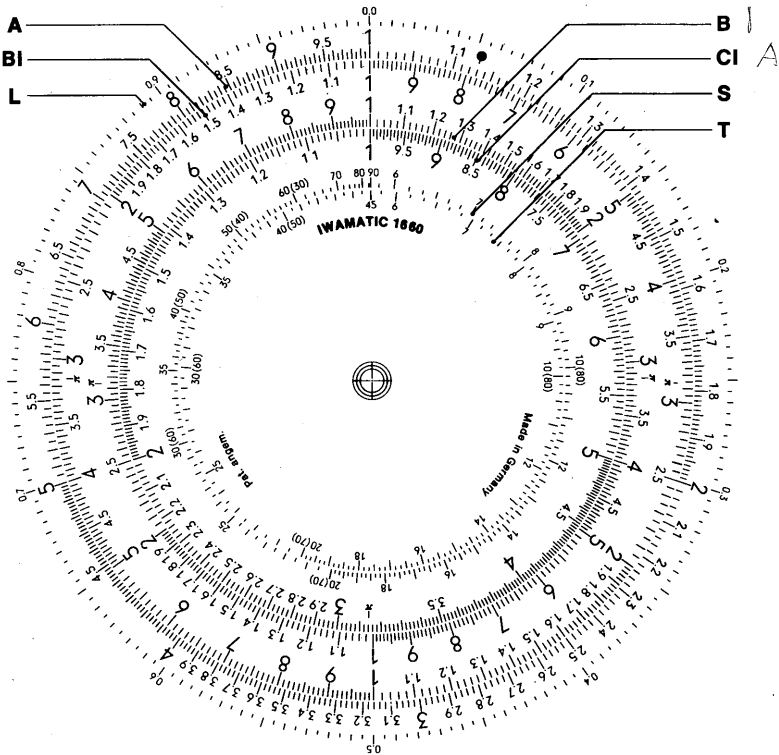
With a little practice the IWAMATIC can also be manipulated with one hand.



The scale rings are operated by turning the operating knob ①. The transparent cursor rings ② and ③ each have 2 red cursor lines. These cursor lines can be set on any reading by turning the ring.

With values marked in this manner it is much easier to carry out progressive calculations. It is also advisable to use the cursor lines to read off results of calculations.

Scales



The IWAMATIC has 4 main scales for multiplication and division. For simplicity in description these are denoted by the letters **A, BI, B** and **CI**. The additional letter **I** denotes an inverse scale, i.e. these scales run counterclockwise.

Main scales

This section deals with how to read the scales. If you know how to use a normal slide rule you can omit this section.

Take up your IWAMATIC and examine the scales.

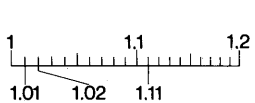
The numbered division lines are not equally spaced as on a ruler but get closer together as the number value increases.

The distance between 1 and a given number corresponds to the logarithm of the number. Adding two such distances corresponds to adding logarithms i.e. multiplication, while subtraction is equivalent to division.

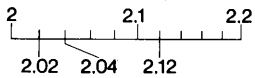
The addition or subtraction of the distances is carried out automatically by the gearing in the slide rule. This means that you are concerned only with the numbers in your calculation and do not have to bother with intermediate or secondary readings.

To acquaint yourself with the outer scale **A**, use the outer cursor ring to read the divisions shown in the illustration below.

Starting at 1 and moving in clockwise direction the numbered division lines are tenths (0.1) while the subdivision lines between them are hundredths (0.01).

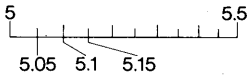


From the number 2 there are only 4 subdivision lines between the numbered "tenth" (0.1) division lines so that each subdivision is 0.02.



From the number 4 the "tenth" division lines are no longer numbered.

From the number 5 the division is so small that there is only a central division line between the "tenth" division lines. The subdivision therefore corresponds to 0.05.



Scale **BI** on the middle ring is more closely divided because there are two scales 1 to 10 included on its circumference.

This scale runs in counter-clockwise direction.

The next inner scale is **B** whose divisions correspond to **BI** but which runs in clockwise direction.

Note that the operating knob rotates these scales underneath the outer cursor ring to bring any number on the scale to either of the two cursor lines.

The innermost scale **CI** is divided in the same fashion as the outer scale **A**, but runs in counter-clockwise direction. When reading numbers you must note the scale direction.

Decimal Point

In the above examples the decimal numbers used were the same as on the scale.

However, in slide rule calculations we can use only the numerical values. The position of the decimal point is not shown.

The number 1 on the scale can represent 1; 10; 100; 1000 and so on — or 0.1; 0.01; 0.001 etc.

The same applies to intermediate values e.g. 1.1; 11; 110 or 0.11; 0.011 etc.

The position of the decimal point is determined by a simple rough calculation.

Function of the gears

The IWAMATIC contains planetary gearing which operates the middle scales **BI** and **B** so that they turn through half the angle moved by the inner scale **CI**. Accordingly, scales **BI** and **B** are only half the length of scales **A** and **CI**.

This is the basis of the simplified slide rule operation.

Examples of calculation

Multiplication

If two values on adjacent scales are placed opposite each other the result of multiplication appears on the same line on the main scale farthest from the two first scales.

Example:

$2 \times 2 = 4$

Place 2 on **BI** directly under 2 on **A**. The answer lies directly below at 4 on scale **CI**.

This answer can be immediately re-multiplied if desired. Retain the answer by using the inner cursor.

Example:

$4 \times 4 = 16$

Place 4 on **B** directly over 4 on **CI**; read off answer 16 directly above on **A** scale.

This answer can also be used immediately in further calculations.

Example:

16 x 3.5 = 56

Place 3.5 on **BI** under 1.6 on **A**, read off answer 56 below on scale **CI**.

To retain the answer place the cursor line over it.

Division

If two values on non-adjacent scales are placed in line, the answer for the division calculation appears in line on the scale adjacent to the divisor.

Example:

8 ÷ 2 = 4

Place 2 on **B** under 8 on **A** and read off answer 4 on scale **CI**.

This answer can be used forthwith in further calculations.

Retain result with inner cursor.

Example:

4 ÷ 2.5 = 1.6

Place 2.5 on **BI** above 4 on **CI**, read off answer 1.6 on **A**.

These examples illustrate one of the most important advantages of the IWAMATIC. You can always continue multiplying and dividing as many times as you wish because the intermediate answer can be easily retained and used in subsequent calculations.

Multiplication and division

If several numbers are to be multiplied and divided this can be done in any order.

Example: $$\frac{2 \times 3 \times 4}{5 \times 6 \times 7} = 0.114$$

Place 3 on **BI** under 2 on **A**. Place inner cursor on answer 6 on **CI**.

Now multiply with 4 on **B** and mark the result 24 on **A** with the outer cursor.

Divide by 5 on **B** and retain the answer 4.8 on **CI** with the inner cursor.

Divide by 6 on **BI** (use the outer cursor to assist in this operation), obtain the answer 0.8 on **A**, and retain the result.

Divide by 7 on **B** and read the final answer 0.114 on **CI**.

Multiplication by a constant

The factor 2.5 must be multiplied in turn by the numbers 2, 3, 4, 5 etc.

2.5	2.5	2.5	2.5	A
2	3	4	5	BI
5	7.5	1	1.25	CI

Set the outer cursor line on 2.5 on **A**. Put 2 on **BI** under the cursor line and read off the answer 5. Then put 3 under the cursor line and read off the answer 7.5. Proceed likewise with the other numbers to be multiplied.

Currency calculations

To obtain conversions from one currency to another the conversion rate is used in a similar fashion to multiplying by a constant.

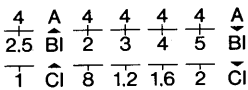
If the exchange rate from dollars to Swiss Francs is $ 1 = SFr. 4.2, to convert from dollars to Swiss Francs the outer cursor is set on 4.2 on the **A** scale. The value in dollars on the **BI** scale is set at the cursor and the Swiss Franc equivalent is read off on the **CI** scale.

Example: $ 10.20 = SFr 42.80

Division of several numbers by a constant

The values 2, 3, 4, 5 etc. are to be divided in turn by 2.5.

To avoid having to divide each number individually by 2.5, it is simpler to first calculate the reciprocal 1/2.5 = 0.4 and use this in the same way as multiplying by a constant.



Squares and Square roots

As mentioned previously the scales **B** and **BI** have two scales 1—10 around their circumference.

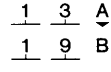
This enables them to be used for squares and square roots.

The number 1 on scale **B** is set at 1 on scale **A**.

Using the outer cursor the square of a number on scale **A** is read off scale **B**.

Example:

$3^2 = 9$



Reading up from scale **B** to scale **A** the square root can be found.

Example:

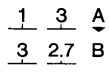
$\sqrt{16} = 4$

Cubes

If a number X on the **B** scale is set under 1 on the **A** scale, then X^3 is found on the **B** scale under X on the **A** scale.

Example:

$3^3 = 27$



Set 3 ond **B** under 1 on **A.** Under 3 on **A** the answer 27 ($= 3^3$) is found on **B.**

Method for finding cube root

To find the cube root of a number, place the number on the **BI** scale at 1 on the **A** scale. The cube root is found where similar numbers line up on the **A** and **BI** scales.

Example:

$\sqrt[3]{8} = 2$

Put 8 on **BI** under 1 on **A.** 2 on **A** and 2 on **BI** line up. 2 is the cube root of 8.

Areas of circles

Above the value 1.13 on scale **A** is a special mark ◍.

To calculate the area of a circle, set the 1 on **B** scale under the mark ◍. You can now set the outer cursor at any desired value of diameter on **A**. The area of the circle with this diameter can be read off below on the **B** Scale.

Example:

Diameter d = 4 A = 12.56

Set 1 on **B** under the mark ◍. Under 4 on **A** read off area 12.56 on **B**.

Volume of cylinder

If the length of a circular cylinder on the **B** scale is set under the mark ◍, the volume of the cylinder of any desired diameter is found on the **B** scale under the diameter value on the **A** scale.

Example:

Length l = 3

Diameter d = 2

Volume V = 9.42

Set length 3 on **B** under mark ◍. Under d = 2 on **A** read volume (V = 9.42) on **B** scale.

Ratios

Values based on constant ratios in the form of

$$\frac{a}{b} = \frac{c}{d} = \frac{f}{e} \quad \text{etc}$$

can be easily calculated by first working out the common ratio and then multiplying.

Example:

4 kg of certain goods cost $ 5.00. How much would 6 kg, 8 kg, 10 kg etc. cost? Under 5 on **A** set 4 on **B** (division). The answer of 1.25 is found underneath on the **CI** scale and marked with the inner cursor. This is multiplied with each weight in turn (6 kg, 8 kg, 10 kg, etc) by lining up with the value of the weight on the **B** scale and reading the answers on the **A** scale of $ 7.50, $ 10.00, $ 12.50, etc.

A photograph of size 13 x 18 cm has to be reduced so that the longer side is 11 cm long. How long will the shorter side be?

Set 18 on **B** under 11 on **A** and mark the reduction ratio 0.61 on **CI** with the inner cursor. Bring cursor value under 13 on **B** scale and read off answer 7.94 cm on **A** scale.

Trigonometric functions

Scales **S** and **T** show angles for trigonometric functions for the quadrants 0—90°. The values are read off scale **CI**.

The following table shows how to express functions of any given angle as a function of an angle in the first quadrant.

	$\pm\ \alpha$	$90° \pm \alpha$	$180° \pm \alpha$	$270° \pm \alpha$	$45° \pm \alpha$
sin	$\pm \sin\alpha$	$+ \cos\alpha$	$\mp \sin\alpha$	$- \cos\alpha$	$\cos(45° \mp \alpha)$
cos	$+ \cos\alpha$	$\mp \sin\alpha$	$- \cos\alpha$	$\pm \sin\alpha$	$\sin(45° \mp \alpha)$
tan	$\pm \tan\alpha$	$\mp \cot\alpha$	$\pm \tan\alpha$	$\mp \cot\alpha$	$\cot(45° \mp \alpha)$
cot	$\pm \cot\alpha$	$\mp \tan\alpha$	$\pm \cot\alpha$	$\mp \tan\alpha$	$\tan(45° \mp \alpha)$

If an angle on **S** or **T** scale is marked with the inner cursor, the value of the corresponding function is read off on scale **CI**.

The angle values in brackets represent the angles for cosine resp. cotangent.

Example:

sin 25° 30′ = 0.43
Set cursor on 25° 30′ on **S** scale, read off 0.43 on **CI** scale.

tan 35° = 0.70
Set cursor on 35° on **T**, read off 0.70 on **CI**.

tan 25° = 0.466
Set cursor on 25° on **T**, read off 0.466 on **CI**.

For arc tan $>$ 45° and arc cot $<$ 45° the rule $\tan \alpha = \frac{1}{\cot \alpha}$ is used.

Example:

$$\tan 60° = \frac{1}{\cot 60°} = 1.732$$

1. Set the rule in zero position, 1 on **BI** under 1 on **A**.
2. Set inner cursor on cot 60° ([60] on **T**).
3. Set outer cursor to inner cursor and read off answer of 1.732 on **A**.

Powers with decimal exponents

Example:

$2.5^{3.5} = 3.5 \log 2.5 = 24.7$

1. Find logarithm of 2.5
   Set cursor over 2.50 on **A** scale and read off logarithm 0.398 on **L** scale.
2. Find product of 0.398 x 3.5 = 1.393
   Set outer cursor on 0.398 on **A** scale and bring 3.5 on **BI** scale under cursor line. Read off product 1.393 on **CI**.
3. Find antilogarithm of 0.393
   Set cursor over 0.393 on **L** scale and read off number 2.47 under cursor line on **A** scale. Multiply by 10 because of characteristic 1 to give answer 24.7.