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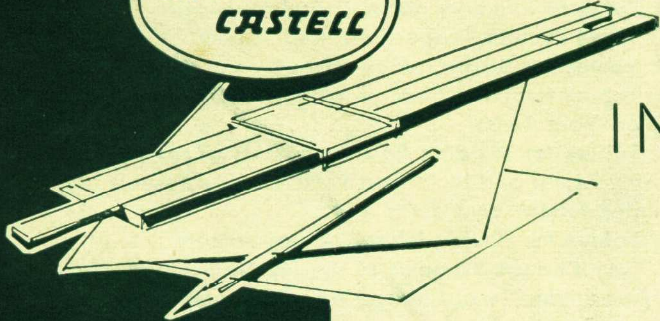

INSTRUCTIONS

for Use of the

TEXTILE SLIDE RULE 57/74

"System Schirdewan"

Special English/American Model

Reprint: UK Slide Rule Circle
2007

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Preface

The Textile Slide Rule 57/74 can be used in many ways in the textile industry. It is adapted not only for special calculations regarding spinning, twisting, weaving, and knitting, but also for computations and calculations of a **general** kind. The following instructions are compiled to indicate the various uses in textile calculations.
After having acquired knowledge of the general setting rules, the owner of the Slide Rule should make himself familiar with the Short Instructions on the inverted Rule. He should then study in the following paragraphs the instructions and examples, which deal with the calculations in his own field.

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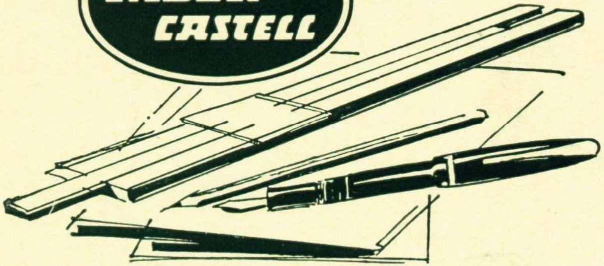

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Symbols on the Textile Slide Rule and in the Text of these Instructions

I. On the Cursor

a) for indirect or "fixed weight" systems of counting yarns:

T	= Typp	= number of 1000 yds. per 1 lb.
C	= Cotton and spun silk	= number of 840 yds. per 1 lb.
r	= American run woollen (Dewsbury woollen and raw silk)	= number of 100 yds. per 1 oz. (1)
Wo	= Worsted (English)	= number of 560 yds. per 1 lb.
M	= Metric	= number of 1000 metres per 1 kilog.
F	= French (old system)	= number of 1000 metres per 0·5 kilog.
G	= Galashiels woollen	= number of 300 yds. per 24 ozs.
W	= West of England woollen	= number of 320 yds. per 1 lb.
L	= Linen, fine hemp, and American cut woollen	= number of 300 yds. per 1 lb.
S	= Yorkshire Skeins woollen	= number of 256 yds. per 1 lb.

b) for direct or "fixed length" systems of counting yarns:

R	= Roving	= number of drams per 40 yds.
g	= grain	= number of grains per 10 yds.
tx	= tex $= \frac{\text{grex}}{10}$	= number of grams per 1000 metres
D	= International Denier	= number of grams per 9000 metres
J	= Jute, coarse hemp, heavy flaxes, and Aberdeen woollen	= number of lbs. per 14400 yds.

II. On the Scales

Scale A:	m = metre
Scale A:	cm = centimetre
Scale A:	kg = kilogram
Scale A, Z_1, and Z_2:	∞ = infinite
Scale B:	y = yard
Scale B:	lbs = pounds
Scale B:	in = inch
Scale C:	$C = \frac{2}{\sqrt{\pi}}$ and $C_1 = 2\sqrt{\frac{10}{\pi}}$

III. In the Text of these Instructions

l. L. = long cursor line

$\approx$ = roughly, approximate

[ ] = letters in brackets always mean the scales

General Remarks about Slide Rule Calculations

Today not only technicians, but merchants and others are familiar with Slide Rule calculations, because of their numerous advantages. These calculations are easy to learn, save much time and work, and can be effected with a sufficient degree of accuracy for most cases occuring in practice. The special advantage of the Slide Rule, however, is: Continued multiplications and table calculations which are frequent in the textile industry can be carried out fast and easily. We may remind you of the tables for conversion of counts, or of English/metric measures, or for the computation of change wheels. The most expensive computing machine does not make your work such a lot easier and clearer. The Slide Rule is easy to handle. You can keep it conveniently in your pocket and it is always ready for calculations, at the desk, near the loom, or at the spinning machine.

If it is realised that the normal Slide Rule considerably simplifies multiplications, divisions, and similar computations, it is evident that certain textile calculations can be effected still more easily and faster with a special Textile Slide Rule.

The memory is relieved of the knowledge of the miscellaneous factors for the conversion of counts, measures of length and weight, etc. by using the special scales, marks, and cursor lines. Moreover, to be able to find the result or to compile a table, very often a **single** setting of the slide or the cursor is sufficient, often without the knowledge and the application of formulae.

Like every normal Slide Rule the Textile Slide Rule, too, has the two main scales [C and D] as well as the two scales for squares [A and B], and in addition the reciprocal scale 100 ÷ 10 ÷ 1 [BI]. All fundamental calculations — multiplication, division, squares, cubes, and square roots — can be made in a familiar manner, so that the Textile Slide Rule can be considered a calculation instrument which has the same value as the normal Slide Rule in addition to which it has special textile applications. Therefore the textile merchant, for example, who wants to calculate prices, to convert foreign money, to carry out statistical or more general computations, can use the Textile Slide Rule as advantageously as the technician for spinning, weaving, or knitting problems. Thus the Textile Slide Rule is a universal calculating instrument for the technician and the merchant in the whole textile industry.

Some knowledge of how to do the usual calculations with the normal Slide Rule is taken for granted, and only a summary is given here. If this is not sufficient for you, and if you have no possibility of asking an acquaintance of yours to explain to you the general Slide Rule calculations, then we call your attention to our instructions for our normal Slide Rules which give you the detailed **general** basis of Slide Rule calculations.

How To Use The Normal Slide Rule

Multiplication and Division

Every Slide Rule consists of the two parts firmly connected, i. e. the rule, of the movable slide, and of the movable cursor which has one or several thin vertical marks. On the rule and on the slide there are scales which are not divided evenly, e. g. like on a centimetre scale, but the higher the number the narrower the graduation. These so-called logarithmic scales make possible multiplications by graphic addition of lengths, and divisions by graphic subtraction.

Fig. 1 shows two movable centimetre scales. The addition 3·5 + 4·5 = 8 is the result of the graphic addition of the two lengths 0 to 3·5 (below) and 0 to 4·5 (above).

The procedure in Fig. 2 is the other way around: The length 0 to 5 (above) is subtracted from the length 0 to 9·5 (below): 9·5 — 5 = 4·5.

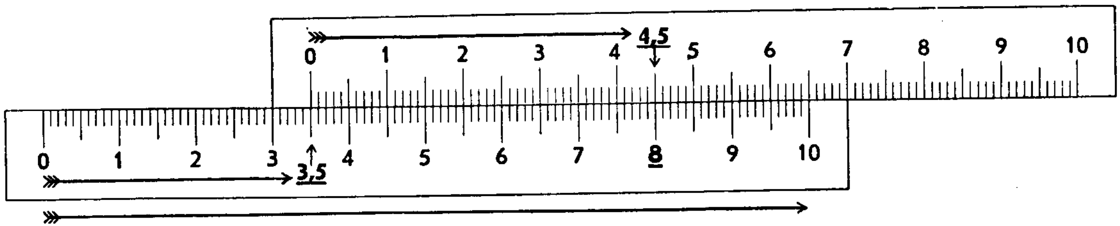

Fig. 1

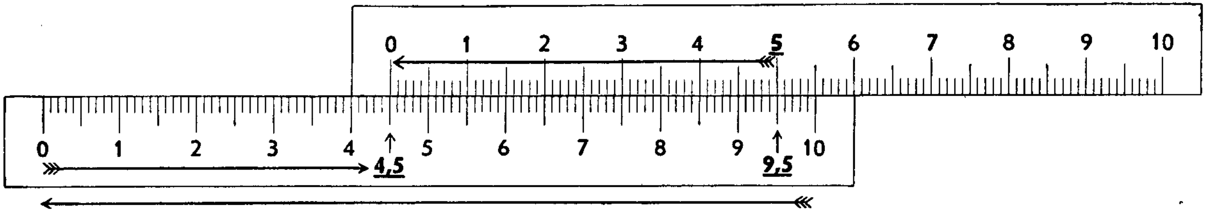

Fig. 2

The multiplication of 2 numbers with the aid of the Slide Rule is analogously carried out, according to the operation shown in Fig. 1. The division is made according to Fig. 2. For the multiplication $3{\cdot}5 \times 4{\cdot}5 = ?$ we set the beginning 1 of the slide scale B (the beginning of logarithmic scales is always 1, not 0) under the number 3·5 on the upper scale A and find the result 15·75 on scale A, over the number 4·5 on scale B. Here we have to estimate the last figures. With the same setting you can read more easily the following products, for example: $3{\cdot}5 \times 2 = 7$ or $3{\cdot}5 \times 4 = 14$ or $3{\cdot}5 \times 13 = 45{\cdot}5$ or $3{\cdot}5 \times 17{\cdot}4 = 60{\cdot}9$ or $3{\cdot}5 \times 23 = 80{\cdot}5$, etc. The setting of the numbers, the reading of the results, and the sometimes necessary estimate of the last figures must be thoroughly practiced.

It is the task of the cursor to set figures, which are between 2 graduation marks, and to get intermediate results. For instance, for the problem $3{\cdot}5 \times 2{\cdot}13 = 7{\cdot}45$ the number 2·13 as well as the result 7·45 are set and read off with the help of a long cursor line. Of the cursor lines it is best to use a long cursor line (abbreviation: l. L.), until further notice; the short cursor lines are meant for the special calculations explained on page 14 ff.

And now the division! Instead of the subtraction $9{\cdot}5 - 5 = 4{\cdot}5$ (Fig. 2) the division $9{\cdot}5 : 5 = ?$ shall be carried out. The problem is solved as follows: We set B 5 under A 9·5 and read the result 1·9 over B 1 on the scale A. But we can read off the result of numerous other divisions, too, by this setting of the slide, for example:

Scale A:
Scale B: $\dfrac{15}{7{\cdot}9} = 1{\cdot}9$ or $\dfrac{23}{12{\cdot}1} = 1{\cdot}9$ or $\dfrac{27{\cdot}2}{38} = 1{\cdot}9$ etc.

The results of numerous multiplications, too, can be read, for example:

$1{\cdot}9$ [A] $\times$ $5{\cdot}9$ [B] $= 11{\cdot}2$ [A] or $1{\cdot}9 \times 14{\cdot}2 = 27$ or $1{\cdot}9 \times 23{\cdot}5 = 44{\cdot}7$

If you combine the foregoing divisions and multiplications with each other, then you can read:

$$\frac{15}{7{\cdot}9} \times 5{\cdot}9 = 11{\cdot}2 \text{ or } \frac{23}{12{\cdot}1} \times 14{\cdot}2 = 27 \text{ or } \frac{72{\cdot}2}{38} \times 23{\cdot}5 = 44{\cdot}7$$

Thus we have learnt to carry out a combined multiplication and division and should remember that problems of this kind require **first** the **division** and after that the multiplication.

All foregoing examples can also be solved with reversed scales, that is, all numbers which were set on scale B can also be set on scale A, and vice versa. Then the final result does not appear any more on the firm scale A, but on the movable scale B. Furthermore, you can also use the lower scales C and D, instead of the scales A and B. C and D give you more accurate final results than the two upper scales, but they may require additional movement of the slide.

Calculating with the Slide Rule you do not care about the decimal point first, but you read the figures of the result 4-4-7 of the problem $\frac{72{\cdot}2}{38} \times 2{\cdot}35$. You put the decimal point by rough estimate. The result can be 4·47 only, but not 0·447 nor 44·7. Merely the square roots, which are explained in the following section, require that the decimal point is observed in certain cases from the very beginning.

Squares and Square Roots

Calculations of this kind are made with the aid of the scales A and D or the scales B and C.

Example: $2{\cdot}5^2 = ?$ We set a l. L. over D 2·5 and read the result 6·25 over it on A. Correspondingly we find out: $5{\cdot}15^2 = 26{\cdot}5$ or $43^2 = 1850$ and many others.

Square roots are extracted by reversing the procedure. It is essential, however, to note the number of digits of the radicand, because it must be set either on the left or the right half of the scale A. We recommend to remember as setting rule that all radicands with an odd number of figures, i. e., 1, 3, 5, etc. figures, before the decimal point, or 1, 3, 5, etc. zeros after the decimal point must be set on the left half of the A scale, but all radicands with an even number of figures must be set on the right half of the A scale.

Example: $\sqrt{32.5} = ?$ We set a I. L. over A 32·5; the result 5·7 is under it on D. Correspondingly we calculate: $\sqrt{40} = 6.32$ or $\sqrt{54.8} = 7.4$, etc. If the radicands are less than 1 or more than 100, then proceed in the same way, thus:

$$\sqrt{169} = \sqrt{1.69} \times \sqrt{100} = 1.3 \times 10 = 13 \quad \text{or} \quad \sqrt{5480} = \sqrt{54.8} \times \sqrt{100} = 7.4 \times 10 = 74;$$

$$\sqrt{0.4} = \sqrt{\frac{40}{100}} = \frac{\sqrt{40}}{\sqrt{100}} = \frac{6.32}{10} = 0.632 \quad \text{or} \quad \sqrt{0.0548} = \sqrt{\frac{5.84}{100}} = \frac{\sqrt{5.38}}{\sqrt{100}} = \frac{2.34}{10} = 0.234, \text{ etc.}$$

The Reciprocal Scale BI

Unlike the scales used so far the beginning of the scale BI (the figure 1) is on the right side. In connection with the A scale we need the BI scale very frequently for textile calculations, for so-called indirect proportions. Multiplications and divisions are made according to the principle of the graphical addition or subtraction of lengths.

Example: $4.8 \times 15 = ?$ We set a I. L. over A 4·8, and BI 15 under it, or the other way around. The result is 72, to be read over BI 1 on the A scale or under A 1 on the BI scale. Now all figures the products of which are 72 are opposite each other on the scales A and BI, e.g.,

$5 \times 14.4, \quad 10.8 \times 6.67, \quad 28.6 \times 2.52 = 72$, etc.

With this position of the slide you can also read:

$$\underset{A}{5} \times \underset{BI}{14.4} \times \underset{B}{7.5} = \underset{A}{540} \quad \text{or} \quad \underset{A}{28.6} \times \underset{BI}{2.52} \times \underset{B}{9.3} = \underset{A}{670}, \text{ etc.}$$

The folowing problems No. 1, 13, etc. include other examples of the application of the BI scale together with the scales A and B.

The Exponential Scale (log-log Scale) LL

a) How to find the decadic logarithms

They are worked out by sliding B 1·0 under LL 10 with the help of a long cursor line, say, S.

Then we can read off:

on the LL scale:	a =	6·31	10	40	100	400	1200	4000	12125
on the B scale:	log a =	0·8	1·0	1·60	2·0	2·60	3·08	3·60	4·08

To get as accurate results as possible, use the left section of the LL scale only, from 1·1 to 10·99, and proceed according to the following example:

log 12125 = ? You slide B 10 (not 1) under LL 10 and read: log 1·2125 = 0·837 : 10 = 0·0837. Consequently: log 12125 = 4·0837 (or log 0·12125 = 0·0837—1).

b) Powers and extractions of roots with any exponent

Example: Powers and extractions of roots of the number 16.

We slide B 10 under LL 16 and read

on the LL scale:	16^n =	2·3	4	5·28	6·96	256	1025	=	$16^{1/x} = \sqrt[x]{16}$
on the B scale:	n =	$^3/_{10}$ (0·3)	$^5/_{10}$ (0·5)	$^6/_{10}$ (0·6)	$^7/_{10}$ (0·7)	$^{20}/_{10}$ (2)	$^{25}/_{10}$ (2·5)	=	$\frac{1}{x}$
on the BI scale:	$\frac{1}{n}$ =	$^{33,3}/_{10}$ (3·33)	$^{20}/_{10}$ (2)	$^{16,7}/_{10}$ (1·67)	$^{14,3}/_{10}$ (1·43)	$^5/_{10}$ (0·5)	$^4/_{10}$ (0·4)	=	x

See also problem No. 3 on page 13.

If the result of an exponential calculation or the number in the n^{th} power is less than 1·1 (= beginning of the LL scale), it is helpful to transform the given values, as the following example shows:

$$0{\cdot}8^{6/10} = 0{\cdot}8^{0{\cdot}6} = \frac{8^{0{\cdot}6}}{10^{0{\cdot}6}} = \frac{3.48}{3.98} = 0{\cdot}875$$

We slide B 10 under LL 8 and read the value $8^{6/10}$ = 3·48 over B 6 on the LL scale. We calculate $10^{0·6}$ = 3·98 accordingly.

We reach this result somewhat earlier by the following calculation:

$$0{\cdot}8^{6/10} = \frac{1^{0{\cdot}6}}{\left(\frac{1}{0{\cdot}8}\right)^{0{\cdot}6}} = \frac{1}{1{\cdot}25^{0{\cdot}6}} = \frac{1}{1{\cdot}143} = 0{\cdot}875$$

We find the quotient $\frac{1}{1.143} = 0{\cdot}875$ fastest by setting a long cursor line (S, for instance) over BI 1·143, without sliding the slide, and by reading the reciprocal value 0·875 over it on the B scale.

Now we can finish summarising the use of the standard Slide Rule. You have revised your basic knowledge of the Slide Rule calculations by reading the foregoing explanations. It should not be difficult now to solve textile calculations, with the aid of the Textile Slide Rule, and to use the special scales, marks, and cursor lines as explained below.

Special Textile Calculations

I. Tables for Production and Efficiency of Looms

Problem 1: A loom has a speed of 150 picks per minute. Make a table of production in thousands of picks per 8 hour day, dependent on the efficiency.
Compiling the table we use the formula:

$$\text{Production in picks} \div 1000 = \frac{\text{p.p.m.} \times \text{working time in minutes} \times \text{efficiency } \%}{100 \times 1000}$$

With the aid of the reciprocal scale BI such a problem having the form $a \times b \times c$ can be solved **with a single sliding.** (Also see the explanations about the reciprocal scale BI on page 9). The following table contains all results of practical value. Setting the slide we use a long cursor line.

Solution:

Set:	[A]	Working time in minutes	480		(4·8)		
	[BI]	p.p.m.	150		(15)		
Read:	[A]	Production in picks ÷ 1000	54	57·5	60	67	72
	[B]	Efficiency %	75	80	83·4	93	100

If n looms are run with the same p.p.m. and the production is required, you set the value "working time in minutes × n" on the A scale.

II. Tables for twists

Problem 2: Compile a table for twists per in. dependent on the hank roving. The twist coefficient is 1·2.

The classic twist formula which the table shall be compiled with is $T = \alpha \sqrt{N}$ (or HR)

T = Yarn twist per in. α = Twist coefficient

N = Counts HR = Hank Roving

Solution:

Set:	[C]	Twist coefficient α		1·2			
	[D]	Beginning of the scale		1			
Read:	[A]	Hank Roving HR	4	4·5	5	5·5	6
	[C]	Twist T per 1 in.	2·4	2·54	2·68	2·81	2·94

If the values α considerably deviate from 1, the following setting is recommended.
Moreover, there is another possibility of setting which shows the counts on the B scale and the twists which belong to it, on the D scale.

Set:	[C]	Twist coefficient α		3·8			
	[D]	End of the scale		10			
Read:	[A]	Counts N	10	24	32	36	40
	[C]	Twist T per 1 in.	12	18·6	21·5	22·8	24

Calculating with the twist formula $T = \alpha \sqrt{N}$ is disadvantageous in that the twist coefficient α is constant only over a small range of counts. With essentially higher or lesser counts the constant has to be changed so that the yarn character andn the specific solidity of the yarn are not affected. For higher counts α is higher and vice versa. This makes it impossible to use one constant α.

Therefore various experiments have been made to find a twist formula with the same twist coefficient throughout. This coefficient should be chosen for a yarn with a quite definite yarn character, and should not be changed for very high or very low counts of the yarn. The most customary form of such a twist formula is $\mathbf{T} = \alpha \times \mathbf{N^x}$ where α is the twist coefficient.

Here the values for the twist exponent x are higher than 0·5 at any rate; among other things they are dependent on the raw material and the kind of yarn (roving or fine yarn), and lie between 0·6 and 0·7, according to the results of our investigations so far. For instance, the US Department of Agriculture has suggested the exponent $^2/_3$ or 0·667 for cotton roving.*) The values α for the new exponential formula are somewhat lower than the corresponding values for the classic twist formula $T = \alpha \sqrt{N}$.

Problem 3: How many twists per inch. has a cotton yarn with the English/American counts 12s. and the constant twist coefficient $\alpha = 2$? The twist exponent is 0·7.

Solution: The counts N are set on the exponential scale LL. With the aid of a I. L. we slide B 10 under LL 12 and read the value $N^{7/10} = 5{\cdot}7$ over B 7 on the LL scale. This value is multiplied by $\alpha = 2$, so that the result is 11·4 twists per inch. (See also the section "The Exponential Scale LL" on page 9.)

III. Conversion Tables for Measures of Length and Weights

These tables are made up with the two scales A and B which are set by bringing opposite each other certain setting marks, e. g. lbs and kg. The following conversions are possible:

Yards (mark y on the B scale)	to metres (mark m on the A scale)
pounds (mark lbs on the B scale)	to kilograms (mark kg on the A scale)
inches (mark in. on the B scale)	to centimetres (mark cm on the A scale)

Problem 4: Compile a table for the conversion of yards to metres.

Solution:

Set:	Mark y (B scale) under mark m (A scale)								
Read:	[A]	Metres	=	1·28	2·1	2·28	2·65	9·14	10
	[B]	Yards	=	1·4	2·3	2·5	2·9	10	10·94

The following conversions can be effected with the help of the four cursor lines T, g, tx/10, and S, as well as the BI scale:

lbs per 1 yd.	to grains per 1 yd.	to kilogs. per 1 metre	to drams per 1 yd.
(T)	(g)	(tx/10)	(S)

Problem 5: Convert 0·5 lbs per 1 yd.

Solution: We push the I. L. T over BI 50, whereupon we can read the 3 conversion values on the BI scale which are given in the following table, horizontal (line a).

*) See also Text. Mercury and Argus 130 [1954], No. 3383, 234.

Problem 6: A cloth has 1·5 yds. per 1 lb. Convert this length.

Solution: We push the I. L. T over 1·5 of the **B** scale and read the four conversion values on the BI scale. These are given in the table (line b).

Unit:		lbs per 1 yd.	grains per 1 yd.	kilogs. per 1 m	drams per 1 yd.
Cursor line:		T	g	tx/10	S
Scale BI:	a)	(0·5)	3 500	0·248	128
	b)	0·667	4 670	0·331	171

In contrast with the conversions of counts which are explained in the next section, the decimal point cannot be read off immediately, but has to be found by consideration, as it is the rule in Slide Rule calculations.

In the foregoing problem 6 you can also read the metric length, with reference to the metric unit of weight, on the B scale under cursor line M = 2F. It is 3·02 metres per 1 kilog. — He who also wants to have ounces in the conversions, on principle, must get used to the following setting from the *beginning: Move the* cursor mark 2r over the number 2 of the A scale and keep this position of the cursor permanently. Then the numerical values are set by the slide, and the weight in ounces is read resp. set over B 1, B 10, or B 100 *on the A scale.* Applying this rule the following conversion values can be read: a) Problem 5: 8 ozs. per 1 yd. b) Problem 6: 10·67 ozs. per 1 yd.

IV. Conversion of Yarn Counts to other Counting Systems

We convert with the *aid* of the special cursor and the scales B and BI. The single cursor lines have the marks T, C... etc. which denote the various counting systems. The meaning of these symbols is *indicated at the beginning of these* instructions on page 3.

The conversion of the counts of a given system is carried out by setting the cursor *line in question* over the yarn counts on the scale B or BI. Then we read the corresponding counts under the other cursor lines. We set and read a fixed weight system on the B scale, and a fixed length system incl. the new international tex system (grams per kilometre) and the American grex system (grams per 10 kilometres) on the BI *scale. In the early stages of using* the Textile Slide Rule, it is advisable (but not absolutely necessary) to have the slide **exactly** point to zero, because then it is impossible to mix up the scales A and B; altogether it makes setting and reading of numerical values easy. Only with experience in the conversion of counts can the initial pointing of the slide *to zero* be dispensed with.

Problem 7: Convert the English/American counts for cotton C = 10s. into other counting systems.

Solution: Have the slide exactly point to zero and then move the mark C on the cursor over the number 10 of the B scale. Now the following counts can be read:

I. on the B scale under the cursor line

T: Typp	$= 8{\cdot}4$
2r: American run (woollen)	$r = 10{\cdot}5 \div 2 = 5{\cdot}25$
Wo: Worsted	$= 15$
M = 2F: Metric	$\approx 16{\cdot}94$
French (old system)	$F \approx 16{\cdot}94 \div 2 = 8{\cdot}47$
$G/_2$: Galashiels (woollen)	$G = 21 \times 2 = 42$
W: West of England (woollen)	$= 26{\cdot}25$
L: Linen and woollen cut	$= 28$
S: Yorksh. Skeins (woollen)	$= 32{\cdot}8$

II. on the BI scale under the cursor line

10 R: Roving (drams per 40 yds.)	$R = 12{\cdot}2 \div 10 = 1{\cdot}22$
T: lbs per 100,000 yds.	$= 11{\cdot}9$
C: grains per 12 yds.	$= 10$
g: grains per 10 yds.	$= 8{\cdot}33$
$tx/_{10}$: tex (grams per 1 kilometre)	$tx \approx 5{\cdot}9 \times 10 = 59$
(grex = grams per 10 kilometres	*≈ 590)*
$D/_{100}$: Denier	$D \approx 5{\cdot}32 \times 100 = 532$
2 J: Jute etc.	$J = 3{\cdot}43 : 2 = 1{\cdot}715$
S: Drams per 100 yds.	$= 3{\cdot}05$

There is some inconvenience in that the number to be set or to be read still has to be divided by 2 or multiplied by 2, for four of the counting systems. On the other hand there is the considerable advantage that special consideration for the decimal point is not necessary, if we set or read counts between 0·8 and 128. For instance, if we convert the Denier counts 532 and set $\text{Denier}/_{100} = D/_{100} = 5{\cdot}32$, then the linen counts in question are L = 28s., and not 2·8s. or 280s., etc.

The meaning of the various cursor lines can be recalled at once simply by inverting the rule, because on the back of the rule body the meaning of each cursor line, with symbols and examples of conversion, are given.

P r o b l e m 8 : Convert the international counts of the tex system tx = tex = 150. (In the USA tex = 150 is grex = 1500).

S o l u t i o n : Have the slide point to zero and then move the cursor line $tx/_{10}$ = $tex/_{10}$ over $150/_{10}$ = 15 on the BI scale. Now we can read

I. on the B scale under the cursor line

T	C	2r	Wo	M = 2F	G/2	W	L	S
3·31	3·94	4·14	5·9	6·67	≈ 8·25	≈ 10·3	11	12·9
		(r = 2·07)		(F = 3·33)	(G = 16·5)			

II. on the BI scale under the cursor line

10 R	T	C	g	D/100	2 J	S
31	30·3	25·4	21·2	13·5	8·72	7·75
(R = 3·1)	lbs per 100,000 yds.	grains per 12 yds.	grains per 10 yds.	(D = 1350)	(J = 4·36)	drams per 100 yds.

He who frequently, has to convert the systems Worsted (Wo) and Dram Roving (R) which are very often used in worsted drawing (preparatory spinning), and who wants to include conversions of the counting system "grains per 40 yds.", too, must get used to the following setting: First we move the cursor mark Wo over A 5 and keep it in this position. Now the counts to be converted are set by moving the slide; the grains per 40 yds. are read resp. set over B 100, — over B 10 or B 1 in case of necessity only. For the foregoing problem 8 we get the value 84·7 grains per 40 yds. corresponding to Wo = 5·9 and R = 3·1 (10 R = 31).
This way you know what to do, if you additionally need the conversion of a counting system which is not marked on the cursor. The initial fixation of the cursor must be found by consideration and then be marked, or taken down, or kept in memory. The additional counts are always read on the A scale for a fixed length system, and on the B scale for a fixed weight system. (See also the explanations in small print on page 14.)

In case you want the relations between two counting systems only and the conversion of many values from one system to the other, we recommend the setting of a table. If it is about two fixed weight systems, you proceed in accordance with the following example:

P r o b l e m 9 : Set a table for the conversion of cotton from the English/American system (C) to the metric system (M), and vice versa.

S o l u t i o n : First you move the cursor line C over the figure 1*) of the firm A scale, and then the figure 1*) of the movable B scale under the cursor line M = 2 F. After that you can read on the A scale that the cotton count C = 1

*) Any other figure can be chosen, 1·1 or 1·2 for instance, but it has to be the same figure in both cases. You can also exchange the scales A and B with each other.

corresponds to the metric count M = 1·694. This relation, however, is set on the B scale and on the A scale at the same time; and you get a conversion table thus: —

Scale A:	M = 1·694	5	10	11	32	50·8	60
Scale B:	C = 1	2·95	5·91	6·5	18·9	30	35·4

You can read these numbers without the aid of the cursor, so that you save time. Likewise a conversion table for any two fixed length systems can be set. We convert a fixed weight system to a fixed lenght system, and conversely, with the reciprocal scales A and BI. That way, however, we cannot do without the cursor; therefore it is recommended that the procedure should be according to the examples 7 or 8.

V. Weight Calculations for Yarns and Cloths and other Uses of the Cursor Lines

The cursor lines need not only be used to convert counts. They can also be used to calculate weights of yarns and cloths fast and simply.

The other way around, the cursor lines compute the counts from the length and the weight, or the length from the counts and the weight. The cursor line T for Typp has an important part in all these calculations; we always use it together with the cursor line for the counting system in question. The following calculations are based on the formula:

$$\text{Weight in lbs} = \frac{\text{length in yds.}}{1000 \times \text{Typp}} = \frac{\text{length in yds.}}{1000 \times \text{counts} \times \text{conversion factor}}$$

It is not necessary to know conversion factors, neither for these calculations nor for the simple count conversions according to section IV. Moreover, we save time, because many calculations can be made **with only one move of** the slide and the cursor, as indicated by the following examples. The standard Slide Rule cannot accomplish that.

P r o b l e m 10: How many lbs does a bobbin with 530 yds. of cotton yarn C = 5s. weigh?

S o l u t i o n: Slide the cursor line T over A 5·3 and B 5 under cursor line C. Now we find the Typp counts T = 4·2s. corresponding to C = 5s., on the B scale under the cursor line T. At the same time the quotient $\frac{\text{length in yds.}}{\text{Typp}} = \frac{530}{4{\cdot}2}$ is set on the scales A and B, according to the abovementioned formula. We read the weight looked for on the A scale: 0·126 lbs (net yarn weight). Furthermore, we can read the weight for any number of bobbins, for instance:

Scale A:	Weight in lbs =	0·126	0·379	3·15	5·18	5·7	8·2	
Scale B:	Number of bobbins =	1	3	25	41	46	65	(see the following Fig. 3)

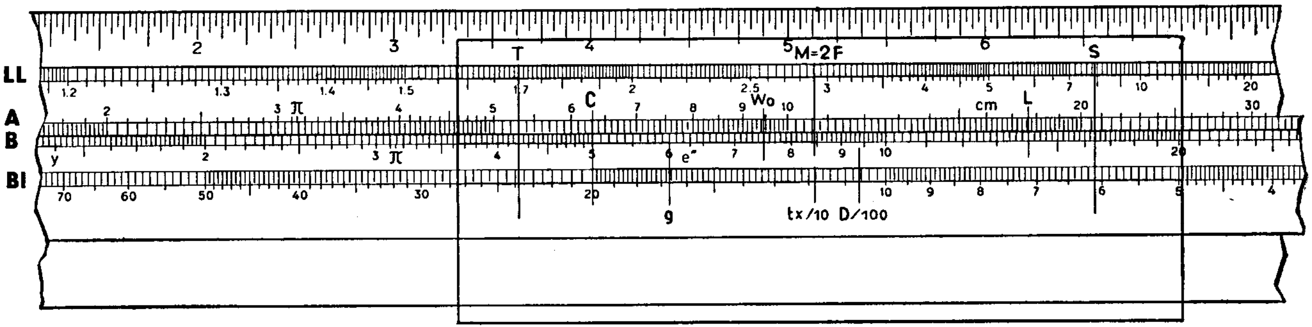

Fig. 3

If the counts are to be calculated from the length and the weight, then we set conversely and read the following counts under the various cursor lines, in case we have the numerical values of our example: T = 4·2, C = 5, Wo = 7·5, M = 8·47, L = 14, S = 16·4, g = 16·67 grains per 10 yds., tex = 118 (grex = 1180), D = 1062. The other cursor lines are left out in Fig. 3, to make the picture clearer.

Problem 11: A towel is one yard long and consists of 530 warp yarns of unbleached linen L = 14s. How much do the warp yarns weigh, with 10 % contraction (percentage of addition)?

Solution: Move the cursor line T over A 5·3 and B 14 under the cursor line L. The weight of the warp yarn is over B 1·10 (1 yd. + 10 %) on the A scale: 0·139 lbs (see Fig. 3).

The weight of the weft yarn, too, can be calculated in a similar way. The total weight of the towel is the addition of both values. Metric units of measure are calculated the same way. The only difference is that we use the cursor line M = 2 F, instead of the cursor line T.

Problem 12: A cloth is 200 metres long and consists of 1067 warp yarns of worsted Wo = 7·5s. How many kilogs. do the warp yarns weigh, with 5% contraction (percentage of addition)?

Solution: Slide the cursor line M = 2 F over A 10·67 and B 7·5 under the cursor line Wo. Now the weight of the warp yarn stands over B 2·1 (200 metres + 5% for contraction): 26·5 kilogs. — The numerical values for this problem are chosen in accordance with the setting of the **Slide Rule in Fig. 3.**

Calculating the length of a cloth in yards per 1 lb you can use a approximate formula which furnishes results of sufficient accuracy, provided that the number of threads per in. is about equal for warp and weft, and that the warp yarn and weft yarn counts differ only slightly. If the number of threads and the yarn counts are equal, then the result is absolutely accurate. The formula reads $l \; \frac{1}{wt} = \frac{Na \times Co \times 1000}{wi \times (p + e)} = \frac{Typp \times 1000}{wi \times (p + e)}$

The symbols mean:

l = length of the cloth in yards per 1 lb.

wt = weigth of the cloth in lbs. per 1 yd.

wi = width of the cloth in in.

$(p + e)$ = (picks and ends), that is, the sum of the number of threads in a square inch.

Co = Conversion factor = $\frac{\text{hank length of the yarn used}}{1000}$

Na = average count. It is calculated according to the "Twisted Yarn Calculations of every Kind" (see section XI, page 27).

$Na = 2 \times \frac{(Np \times Ne)}{Np + Ne}$ (and not by any chance $\frac{Np + Ne}{2}$

P r o b l e m 1 3 : $(p + e) = 29 + 31 = 60$, $wi = 21$ in. and $Na = 6{\cdot}31$ (Cotton of the English/American counting system C). What is the weight of (a) one yard and (b) one metre of this cloth?

S o l u t i o n : The abovementioned formula is changed to $(p + e) \times wi = \underbrace{(Na \times Co)}_{Typp} \times wt \times 1000 =$

$$\frac{\overbrace{(Na \times Co)}^{Typp} \times 1000}{l}$$

We set accordingly, as follows:

Set:	Slide	[A]	(p + e) = 29 + 31 = 60 (6)
		[BI]	wi = 21
	Cursor	[A]	cursor line C over average count 6·31
Read:*		[B]	under cursor line T = 4·2 yds. per 1 lb (= l)
			„ „ „ M = 2 F = 8·47 metres per 1 kilog.
		[BI]	„ „ „ T = 0·238 lbs. per 1 yd. (= wt)
			„ „ „ g = 1667 grains per 1 yd.
			„ „ „ tx/10 = 0·118 kilogs. per 1 metre
			„ „ „ S = 61 drams per 1 yd.
*) See chapter III, especially problem 6 on page 14			

It may still be mentioned on the side that we can read the approximate (not accurate) value "kilog. per 1 yd." on the BI scale under the cursor line D/100. The accurate value is less than 2% higher than the value 0·1062 kilogs. per 1 yd. on the BI scale.

Again the numerical values of this problem were chosen in accordance with the setting of the Slide Rule in Fig. 3.

If the average contraction c with its percentage of addition shall be taken into account, then we must add this percentage to the values wi, or (p + e), before setting the Slide Rule. For instance, c = 5% and wi = 20; now the adjusted value is wi = 20 + 5% = 21 which we set on the BI scale. In that case the numerical values compiled in the foregoing table and in Fig. 3 are valid for a cloth width wi = 20 in. and an average contraction c = 5% (instead of wi = 21 without taking the contraction into account).

Of course, the cloth width, the number of warp yarns and weft yarns, or the average count can be calculated, if we have a fixed cloth weight. — The most important calculations explained in this section may appear a little complicated at first. But after some practice they will not appear so difficult and will save much time and mental labour, provided that you are completely familiar with the special calculations explained in the foregoing sections III and IV, and with the sense and the scope of the long cursor line T.

VI. General Remarks about Calculations with Three Factors, Proportions, and Tables

Calculations with factors (proportions), whose solution allows the compiling of tables, are very frequent in textile calculations. Hence such problems, to which belong some of the foregoing problems, are discussed below. These may have direct and indirect proportions, among others, and may be linear as well as in square root relation.

a) Direct proportions, linear

for instance, according to the relations:
double working time — double production
half Denier counts — half yarn weight

Proportions of this kind are set on two scales movable to each other, whose scales run in the same direction and agree with each other. On the Textile Slide Rule these are the pairs of scales A and B or C and D.

Among others, the problems No. 4 and 9 bring the examples for proportions of this kind which are the easiest among the proportions a) to d).

b) Indirect proportions, linear

for instance, according to the relations:
double number of machines — half working time
half English/American
cotton counts — double yarn weight

Proportions of this kind are set on two scales movable to each other, whose scales run reciprocally, but have equal graduations. On the Textile Slide Rule these are the scales A and BI.

Among others, the problems No. 14 and 15 bring examples for proportions of this kind.

c) Direct proportions, square root

for instance, according to the relations known by the twist formula $T = \alpha \sqrt{N}$

counts 4 times as high — $\sqrt{4}$ times (= double) number of twists

counts 4 times as low — $\sqrt{\frac{1}{4}}$ (= half) number of twists

Proportions of this kind are set on two scales movable to each other, whose scales run in the same direction. One scale gives the square roots of the figures of the other scale. On the Textile Slide Rule these are the pairs of scales C and A or D and B.

Problem No. 16 is an example for proportions of this kind.

d) Indirect proportions, square root

for instance, according to the relations valid for driving twist change wheels

counts 4 times as high — $\sqrt{\frac{1}{4}}$ (= half) number of teeth

counts 4 times as low — $\sqrt{4}$ times (= double) number of teeth

Proportions of this kind are set on two scales movable to each other, whose scales run reciprocally. One scale gives the square roots of the other scale. On the Textile Slide Rule these are the scales D and BI.

Problem No. 17 is an example for proportions of this kind.

VII. Tables for Draft Change Wheels

Draft change wheels are driving wheels, as a rule. On this condition the following two formulae are valid:

I) $\text{Draft} = \dfrac{\text{counts of delivered yarn}}{\text{counts of feed}} = \dfrac{\text{draft constant}}{\text{draft change wheel}}$

II) $\dfrac{\text{Required draft change wheel}}{\text{present draft change wheel}} = \dfrac{\text{present counts}}{\text{required counts}}$

Problem 14: The counts 45s. were spun by a driving draft change wheel with 25 teeth. Without changing the counts of feed it is required to go over to higher or lower counts. What is the relation between the number of teeth of the required draft change wheels and the required counts belonging to them?

Solution: This is a question of forming an indirect linear proportion, as explained in section VI b, page 21. We set the numerical values in accordance with formula II), as given in the third and fourth line (II) of the following table: Then the results to compile a table, can be read.

If the abovementioned setting values (25 and 45) are not known, or the count of feed is changed, then we use the draft constant and the count of feed at the beginning. For instance, if the draft constant is 281 and the count of feed 4, then we set the values, as given in the first and second line (I). The results of both settings will be the same, because we have chosen the numerical values accordingly. (Combining two yarns we must set the count of feed 4 : 2 = 2, combining n yarns the count of feed is 4 : n. If the doubled yarns or slivers consist of various counts, first we calculate the resultant count according to the information in the section XI "Twisted Yarn Calculations of every Kind" on page 27 ff.)

Set:	either (I)	[A]	Count of feed	4	(40)
		[BI]	draft constant	281	(28,1)
	or (II)	[A]	present counts	45	
		[BI]	present draft change wheel	25 teeth	
Read:		[A]	required counts	40 35 28 22 20	
		[BI]	required draft change wheel	28 32 40 51 56 teeth	

In case we must set or read two numbers on reciprocal scales with equal graduation (for instance, the scales A and BI), the first number can be set or read on the upper scale A and the second number on the lower scale BI, or vice versa.

We have direct linear proportions for driven draft change wheels, so that we set and read the numerical values on the scales A and B or C and B.

VIII. Tables for Twist Change Wheels dependent on Yarn Twist

As a rule twist change wheels are driving wheels. On this condition the relations are

I) $\text{Turns per inch} = \dfrac{\text{twist constant}}{\text{twist change wheel}}$

I) $\dfrac{\text{required twist change wheel}}{\text{present twist change wheel}} = \dfrac{\text{present turns per inch}}{\text{required turns per inch}}$

Problem 15: A roving with 0·94 turns per inch was spun by a driving twist change wheel with 50 teeth. Another roving of more or less than 0·94 turns per inch is to be produced. How must we change the number of teeth of the twist change wheel?

Solution: Again we must form an indirect linear proportion. The given values are set according to formula (II), as stated in the third and fourth line of the following table (II). The results again compile a table.

When the twist constant is known, e. g., 47, we set the Rule according to formula I), as stated in the first two lines (I). The table values in this case are the same because the twist constant was chosen accordingly.

Set:	either (I)	[A]	Twist constant	47
		[BI]	beginning or end of the graduation	1
	or (II)	[A]	present yarn twist	0·94
		[BI]	present twist change wheel	50 teeth
Read:		[A]	required yarn twist	≈ 0·98 0·9 0·87 0·84
		[BI]	required twist change wheel	= 48 52 54 56 teeth

Driven twist change wheels are rarely used (for instance, in the spinning machines of J. J. Rieter & Cie, Winterthur, Switzerland). Their proportions are direct and linear, so that the numerical values have to be set on the equal scales A and B, or C and D, which run in the same direction.

Further examples for indirect linear proportions are, the relations between the counts of a fixed length system (tex, grex, Denier, etc.) and the corresponding counts of a fixed weight system (Metric M, English/American Cotton counting C, etc.), between the diameters of a driven belt pulley and the corresponding r.p.m., and on many loom types between the number of teeth of the weft change wheels and the corresponding threads per inch.

IX. Tables for Winding Ratchet Wheels of the Fly-Frame and for driven Twist Change Wheels dependent on Counts

The number of teeth of the winding ratchet wheels of the fly-frame is directly proportional to the square root of the count of the roving. Accordingly, this is valid for driven twist change wheels, too, which require the following formulae:

I) Turns per inch $=$ twist multiplier $\alpha \times \sqrt{\text{counts (or roving)}}$ $=$ twist constant $\times$ twist change wheel or transformed into:

$$\frac{\text{twist constant}}{\text{twist multiplier}} = \frac{\sqrt{\text{counts}}}{\text{twist change wheel}}$$

$$\text{II)}\quad \frac{\text{Required twist change wheel}}{\text{present twist change wheel}} = \frac{\sqrt{\text{required counts}}}{\sqrt{\text{present counts}}}$$

(valid for constant twist multiplier α)

P r o b l e m 16: The counts 25s. was spun by a driven twist change wheel with 43 teeth. It is required to go over to higher or lowers counts. What is the relation between the number of teeth of the required twist change wheels and the corresponding new counts?

S o l u t i o n : Here it is about a direct proportion with a square root relation, according to the explanations in section VI c, page 21. The given values are set in accordance with formula II) as stated in the third and fourth line (II) of the following table. The results compile a table which is valid for a constant α.

If the setting values (43 and 25) are not known or if you have to figure on a change of α, then you start setting the twist constant and the twist multiplier α. If the twist constant is 0·465 and $\alpha = 4$, for instance, then you set these values according to formula I), as stated in the first two lines (I). The resulting values of the table are the same, because the figures of the example are chosen accordingly.

S e t :	either (I)	[C]	Twist multiplier α	4
		[D]	twist constant	0·465 (4·65)
	or (II)	[A]	present counts	25
		[C]	present twist change wheel	43
R e a d :		[A]	required counts	≈ 30 38 41 44
		[C]	required twist change wheel	= 47 53 55 57 teeth

When setting the counts in this and the next problem care must be taken regarding the decimal point. For details see the section "Squares and Square Roots" on page 8. The counts can also be read on the B scale, and the number of teeth of the twist change wheels on the D scale, if we set correspondingly. To calculate fly frame winding ratchet wheels we must proceed according to the foregoing example.

X. Tables for driving Lifter Change Wheels (Lay Change Wheels) of the Fly Frame and for driving Twist Change Wheels dependent on Counts

The number of teeth of driving lifter change wheels (lay change wheels) of the fly frame is in reciprocal relation to the square roots of the roving. Driving twist change wheels are calculated accordingly; the two following formulae are valid for them:

I) Turns per inch = twist multiplier $\alpha \times \sqrt{\text{counts (or roving)}} = \dfrac{\text{twist constant}}{\text{twist change wheel}}$ or transformed into:

$$\frac{\text{twist constant}}{\text{twist multiplier}} = \text{twist change wheel} \times \sqrt{\text{counts}}$$

II) $\dfrac{\text{Required twist change wheel}}{\text{present twist change wheel}} = \dfrac{\sqrt{\text{present counts}}}{\sqrt{\text{required counts}}}$ (valid for constant twist multiplier α)

Problem 17: The counts 20s. was spun by a driving twist change wheel with 26 teeth. In order to go over to higher or lower counts, how is the number of teeth of the twist change wheel varied?

Solution: Here we have an indirect proportion with a square root relation, as explained in the section VI, on page 22. The given values are set according to formula II), as stated in the following table in the third and fourth line (II). The resulting table is valid on condition that α is constant.

In cases where we do not know the abovementioned setting values (26 and 20), or where we have to calculate with a changed α, we start setting the twist constant and the twist multiplier on the Rule. For example, if the twist constant is 465 and $\alpha = 4$, then we set these values according to formula I), as stated in the first two lines (I). The table values of the result do not change, because here again we have chosen the numerical example accordingly.

Set:	either (I)	[C]	Twist multiplier α		4			
		[D]	twist constant		465			
	or (II)	[BI]	present counts		20			
		[D]	present twist change wheel		26 (2·6) teeth			
Read:		[BI]	required counts	$\approx$	16	15	14	11
		[D]	required twist change wheel	=	29	30	31	35 teeth

In the same way we can calculate the driving lifter change wheels (lay change wheels) of the fly frame.

XI. Twisted Yarn Calculations of every Kind

Calculating the twisted yarn counts on a fixed weight system the following familiar twisted yarn formulae are used:

$$tw = \frac{N_1 \times N_2}{N_1 + N_2}, \text{ for a 2-fold yarn,}$$

$$tw = \frac{N_1 \times N_2 \times N_3}{(N_1 \times N_3) + (N_2 \times N_3) + (N_1 \times N_2)}, \text{ for a 3-fold yarn, etc.}$$

The Textile Slide Rule makes unnecessary the knowledge and use of these formulae which are quite clumsy for three-fold and cabled yarns. We calculate the counts of a 2-, 3- or 4-fold thread with the aid of the special scales Z_1 and Z_2, partly also Z_3. With only 1, 2, or 3 moves of the slide calculation is as fast and convenient as the multiplication of 2, 3, or 4 figures. Intermediate additions, which are unavoidable with the foregoing formulae, are not necessary with the Textile Slide Rule method.

To make calculations for twisted yarns we first invert the slide so that the complete scales Z_1, Z_2, and Z_3 appear upright on the face of the Slide Rule. Then the following general rule is valid for the computation of twisted yarn counts:

The twisted yarn counts for 2 (or more) single yarns are calculated with the aid of the scales Z_1 and Z_2 by exactly the same method as the product of 2 (or more) figures with the aid of the scales A and BI.

The calculations with the reciprocal scales A and BI have been fully described on page 9, among others. — After inverting the slide we will explain the use of the foregoing rule by some examples.

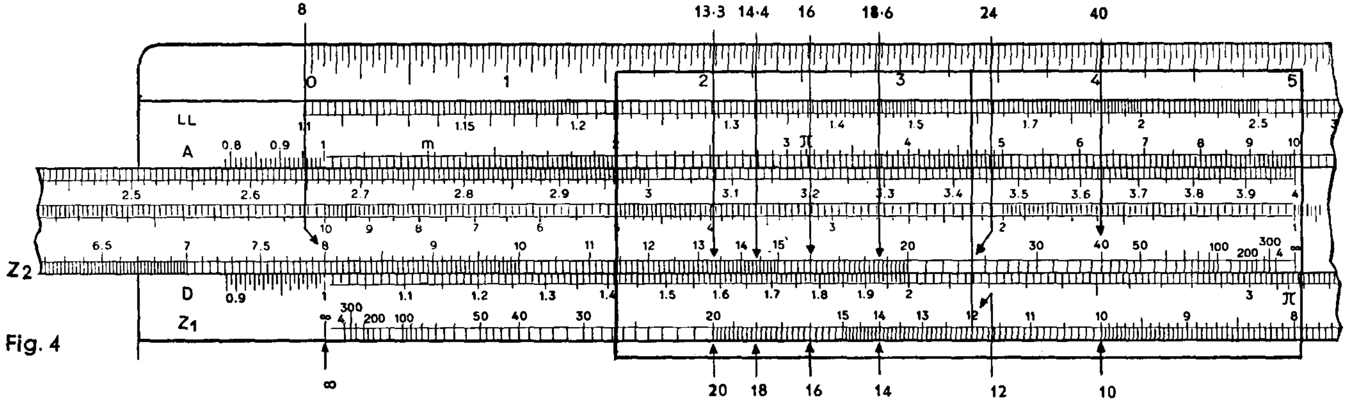

Fig. 4

Problem 18: Calculate the twisted yarn counts tw for a 2-fold twisted yarn which consists of the single yarns C = 24s. and C = 12s.

Solution: Move Z_2 24 over Z_1 12, or reversed, with the help of a I. L. After that the result is opposite the graduation mark ∞ which has to be considered the beginning of the graduation, in a way, and can be read on Z_2 as well as on Z_1. It is useful, however, to read the result for 2-fold twisted yarns always on the movable scale Z_2, because one does not need any more the I. L. for that. As the foregoing Fig. 4 shows: tw = 8s.

Problem 19: We want to produce a 2-fold twisted yarn tw = 8s. Which counts can the single yarns N_1 and N_2 have?

Solution: We set Z_2 8 over $Z_1 \infty$, or vice versa. Then the slide is in exactly the same position as in the preceding problem. Those counts which together give the 2-fold twisted yarn with the counts tw = 8s., are opposite each other on the two scales Z_1 and Z_2. A table of possible pairs of singles can be compiled as follows.

Set: Z_2 8 over Z_1 ∞ or	N_2	Z_2	or conversely	13·3	14·4	15·1	16	18·6	24	40
conversely	N_1	Z_1		20	18	17	16	14	12	10

Problem 20: Calculate the twisted yarn counts for a 3-fold twisted yarn which consists of the single yarns C = 24s., C = 12s., and C = 6s.

Solution: Z_2 24 over Z_1 12, just like problem 18. Then I. L. over Z_2 ∞ and finally Z_2 6 under I. L. The result stands opposite the graduation mark ∞ on the A scale to the right, or under A 100 on the Z_3 scale: tw = 3·429s.
We see two different things by this setting:

1. An intermediate result (here 8) is not read off, but only held by the I. L. on the firm Z_1 scale. We make use of it by continuing the calculation at once.
2. If the result cannot be read any more on Z_1 or Z_2, because the graduation has not these figures, then we take the result from the Z_3 scale.

If it is required to calculate the twisted yarn counts for C = 240s., 120s., and 60s., this can be done by the familiar method, the result is not very accurate, because of the peculiar scales. It will be estimated about 34·2. We obtain a more accurate result if we calculate the twisted yarn counts with the tenth part of the counts, then 24s, 12s, and 6s. According to the foregoing problem the resulting counts are 3·429s. The more accurate result is obtained after multiplication by 10, that is tw = 34·29s.

Problem 21: *A three-fold twisted yarn with the counts tw = 8s. is required. Two singles for this twisted yarn have* the counts C = 30s. and C = 24s. What are the counts of the third single?

Solution: Z_2 24 over Z_1 30, or vice versa. — An I. L. over Z_2 ∞: we leave the I. L. on this mark. Z_2 8 over Z_1 ∞. The result stands under the I. L. on Z_2: the third single has the counts C = 20s.

Problem 22: 45 lbs of the three-fold twisted yarn tw = 8s. given in the foregoing problem are to be produced. Calculate:

a) the single weights W_1, W_2, and W_3 of the singles with the counts C_1 = 20s., C_2 = 24s., and C_3 = 30s.

b) the shares of weight of the singles in percentage.

It is evident that the higher the yarn counts, the smaller is the weight of the single yarn. Therefore we have indirect linear proportion (page 21); the required values are set and read on the scales A and BI. The following two tables which give the solution to a) and b) are easily understood.

Solution:

Table for a)

<table>
<tr><td rowspan="2">Set:
tw = 8 [A]
over
W = 45 [BI]</td><td rowspan="2">or conversely</td><td>Counts C_1, C_2, C_3 [A]</td><td>20 24 30</td><td>Total</td></tr>
<tr><td>Yarn Weights W_1, W_2, W_3 [BI]</td><td colspan="2">18 + 15 + 12 = 45 lbs</td></tr>
</table>

Table for b)

<table>
<tr><td rowspan="2">Set:
tw = 8 [A]
over
% = 100 [BI]</td><td rowspan="2">or conversely</td><td>Counts C_1, C_2, C_3 [A]</td><td>20 24 30</td><td>Total</td></tr>
<tr><td>Percentage of weight [BI]</td><td colspan="2">40 + 33·4 + 26·6 = 100%</td></tr>
</table>

If the counts of the singles of a twisted yarn are not specified on the same counting system, they must be converted to a unitary fixed weight system. This can be done by means of the inverted slide, with the aid of the A scale and the cursor lines. Make the slide point to zero, if you also need the BI scale. In the foregoing calculations it is assumed that the original length of the singles, and the length of the twisted yarn produced are *equal i.e.*, that there is no contraction due to twist. We have also assumed this in the calculation of the twisted yarn counts. This assumption is not quite right, as the threads contract in length due to the twist. The greater the twist and the lower the counts of the singles, the shorter the length of twist yarn obtained. By this loss in length the effective (real) counts of the twisted yarn, in a fixed weight system, are lower than the result of a merely theoretical calculation which does not take into account this contraction or "take-up".

For example, if the length of a twisted yarn is 0·87 yds. and the length of each single 1 yd., after untwisting and stretching, then the "take-up" is 0·13 yds., i.e., in percentage:

a) 13%, with reference to the original length of 1 yd., before twisting the singles. This percentage is called — % or loss percentage.

b) 15%, with reference to the length 0·87 yds. of the produced twisted yarn. This percentage is called + % or percentage of addition.

The percentage take-up to allow is found out only by experience or practical experiments. To convert the counts calculated as above to the effective counts, use the two short scales which are on the back of the slide, on the left and on the right of the long Z_3 scale, and which have always to be used together with the A scale over it, after inverting the slide. You use

a) the short scale on the left marked — %, calculating loss percentage

b) the short scale on the right marked + %, calculating percentage of addition

The practical use of these two scales is explained by the following examples:

P r o b l e m 2 3 : The theoretical twisted yarn counts calculated which the aid of the two scales Z_1 and Z_2 are 9·2s. What are the effective twisted yarn counts taking into consideration a shortening of all singles by 13% each (loss percentage)?

S o l u t i o n : Slide the percentage cipher 13 of the short scale on the left under 9·2 and read the result over the beginning of the short scale on the left (figure 0) on the A scale. Then the effective counts of the twisted yarn are 8s.

P r o b l e m 2 4 : We want to produce a 2-fold twisted yarn with the effective twisted yarn counts 8s. According to the table of the problem 19 we can use, among other pairs, the singles with the counts 17s. and 15·1s. provided these are corrected by taking into account the take-up. What are the effective counts of the singles if we allow an addition of 6% for the take-up?

You must use the short scale on the right, because you have to calculate with the percentage of addition.

S o l u t i o n : Slide the percentage figure 6 of the short scale on the right

1) under A 17 and read the result 18 over the beginning of the short scale on the right (figure 0) on the A scale; then slide 6
2) under A 15·1 and read the result 16.

Then the two effective counts which have the effective twisted yarn counts 8s. are 18s. and 16s., taking into consideration the addition of 6% (= 5·66 loss percentage) as allowance for "take-up" in twisting.
Bleaching and gassing of yarn make it lighter which causes higher counts for the yarn of the fixed weight system. Dying and burnishing produces the reverse effect. Such changes of the counts, too, may be calculated advantageously with the help of the short scale on the left or on the right.
To this section another problem which combines all calculations for twisted yarn is given as follows:

Problem 25: It is required to produce 85 lbs of twisted yarn with the following threads:

Thread I: Metric M = 15 with 8% (+ %) allowance for take-up
„ II: Worsted Wo = 27 with 5% (+ %) allowance for take-up
„ III: Cotton C = 20 with 5% (+ %) allowance for take-up
„ IV: Denier D = 140 with 8% (+ %) allowance for take-up

Calculate the metric counts of the twisted yarn, and the weights and the weight percentage of the singles.
The answers are calculated as shown in the following table, and the method follow the explanations 1. — 4.:

Thread	I	II	III	IV	Twisted yarn	Explanation
Given counts	M = 15	Wo = 27	C = 20	D = 140	—	—
Metric counts **without** allowance for take-up	15	30·5	33·8	64·3	—	1.
Given percentage of addition for take-up	8	5	5	8	—	—
Metric counts **with** allowance for take-up	13·9	29·1	32·2	59·5	≈ 6·5	2.
Weights in lbs. ≈	39·6 +	19 +	17·1 +	9·3	= 85 lbs	3.
Weight percentage ≈	46·6 +	22·4 +	20·1 +	10·9	= 100%	4.

1. The inverted slide points to zero. Use scales A and BI and the cursor lines for the conversion of the counts.
2. Use the short scale on the right according to problem 24. Then calculate the twisted yarn counts with the aid of [Z_1] and [Z_2]. (Read the final result over $Z_1 \infty$).
3. Calculate according to the problem No. 22a.
4. Calculate according to the problem No. 22b.

It will be observed that the slide may remain inverted for all four calculations.

XII. Conversion of Loss Percentage to Percentage of Addition

The relations between loss percentage (— %) and percentage of addition (+ %) may also be tabulated using the special scales for twist yarn calculations.

Problem 26: Compile a table for the conversion of loss percentage to percentage of addition.

Solution: First the inverted slide is set so that the Z_2 scale is against scale A and so runs in the same direction as the Z_1 scale. It is known that loss percentages 50 = percentage of addition 100. These are set opposite with the aid a I. L. on [Z_2] and [Z_1] respectively. Hence the conversion table is complied by reading the values opposite each other.

Setting

50	[Z_2] inverted	— % [Z_2]	100	70	30	20	10	8	6	5·66
100	[Z_1]	+ % [Z_1]	∞	230	43	25	11·1	8·7	6.39	6

Because of the peculiarity of the scales the percentage values are less accurate, the more they approach the values 100 and ∞ for loss percentage and percentage of addition respectively. From about 70 to 100 the accuracy is completely unsatisfactory for most purposes. To get more accurate results use the figures 5 and 10 instead of 50 and 100, on [Z_2] and [Z_1], and then multiply the results on both scales by ten right away. The following table with its greater accuracy is compiled in this way.

Setting

5	[Z_2] inverted	— % [Z_2]	90	80	70	60	55	45	40	38
10	[Z_1]	+ % [Z_1]	900	400	233	150	122·2	81·8	66·7	61·3

The above explanations and the problems given in illustration may be considered sufficient to demonstrate the value of the Textile Rule. However, it is probable that a textile expert will realise other possibilities for calculation using the special scales and cursor which are easier, faster and safer than with the standard instrument.

The accuracy of the computations with the Textile Slide Rule will probably be sufficient for most textile calculations. If it is taken into account that they often have very uncertain calculation factors, for example, counts which deviate from the nomiral count by up to 2% and more in practice, it is obvious that minor mistakes arising by slightly inaccurate setting and reading of values are absolutely insignificant.

The calculation to an accuracy completely sufficient in practice, the extraordinary timesaving which results by the use of the special instrument, the relief of the memory from conversion factors, constants, and some formulae, as well as the possibility of compiling tables quickly, make the Textile Slide Rule system Schirdewan an indispensable calculating means for each textile expert who reaches mastership by practice remembering the saying:

NO MAN IS BORN A MASTER OF HIS TRADE.