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B-R-L

COMPREHENSIVE SLIDE RULE INSTRUCTION BOOK

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DORSET, ENGLAND.

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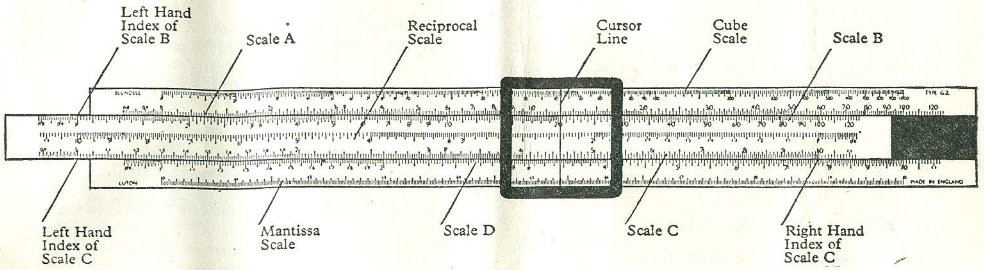
INDEX

SIMPLE INSTRUCTIONS IN THE USE OF

B-R-L SLIDE RULES



These instructions are intended for those who have not previously used slide rule and pre-suppose only familiarity with the decimal system.

MULTIPLICATION

Example I

Multiply 2·75 x 16·7 Answer=45·925

Slide the scale C to the right until the 1 on Scale C (called the left hand index) is over 2·75 on Scale D.

Now find 16·7 on Scale C and the answer lies underneath it on Scale D.

It is usual to slide the cursor along until the centre black line coincides with the 16·7 on Scale C—the answer 45·9 can then easily be read off Scale D.

Note.—No greater accuracy than 45·9 can be achieved with a 10″ rule and the position of the decimal point must be fixed by inspection.

Example II

Multiply 192 x 72·1 Answer=13843

If the left hand index on Scale C is placed over 192 on Scale D it will be seen that when you slide the cursor to cover 721 on Scale C it will fall off the rule.

In this case you use the right hand 10 on Scale C (called the right hand index) to cover the 192 on Scale D.

Find 721 with the cursor on Scale C an read off the answer underneath on Scale D.

The nearest answer obtainable on a 10″ rule lies between 13830 and 13850.

Example III

Calculate the selling price of 17 articles costing 84/3d. each to secure profit of $12\frac{1}{2}$% on cost.

The sum to be worked out can be expressed as follows:

$$84{\cdot}25 \text{ (shillings)} \times 17 \text{ (articles)} \times \frac{112{\cdot}5}{100} \text{ increase}$$

or (84·25 x 17 x 1·125) shillings=£80-11-3.

Find the first number 84·25 on Scale D and slide the right hand index of Scale C over it. Slide the cursor to 17 on Scale C and the product of 84·25 x 17 (viz. 1432 shillings) lies on the cursor line on Scale D.

For the percentage increase one must multiply this product by 1·125. It is convenient to keep the cursor where it is and slide the left hand index of Scale C until it coincides with the cursor line. Now slide the cursor to 1·125 on Scale C and the answer (1611 shillings) lies below on Scale D.

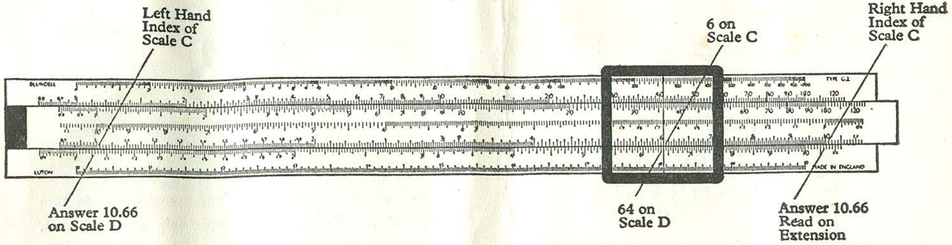
DIVISION

Example IV

To divide say 64 by a series of numbers.

Find 64 on Scale D and place the cursor line over it. Keeping the cursor stationary find the number which you wish to divide by (divisor) on Scale C and slide the Scale C along until that number coincides with the line on the cursor. The answer will lie on Scale D under either the left or right index of Scale C.

Note the positions on the rule are the same whether the dividend be 64, 0·64 or 6400 and the divisor 32, ·032 or 3200.



The illustration shows 64 divided by 6=10·66 and demonstrates the use of the extension on the scales since the answer can be read from either end.

COMBINED MULTIPLICATION & DIVISION

Example V

To find 3/16th of 5.2/7ths.

This sum can be written 3/16 x 37/7 and can be tackled in various ways on the slide rule.

Perhaps the easiest is first to multiply 3 by 37 and then divide the product by 7 and the answer by 16. The operations are as follows:

Place the left hand Scale C index over 3 on Scale D and slide the cursor to the extreme right over 37 on Scale C. The product lies where the cursor line cuts Scale D at 111.

To divide by 7, hold the 111 on the cursor, and slide 7 of Scale C on to the cursor line. The answer (15·86) lies on Scale D under the Scale C left hand index.

To divide by 16, hold the position by sliding the cursor to 15·86 on Scale D (where the Scale C left hand index is) and then slide the 16 on Scale C to the cursor line.

The final answer (·991) lies underneath the right hand Scale C index on Scale D.

These operations can be performed in 20 seconds or less with practice.

Position of the decimal point

The quickest way to determine the position of the decimal point is to make a quick mental calculation. This has proved to be more effective than any set rules.

Example. 33 x 600

Answer is in the region of 20,000, and not 2,000 or 2,000,000.

A & B SCALES

The *Examples I–V* illustrate the use of the slide rule in multiplication and division, singly or combined. These operations can be equally well performed using Scales A & B with more convenience but less accuracy.

Scale A being divided into two equal halves can be used for quickly finding the square or square root of a number.

SQUARE, SQUARE ROOT

Example VI $2{\cdot}2^2$ Answer=4·84

Put cursor on 2·2 on Scale D, and read result on Scale A. The answer lies between 4·8 and 4·85.

Example VII $\sqrt{15}$ Answer=3·87

Put cursor line on 15 on Scale A, and read result on Scale D. The answer lies between 3·86 and 3·88.

CUBE SCALE
(sometimes marked " K ")

This scale is used for quickly finding the cube or cube root of a number.

Example VIII To find the cube root of 19·7.

As two whole numbers precede the decimal point use the middle of the three equal scales (into which the cube scale is divided). Place the cursor line on 19·7 and read off 2·7 approximately underneath on the D scale. For amounts with one or four whole numbers before the decimal point use the left hand section of the cube scale and so on.

RECIPROCAL SCALE (CI)

The reciprocal scale in the centre of the slide, apart from its use in calculating the reciprocal of numbers, can be used in multiplication to save unnecessary movement of the slide, but beginners are advised first to master the use of the ordinary scales to avoid confusion.

Example IX Multiplication 82 x 3 Answer=246

Set cursor line over 82 on Scale D, and slide 3 on reciprocal scale along to cover it. Read result, 246, on Scale D, under left hand index of Scale C.

Example X Division $\frac{25}{4}$ Answer=6·25

Set left hand index on Scale C over 25 on Scale D, move cursor to 4 on reciprocal scale, and read result, 6·25, where cursor line cuts Scale D.

MANTISSA SCALE (L.)

If the cursor line is placed on any number on Scale D, the mantissa of the logarithm of that number can be read off on the scale at the bottom of the rule and vice-versa.

Where the mantissa scale is engraved on the back of the slide as in our Technician's Rule Type T12, slide any number on Scale C over the left hand index of Scale D, and the mantissa of that number will appear under the left hand window index at the back of the rule.

AUXILIARY CURSOR LINES

(1) The red lines to the left and right of the cursor, over scales A and D respectively, enable you to read the area of a circle at a single setting, when used in conjunction with the centre line.

Set Diameter on Scale D, under R.H. red line and read area on Scale A, under centre line. Or, set diameter on Scale D under centre line, and read area on Scale A under L.H. red line. Reverse either settings to find diameter from area.

(2) A short black line to right of centre over Scale A, used on some models, is the factor for converting Watts to H.P. Thus when the centre line is placed on 746 watts, the factor line is over 1 H.P.

(3) **Mark 36 for Folded Scales**

With central cursor line over X on D Scale read 36 x X on DF Scale under right hand mark on cursor. 3600 seconds=1 hour. 3600″=1°. 3.6 Kilometres per hour=1 metre per second. 360 days=1 year approx.

LOG-LOG SCALES

For the sake of uniformity, Log-Log Scales will be marked LL1, LL2, LL3 in all new editions of existing models as they are brought out.

Particulars are as follows:

LL1 Scale extends from 1·01 to 1·1
LL2 ,, ,, ,, 1·1 to 2·72
LL3 ,, ,, ,, 2·72 to 10^4

On a few models these Scales are marked LI, UL, and LL respectively, and until the change over is complete both sets of markings may be used.

The uses of the log-log scales in combination with the linear scale, usually described as C scale, are manifold, and after having studied the main applications, as shown in the following paragraphs, the mathematically trained user will have no difficulty in becoming familiar with all its applications.

Raising to Powers

Example: $1{\cdot}13^{2\cdot5}=1{\cdot}357$.

With the cursor line, set 1 on linear Scale C under 1·13 on LL2 scale, and over 2·5 on Scale C read the result 1·357 on LL2 scale.

Extraction of Roots

Example: $\sqrt[4\cdot1]{65}=2{\cdot}768$.

With the cursor line, set 4·1 on Scale C above 65 on LL3 scale, and read under 1 on Scale C the result on LL3 scale, which is 2·768.

The logarithm of a number to any base may be found within the limits of the log-log scales.

Example: Find $\log_e 4{\cdot}26$.

With the cursor line, align the 10 of Scale C with 2·718 on the LL2 scale, (at this point it will be seen that Scales C and D are coincident), slide the cursor to 4·26 on the LL3 scale, and the answer 1·446 is read above on Scale C.

Note also:

(1) The LL3 scale represents the 10th power of any number above it on the LL2 scale. The corresponding rule applies for the 10th root.

(2) Under every number " a " on the linear Scale D of the body will be found e^a on the LL3 scale.

(3) Since the log-log scale does not extend to negative values, when evaluating expressions of the form x^{-n} use must be made of the relationship $x^{-n}=\frac{1}{x^n}$ or $\left(\frac{1}{x}\right)^n$ for which the red reciprocal scale on the slide will be useful.

PROCEDURE FOR USE OF LOG-LOG SCALES ON THE DARMSTADT RULE

Scales LL1, LL2 and LL3 are engraved on the reverse of the slide and are designed to be read through the windows at each end of the back of the rule.

To find $1{\cdot}13^{2\cdot5}$

Slide 1·13 on Scale LL2 under the left-hand window.
Place cursor line over 10 on Scale C.
Slide 2·5 on Scale C under cursor line.
Read off 1·357 on Scale LL2 under right-hand window.

To find $\sqrt[4\cdot1]{65}$

Slide 65 on Scale LL3 under the right-hand window.
Place cursor over 4·1 on Scale C.
Slide 10 on Scale C under cursor line.
Read 2·768 on Scale LL2 under right-hand window.

JANUS SERIES OF DOUBLE-SIDED SLIDE RULES

MODELS T.50 & T.51

These models contain a number of scales used in the range of single-faced rules and in addition, a set of extra Log-Log scales.

Details concerning all Log-Log scales are as follows:

(A) *Log-Log Scales*

LL1 extends from 1·01 to 1·105
LL2 ,, ,, 1·105 to 2·72
LL3 ,, ,, 2·72 to 22,000

(B) *Reciprocal Log-Log Scales, relative to the A and B Scales* $e^{-.001}$ *to* e^{-10}

LL0 extends from ·999 to ·905
LL00 „ „ ·905 to ·00009

A.1 *Examples in the use of Log-Log Scales LL1, LL2, LL3. Raising to Powers:*

Example: $1{\cdot}13^{2\cdot5}=1{\cdot}357$

Set the hair line over 1·13 on scale LL2. Slide the 1 of Scale C to the hair line and then set cursor to 2·5 on Scale C and read off 1·357 on Scale LL2. The same applies to values on LL3 scale.

Extraction of Roots:

Example: $\sqrt[4\cdot1]{65}=2{\cdot}768$

With the cursor line set 4·1 on Scale C above 65 on LL3 scale, and read under 1 on Scale C the result on LL3 scale, which is 2·768.

Logarithms

The logarithm of a number to any base may be found within the limits of the Log-Log scales.

Example: Find $\log_e 4{\cdot}26$

With the cursor line set the 10 of Scale C in line with 2·718 on the LL2 scale (at this point it will be seen that scales C and D are coincident), slide the cursor to 4·26 on the LL3 scale, and the answer 1·446 is read above on Scale C.

Note also:

(1) The LL3 scale represents the 10th power of any number below it on the LL2 scale. The corresponding rule applies for the 10th root.

(2) Under every number " a " on the linear Scale D will be found e^a on the LL3 scale.

B1. *Examples in the use of reciprocal Log-Log scales LL0 and LL00.*

These scales bear a relationship to the A scale such that $y=e^{-x}$ where y is the reading on LL0 or LL00 and x is the value on Scale A.

Value of e^{-x} can be read off directly from Scales LL0 and LL00. The cursor line is placed on the value of x on Scale A and the corresponding value of e^{-x} is found immediately above on Scale LL0 or LL00.

Example 1. To evaluate e^{-3} set the cursor line on 3 of the right-hand decade of Scale A and read off 0·05 above on Scale LL00.

or

e^{-1} that is $\frac{1}{e}$ can be seen to be 0·368 by moving the cursor line over the central 1 on Scale A.

It should be noted that values on Scale LL0 are the 10th root of corresponding values on Scale LL00.

Example 2. Evaluate $0{\cdot}8^{2}$. Set cursor line over 0·8 on Scale LL00 slide 1 on B scale under cursor line. Move cursor line to 2 on Scale B. Read off answer 0·64 on Scale LL00.

Example 3. Evaluate $\sqrt[4]{0{\cdot}2}=0{\cdot}2^{0\cdot25}$. Set cursor line over 0·2 on Scale LL00 slide 1 on Scale B under cursor line. Move cursor to the left on to 0·25 on Scale B. Read off answer 0·669 on Scale LL00.

TRIGONOMETRICAL SCALES

Trigonometrical Scales are either drawn relative to Scales A or D. Where they are drawn relative to Scale A, the angles begin at 0·5°, and when relative to Scale D, they begin approximately at 5°.

These Scales usually appear on the back of the Slide, and should be read through the windows provided. It is sometimes useful to reverse the Slide, where a table of Sines or Tangents is required, although Slides are not made to fit flush for ordinary use in that position.

Note.—The sub-divisions between the figures are not necessarily constructed in decimal intervals on the trigonometrical scales, as on the rest of the rule, but on the basis of 60 minutes to one degree, and special care should be taken when reading.

To find the numerical value of the Sine or Tangent of an angle

Align the ends of the trigonometrical scales with the left and right indices on Scale D. Slide the cursor line over any angle marked on Scales S & T or S, and the numerical value of the sine of that angle will appear lower down the hair line on Scale D.

By using the Scales S & T or T, the numerical value of the tangent of any angles less than 45° will be found in the same way.

The position of the decimal point can be found by memorising or referring to the following table:

Sin 0° 34′=0·01	Tan 0° 34′=0·01
Sin 5° 43′=0·1	Tan 5° 43′=0·1
Sin 90° =1·0	Tan 45° =1·0
	Tan 84° 17′=10·0

For angles greater than 45° up to 84° 17′ use

$$\text{Tan } \theta = \frac{1}{\text{Tan } (90-\theta)}$$

Example I. To find Tan 72° 30′
90°—72° 30′=17° 30′

Place cursor line on the right hand index of Scale D and slide 17° 30′ on the T scale also on to the cursor line. Under the left hand index of the T scale one can read 3·17 on Scale D.

Example II. To evaluate 2·17 sin b where b=31° 20′

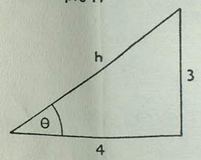
Slide 31° 20′ on the S scale under the right hand window at the back. Now looking at the face of the rule move the cursor line on 2·17 on Scale D. The answer 1·128 lies above on Scale C.

Example III. To evaluate $\frac{\tan b}{2 \cdot 17}$ where $b = 31° \ 20'$

Slide 217 on Scale C over the left hand index of Scale D. Place the cursor line on the right hand index (10) of Scale C. Now looking at the back of the rule move the slide to the right until 31° 20′ on Scale T appears over the lower index in the right hand window.

The answer ·2807 can be read on the hair line on Scale C.

Example IV



i.e. $\tan \theta = \frac{3}{4}$ and $h = \frac{3}{\sin\theta}$

To find the hypotenuse h and angle θ given the 2 sides of a right angled triangle. Place 3 on C over 4 on D and read off tan 36° 52′ under RH window. Now slide sine 36° 52′ under RH window, and read off h=5 on D, under 3 on C.

For the solution of triangles, by making use of the appropriate formula, the slide rule is invaluable and with practice great saving in time can be achieved.

PROCEDURE FOR TRIGONOMETRICAL SCALES ON DARMSTADT RULE

The S and T scales being engraved on the body of the rule are particularly well placed for quick readings.

The value of the Sine or Tangent of any angle on S or T appears above on Scale D, and can be multiplied or divided by any factor using Scale C in the usual way.

For tangents of angles over 45° slide the cursor over the complement of the angle $(90° - \theta)$ some of which are marked in red figures on the T scale. First place the hair line over this angle on Scale T then slide the index of Scale C under the hair line and read off the tangent on Scale C over the index on Scale D.

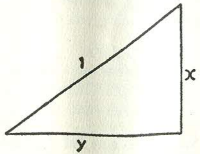
Or alternatively the Scales C and D can first be aligned with the indices coincident when the tangent of angles over 45° can be read direct off the Reciprocal Scale CI on the slide.

When reading off the Sine of an angle or tangent of an angle up to 45° the cursor also cuts the M scale from which can be read the log-sine or log-tan.

The cosine of an angle is obtained from the S scale using the red complementary figures instead of the black.

THE $\sqrt{1-x^2}$ SCALE OR THE PYTHAGORIAN SCALE (P.)

For a right angle triangle with a hypotenuse of unity we have referring to Fig.



$y = \sqrt{1-x^2}$

It is according to this relationship that the scale $\sqrt{1-x^2}$ is calculated so that direct reference to the D scale gives an immediate solution to the foregoing equation. The $\sqrt{1-x^2}$ is usually engraved on a slide rule immediately below the D scale and runs from the approximate value of $y = \sqrt{1-x^2} = 0 \cdot 995$ situated immediately below $x = 1$ on the D scale to $y = \sqrt{1-x^2} = 0$ situated immediately below $x = 10$ on the D scale. It should be appreciated that in actual fact the scale is calculated for value of x less than unity.

1. *Example* $\sqrt{1-0 \cdot 6^2} = 0 \cdot 8$

Place the cursor line on 0·6 on the D scale and read the corresponding value of $y = 0 \cdot 8$ on the $\sqrt{1-x^2}$ scale. Alternatively, place the cursor line on 0·8 on the D scale and read the corresponding value of $y = 0 \cdot 6$ on the $\sqrt{1-x^2}$ scale.

2. The solution of any right angle triangle.

Consider a right angle triangle whose hypotenuse is 25, whose base is 15. To find the vertical "y".

$$y = \sqrt{25^2 - 15^2}$$
$$= 25\sqrt{1 - \left(\frac{15}{25}\right)^2}$$
$$= 25\sqrt{1 - 0 \cdot 6^2}$$
$$= 25 \times 0 \cdot 8$$
$$= 20$$

3. *In the Vector calculations*

Consider an apparent electrical load (KVA) = 100% where the actual effective load (KW) is 85%, i.e. where the phase angle $\phi = 31° \ 47'$ or $\cos \phi = 0 \cdot 85$ then the wattless load $= \sqrt{1 - 0 \cdot 85^2} = 0 \cdot 526$, i.e. 52·6% wattless KVA or reactive KVA.

4. *Trigonometrical Functions*

Since $\cos \theta = \sqrt{1 - \sin^2\theta}$ and
$\sin \theta = \sqrt{1 - \cos^2\theta}$
the $\sqrt{1-x^2}$ scale provides a ready means of conversion from $\sin \theta$ to $\cos \theta$ and vice-versa.

For example if cos $\theta=0\cdot5$ set the cursor to 0·5 on the D scale. An immediate value for sin $\theta=0\cdot866$ can be read off from the $\sqrt{1-x^2}$ scale.

Naturally, each individual operator will most probably find specialised uses of the scale to suit the specific jobs in hand.

LOG-LOG SCALE for COMPOUND INTEREST (LL1)

The log-log scale LL1 on Technician's slide rules extends from 1·01 to 1·10 and therefore can be used for speedy calculation in compound interest.

Using the formula $A=P\left(1+\frac{p}{100}\right)^n$ where—

A stands for accrued amount.
P ,, ,, principal invested.
p ,, ,, rate of interest (percentage).
n ,, ,, number of years.

with three of these values given the fourth can easily be found on the slide rule.

Example I. £557 invested at $7\frac{1}{2}$% for $13\frac{1}{2}$ years. How much has it become?

substituting in the above formula:

$$A=557\left(1+\frac{7\frac{1}{2}}{100}\right)^{13\frac{1}{2}} \quad \text{or } 557\ (1\cdot075)^{13\cdot5}$$

we now require to raise 1·075 to the power of 13·5 and multiply the result by 557.

With the cursor place the right hand index of Scale C under 1·075 on LL1 scale. Slide the cursor to the left over 13·5 on Scale C and read off 2·66 underneath on the LL3 scale. Now multiply 2·66 by the principal, £557 on the C & D scales which gives £1,482 approximately.

Note.—When raising a number to a power as high as 13·5 it is sometimes difficult without practice to decide on which log-log scale to read off the answer.

With the cursor on 1·075 on the LL1 scale the number appearing immediately underneath on the LL2 scale is the 10th power of 1·075, viz. 2·06 while the 100th power will appear lower down still on the LL3 scale, viz. 1,380 approximately.

It is clear when remembering this that the result of raising a small number like 1·075 to the 13·5th power will not be much greater than raising it to the 10th power.

Example II. What sum must be invested at $4\frac{1}{4}$% to accrue to £2,000 in 16 years?

Substituting known values in the formula we have $2000=P\ (1\cdot0425)^{16}$.

To find P we must raise 1·0425 to the 16th power and divide the result into 2000.

Place the cursor over 1·0425 on LL1 scale and move the slide to the right until the left hand index of the C scale coincides with the hair line. Now move the cursor to the right over 16 on the C scale and read off 1·945 on the LL2 scale.

Divide this into 2000 with the CD scales.

Answer=£1,030 approximately.

FOLDED SCALES

The CF and DF scales on rules engraved with these instead of the usual AB, are of the same length and dividings as the CD but they commence and end with π and the one index is near the centre of the scale. They may therefore be used for multiplying or dividing a number by π, e.g. set the hair line opposite a number on the D scale. That number is multiplied by π on the DF Scale. Conversely a number on the DF Scale is divided by π on the D Scale. This is useful for example in calculating the diameters of circles. They may be used interchangeably with the CD and thus an answer may be read somewhere off the face of the rule without re-adjustment and with the same accuracy, or alternatively a setting can be made on either set of scales to avoid unnecessary slide movement.

To evaluate $\frac{3\cdot26 \times 2\cdot54}{9\cdot8}$

Slide the 9·8 on C over the 3·26 on D (which is the same thing as sliding the 9·8 on CF under the 3·26 on DF).

Since 2·54 on C is off the scale use the CF and with the cursor over 2·54 on CF read the answer ·845 on DF.

GAUGE POINTS

Some constants appearing in everyday calculations are engraved on the rules.

Those appearing on various rules are as under:

Gauge Point	*Formula*	*Value*
π		3·14
$\frac{\pi}{4}$		0·786
c	$\sqrt{\frac{4}{\pi}}$	1·128
C_I	$\sqrt{\frac{40}{\pi}}$	3·568
ς	$\frac{200 \times 100 \times 100}{\pi}$	636620
ς'	$\frac{180 \times 60}{\pi}$	3438
ς''	$\frac{180 \times 60 \times 60}{\pi}$	206265

Gauge Point	Formula	Value
746	1 HP=746 W	745·47
Cu^1	$\sqrt{\frac{4\cdot\rho}{\pi}}\left(\rho=0{\cdot}0175\,\frac{\Omega mm^2}{m}\text{ at }20^\circ\text{ C}\right)$	0·1493
Cu^2	$\sqrt{\frac{4}{\pi\cdot\gamma}}\left(\gamma=8{\cdot}87\,\frac{g}{cm^3}\right)$	0·379
Al^1	$\sqrt{\frac{4\cdot\rho}{\pi}}\left(\rho=0{\cdot}029\,\frac{\Omega mm^2}{m}\text{ at }20^\circ\text{ C}\right)$	0·1922
Al^2	$\sqrt{\frac{4}{\pi\cdot\gamma}}\left(\gamma=2{\cdot}69\,\frac{g}{cm^3}\right)$	0·688

VOLTAGE DROP

Is given by the formula:

$$\text{V.D.}=\frac{\text{Length in yards x current in amps. x }{\cdot}000024008}{\text{Area of conductor in sq. ins.}}$$

The V.D. scale is so placed in relation to scale A that the factor ·000024 is introduced when reading the answer.

Example I. What is the voltage drop when 25 amps flow along a conductor 20 yds. in length having a cross-sectional area of ·0045 sq. ins.?

The sum is: $\frac{20 \times 25 \times {\cdot}000024}{{\cdot}0045}$

The easiest way is to set the cursor line to 25 amps. on the ampere scale (Scale A), and slide Scale B along until 45 on Scale B is also on the cursor line. Keeping the slide fixed, now move the cursor until the hair line corresponds to 20 on Scale B.

Bring the left hand index under the cursor line and read off 2·66 volts under the slide window.

When using the voltage drop scale select that part of Scale B which coincides with the V.D. Scale, e.g., in the example given, the same result would have been obtained by setting the cursor line on 2 of Scale B (instead of 20) if the V.D. scale could have been extended sufficiently to the left.

Perhaps the simplest way to fix the decimal point in reading the answer in voltage is to remember that a current of 10 amps. flowing in a conductor of 10 yds. length and cross-sectional area of ·0024 sq. ins. is exactly 1 volt. Remembering that the V.D. is proportional to the amps. and yards and inversely proportional to the area it is fairly easy to estimate the magnitude of the required result.

Example II. What is the cross-sectional area of a conductor to carry 80 amps. 120 yds. with a voltage drop of only 2·5 volts?

Place the slide window on 2·5 volts on the V.D. Scale, and set the cursor line over the left hand index of Scale B. Slide Scale B until 120 yds. on Scale B is under the cursor line. Under 80 amps. on Scale A read off 92 on Scale B, which is the answer, viz. ·092 sq. ins.

MOTOR AND DYNAMO EFFICIENCY

Motor Efficiency is given by the formula:

$$\text{Efficiency}=\frac{\text{Horsepower x }{\cdot}746}{\text{Kilowatts}}$$

Dynamo Efficiency $=\frac{\text{Kilowatts}}{\text{Horsepower x }{\cdot}746}$ and both can be read as a percentage if multiplied by 100.

The Efficiency Scale and Arrow is so placed on the rule relative to Scale A that the constant ·746 or its reciprocal is brought into calculations without further movement of the slide.

Scale A serves as the Kw. Scale and Scale B as the h.p. Scale. The left hand half of the Efficiency Scale is used for Dynamos (20–100%) and the right hand half for Motors (100–20%). In the latter case the percentage is read backwards.

Example I. Find the efficiency of a Motor which, with an input of 17 Kw., delivers 19·5 h.p.

Line up 19·5 on the h.p. Scale (Scale B) with 17 on the Kw. Scale (Scale A) in such a way that the Efficiency Arrow or window in slide is on the motor side of the efficiency scale.

Now read off from the arrow or window in slide the efficiency. Answer, 85·5%.

Example II. How many Kws. would you get from an 82% efficient dynamo driven by 25 h.p.?

Align the arrow or window in slide with 82% on the left hand half of the Efficiency Scale and above 25 on the h.p. Scale (Scale B), read off 15·2 Kw. on Scale A.

VARIATION OF RESISTANCE OF A COPPER CONDUCTOR WITH TEMPERATURE

The small scale on the right of the slide indicates temperatures from 40° to 130° F. and/or 5° -50° C. and can be used to calculate the increase or decrease in resistance for temperatures varying from the standard 60° F.

Example. The resistance of a copper conductor is 13 ohms at 60° F. What is it at 80° F.?

Move the slide until 60° F. coincides with 13 ohms on Scale A. The resistance at 80° F. can be read off over 80° on the Temperature Scale. Answer=nearly 13·6 ohms.

Since the cross-sectional area of a conductor can be decreased as the temperature decreases without reducing the current flow, the scale can be used for calculating the change in area when the temperature deviates from the standard 60° F., exactly as in the example above.

POWER LOSS IN A COPPER CONDUCTOR

The loss in watts can be evaluated from the expression I^2R quite simply on the rule using Scales A, B and D.

Example. What would be the loss in watts of a Power line having a total resistance of ·494 ohms assuming current load of 24 amps.?

The sum is 24 x 24 x ·494.

Place the cursor line on 24 on Scale D and read off the square of 24 on the cursor line where it cuts Scale A at 576.

To multiply 576 by ·494 slide the middle index or any other index of Scale B on to the cursor line. Find ·494 on Scale B and read off above it 285 watts on Scale A.

A.C. POWER

Example. A 3-phase 415 volt circuit supplies a load to a small factory which is found by taking readings to have a demand of 120 amperes at a Power Factor of ·85. Find the power in the circuit.

This is given by the formula $\sqrt{3}$ E.I. (cos ϕ) and the sum is $\sqrt{3} \times 415 \times 120 \times {\cdot}85$.

Set the left hand index of Scale C over $\sqrt{3}$ on Scale D which is marked with an engraved line at 1·732 and slide the cursor to 415 on Scale C.

Now slide the left hand index of Scale C to the line on the cursor and move the cursor to the right to cover 120 on Scale C. Slide the right hand index of Scale C to the cursor line and the answer lies under ·85 of Scale C on Scale D. Answer=73400 watts=73·4 Kw.

In models which have a Cosine and Angle scale it can be used to convert Power Factor (cos ϕ) to regular notation for use in giving the actual value of phase displacement in degrees for making vectorial diagrams. In the above example cos (ϕ)=·85 and the value of (ϕ)=31·8° can be read off above the cosine reading of ·85.

To calculate the voltage drop in an O/H line having a total resistance of ·4 ohms and a reactance of ·288 ohms when supplying a current of 12 amps. at a power factor of ·906. In this case the volts drop=I (R cos (ϕ) + X sin (ϕ)) and substituting the values the sum becomes: 12 (·4 x ·906 + ·288 x sin (ϕ)). Without using tables (ϕ) can be read from the cosine/angle scale and sin (ϕ) can be found by using the sin (ϕ)= cos (90—(ϕ)) rule.

The 2 parts of the sum can then be worked on the rule and added to give the answer 5·8 volts.

The foregoing examples are intended only to demonstrate how the rule can be used for electrical calculations.

3-PHASE AC MOTOR AND GENERATOR EFFICIENCIES

In the case of 3-Phase AC machines, the two known quantities are generally Line Volts (EL) and Line Current (IL).

Therefore motor input or generator output is equal to $\sqrt{3}$ EL.IL watts at Unity PF. or $\frac{\sqrt{3}\ \text{EL.IL}}{1000}$ kW

$$\text{Motor efficiency} = \frac{\text{HP} \times {\cdot}746}{\text{kW}} = \frac{\text{HP} \times {\cdot}746 \times 1000}{\sqrt{3}\ \text{EL.IL}}$$

$$\text{Gen. efficiency} = \frac{\text{kW}}{\text{HP} \times {\cdot}746} = \frac{\sqrt{3}\ \text{EL.IL}}{1000 \times \text{HP} \times {\cdot}746}$$

The right hand 3-phase Motor/Generator scale in the well is so arranged relative to scale A, that the factor $\frac{\sqrt{3}}{{\cdot}746}$ or its reciprocal is included in the calculations automatically.

Example 1. Find the efficiency of a 3-phase AC motor where the output is 15 H.P. at Line pressure (EL) 400 volts and line current (IL) 20 amps.

The product $\frac{\text{EL.IL}}{1000} = \frac{400 \times 20}{1000} = 8$ kW

(True input being $8\sqrt{3}$ kW.)

Adjust the position of the slide until 8 kW on scale A is in line with 15 H.P. on scale B so that the slide window is on the motor side (R.H.) of the 3-phase efficiency scale.

Read off from the window the efficiency=80·5%.

Similarly, for generator efficiencies, set up kW and H.P. so that the slide window is over the left hand side of the efficiency scale.

Example 2. What line current would be supplied by a 660 volt 3-phase generator driven by a 20 H.P. motor, assuming an efficiency of 85%?

Set slide window over 85% on L.H.S. of 3 scale and above 20 H.P. on scale B read 7·3 kW on scale A (equal to $\frac{1}{\sqrt{3}}$ x actual power)

Divide this by 660 volts, giving a current of 11·02 amps.