You should judge which procedure is more efficient from the stand point of lessening the slide shifting.

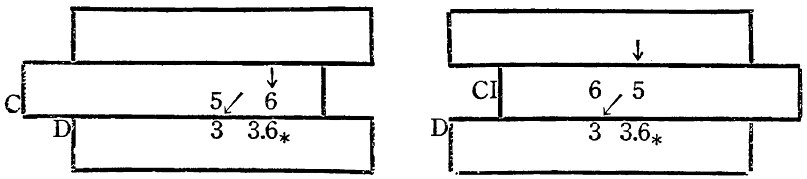


Fig..115

As the methods of operating *C* and *D* for direct proportion and that of *CI* and *D* for inverse proportion, we have explained them for several times already in the chapters regarding instruction of other rules.

(3) Square and Cubes

This slide rule is provided with *A, B* scales for calculations of squares and square roots and *K* scale for those of cubes and cube roots. These operations are fully explained in III-(3) and IV-(3).

(5) Logarithm and Higher exponents

Operations for Common logarithm using *L* scale, and those for Natural and Common logarithms using LL scale are the same as mentioned in IV-(4).

And the operation for Higher exponents using *C* and *LL* scales are also the same as that in IV-(4).

(5) Trigonometric functions

This slide rule is different from other rules for calculations of trigonometric functions and has to use Angle scale θ (for degree measure) or Rθ (for radian measure) in cooperation with un-logarithmic scales, so called Square scales, *P* and *Q*. Fig. 116 shows the general relation of it.

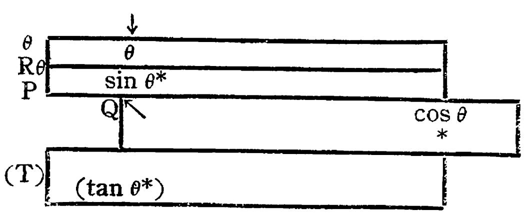


Fig. 116

Symbols in parenthesis mean that is on the opposite face of the slide rule.

Example 4 $\sin 25° = 0.422$

$\cos 25° = 0.906$

$\tan 25° = 0.466$

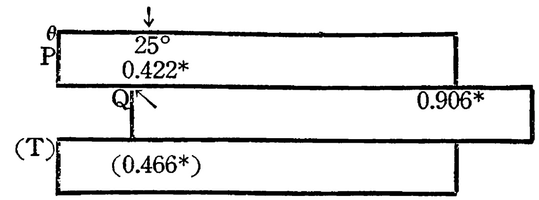


Fig. 117

Example 5 $\text{Sin}\ 0.9 = 0.783$

$\cos 0.9 = 0.622$

$\tan 0.9 = 1.260$

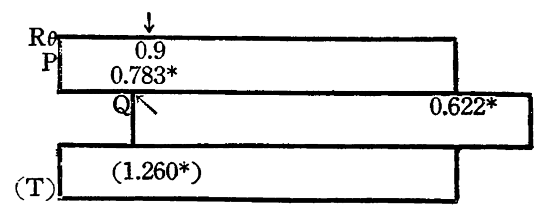


Fig. 118

(6) Vector calculations

Absolute value

Absolute value of the vector which is given in form of $A+jB$ can be obtained from the equation $\sqrt{A^2+B^2}$, This calculation will be done using *P*, *Q* and *Q′* scales as easily as that of ordinary multiplication.

Example 6 Get the absolute value of $20+j15$.

set 0 on *Q* scale against 15 on *P* scale, then we can read off the answer $Z=25$ on *P* scale against 20 on *Q* scale.

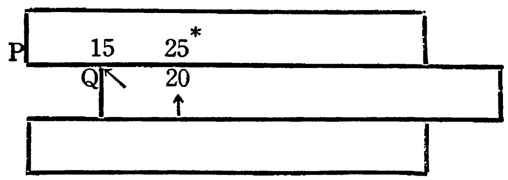


Fig. 119

Example 7 $\sqrt{38^2+95^2}=102.3$

If we perform this calculation as the example 6, then, we shall see that P scale becomes "Off scale".

So, we must take one of the other convenient processes as follows

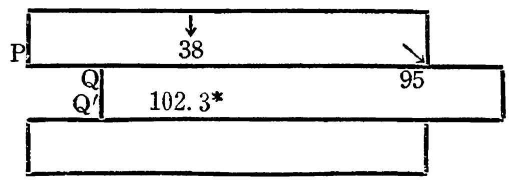
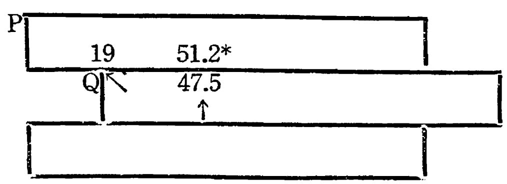


Fig. 120

In case you do not use Q' scale, multiply or divide the given numbers by a simple digit as 2 or 1/2 so as to be treated them in the range of P and Q scale, and its sequence must be reduced by reverse treatment to get the right answer (Ref. Fig. 121)



$38\div2=19$

$95\div2=47.5$

$51.2\times2=102.4$

Fig. 121

Phase angle

The phase angle θ between the real part A and the absolute value of given vector which is represented by the form $A+jB$, can be solved as, $\theta=\tan^{-1}\dfrac{B}{A}$. For instance, in the example 6, $\theta=\tan^{-1}\dfrac{15}{20}=36.9°$,

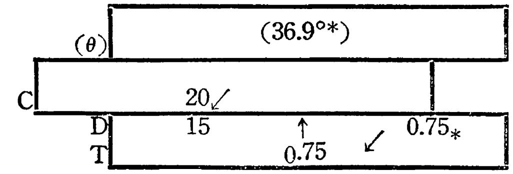


Fig. 122

Firstly, calculate $\dfrac{15}{20}$ using C and D and replace its sequence 0.75 on T scale by the aid of indicator. Then, we can read $\theta=36.9°$ on θ scale on the back face under the hairline.

Conversion of measure of angle

Using scales θ and $R\theta$ in "Reference scales", we can convert the measure of angles, degree into radian and vice versa.

Example 8 Convert 42° into radians

" 1.005 radian into degrees

Ans. 0.733 radian

57.6 degree

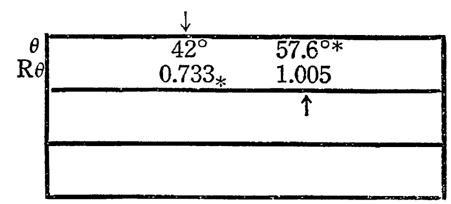


Fig. 123

Conversion of coordinates

Summerizing above mentioned techniques, we can convert the coordinates of given vector of the form $A\pm jB$ into that of $Z\,\underline{|\theta}$, and vice versa.

Example 9 Convert $6.85+j22.8$ into polar coordinates.

In convenience, multiply every term of given numbers by 2, and operate as shown in Fig. 124.

Dividing its sequence 47.6 by 2, we get the absolute value $Z=23.8$

For the Calculation of phase angle, firstly divide 22.8 by 6.85 using C and D scale.

Replacing its sequence on T scale, we get $\theta=73.3°$ on θ scale.

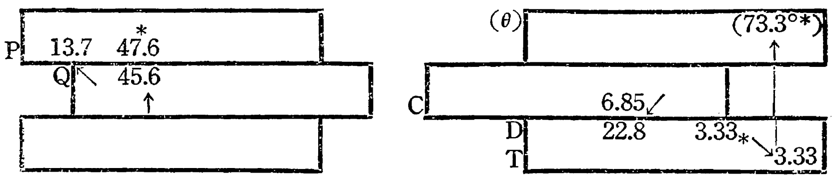


Fig. 124

Example **10** Convert 1.407 |0.594 into rectangular coordinates.

Calculate Sinθ=0.559 and Cosθ=0.829 by cooperative use of $R\theta$, P and Q and then, by ordinary multiplication using C and D, we get as the real part of the vector 1.407×0.829=1.17 and the imaginary part 1.407×0.559=0.786.

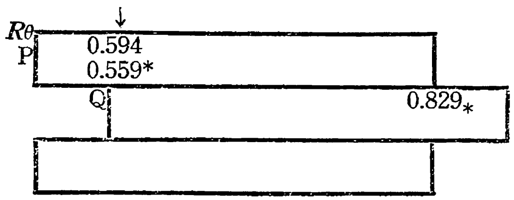


Fig. 125

(7) Hyperbolic functions

To get hyperbolic functions, $G\theta$ scale is available. If you set the given argument x on $G\theta$ scale you can get the value of sin hx on T scale, and that of tan hx on P scale under the hairline of indicator.

Example **11** sin h 0.32=0.325

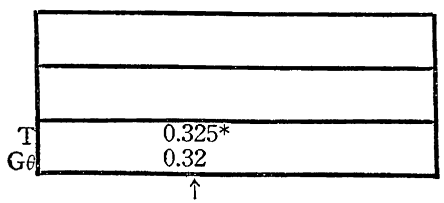


Fig. 126

Example **12** tan h 0.83=0.681

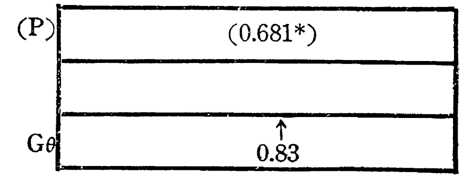


Fig. 127

Example 13 cos h 0.55=1.155

Procedure 1

Firstly using $G\theta$, get sin h 0.55=0.578 on T scale. Then, replacing this sequence on Q scale, and against it, get the answer on Q' scale as 1.155.

Procedure 2

By the aid of hairline, she the left index of C to 0.55 on G^θ scale. Against the right index of P, we get sec h 0.55=0.866 on Q scale. Finally, its reciprocal cos h 0.55=1.155 can be read easily using C and CI scales.

Hyperbolic function of complex argument

Hyperbolic functions of complex argument as sin $h(a\pm jb)$ and tan h $(a\pm jb)$, will be obtained from formulas as shown in V-(6) or VIII-(5).

(8) Application on Electrical problems

Example **14**

Compute the effective value of a voltage wave which contains higher harmonics, assuming effective values of its component as follows.

The fundamental wave $E_{e1}=82$

The 3rd harmonics $E_{e3}=25$ and

The 5th harmonics $E_{e5}=12$

$$E_{e0}=\sqrt{E^2_{e1}+E^2_{e3}+E^2_{e5}}=\sqrt{82^2+25^2+12^2}=86.6$$

Set 0 on Q to 82 on P, move the hairline to 25 on Q, set 0 on Q to the hairline, and then, we can read the answer 86.6 on P against 12 on Q.

Example **15**

Compute the current in an electric circuit, which impedance is $2+j3.2$ and the potential difference between its terminals is $50+j15$.

$$\dot{I}=\frac{\dot{E}}{\dot{Z}}=\frac{50+j15}{2+j3.2}$$

Representing both numerator and denominator in a polar coordinates, we have

$$50+j15=52.2\ \underline{|0.29}$$

$$2+j3.2=3.77\ \underline{|1.011}$$

and then

$$\dot{I}=\frac{52.2}{3.77}\ \underline{|0.29—1.011}=13.85\ \overline{|0.721}$$

If necessary, the answer can be converted into rectangular coordinates as below:

Using P and Q scales,

Sin 0.721=0.661

cos 0.721=0.751

and multiplying on these sequences by the absolute value 13.85, we get

$$\dot{I}=10.4—j9.15$$

Gauge marks:

This slide rule has gauge marks as follows:

π, 2π (on C, D scales)...The ratio of circumf. to the diameter of a circle.

c (on C scale) ...Area of a circle.

ρ°, ρ', ρ'', (on C scale)...Conversion between degree and radian.

X. No. 200 (16 inches) Duplex Slide Rule

(Four figures slide rule)

(1) General Description (See figure on page 108)

Characteristics

This slide rule has been specially designed to meet with the requirement of approximate calculation for four figures, and the function of this rule is limited to multiplication, division and proportion. Principle of this slide rule is based on the system to improve the accuracy of calculation with "long scale" idea.