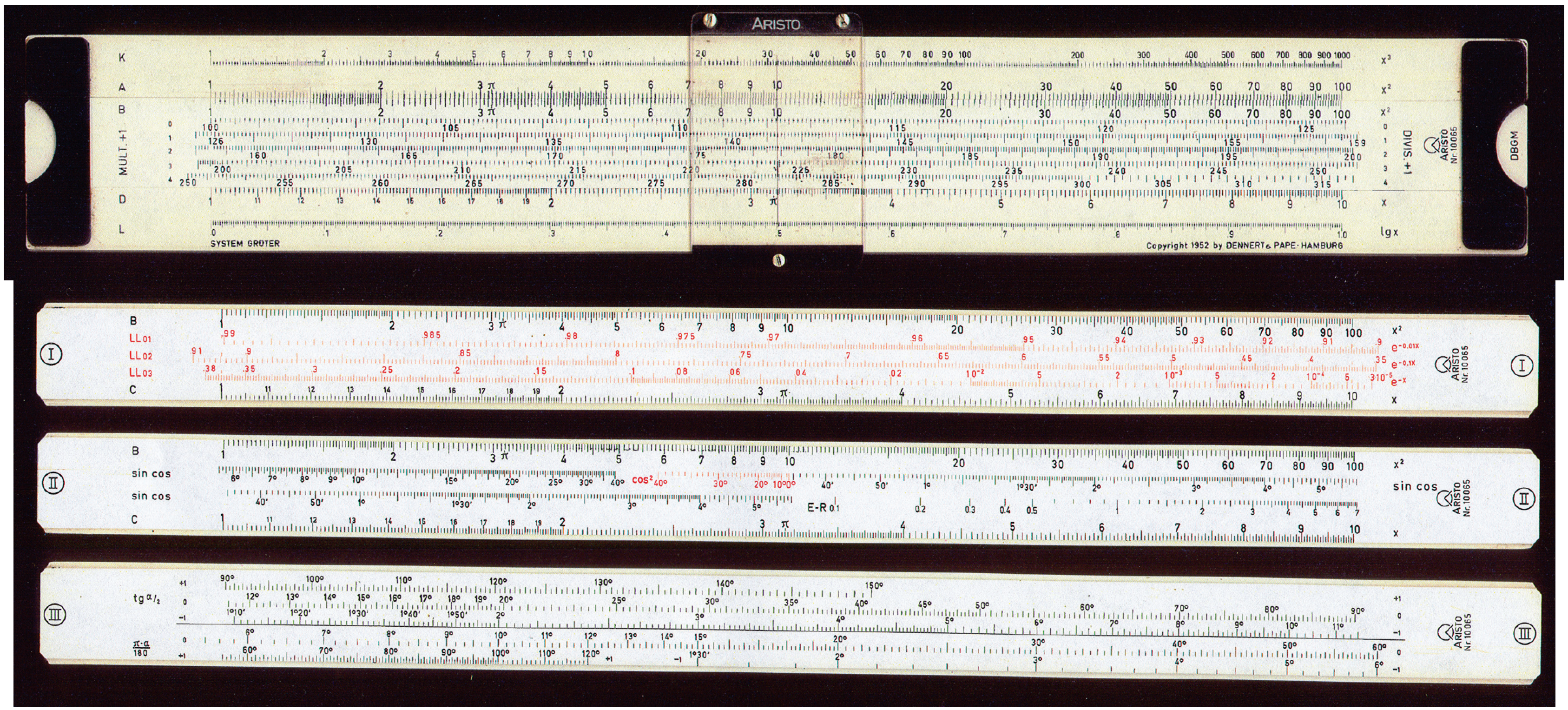
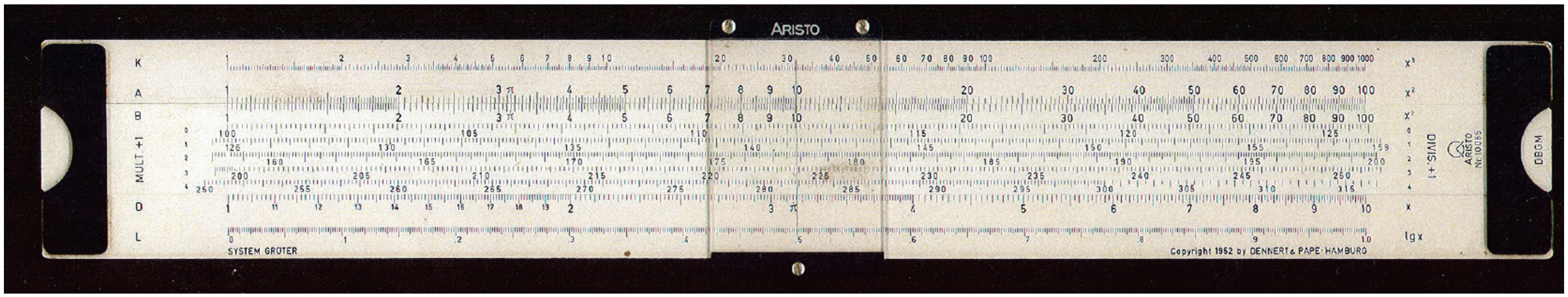
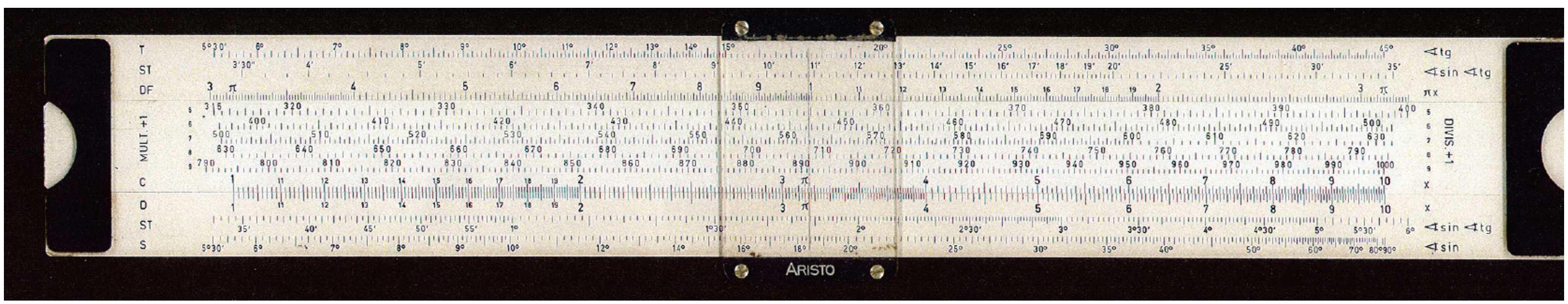
PLUS

Aristo Nr. 10065 System Gruter
Operation and Examples
Richard Smith Hughes



PRECISION SLIDE





Multiplication, Division; Three Digit + Estimate Accuracy (Minimum)
Log, Antilog; Four Figure Accuracy

Multiplication and Division

Multiplication

(a)(b) = (8.2736)(9.5927) = 79.36616

1) Determine the decimal point;

(8)(10) = 80

2) Find the solution scale. Using the C/D scales solve for (a)(b) = 79.3; the solution will be found on scale 8, 630 to 795.

Slide Rule Operation

a) Initial Position; A/B, C/D indexes aligned.
b) Move the cursor to a = 82736 on scale 9.
c) Bring the C/B index (left) under the cursor.
d) Move the cursor to b = 95927 on scale 9.
e) Initial Position; A/B, C/D indexes aligned.
f) Read (a)(b) on scale 8 (see 2 above) = 79.38.
g) Error = 0.02%.

Division

a/b = 9.8285/8.8359 = 1.112337

1) Determine the decimal point;

10/10 = 1

2) Find the solution scale. Using the C/D scales solve for a/b = 1.11; the solution will be found on scale 0, 100 to 126.

Slide Rule Operation

a) Initial Position; A/B, C/D indexes aligned.
b) Move the cursor to a = 98285 (scale 9).
c) Bring b = 88359 (scale 9) under the cursor.
d) Move the cursor to the C/B (left) index.
e) Initial Position; A/B, C/D indexes aligned.
f) Read (a)/(b) on scale 0 (see 2 above) = 1.1121.
g) Error = -0.02%.

Logs and Anti Logs

$\text{Log}_{10}\, y = + N$

A) y>1 (N>1, positive); y = 982,460

Write y as $Y.yyyyE^x$ (Note; $E^x = 10^x$) = $9.8246E^5$

$N = \text{Log}_{10}\, y = \log_{10}(Y.yyyyE^x) = \text{Log}_{10}E^x + \text{Log}_{10}(Y.yyyy) = x + \text{Log}_{10}(Y.yyyy) =$

Characteristic C (C = x) + Mantissa M (M = 0.mmm = $\text{Log}_{10}(Y.yyyy)$)

$y = Y.yyyyE^x = 9.8246E^5$

$N = \text{Log}_{10}(9.8246E^5) = \log_{10}(Y.yyyy\, E^x) = \text{Log}_{10}E^5 + \text{Log}_{10}(9.8246)$

Characteristic C (C =5) + Mantissa M (M = 0.mmm = $\text{Log}_{10}(9.8246)$ = 5 + 0.99231

$Log_{10}(9.8246E^{-5}) = 5 + 0..99231 = 5.99231$

Slide Rule Operation

a) Initial Position; A/B, C/D indexes aligned.

a) Move the cursor to Y.yyyy = 9.8246 on scale 9 (this scale number, 9, is the most significant mantissa number; M = 0.mmm = 0.9mmm).

b) On the L scale read the remaining mantissa numbers, 0.09238.

c) The mantissa M = 0.mmm = 0.99238.

d) The characteristic $C = Log_{10}E^x = Log_{10}E^5 = 5$.

e) $Log_{10}(9.8246\ E^5) = C + M = 5 + 0.99238 = 5.99238$.

f) Error = 0.001%.

$y = 10^{+N}$

B) N>0, positive (y>1); N = 5.99231

Write N as C (characteristic) + M (mantissa = 0.mmm)

$$y = 10^N = [10^C][10^{0.mmm}] = 10^{0.mmm}E^C$$

N = 5.99231 = Characteristic (C = 5) + Mantissa M (0.mmm = 0.99231)

$$y = 10^{5.99231} = [10^{0.99231}]\ [10^5] = 9.8245E^5$$

Slide Rule Operation

a) The most significant mantissa number is 9 and $10^{0.mmm} = 10^{0.99231}$ will be found on this scale, 9.
b) Place the cursor over the remaining mantissa numbers, 0.09231, on the L scale.
c) Initial Position; A/B, C/D indexes aligned.
d) Under the cursor on scale 9, remember this is the most significant mantissa number, read $10^{0.mmm} = 10^{0.99231} = 9.824$.
e) $10^C = E^5$.
f) $y = 10^{+N} = 10^{0.9923148}E^5 = 9.824E^5$.
g) Error = -0.005%.

$Log_{10}\ y = -\ N$

C) 0<y<1 (N<0, negative); $y = 9.8246E^{-5}$

Write $y = Y.yyyyE^{-x} = 9.8246E^{-5}$

$N = Log_{10}(9.8246E^{-5}) = log_{10}(Y,yyyyE^{-x}) = Log_{10}E^{-5} + Log_{10}(9.8246) =$

Characteristic (C =-5) + Mantissa ($M = 0.mmm = Log_{10}(9.8246) = -5 + 0.99231$

$Log_{10}(9.8246E^{-5}) = 5 – 0.99232 = -4.00769$

Slide Rule Operation

a) Initial Position; A/B, C/D indexes aligned.
b) Move the cursor to Y.yyyy = 9.8246 on scale 9 (this scale number, 9, is the most significant mantissa number; M = 0.mmm = 0.9mmm).
c) On the L scale read the remaining mantissa numbers, 0.0924
d) The mantissa M = 0.mmm = 0.9924.
e) The characteristic $C = Log_{10}E^{-5} = -5$.

f) $N = Log_{10}(9.8246E^{-5}) = C + M = -5 + 0.9924 = -4.0076$.
g) Error = 0.002%.

$y = 10^{-N}$

D) N<0, negative (0<y<1); N = -4.00769

Since N is negative, $-N \neq$ Characteristic (C) + Mantissa M (0.mmm). We must find the characteristic, C, and mantissa, M = 0.mmm

Write -N = -N.nnnn

Characteristic $C = -(1 + |N|)$

Mantissa M = 0.mmm = (1 – 0.nnn)

N = -4.00769 = N.nnnn = C [-(1 + |N|)] + M [(1 – 0.nnn)] =

C [-(1+ |-4|) = -5] + M [(1 – 0.00769) = 0.99231] = -5 + 0.992315 = -4.0769

Now; $y = 10^{-4.00769} = 10^C 10^M = [10^{-5}][10^{0.992315}] = 9.8245E^{-5}$

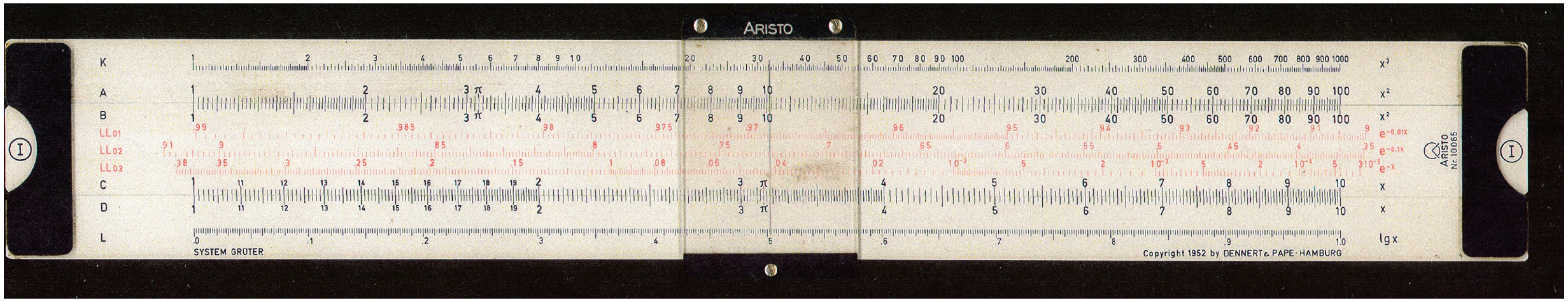
Slide Rule Operation

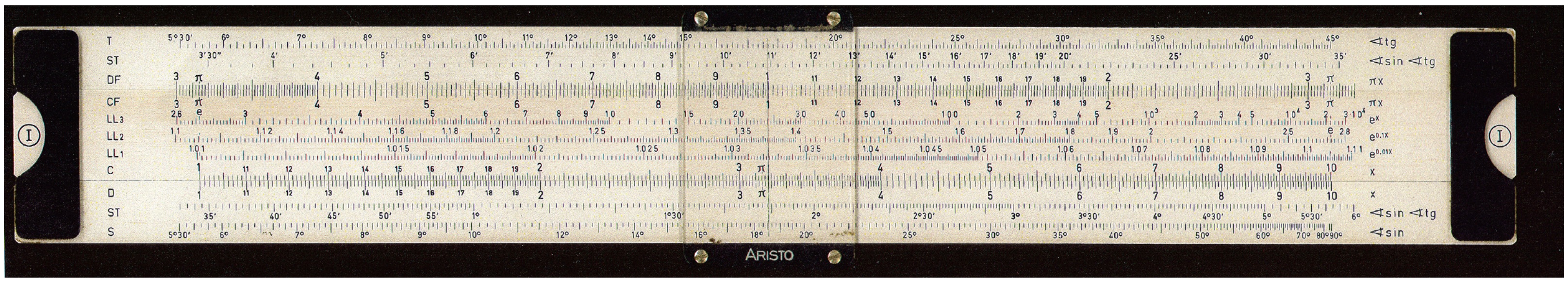
a) The most significant mantissa number is 9; $y = 10^{-N}$ will be found on this scale, 9.
b) Place the cursor over the remaining mantissa numbers, 0.092315, on the L scale.
c) Initial Position; A/B, C/D indexes aligned.
d) On scale 9 read $10^{0.mmm} = 10^{0.992315} = 9.824$ on scale 9.
e) $10^C = 10^{-5} = E^{-5}$.
f) $y = 10^{-N} = 10^C 10^M = [10^{-5}][10^{0.992315}] = 9.824E^{-5}$.
g) Error = -0.006%.

Precision Slide Accuracy

Multiplication (8.2736)(9.5927) = 79.36616; Precision Slide = 79.38 Accuracy = 0.02%			
Division 9.8285/8.8359 = 1.112337; Precision Slide = 1.1121 Accuracy = -0.02%			
Logs; $N = Log_{10}y$			
y	Actual	Precision Slide	Accuracy
$y>1 = 9.8246E^5$	5.99231	5.99238	0.001%
$y<1 = 9.8246E^{-5}$	-4.00769	-4.0076	-0.002%
Antilogs; $y = 10^N$			
N	Actual	Precision Slide	Accuracy
N>0 = 5.99231	$9.8245E^5$	$9.824E^{-5}$	-0.005%
N<0 = -4.00769	$9.8245E^{-5}$	$9.824E^{-5}$	-0.006%

Slide I
Log Log





Scales
Front Side
K/A//B/LL01/LL02/LL03/C//D/L

Back Side
T/ST/DF//CF/LL1/LL2/LL3/C//D/ST/S

Slide I
Log Log

Tan Scale

The tan scale only goes to 45°. For angles greater than 45° simply remove the C scale and invert; a manual CI scale.

Log Log Scales

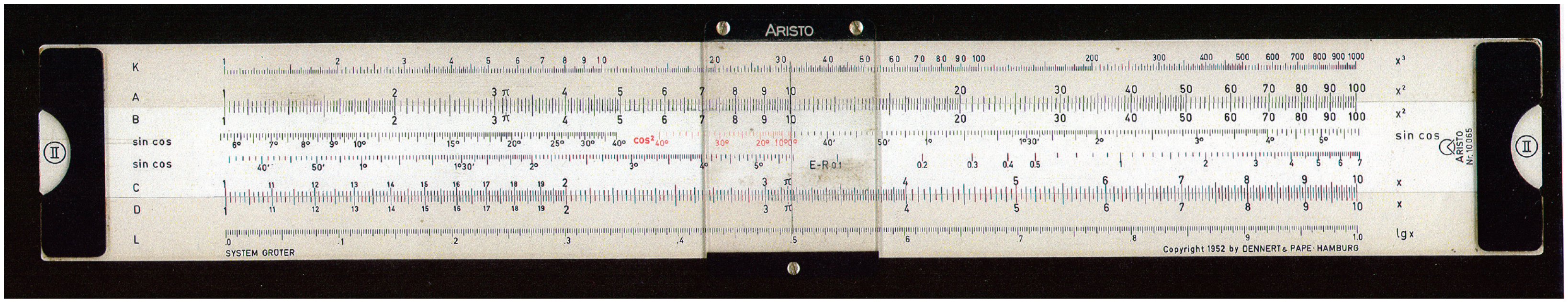
The Initial position must be used solving Log_a y = N and y = 10^N

1) Log_a y = N; Log_{10} 37.5 = 1.574031
   a) Initial position, C/D and A/B indexes aligned
   b) Move the curser to y = 37.5 on the LL3 scale
   c) Move the slide such the base a = 10 is under the cursor
   d) Read Log_a y = N = Log_{10} 37.5 = 1.575 under the C index on the D scale

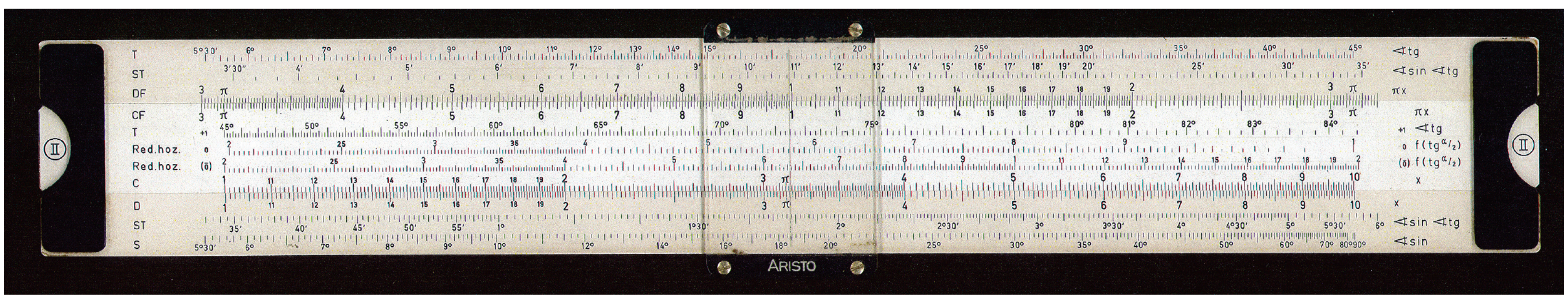
2) y = a^N; y = $4.2^{3.8}$ = 233.533
   a) Move the C index to N = 3.8 on the D scale
   b) Move the cursor to a = 4.2 on the LL3 scale
   c) Initial position, C/D and A/B indexes aligned
   d) Read y = 10^N = $4.2^{3.8}$ = 233.5 on the LL3 scale

To solve Log_ey = N and e^N = y, leave the slide in the Initial position and solve in the normal manner.

Slide II
Stadia



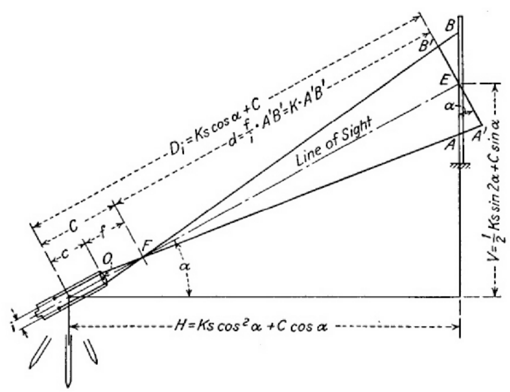
Note the E-R scale; for correcting the vertical height, V, due to the earths curvature and refraction



Red.hoz = Reduction to Horizontal

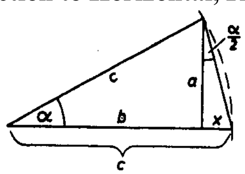
Table 1
Stadia/Topographic Equations

Stadia Method



$K \equiv f/i = 100$
S = Stadia rod reading=B-A (in feet or meters); C = 0
Di = Line of sight distance = 100S(cos α)

Reduction to Horizontal, Red.hoz



c = DI and α are known
b = H = c – x = DI – ΔDI = DI – DI(sin α)(tan α/2)
a = V = DI sin α

Horizontal Distance, H

$40^o > \alpha > 35'$	$40^o > \alpha > 10^0$
H = 100S – ΔH ΔH = 100S($\sin^2 \alpha$)	H = 100S($\cos^2$ α)
Scales Used	
S/ST/A/B Scale Index; B scale Index	$\cos^2\alpha$/A Scale Index; 0^o on $\cos^2$ scale

Decimal Point

α	ΔH	
0^o 35′	0.0001(100S)	100S > H > 0.59(100S)
1^o 48.7′	0.001(100S)	
5^o 44.4′	0.01(100S)	
18^o 26.1′	0.1(100S)	
40^o	0.59(100S)	

Horizontal Distance, H	**Elevation (Vertical Height), V**
DI and α known H = Di – ΔDi ΔDi = Di (sin α)(tan α/2)	V = 100S(sin α cos α)
Scales Used	
S/ST/C/D/Red.hoz, 0/Red hoz. 0^- Index; C scale Index 1 > sin α > 0.2; Red.hoz 0 0.198 > sin α > 0.02; Red.hoz 0^-	V = DI(sin α) Index; C scale index

Decimal Point

sin α	α	ΔDI	α	V
0.0447	2^o 33.7′	0.001DI	0^o 35′	0.01DI
0.141	8^o 06.4′	0.01DI	5^o 46.1′	0.1DI
0.436	25^o 50.9′	0.1DI	45^o	0.0.707DI

Stadia/Topographic Slide II Examples

The following examples use the equations given in Table 1. The 10065 manual uses a "digit" counting technique to determine the decimal point, however the decimal point listings in Table 1 are easier to use. The equations listed in Table1 are not given in the manual.

Measured Values

Stadia rod reading , S = 7 ft; 100S = 700 ft

$\alpha = 25^o\ 50.32'$

Horizontal Distance, H = 100S($\text{Cos}^2\ \alpha$) = 567.03 ft.

a) Place Cos^2 index, 0^o, under 100S = 700 ft. on scale A.
b) Move the cursor to $\alpha = 25^o\ 50.32'$ on the $\cos^2$ scale.
c) Read H = 570 ft. under the cursor on the A scale. Note; use the decimal point table.
e) Error = 0.53%. Obviously this scale isn't intended for accuracy.

Horizontal Distance, H = 100S – ΔH

$\Delta H = 100S(\sin^2 \alpha) = 132.97$ ft.

H = 700 – 133 = 567.03 ft.

a) Place the cursor over $\alpha = 25^o\ 50.32'$ on the S scale.
b) Read $\sin^2 \alpha = 0.19$ on the A scale. Use the decimal point table.
c) Using the C/D scales calculate $\Delta H = 100S(\sin^2 \alpha) = 133$ ft.
d) $H = 100S - \Delta H = 700 - 133 = 567$ ft.
e) Error = -0.005%.

Horizontal Distance, H = Di – ΔDI; DI and α known

$\Delta Di = Di\ (\sin \alpha)(\tan \alpha/2)$; $V = Di\ (\sin \alpha)$

DI = 63 ft; $\alpha = 26^o$.

a) Place the cursor over $\alpha = 26^o$ on the S scale
b) Move the C index under the cursor.

c) Move the cursor to DI on the C scale (read V = 27.6 ft under the cursor on the D scale)

d) Move the C index under the cursor

e) Move the cursor to Sin α = Sin 26° = 0.438 0.436 on the Red.hoz.0 scale; labeled tan α/2 on the right.

The two Red. hoz. scales are labeled tan α/2, however the numerical values are sin α. Thus sin α on the Red.hoz. scale gives tan α/2 on the C scale.

f) Determine the decimal point; for α = 26°

$$\Delta DI > 0.1 DI; \ \ \Delta DI > 6.3 \text{ ft}$$

g) Read ΔDI = DI (sin α)(tan α/2) = 6.37 ft on the D scale.

h) H = DI – ΔDI = 63 ft. – 6.37 ft. = 56.63 ft. (theoretical = 56.62402 ft)

i) Error = +0.01%.

Elevation (Vertical Height), V = 100S(sin α cos α) = 274.6 ft.

a) Place the cursor over 100S = 700 on the A scale.

b) Bring the $\cos^2$ index 0°, on the slide, under the cursor.

c) Move the cursor to α = 25° 50.32′ on the sincos scale. See Table A1 for the decimal point.

d) Read V = 100S(sin α cos α) = 275 ft. Note; the Transit height must be subtracted from V.

e) Error = 0.14%.

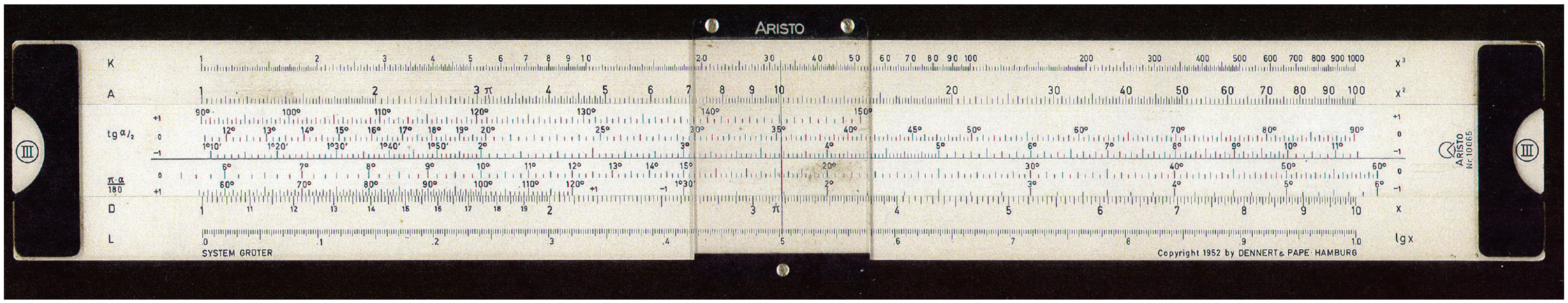
Earth Curvature and Refraction correction scale, E – R

The elevation, V, for long horizontal distances, 1 km to 10 Km, must be reduced due to the Earths curvature and atmospheric refraction;

$$E - R = \text{Correction, in meters, } \approx 0.68(\text{H in Km})^2$$

The ARISTO System Gruter has the E – R scale, in meters, on the slide referenced to H on the right B scale, in Km; under H, in Km, on the right B scale read E – R, in meters, on the E –R scale. The actual height is less the calculated value, V, by the E – R correction value.

Slide III
Circular Curves



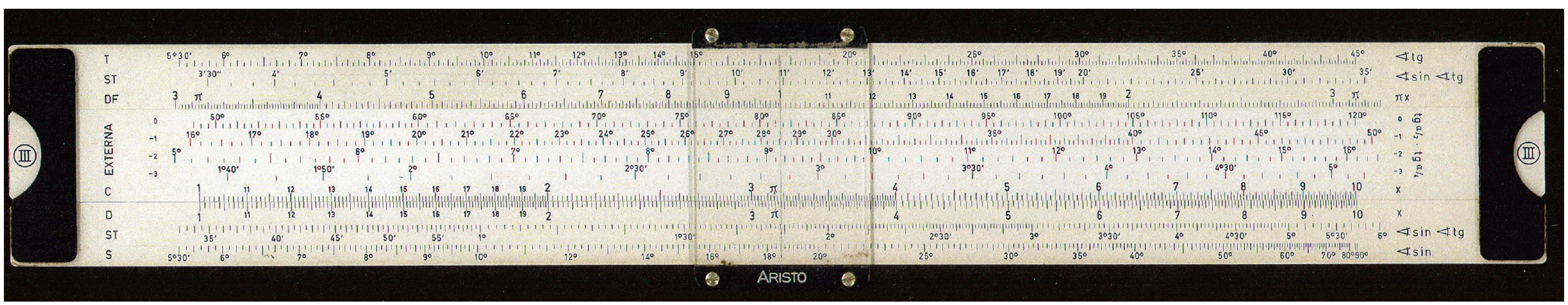
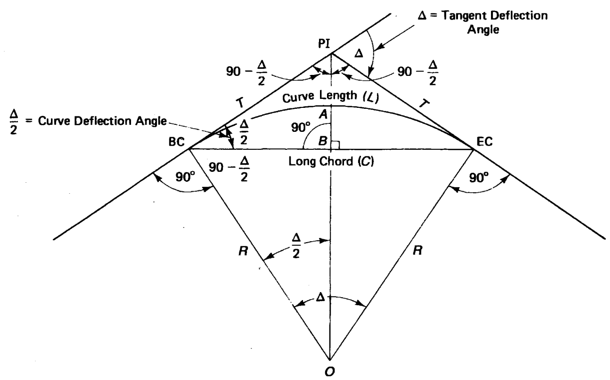


Table 2

Slide III; Circular Curves

Circular Curves

(Note; Δ is our α)



R = Radius, T = Sub tangent

Δ (our α) = Tangent Deflection Angle

PI = Point of Tangent Intersection , L = Curve Length

E = External=PI-A = PI – R

C = Long Cord = EC – BC

M = Mid Ordinate = A - B

Sub tangent T = R(tan α/2)	
Scales Used; Tg α/2 (three scales, 1° 10' to 150°) and D index; 90° on the Tg α/2 scales	
Decimal Point	
α	R(Tan α/2)
1° 10'	0.0102R
11° 25.27'	0.1R
90°	R
150°	3.73R
Curve Length L = R(πα/180)	
Scales used; πα/180 (three scales; 1° 40' to 120°) and D index; 90° Tg α/2 (0) Decimal Point ≈ 0.02R(α)	
External E = R(tan α/2)(tan α/4)	
Scales used; Tgα/2 Tg α/4 (four scales; 1° 40' to 120°) and D index; C index	
Decimal Point	
α	R(tan α/2)(tan α/4)
1° 40.1'	0.000106R
5° 07.4'	0.001R
16° 08.3'	0.01R
49° 14.4'	0.1R
Long Cord, C = 2R(sin α/2)	
Decimal Point	
α/2	2R(sin α/2)
3.44'	0.002R
34.38'	0.02R
5° 44.3'	0.2R

Circular Curves, Slide III Example

The circular Curves slide is for the professional land surveyor! It's function is summarized as follows

This slide is very useful for plotting roads and canals as well as general calculations for circular curves. This slide is also much easier to use in the field than published tables and will give the user substantial time savings on the job.

Preliminary calculations in laying out and designing railway lines and primary highways can easily be performed. Also, since the precision for secondary highways and irrigation canals is less demanding, the slide can be used for these calculations with good results. When using the scales on this slide during calculations, use the index of the scale that contains the value used in the calculation.

Table 2 summarizes the equations for those interested.

Example

$R = 500$ ft $\alpha = 10^o$

Sub tangent $T = R(\tan \alpha/2) = 43.74433$ ft

a) Place the cursor over R – 500 on the D scale
b) Move the slide; tg $\alpha/2$ index (90^o) under the cursor
c) Move cursor to $\alpha = 10^o$ on the tg $\alpha/2$
d) Determine the decimal point;

$$50 \text{ ft} > R(\tan \alpha/2) > 5 \text{ ft}$$

e) Read R = 4303 ft on the D scale under cursor
f) Error = -0.1%

Curve Length $L = R(\pi\alpha/180) = 87.26646$ ft

a) Place cursor over R = 500 on D scale
b) Move slide; tg $\alpha/2$ index, 90^o, under cursor
c) Move cursor to $\alpha = 10^o$ on the $\pi\alpha/180$ scale
d) Determine the decimal point using Table 2'

$$R(\pi\alpha/180) \approx 0.2R = 100 \text{ ft}$$

e) Under cursor read L = 87.2 ft on D scale
f) Error ≈ +0.008%

External, E = External $E = R(\tan \alpha/2)(\tan \alpha/4) = 1.909919$ ft

a) Move slide; C index over R = 500 on C scale

b) Move cursor to $\alpha = 10^o$ on the $(\tan \alpha/2)(\tan \alpha/4)$ scale

c) Determine the decimal point using Table 2;

$$5 \text{ ft} > (\tan \alpha/2)(\tan \alpha/4) > 0.51 \text{ ft}$$

d) Read E = 1.91 ft on D scale under cursor

e) Error ≈ +0.004%

$$\text{Long Cord, } C = 2R(\sin \alpha/2) = 87.15574 \text{ ft}$$

a) Move cursor to $\alpha/2 = 5^o$ on ST scale

b) Move slide; C index under cursor

c) Move cursor to 2R = 1,000 on C scale

d) Determine the decimal point using Table 2;

$$0.2R > 2R(\sin \alpha/2) > 0.02R$$

$$100 > 2R(\sin \alpha/2) > 10$$

e) Read C = 87.25 under cursor on D scale

f) Error ≈ +0.1%