

William Lukens Potts

Compass Maker *par excellence*

Colonial Compass Collectors Association

Smithsonian Meeting

Sept 13, 2013

Paul Temple, PhD

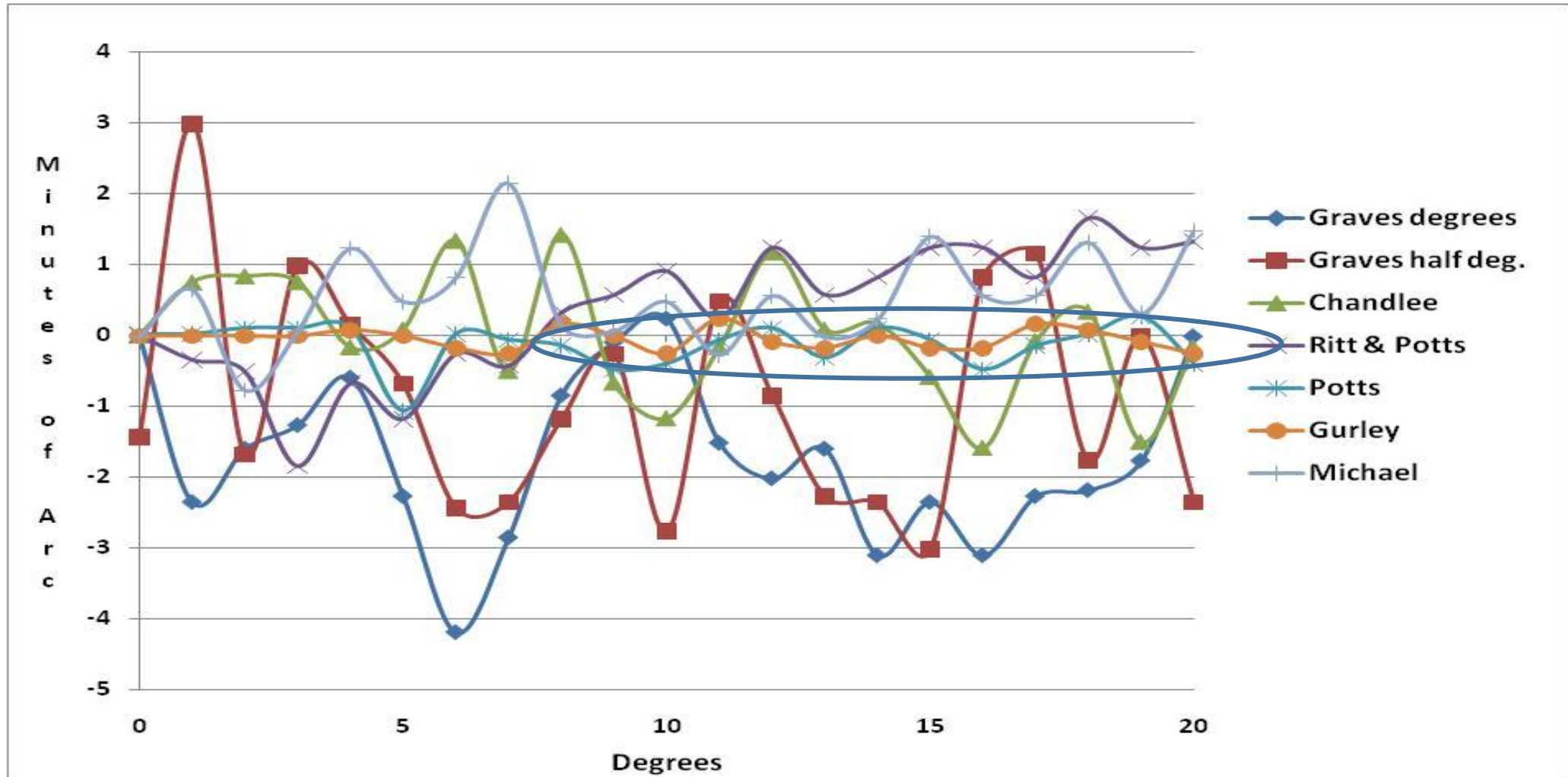
William Lukens Potts (1771-1854)



Potts Vernier Compass

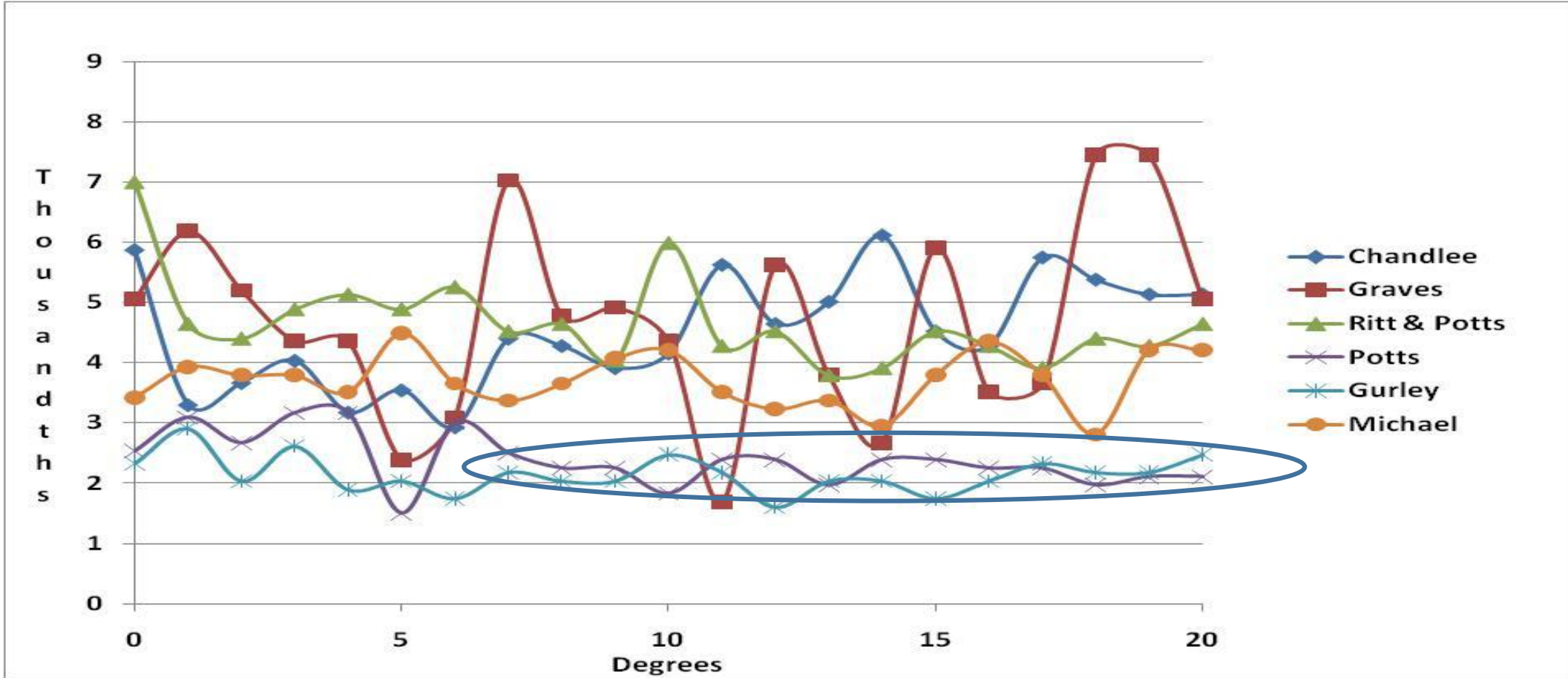


2010 Line Position Survey Summary



2010 Line Width Survey

Uniformity of Potts and Gurley vs. Other Makers



Outline

- ➔ • **William Lukens Potts**
 - **Association with Benjamin Rittenhouse**
- **Qualitative Description of Potts' execution**
- **Quantitative description of Potts' needle rings**
- **Comparisons with other compass makers**
- **Conjecture about Potts' method of dividing**
- **Summary**

Potts Timeline

- **William Lukens Potts born in Sussex Co., NJ 1771**
 - Lukens is a well known clock-maker family
- **Benjamin Rittenhouse advertised for an apprentice in 1785 while living in Worcester Township in Montgomery County (Potts was 14 years of age)**
- **Potts “worked for” Rittenhouse 1796-98 (why not earlier than 1796?)**
- **Evans apprentices with B. Rittenhouse 1791-92, replaces Potts in 1798**
 - Evans is a nephew of Rittenhouse
 - Rittenhouse and Evans compasses in NMAH collection (1798-1801)
- **Rittenhouse goes bankrupt in 1801**
- **1796 Potts appears in Worcester, PA tax records (25 years old)**
- **Potts moves to Pitts Town, NJ in 1798 (stays until 1807?)**
 - 1800 Potts advertised compasses from Pitts Town, NJ in Philadelphia paper (where his brother-in-law ran a store)
 - Marries in 1801 and is living in Alexandria Township, Hunterdon County, NJ in 1802
 - Potts “farmbook” with dates from 1805 to 1809 (notes two compasses ordered)
- **1807 Potts moves to farm in Bucks County, PA; he moves to Philadelphia in 1817**
 - “W.L.Potts, Bucks Penna” compass in NMAH collection
- **Iron merchant in 1817 in Philadelphia until his death in 1854**

} **1796?-98**
} **Rittenhouse &**
} **Potts Compasses**
} 1798-1801
} Rittenhouse &
} Evans Compasses

} Rittenhouse &
} Thomas?

} **1798-1807** Pitts Town,
} **NJ and NJ Compasses**

} 1807-1817 Bucks,
} Penna Compasses

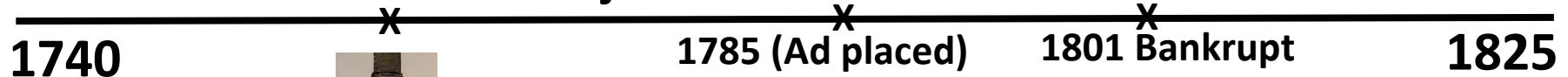
Rittenhouse – Potts Timelines

1730 1740 1750 1760 1770 1780 1790 1800 1810 1820

David Rittenhouse



Benjamin Rittenhouse



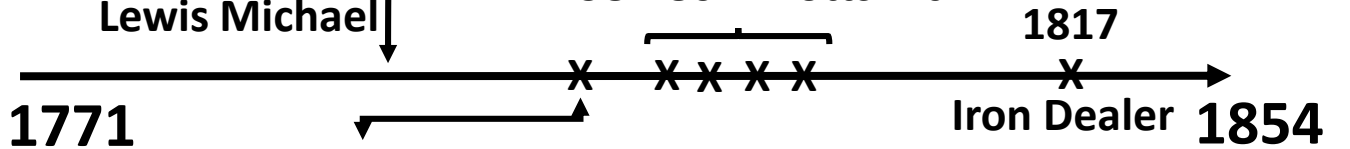
B. Rittenhouse



Lewis Michael

W.L. Potts

1798-1807 "Potts N.J."



R&P (1790-1792)



1



2



3



4

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“Early Career” Engraving Details



Early Benjamin Rittenhouse



Rittenhouse & Potts

Potts Engraving Details

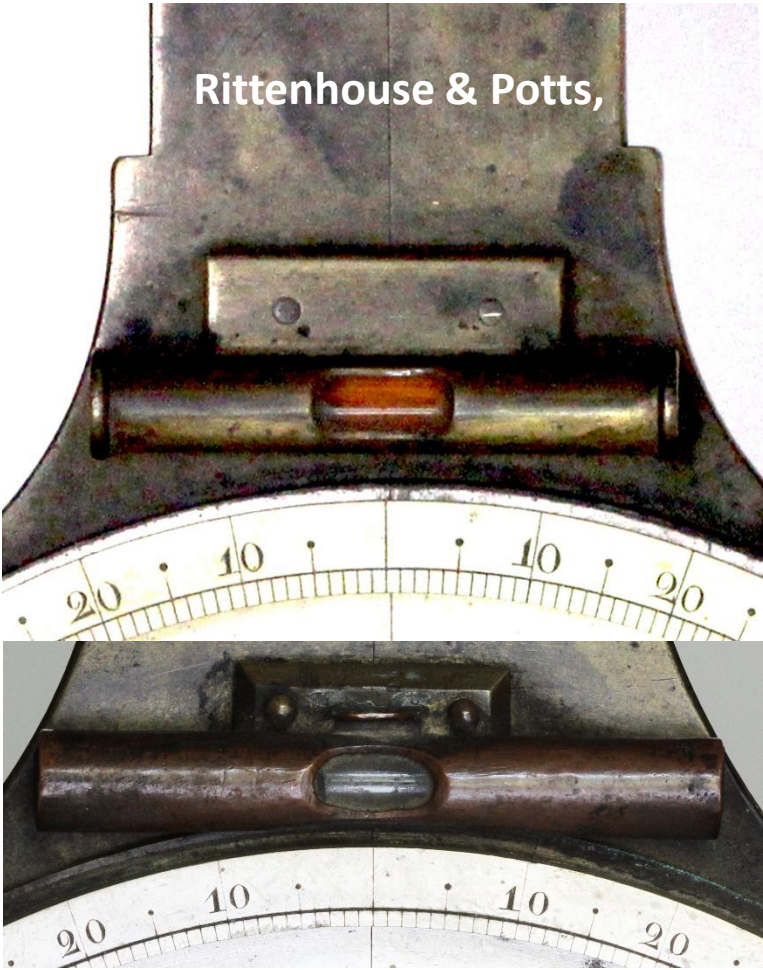


Rittenhouse & Potts



Potts 2

Potts Details



Potts 1



Potts 2, 3, 4



Potts 2

Potts Fleur de Lis



**Rittenhouse
& Potts**



Potts 1



Potts 2

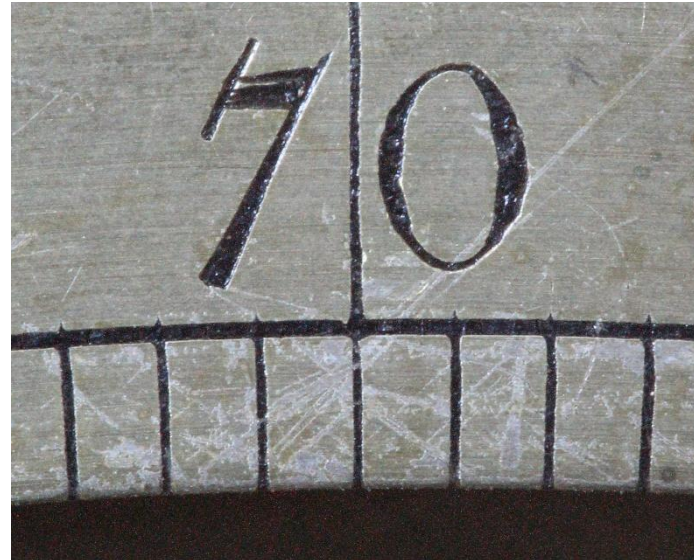


Potts 3



Potts 4

Rittenhouse and Potts Uniformity



Potts 1 Uniformity



Potts 2 Uniformity




Potts 3 Uniformity



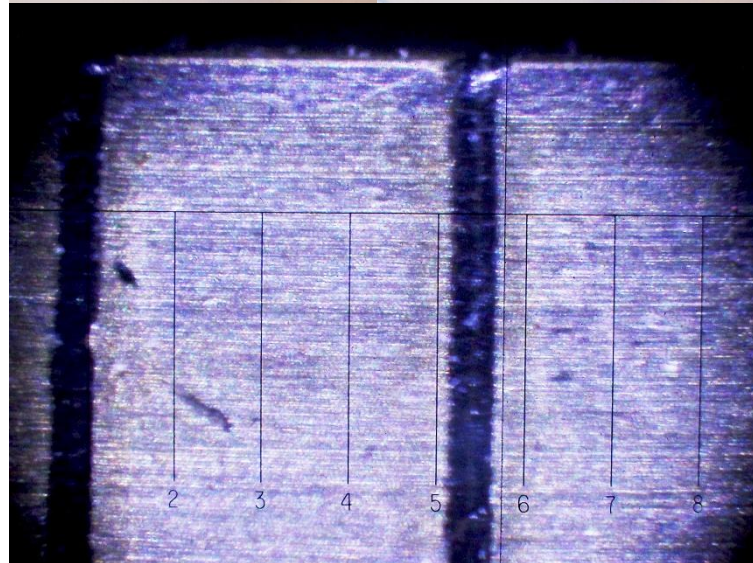
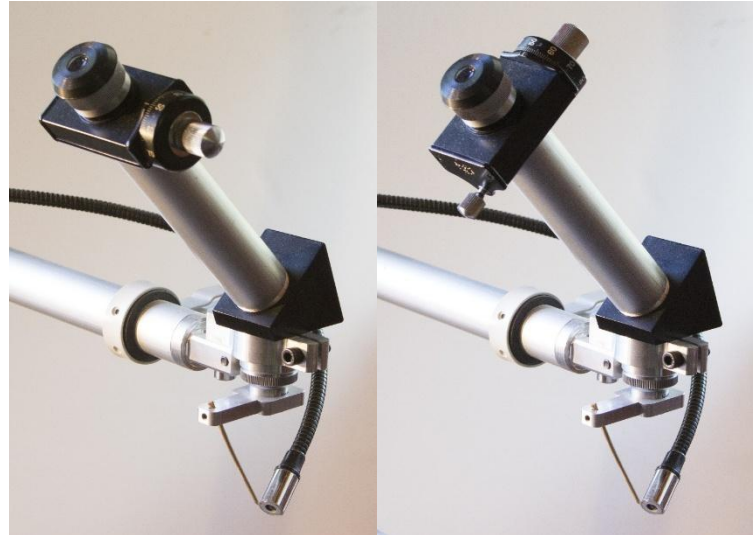
Potts 4 Uniformity



Outline

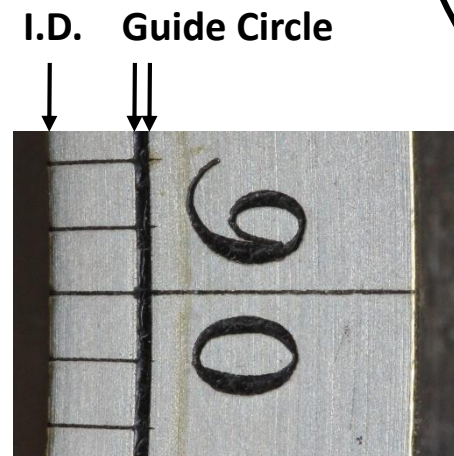
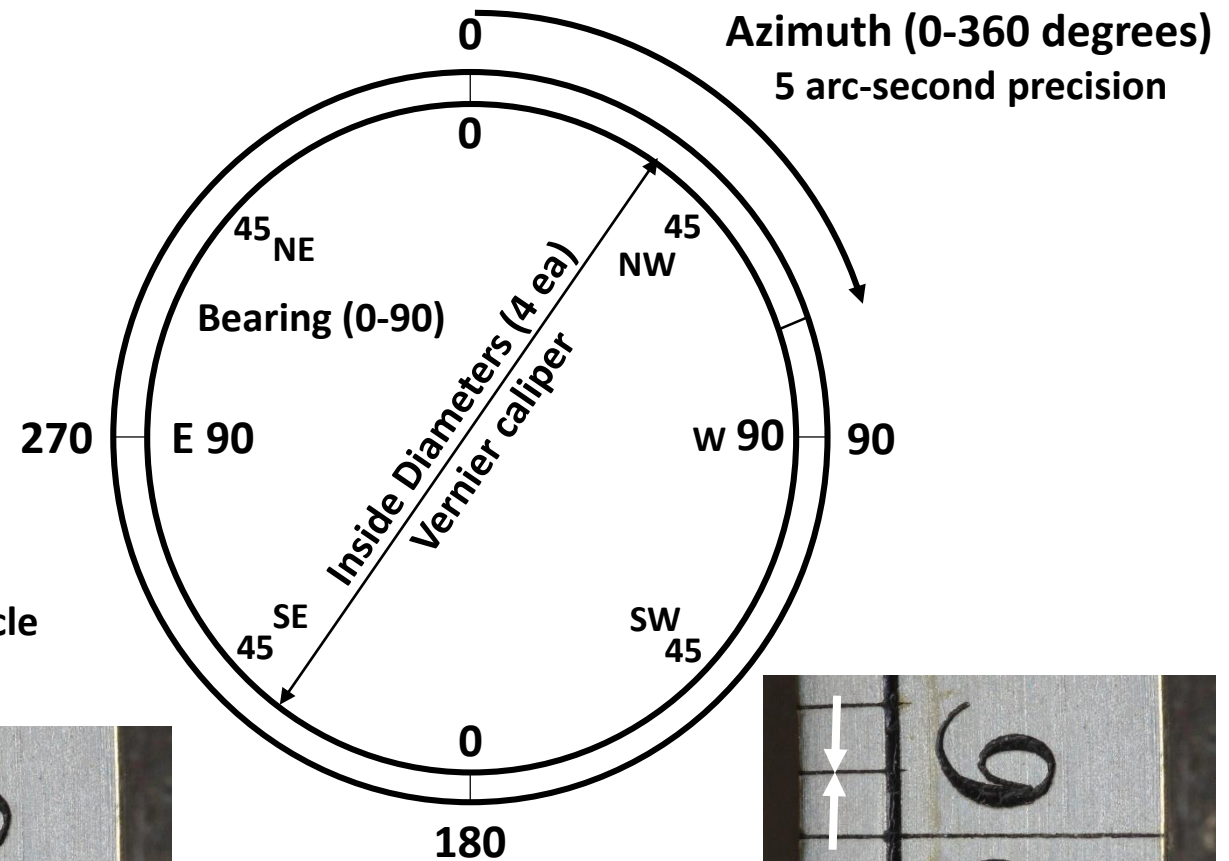
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X-Y-Theta Instrument

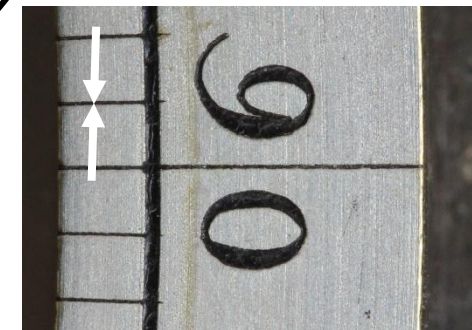


Measurements

- Azimuth angle measured to nearest 5 seconds of arc with Sokkia Total Station
 - 5 degree survey, or every degree
- Inside diameter of needle ring
 - N-S, E-W, SE-NW and SW-NE
- Relative needle ring radii w.r.t. north— deviation from circle
 - To nearest 0.0001 inch
- Relative location of guide circle edges
 - To nearest 0.0001 inch
- Line widths



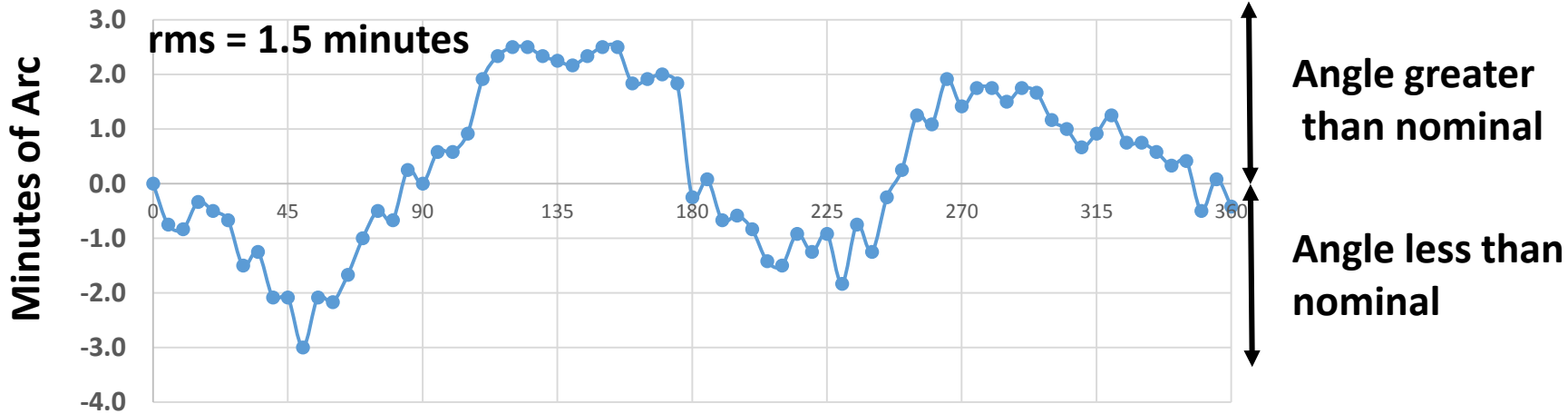
Radii



Line Width

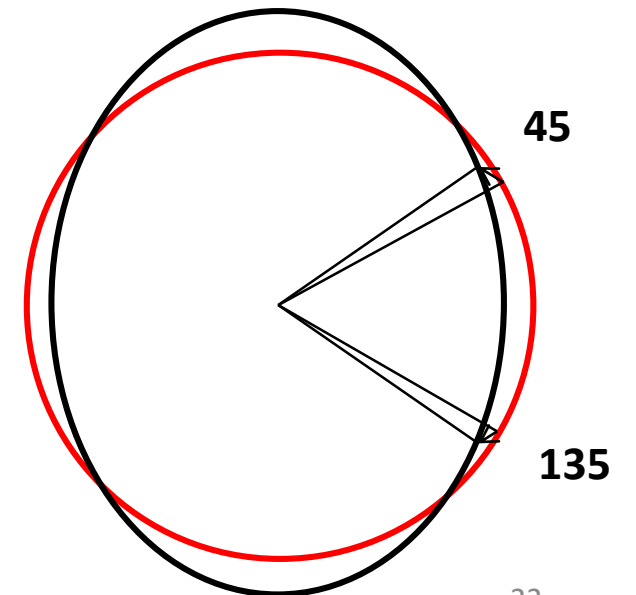
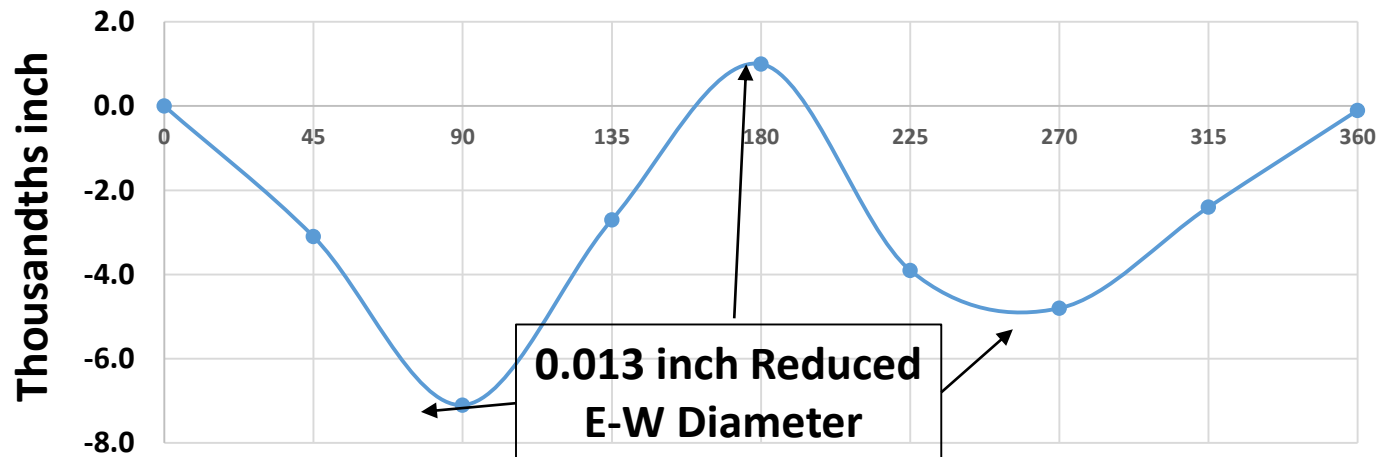
Angular Displacement due to Needle Ring Distortion: Potts 1

Potts 1



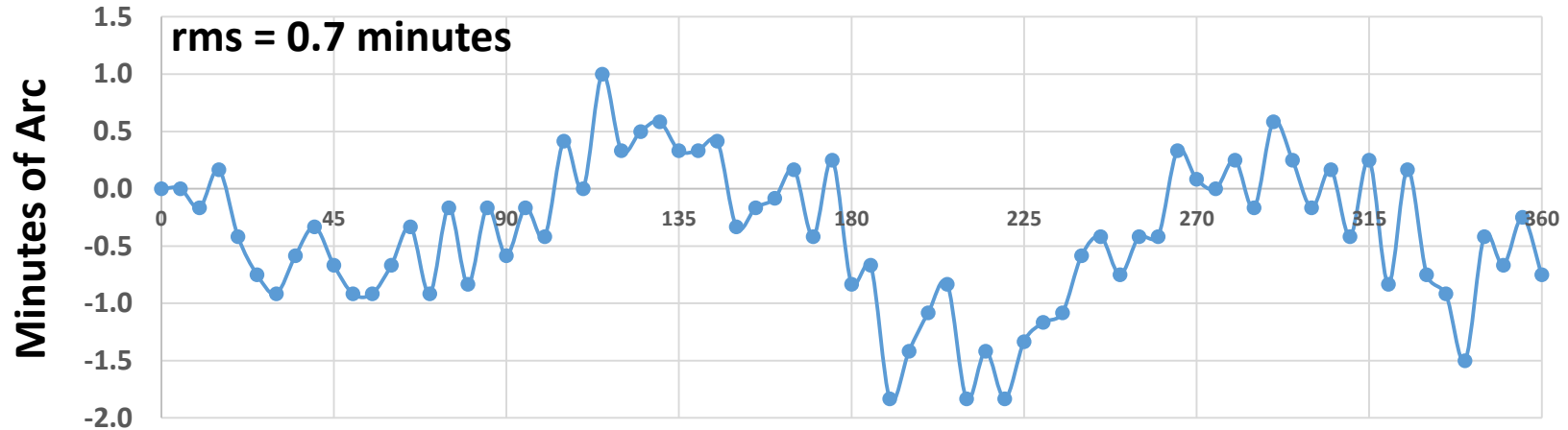
- Egg shape causes apparent decrease of angle at 45 and 225 degrees, increase at 135 and 270 degrees

Potts 1 Deviation From Circle



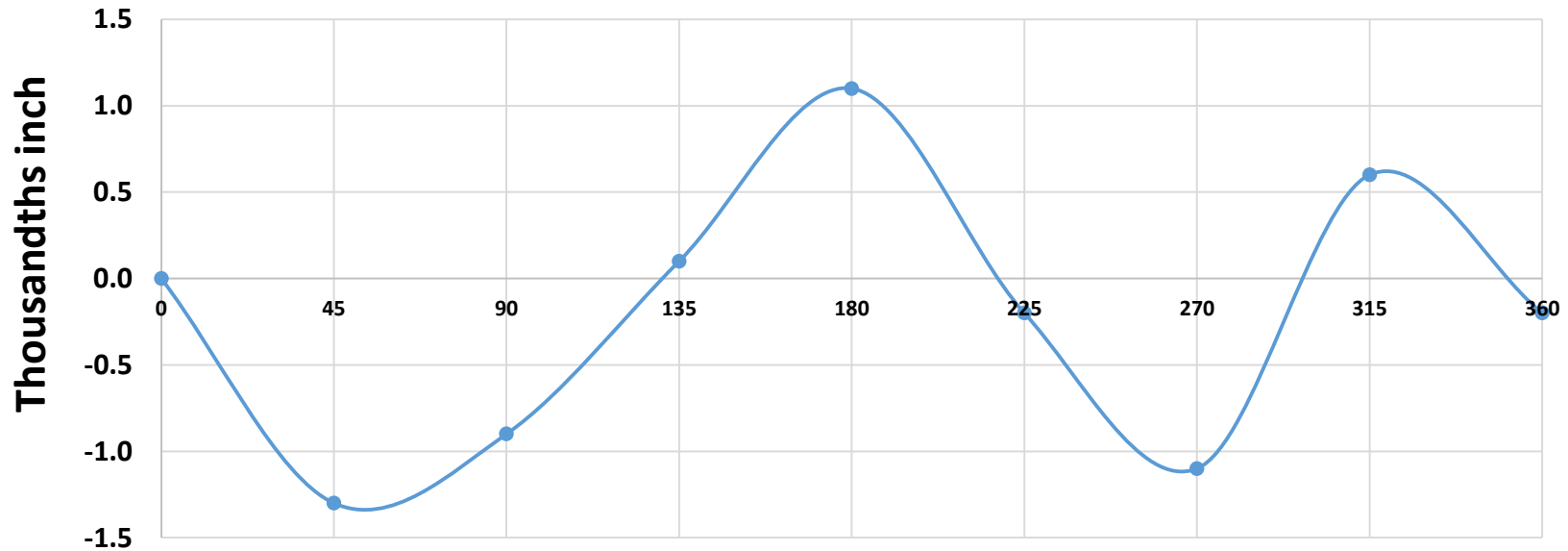
Potts 2

Potts 2

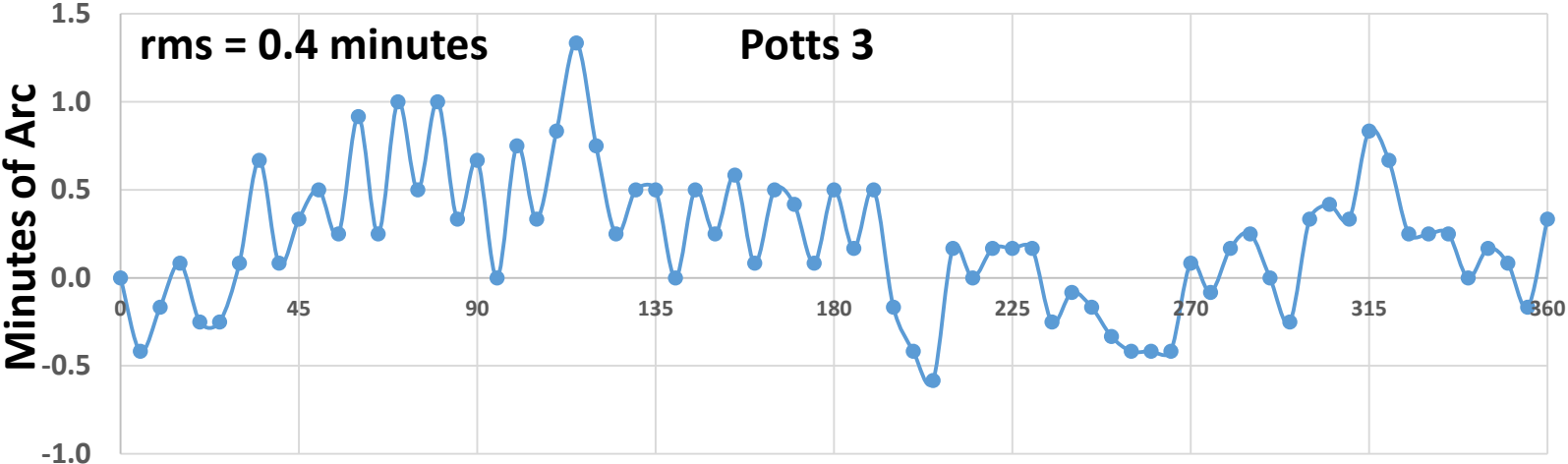


Small needle ring distortion and quite accurate dividing

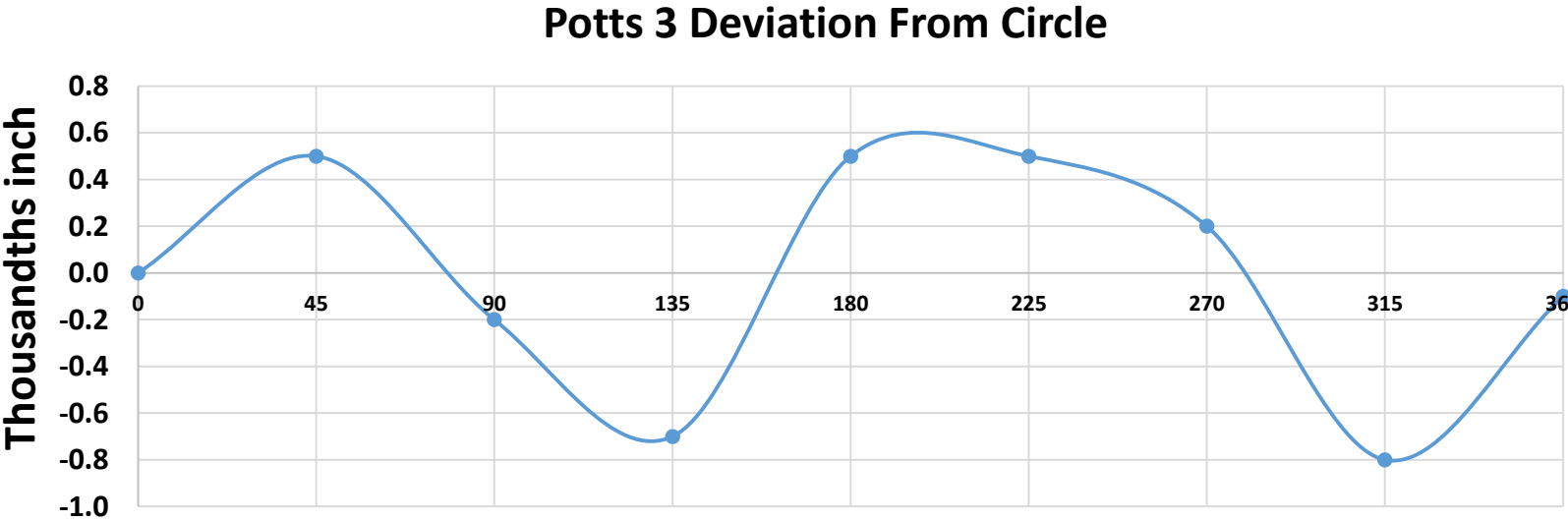
Potts 2 Deviation From Circle



Potts 3

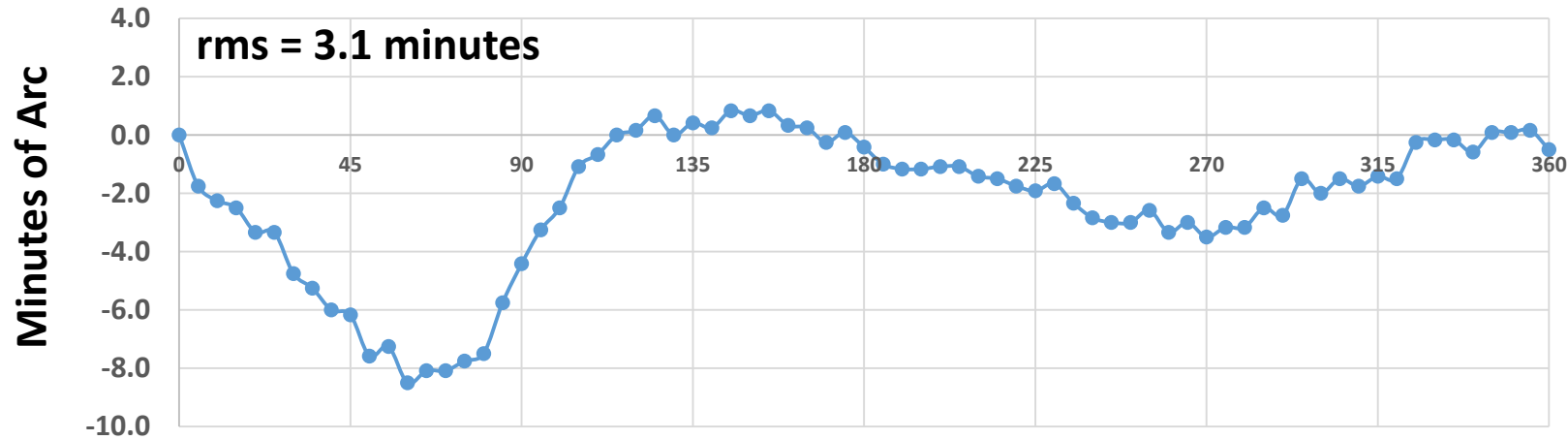


- Least needle ring distortion and most accurate dividing



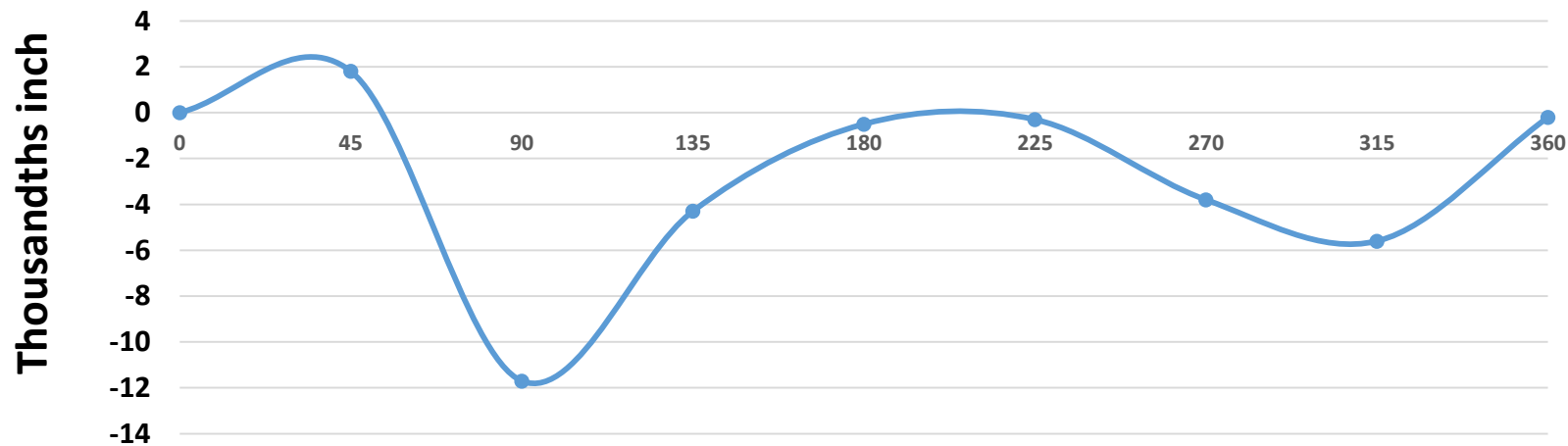
Potts 4

Potts 4



- Most needle ring distortion and least accurate Potts dividing
- Likely that dividing was done as well as on Potts 3 but ring subsequently distorted through aging

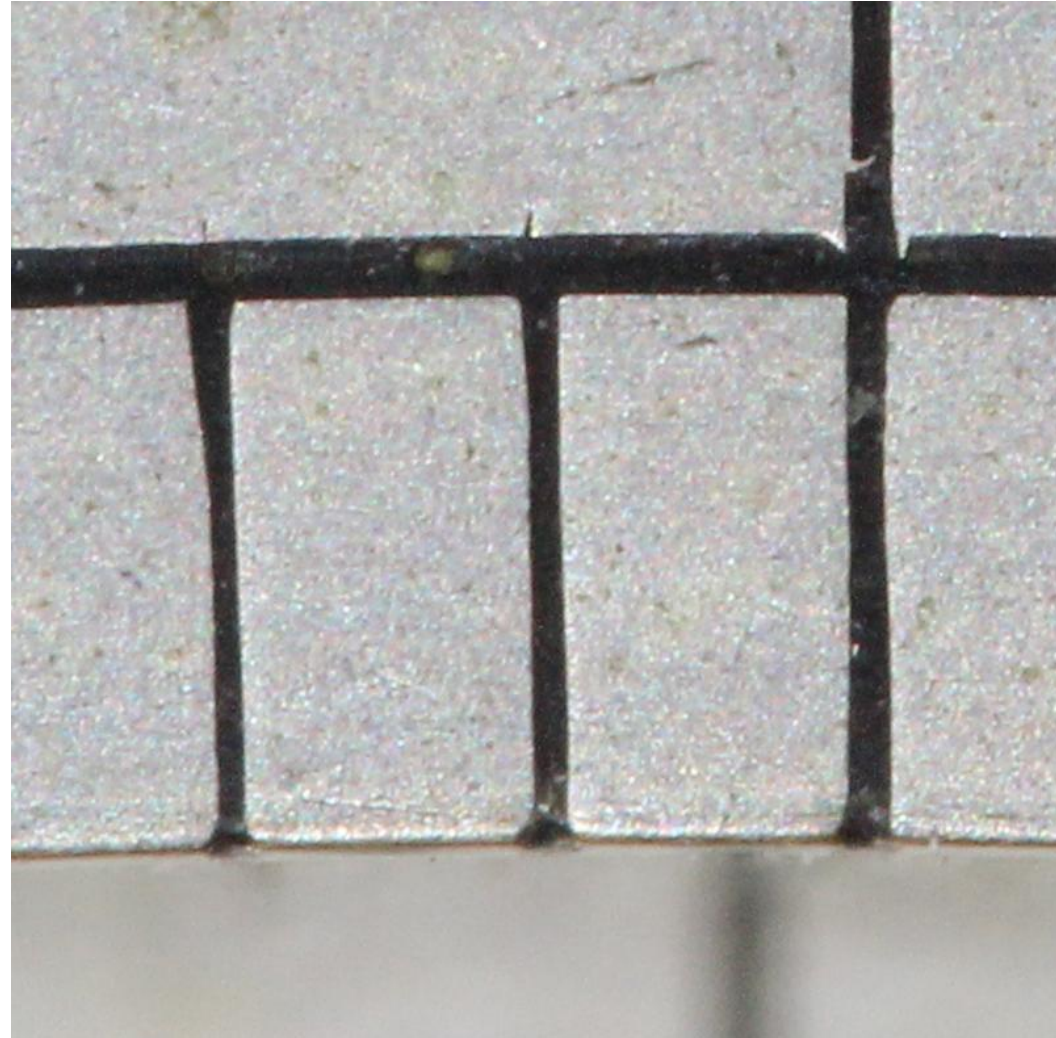
Potts 4 Deviation from Circle



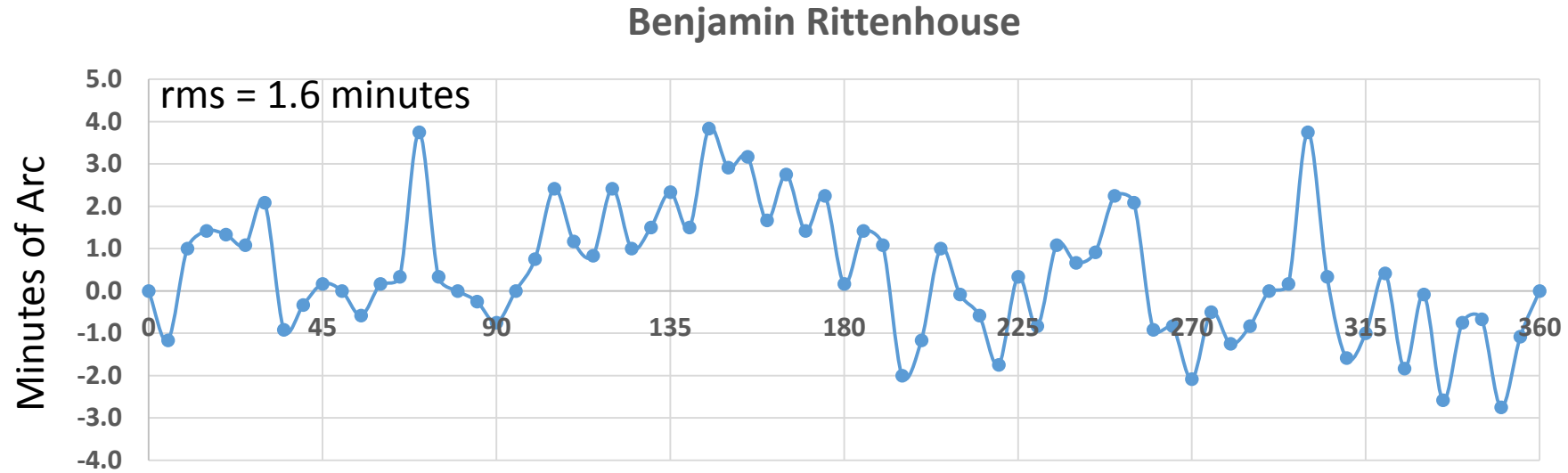
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Benjamin Rittenhouse



Benjamin Rittenhouse

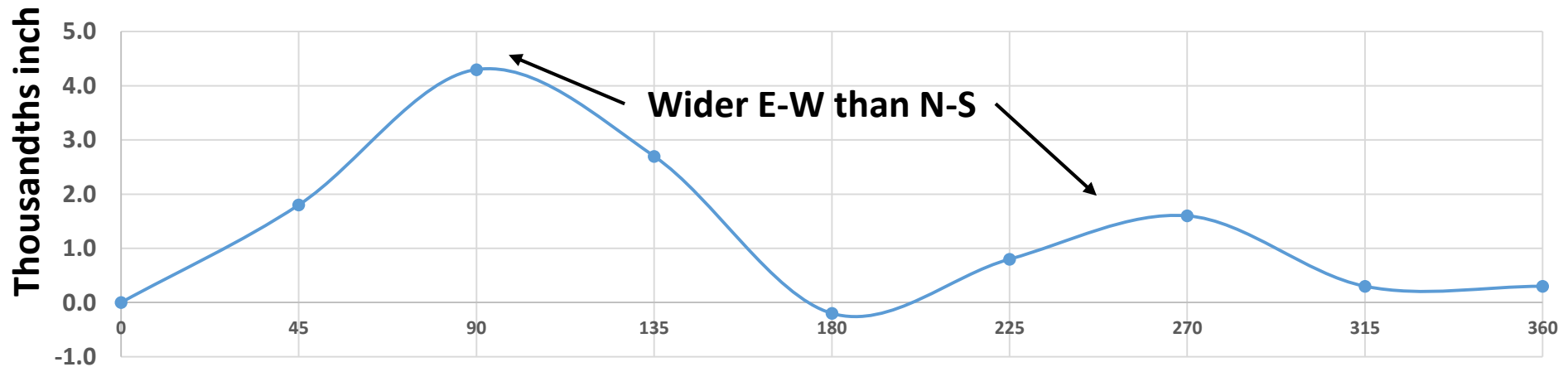
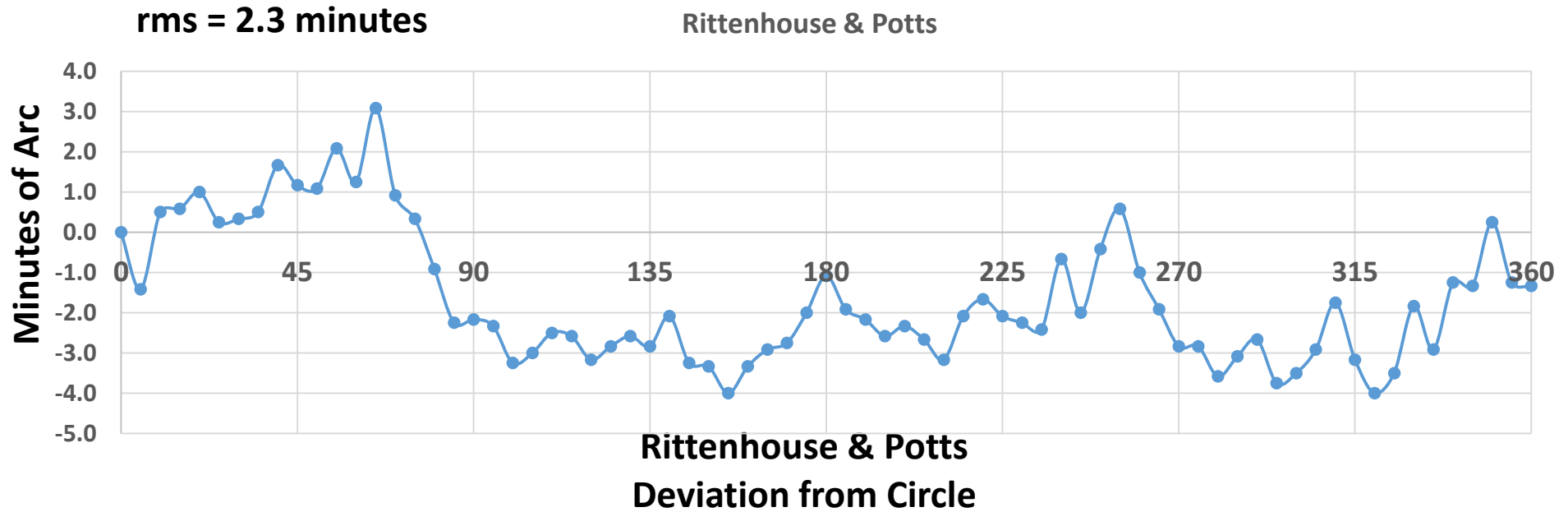


- **Measurements across diameters of Benjamin Rittenhouse needle ring showed ~ 0.002 inch maximum runout**
- **Short term variations dominate rms**

Rittenhouse & Potts



Rittenhouse & Potts

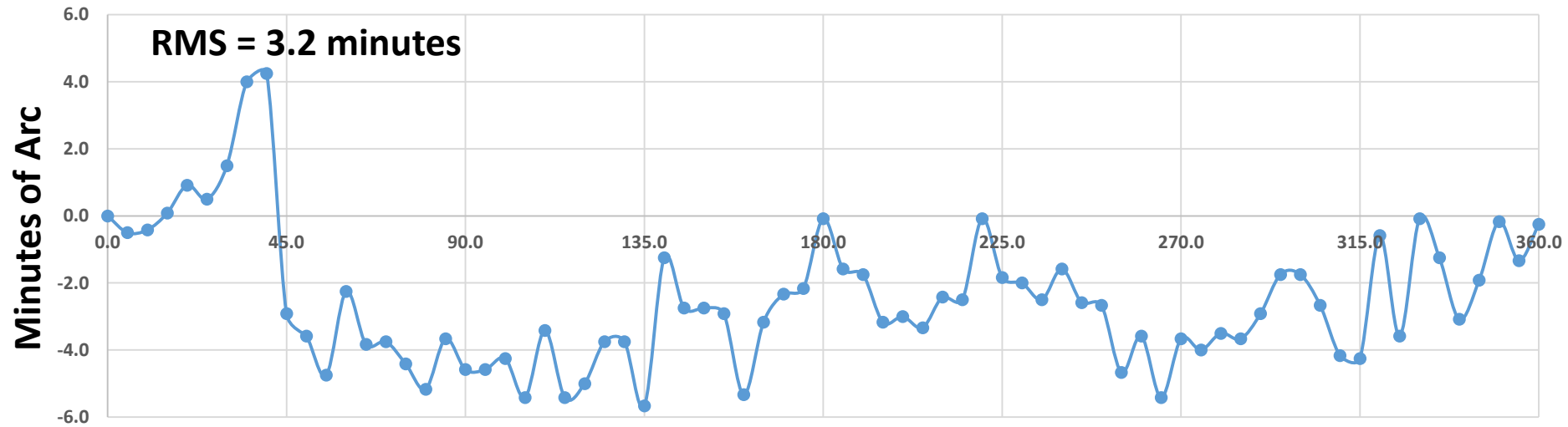


Lewis Michael

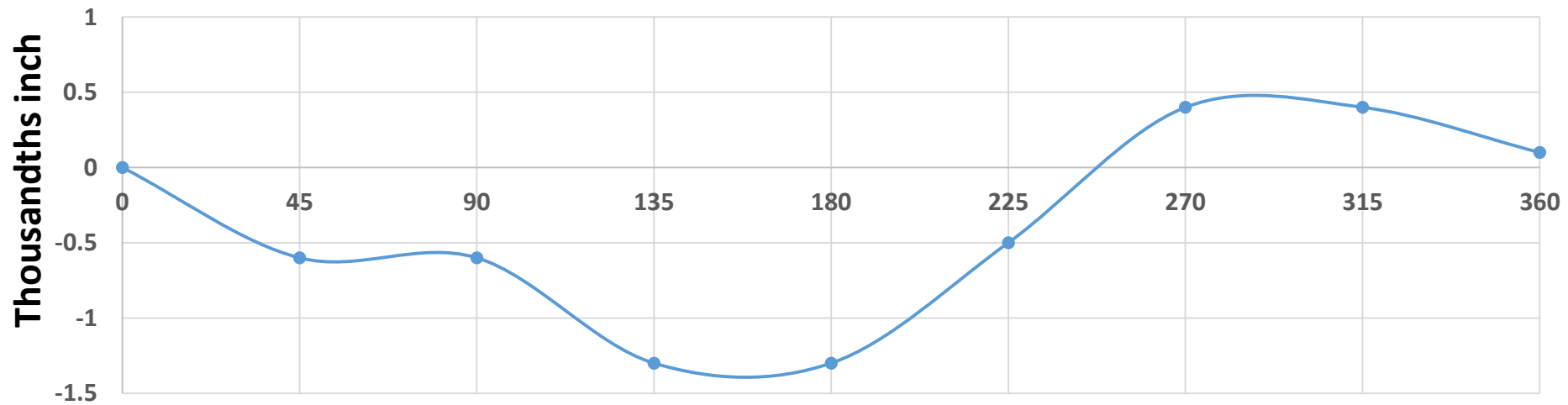


Lewis Michael (18th Cent.)

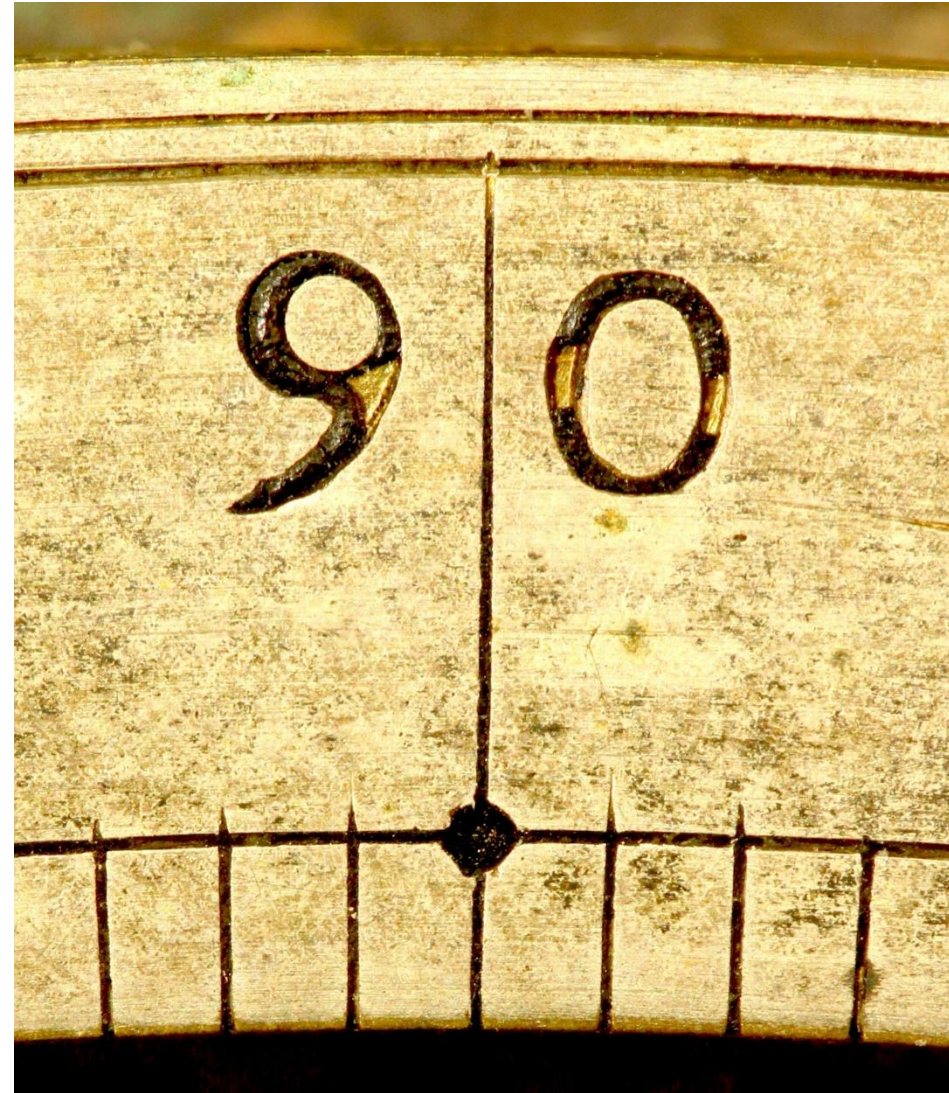
Lewis Michael Fives



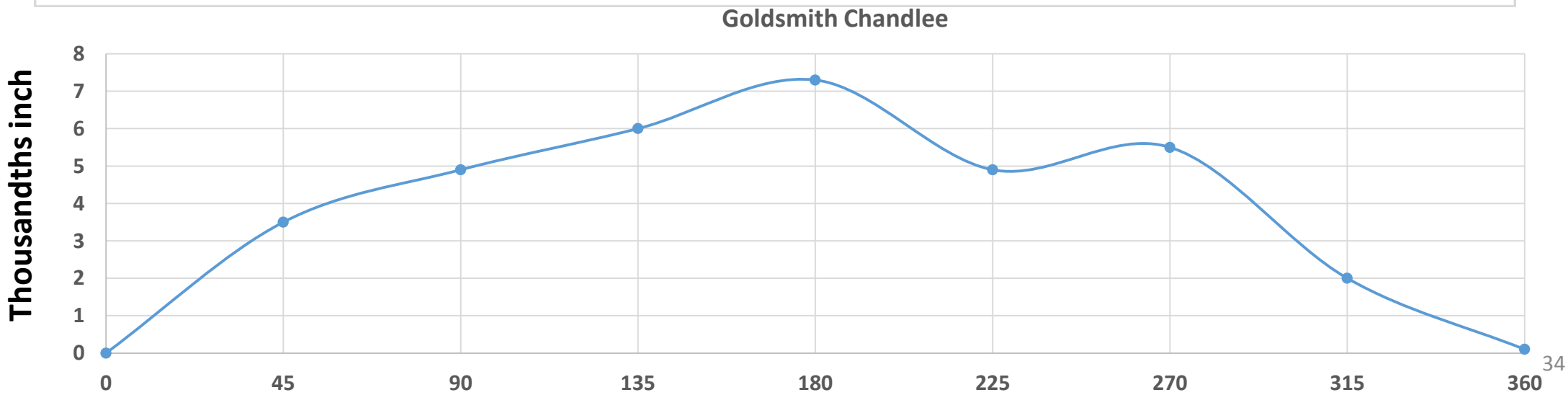
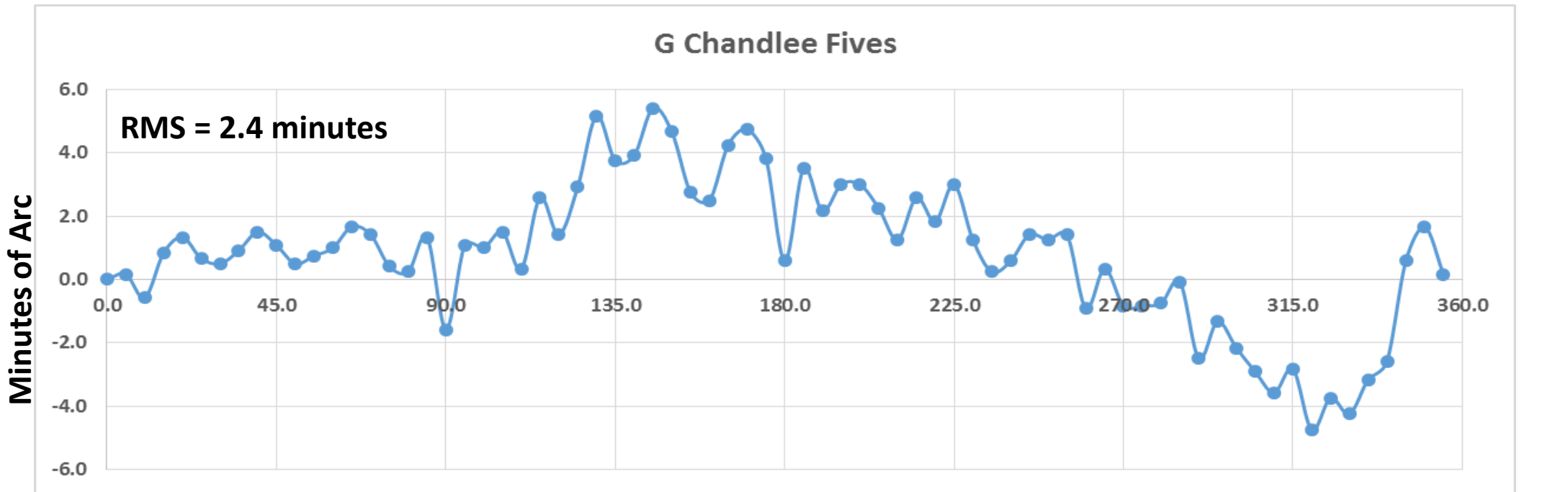
Lewis Michael Delta from Circle



Goldsmith Chandlee (1751-1821)



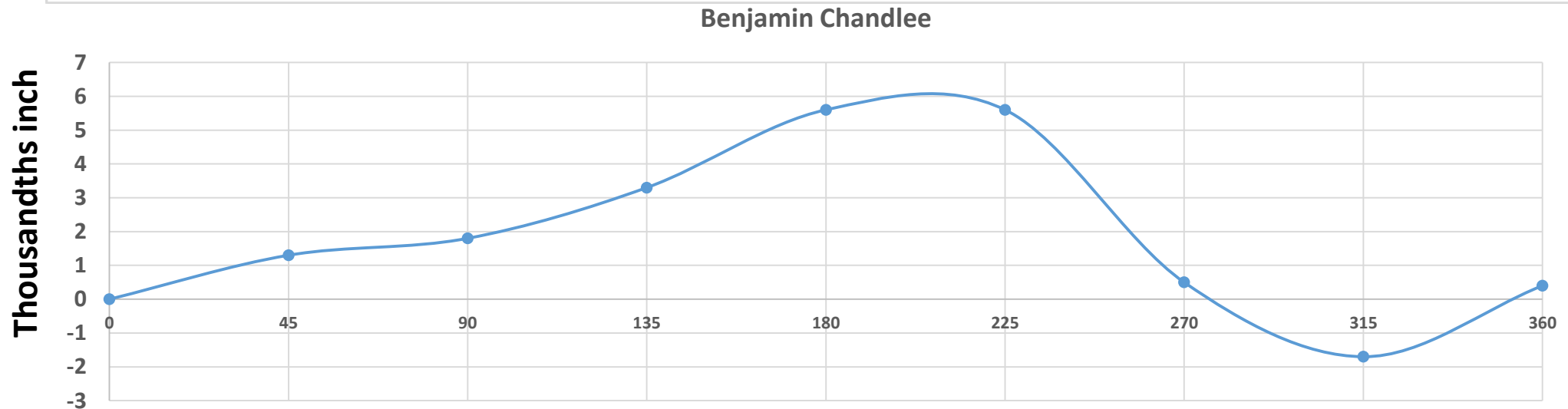
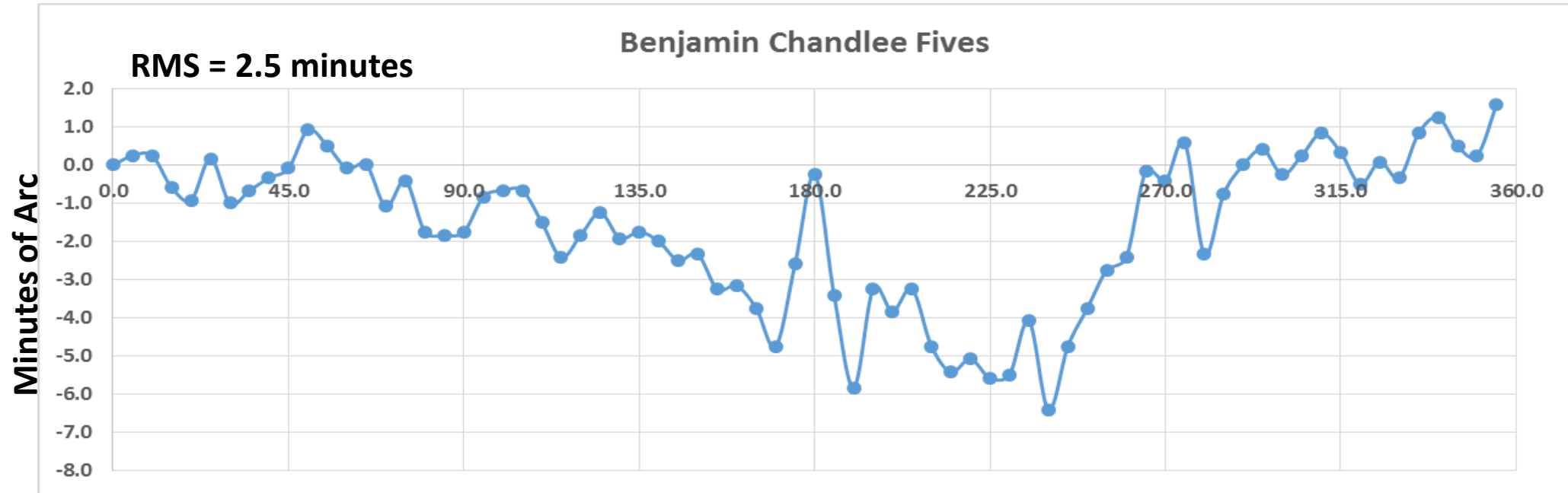
Goldsmith Chandlee



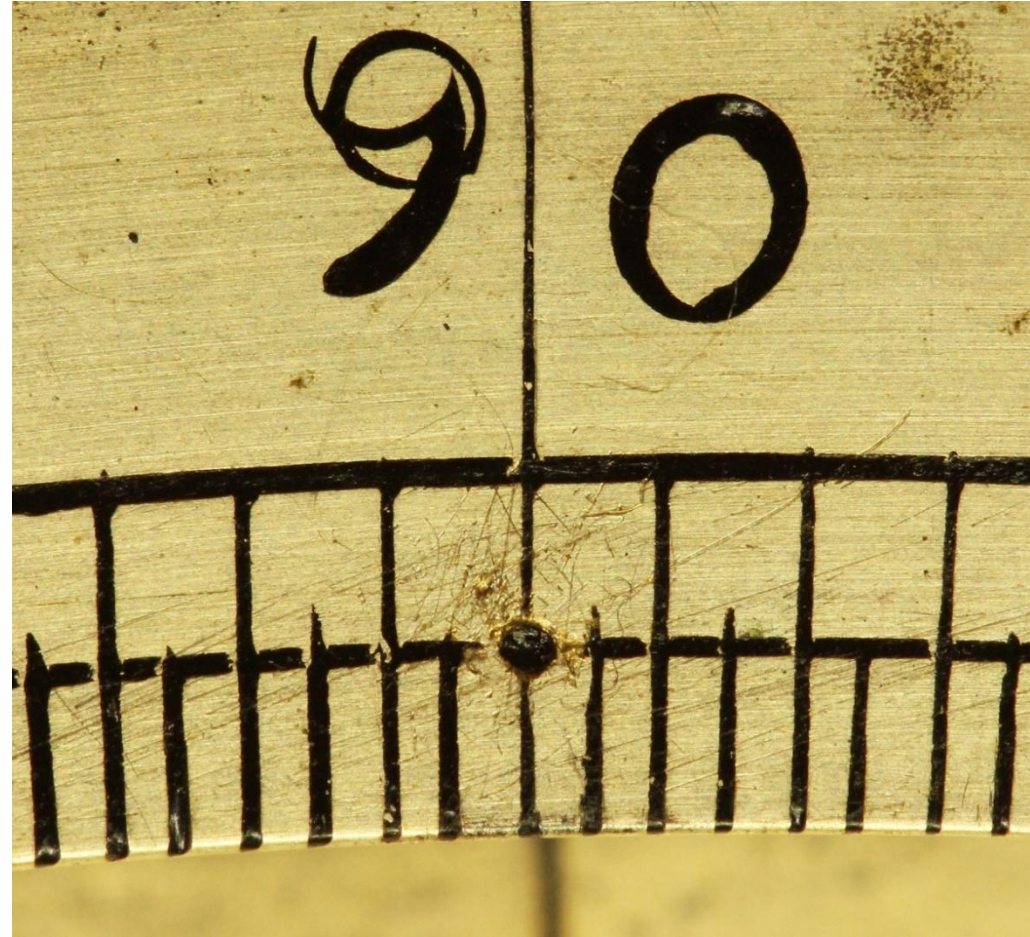
Benjamin Chandlee III (1780-1822)



Benjamin Chandlee III

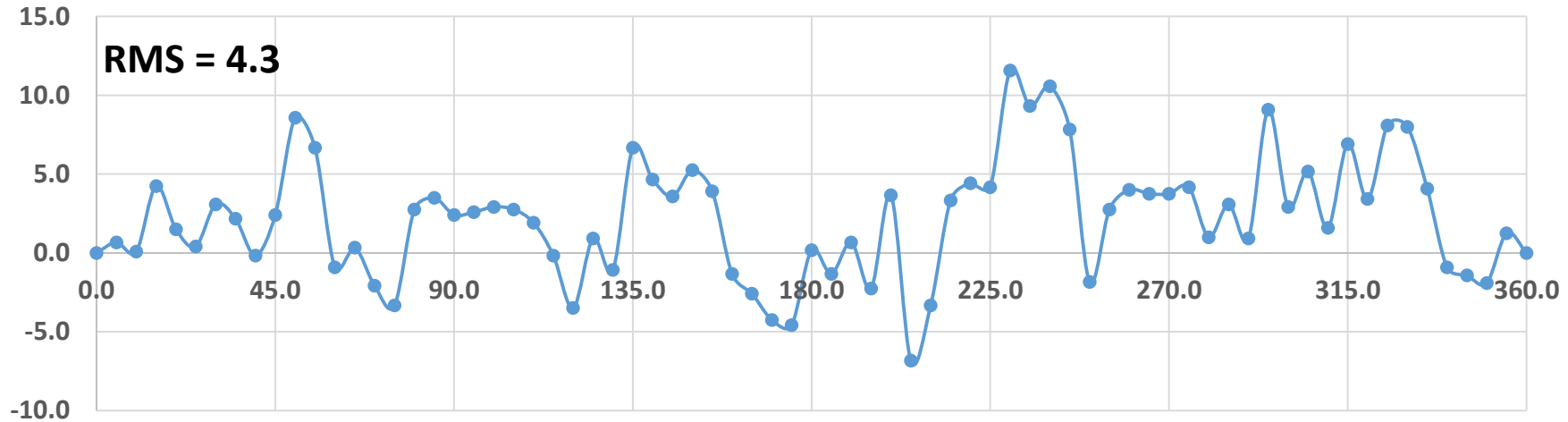


George B. Graves (1792-1873)

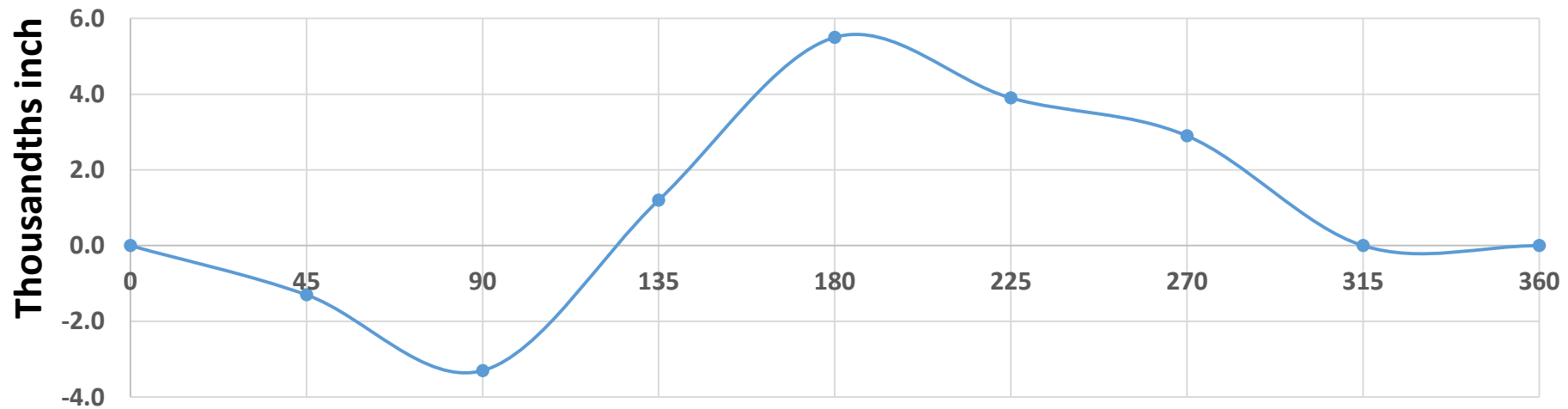


G. B. Graves

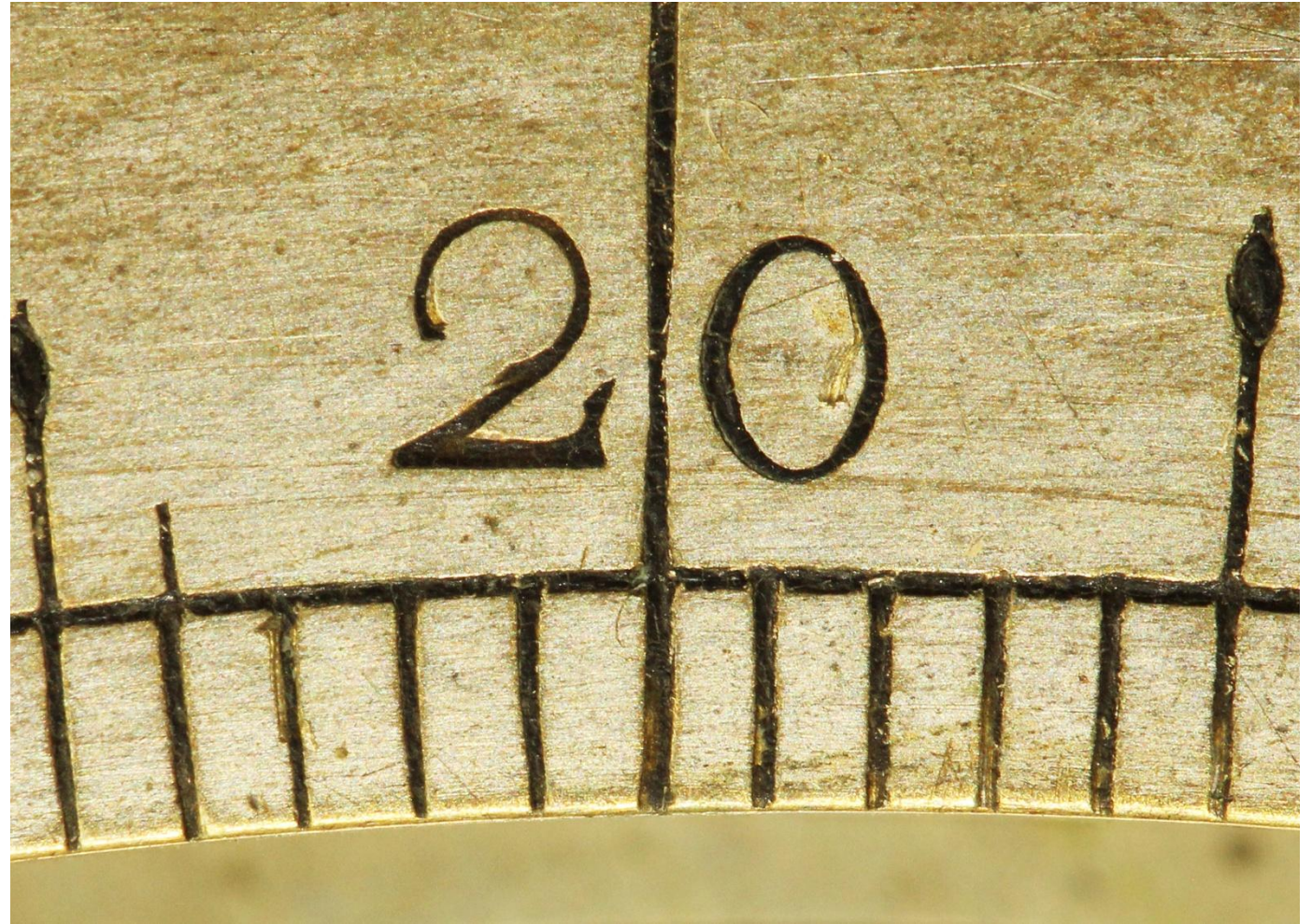
Graves fives



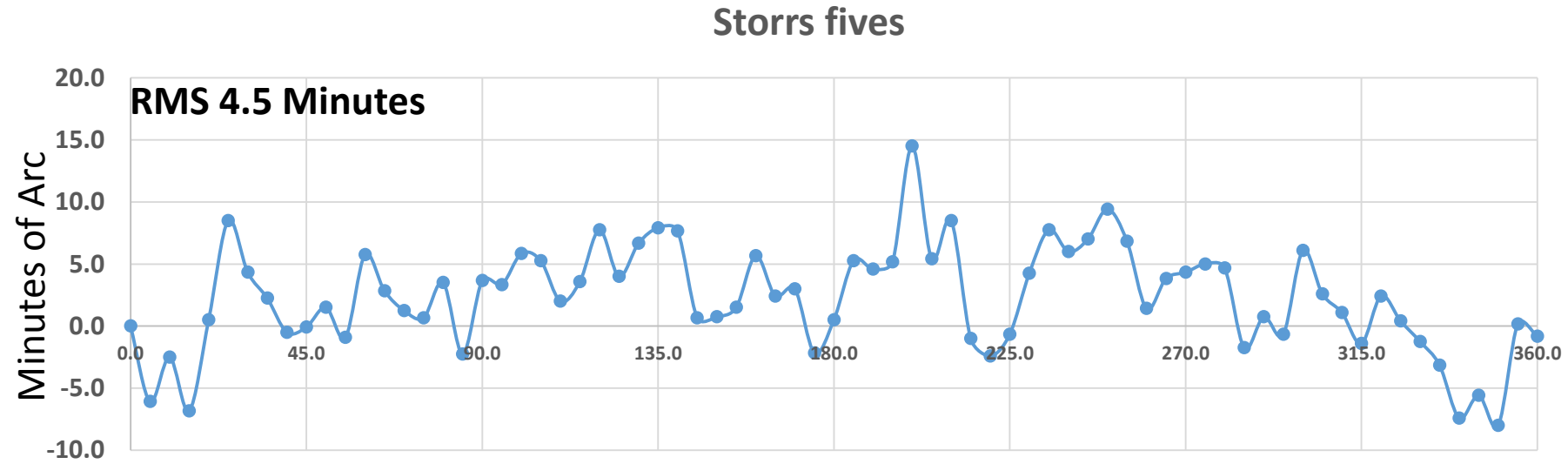
Graves



Nathan Storrs Northampton (1791?)



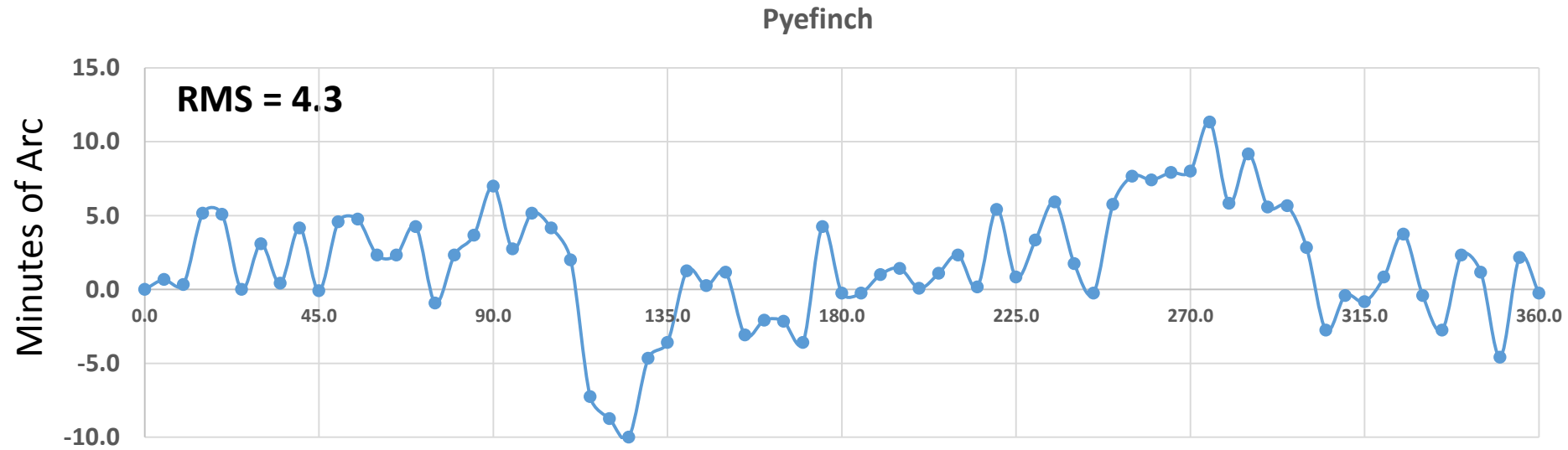
Nathan Storrs Northampton (1791?)



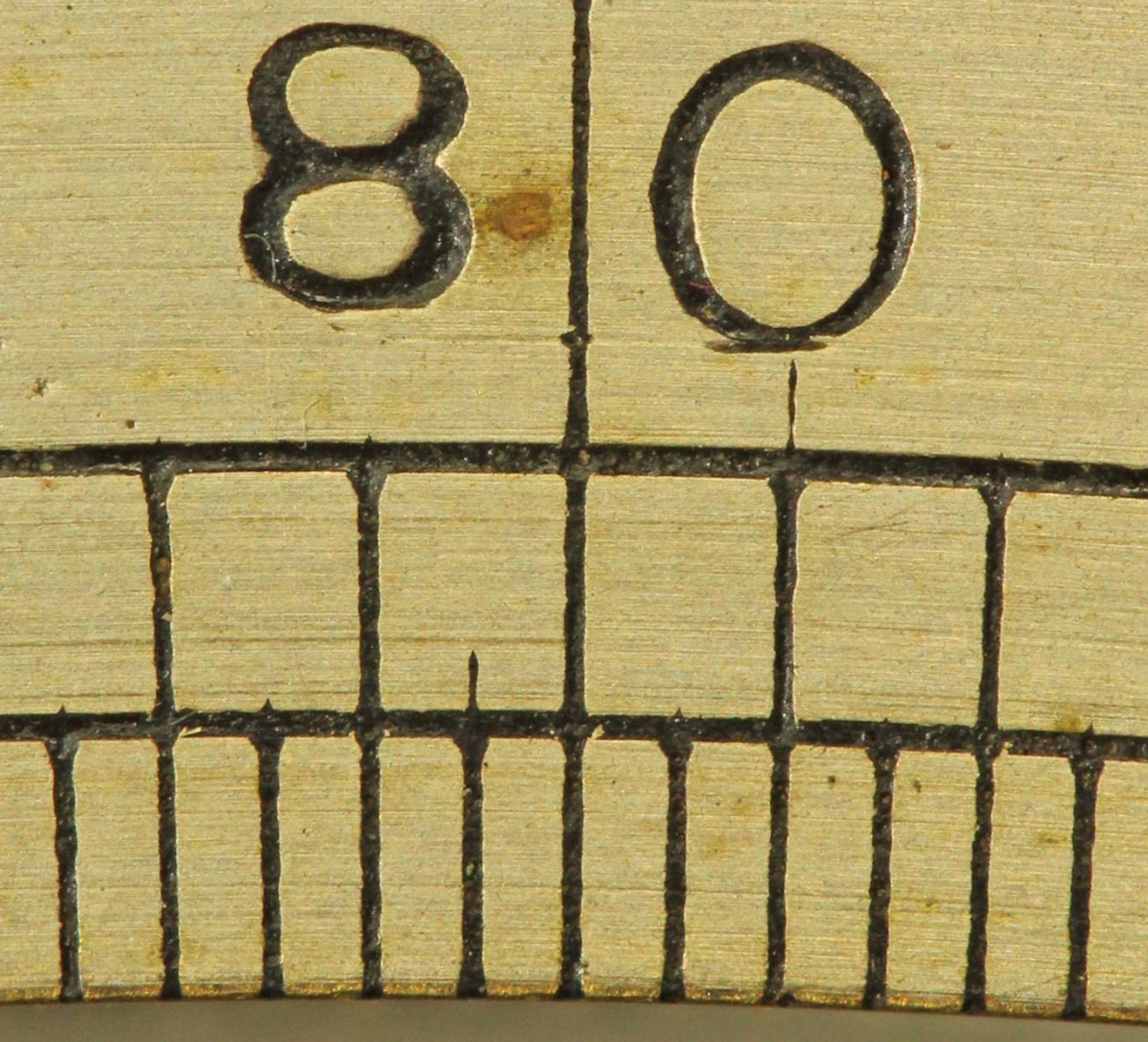
Henry Pyefinch – London (1763-1790)



Henry Pyefinch - London (1763-1790)

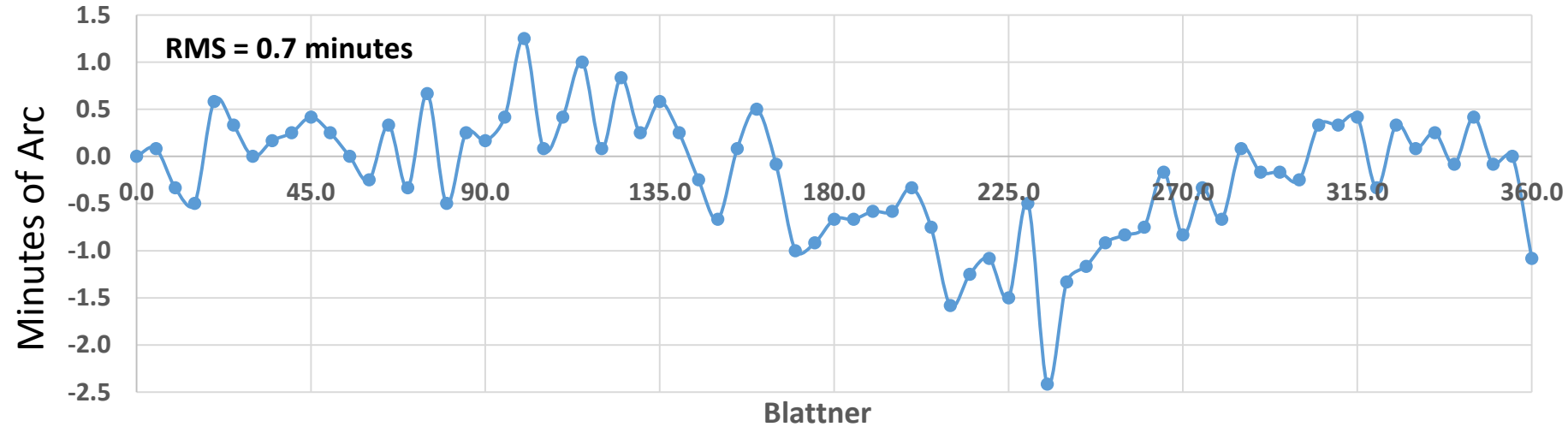


Blattner Dots (1840-1870)

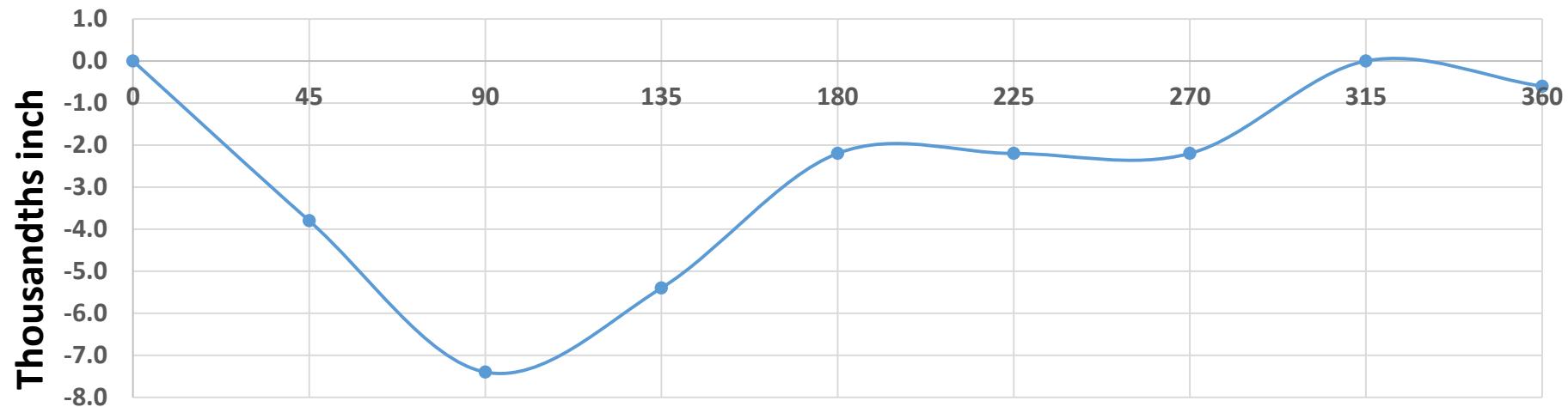


Jacob Blattner (1840-1872)

Jacob Blattner fives



- Large radial runout (0.007 inch) and small amount of angular variation may indicate that dividing was done after needle ring distortion occurred

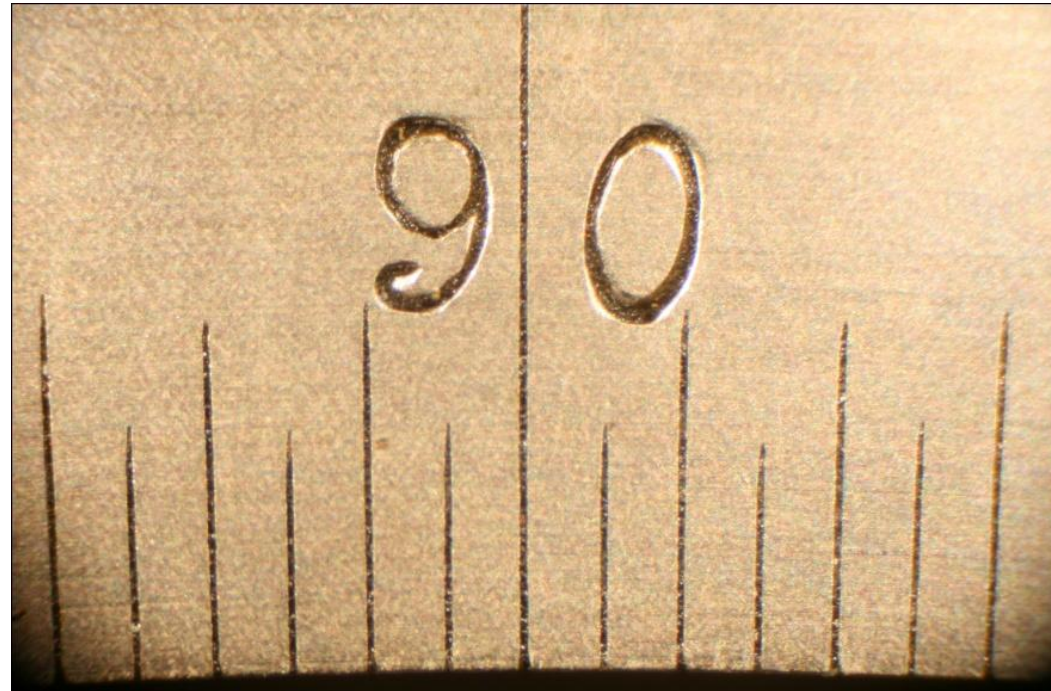


Gurley Vernier Compass

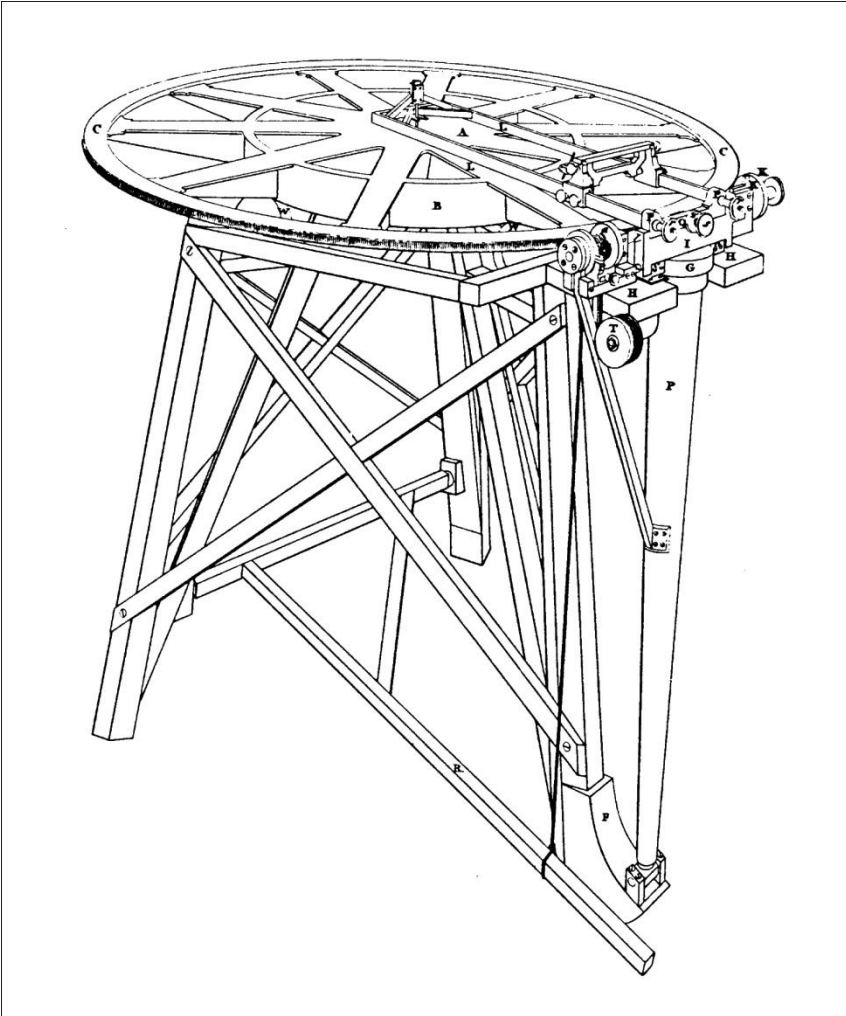
1867-1875



- 7" diameter
- 5-7/8" needle
- 1 minute reverse folded Vernier
- Machine divided using Gurley's "hand machine"

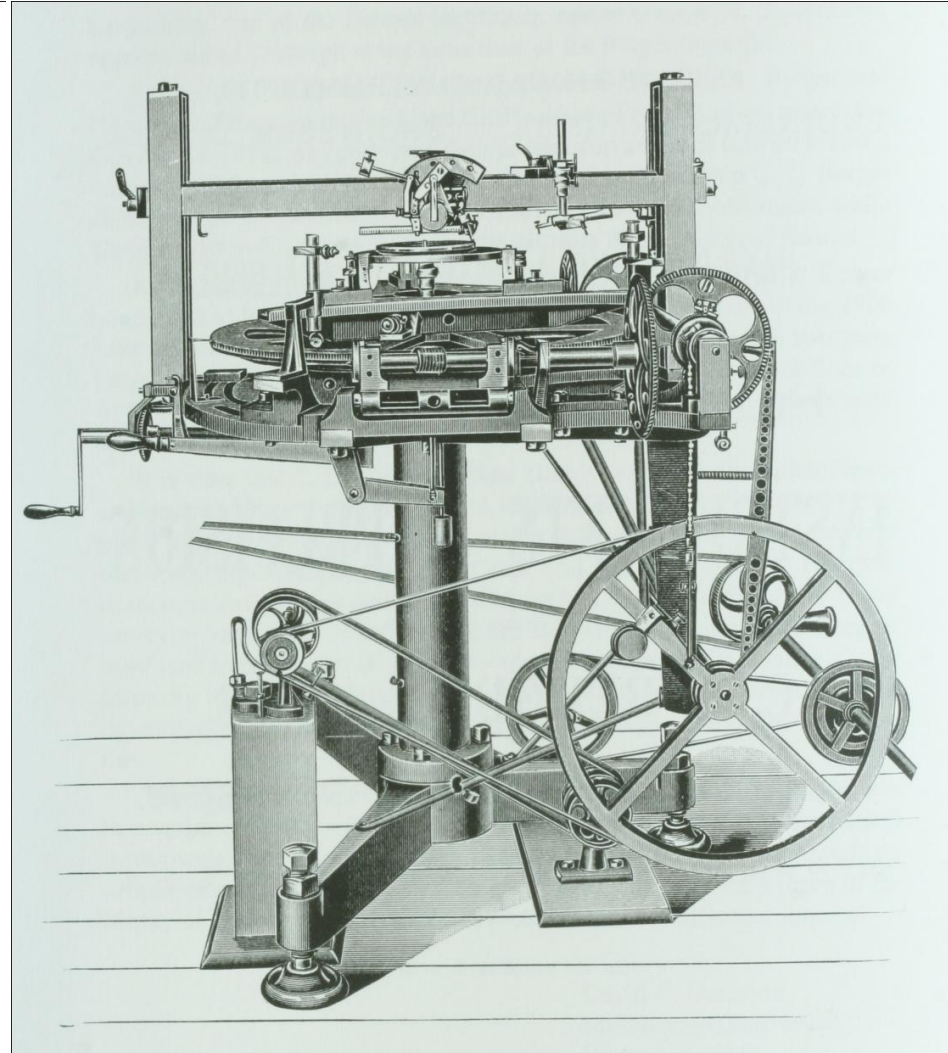


Ramsden Dividing Engine 1768



Ramsden "hand machine"

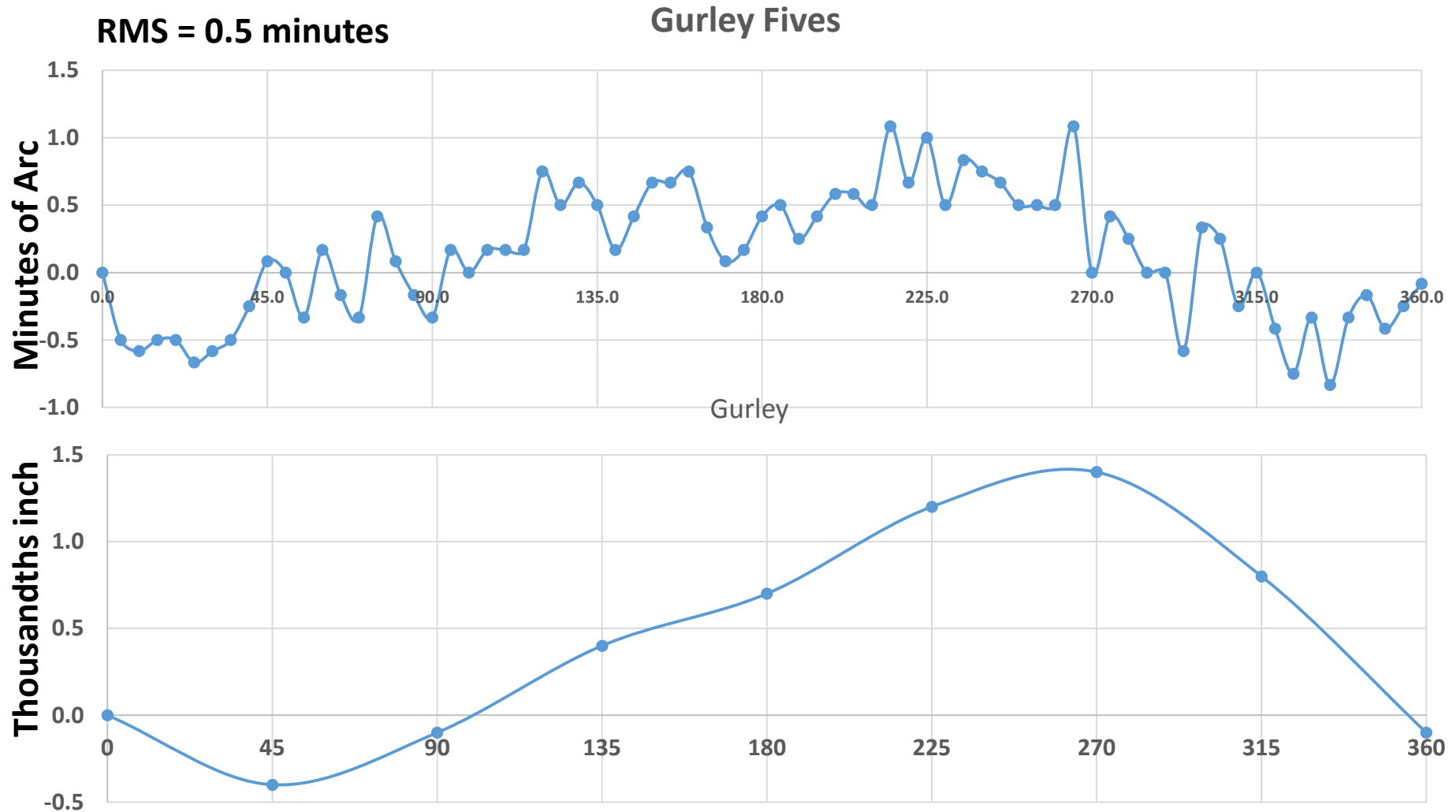
Chapman



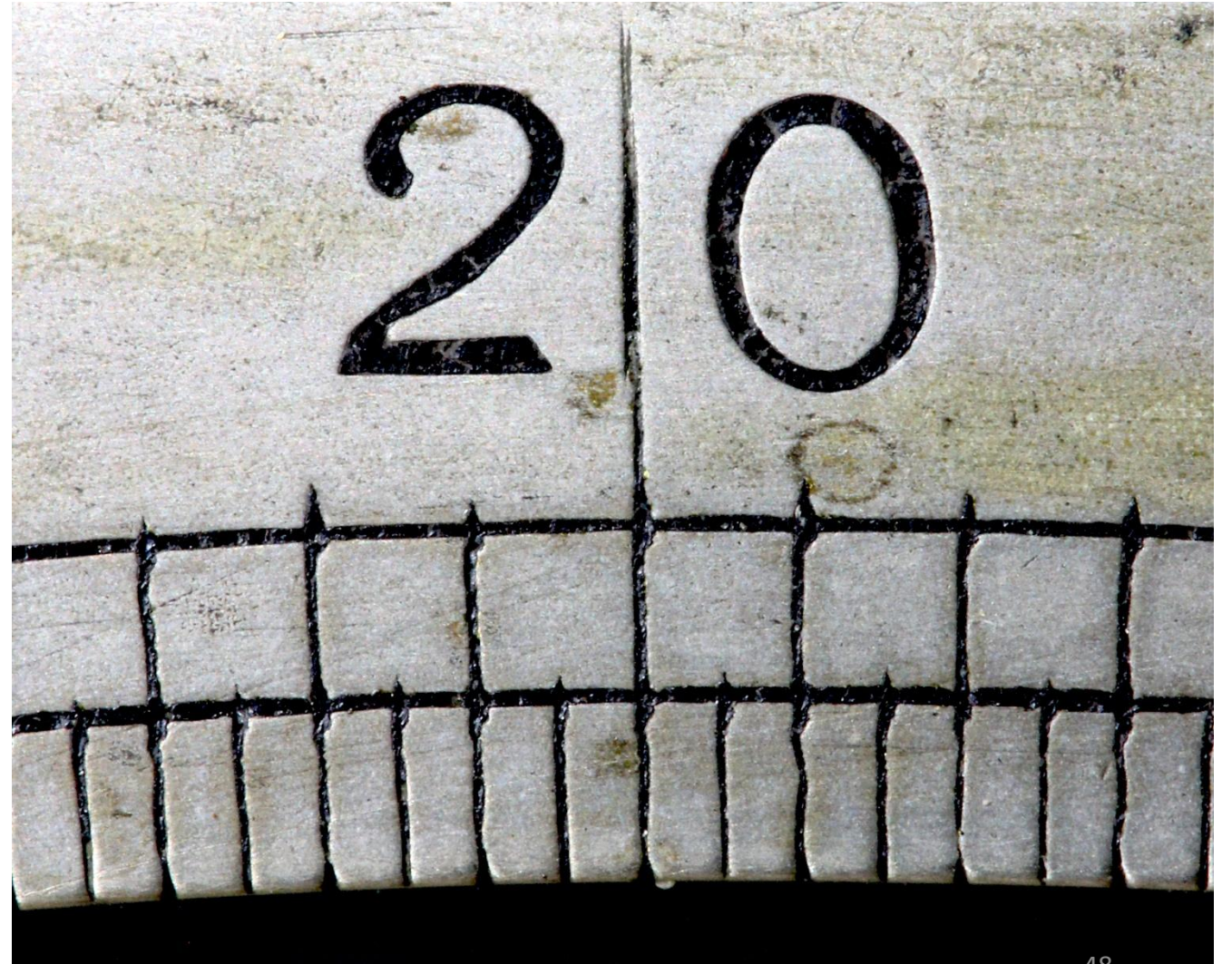
Berger & Sons Automatic Engine

Berger & Sons

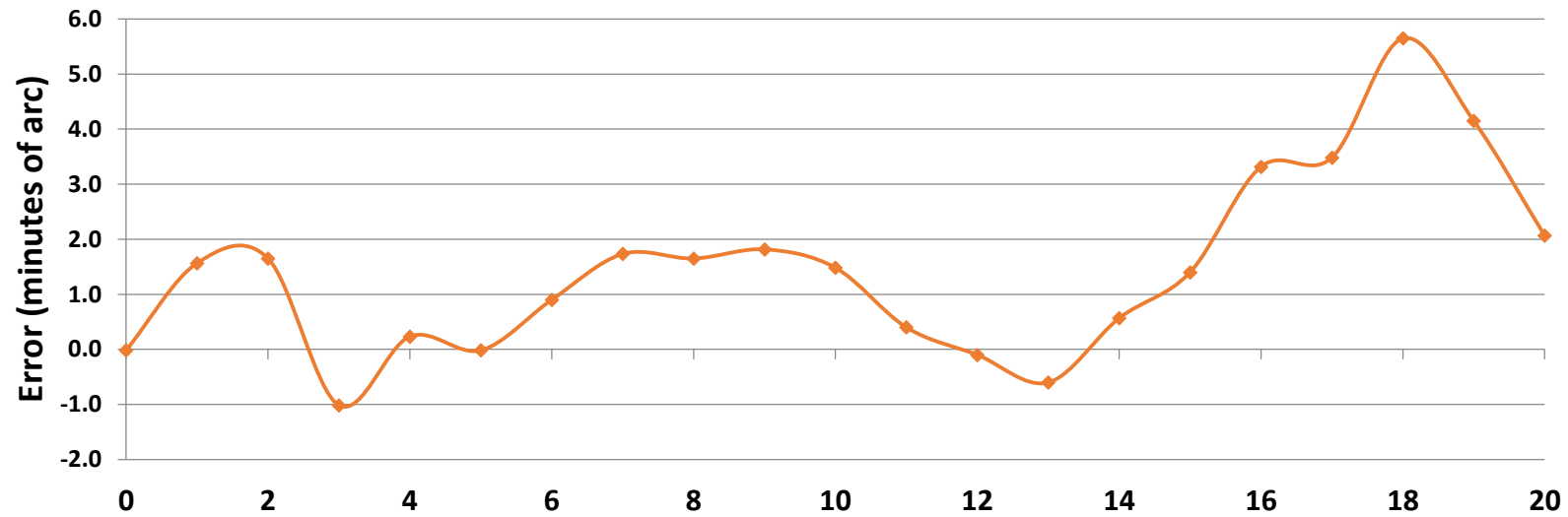
W. & L.E. Gurley (1867-1875)



Philadelphia Unsigned

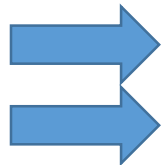
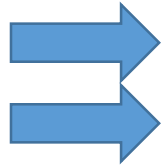


Philadelphia Unsigned (0-20 deg. Survey)



Summary of Properties

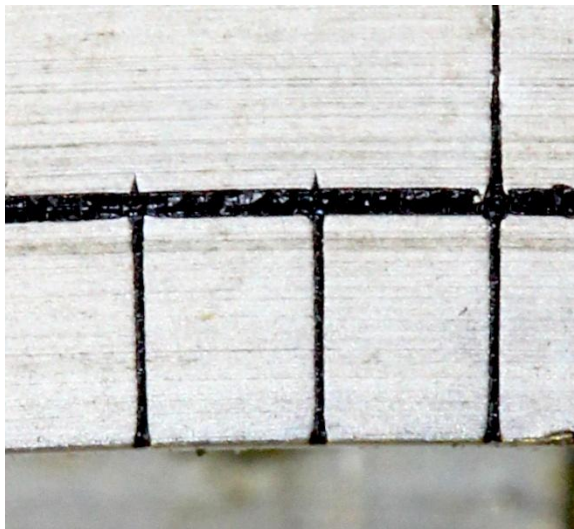
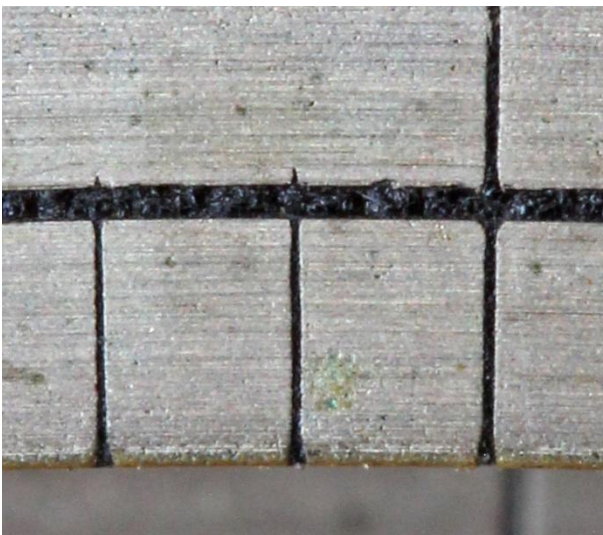
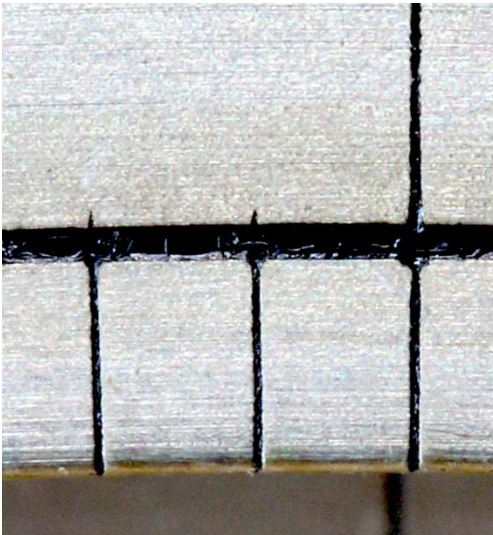
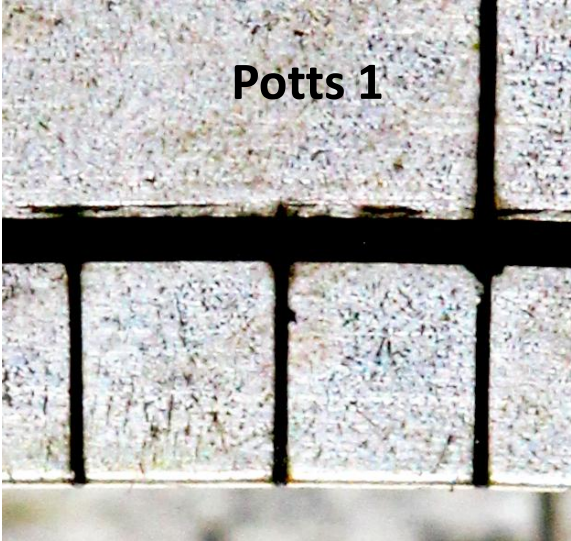
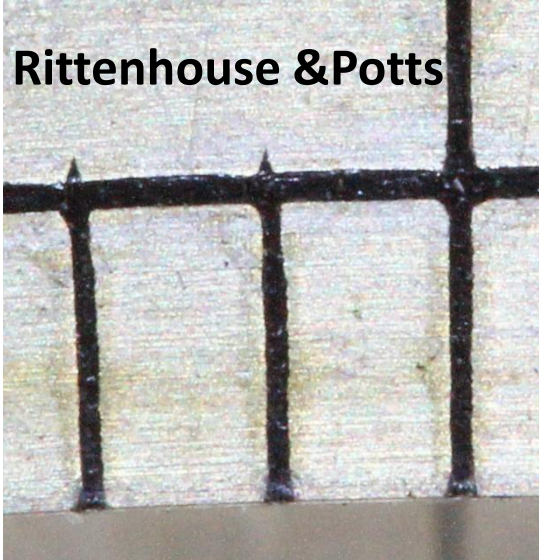
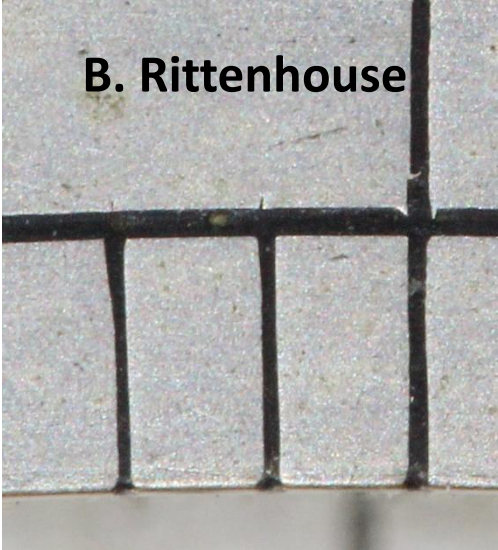
Compass	Diameter inches	Roundness (Runout)	Line Width Inches	RMS Minutes
Potts 1	5.89	0.008 inch	0.0025	1.5
Potts 2	5.85	0.0025	"	0.7
Potts 3	5.86	0.0013	"	0.4
Potts 4	6.02	0.014	"	3.1
B. Rittenhouse	5.26	0.002		1.6
Rit. and Potts	5.13	0.0045 inch		2.3
Lewis Michael	5.05	0.0022	0.0035-0.0045	3.2
N. Storrs	4.33		0.005-0.007	4.5
H. Pyefinch	4.40			4.3
G. Chandlee	5.03	0.007		2.4
B. Chandlee	4.88	0.0075		2.5
G. B. Graves	5.855		0.0025	4.3
J. Blattner	6.015	0.0085	0.0055	0.7
Gurley	5.99	0.0018	0.0027	0.5



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Potts dots

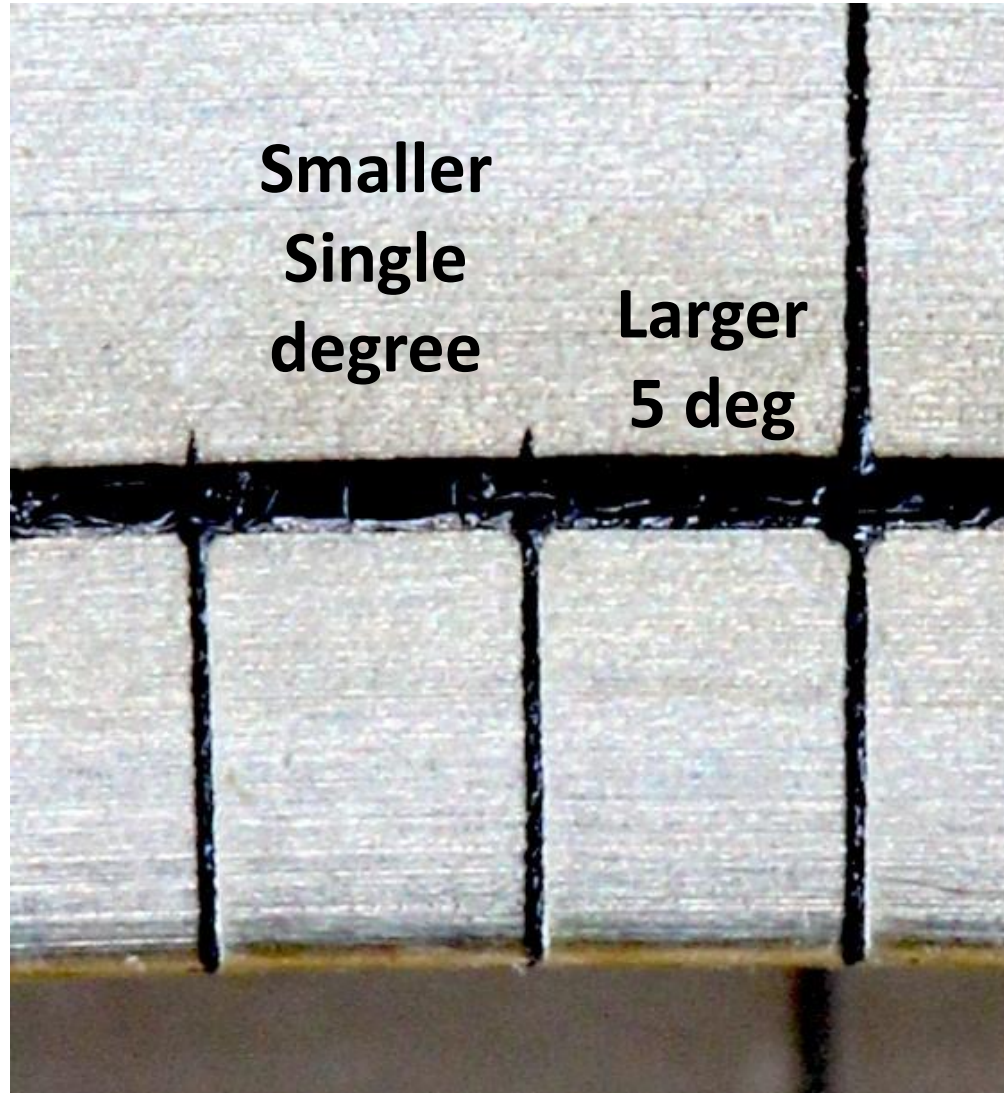


Potts 2

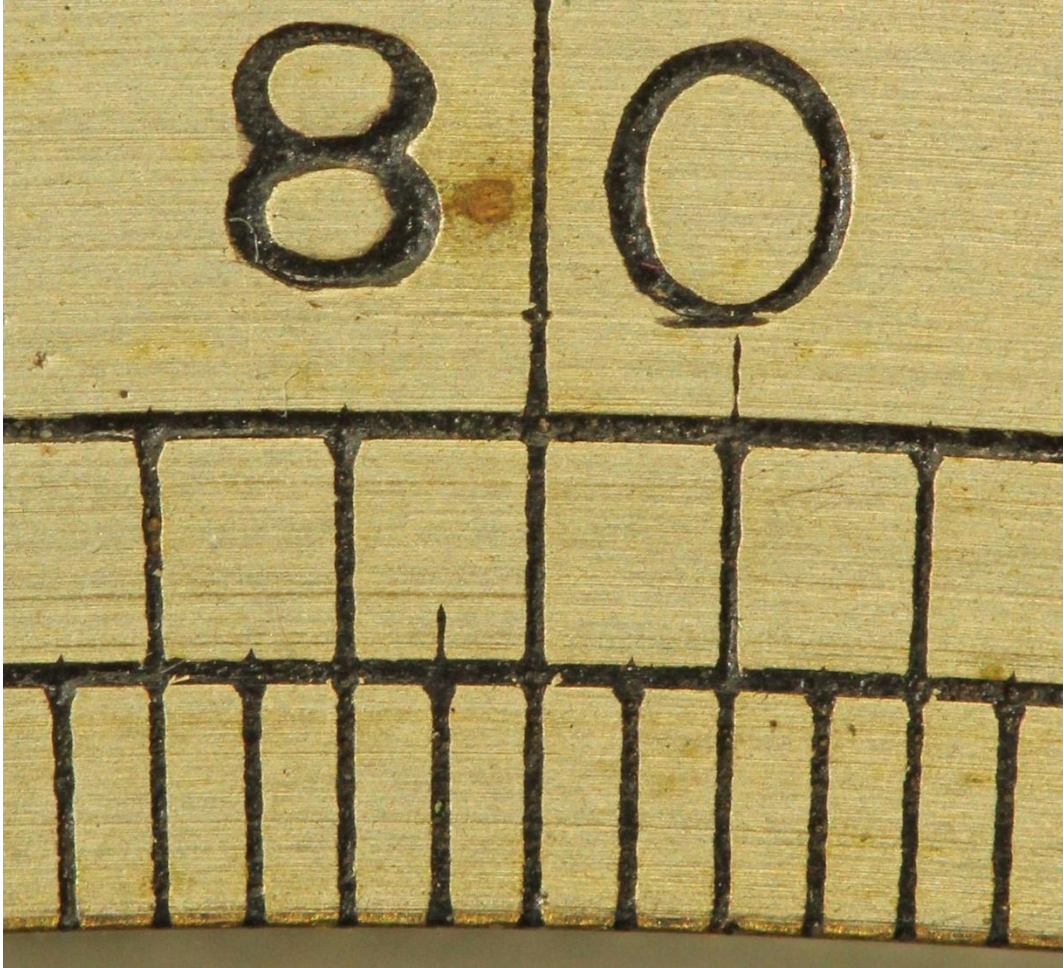
Potts 3

Potts 4

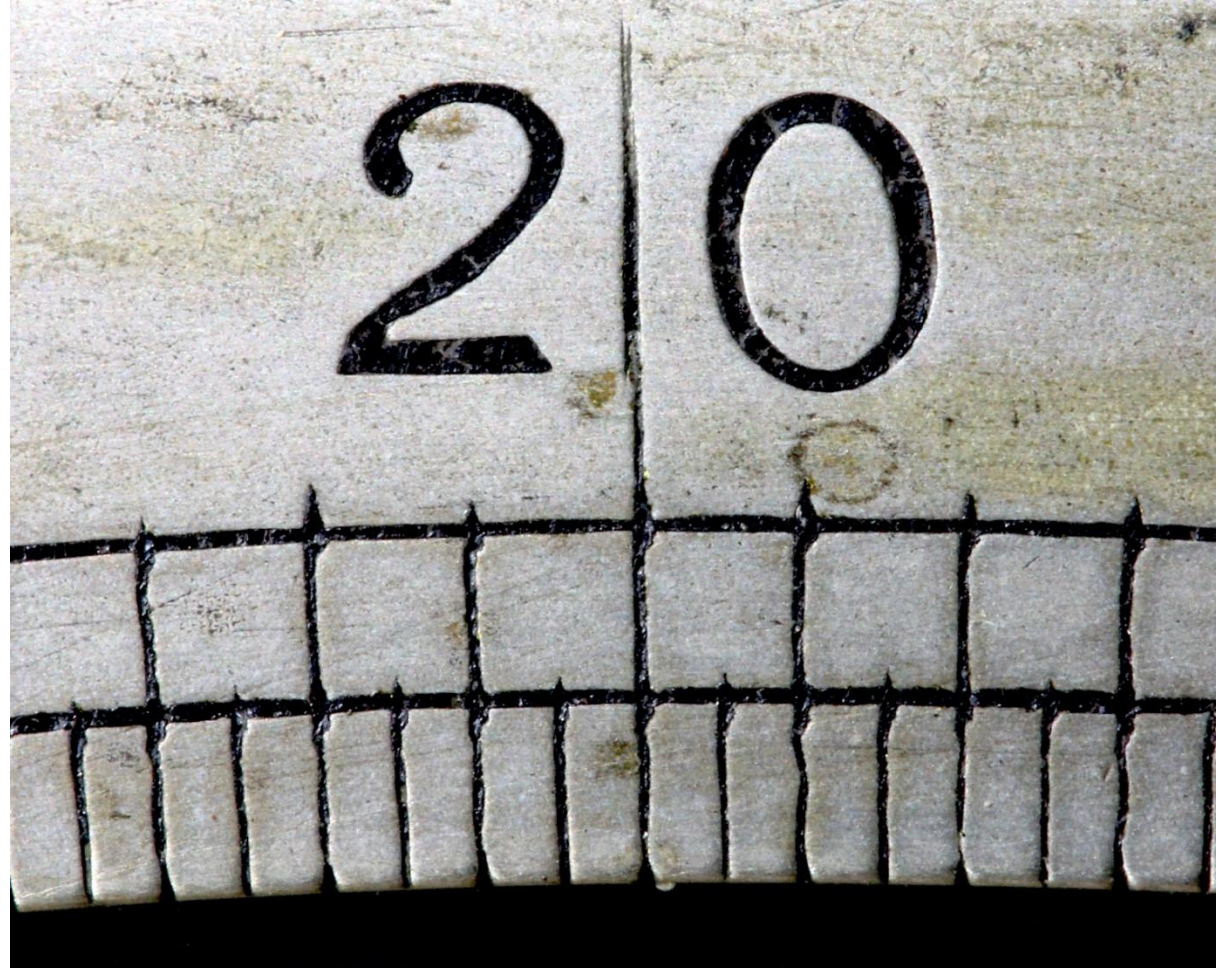
Potts Dots Sizes



Other Multiple Dots Compasses



Joseph Blattner

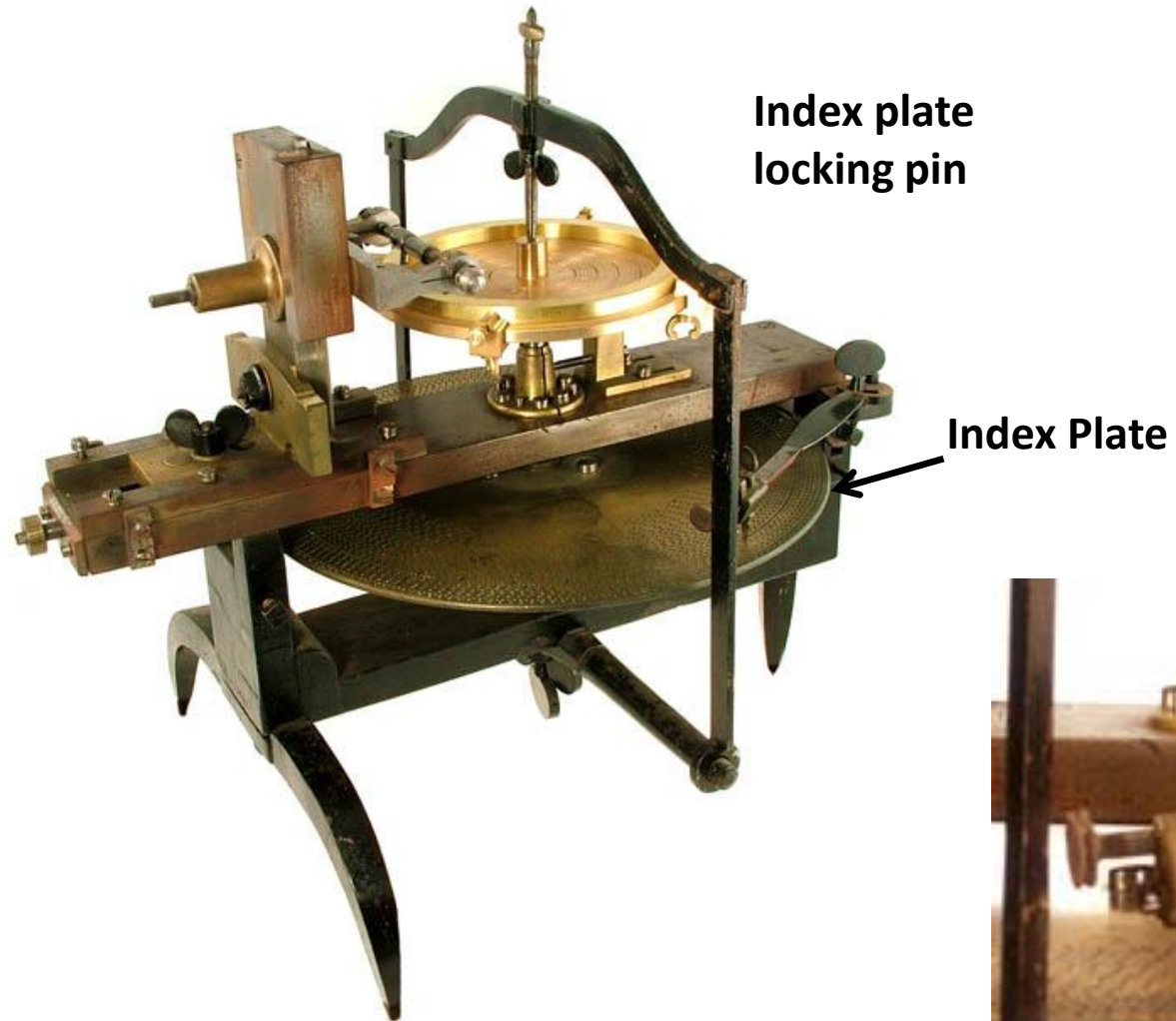


Philadelphia Unsigned

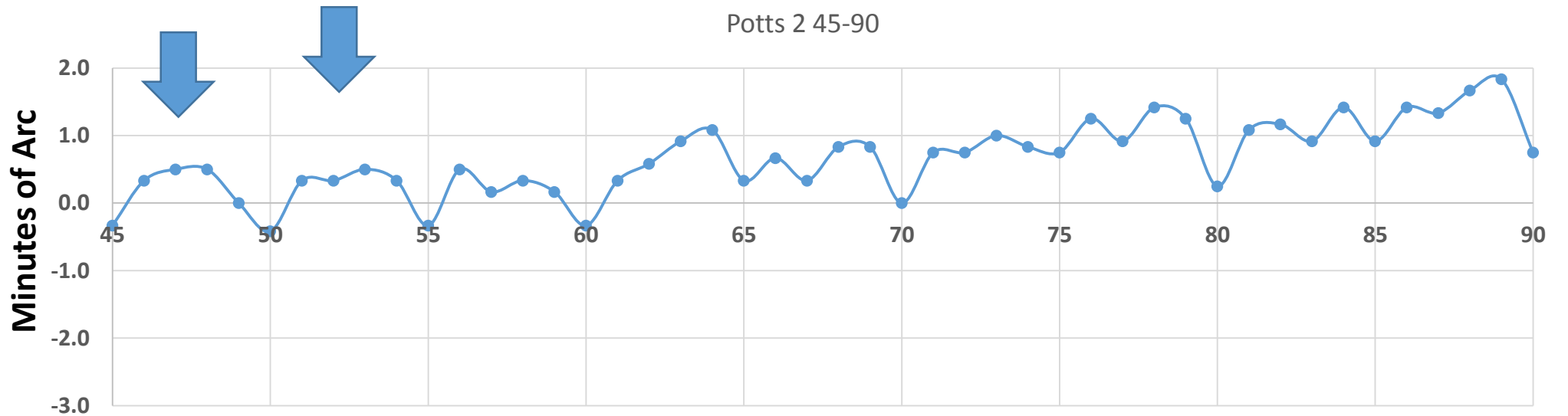
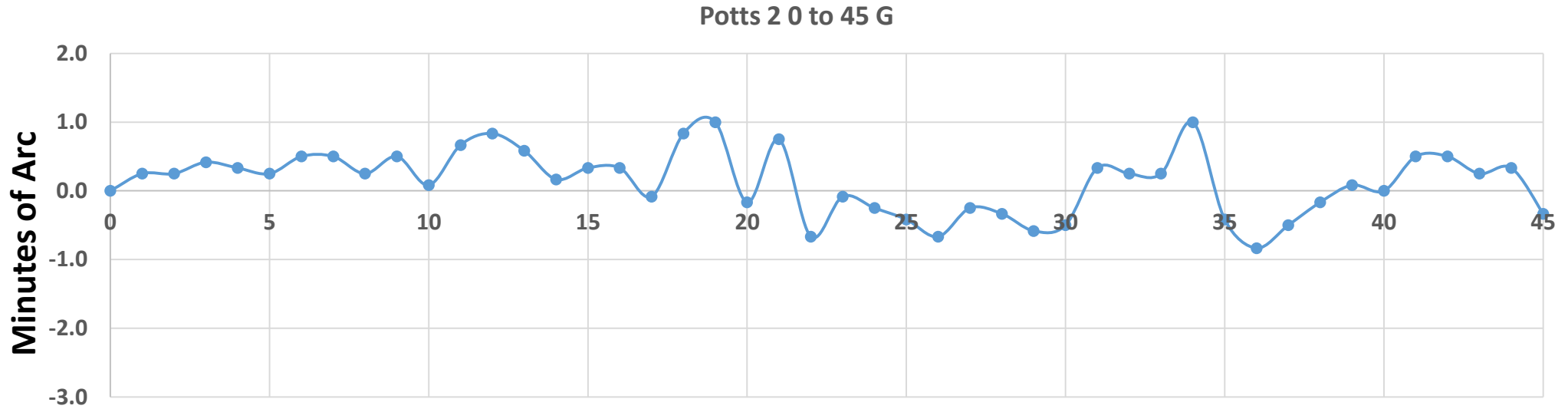
“Potts N.J.” Primary and Intermediate Degree Marks - Conjecture

- **Primary five-degree “dots” larger than one-degree dots**
 - **Fives placed first, based on clock makers wheel cutting engine 72 tooth hour gear using precisely divided index plate?**
 - **Benjamin Rittenhouse was a clock maker but no know W.L. Potts clocks**
- **Intermediate degree dots (2, 3, 4) placed later using a small template or three templates indexing off each primary dot**
- **All degree lines subsequently engraved by hand(?)**
 - **Remarkably straight and of uniform thickness (and quite narrow)**
- **5 degree heritage – “hour wheel” of 72 teeth cut on a wheel cutting engine**

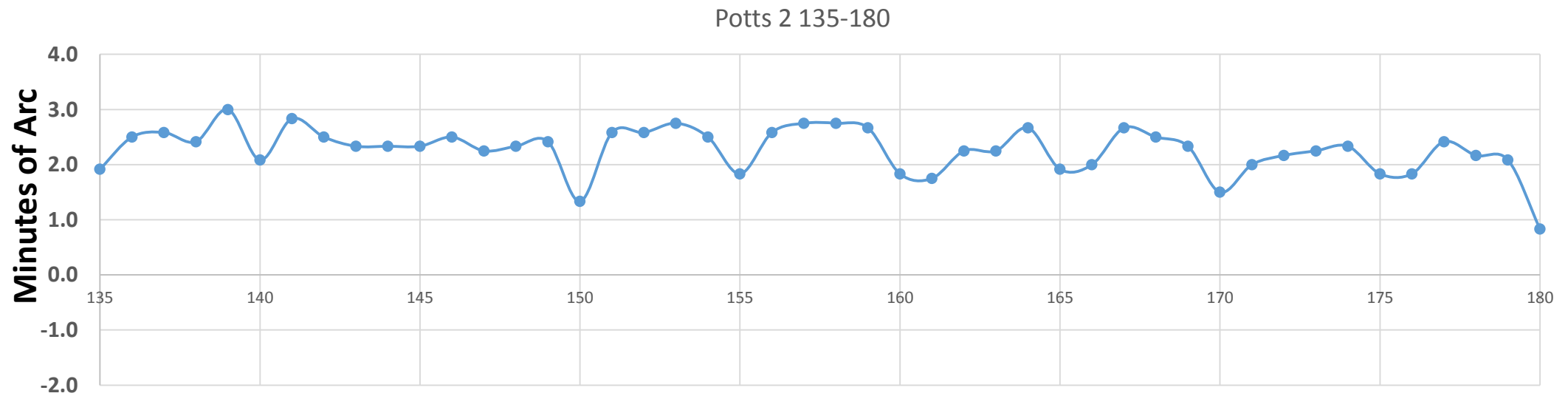
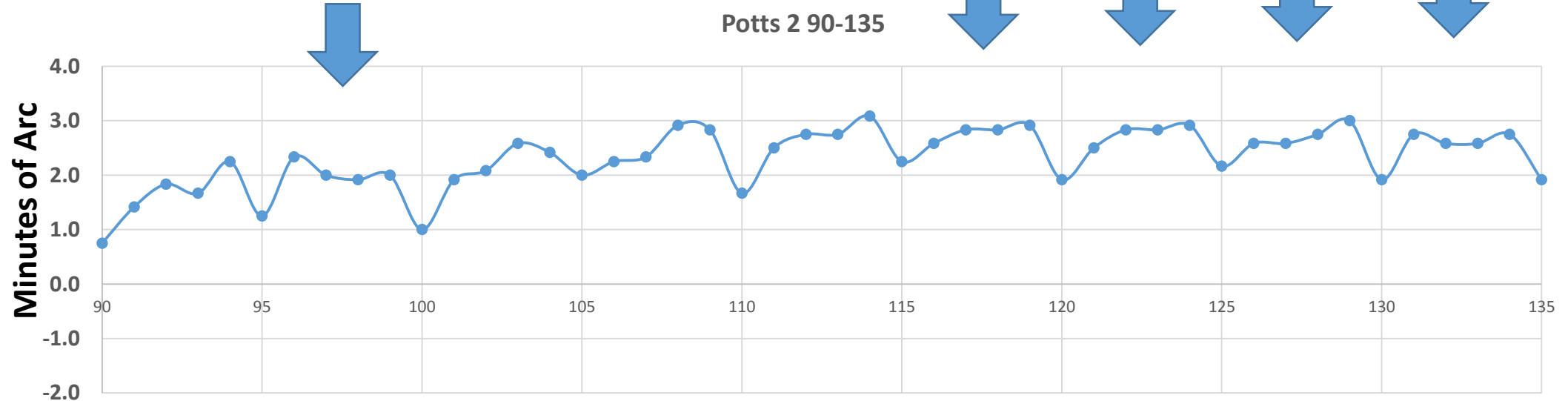
Setting Angle with an Index Plate



Potts 2 0-90 Degrees

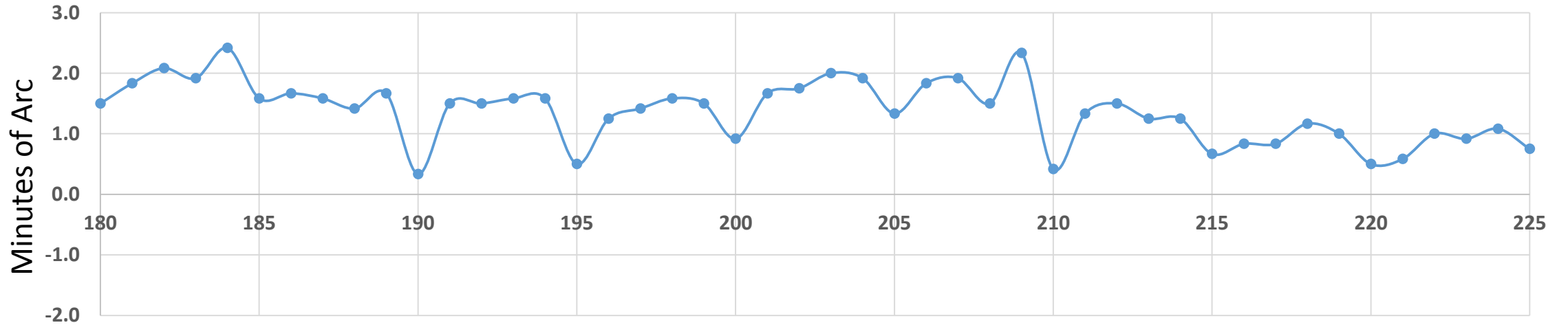


Potts 2 90-180 Degrees

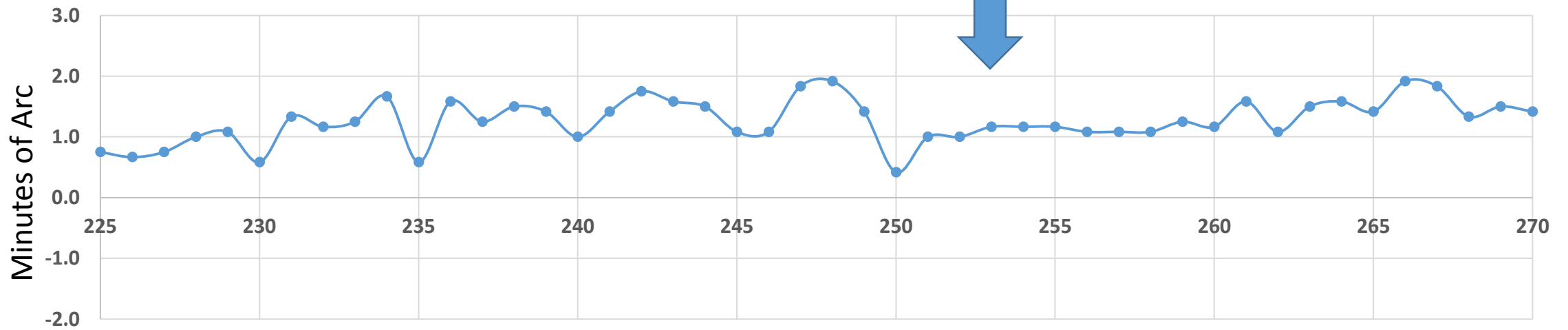


Potts 2 180-270

Potts 2 180-225

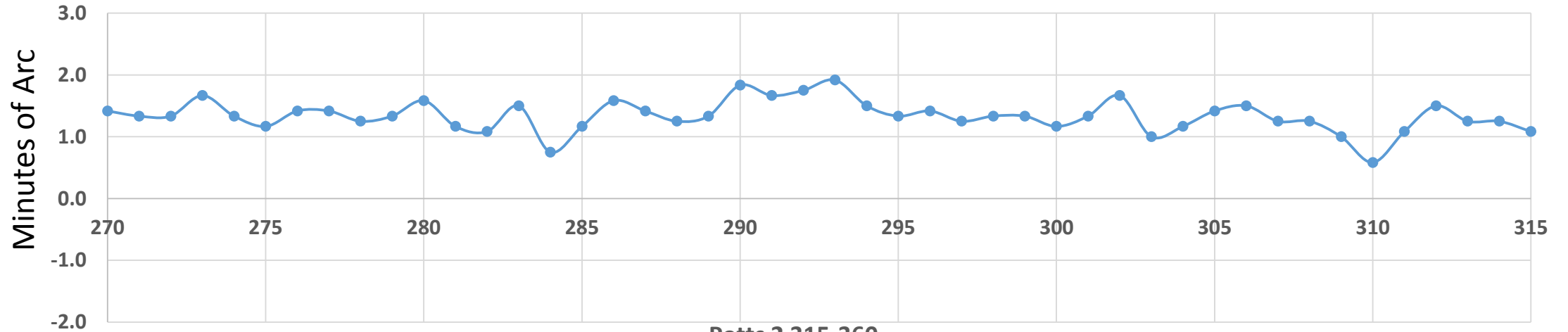


Potts 2 225-270

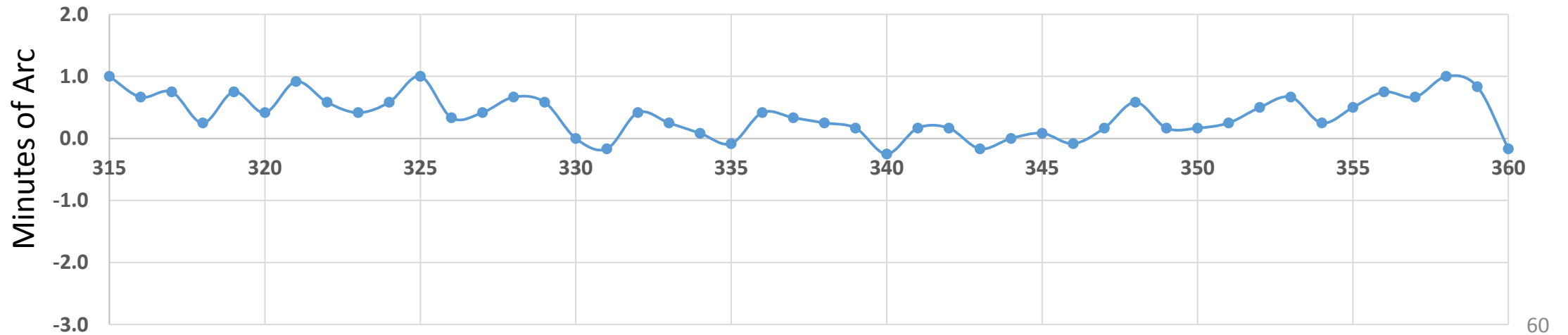


Potts 2 270-360

Potts 2 270-315



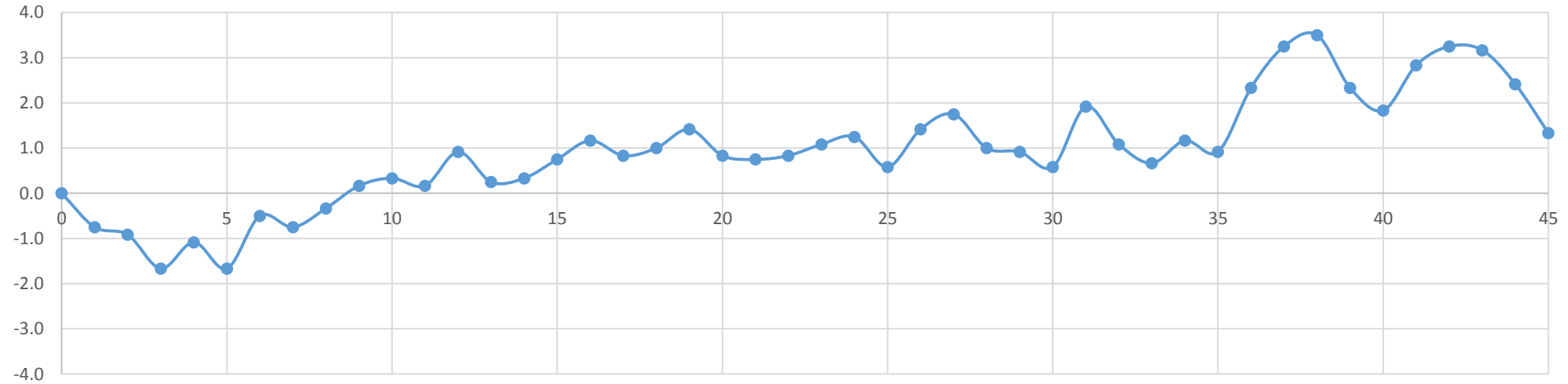
Potts 2 315-360



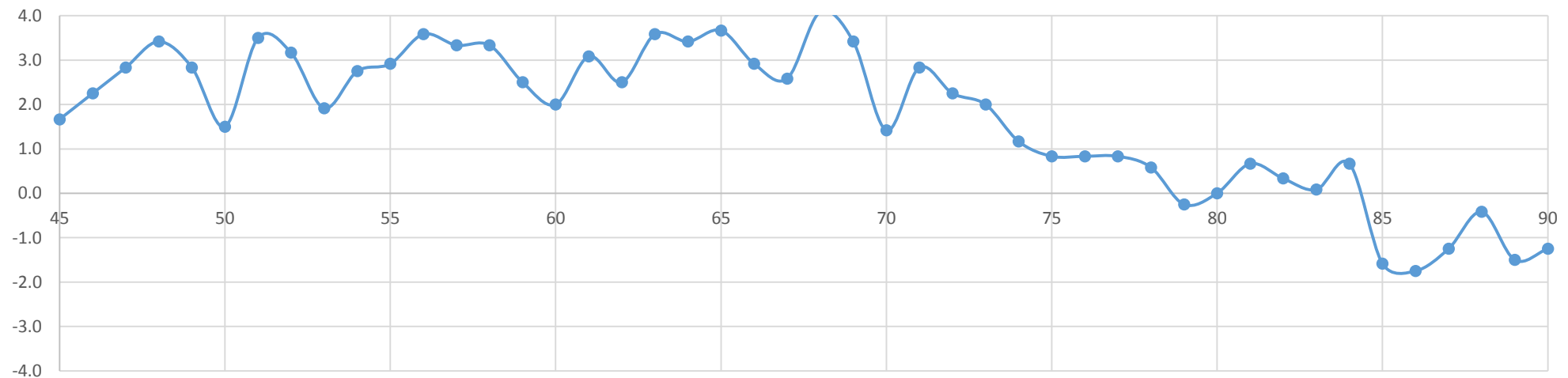
Rittenhouse & Potts Every Degree

Rittenhouse and Potts 0-90 degrees

Rittenhouse and Potts 0 to 45

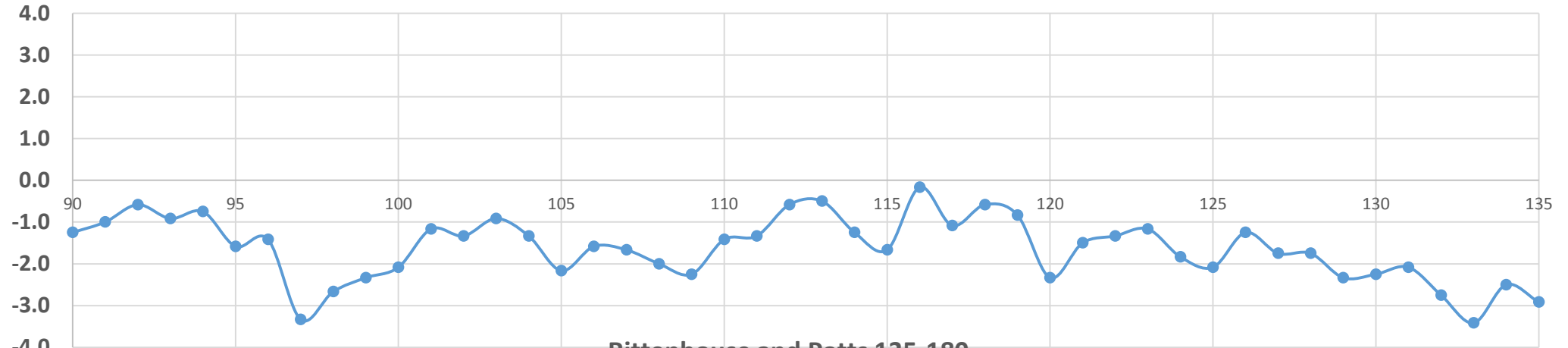


Rittenhouse and Potts 45-90

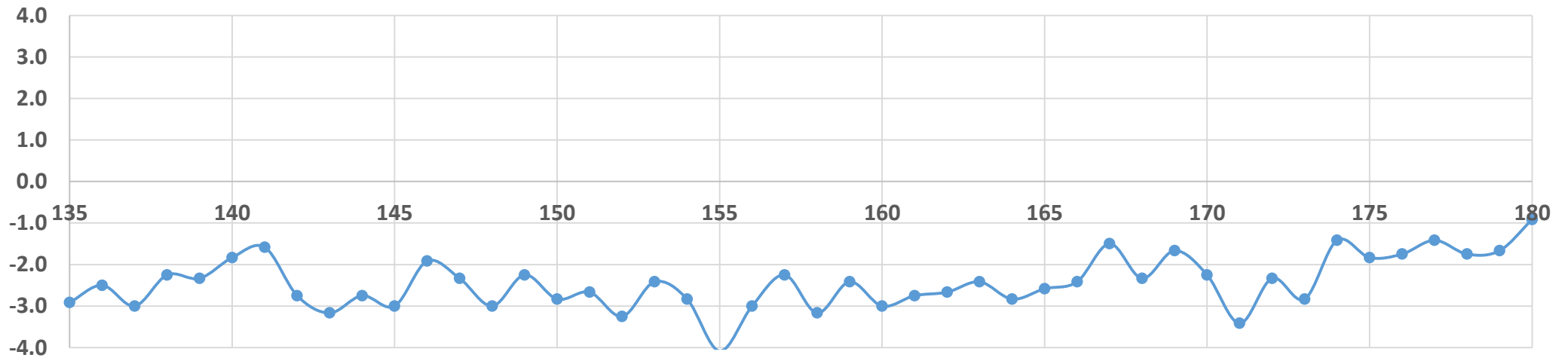


Rittenhouse and Potts 90-180 degrees

Rittenhouse and Potts 90-135

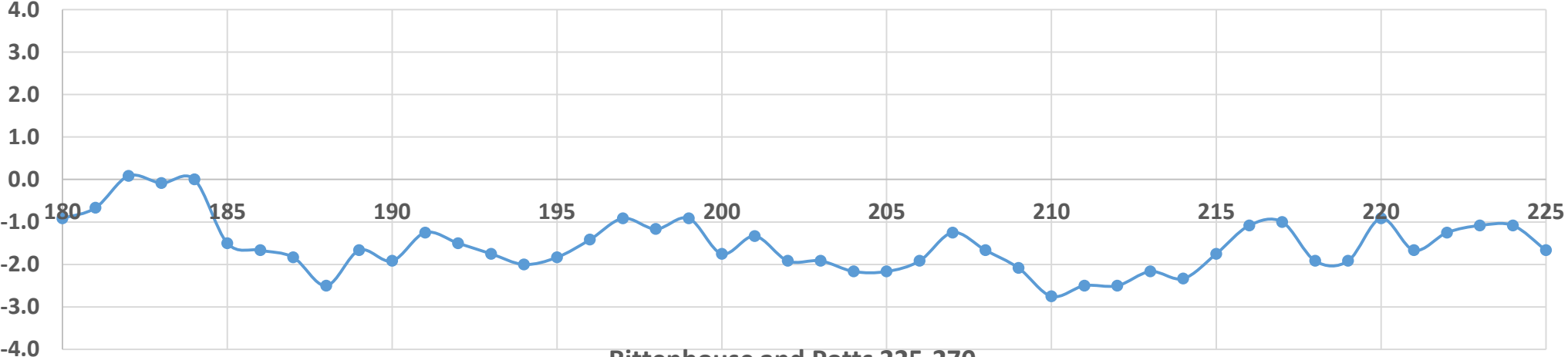


Rittenhouse and Potts 135-180

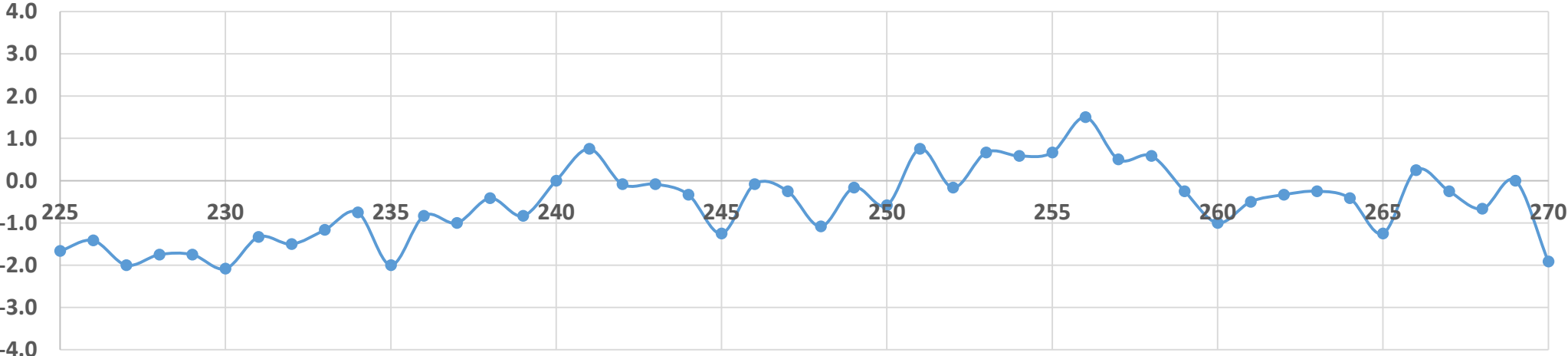


Rittenhouse and Potts 180-270 degrees

Rittenhouse and Potts 180-225

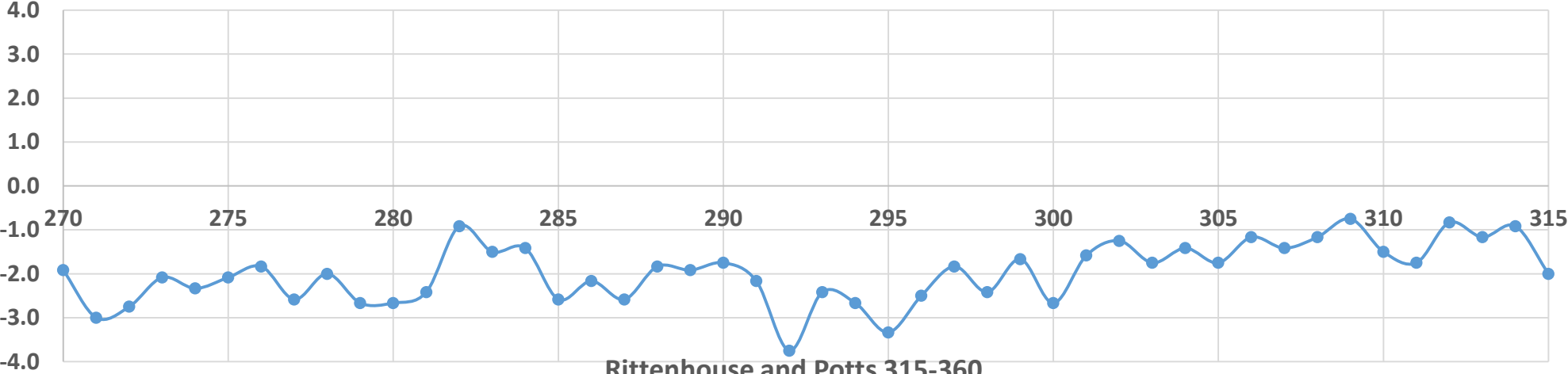


Rittenhouse and Potts 225-270

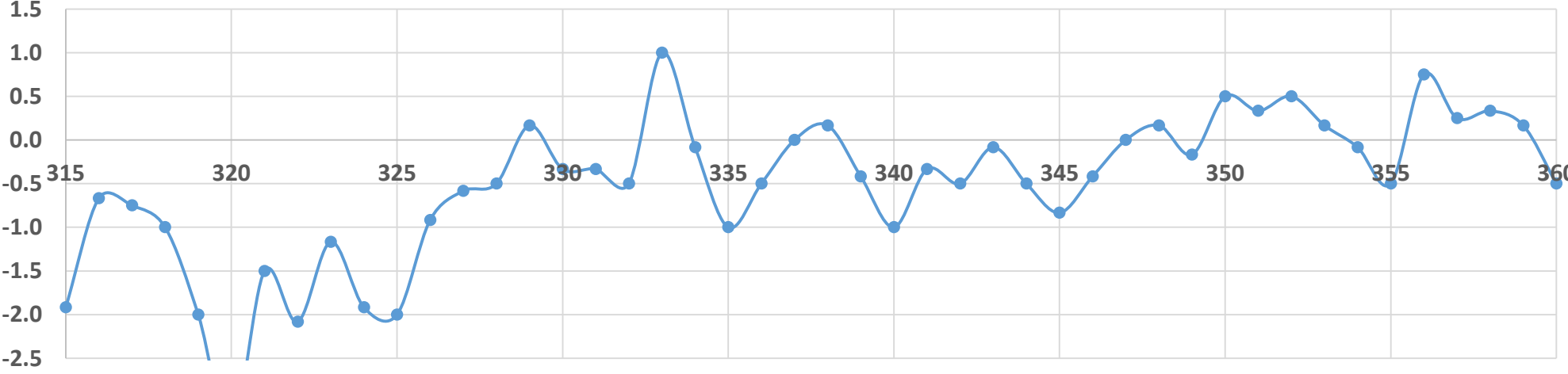


Rittenhouse and Potts 270-360 degrees

Rittenhouse and Potts 270-315



Rittenhouse and Potts 315-360

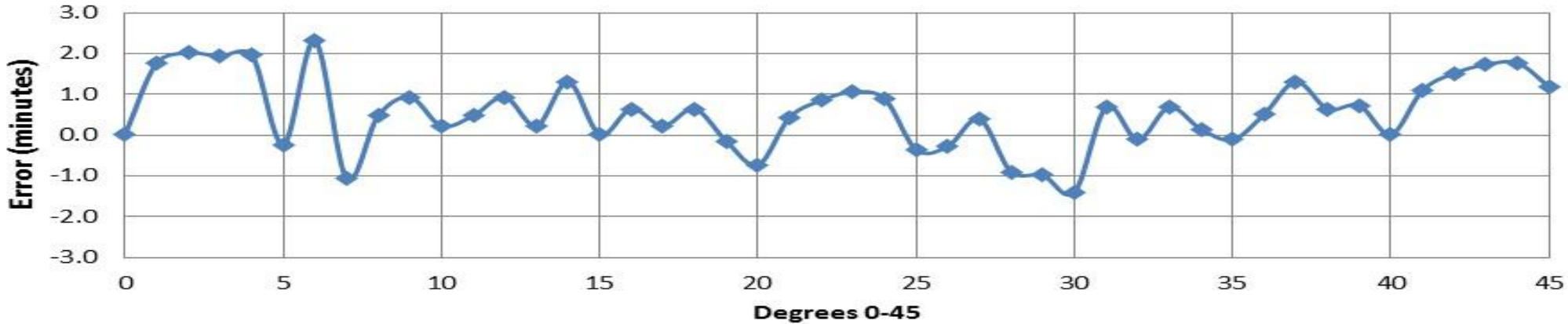


Second Rittenhouse and Potts 0-360 Degrees

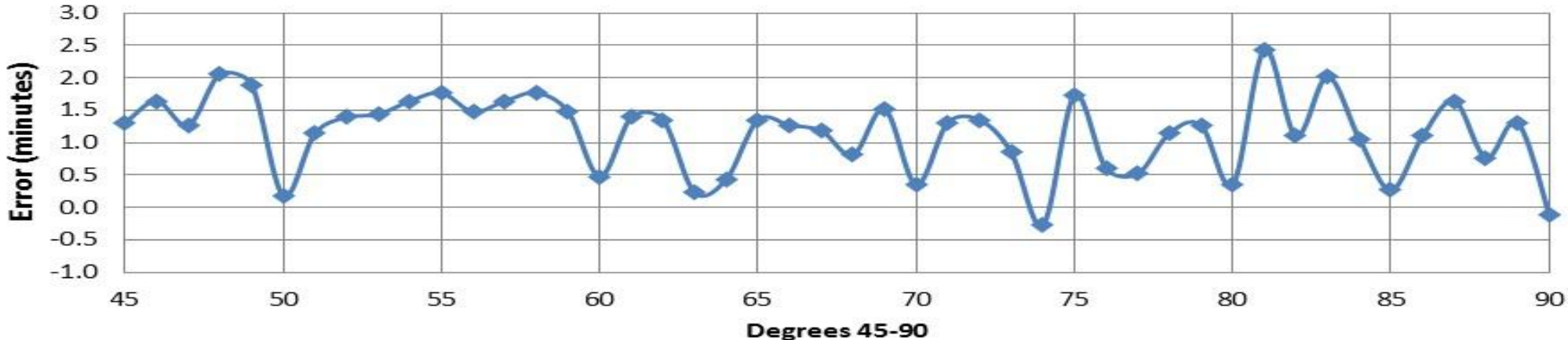
Feb 17-19, 2013

0-90 Degree Segment

Rittenhouse and Potts Loaned Feb 2013

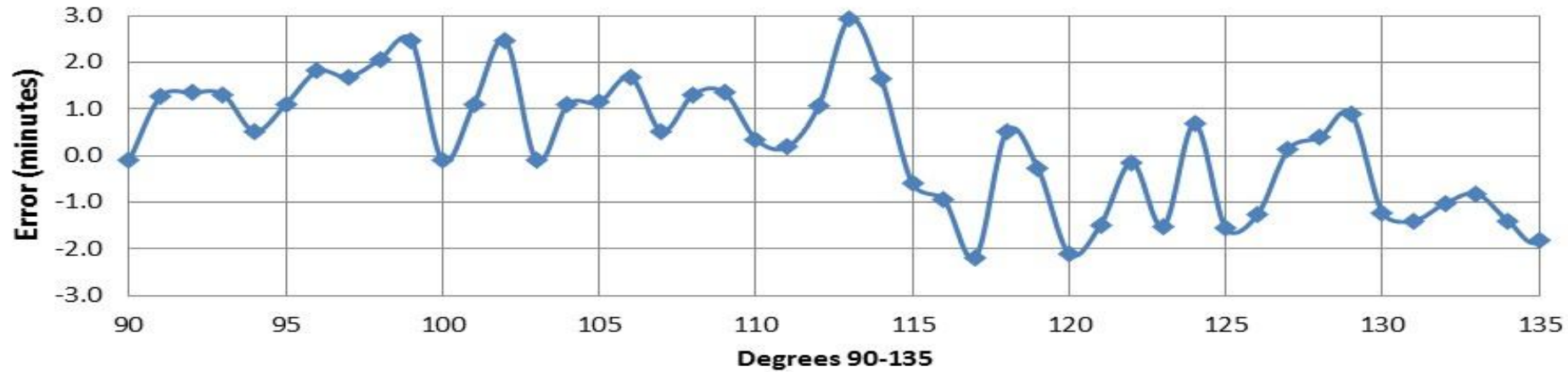


Rittenhouse and Potts Loaned Feb 2013 1st set

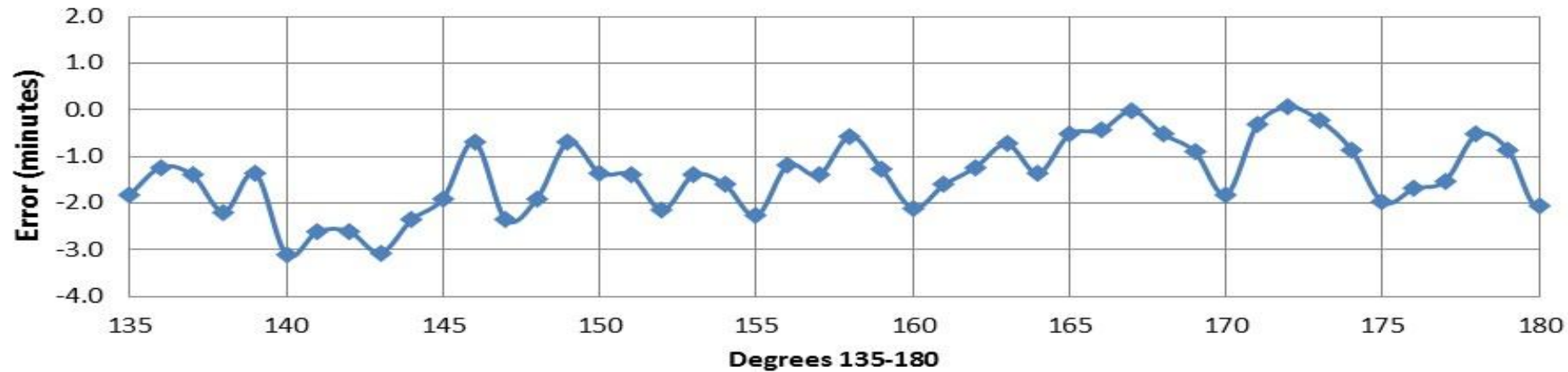


90 - 180 Degree Segment

Rittenhouse and Potts Loaned Feb 2013

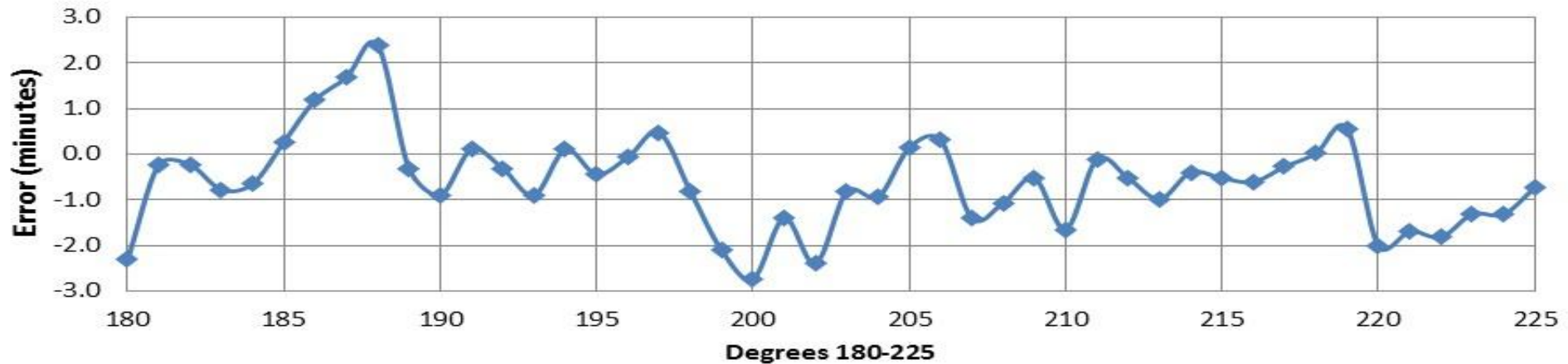


Rittenhouse and Potts Loaned Feb 2013

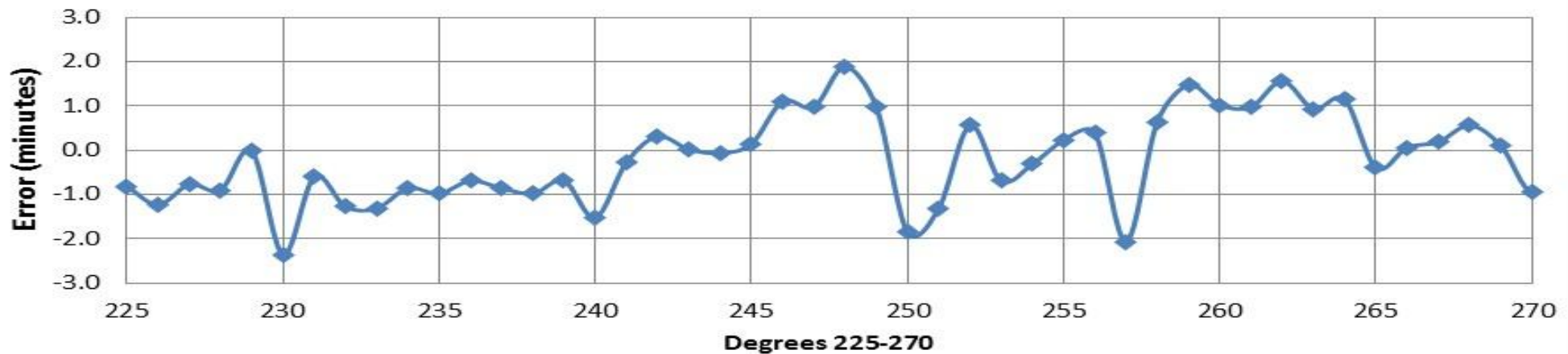


180 - 270 Degree Segment

Rittenhouse and Potts Loaned Feb 2013

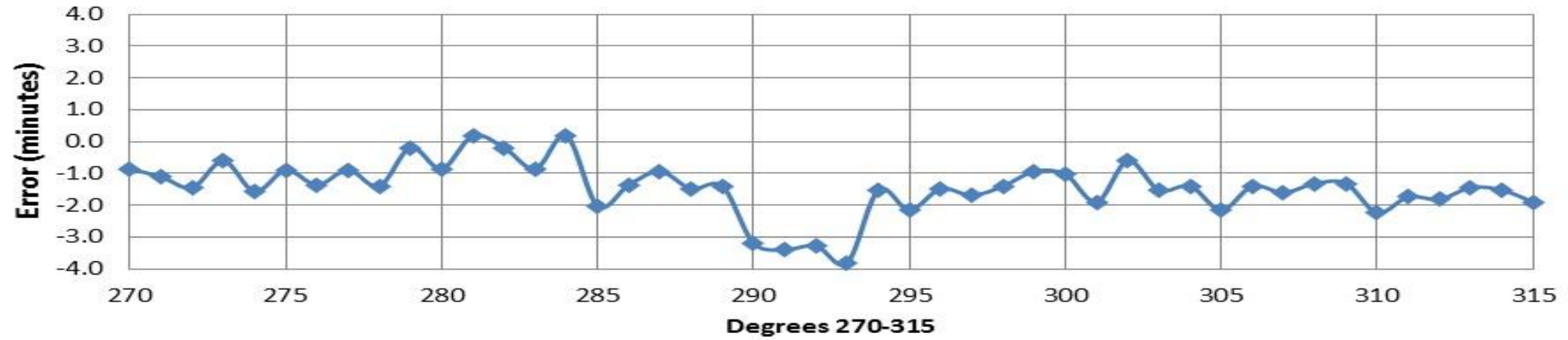


Rittenhouse and Potts Loan Feb 2013

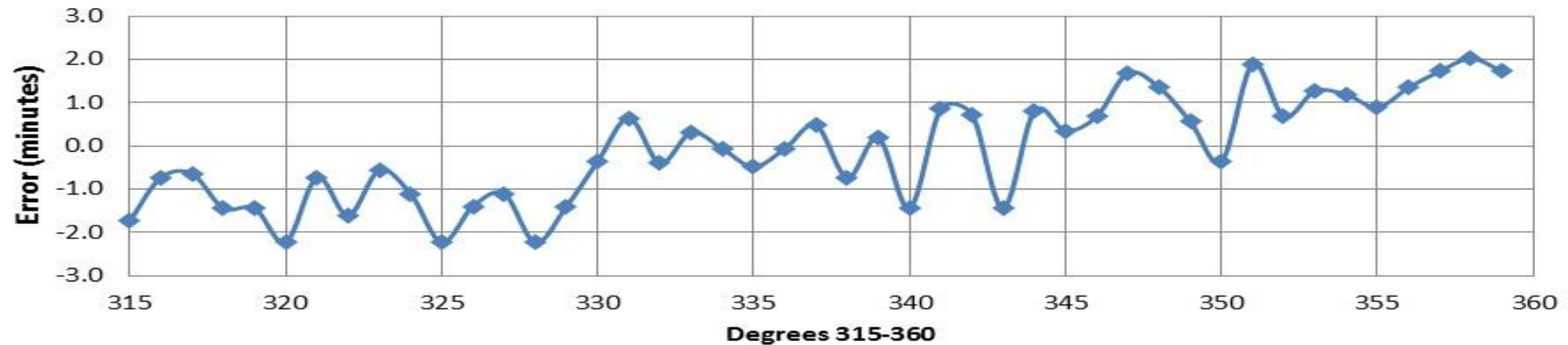


270 - 360 Degree Segment

Rittenhouse and Potts Loaned Feb 2013



Rittenhouse and Potts Loaned Feb 2013



Conclusions and Questions

- **Potts compasses far exceed any accuracy requirement at that time (needle instruments only read to 5 minutes at best).**
- **Two compasses made 60 years later by Gurley (Ramsden dividing engine) and Blattner (probably used a template) are similar in accuracy**
- **Required a very accurate template AND very careful execution**
 - **Was this developed by B. Rittenhouse or by Potts or the two of them together?**
 - **How?**
 - **Did Potts take a copy with him when he left, or did he build a new template?**
- **Why are the 5 degree “Potts dots” larger than the single degree dots?**
 - **Evidence suggests that on Potts compasses it was a two step process: 1st 5 degrees were marked and then filled in the 1 degree marks – not so with R & P**
- **Can a template “pattern” be discerned on the four Potts compasses?**
 - **Future work**

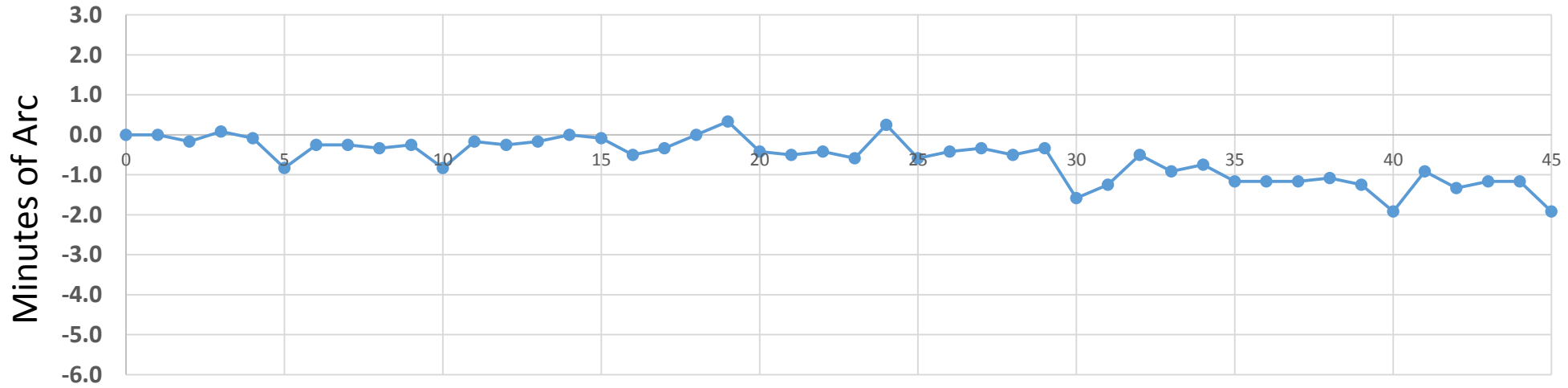
Backup

Conclusions

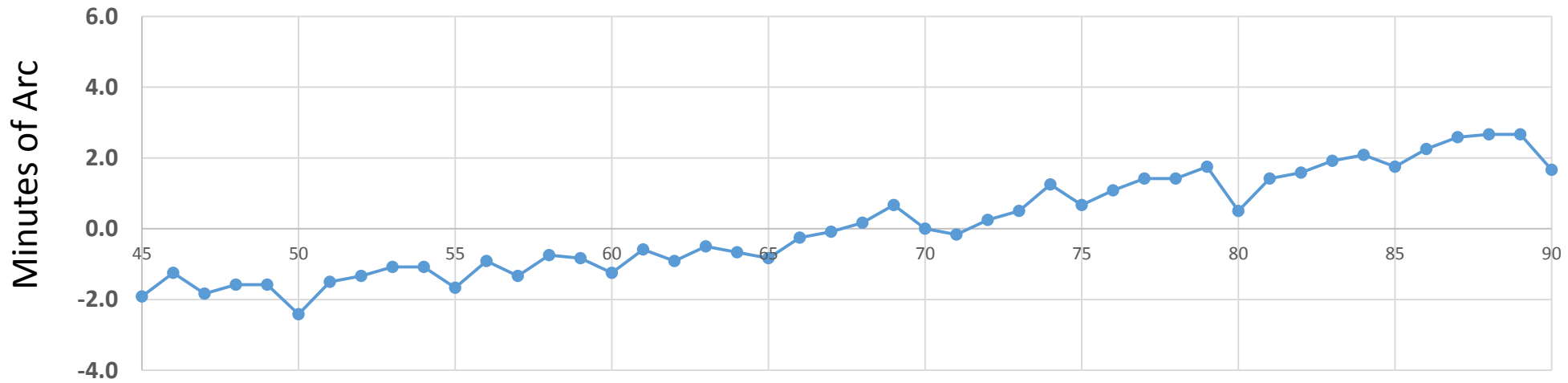
- **Excellent execution of engraving on Potts compasses**
- **Machine-like control of degree line widths, alignment and positioning on Potts compasses**
- **All Potts needle rings were circular at time of engraving, some degraded later due to warping by few thousandths The Rittenhouse and Potts probably distorted after truing on lathe but before dividing**
- **Appears that five-degree positions may have been established first and then a template was used to position the four remaining degree marks between the five-degree positions**
- **Comparisons with several contemporary compasses show the quality of the Potts workmanship was not met or exceeded until many decades later**

Potts 1 0-90 Degrees

Potts 1 0-45

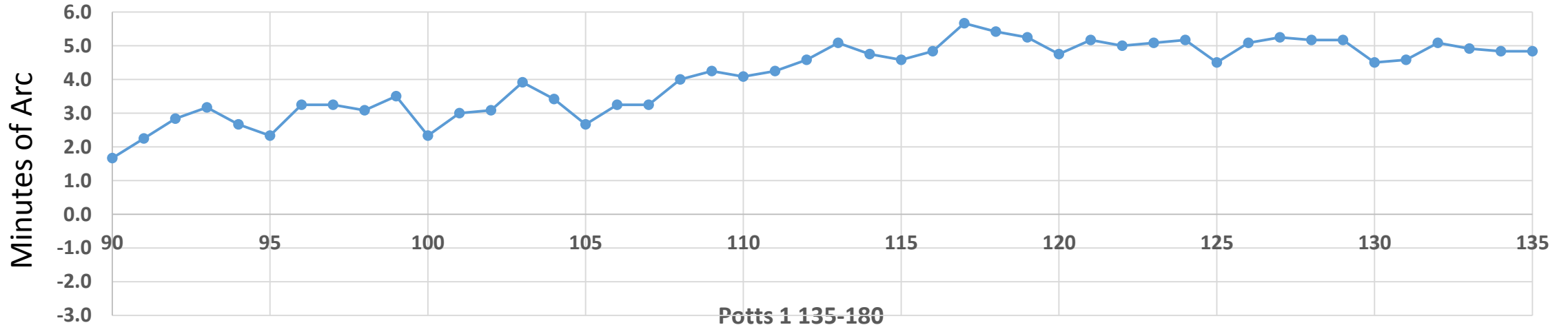


Potts 1 45-90

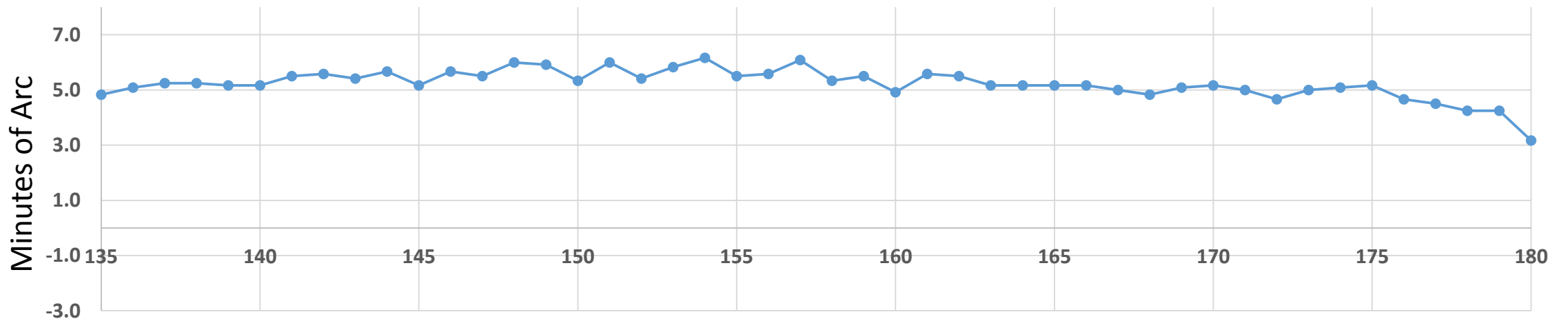


Potts 1 90-180 Degrees

Potts 1 90-135

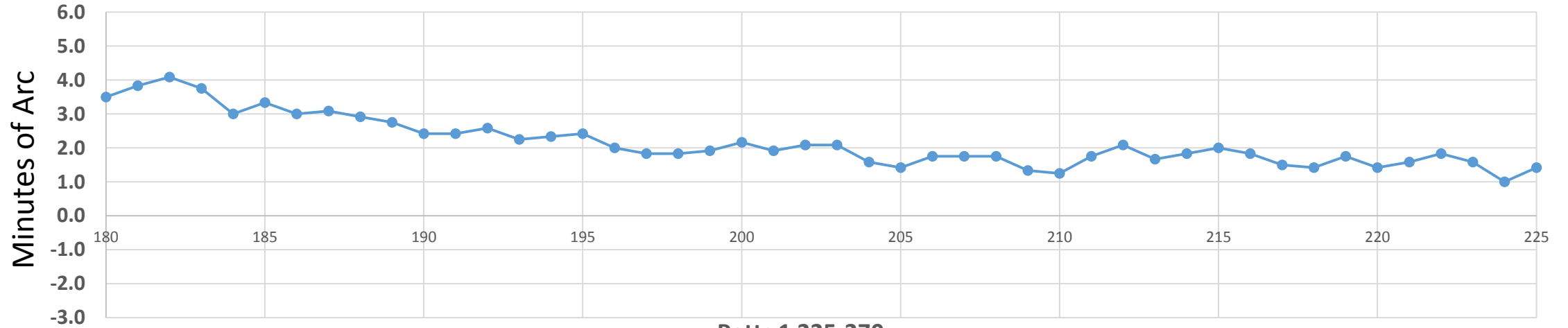


Potts 1 135-180

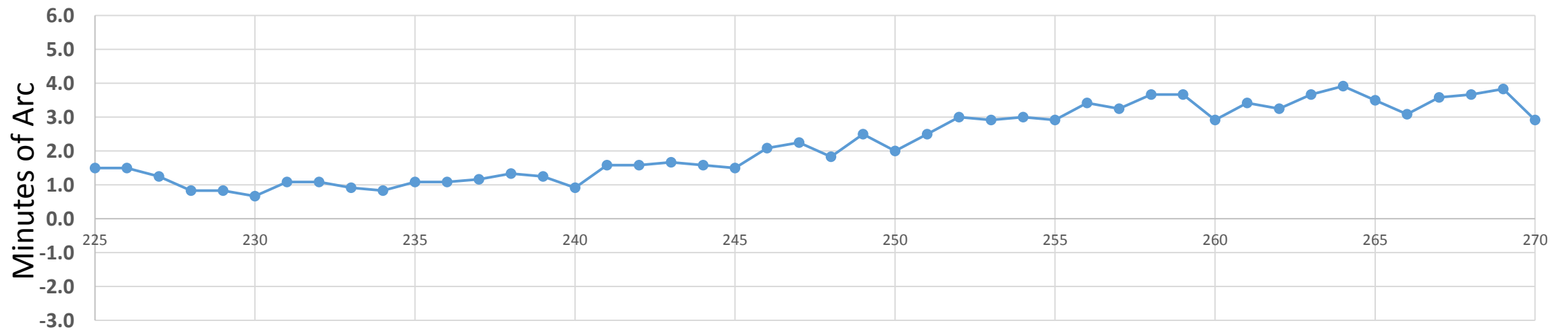


Potts 1 180-270

Potts 1 180-225

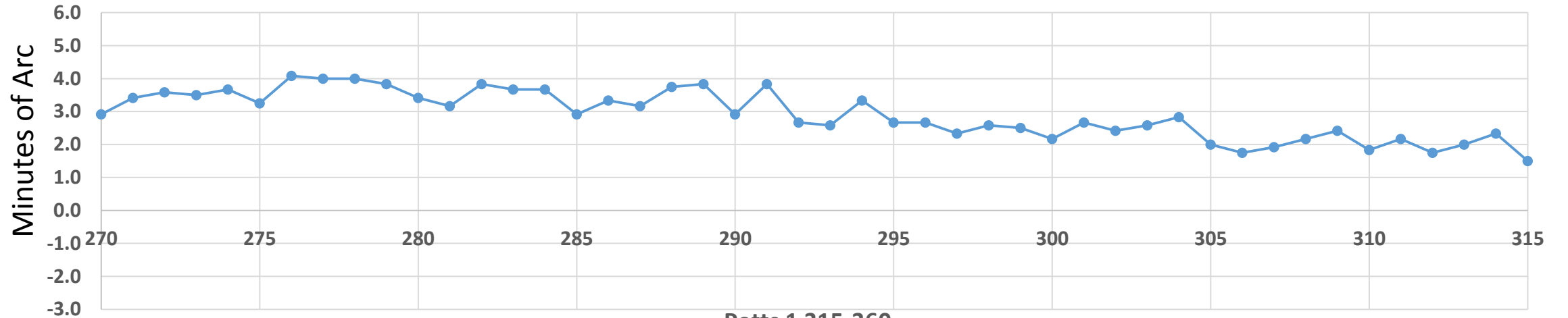


Potts 1 225-270

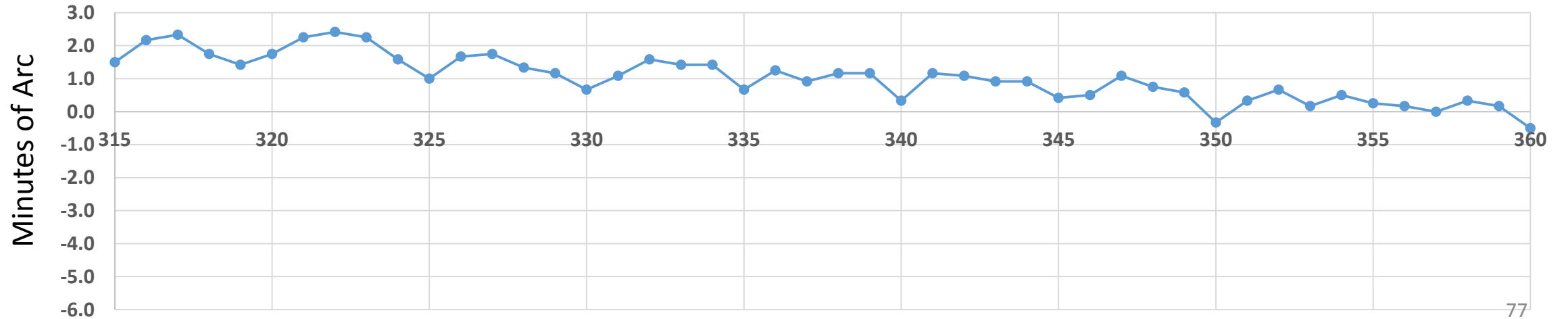


Potts 1 270-360

Potts 1 270-315

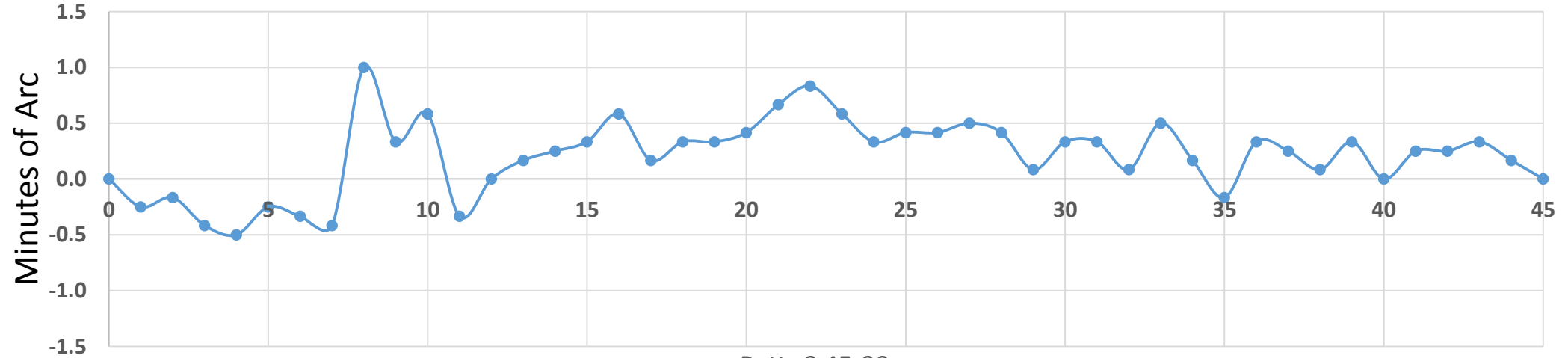


Potts 1 315-360

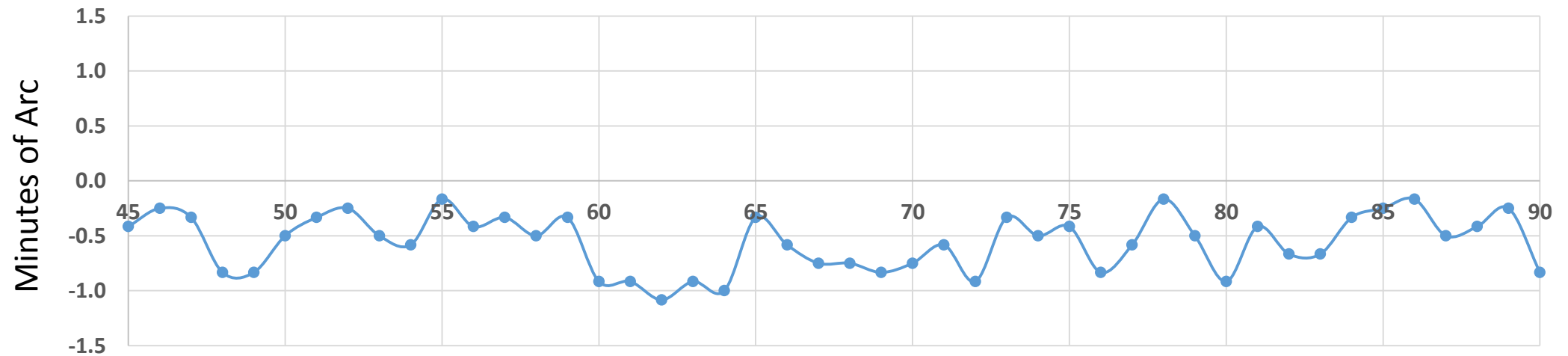


Potts 3 0-90

Potts 3 0 to 45

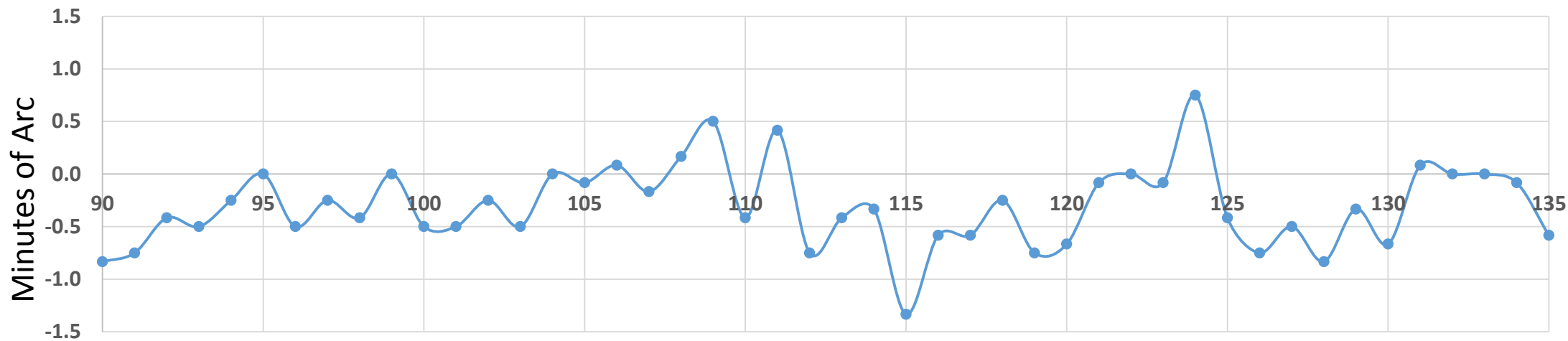


Potts 3 45-90

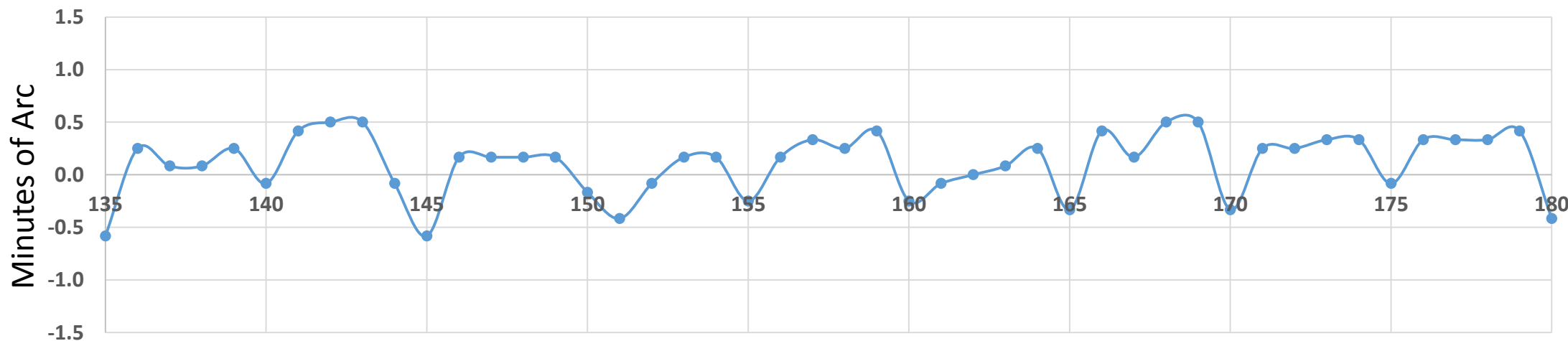


Potts 3 90-180

Potts 3 90-135

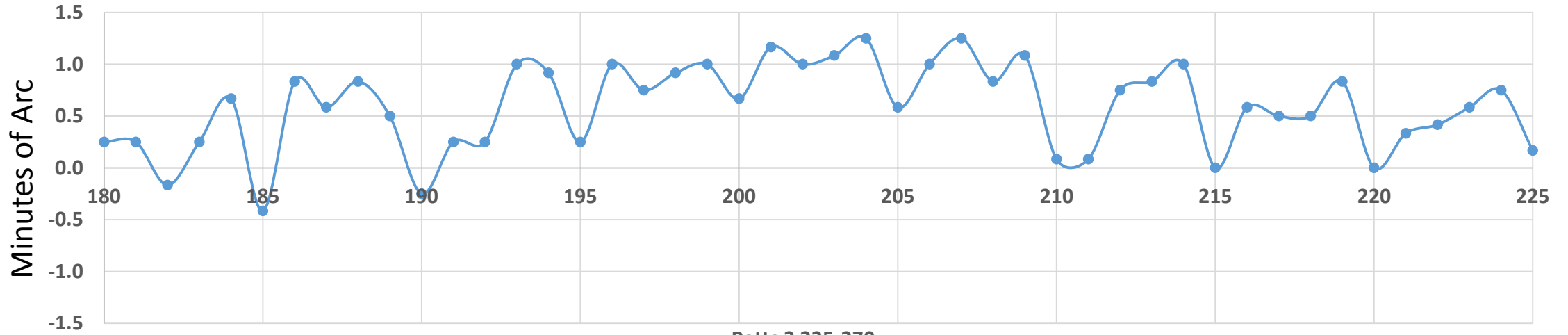


Potts 3 135-180

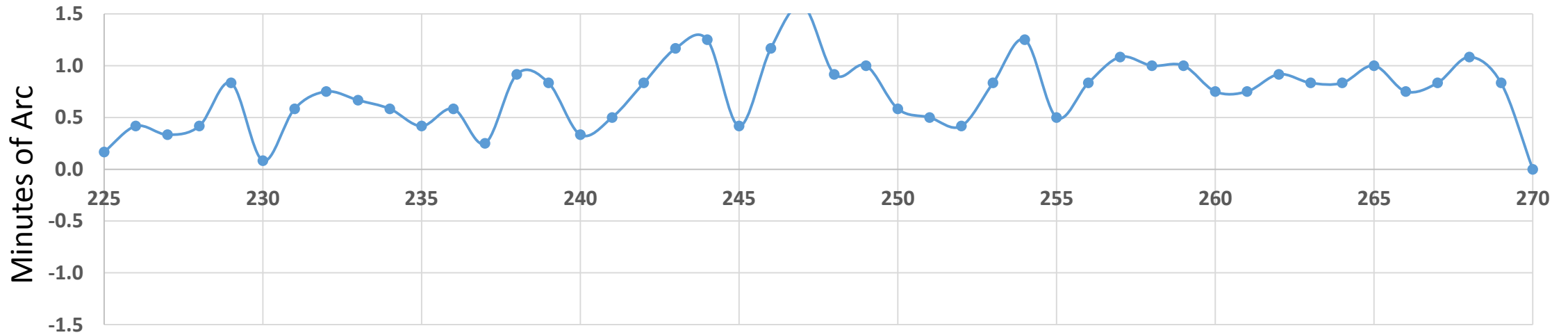


Potts 3 180-270

Potts 3 180-225



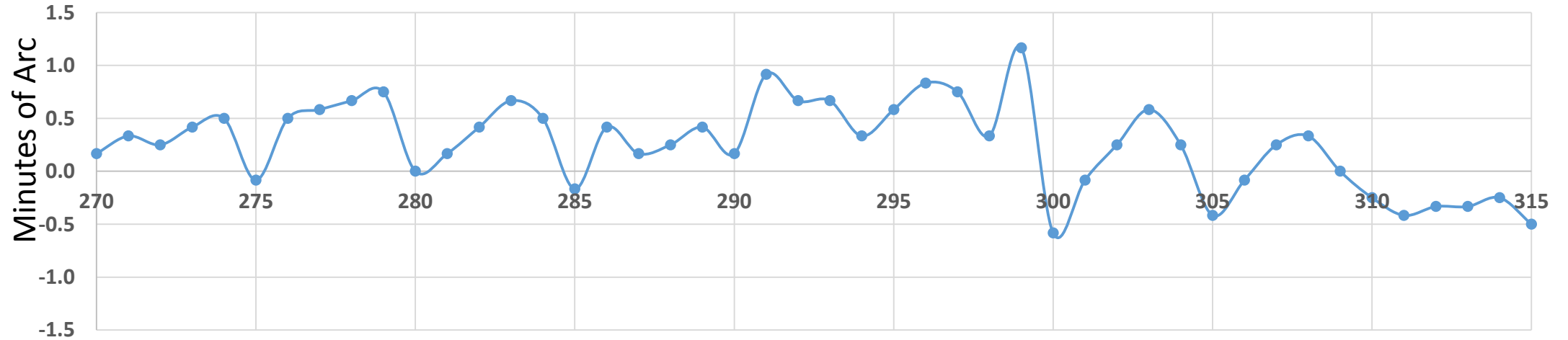
Potts 3 225-270



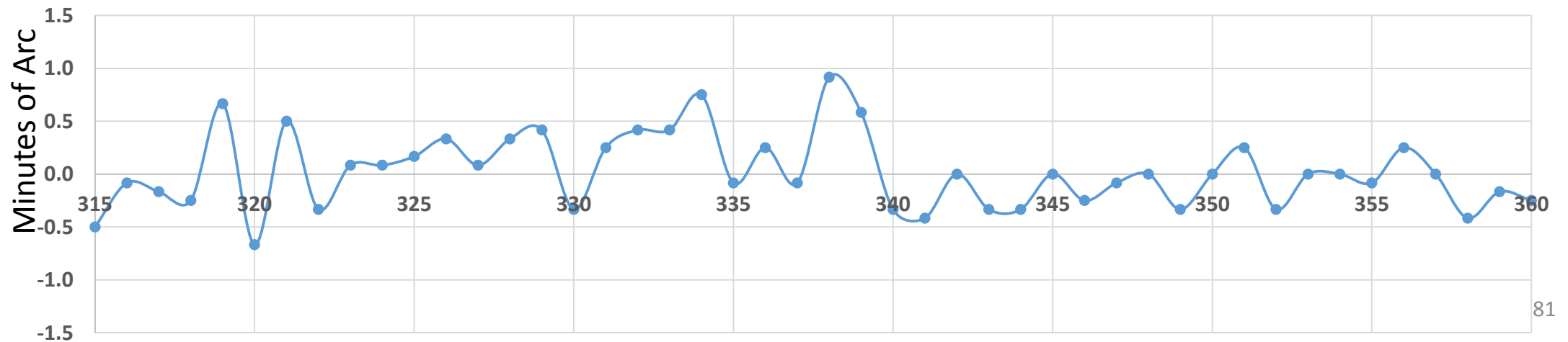
Potts 3 270-360

Grand RMS =0.6 minute of arc

Potts 3 270-315

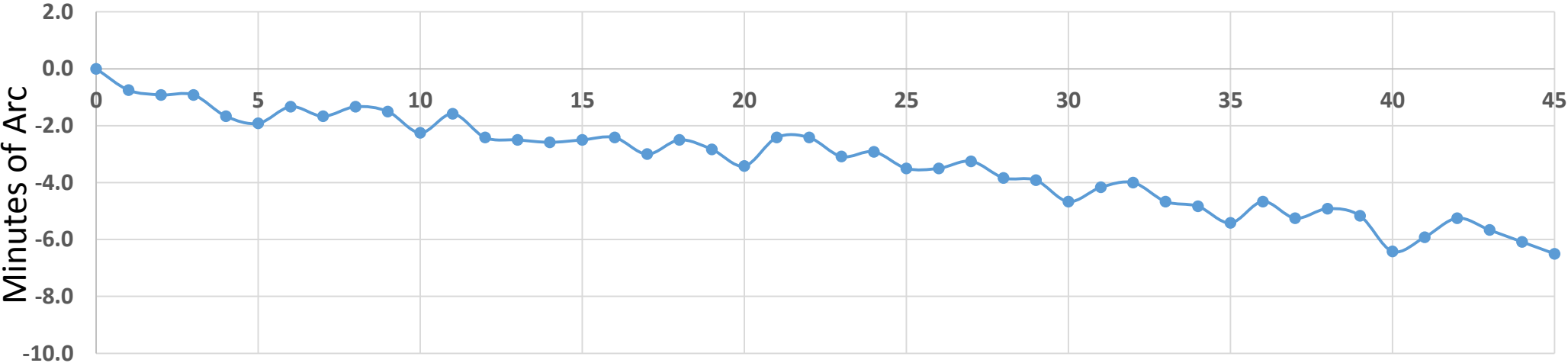


Potts 3 315-360

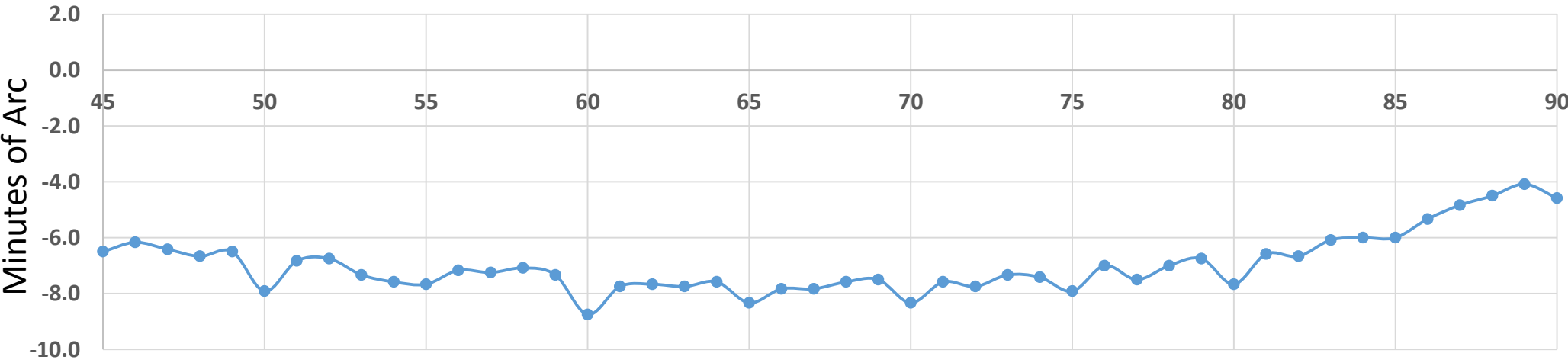


Potts 4 0-90

Potts 4 0 to 45

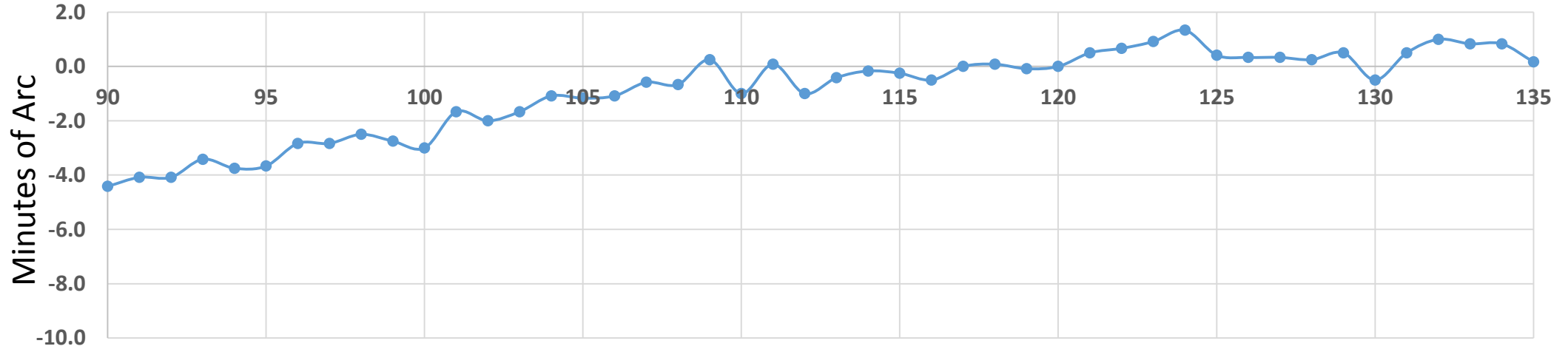


Potts 4 45-90

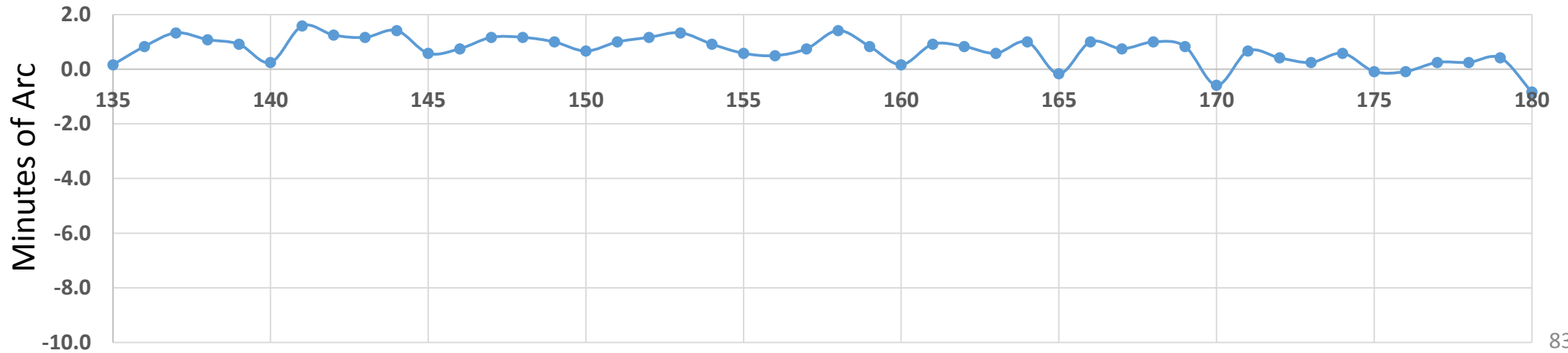


Potts 4 90-180

Potts 4 90-135

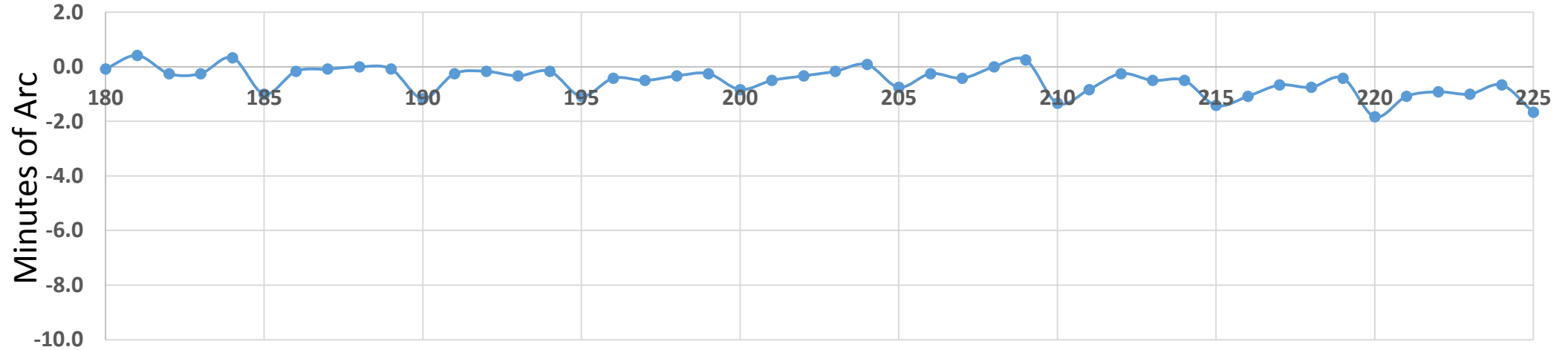


Potts 4 135-180

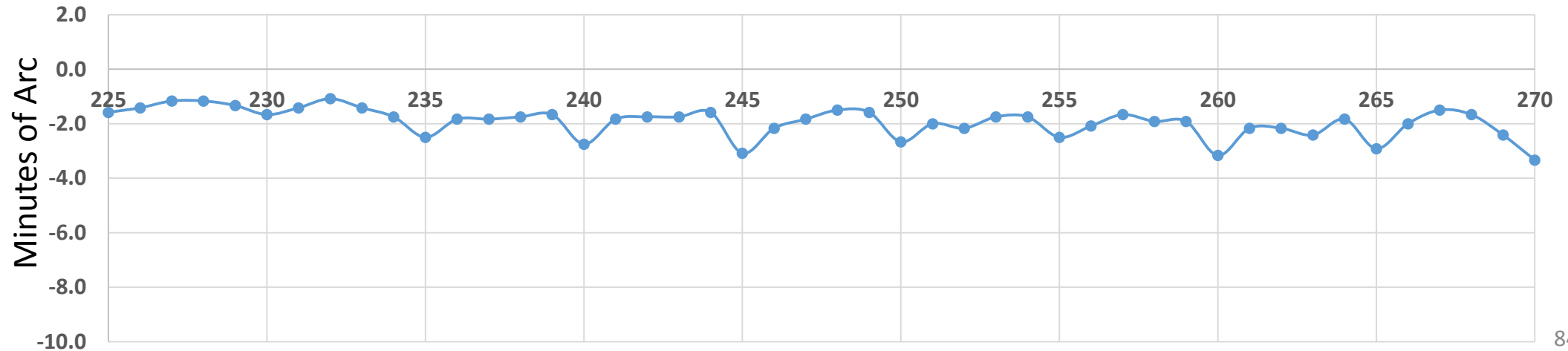


Potts 4 180-270

Potts 4 180-225

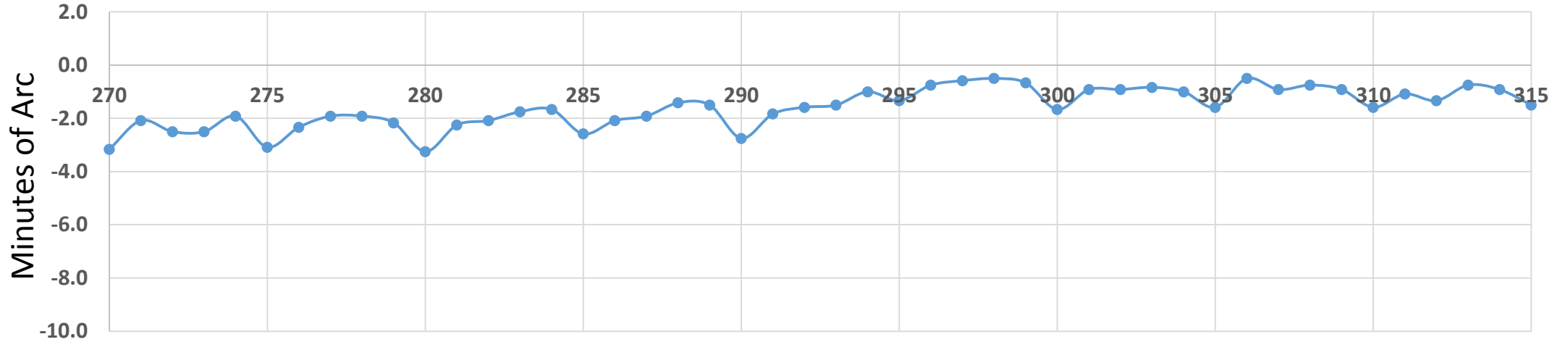


Potts 4 225-270

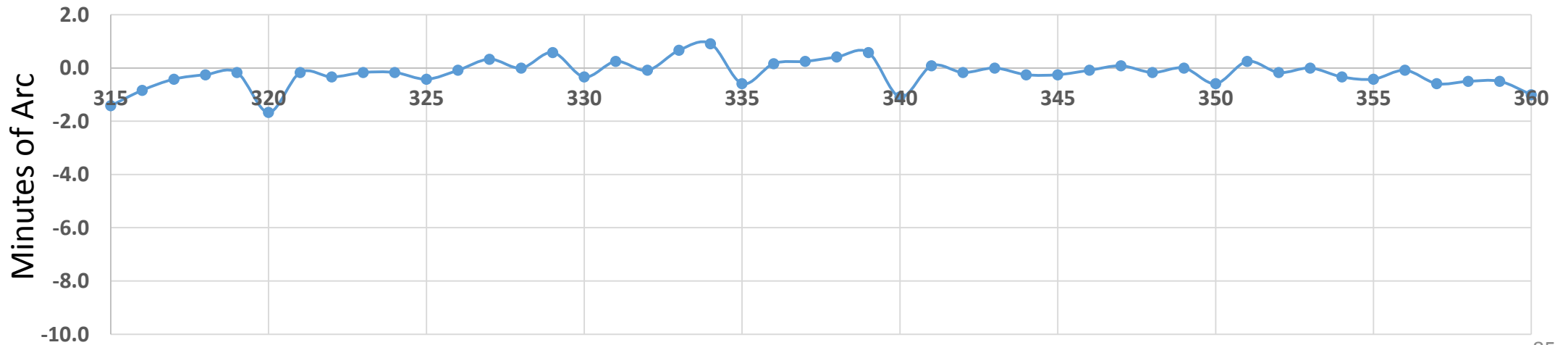


Potts 4 270-360

Potts 4 270-315



Potts 4 315-360



Potts 2 Compass



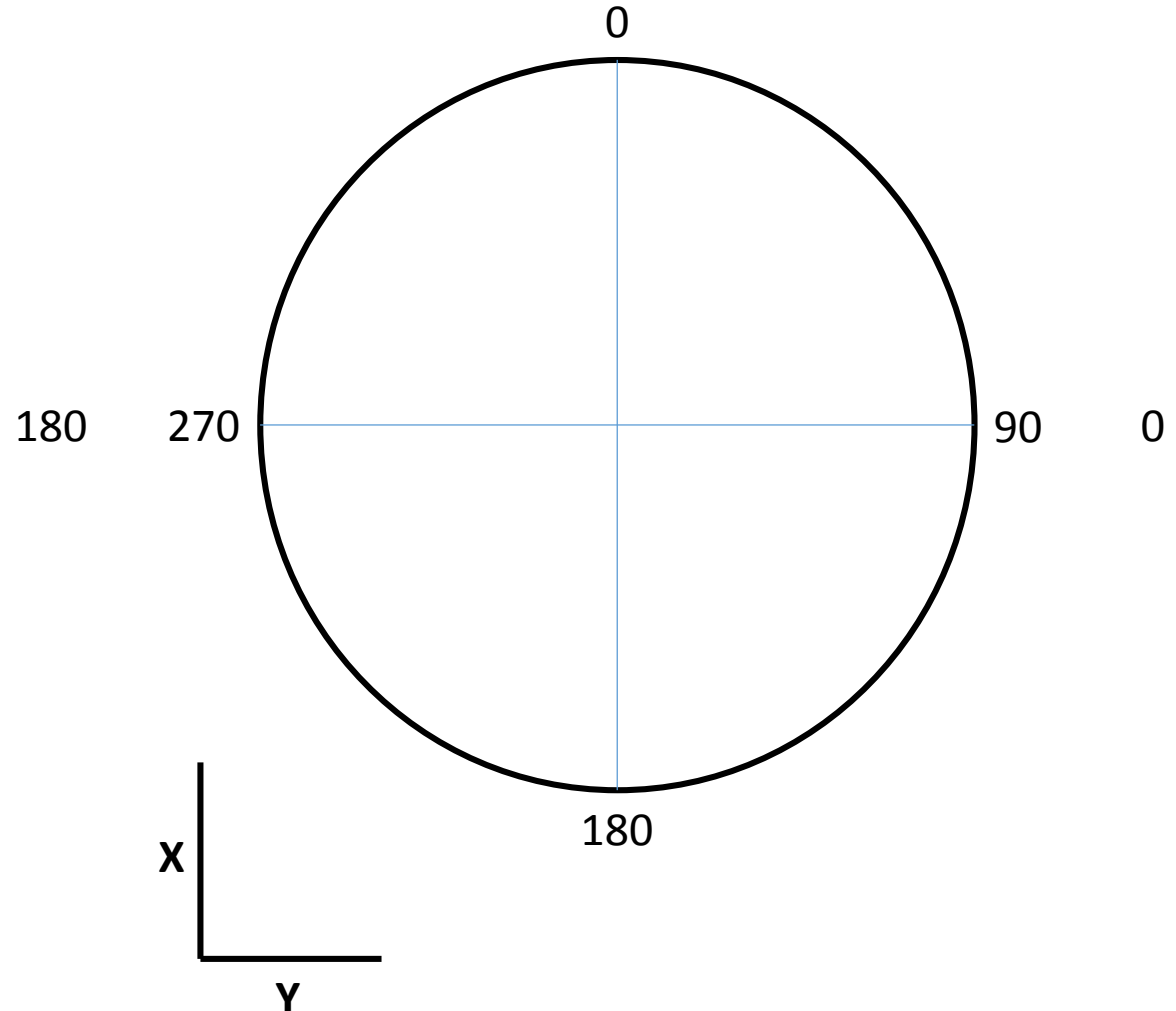
Lewis Michael Plane Compass

- 6" Diameter
- 5" needle
- Benjamin Rittenhouse's first "apprentice"

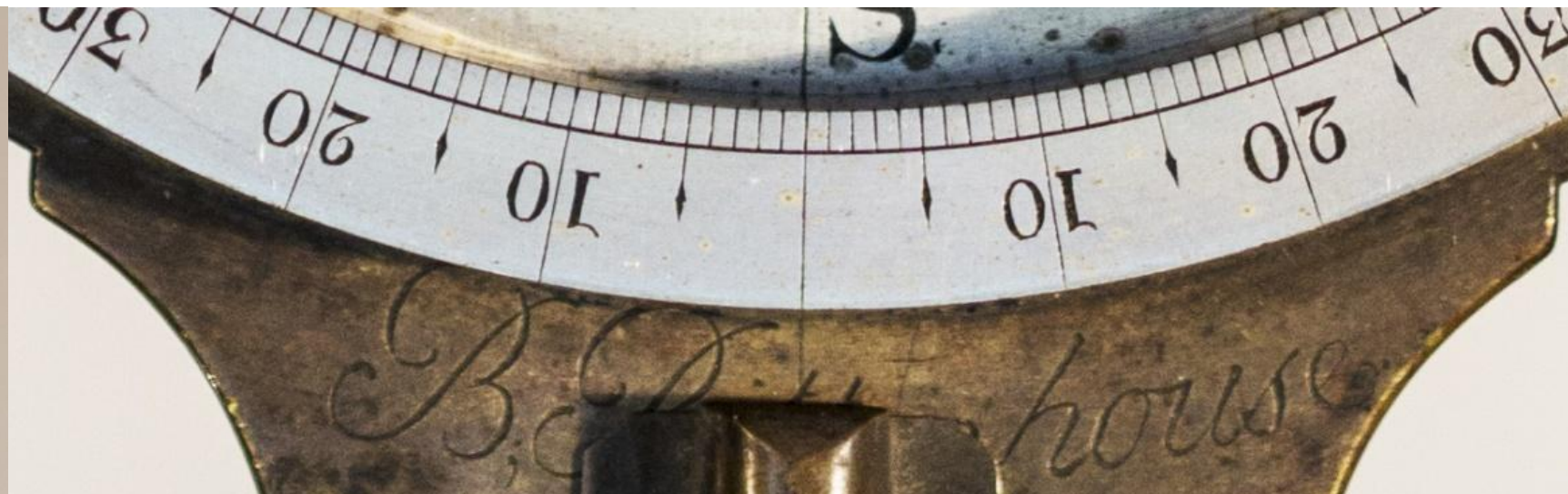


Centering Compass Prior To Measurement

- **Observe 0 degree mark, zero Sokkia**
- **Rotate compass, observe 180 degree through microscope, read Sokkia**
 - Iterate: Adjust Y-Micrometer until Sokkia reads $180^{\circ} 00' 00''$
- **Observe 90 degree mark, zero Sokkia**
- **Rotate compass, observe 270 degree through microscope, read Sokkia**
 - Iterate: Adjust X-Micrometer until Sokkia reads $180^{\circ} 00' 00''$
- **Compass is now centered as a user would adjust needle pivot**
- **Observe 9 degree mark, zero Sokkia, begin measurements**



Early B. Rittenhouse Compass

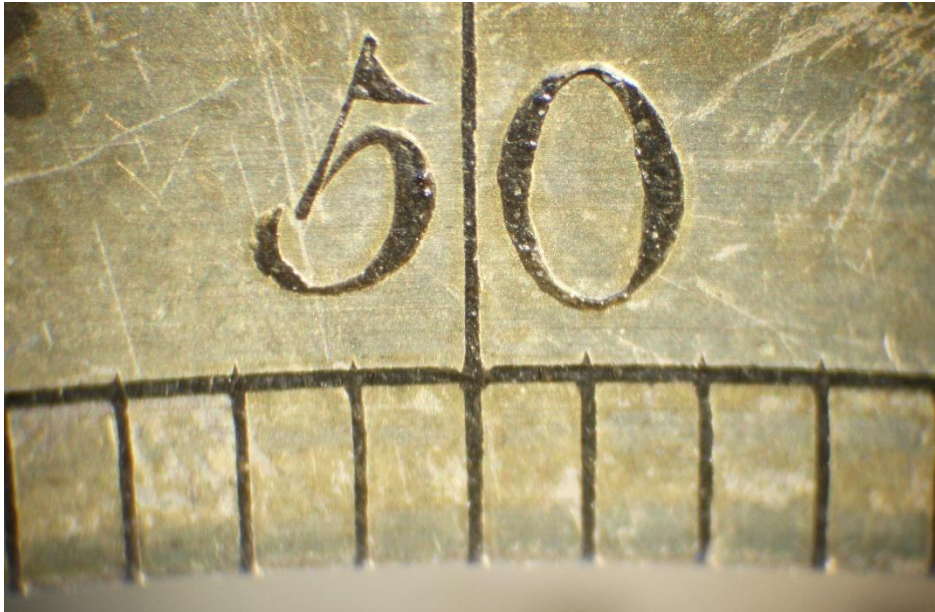


Flat Topped Eights



Curved Engraving 89

Rittenhouse and Potts Uniformity



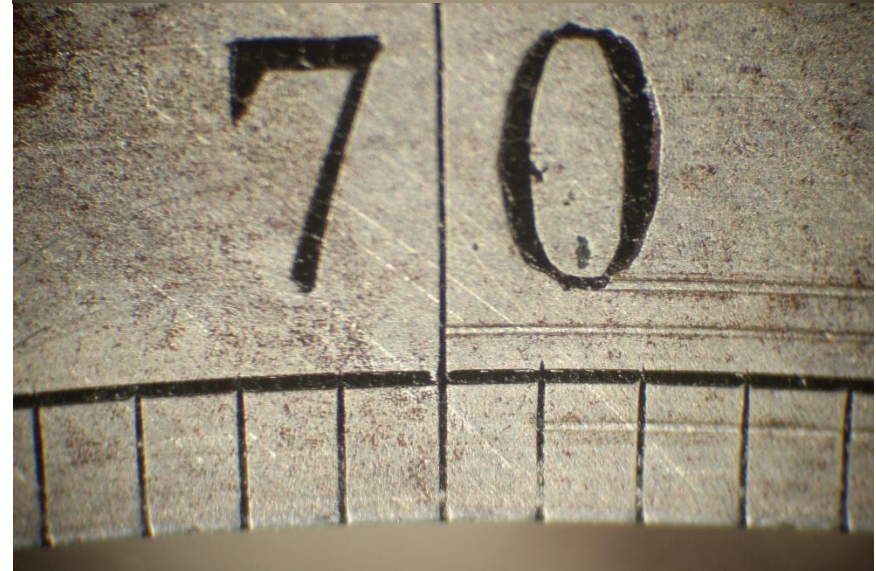
Potts 1 Uniformity



Lewis Michael

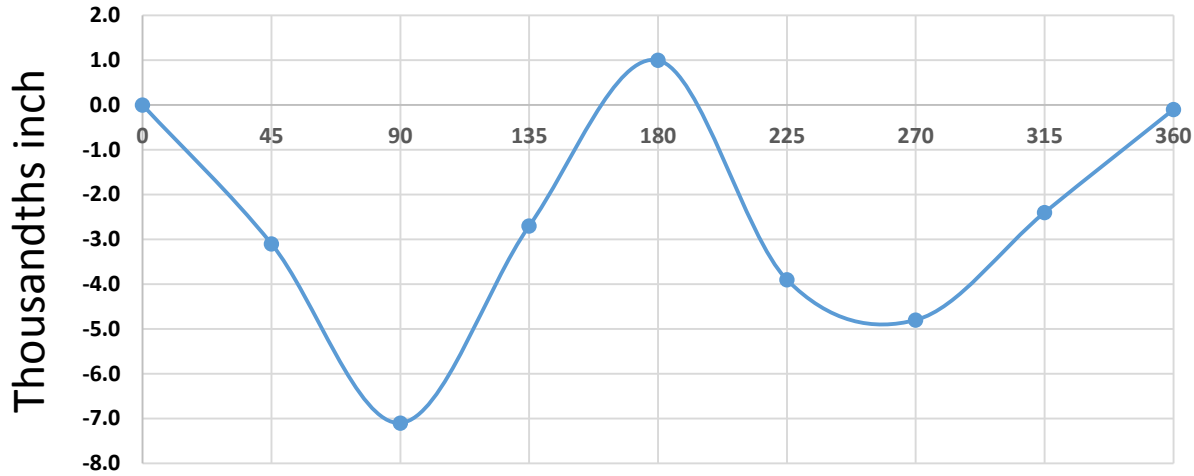


Lewis Michael

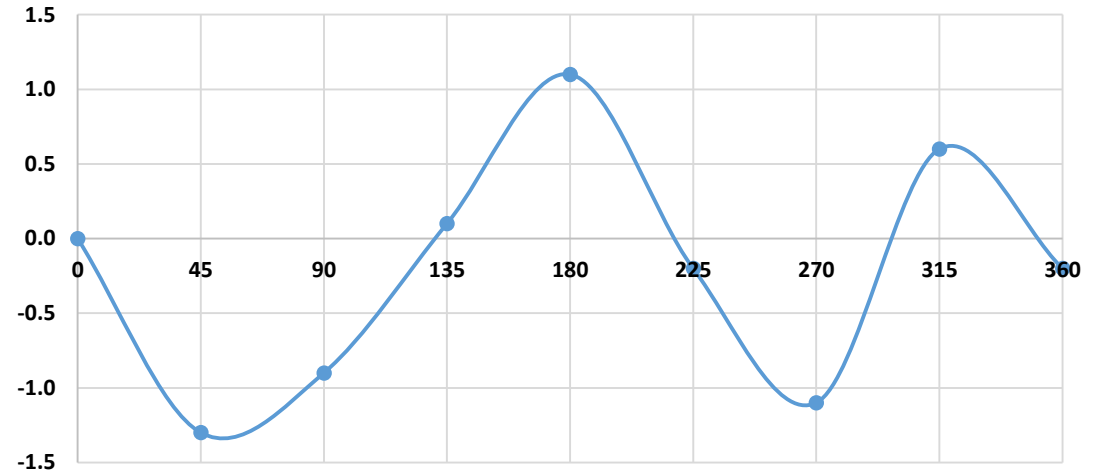


Potts 1 and 2 Radii

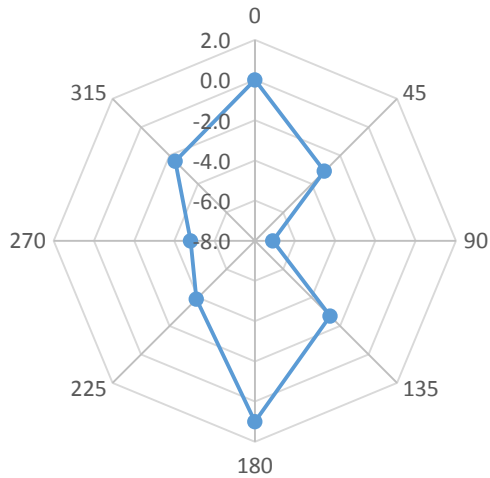
Potts 1 Delta from Circle wrt N



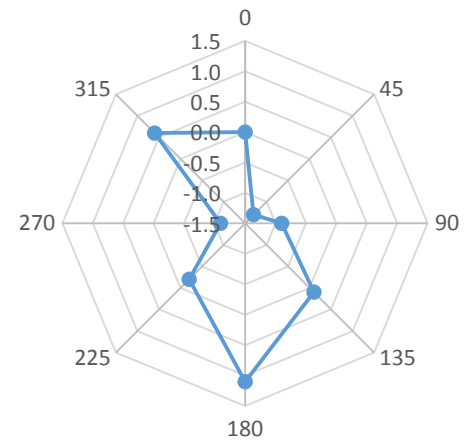
Potts 2 Delta from Circle wrt N



Potts 1 Delta from Circle wrt N

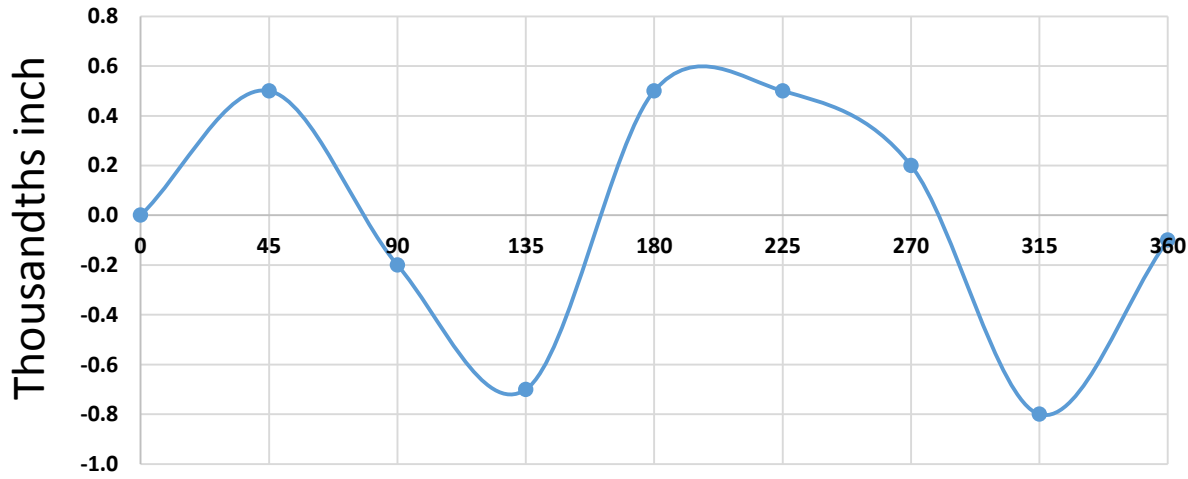


Potts 2 Delta from Circle wrt N

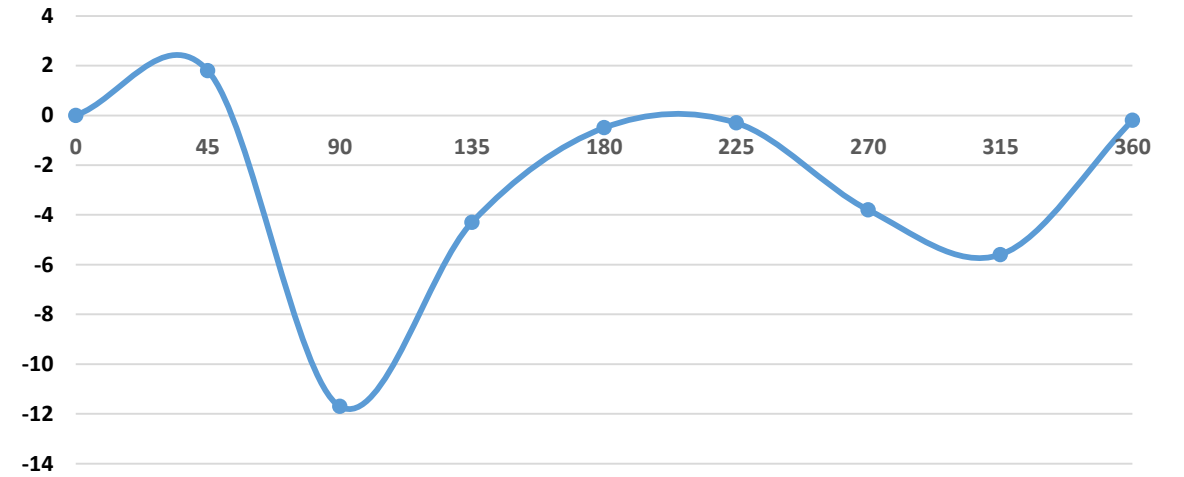


Potts 3 and 4 Radii

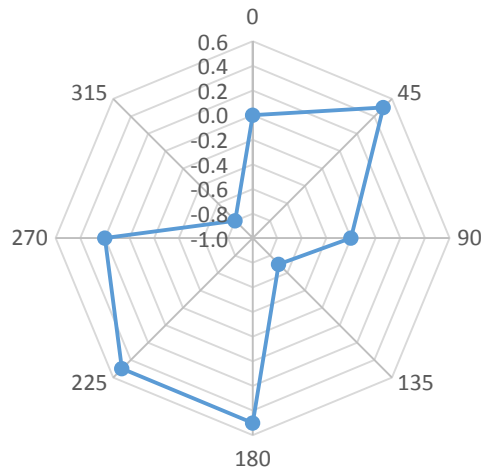
Potts 3 Delta from Circle wrt N



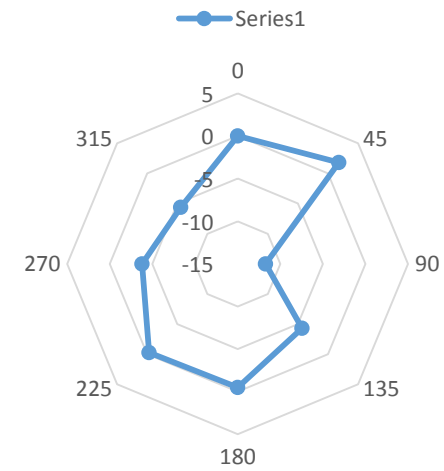
Potts 4 Delta from Circle wrt N



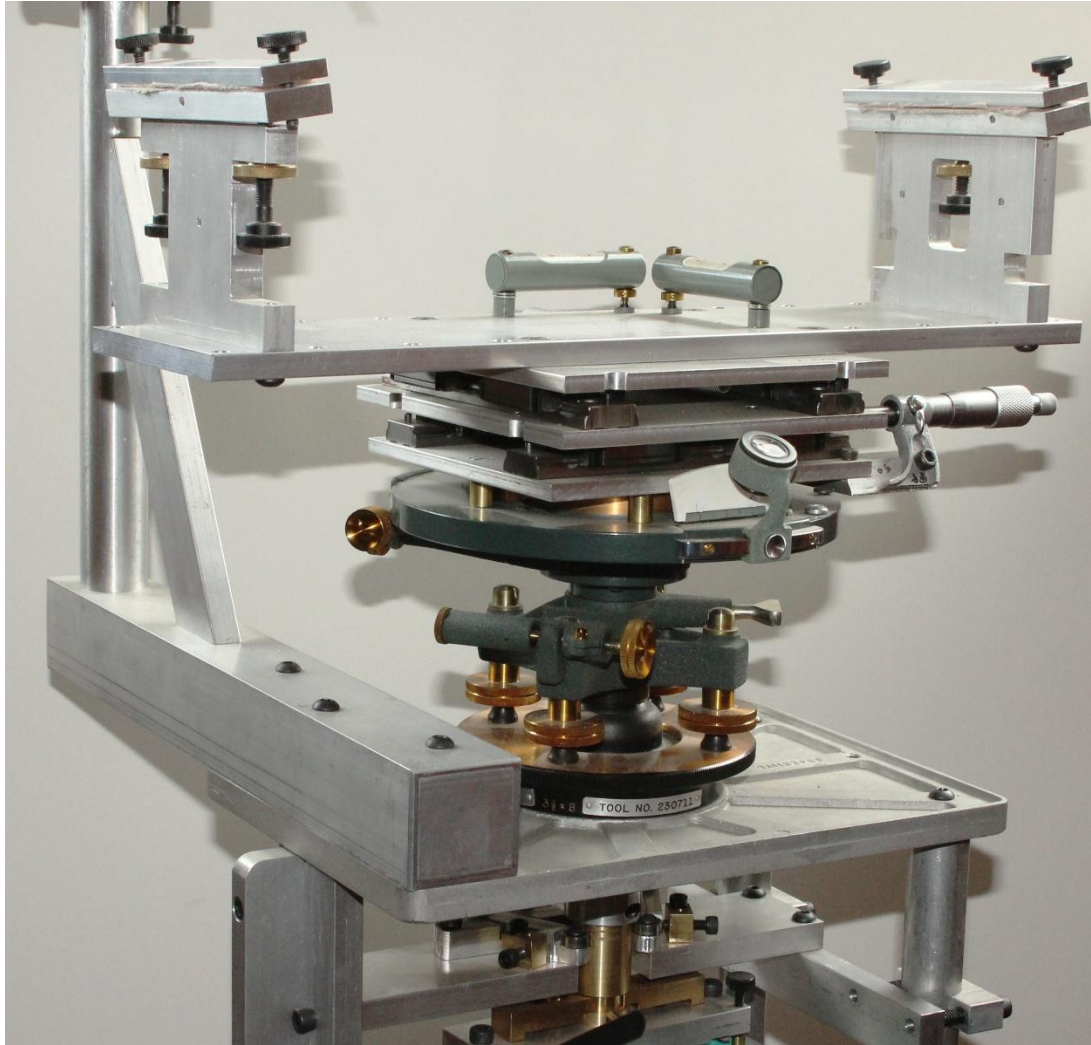
Potts 3 Delta from Circle wrt N



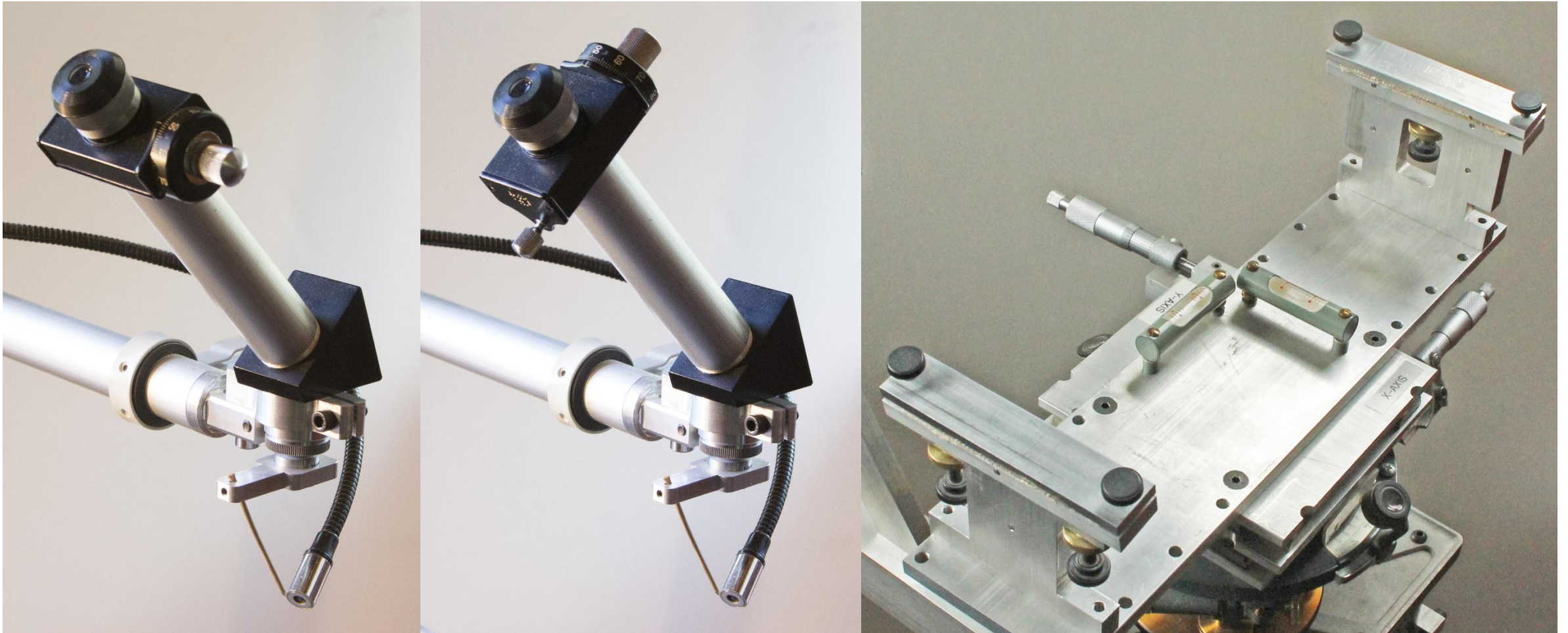
Potts 4 Delta from Circle wrt N



K&E and Sokkia Stages



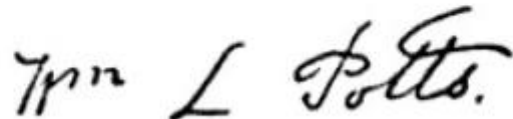
Microscope, Cradle, X-Y stages and Plate Levels



William Lukens Potts

55 **William Lukens Potts**,⁴ (Thomas,³ John,² David,¹) son of Thomas and Elizabeth (**Lukens**) **Potts**, was born 7 mo. 17, 1771, in Sussex County, New Jersey. He married Rachel Hughes, daughter of Col. Isaac⁴ (John,³ Hugh,² John,¹) and Hannah (Holstein) Hughes, March 31, 1801. She was born April 18, 1774, and died Feb. 24, 1866. He removed to Philadelphia about the year 1817, and engaged in the iron business on Second Street, near Race, where he continued until his death, January 17, 1854. He was strong mentally and physically, generous, kindly and popular, and of fine appearance. He was a member of the Friends Society and refused to accept any public office.

The following is a good copy of the signature of **William Lukens Potts**.



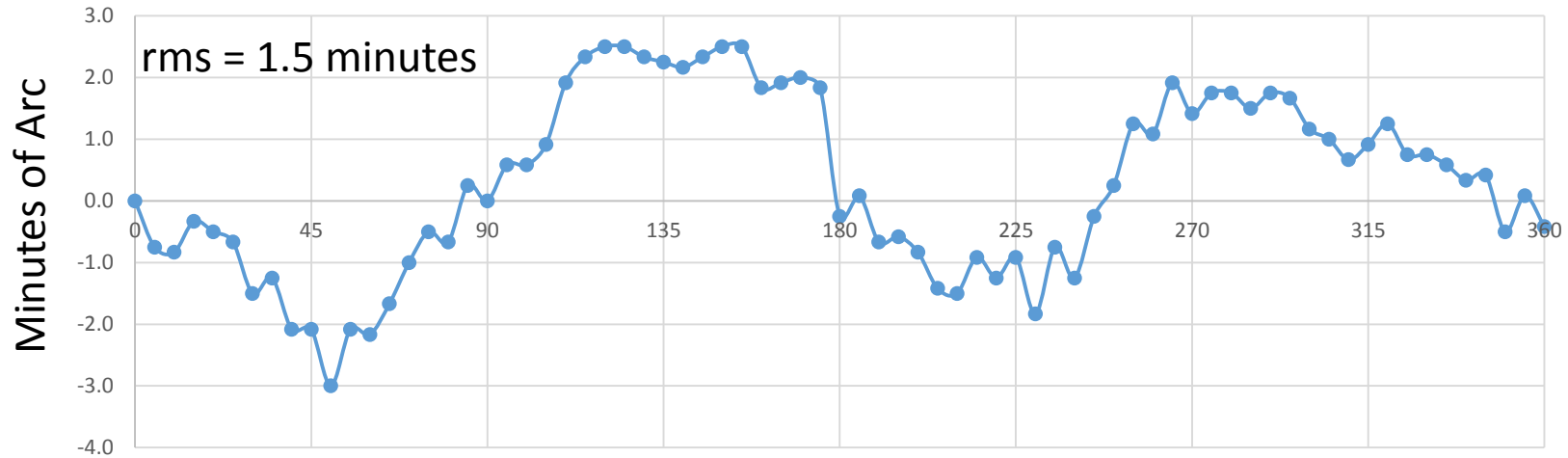
Wm L Potts.



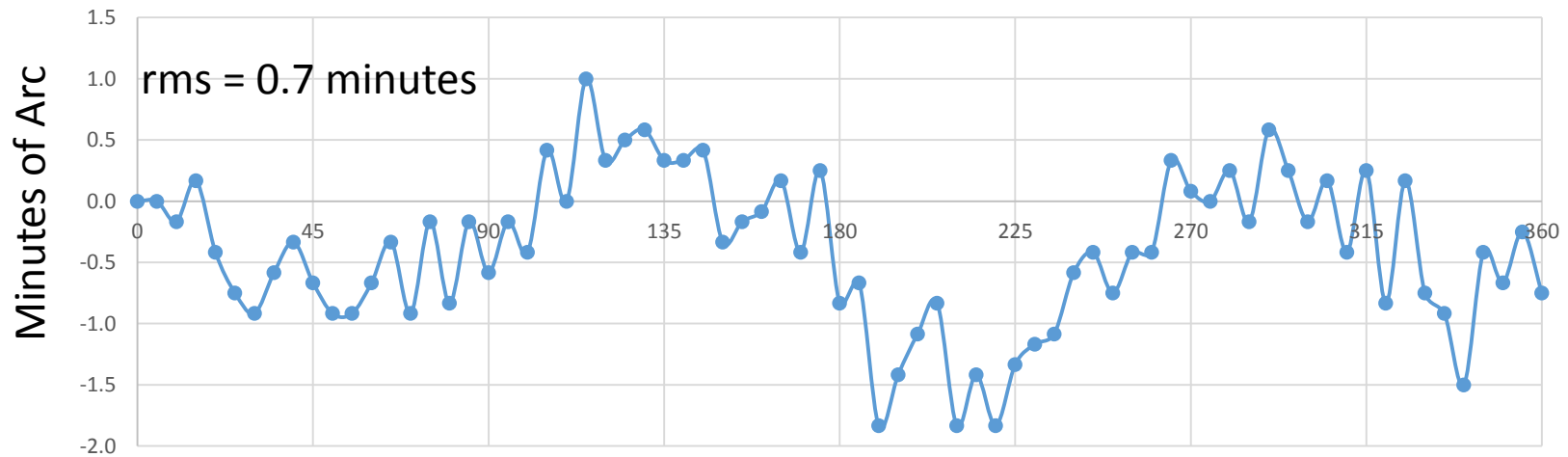
Potts 1 and 2 Every Five Degrees

Note Vertical Scale Changes!

Potts 1 Fives 7-6-13

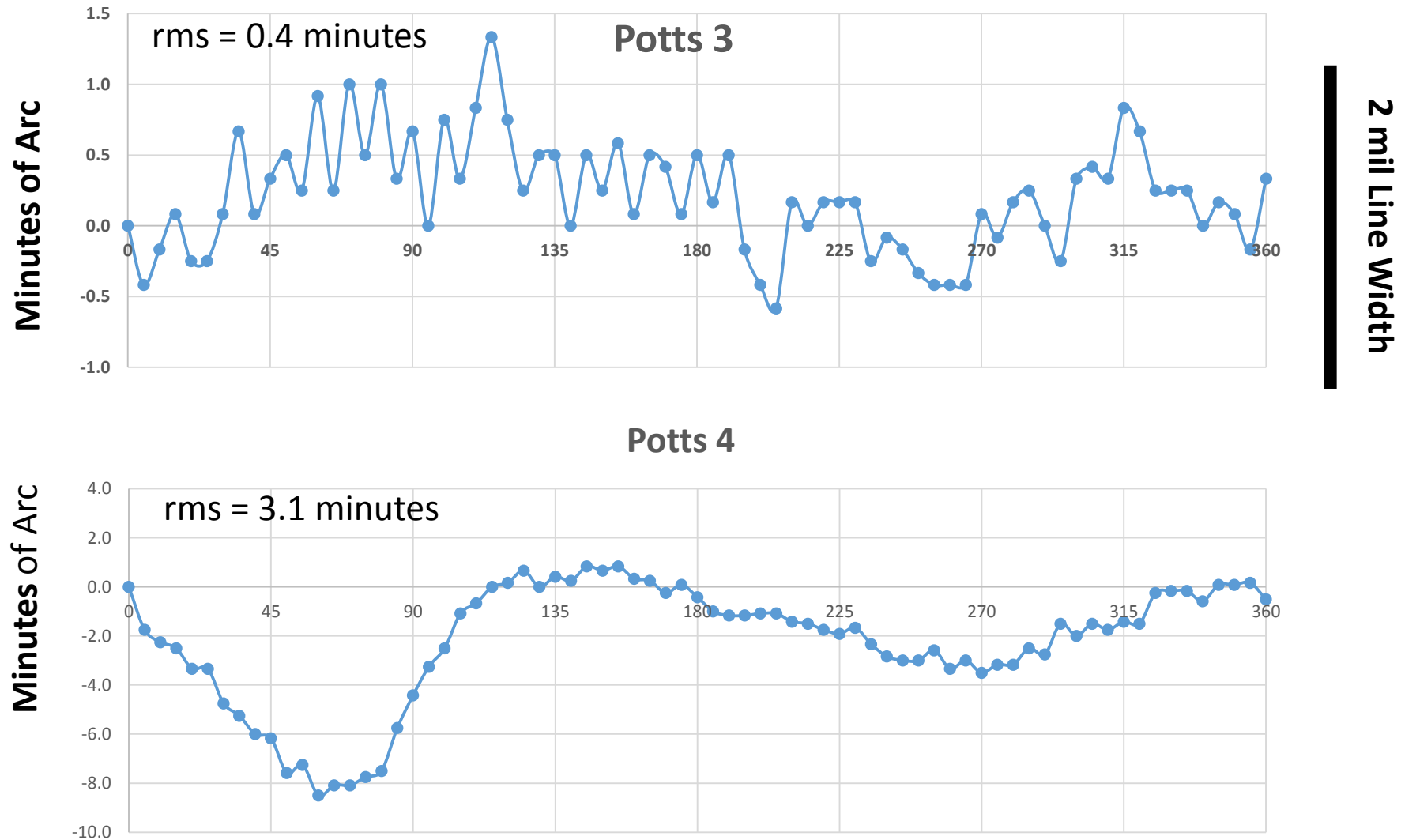


Potts 2 Fives 7-8-13



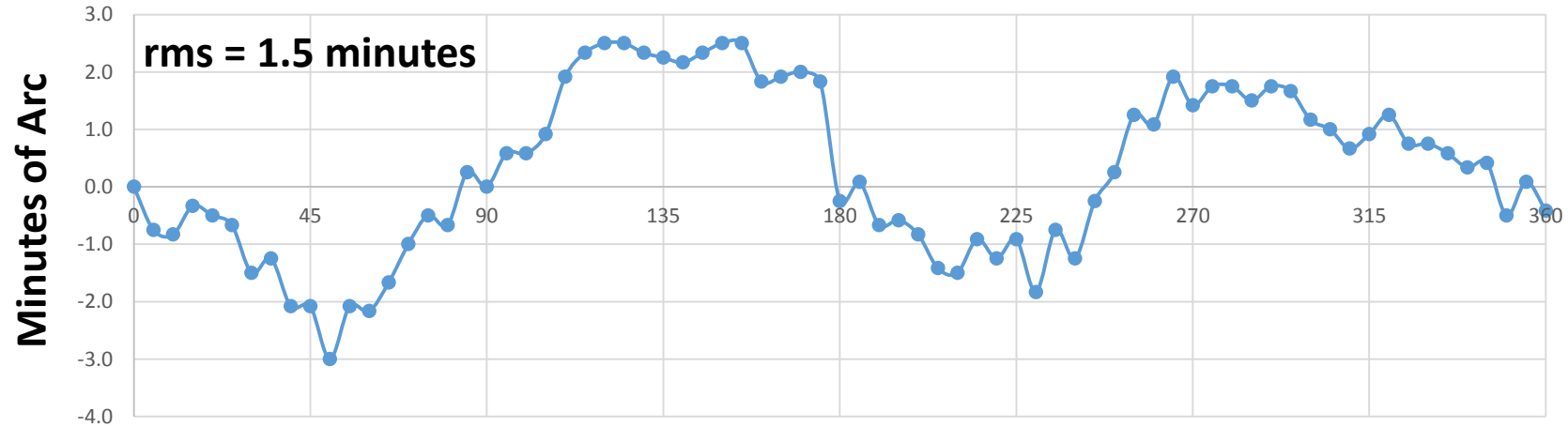
2 mil Line Width

Potts 3 and 4 Every Five Degrees

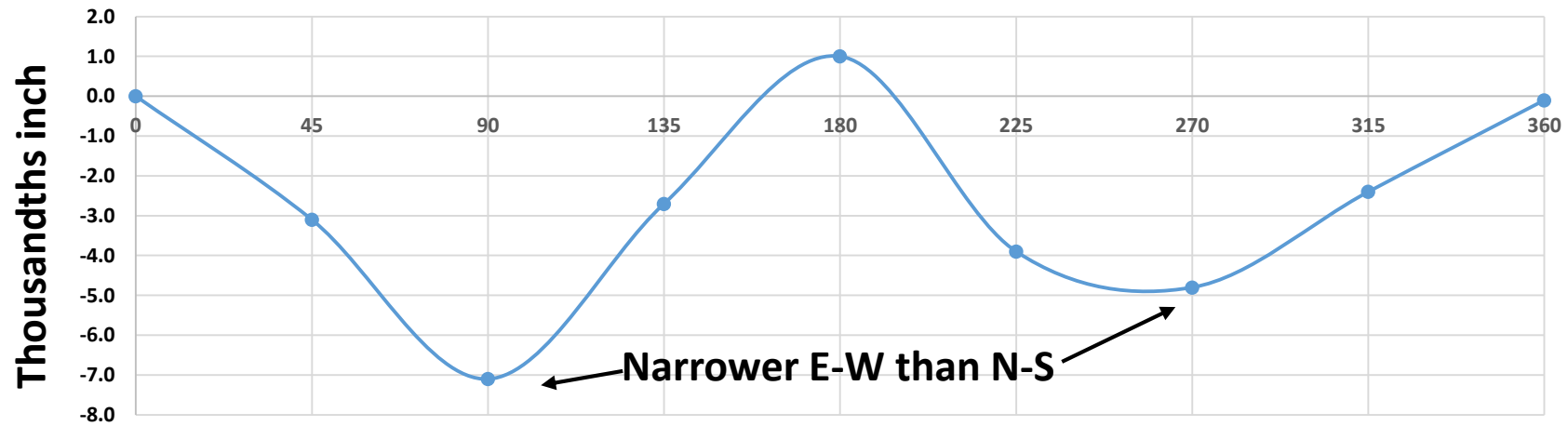


Potts 1

Potts 1



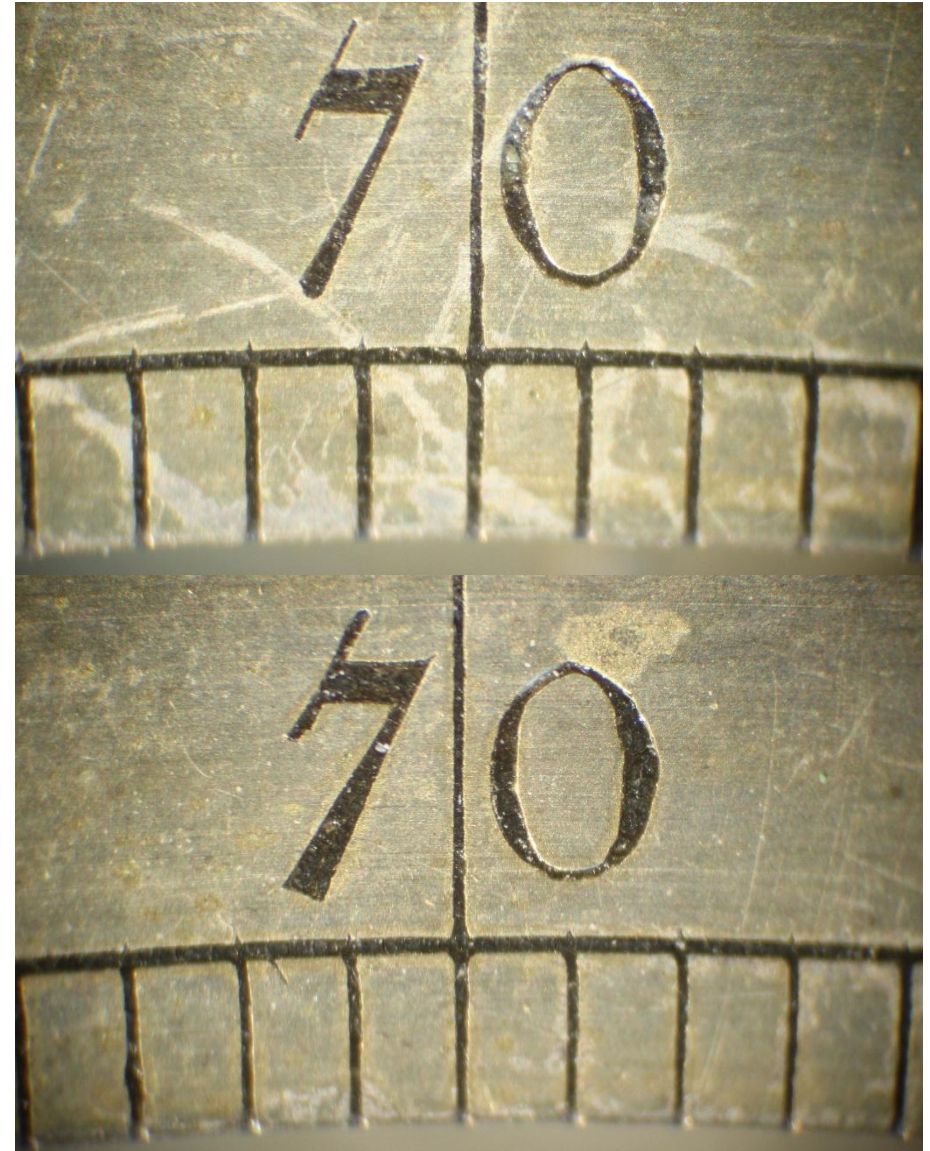
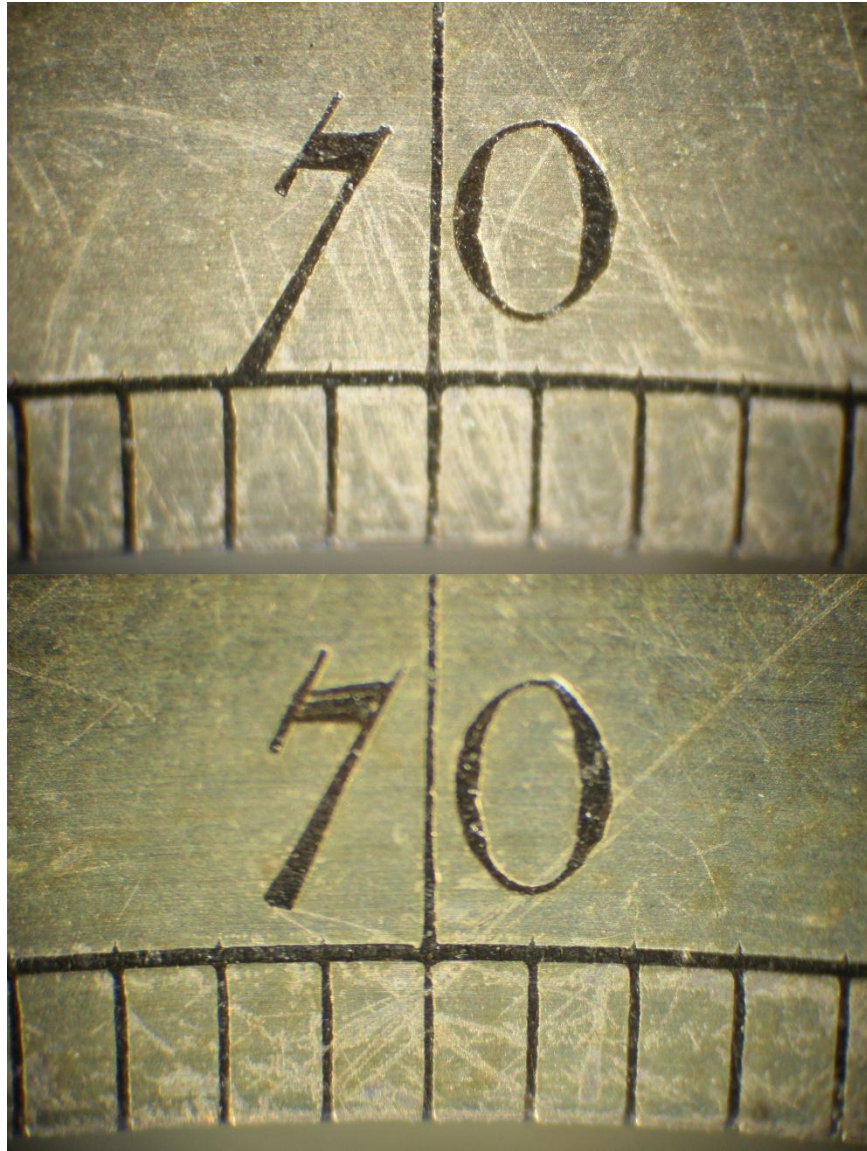
Potts 1 Deviation From Circle



Potts 1 Uniformity



Rittenhouse and Potts Uniformity



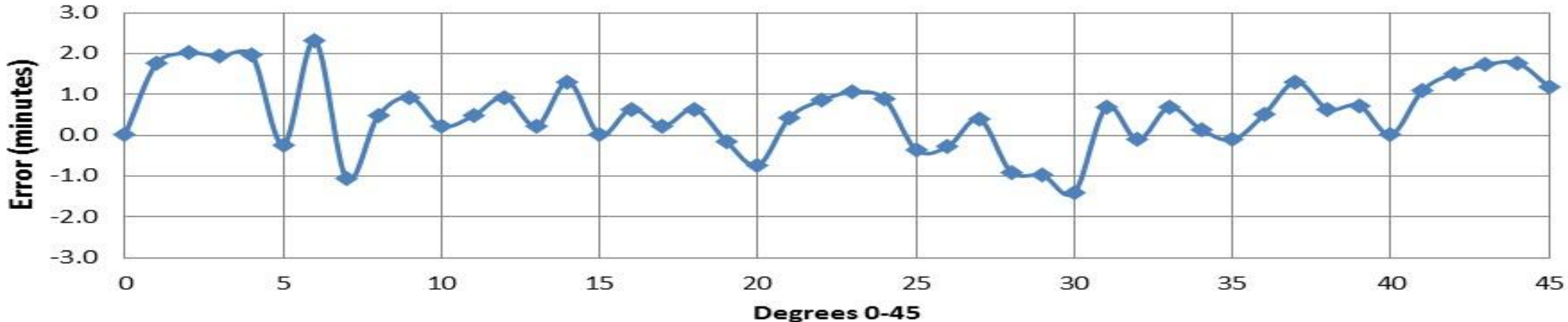
Loaned Rittenhouse and Potts

Two complete sets of measurements

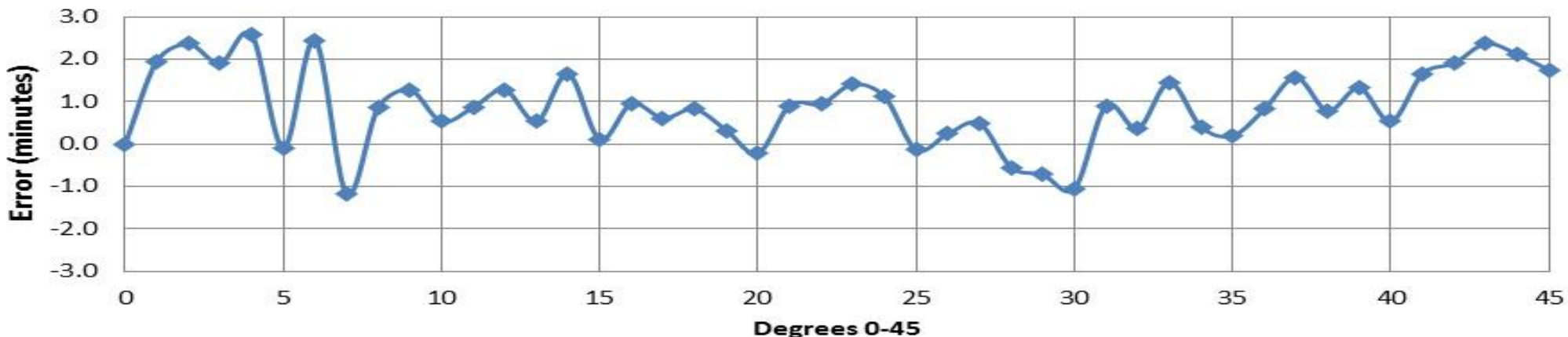
Feb 17-19, 2013

0-45 Degree Segment

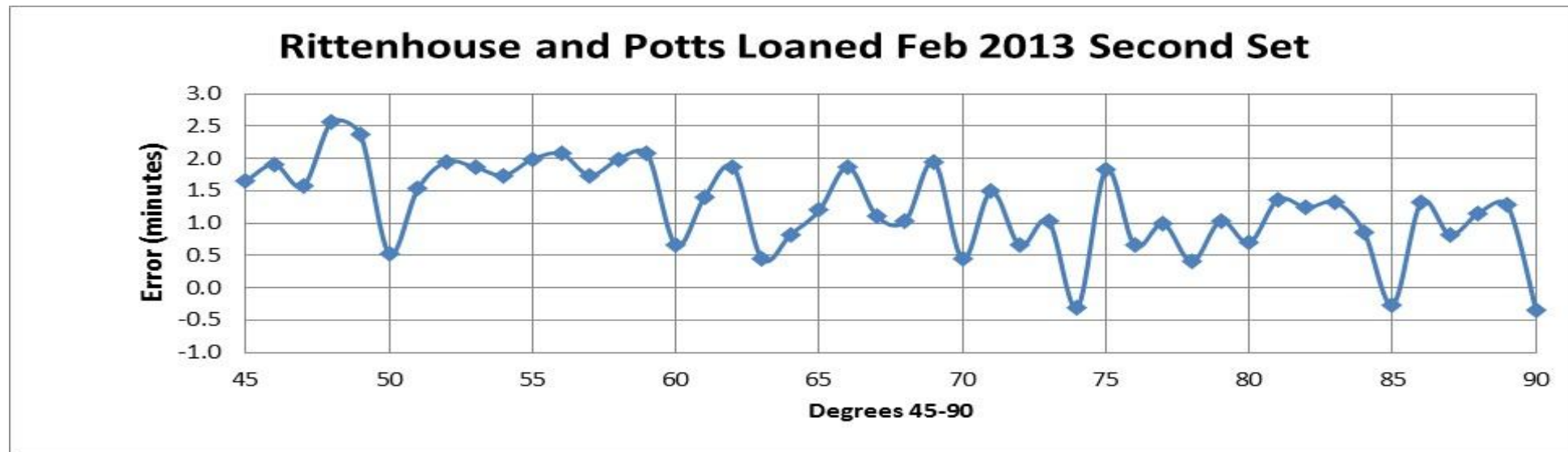
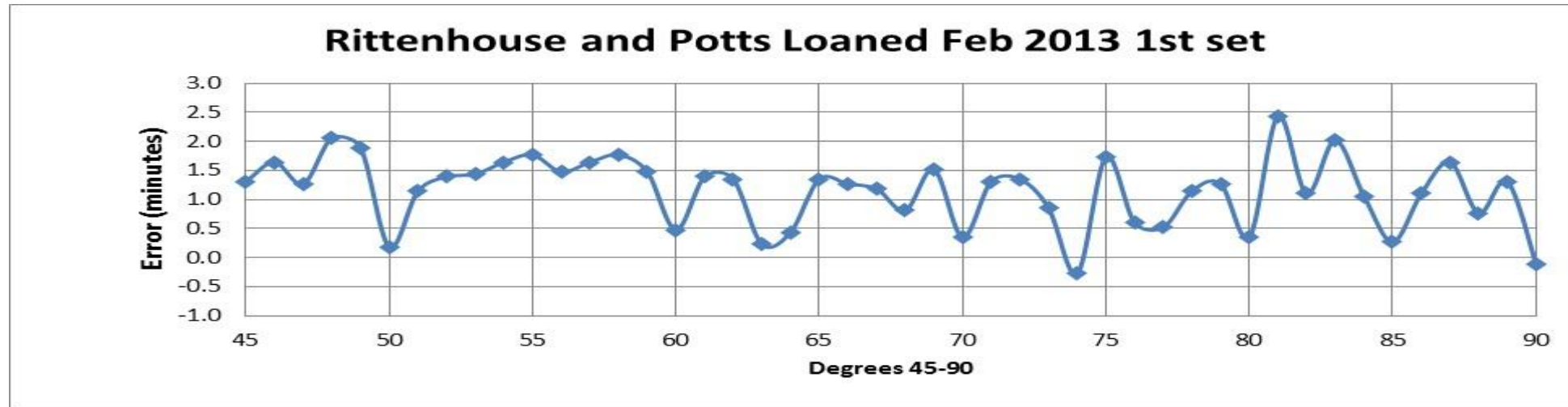
Rittenhouse and Potts Loaned Feb 2013



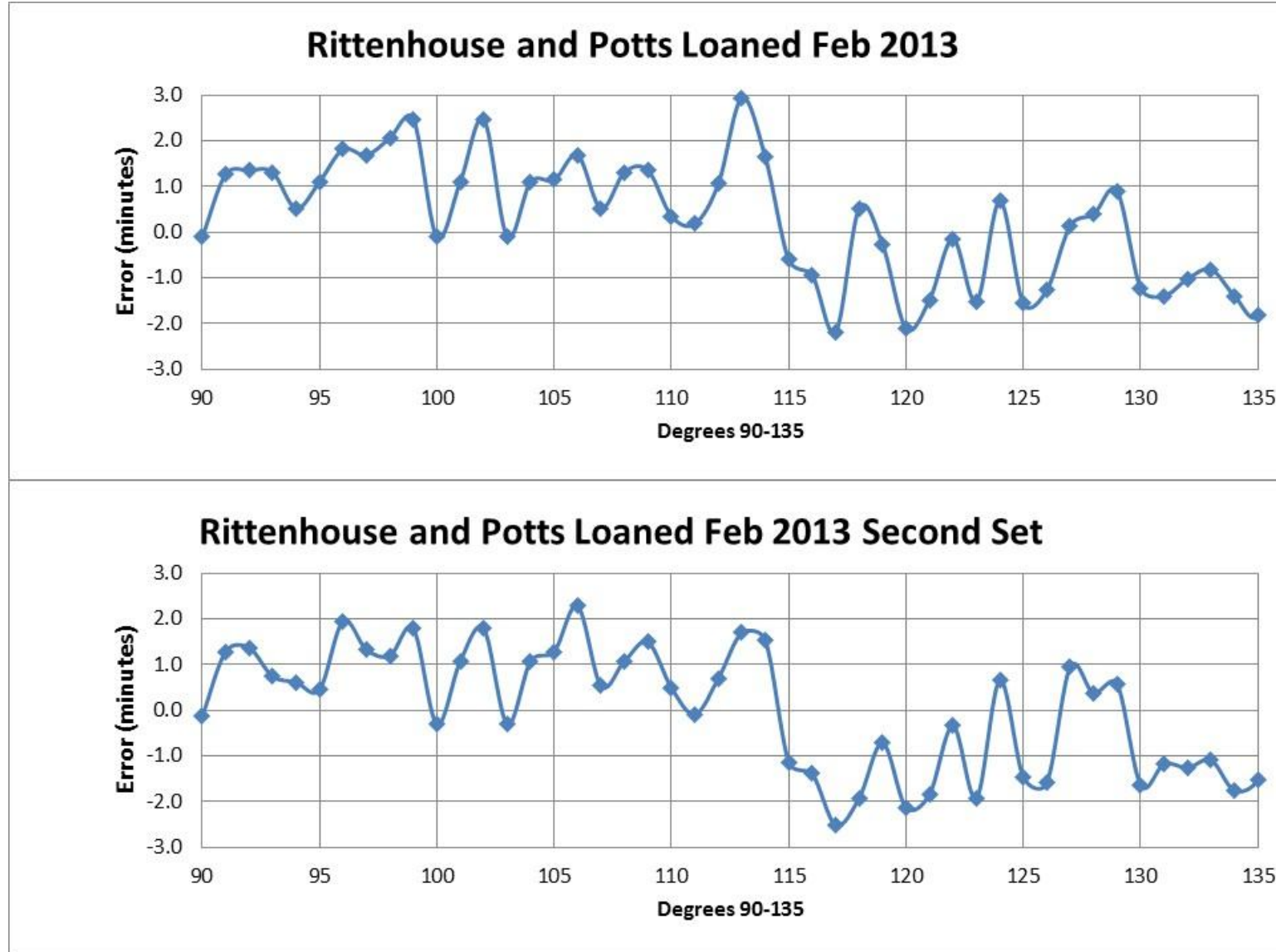
Rittenhouse and Potts Loaned Feb 2013 2nd set



45-90 Degree Segment

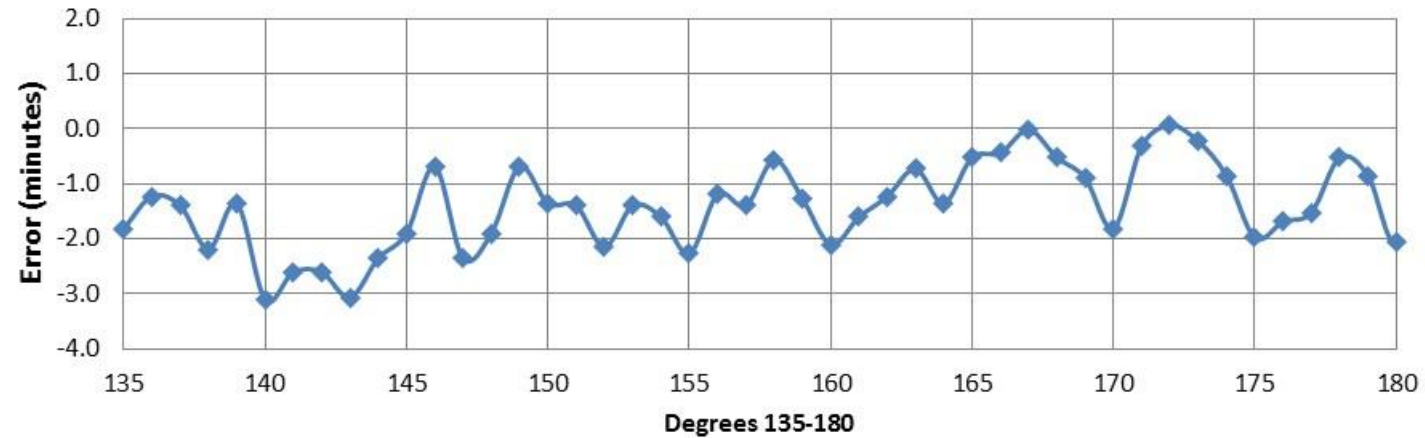


90 - 135 Degree Segment

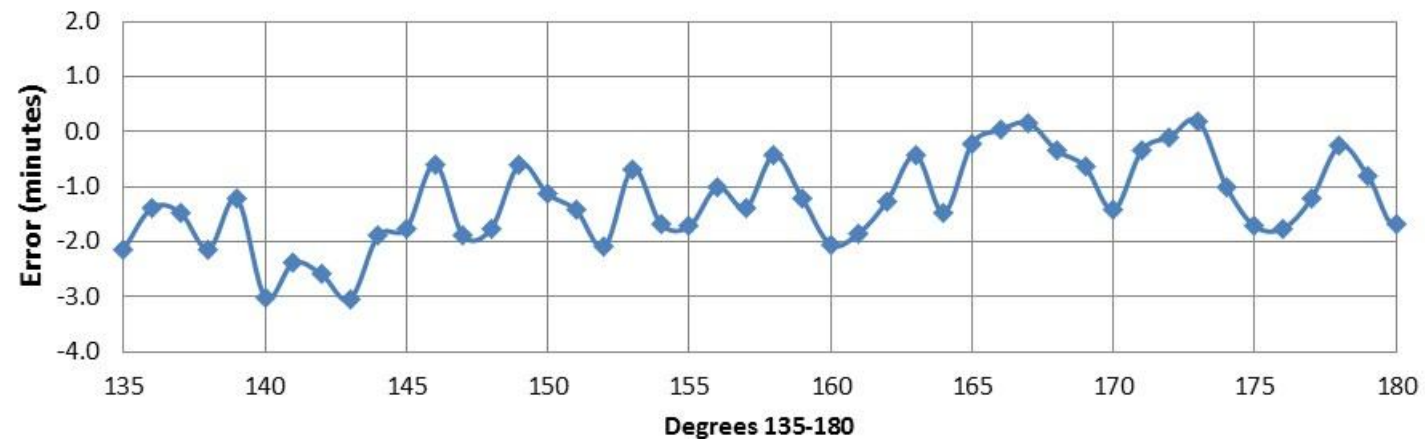


135-180 Degree Segment

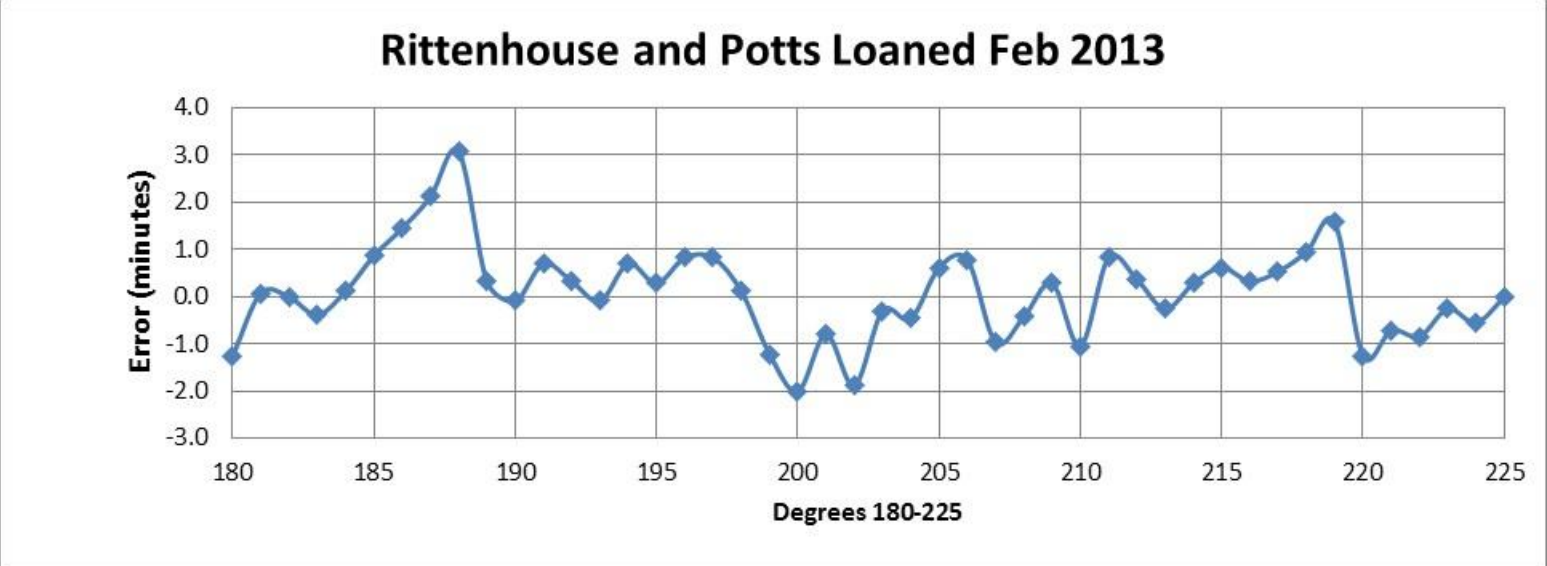
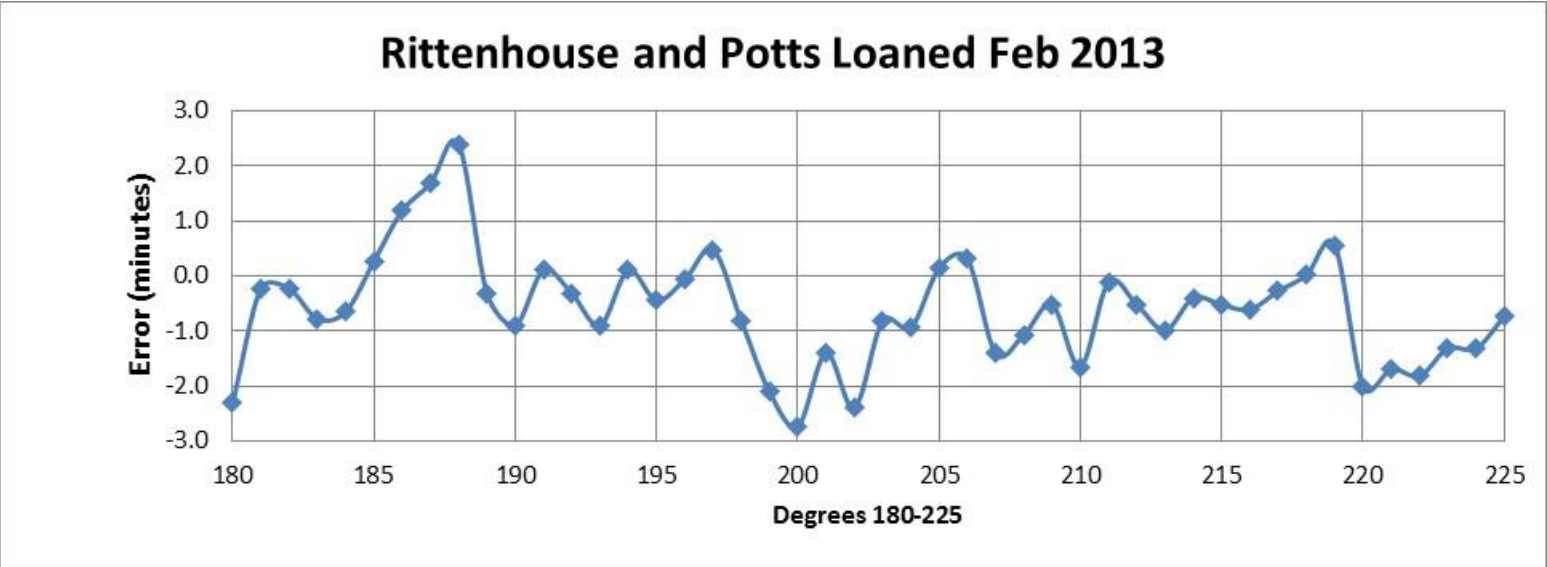
Rittenhouse and Potts Loaned Feb 2013



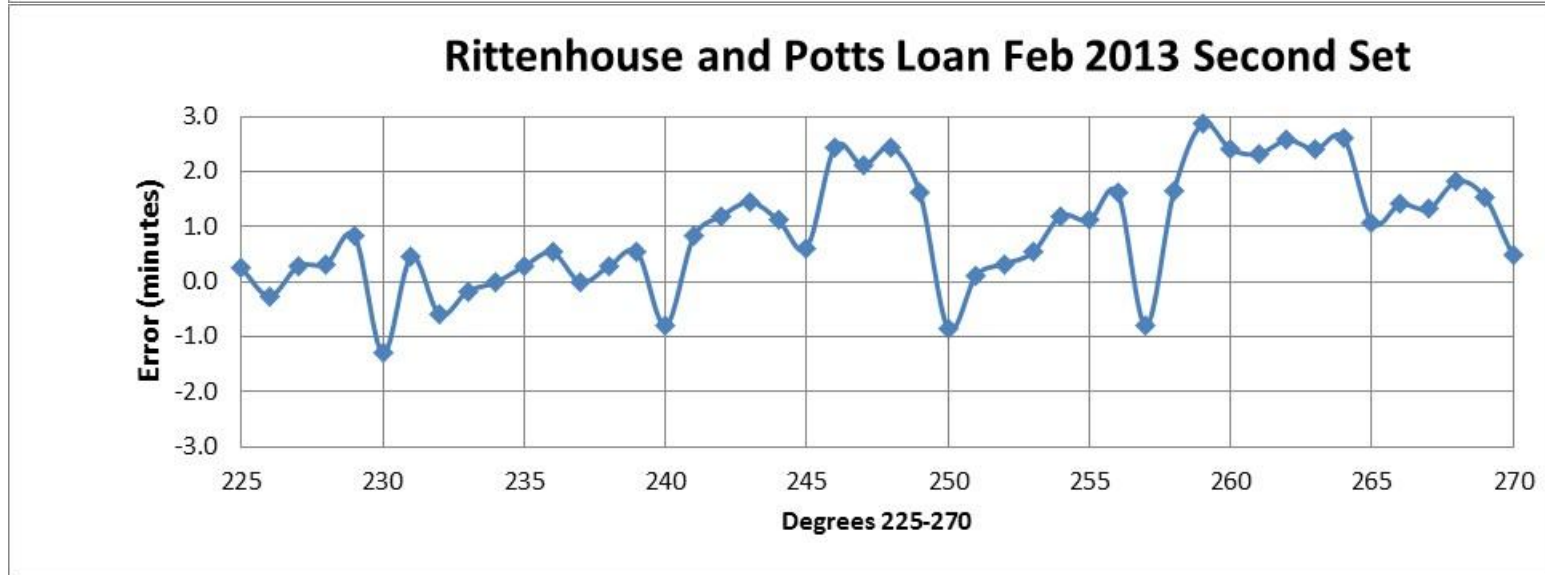
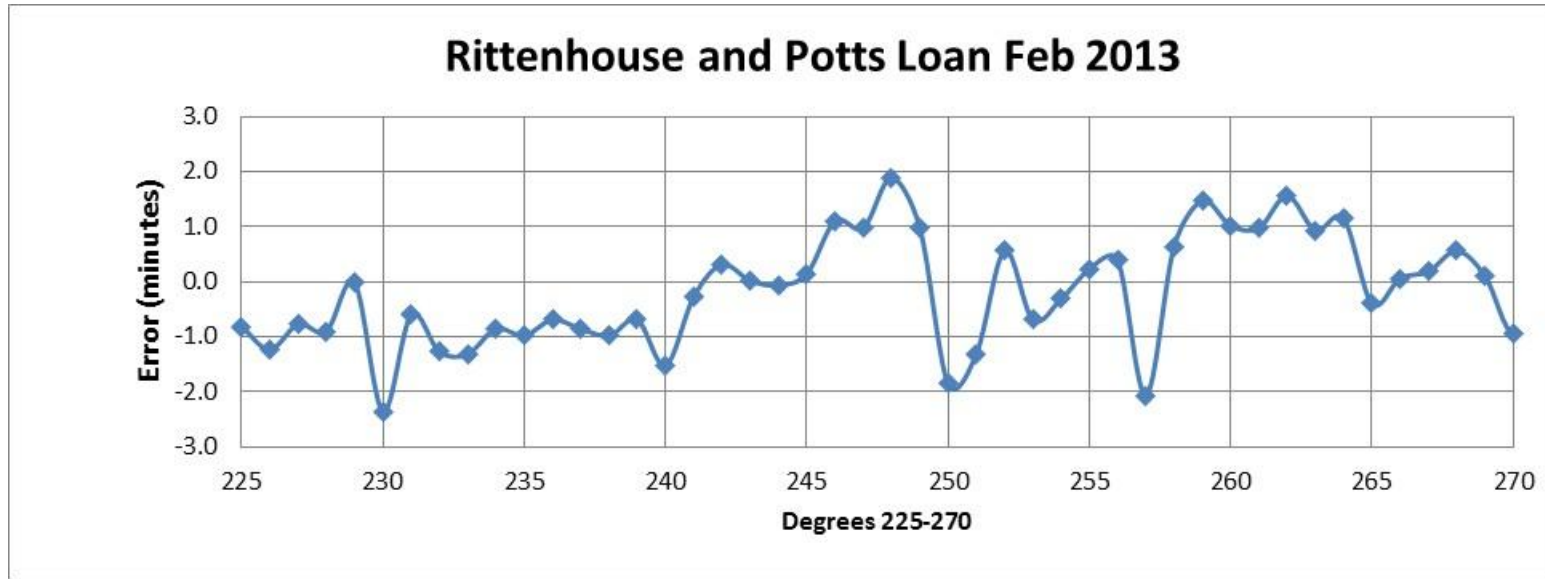
Rittenhouse and Potts Loaned Feb 2013 Second Set



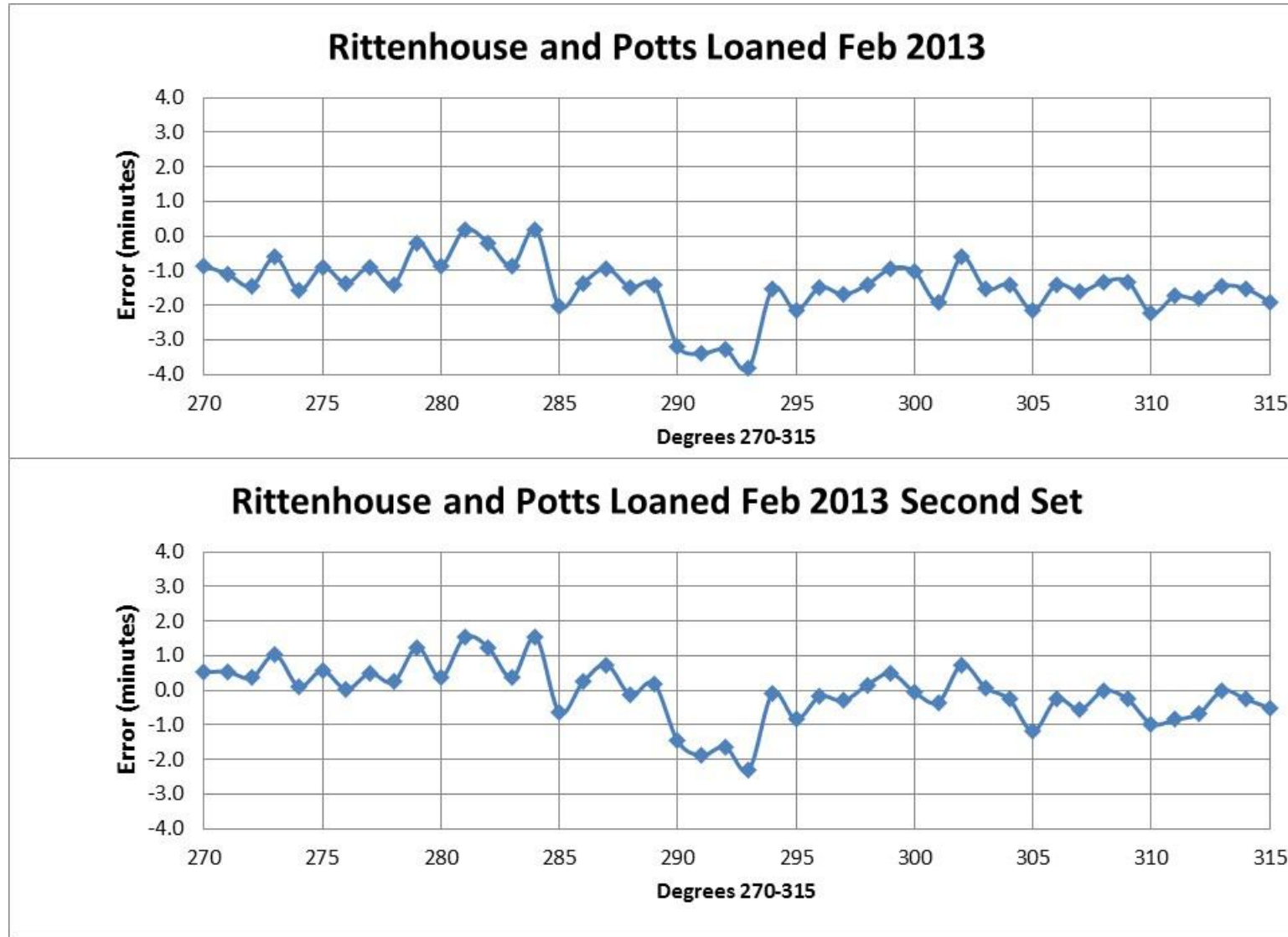
180 - 225 Degree Segment



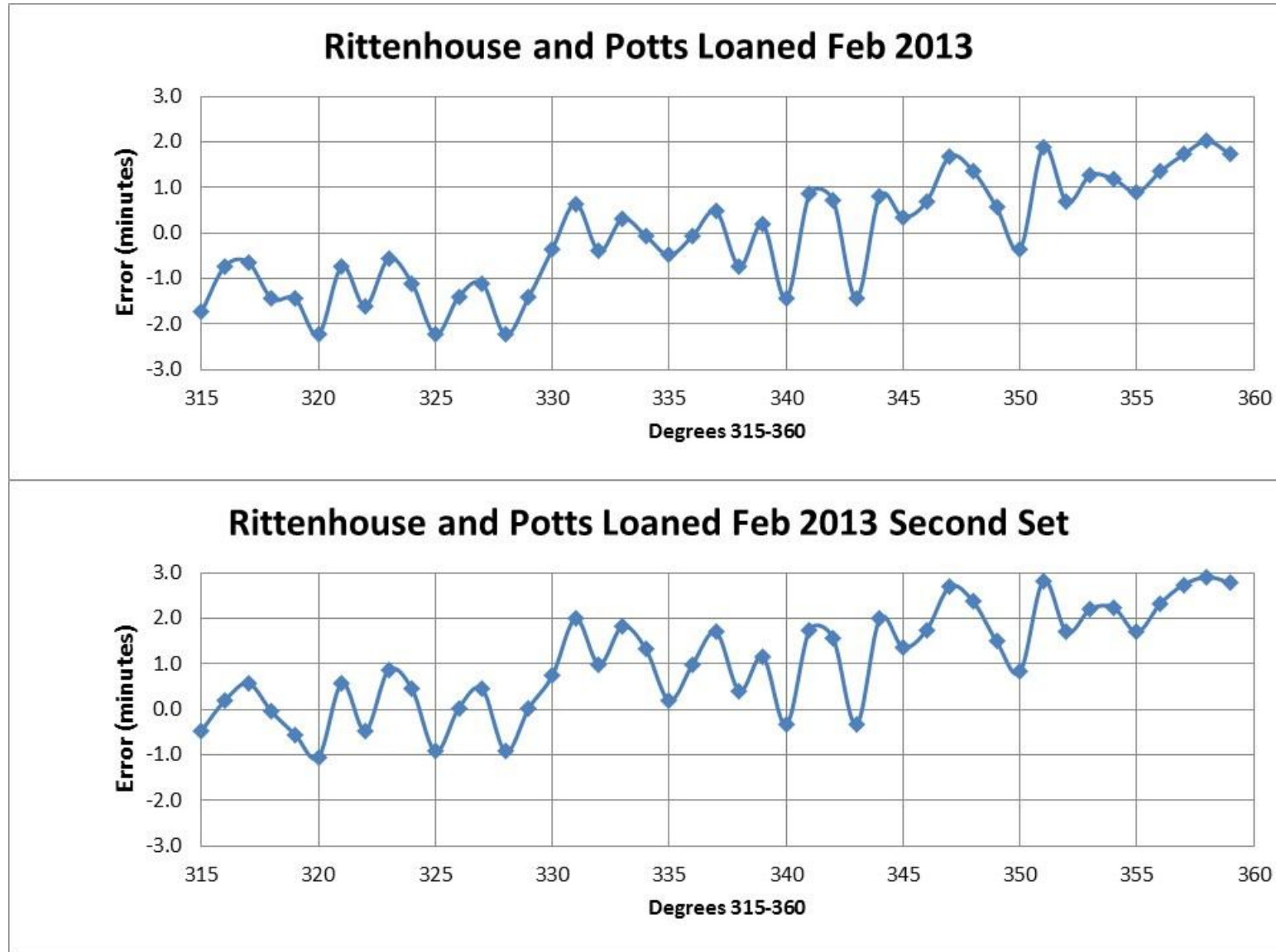
225 - 270 Degree Segment



270 - 315 Degree Segment

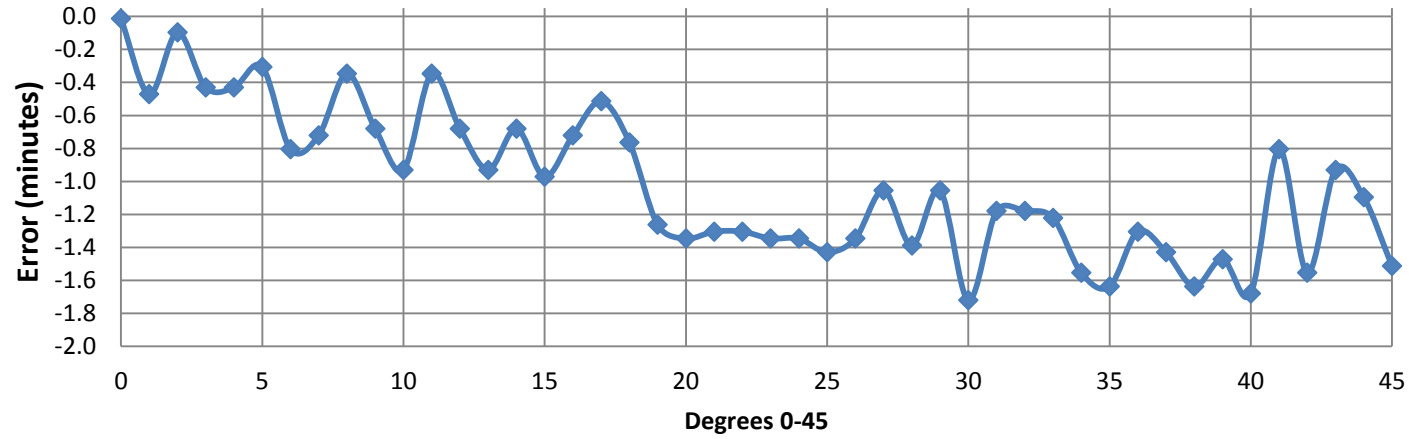


315 - 360 Degree Segment

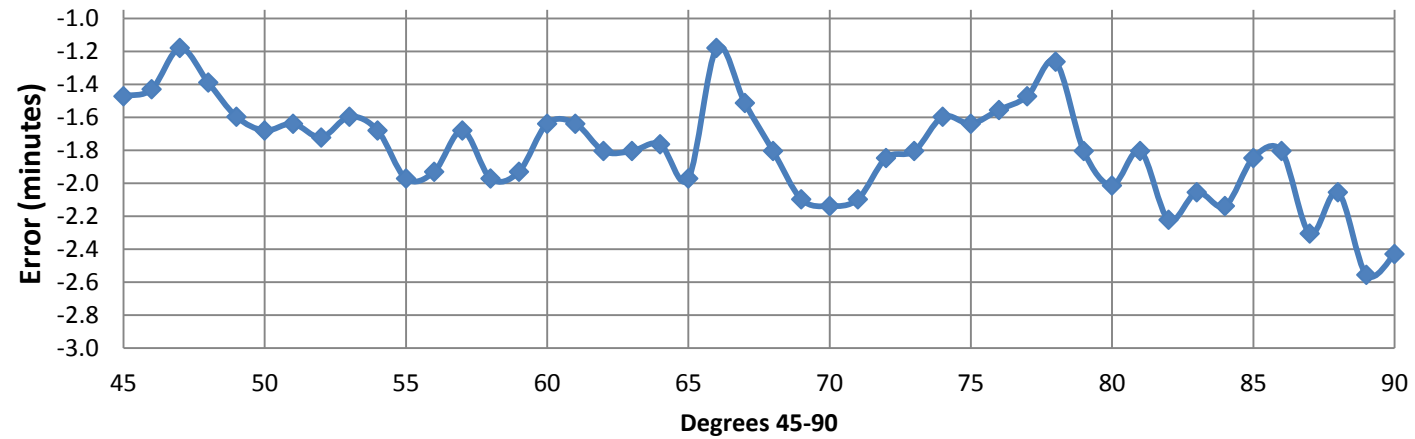


Gurley 0-90

Gurley Vernier compass

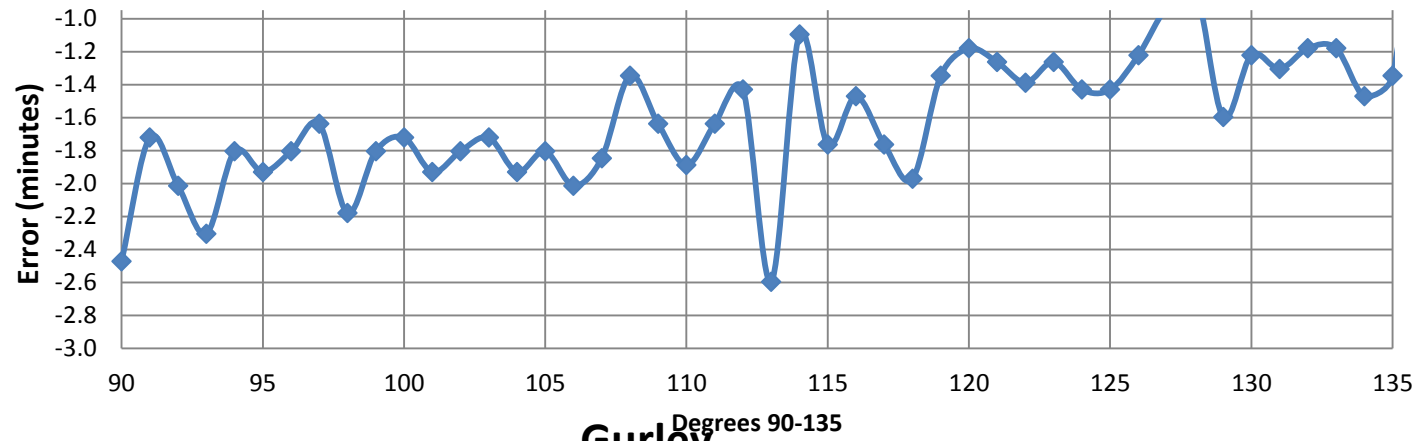


Gurley

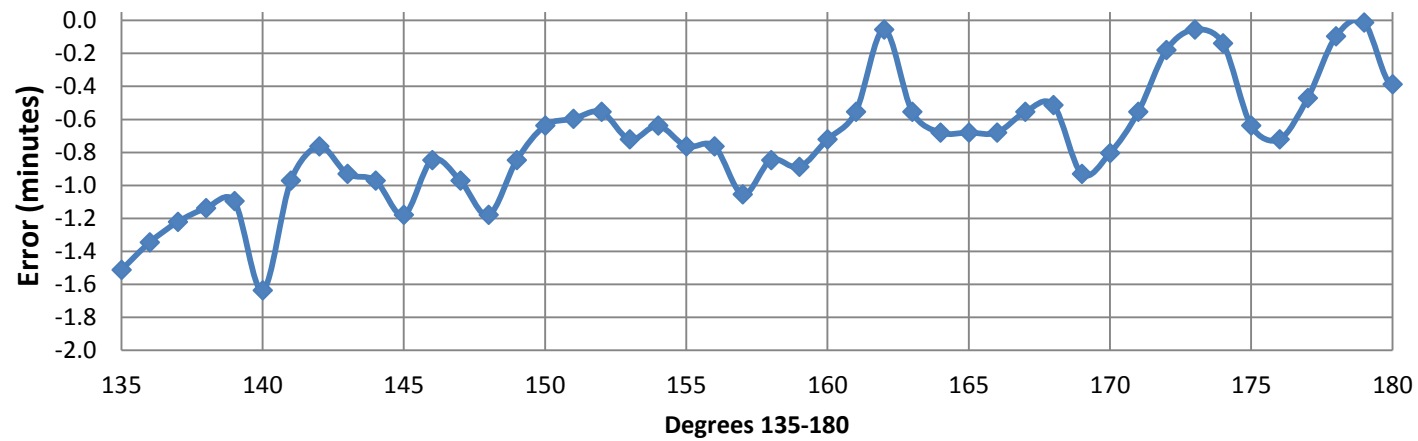


Gurley 90-180

Gurley Vernier

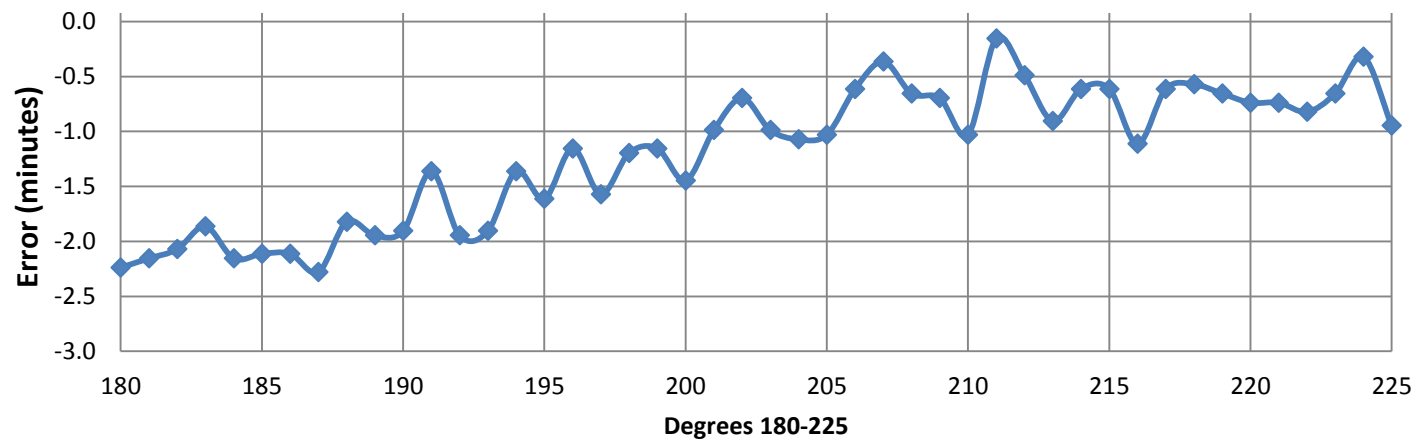


Gurley

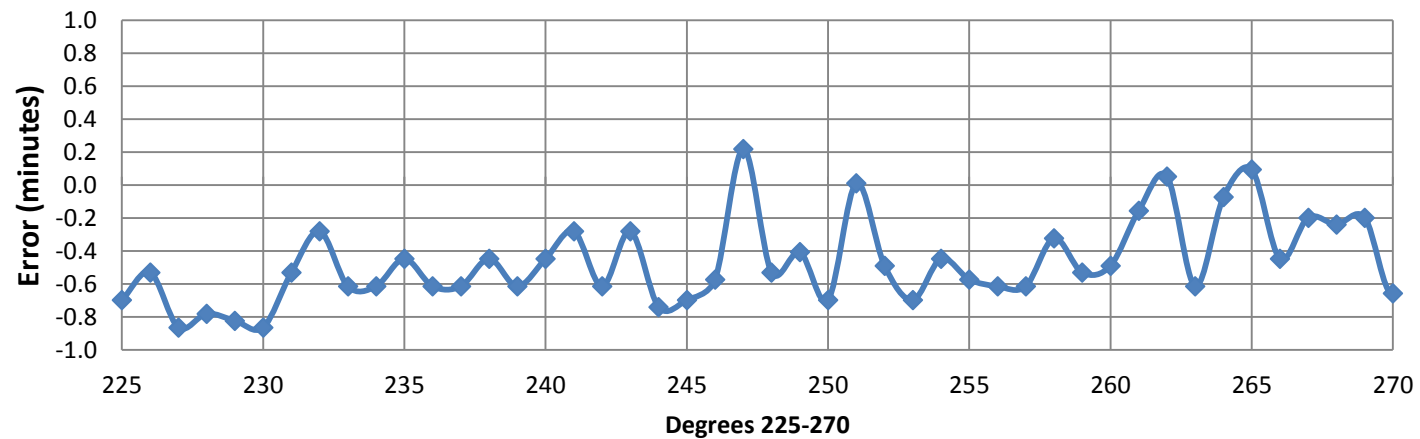


Gurley 180-270

Gurley Vernier

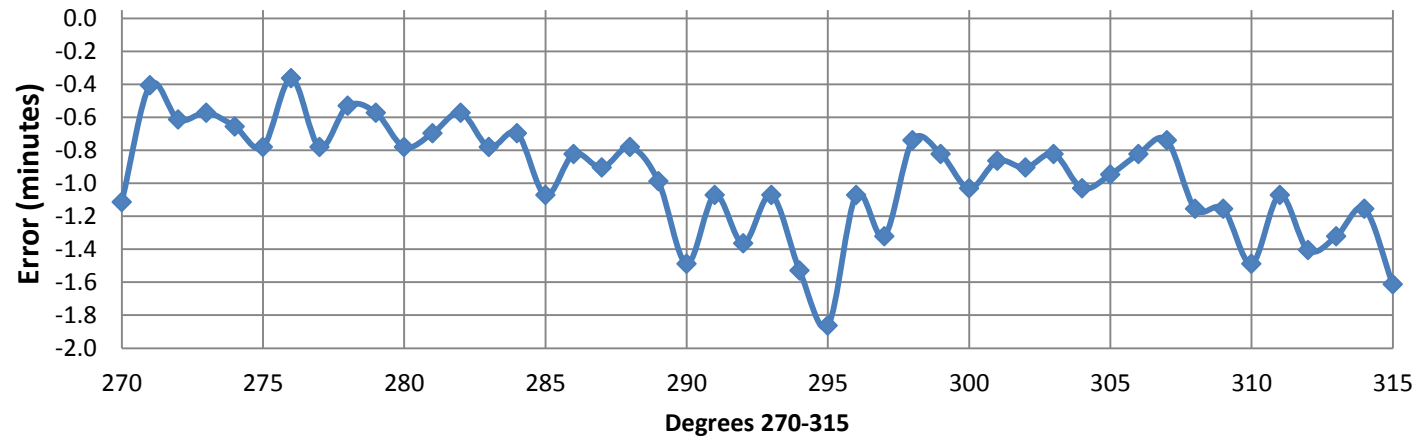


Gurley

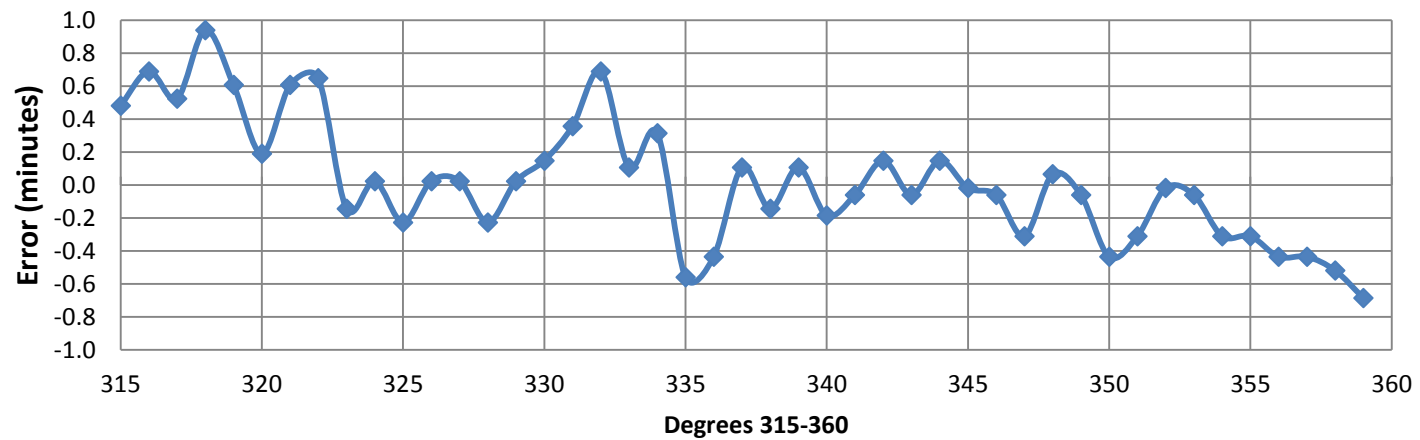


Gurley 270-360

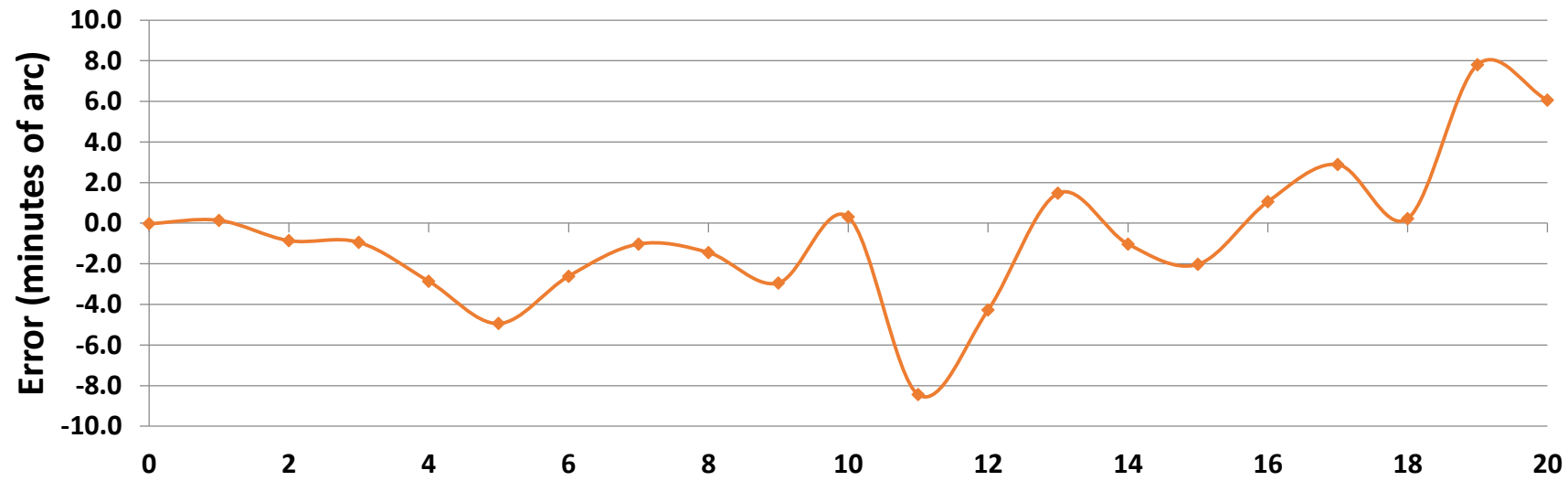
Gurley Vernier



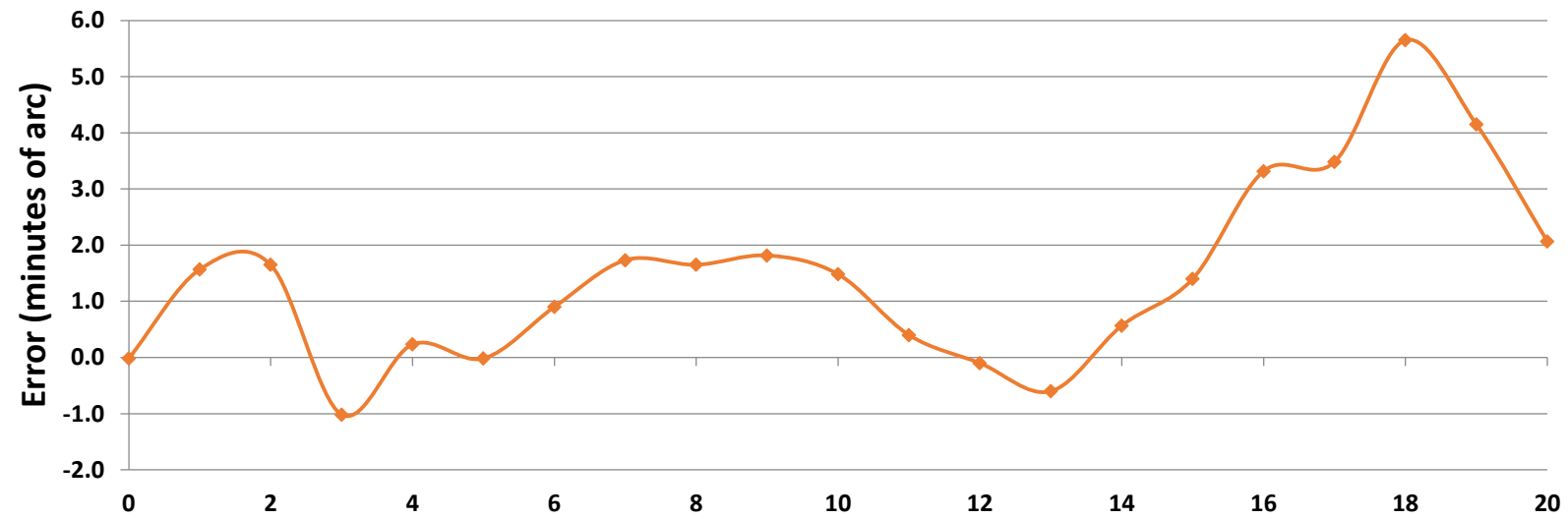
Gurley Vernier



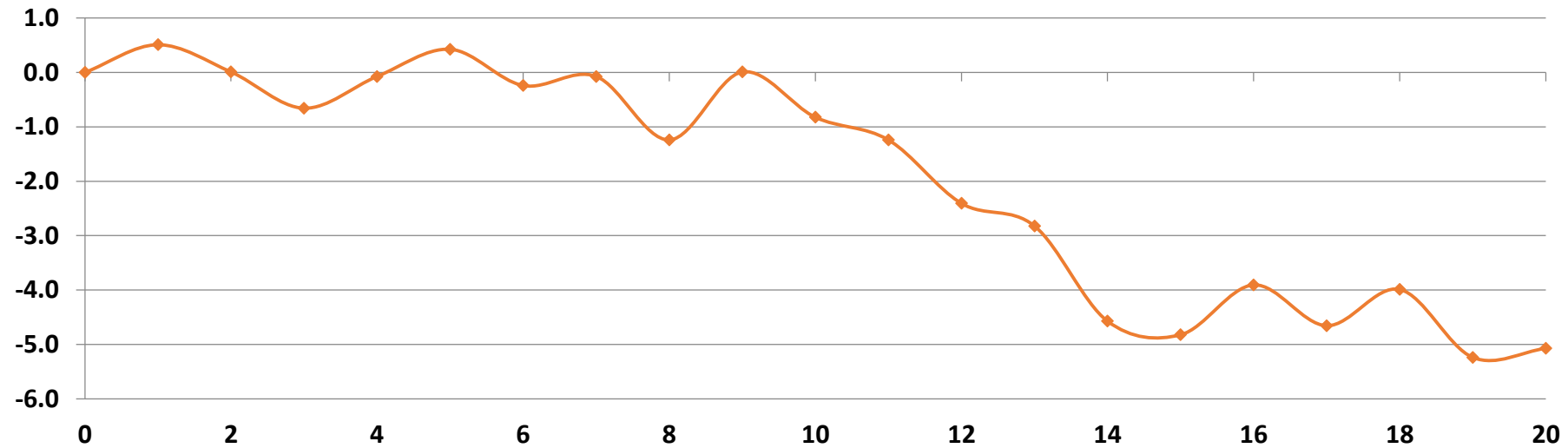
Nathan Storrs 0-20 deg



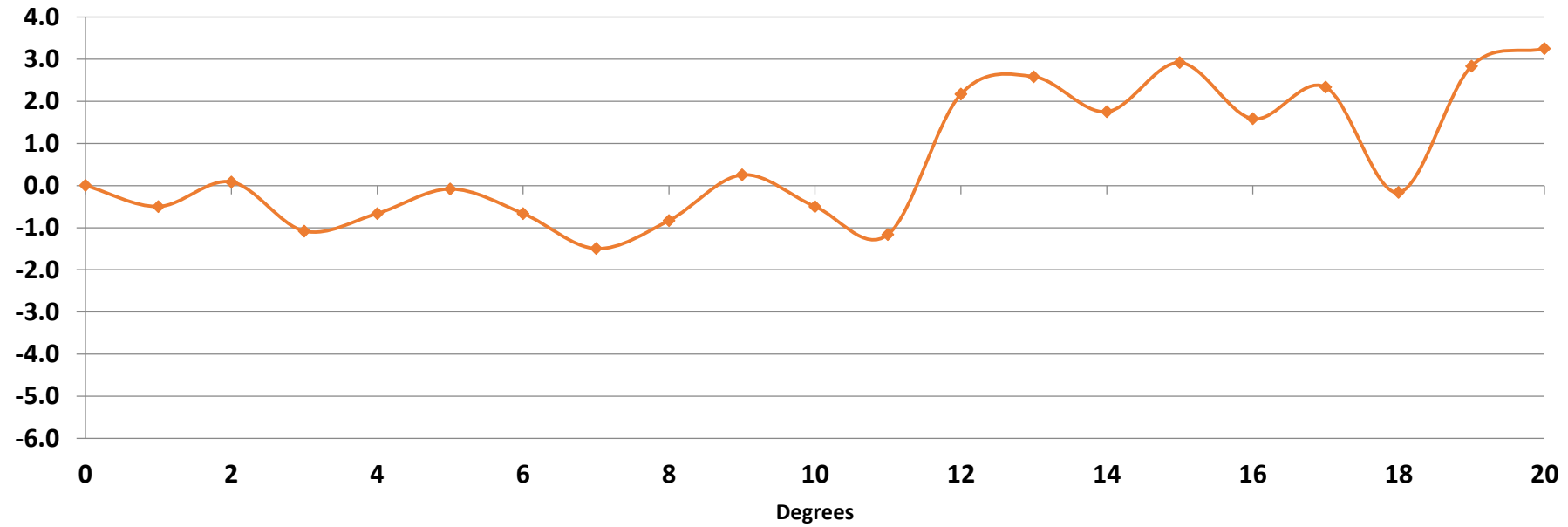
Philadelphia Unsigned 0-20 deg



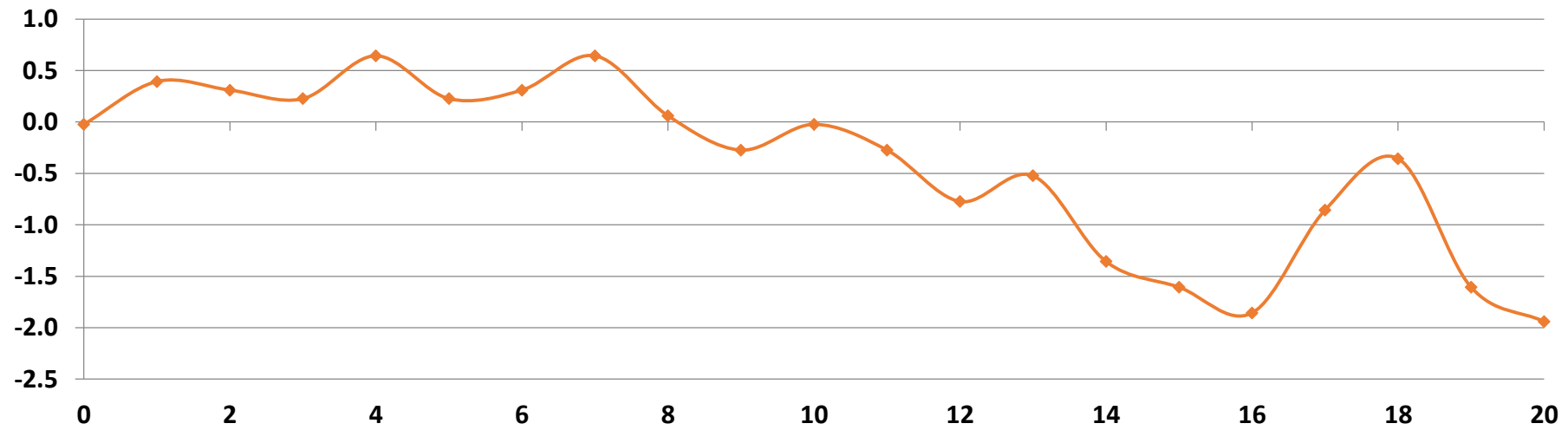
Heisley 0-20 deg



Pyefinch 0-20 deg

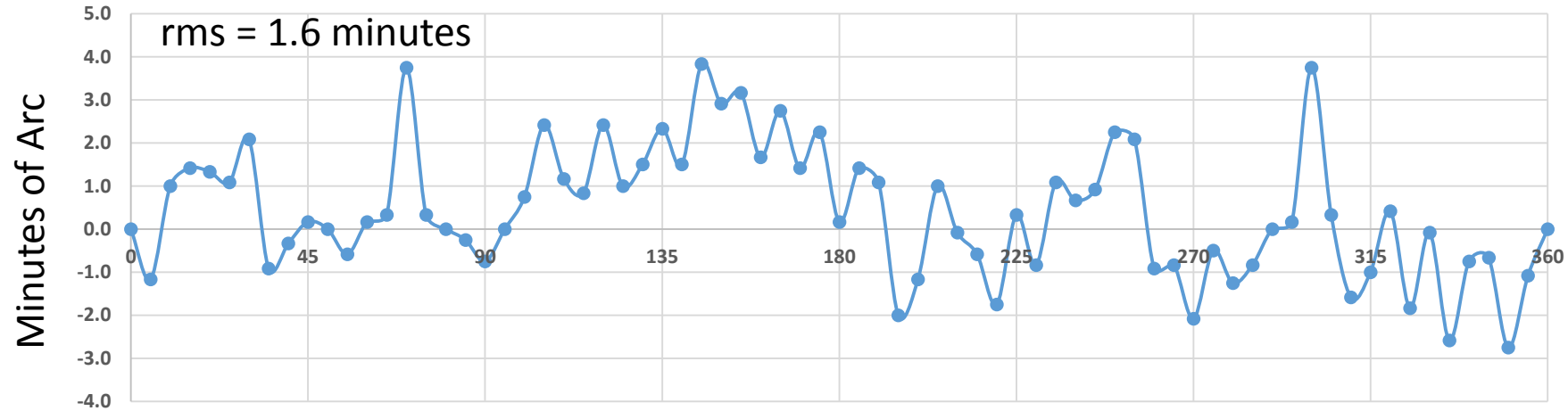


Benjamin Chandlee 0-20 deg

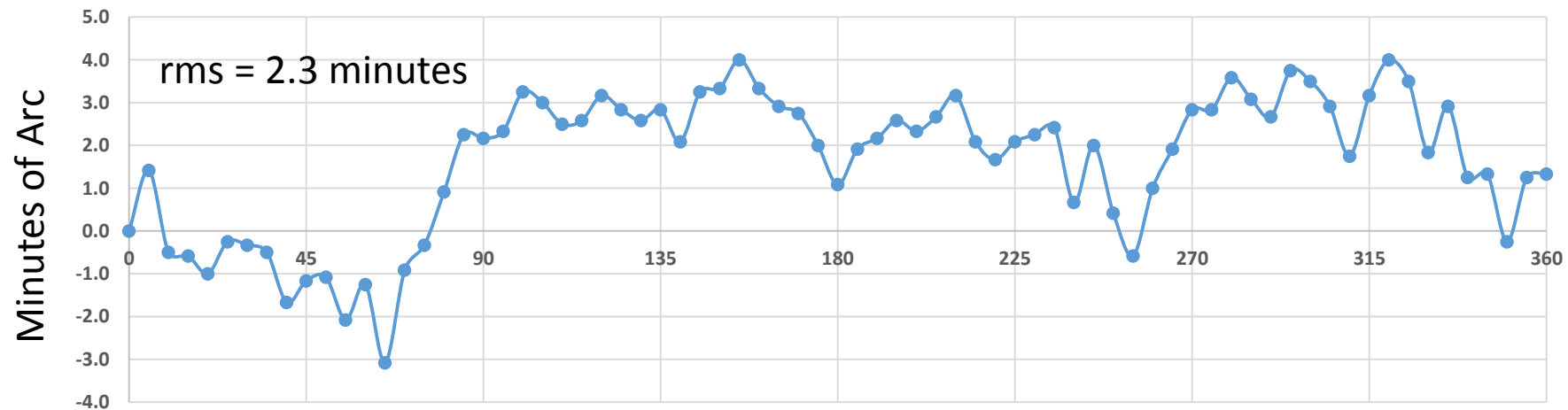


Rittenhouse, Rittenhouse & Potts

Benjamin Rittenhouse

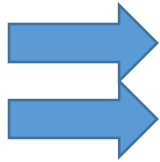


B. Rittenhouse & Potts



Summary of Properties

Compass	Diameter inches	Roundness (Runout)	Line Width Inches	RMS Minutes	Grand RMS (360 deg)
Gurley	5.99	0.0018	0.0027	0.5	
B. Rittenhouse	5.26	0.002		1.6	
Rit. and Potts	5.13	0.0045 inch		2.3	1.8
Potts 1	5.89	0.008 inch	0.0025	1.5	
Potts 2	5.85	0.0025	"	0.7	
Potts 3	5.86	0.0013	"	0.4	0.6
Potts 4	6.02	0.014	"	3.1	
Lewis Michael	5.05	0.0022	0.0035-0.0045	3.2	
G. Chandlee	5.03	0.007		2.4	
B. Chandlee	4.88	0.0075		2.5	
N. Storrs	4.33		0.005-0.007	4.5	
H. Pyefinch	4.40			4.3	
J. Blattner	6.015	0.0085	0.0055	0.7	
G. B. Graves	5.855		0.0025	4.3	



Line Width vs. Angle Subtended

- 6 inch needle ring diameter
- Using $\delta s = r \delta \Theta$
- One minute = 0.00087 inch
- 0.002 inch width = 2.3 minutes of arc
- Degree-to-degree spacing = 0.0522 inch
- Five degree spacing = 0.261 inch

