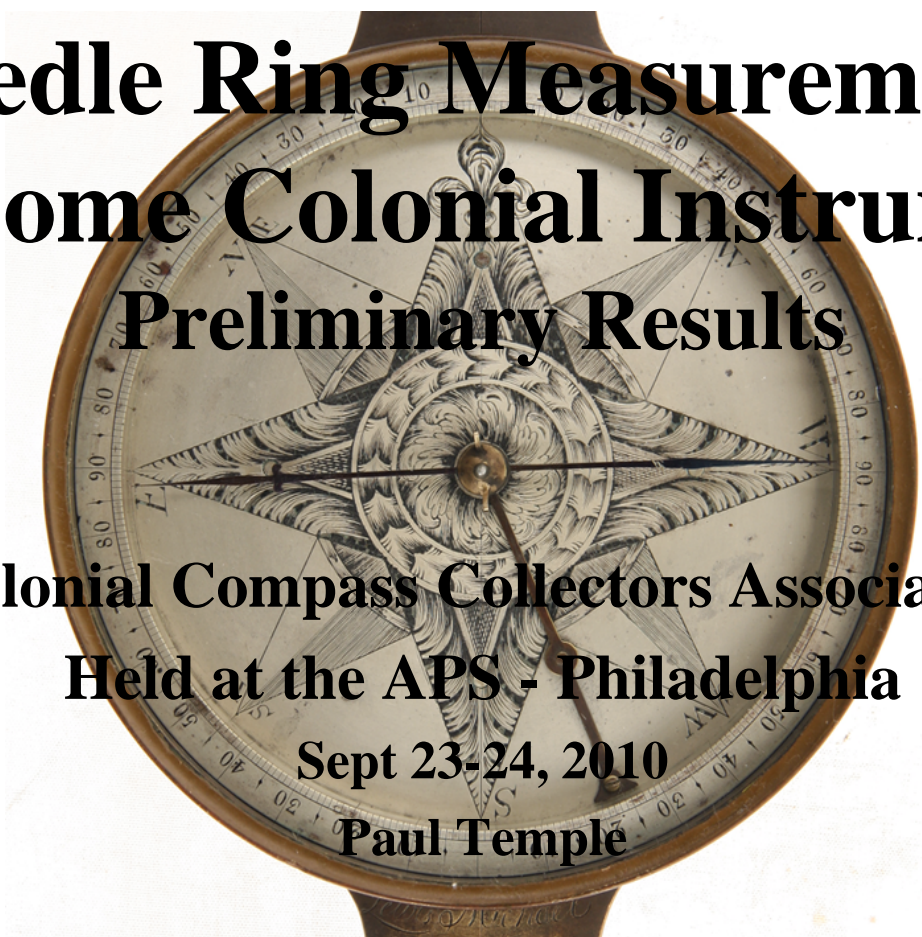

Needle Ring Measurements On Some Colonial Instruments Preliminary Results



**Colonial Compass Collectors Association
Held at the APS - Philadelphia
Sept 23-24, 2010
Paul Temple**

Outline

- ➔ • **Last Year – A Retrospective**
- **Some Questions About Colonial Compasses**
- **Measurement Approach: An $X - Y - \Theta$ Instrument**
- **Dividing Needle Rings In Colonial Instruments – Jeff Lock’s Paper**
- **Lathes and Wheel Cutting Engines – The Essential Part**
- **Several early compasses**
- **Summary**

Requirements

1 Degree
Of Arc

1 Minute
of Arc

1 Second
of Arc

1/10 Second
of Arc

Relative Location

Engineering

- **Property surveys**
 - Semicircumferenter
 - Plane table
 - Plain compass
 - Vernier compass (magnetic variation)
 - Burt's solar compass
- **GLO Cadastral Surveys**
 - 1786 to present
 - Plats showing townships, sections etc. down to 40 acres lots

Absolute Location

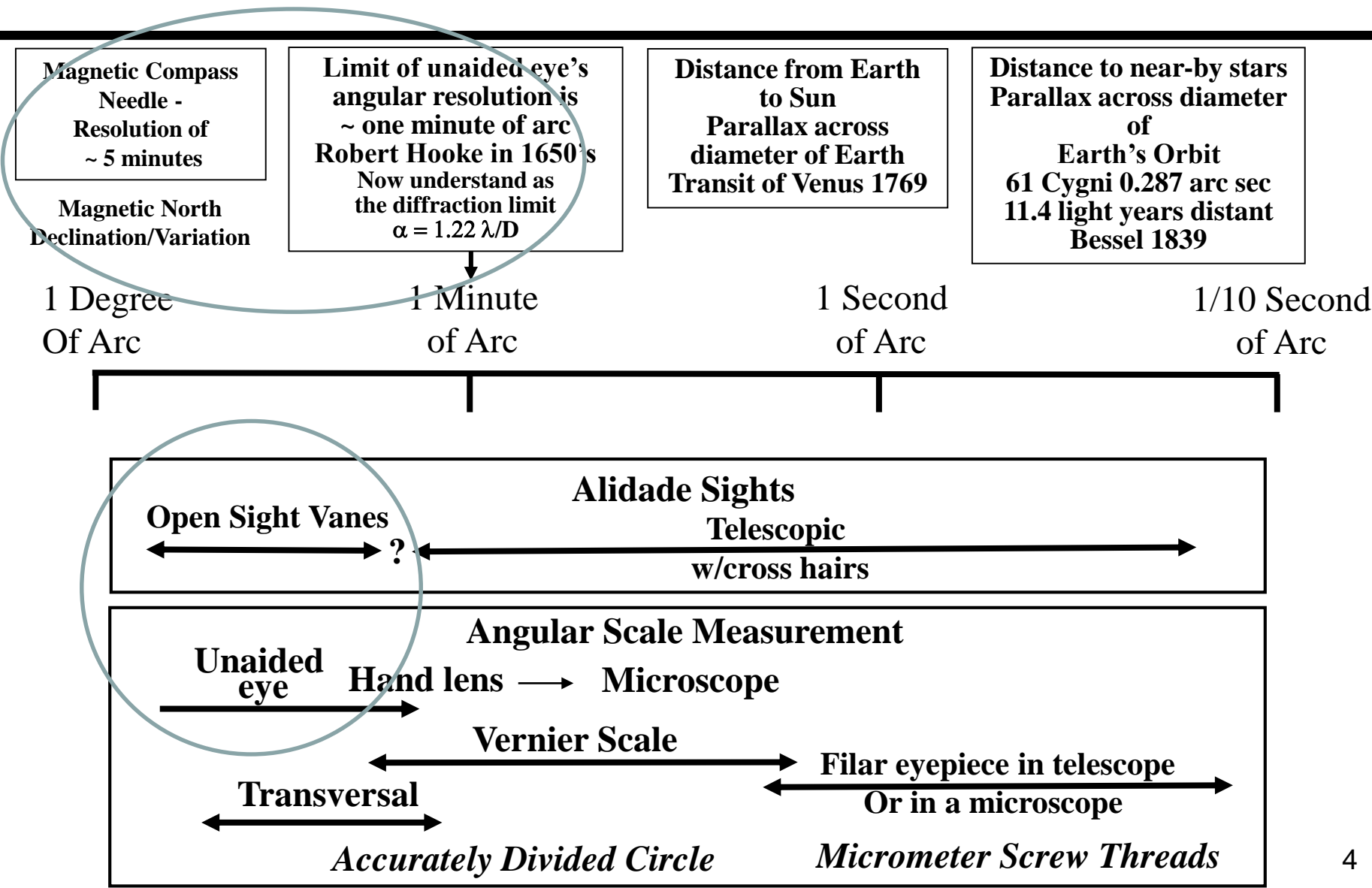
Geodetic Surveys

- **Colony and/or State boundaries**
 - Specified by latitude and longitude
- **Initial points of the rectangular survey system (GLO) - 37**
- **Triangulation**
 - Plane table / alidade (1950's)

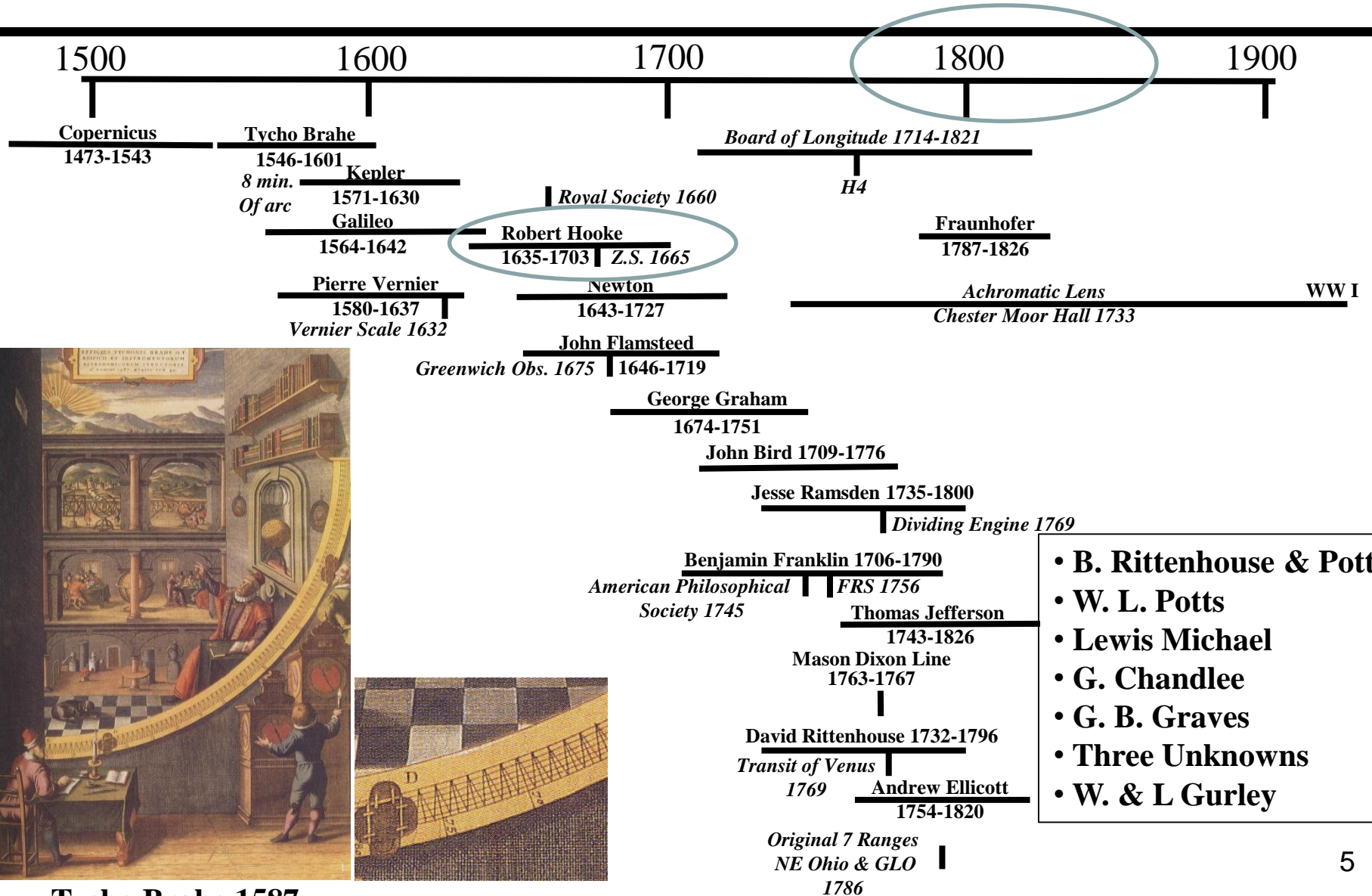
Astronomy

- **Stellar atlas – navigation**
- **Mason & Dixon**
- **Andrew Ellicott**
- **David Rittenhouse**
- **Length of the meter**
- **Shape & motion of the earth**
- **Size of the solar system**
- **Distance to the stars**

Levels Of Angular Measurement Accuracy



Time Lines: European Science and America



Tycho Brahe 1587

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Some Questions – Forensics

- **How accurately placed are the individual needle ring divisions?**
- **What can be learned by measuring line widths?**
- **Can anything be learned about the manufacturing techniques?**
 - **Techniques passed from master to apprentice – “genetic” groups**
- **Is it possible to find any characteristics which could tie instruments together as having been made using a particular piece of equipment (e.g., wheel engine)?**
- **Is there a “signature” left by a particular horological wheel engine or dividing engine?**
 - **E.g., the dividing plate used in locating marks**

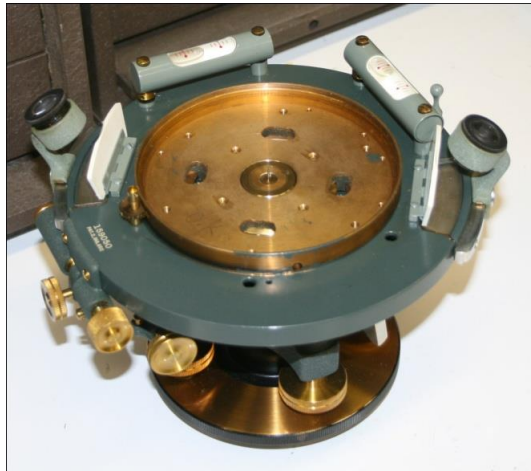
What Features Might be Measured?

- **Line shapes (curved vs. straight), uniformity**
- **Line sequences where they overlap (scribed ring and degree mark)**
- **Line widths (thousandths of an inch) and variation in width**
- **Line positions (deviation from exact location)**
- **Line “Radialness”:** are they aligned with a line drawn from the center of the ring outward?
- **Needle ring circularity**
- **Layout marks**
- **???**

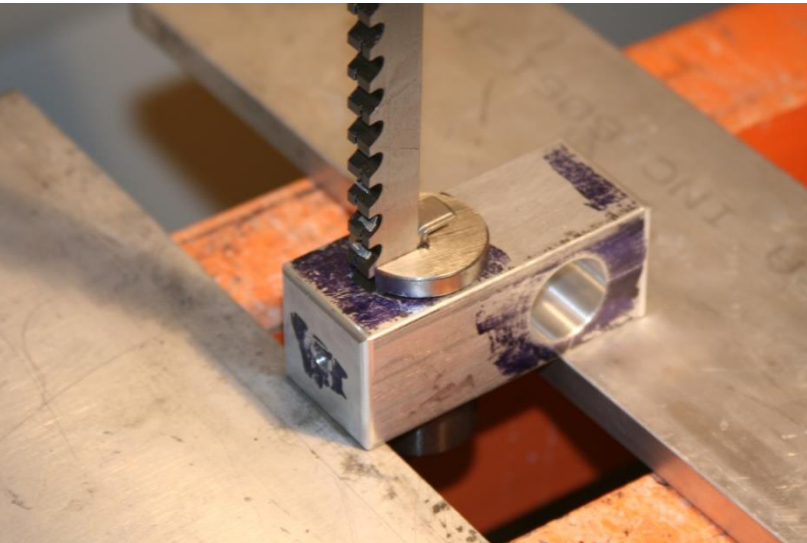
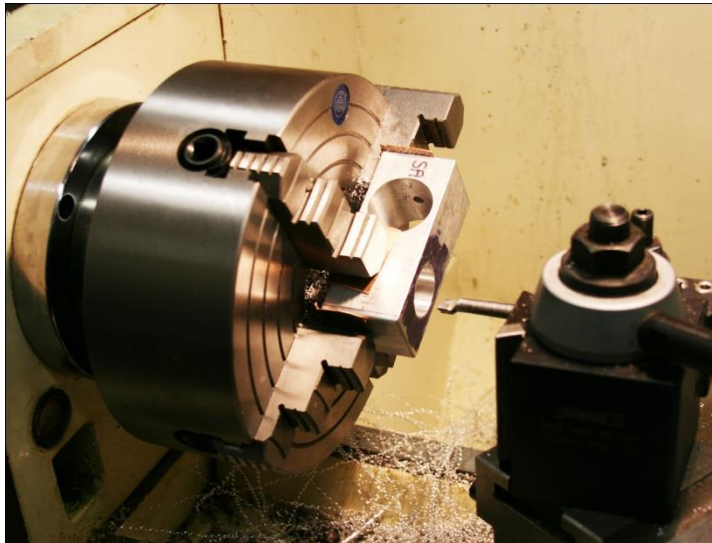
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K & E Basic \odot Unit

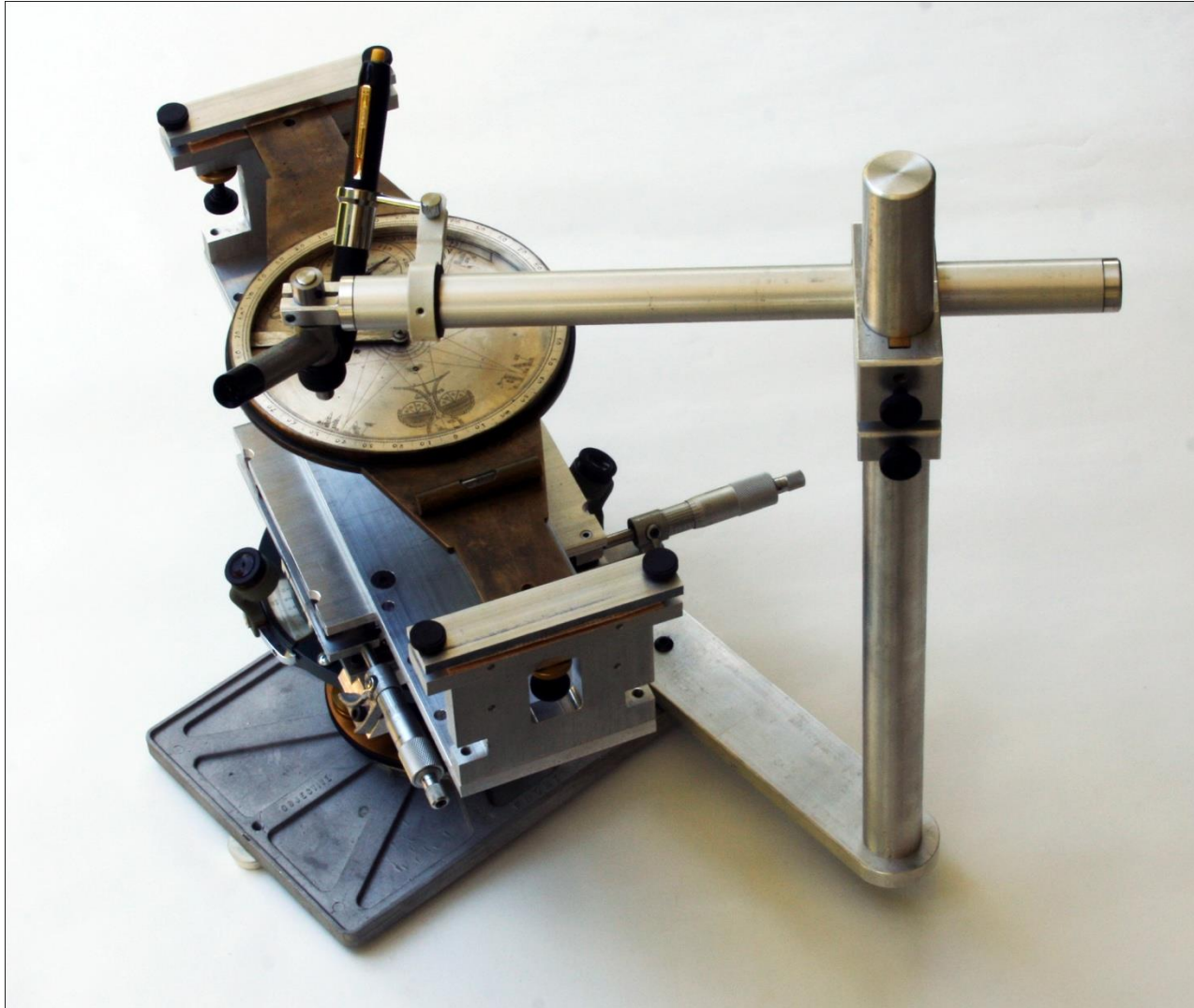


Machining Parts



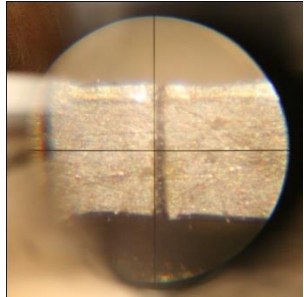
Stress Relief!

X-Y- Θ Instrument

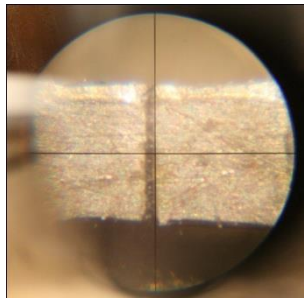


The Measurements

Plot *Line Width* and *Error in Location*



Left Edge

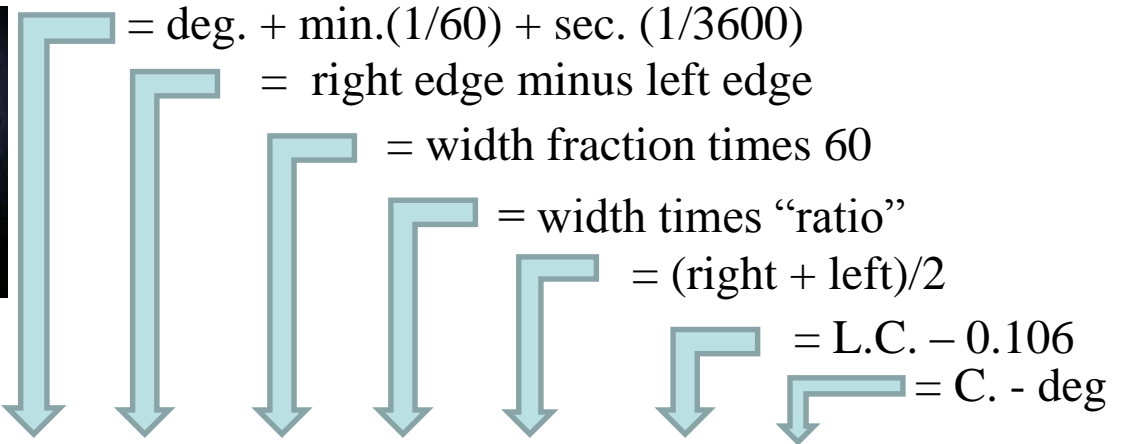


Right Edge

0.080 inch

L. Edge

R. Edge



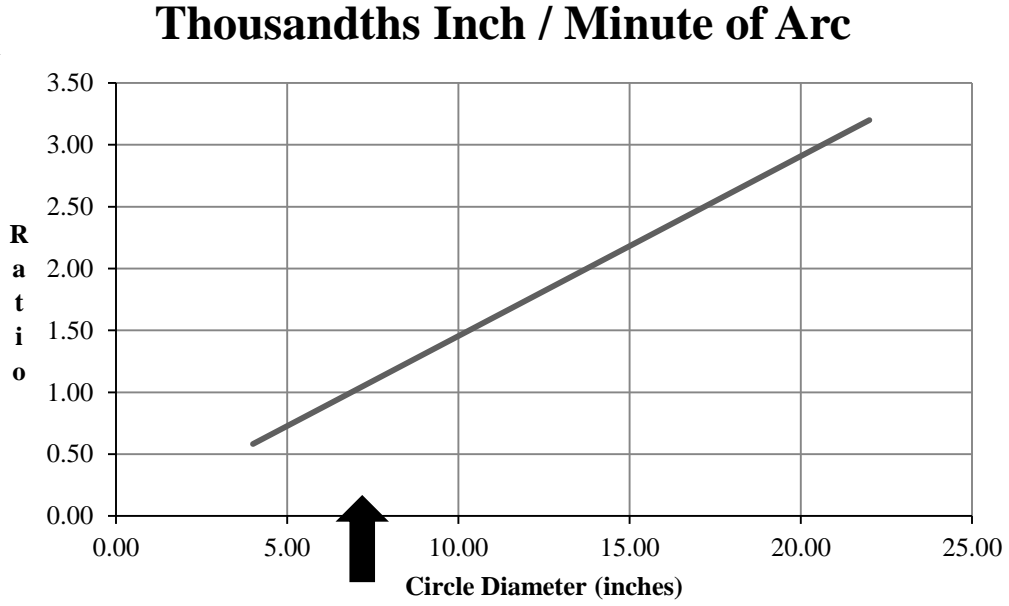
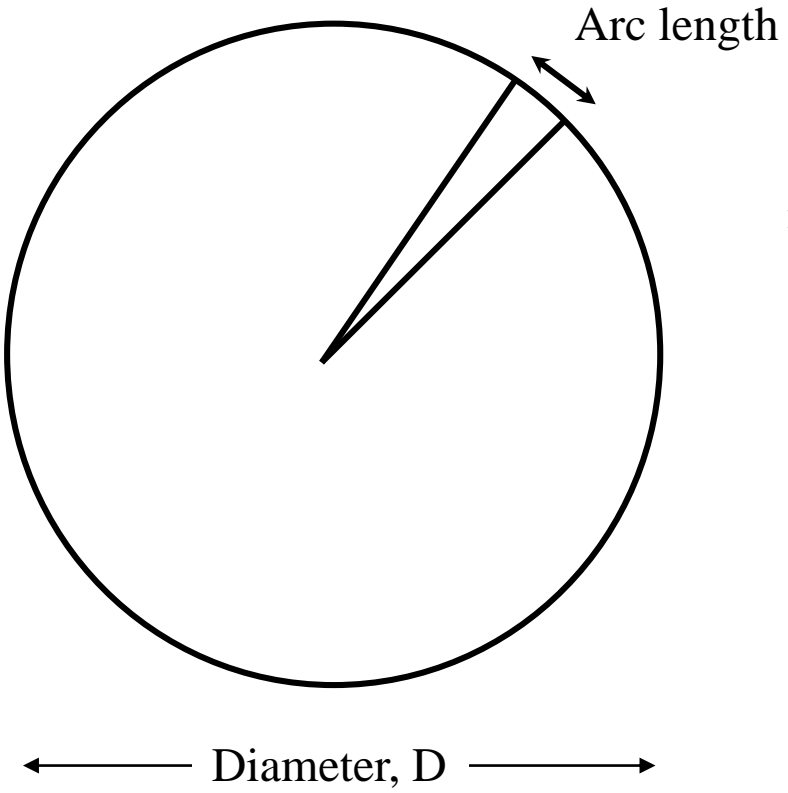
Deg	deg	min	sec	Angle (Fraction)	Line width (fraction)	Line Width (Min)	Line Width (Th. Of inch)	Line Center (fraction)	Corrected to 0 deg center (fraction)	Delta from exact (fraction)	Delta from exact (min)
Lewis Michael											
0	0	4	0	0.067							
	0	8	40	0.144	0.078	4.7	3.4	0.106	0.000	0.000	0.0
1	1	4	40	1.078							
	1	9	20	1.156	0.078	4.7	3.9	1.117	1.011	0.011	0.6
2	2	3	20	2.056							
	2	7	50	2.131	0.075	4.5	3.8	2.093	1.987	-0.013	-0.8

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How Angles Translate To Distance

Ratio Depends Upon Diameter



21,600 minutes in a Circle: $360 \times 60 = 21,600$
21.600" is circumference of 6.87" Diameter
circle 21,600 thousandths of an inch

Placement accuracy of ~1 one-thousandth of an inch to maintain ~1 minute of arc accuracy

Minute of Arc

- **Precision of typical “mechanical “ transits (read with Vernier scale)**
 - **K & E used for these measurements graduated to 1/3 minute (20 seconds of arc)**
- **Needle instruments are considered to be “readable” to ~5 minutes of arc (1/12th degree)**
- **1 minute of arc is 1 inch at 100 yards**
- **Resolving power of the unaided eye is about 1 minute of arc**
 - **Two points of light (e.g. stars) are seen as two if they are no closer than 1 minute of arc**
 - **Hooke determined this by experiment (using black and white squares) in 1600’s**

Ways Of Dividing A Circle

- **Primary Dividing:** Using geometry, geometrical relations, dividers and linear rules to locate each degree mark by bisection, trisection, etc.
 - Each circle is unique
 - Chapman's book, "Dividing The Circle" goes into great detail on techniques used, in particular on dividing large quadrants
 - Great skill and artistry needed to execute a precise scale
- **Machine Dividing:** Precision spur gear and tangent screw - Ramsden
 - Less skill needed to produce circles /faster / attained great precision
- **Replication Dividing:** Using a previously divided "template" to replicate subsequent arcs or circles
 - Replicated circles will likely replicate irregularities in the template
 - Accuracy of the replicated scale depends on *quality of the template* and the *skill* of the worker - poor skill may mask template properties
 - Jeff's 2004 paper on dividing needle rings assumes replication

Colonial Clock / Compass Makers

Some were skilled machinists and artisan clockmakers

- They used “clock engines” or “wheel cutting engines”
- Had some form of lathe – prepare gear blanks
- Quite capable of making their own equipment – part of an apprenticeship

Two important steps in any compass needle ring

- Locate the degree position
- Engrave the line

Similar steps in wheel cutting

- Locate the tooth position
- Cut the (space between) teeth

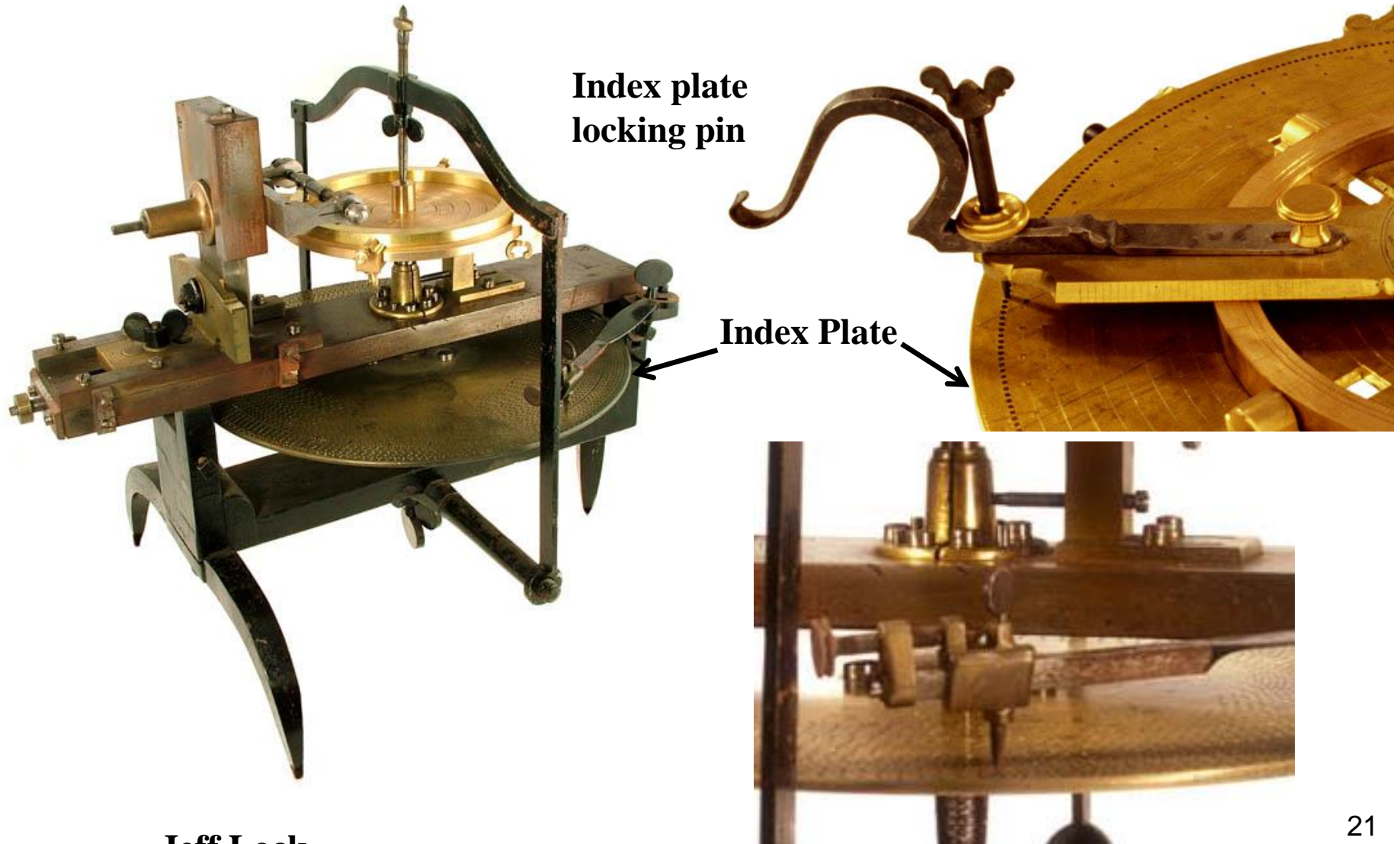
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Wheel Cutting Engines

- **Nearly all contained a template which was used to locate teeth**
- **Index Plates have series of holes for different numbers of teeth**
 - **Either made by the clockmaker or purchased**
 - **At some point, a primary dividing technique has to have been employed to make a master Index Plate**
 - **Crom, in his *“Horological Wheel Cutting Engines 1700 to 1900”* does not speak to the technique used to create index plates**
 - **Minute of arc accuracy not necessary for clock gears**
- **By making two Index Plates simultaneously one suspects one could likely iterate and average errors to improve the accuracy...**
 - **They can be drilled and then rotated and positions compared and averaged**
 - **They can be flipped over and compared**
 - **Need to think about this a little more to be sure**

Setting Angle by an Index Wheel



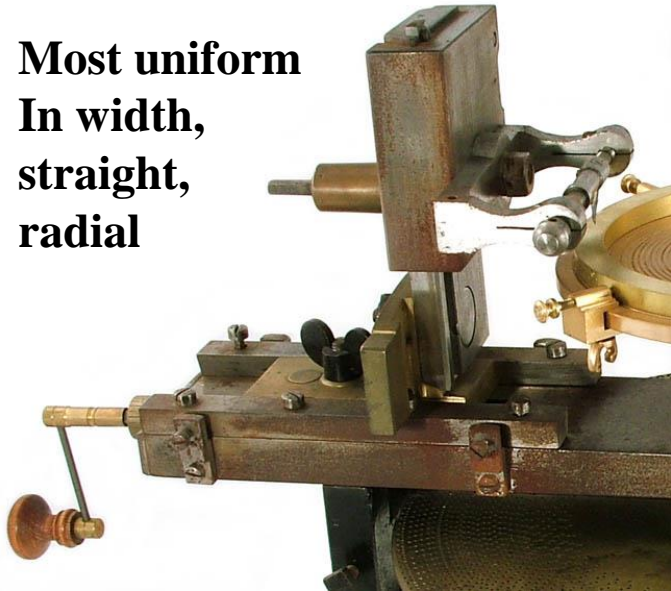
Jeff Lock

Single Purpose Dividing Engine



Scribing The Degree Lines

**Most uniform
In width,
straight,
radial**



**Straight,
radial**

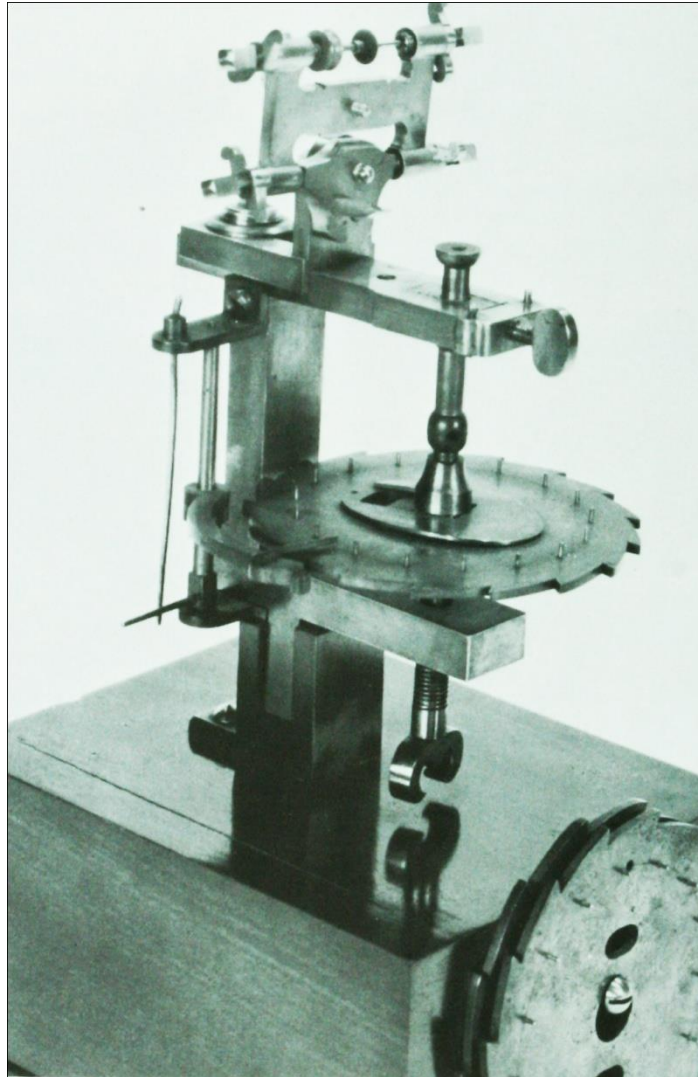


Jeff Lock

**Curved, not necessarily
Radial, not uniform depth**

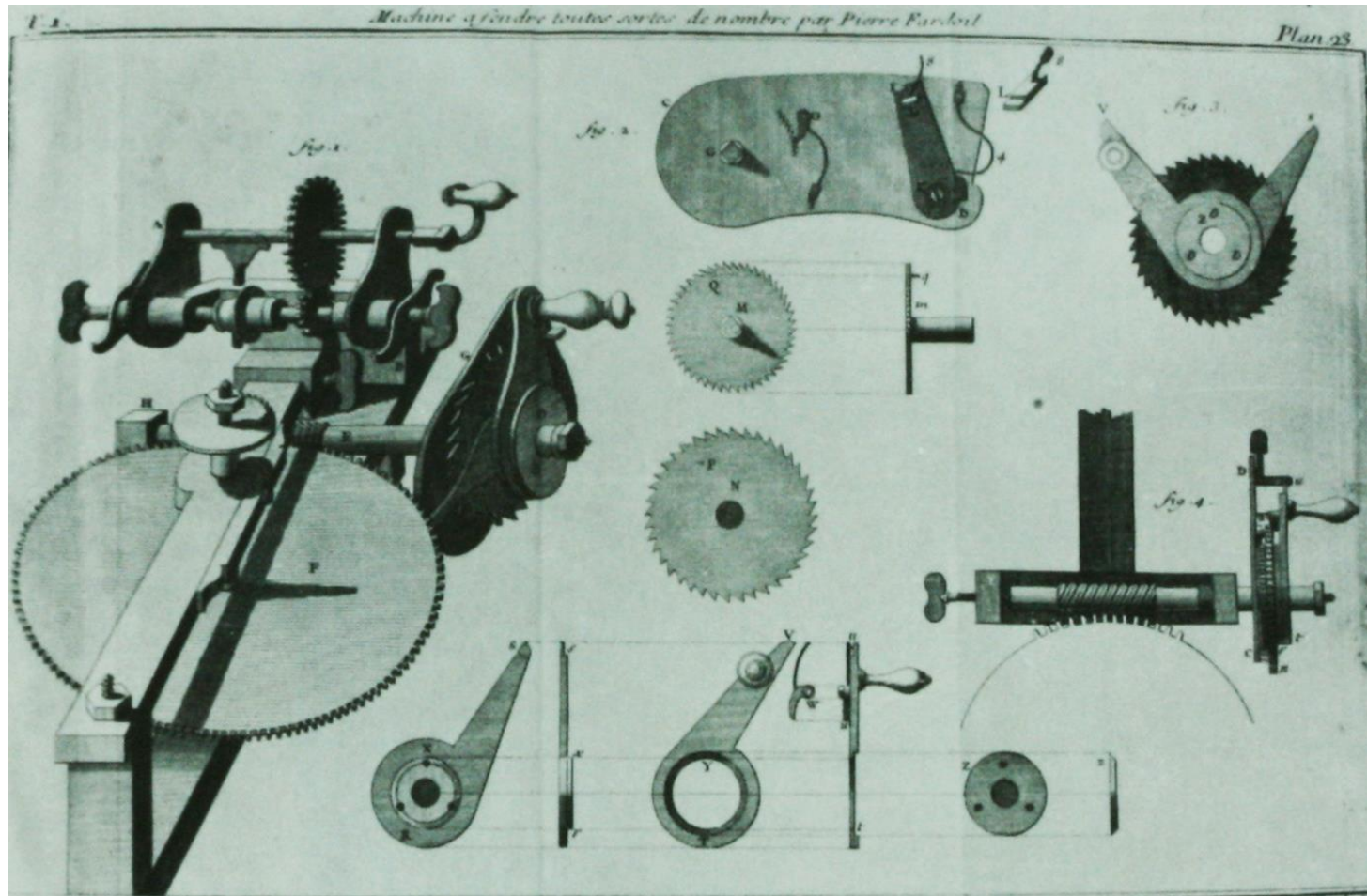


18th Cent. Latch Plate Indexing



Crom

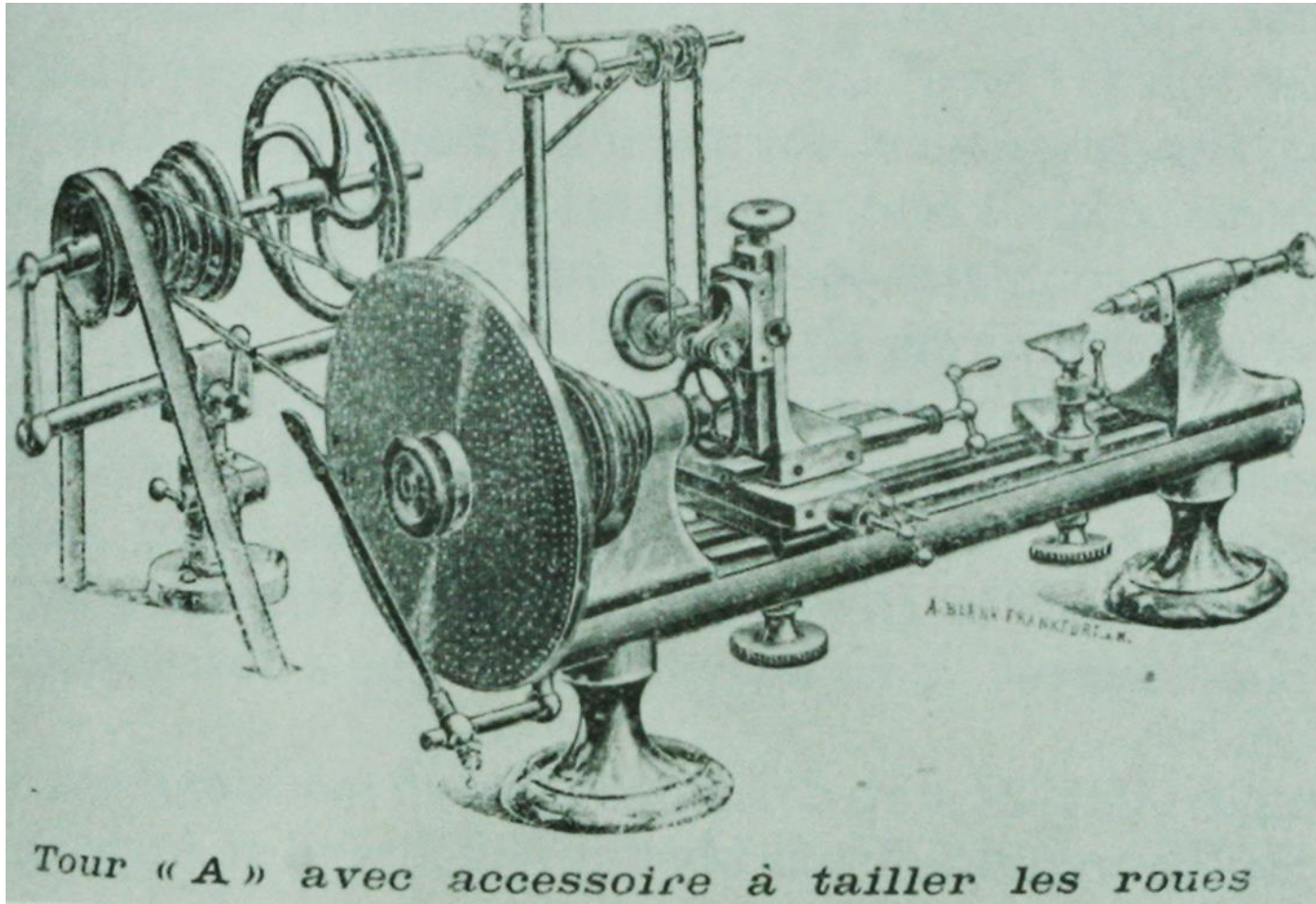
Early Spur Gear Divider



Crom

17th Century

Lathe Attachment



Drum Index Method

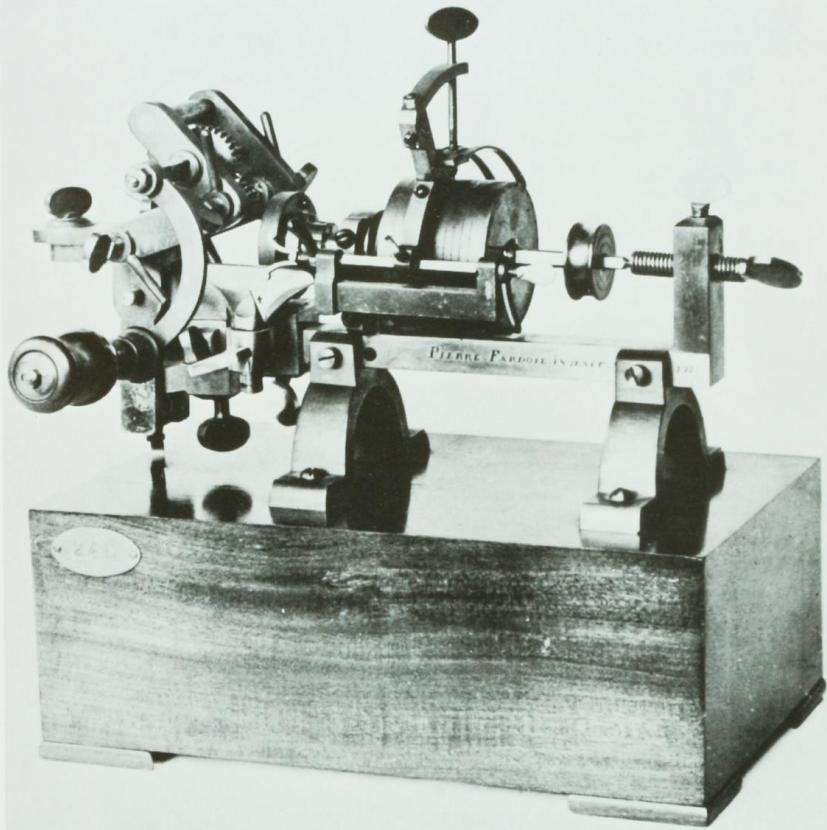


FIGURE 13

Crom

A method for making an index plate is described, where a tape of evenly spaced holes is wrapped (and re-wrapped) around a wooden drum turned to successively smaller diameters, each time drilling a set of holes in a plate attached to the face of the wooden drum. The drum diameter is carefully adjusted each time to cause the holes to line up (overlap) for each successive set of (ever fewer) holes.*

*** A method used by Hindley (~1740's), described by Randall Brooks, page 5, in Duc da Chaulnes' "A New Method of Division for Mathematical and Astronomical Instruments" , Classical Science Press 2009**

Index Plate and Spur Gear Variants

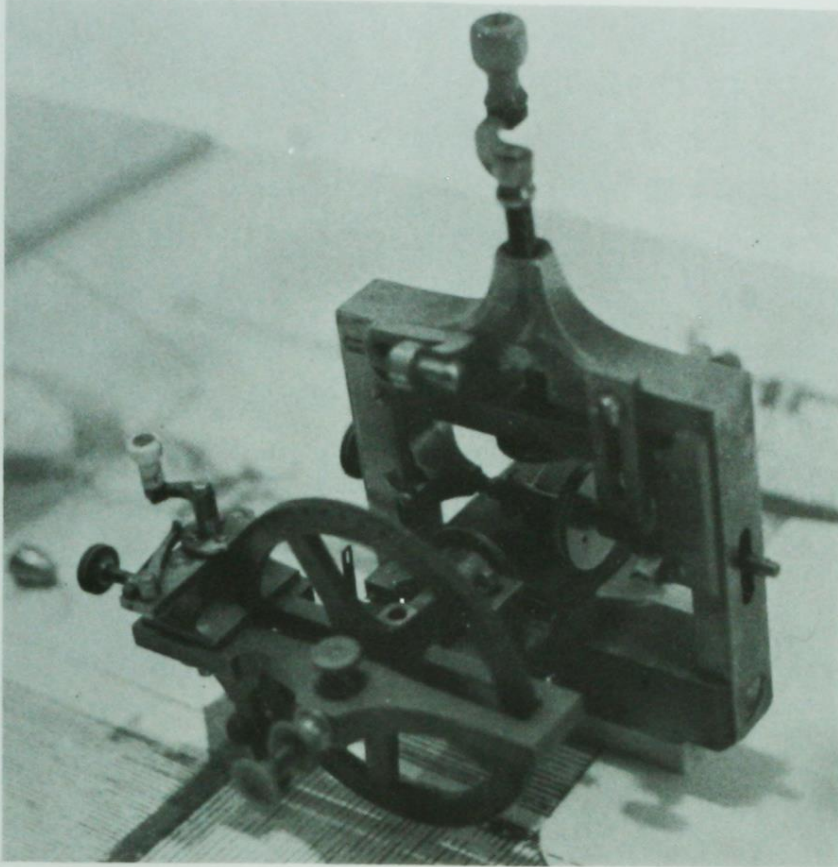


FIGURE 63

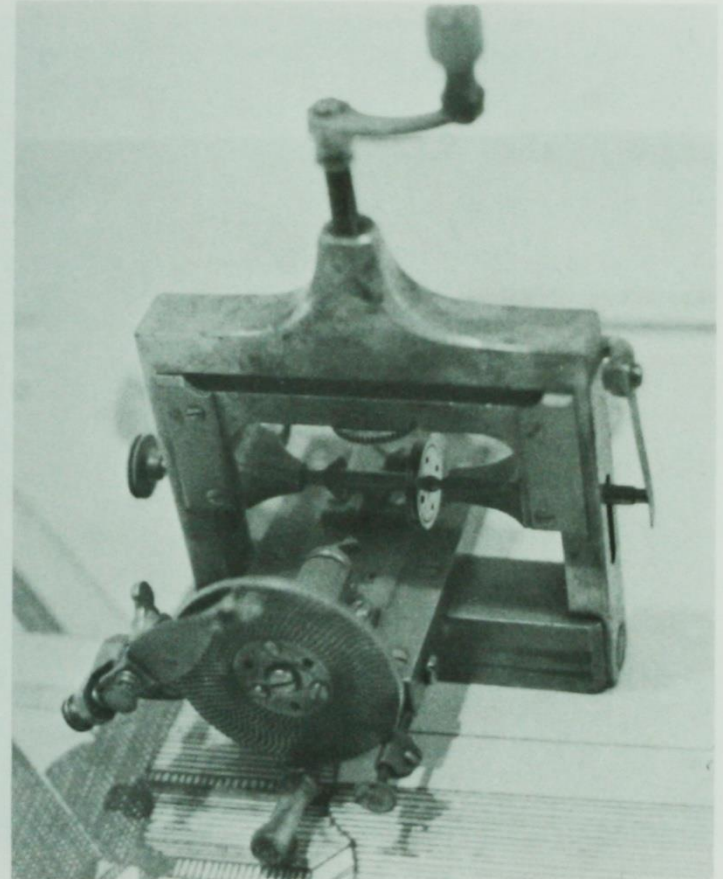
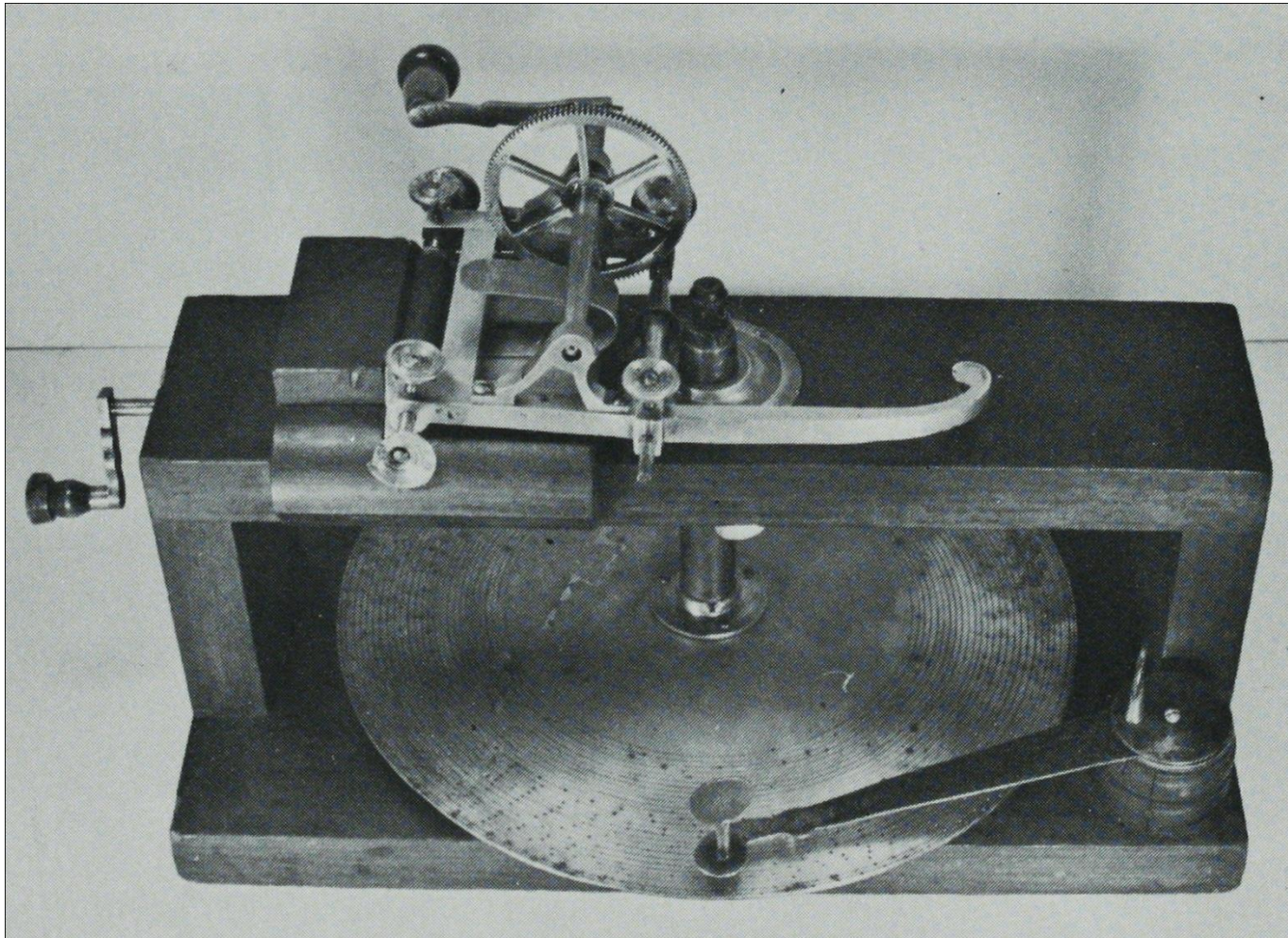


FIGURE 64

Early American Wheel Cutting Engine



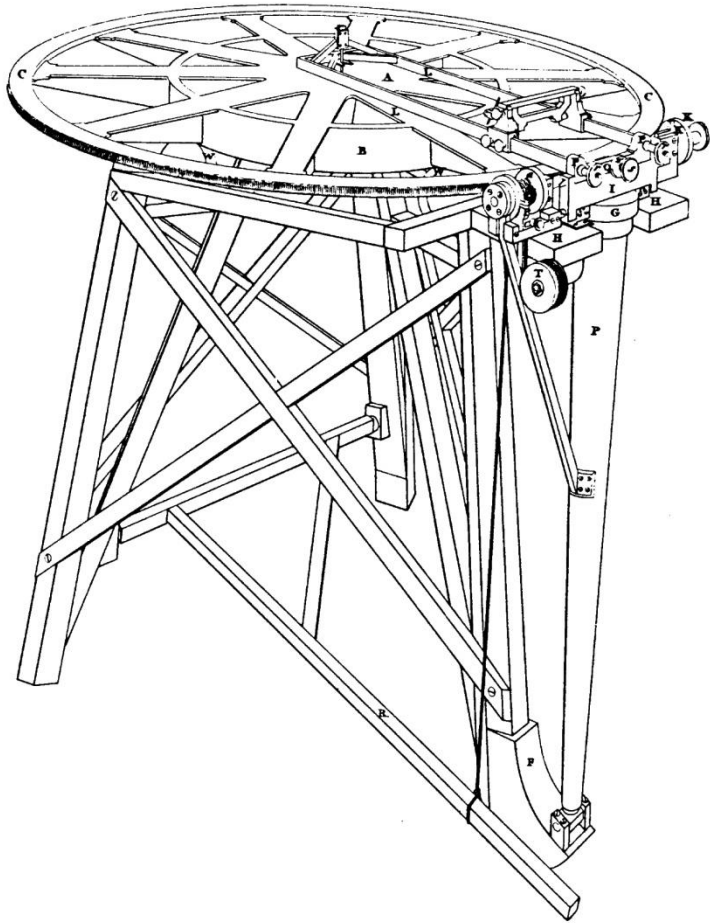
Crom

Dividing Engines

- **Jesse Ramsden (1767), Duc de Chaulnes, Hindley**
- **Enabled less skilled laborers to produce scales**
 - **Smaller sextants, etc.**

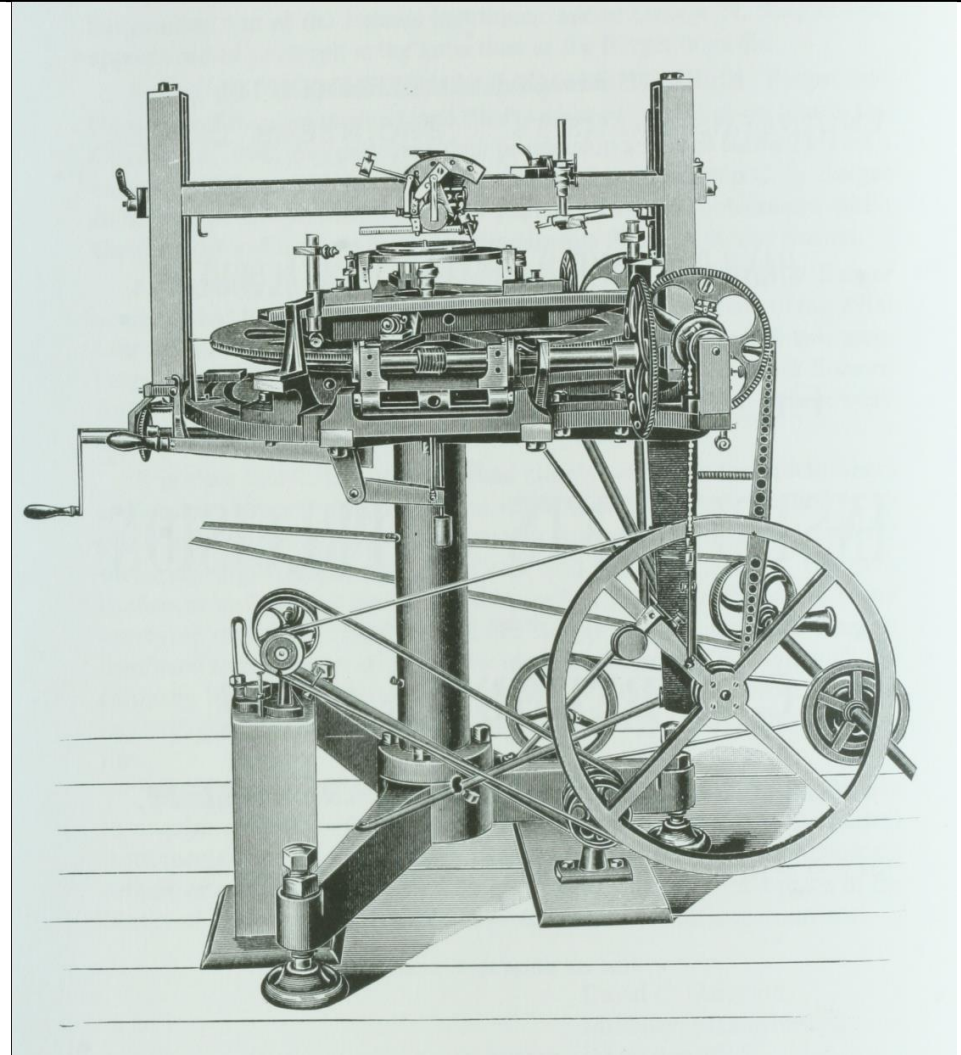
- **American usage began in the 1820's**
 - **Hanks Troy 1826**
 - **William Young (Philadelphia) 1820's**
 - **Some owners divided scales for other makers (Potts? - No)**
- **Used into the 2nd half of the 20th century**
- **Gurley claimed one millionth inch accuracy ~1970**

Ramsden Type Dividing Engine



Ramsden "hand machine"

Chapman



Berger & Sons Automatic Engine

Berger & Sons

Gurley Dividing Engines

Fauth & Co. ²²	Large engine. This was later owned by G.N. Saegmuller, by Bausch, Lomb & Saegmuller, and by Bausch & Lomb.	G.N. Saegmuller	< 1885
Fauth & Co. ²³	Small. Later owned by Bausch & Lomb.	G.N. Saegmuller	< 1892
W.&L.E. Gurley ²⁴	Hand machine	W.H.	1867
W.&L.E. Gurley	Hand machine	G.N.T.	1868
W.&L.E. Gurley	Power feed, half automatic. This was later owned by Warren-Knight. R.C. Miller purchased it in 1991.		1880
W.&L.E. Gurley	Upcutting automatic		1881
W.&L.E. Gurley	"general automatic" later owned by Warren-Knight, and by R.C. Miller.		1882
W.&L.E. Gurley	Large automatic	E.W. Arms	1883
Heller & Brightly ²⁵	"graduating engine" later owned by George Kegelman, and by R.C. Miller.	C. Brightly	1870
Horatio Hanks ²⁶	"three feet radius, on Troughton's plan of his own make"	H. Hanks	1826
Keuffel & Esser ²⁷	not named, but implied		ca. 1885
Knox & Shain ²⁸	Ramsden's second engine with plate of 45 inches diameter. It came to Knox & Shain in the 1850s after having been owned by Matthew Berge (1800) and Nathaniel Worthington (1821). It is now in the National Museum of American History.	J. Ramsden	1775
A. Lietz ²⁹	not named, but implied		< 1890
Mahn & Co. ³⁰	not named, but implied		< 1893

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Time Lines

1725 1750 1775 1800 1825 1850 1875

David Rittenhouse (1732-1796)

Benjamin Rittenhouse (1740-1825)

B. Rittenhouse bankrupt (1802)

Lewis Michael (~1765-1840's?)

William Lukens Potts (1771-1854)

Apprentice to B.R. (1785)

Goldsmith Chandlee (1751-1821)

G.C. Moved to VA (1775)

Benjamin Chandlee III (1780-1822)

George B. Graves (1792-1873)

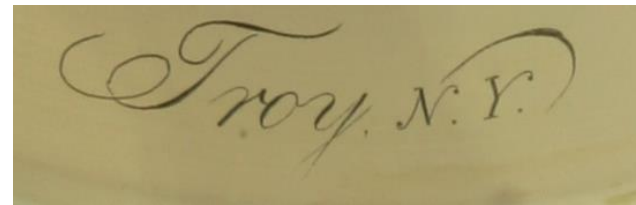
W. & L Gurley (Myron King)

Gurley Vernier Compass

1867-1875*



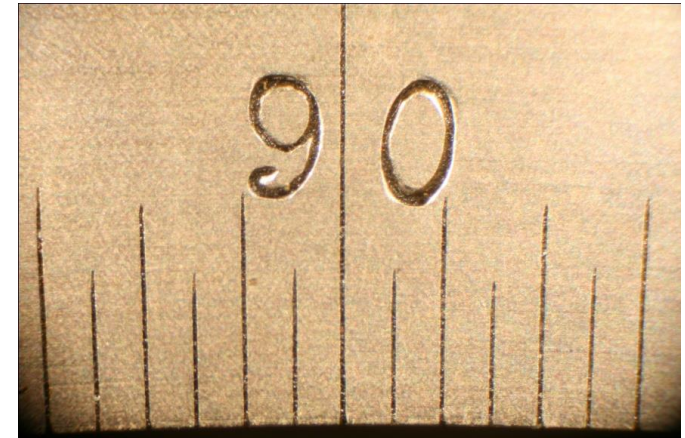
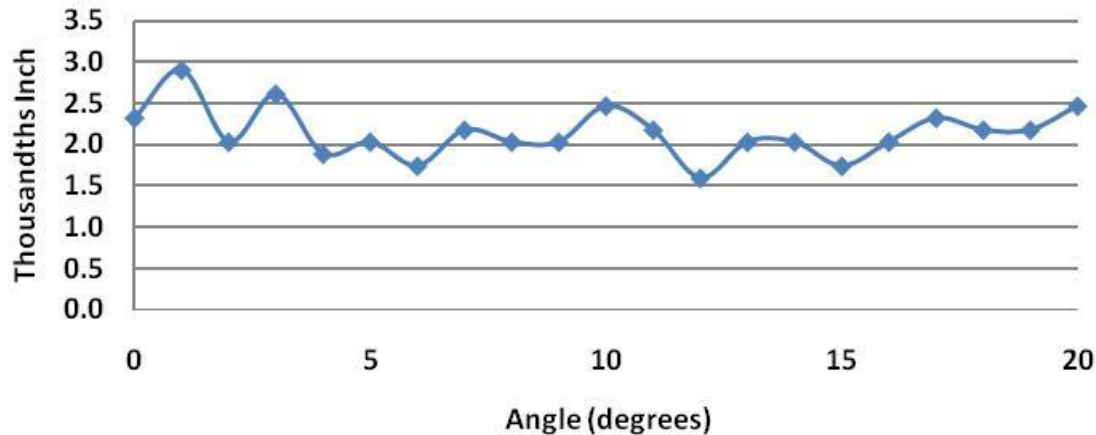
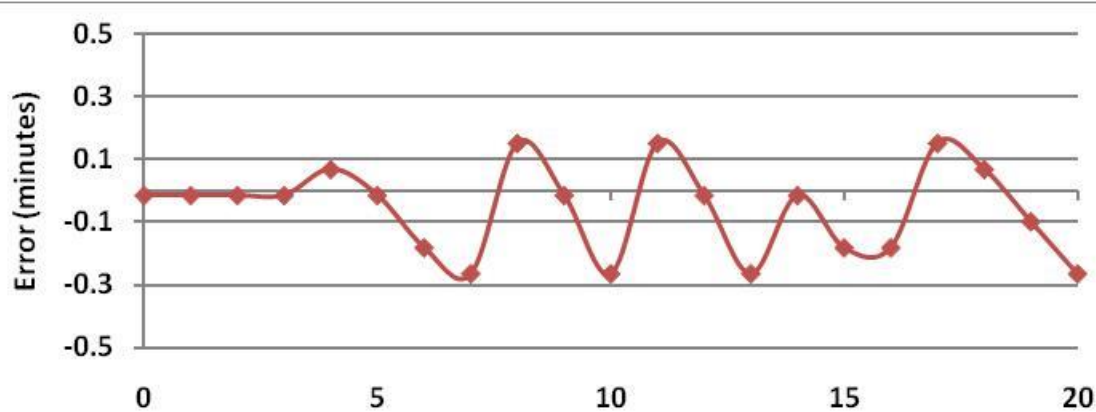
- 7" diameter
- 5-7/8" needle
- 1 minute reverse reading Vernier
- Machine divided using Gurley's "hand machine"
- Use data here to show X-Y- \odot capability and as a baseline – sharp degree line engraving



Typical Myron King hand engraving

*Myron King left Gurley 1875, first Gurley "hand machine" dividing engine finished 1867

W. & L. Gurley Vernier Compass



- Note unequal line lengths, no circle to mark end of lines
- Representative of an early machine divided compass
- Error of $X - Y - \theta$ about 0.15 minute (10 seconds) so oscillation *probably* is real

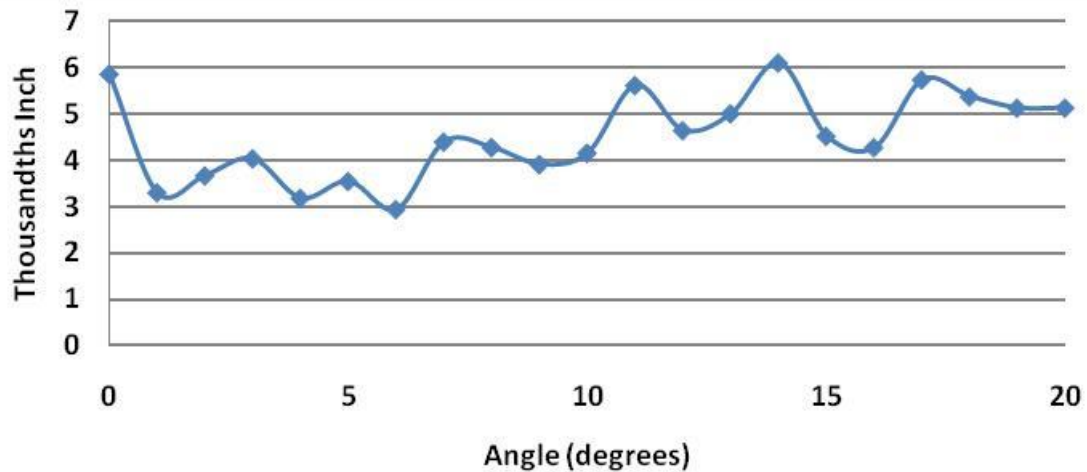
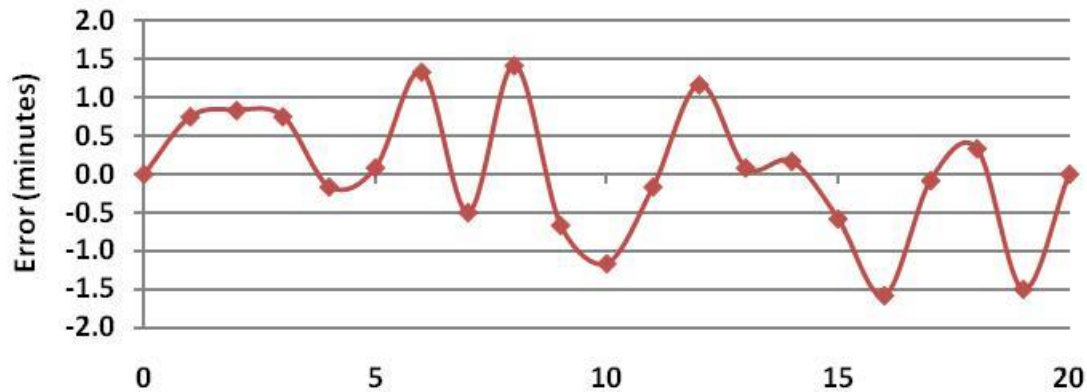
Note: Vertical scales different for each maker

Goldsmith Chandlee (1751-1821)



- Plain Compass, 6” dia, 5” needle
- Moved to Winchester, VA ~1775
- Graves and Benjamin III were apprenticed to Goldsmith
- Unique style outkeeper , L-T scale on alidade, stippled engraving
- Customer identified on face of compass on some compasses
- “Six Quaker Clockmakers” lists items sold at Chandlee’s estate sale in 1821 – Graves and Benjamin (son) purchases

Goldsmith Chandlee



- **Dot at East and West positions**
- **No other layout marks**

Note: Vertical scales different for each maker

George B. Graves (1792-1873)

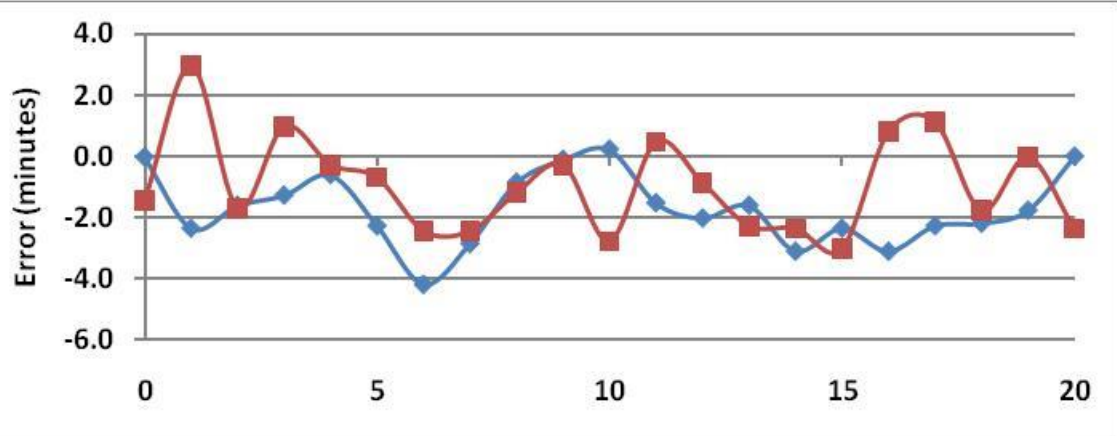


- Plane compass
- 7 ¼” diameter
- 5 ¾” needle length
- Compass is labeled Winchester, VA
- Graves was trained by Goldsmith Chandlee and purchased many of Chandlee’s tools at his estate auction, including *small dividing engine* and *graduating engine and appt.*
- Graves was 29 years old at the time
- Benjamin Chandlee was 41 years old and lived only one year more

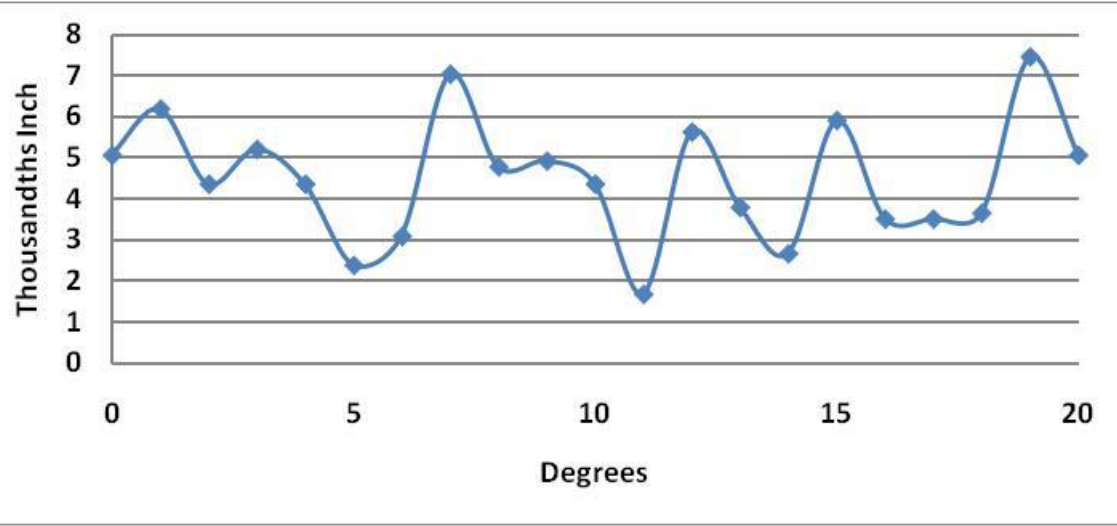
Goldsmith Chandlee's Estate Sale - 1821

	Benj. Chandlee.	Clock engine.	54.00
	do	one round horn Stake.	2.75
→	George Graves.	Graduating engine & appt.	25.00
→	George Graves.	Small dividing engine.	5.00
	Benj. Chandlee	pair button models.	.65
→	George Graves.	1 pair dividers.	.51
	H. Beatty.	1 " "	.41
→	George Graves.	6 " "	1.50
	George Sharp.	3 " "	.82
	James Roper.	2 " "	.76
	Daniel Hartman	1 " "	.50
	Ely Beal.	1 " "	.50
	Moses Walton	1 " "	.26
	I. Bryarly	2 " "	.52
	George Sharp.	1 " "	.50
	Moses Walton	2 " "	.32

George B. Graves (1792-1873)



*



- Dot at East and West position, just as with Chandlee
- Few thousandths out of round

Note: Vertical scales different for each maker

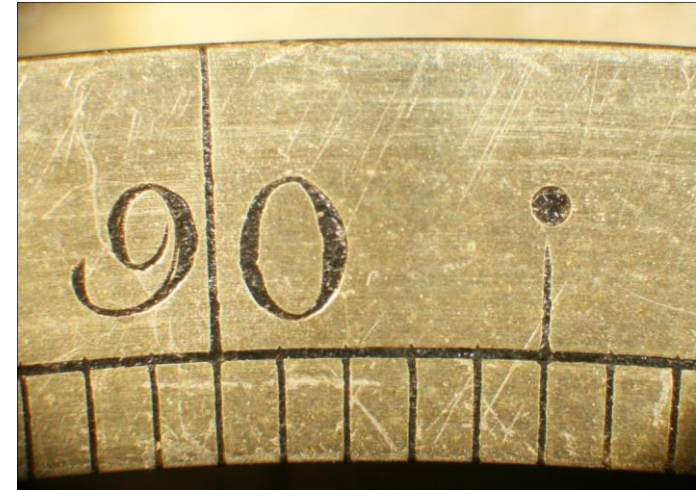
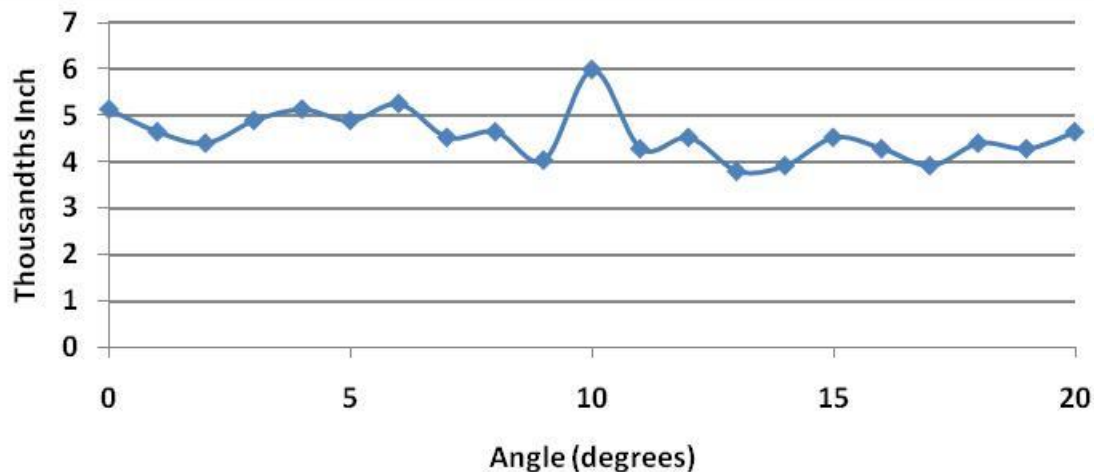
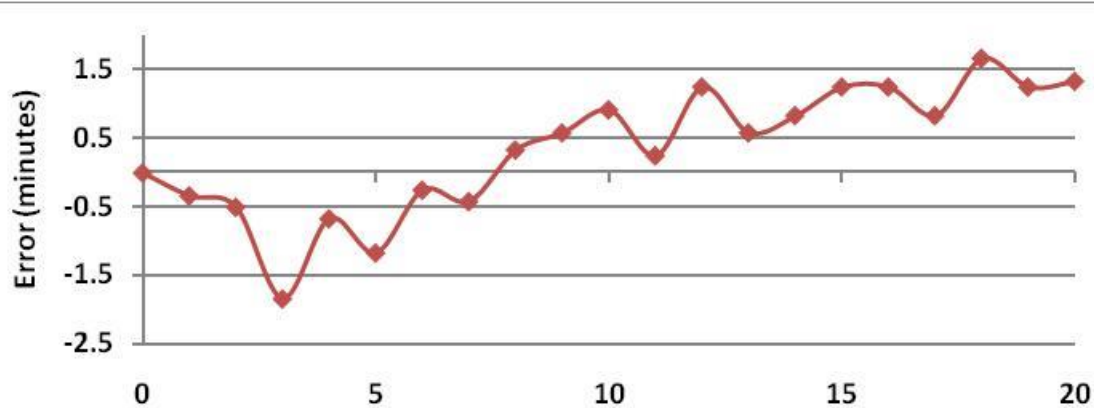
* Red trace: degree measurements and blue trace: half-degree measurements

Benjamin Rittenhouse and Potts



- Vernier Compass
- 6" diameter
- 5" needle
- 5 minute reverse reading
folded Vernier
- Potts was apprenticed to
Rittenhouse
- Rittenhouse went bankrupt
in 1802

Benjamin Rittenhouse and Potts



- **Round punch marks every 5 degrees placed AFTER demarcation circle was scribed**
- **Note *slope* of error**
- **May be some “non-radial-ness” to the lines – needs further study**

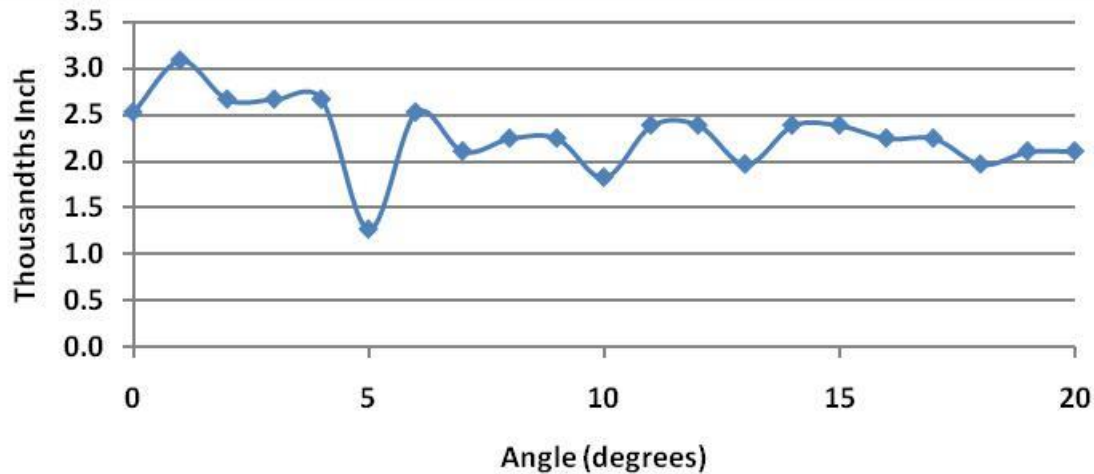
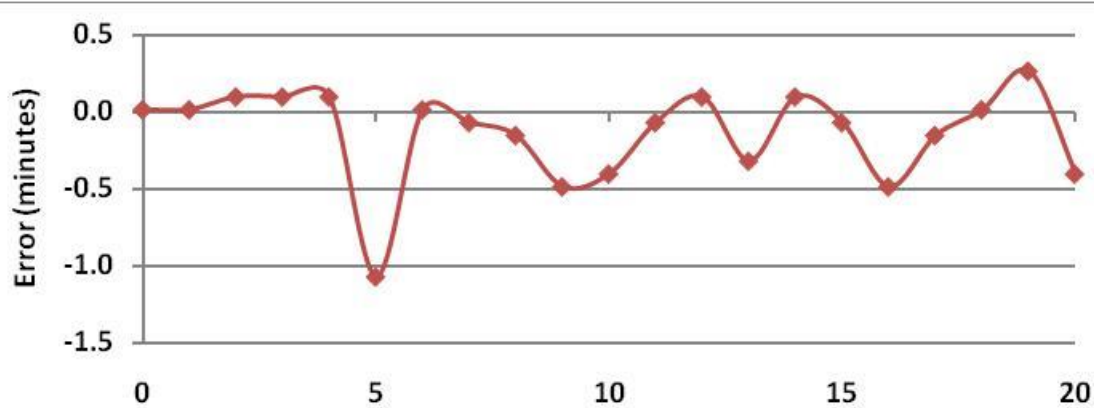
Note: Vertical scales different for each maker

William Lukens Potts (1771-1854)



- Vernier compass
- 6 ³/₄" diameter
- 5 ³/₄ needle
- 5 minute reverse reading
folded Vernier
- Potts was apprentice to
Benjamin Rittenhouse

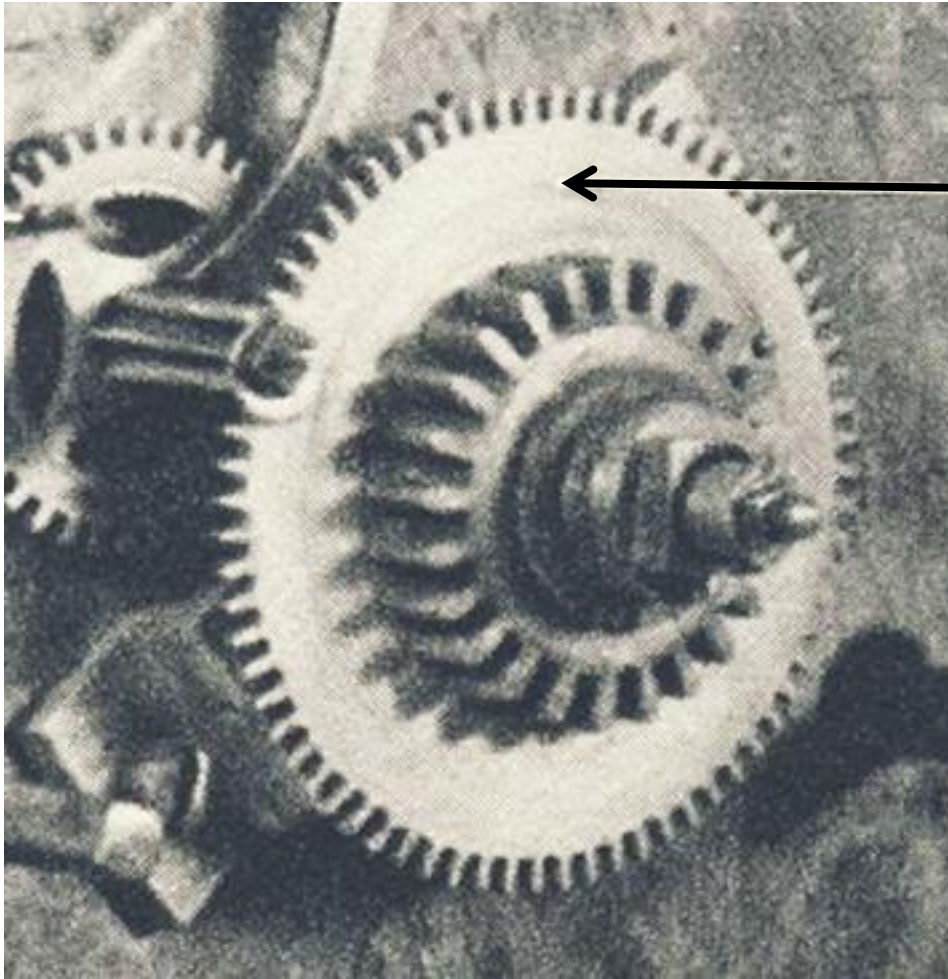
William Lukens Potts (1771-1854)



- Square punch marks every 5 degrees placed after demarcation circle was engraved
- ~ Dividing engine accuracy but layout marks preclude this method

Note: Vertical scales different for each maker

B. Chandlee Jr. Clock Hour Wheel



Hour Wheel

72 teeth (every 5 degrees)

- **Typical wheel cutting engine would be able to cut 72 teeth**
- **Appears as though Potts (B. Rittenhouse?) used a wheel cutting engine to mark every 5 degrees and then used another means to subdivide into degrees**
- **Maybe he didn't have 360 degree index plate?**

Lewis Michael Plane Compass



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

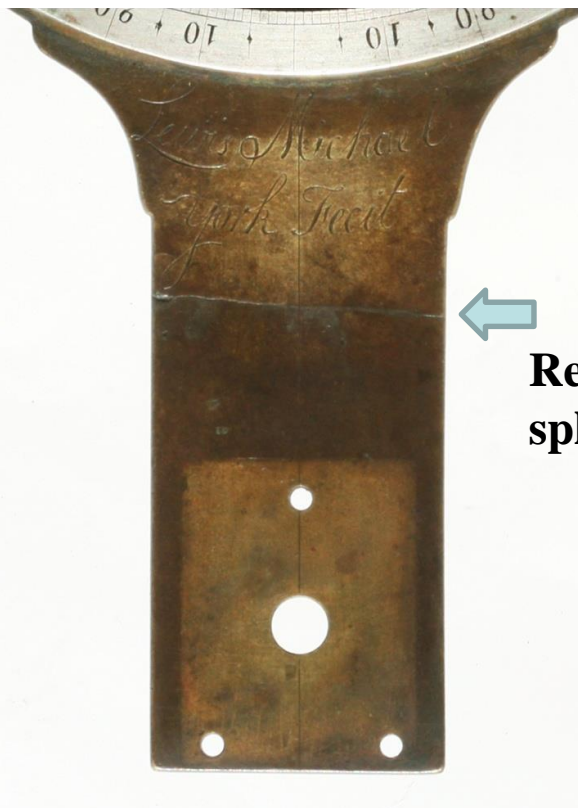


Lewis Michael Plane Compass

- 6” Diameter
- 5” needle
- Benjamin Rittenhouse’s first “apprentice”



Lewis Michael Plain Compass



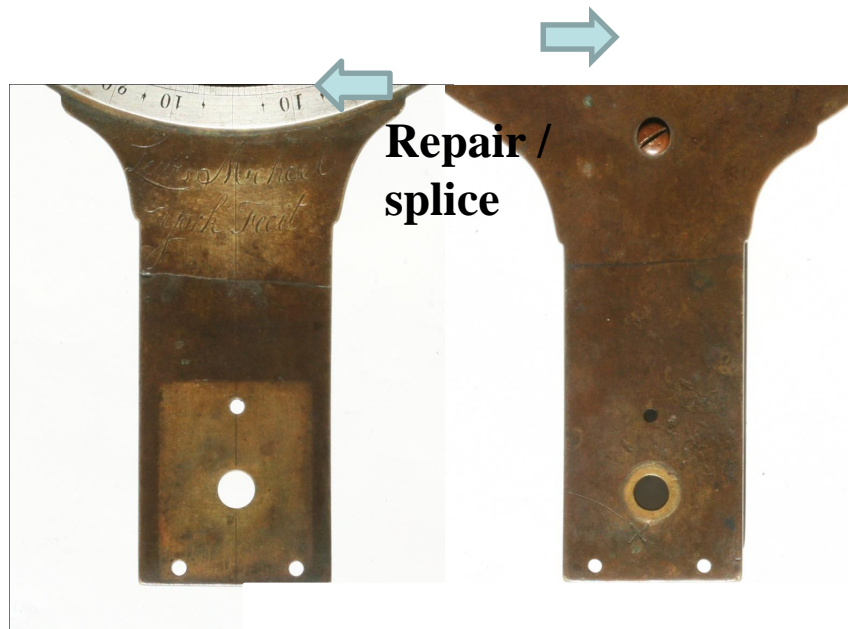
**Repair /
splice**



Joins



Lewis Michael Plain Compass



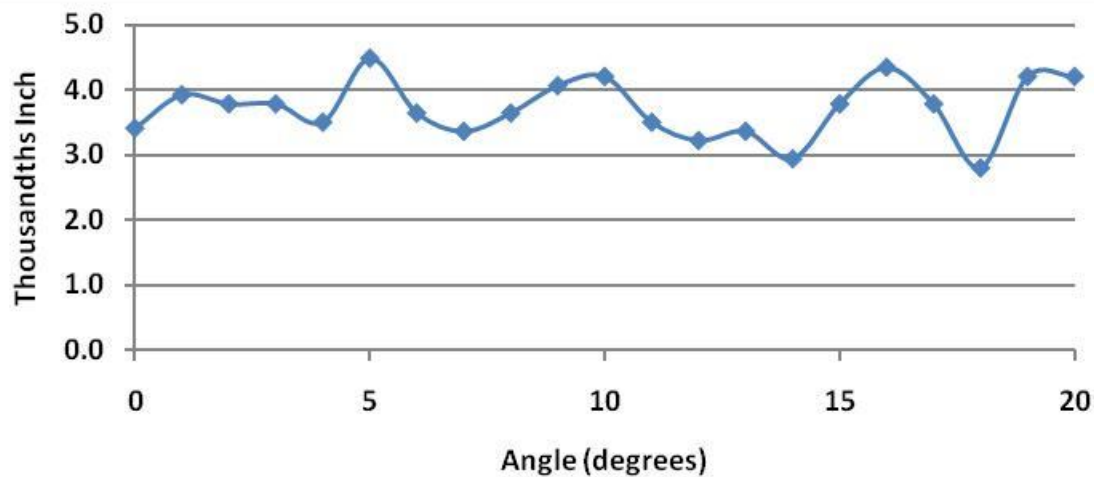
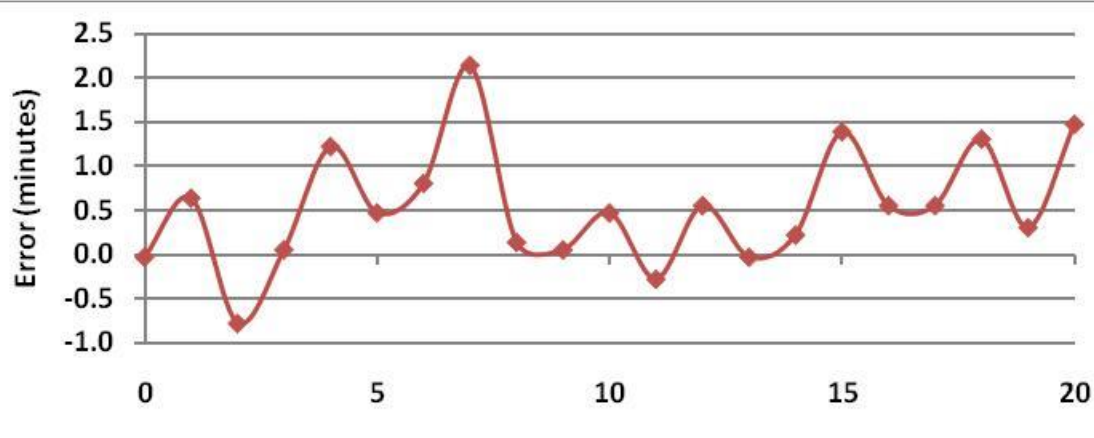
Joins



The text "Joins" is positioned above a light blue arrow pointing to the right.



Lewis Michael



- Lewis Michael was Benjamin Rittenhouse's first apprentice
- No punch marks

Note: Vertical scales different for each maker

Early vs. Later Lewis Michael



Early compass



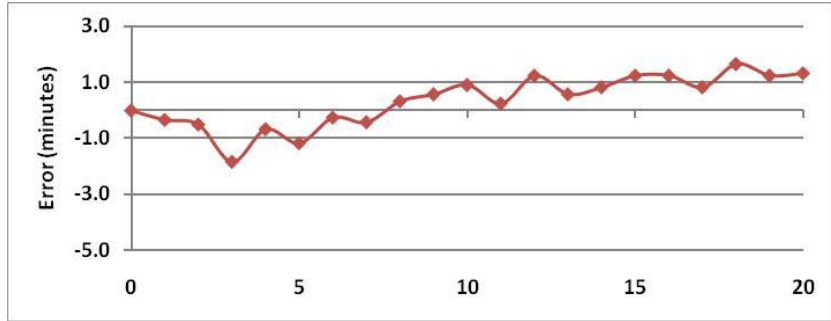
Jeff Lock



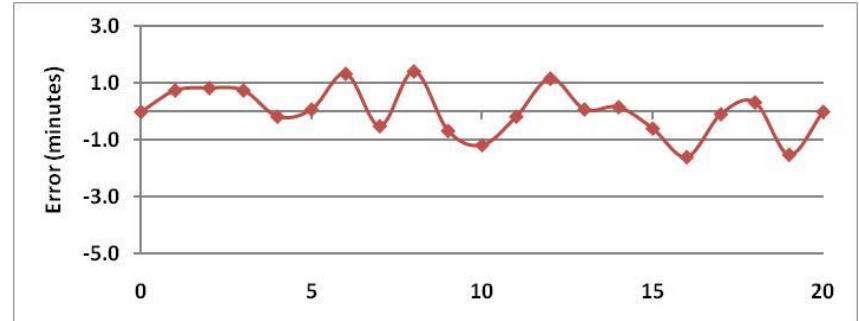
Two later compasses

Comparison of Accuracy

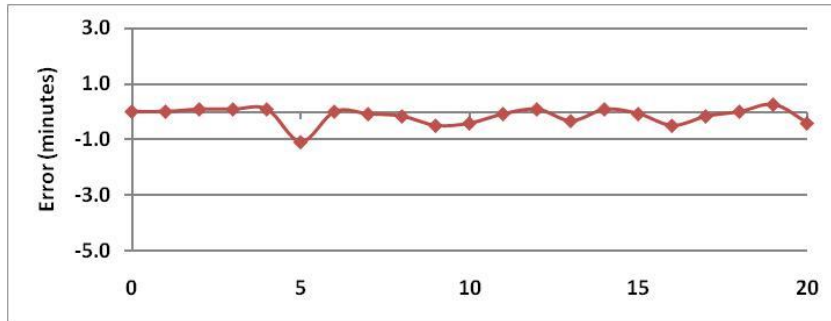
Rittenhouse & Potts



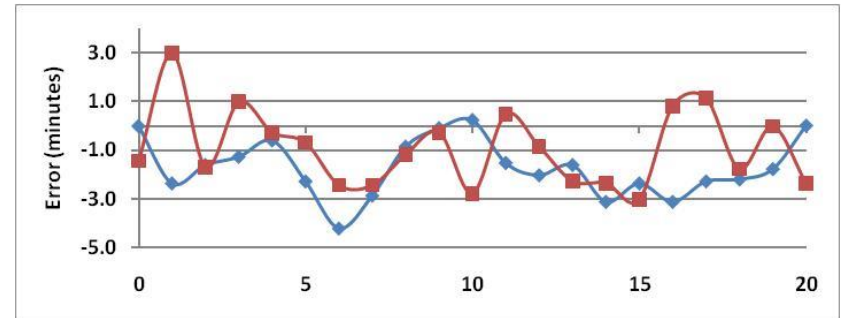
Goldsmith Chandlee



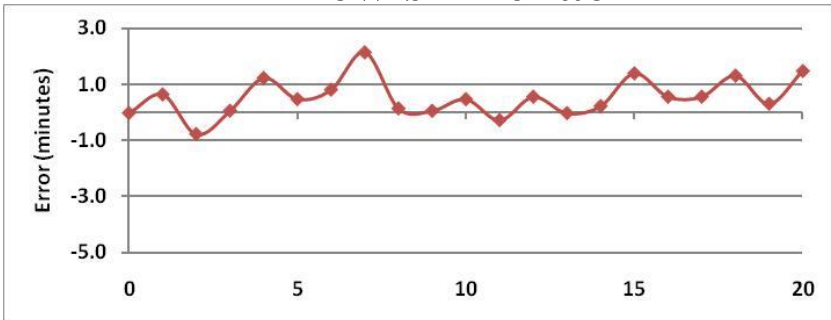
Potts



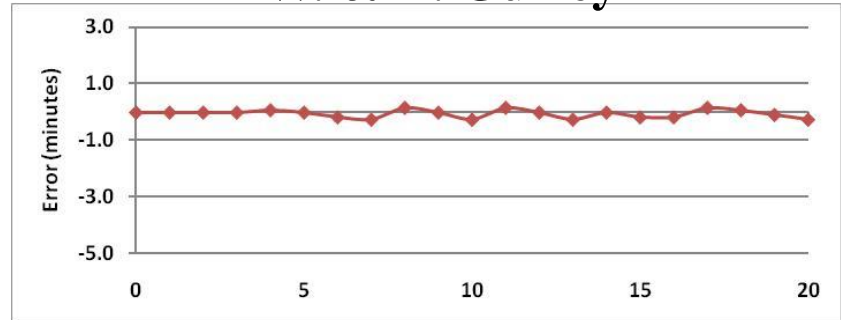
G.B. Graves



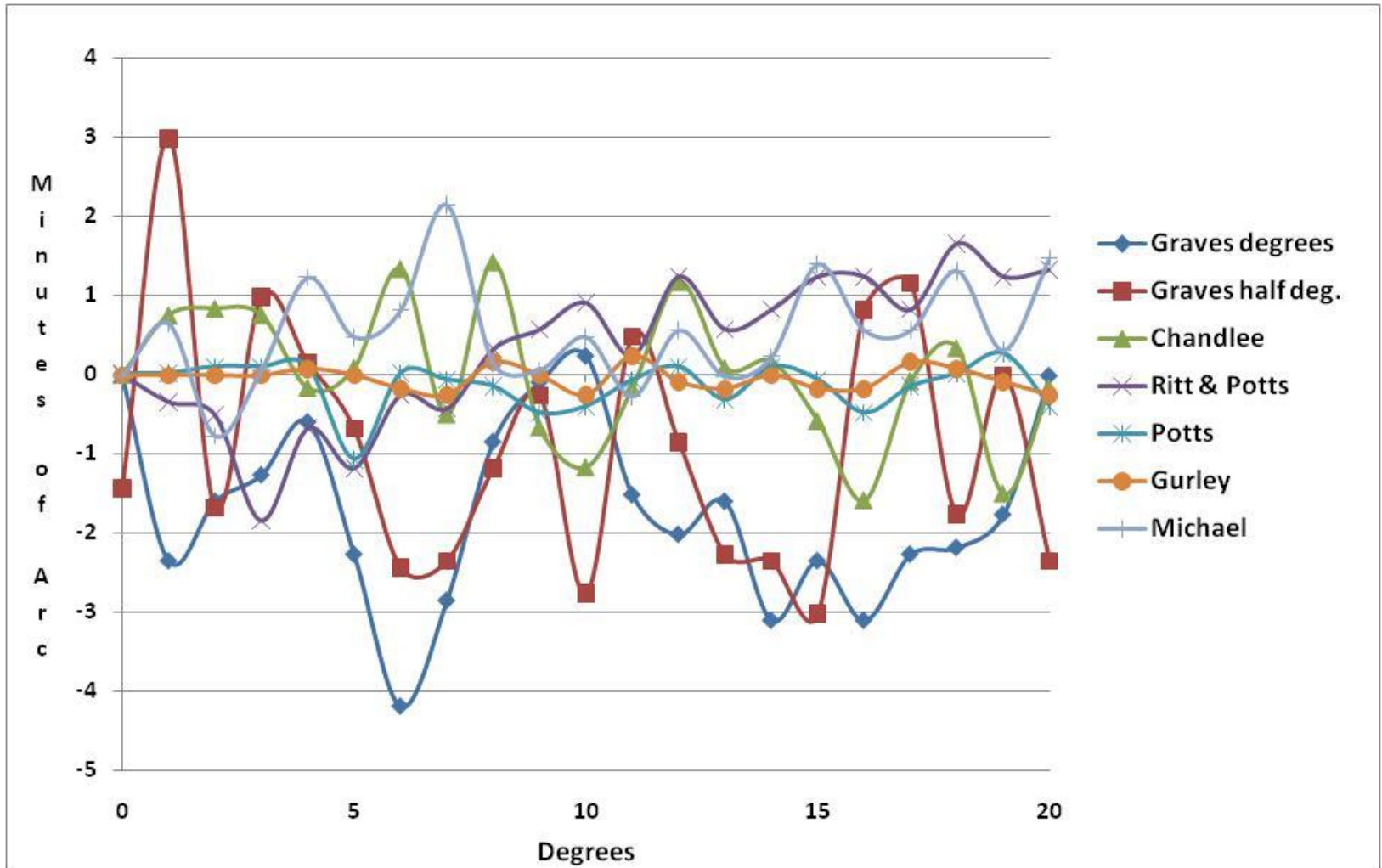
Lewis Michael



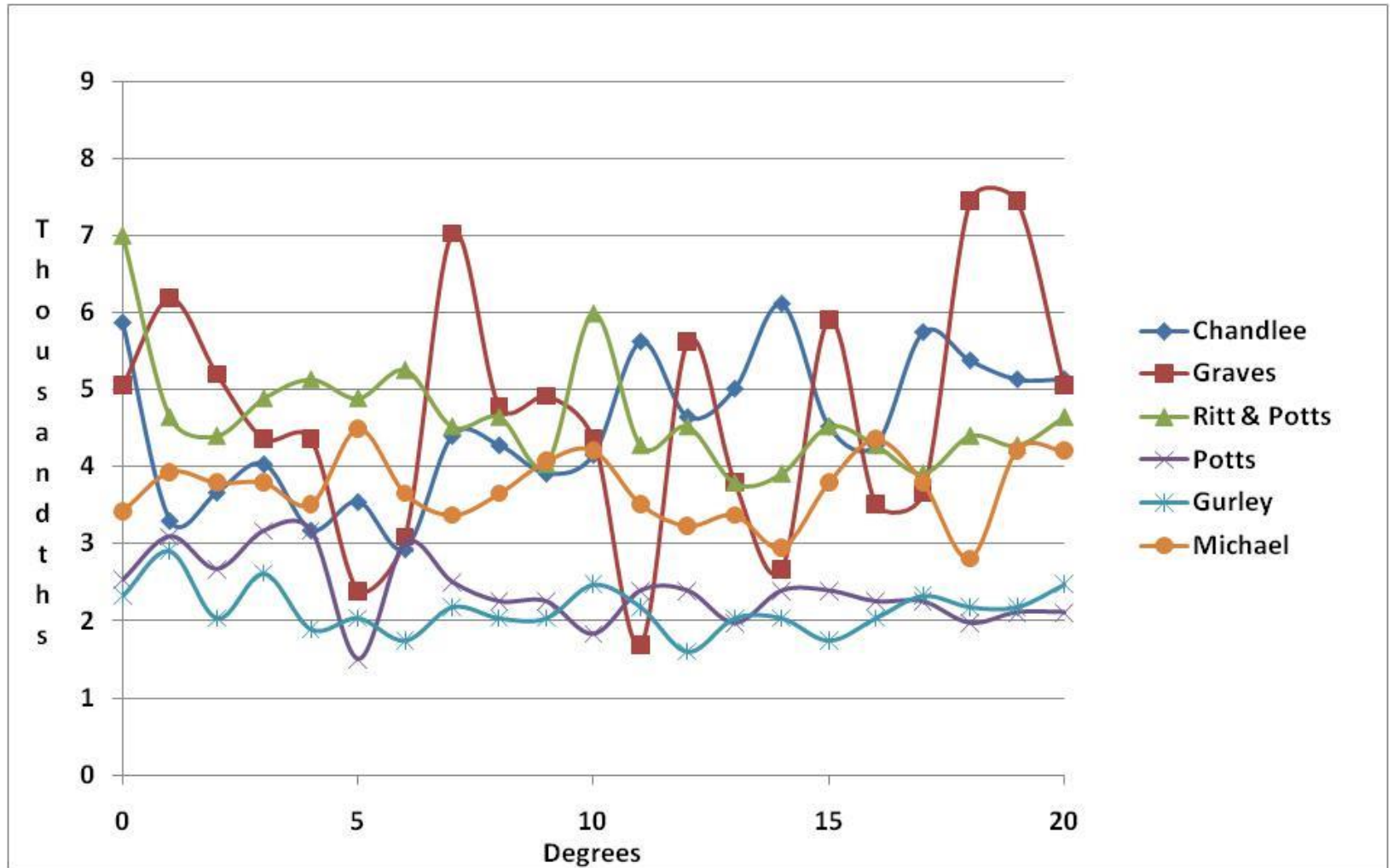
W. & L. Gurley



Line Position Summary



Line Width Summary



Unsigned Compass Examples

- **Potts (?) engraving**
- **18th century boxed with unique uprights**
- **“Copper” with nicely contoured alidade**
- **Jeff Lock’s primary dividing technique needle ring for comparison**

Potts?



Unknown

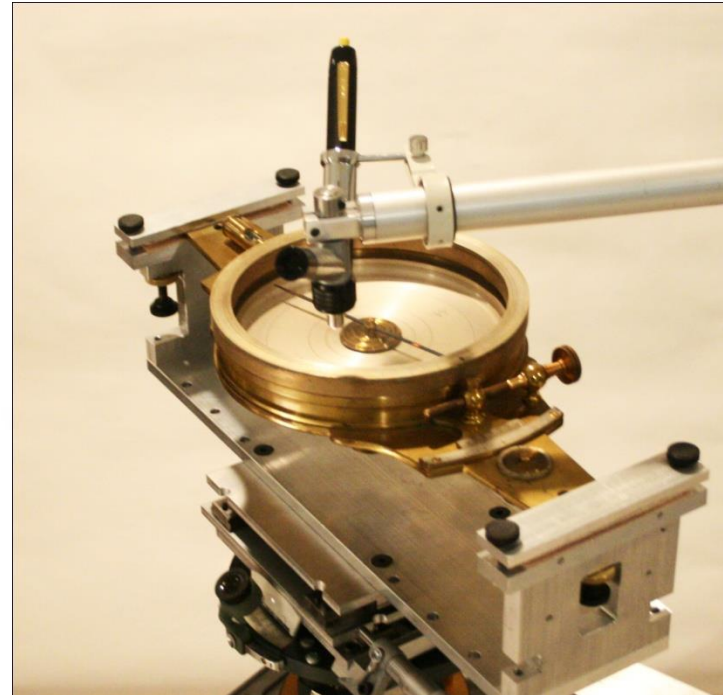
Potts

Ritt. & Potts

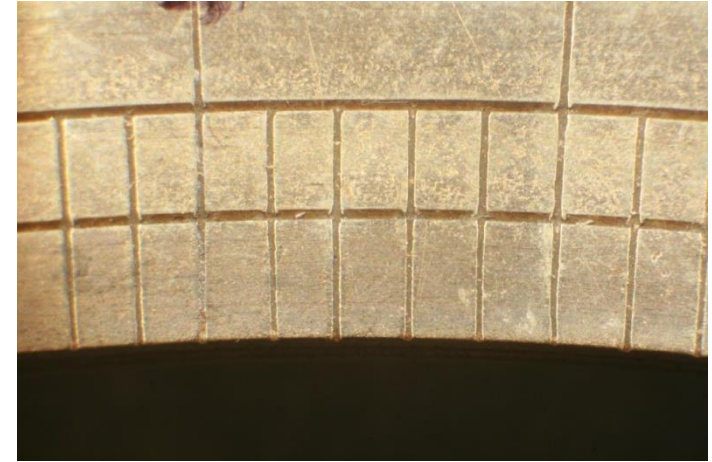
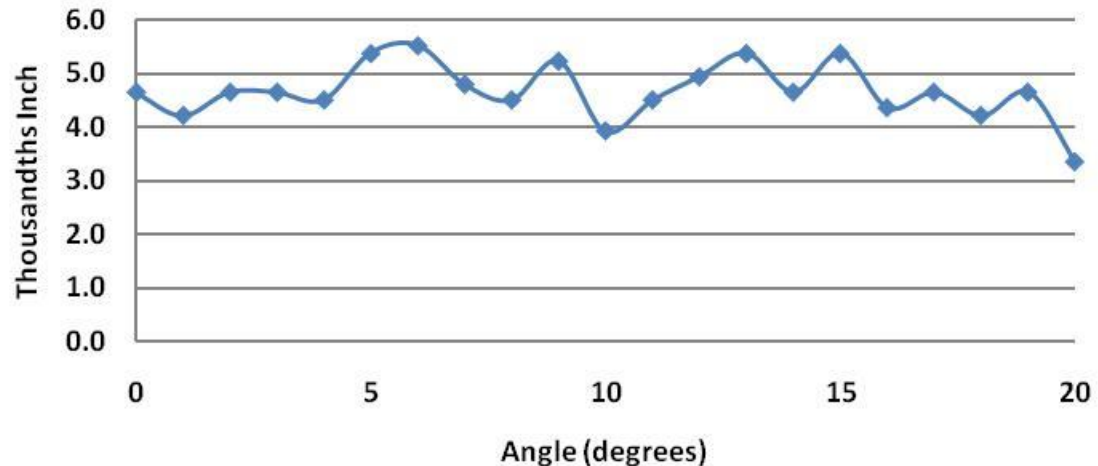
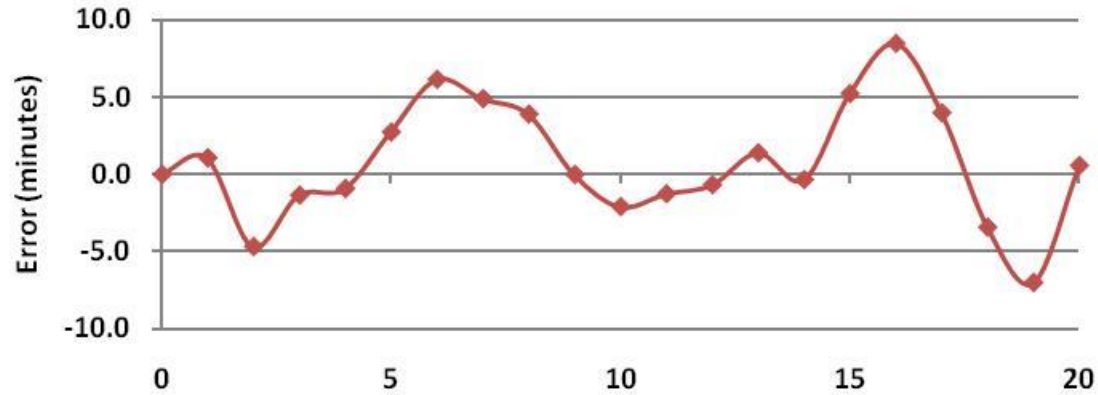
Jeff Lock Needle Ring



- Divided by “Primary Dividing” method as described in Chapman’s “Dividing the Circle”
- Rested the needle ring on the Gurley compass glass cover



Jeff Lock Primary Dividing



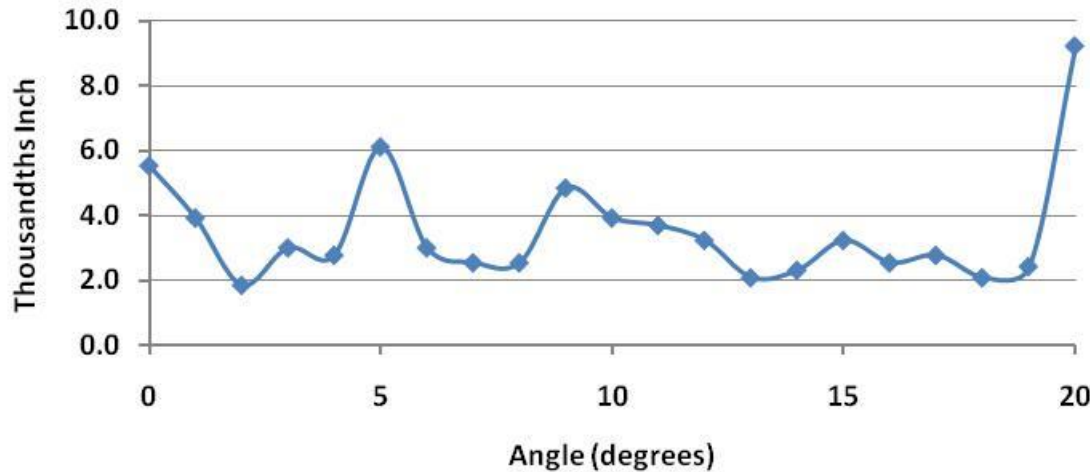
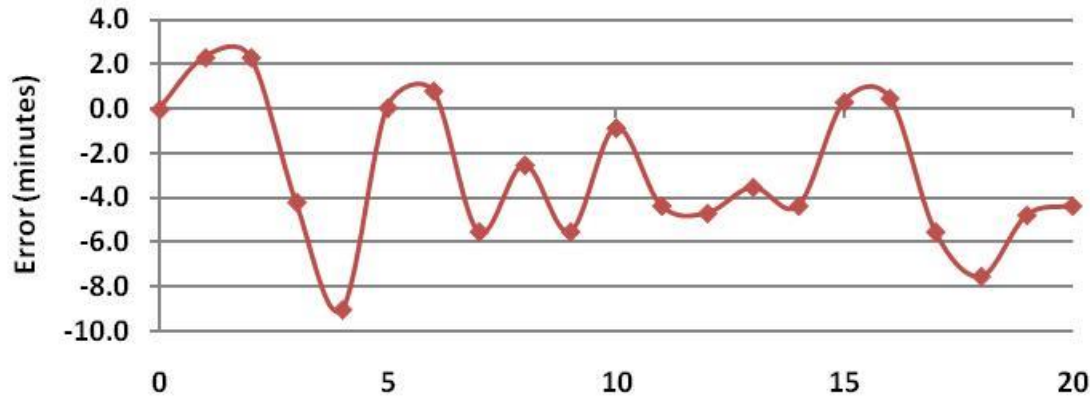
- This is the actual 0 to first 6 degrees measured
- Very good baseline of primary dividing vs. protractor or wheel cutting engine

Note: Vertical scales different for each maker

Eighteenth Cent. Unsigned #1



Eighteenth Cent. Unsigned #1



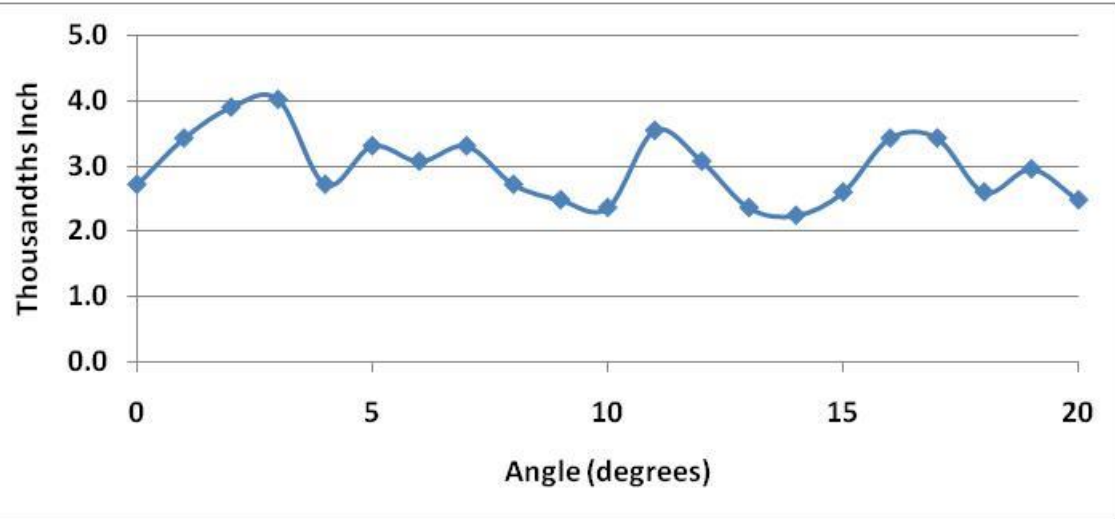
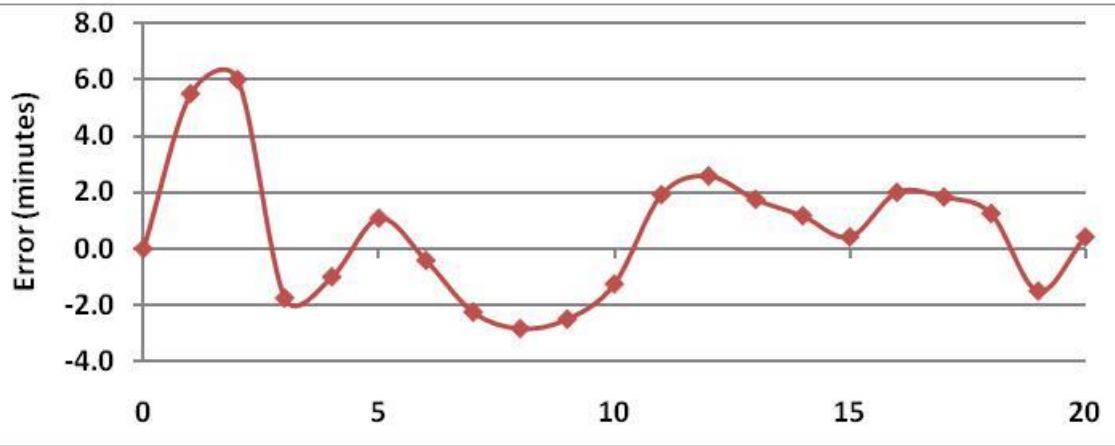
- **Non-radial degree lines**
- **5 degree mark more nearly radial?**
 - Did he mark every 5 degrees with a wheel engine and then fill in individual degrees?
- **Did he use a protractor?**

Note: Vertical scales different for each maker

“Copper” Unsigned #2



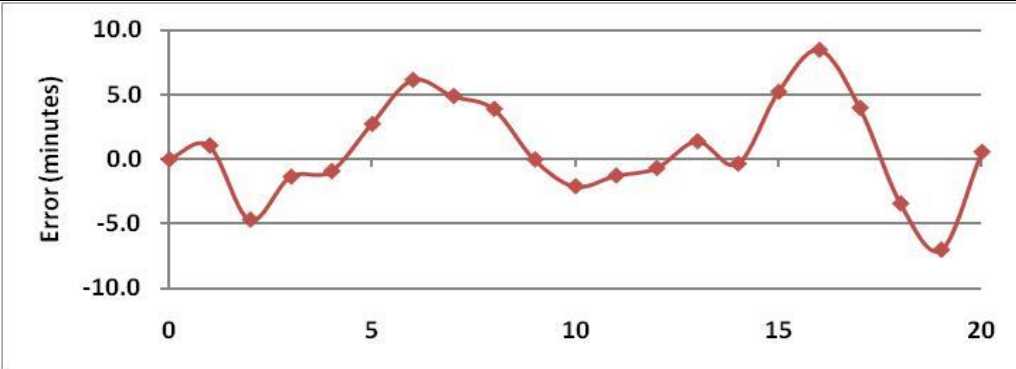
“Copper” Unsigned #2



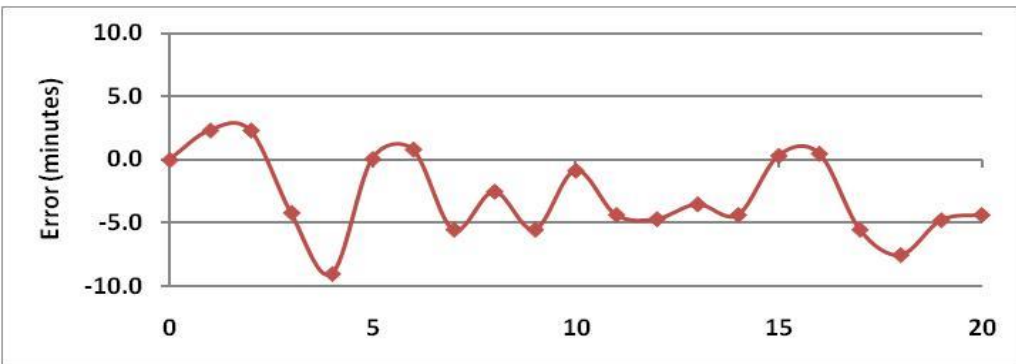
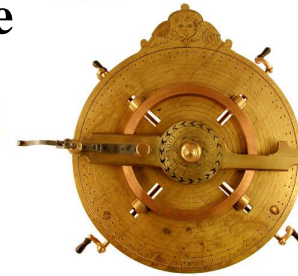
- **Clearly better execution from #1**
- **Some curvature?**
- **Are the 5 degree lines continuous?**

Note: Vertical scales different for each maker

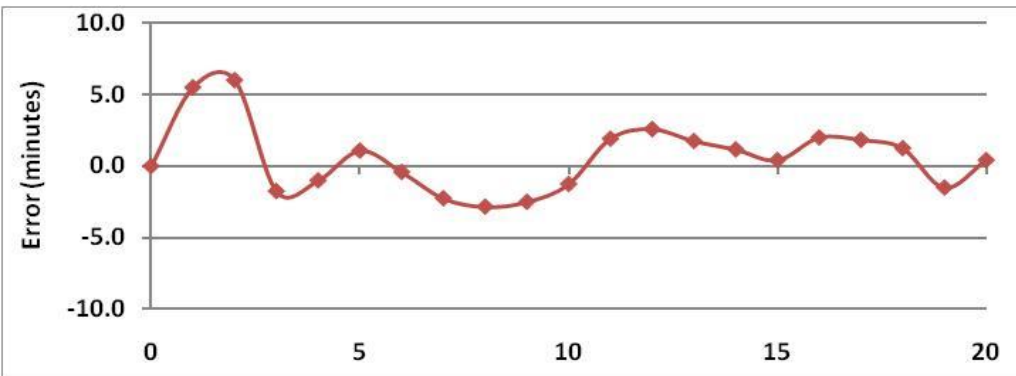
Comparisons



Jeff Lock Primary Dividing Plate




18th Century unsigned



"Copper" unsigned



Outline

- **Last Year – A Retrospective**
- **Some Questions About Colonial Compasses**
- **Measurement Approach – An $X - Y - \Theta$ Instrument**
- **Dividing Needle Rings In Colonial Instruments – Jeff Lock’s Paper**
- **Lathes and Wheel Cutting Engines – The Essential Part**
- **Several early compasses**
-  **Summary**

Summary

- **An instrument has been used to make a set of preliminary measurements over first 20 degrees to sample needle rings of contemporary compass makers – see similarities and differences - show promise of forensic progress**
- **Next step is to enlarge the data base for each compass and possibly to add more compasses**

References

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- **Bion, M.** *The Construction and Principal Uses of Mathematical Instruments*, Astragal Press 1995
 - Translated and Supplemented by Edmond Stone, 1758
- **Skerritt, William W. & L.E. Gurley's** *Engraving Machine* *Rittenhouse Journal* p.p. 97-100 Vol. 11 Issue 44, August 1997
- **Miller, Robert C.** *Circular Dividing Engines in the United States Before 1900* *Rittenhouse Journal* 0.p. 12-21 January 1998
- **Crom, Theodore R.** *Horological Wheel Cutting Engines 1700 to 1900*, Gainesville, Florida 1970
- **Chapman, Allan** *Dividing The Circle* Ellis Horwood 1990
- **Berger, C.L. & Sons** *Instruments of Precision*, Astragal Press reprint of 1900 catalog 1993
- **Chandlee, Edward E.** *Six Quaker Clockmakers*, The Historical Society of Pennsylvania, Philadelphia 1943
- **Bedini, Silvio A.** *Benjamin Rittenhouse and his Apprentices and Partners*, *The American Surveyor*, Vol. 1 No. 7 Dec. 2004
- **Duc De Chaulnes** *New Method of Division for Mathematical and Astronomical Instruments*, Classical Science Press 2009

Backup

Benjamin Chandlee III (1780-1822)



- Goldsmith Chandlee's son
- Purchased several items at his father's estate sale

“Bedini” Semicircumferenter



Unsigned Bedini





Potts?



- **a**

Lewis Michael Detail



Goldsmith Chandlee's Estate (1)

Goldsmith Chandlee was a small, spare man with dark brown eyes, and fond of company. He was much given to hospitality and entertaining, and possessed a local reputation for a kind of sly humor. He died in Winchester in 1821, and was buried in Center Meeting graveyard on the Valley Pike. His estate was finally settled by Samuel Brown, administrator, after there had been ten annual accountings. One item charged to the estate was for the "expenses in traveling 6-30-1824 to Nottingham County in Maryland to settling and an Accounting of the Estate with E. G. Trimble [Ellis Chandlee's widow and Goldsmith's sister-in-law] returning by way of Montgomery County \$14.37."

From the sale of personal property there has been omitted a great quantity of articles which were found in the home and on the farm. Goldsmith Chandlee apparently had no slaves because no mention has been found in meeting minutes or other records of ownership.

A MEMORANDUM OF ARTICLES BELONGING TO THE ESTATE OF GOLDSMITH CHANDLEE, DECEASED SOLD THE 10TH DAY OF 4TH MONTH 1821.

Andrew Bush	1 Lot old Keys and barrels	.60
James Roper.	1 pair Saddle bags.	1.30
William Seabright.	2 pieces upper Leather.	1.52
Andrew Bush	1 old looking glass and 1 cord	.13
Joseph Sidebottom.	2 Pewter tea pots and 1 salt cellar	.40
Eunice Chandlee	14 Pewter Plates	2.08
Jonathan Robinson	1 Pewter Dish	1.06
Mary Thompson	2 pewter Dishes and 1 pewter Basin	.70
Joseph Sidebottom.	1 Brass Clock	.12½
John Hardy	1 Small wheel	.50
Josiah Fawcett	1 dO do	1.25
Beall Bishop	1 dO do	.50
Jonathan Lukins	7 Chairs (armed)	6.50
George Culler	8 old chairs.	1.25
Daniel Gold	old carpet & old table	.35
Samuel Johnson	1 duger and 1 plane	.35
Jonathan Lukins	2 pair old andirons, pick & Shovel	.50
T. T. Baldwin	1 pair scales.	1.37½
Jonah Fawcett.	1 pair small scales.	.38

Josiah Fawcett	1 sett Weight.	.71
William Thompson.	1 glass ink stand	.13
do	1 perpetual Almanac	.25
Wm. G. Singleton	" "	.40
Mary Thompson	1 wheel head	.40
H. Beatty	1 lot Black Ball, grator	.30
Mary Thompson	1 pair brass topped andirons	2.90
Andrew Bush	1 pair stalyards	.57
Mary Thompson	1 mortar	.90
Andrew Bush	1 Lanthorn, Candle moles & Sugar Funnel.	.80
George Sharp	1 candle stand.	.12½
Samuell Brown	1 knife cleaner.	.12½
Samuel Brown.	1 keg with some grass seed	.06½
Eunice Chandlee	1 large wheel	.26
John Hoff (Butcher)	1 wood saw carriage 1 hand saw	1.30
James Roper.	1 compass.	55.50
Joseph Castleman	1 ditto	54.00
William Davidson	1 ditto	35.50
George Graves.	1 ditto	26.50
ditto	1 ditto	26.00
Benj. Chandlee.	1 case surveyor's instruments.	7.50
A. C. Smith.	1 case surveyors instruments.	8.75
George Graves.	1 do do	7.45
do	1 small compass.	2.50
do	1 brass square.	2.50
do	1 do	2.25
do	1 do	2.31
George Sharp.	1 protractor.	.50
George Graves.	1 brass scale (12 inches.	1.50
do	1 do (12 inches)	1.50
H. Beatty,	1 Brass scale 6 inches	1.25
George Graves.	1 " 6 inches	.75
James Roper.	1 " 6 inches	.75
George Graves.	1 " 9 inches	1.00
do	1 " 9 inches	.95
William Naylor	1 protractor	.40
Ely Beall.	1 do	.30
George Graves.	1 "	.29
George Sharp.	1 "	.27
James Roper.	1 "	.26
H. Beatty	1 "	.28
George Graves	1 "	.26

Goldsmith Chandlee's Estate (2)

Benjamin Chandlee	1	"	.27
do	1	Quadrant.	4.75
George Graves.	1	pair dividers.	.51
H. Beatty.	1	"	.41
George Graves.	6	" "	1.50
George Sharp.	3	" "	.82
James Roper.	2	" "	.76
Daniel Hartman	1	" "	.50
Ely Beal.	1	" "	.50
Moses Walton	1	" "	.26
I. Bryarly	2	" "	.52
George Sharp.	1	" "	.50
Moses Walton	2	" "	.32
John Pugh.	1	Clock (without case/	32.00
Mary Thompson	1	do with mahogany case.	61.00
William Thompson	1	Steel watch chain	.47
William G. Singleton	3	Steel Watch chains.	1.38
Mary Thompson	½ doz	steel watch chains.	2.40
H. Beatty	1	watch	1.00
Josiah Fawcett	1	do with Walnut case.	40.50
Benjamin Chandlee.	a lot	(about 3 doz watch keys)	2.25
Mary Thompson	1	watch	1.00
James Mindeth	1	Clock without case.	27.00
Eunice Chandlee	1	clock with Walnut case.	20.00
George Graves	1	Clock.	6.80
Nathan Parkins.	1	Whetstone.	.55
Daniel Hartman,	2	Watch Seals.	.50
Alfred McVicker.	5	Steel Watch chains	2.36
Edward Pendleton	1	watch	1.00
Thomas Campbell.	½ doz	chains.	2.30
Nathan Parkins.	1	box and compass	1.25
James Meredith	4	watch seals.	.80
Dan'l Hartman	6	doz watch glasses.	6.26
	6	" "	
ditto	1	gross watch glasses.	4.25
ditto	1	gross " "	6.25
ditto	1	gross " "	4.80
Benjamin Chandlee	1	gross " "	7.10
Eunice Chandlee	1	window blind.	.32
George Culler.	2½ doz	mainsprings.	1.25
ditto	2	watch seals.	.29
Joseph Castleman	1	surveyor's chain.	1.52

William Davidson	1	" "	1.50
Henry Beatty	1	" "	1.40
George Graves.	1	Lot Steel wire.	1.40
James Meredith,	2	Gravers.	.12½
George Graves.	8	brass pinions.	.12½
do	½ doz	clock second hands.	.50
do	9	pair clock hands (gilt)	3.05
George Cullen.	4½ doz	gilt watch hands	1.30
George Graves.	2	saw blades.	.55
do	1	doz files.	1.46
Benjamin Chandlee,	1	Burnisher.	.30
George Graves.	19	pair clock hands.	1.30
Thomas Campbell	a lot	of files (26	3.00
George Graves.	a lot	of Watch hands in a box.	1.01
do	14	level tubes. for compasses	1.25
do	6½ doz	key pipes.	.33
do	a lot	case springs and buttons.	.65
George Cullen	a lot	chain hooks, springs and hands.	.35
do	8	verges.	.13
Thomas Campbell	1	size stick.	.40
George Cullen	1	do	.40
do	3	watch dials.	.40
George Graves.	8	Watch brushes.	1.25
George Cullen	a lot	file handles.	1.32
James Meredith.	a lot	of polishing and ink powder	.50
George Graves.	3	clock bells.	1.55
Henry Beatty.	1	Pocket Compass (returned to Benj)	.50
Jonathan Lukins.	1	do dO	.29
J. Bryarly	1	do do	.31
Samuel Johnston	1	do do	.32
George Graves.	a pr	Scotch stone	.51
Eunice Chandlee	a lot	of castings, etc.	2.00
Mary Thompson.	a lot	of castings, etc.,	2.50
Thomas Hieste,	1	Bench	.26
Josiah Fawcett.	1	piece of iron.	.56
Thomas Keenan	2	pieces stone	.25
Mary Thompson	1	doe trough.	.75
James Meredith	1	corner cupboard.	4.00
Daniel Gold.	3	pieces stair carpet.	2.45
do	25-¾	yards carpeting.	13.30
Wm. Henning.	1	Sett knives and forks.	1.55
George Sharp.	1	pair brass candlesticks.	1.00

Goldsmith Chandlee's Estate (3)

Mary Thompson	1 pair do do	.55
Thomas Keenan	3 brass candlesticks.	.55
Henry Grove.	2 iron & 1 brass candlesticks.	.25
George Sharp.	1 Spice case.	3.05
Thomas Brown.	a lot Black Bottles (17)	1.10
George Graves.	1 box clock glass.	13.00
do	2 phials lacker.	.25
George Sharp.	6 flasks	.37½
Josiah Fawcett..	1 cupboard.	2.00
Augustine C. Smith	1 Rileys narrative.	2.00
William Bryarly	Voyage round the world.	.95
James Stackhouse	1 book (History)	.36
Benjamin Chandlee	1 book Flu Works.	.65
Jonathan Lukins.	Clarkson's works, 3 vols.	2.50
Benjamin Chandlee	Johnson's dictionary.	1.10
Joshua Lupton	Christians Progress.	.80
Nathan Parkins.	Rural Visitor.	.42
George Sharp.	9 Table books.	.09
Nathan Parkins	Paradise Lost.	.25
Josiah Fawcett	1 book Churchman	.25
David Hollingsworth	Moore's Journal.	.25
Benjamin Chandlee.	Spy.	.25
do	John Richardson.	.25
David Hollingsworth	Josephus 5 vol.	1.37½
B. Chandlee	1 sermon book	.25
Nathan Parkins.	Christian Primitive.	.51
B. Chandlee	Washing " Will.	.25
R. T. Baldwin	1 Thermometer.	5.00
Graves.	2 Clock faces.	9.00
B. Chandlee	4 Razors.	1.55
Mary Thompson.	1 dining table.	3.75
Mary Thompson	1 Breakfast. Table.	2.50
Mary Thompson	lot of spoons.	.42
Jonathan Lukins.	1 real (Wheel)	.50
James Stockhouse.	6 wine glasses & waiter.	.50
Richard Kid.	Lot Queen's ware.	.30
Andrew Bush.	lot of small plates & dishes	1.69
Richard Kid.	Candle stick & Candle	.32
do	Box knives & forks.	.38
Thomas Brown	Watering pot.	.75
Jonathan Robinson	Pewter dish.	.75
Daniel Gold.	Lot pewter plates.	.48

Andrew Bush.	" " "	.63
Daniel Gold	Rocking Chair	1.30
Eunice Chandlee	lot chairs ½ doz.	6.07
Hickey	Gingerbread chest (box)	.22
Thomas Brown	Saddle	1.10
Andrew Bush	Saddle pad.	.25
Samuel Bryarly	7 Stuff Bottom chairs one armed.	6.00
Jacob Bowers.	one walnut dining table.	2.00
Hickey	one ditto breakfast do.	1.25
Josiah Fawcett,	Horse.	10.00
James Stockhouse.	Blacksmith's vise.	2.36
Jonathan Lukins	one ditto.	2.30
George Cullen.	one ditto.	3.05
Jonathan Robinson	4. <i>frizzing</i> tongs	.17
Thomas Brown	small grindstone	.50
Benj. Chandlee.	Clock engine.	54.00
do	one round horn Stake.	2.75
George Graves.	Graduating engine & appt.	25.00
George Cullin.	Glass stand Springtools.	.55
Benj. Chandlee	Dial plates.	3.30
George Graves	lot watch tools.	5.75
Thomas Brown.	1 Dial.	.29
George Sharp.	1 do	.25
Moses Walton	1 do	.25
Bell.	1 do	.26
James Meredith	1 Dial	.28
Andrew Nolan	1 do	.27
Benjamin Chandlee	glass cover and letters	.50
George Groves	Balance Tool.	.50
do	Sundry Brass plates.	.76
Charles Little	Pocket compass and box Mahogany	1.00
Benjamin Chandlee	<i>Dial Model</i>	5.00
do	Magnet.	4.00
Jos. Sidebottom.	Small scales & weights.	.08
George Graves.	do do do	.39
do	lot of tools rulers & weights	.37
do	one set of dyes for stamping figures	1.00
do	one compass part finished.	9.00
Benj. Chandlee.	2 small pocket compass part finished.	1.00
Samuel Meredith.	Small pocket compass.	.31
George Graves.	Small dividing engine.	5.00
Benj. Chandlee	pair button models.	.65

Goldsmith Chandlee's Estate (4)



George Graves.	one scale tool.	2.00
do	1 pr brass scales.	.47
do	3 lots of old brass.	2.50
do	8 pr Brass castings.	1.00
Benjamin Chandlee.	Punch and Stake.	.25
George Graves.	Stake.	.51
do	Lot of tools.	.80
Thomas Brown.	Spoon models.	.70
Jonathan Lukins.	Large Shears.	.71
Thos. Heist.	one lot old files.	.17
George Graves.	Role Lathe.	6.25
do	lot tools punches, etc etc.,	.12½
do	one large lathe.	13.00
do	lot sundry tools.	4.25
John Foster.	lot clock work.	7.00
George Graves.	one do do	4.75
do	2 lathes.	4.25
Alfred W. Vickers.	2 do	4.50
George Graves.	lot tools.	3.75
do	barrel tool.	1.50
Benj. Chandlee	Bell patterns.	.25
George Graves.	2 lot tools.	12.75
do	large turkey oil stove	1.00
Benj. Chandlee	3 clock wheel patterns.	.12½
George Graves.	Stake and Block.	4.75
George Reed.	4 boxes sundries (old brass)	2.60
Thomas Brown	4 boxes sundries (old brass)	.60
Thomas Heist.	lot of sheet lead	1.45
Benjamin Chandlee.	one clock.	20.00
Thomas Heist.	Iron wire.	.56
George Graves.	Sheet brass 41 cts. (continued)	
George Reed.	Spelter. 78½ at 12½ cts.	9.81½
George Reed.	Show case.	1.00
Benjamin Chandlee	lot Shark's skins.	1.00
George Reed.	Box pewter	.65
Alfred McVicker.	one clock face.	2.15
Thomas Brown,	one waggon	7.56
Eunice Chandlee	Carriage.	60.00
Hickey	Cow.	10.50
Josiah Massie.	Waggon Gears.	2.86
Thomas Brown.	Sett Gears.	3.20
Henry Beatty	3 hogs.	10.25

Andrew Bush.	1 plane.	.65
George Graves.	Sundries bellows & flasks & sands	5.00
Thomas Brown.	Charcoal.	1.10
Thomas Kennin	old desk.	3.50
Thomas Heist.	Walnut desk	10.00
M. R. Seal.	looking glass.	2.05
Benjamin Chandlee.	map of Frederick County.	2.00
Andrew Bush.	4½ yds Linen.	2.11½
Eunice Chandlee	Lot of Bed quilts.	16.50
do.	Looking Glass	2.00
do	Bed Bedstead etc.	18.00
Mary Thompson.	Bed, Bedding & bedstead.	19.00
Rueben Stramge.	Waggon tent (cover)	3.50
George Cullin.	Window Curtains.	1.00
Andrew Bush.	do do	1.60
Benj. Chandlee	two pair window curtains.	1.00
Thomas Robinson	one case drawers.	8.25
Benj. Chandlee.	lot bed curtains.	6.00
Thos. Kennan	Walnut Bureau.	6.75
Benj. Chandlee.	Bed & Bedstead, etc.,	19.00
Jacob Bowers.	Cot bedstead.	3.25
George Graves,	case of Drawers	6.13
Eunice Chandlee.	Walnut chest & side saddle.	2.00
Eunice Chandlee	1 arm chair.	.25
"	bed and furniture.	22.00
"	warming pan	1.00
"	2 chairs.	1.00
"	candle stand	1.00
"	wash stand	1.00
"	Table and furniture.	5.00
"	writing desk & Bible	6.00
"	Lot Silver spoons.	12.00
"	do cups & Saucers & Spoons,	7.00
"	Bottles & Vial.	.50
"	Shovel & Tongs.	1.50
"	Andirons.	1.00
"	Carpet.	.50
"	Looking Glass.	.50
"	Window Curtains.	1.00
Jonathan Lukins.	Desk & bookcase.	8.60
Mary Thompson	Carpet, Chairs & Knives.	10.00
Henry Beatty.	Ground plaster Paris. at 40 cts.	2.86

Goldsmith Chandlee's Estate (5)

Jos. Fawcett.	Barrel Tar.	1.50
Henry Beatty	Barrel Tar.	1.50
B. Chandlee.	Tallow	10.00
Andrew Bush.	40 pounds of Tallow at 11 ½	4.60
Hickey	40 " " " "	3.90
Benjamin Chandlee.	42 pounds of Hard soap.	4.62
Levi Wickham.	1 keg Tobacco 130 pounds	31.84
George Graves.	1 tenplate stove & pipe.	13.15
George Graves.	15¾ Sheet Brass.	6.45¾
do	5 pouns sheet brass at 41°	4.62
Josiah Fawcett.	Carpet yarn at 7 cts.	2.30
Henry Beatty.	10 bushel ground Plaster Paris	4.00
		<hr/>
	Old Barrels etc., sold at Market to divers persons amounting to	\$1,586.48¾
		16.00
		<hr/>
		1,602.48¾
Mary Thompson	1 lot spoons. etc.,	5.00
		<hr/>
		1,607.48¾

At a Court held for the Corporation of Winchester the 31st day of October, 1823.
This Sale Account for the Estate of Goldsmith Chandlee deceased was produced to the Court, and ordered to be Recorded.

Teste:
Lent. Grent. Clerk.,

All the illustrations in this chapter represent articles made by Goldsmith Chandlee. The eight-day repeating clocks were signed *G. Chandlee Winchester*, or *Stephensburg*, and were made with brass works and the rack and snail device for the striking train. The dials were made of iron painted white, with the exception of Figure 63. Many dials are not described because they are similar, except for the varied decorations.

Time Lines

1725 1750 1775 1800 1825 1850 1875

David Rittenhouse (1732-1796)

Benjamin Rittenhouse (1740-1825)

Lewis Michael (~1765-1840's?)

William Lukens Potts (1771-1854)

Apprentice to B.R. (1786)

Goldsmith Chandlee (1751-1821)

George B. Graves (1792-1873)