A Clock Making Investigation

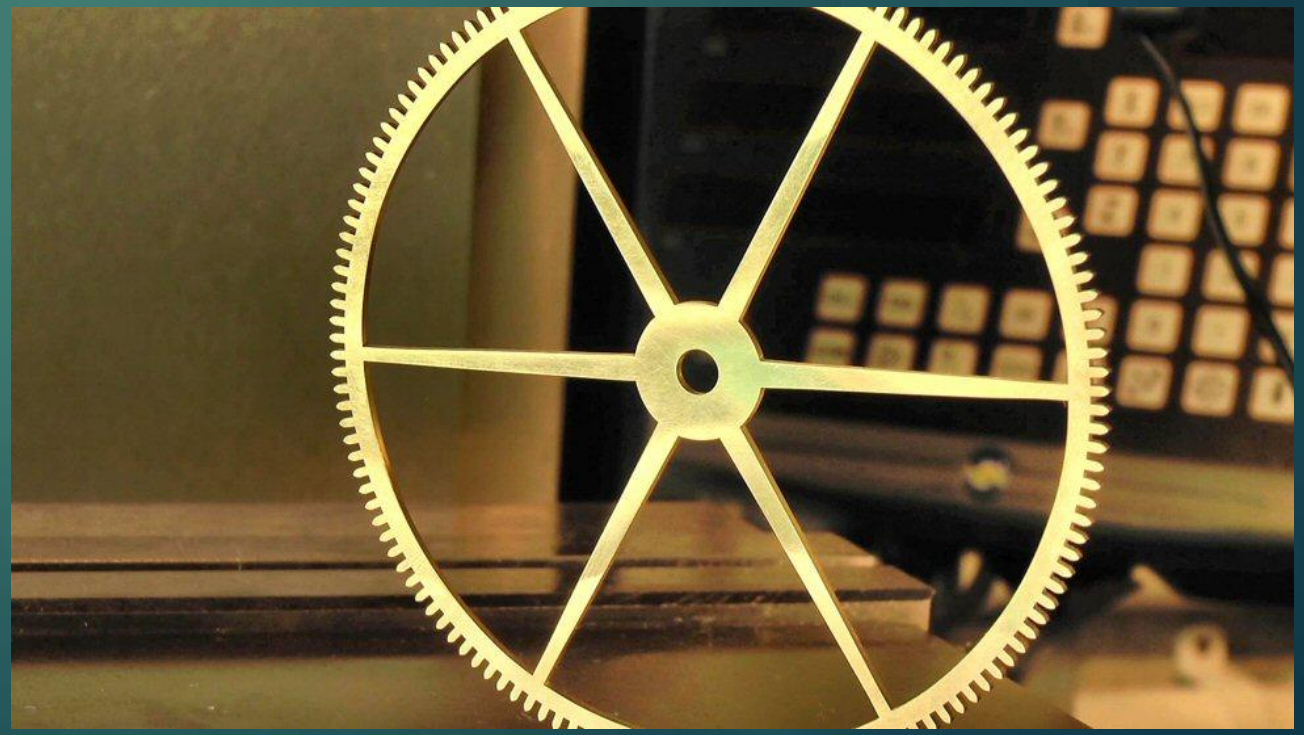
BY

NORM BERLS

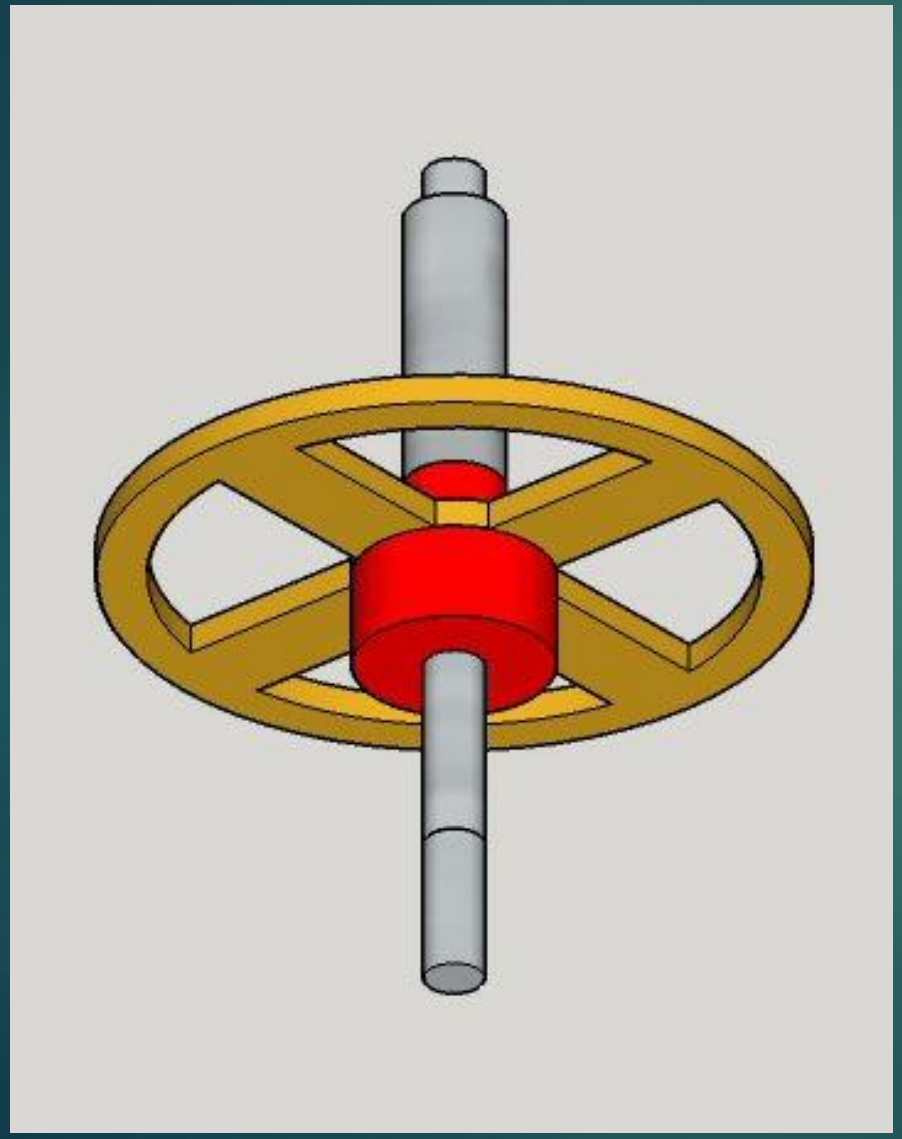
Terminology

- Horology - the study and measurement of time. Or the art of making clocks and watches
- Skeleton Clock
  - Completely reveals the inner workings of the clock.
  - Parts are designed and configured to make an attractive display.
  - Popularized in the mid 19th century
  - Often encased in glass
  - Every part must be as perfect as possible
  - As much a work of art as a mechanical wonder

Pinion: <20 teeth
Wheel: 20 teeth or more
Pinions and Wheels mount on Arbors

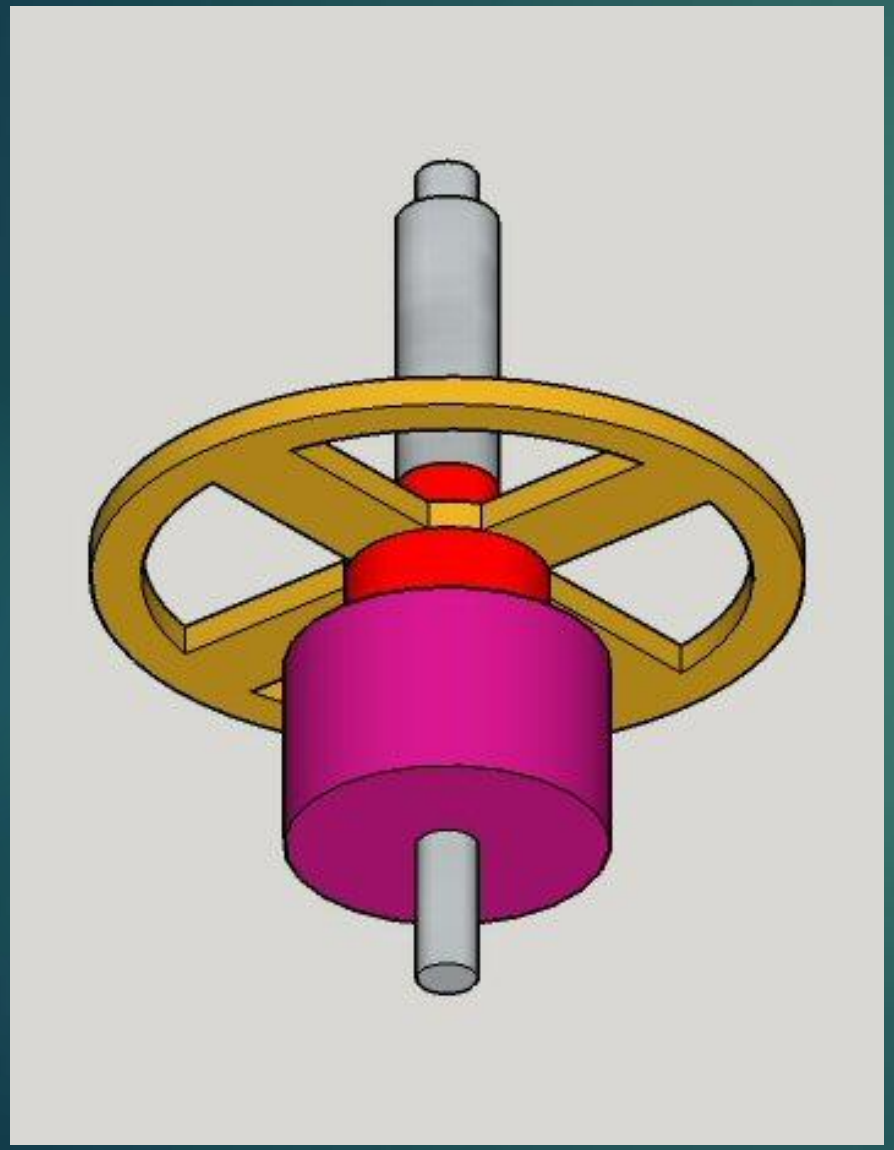


Clocks are Simple



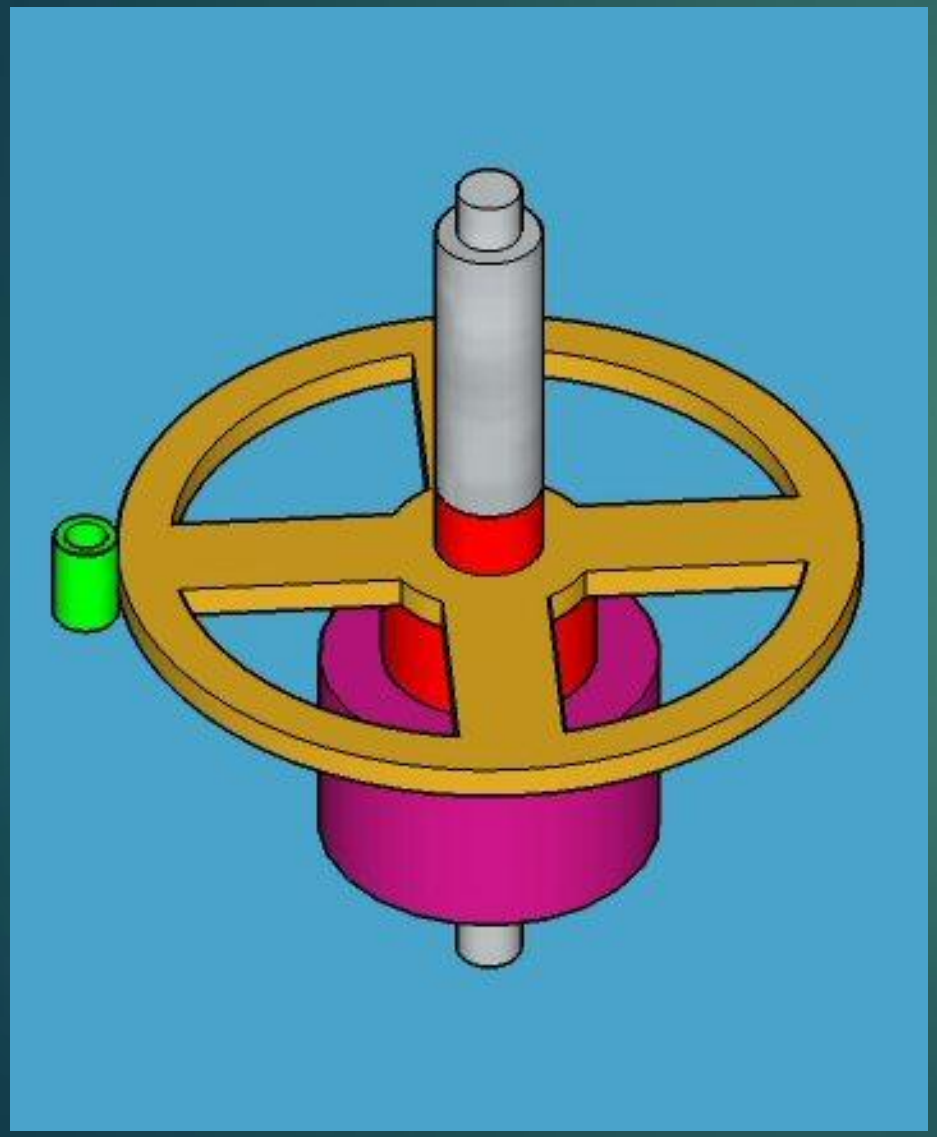
- Collets are used to attach wheels to arbors.
- In the past:
  - Wheels were crimped to the collet.
  - Wheels were soldered to the collet.
  - Wheels were attached with screw fasteners to the collet.
- Today Locktite is used

Clocks are Simple



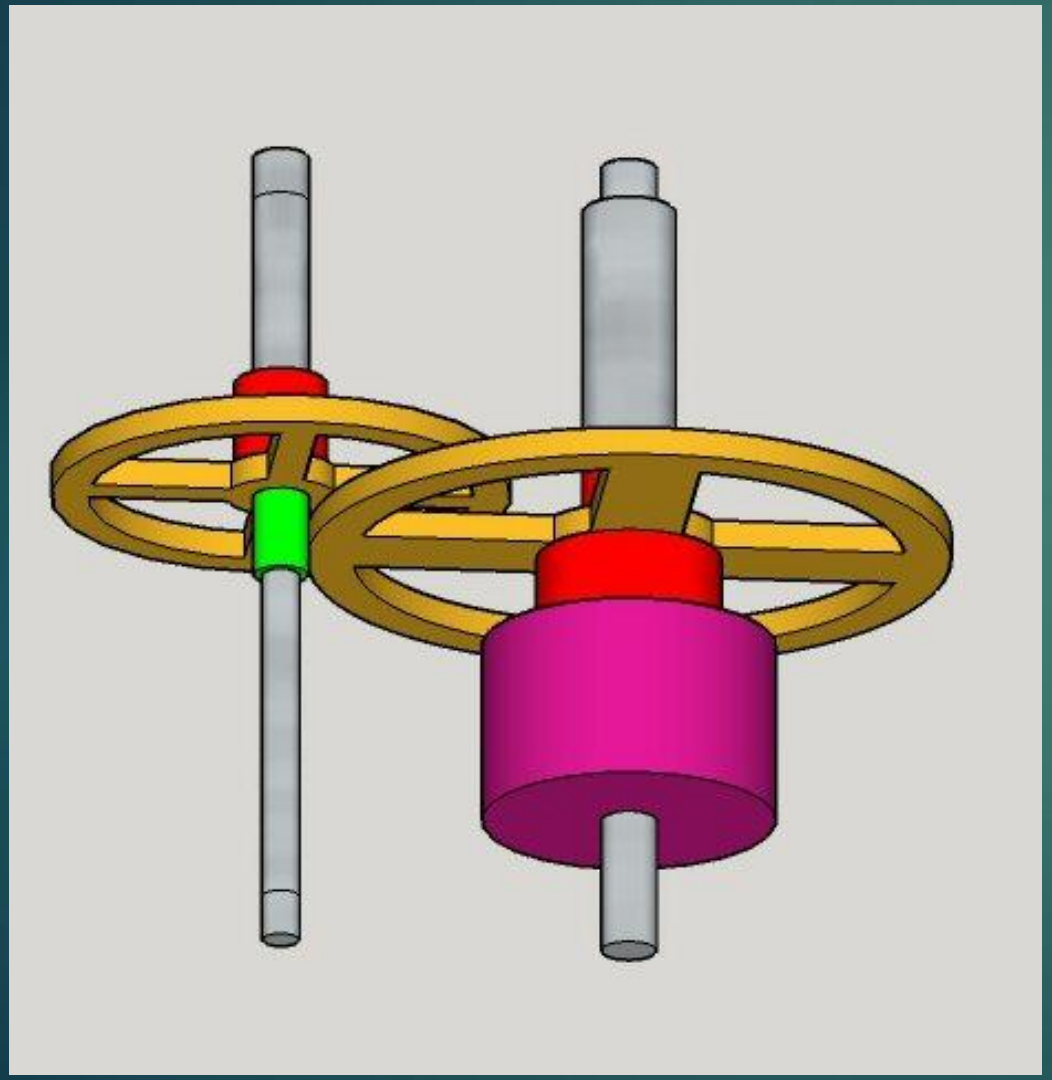
- Power is applied to the “big wheel”.
- Sometimes called the “center wheel” or the “main wheel”.
- Purple cylinder might contain a wound spring or, might have a wire wrapped around it with a weight hanging down.

Clocks are Simple



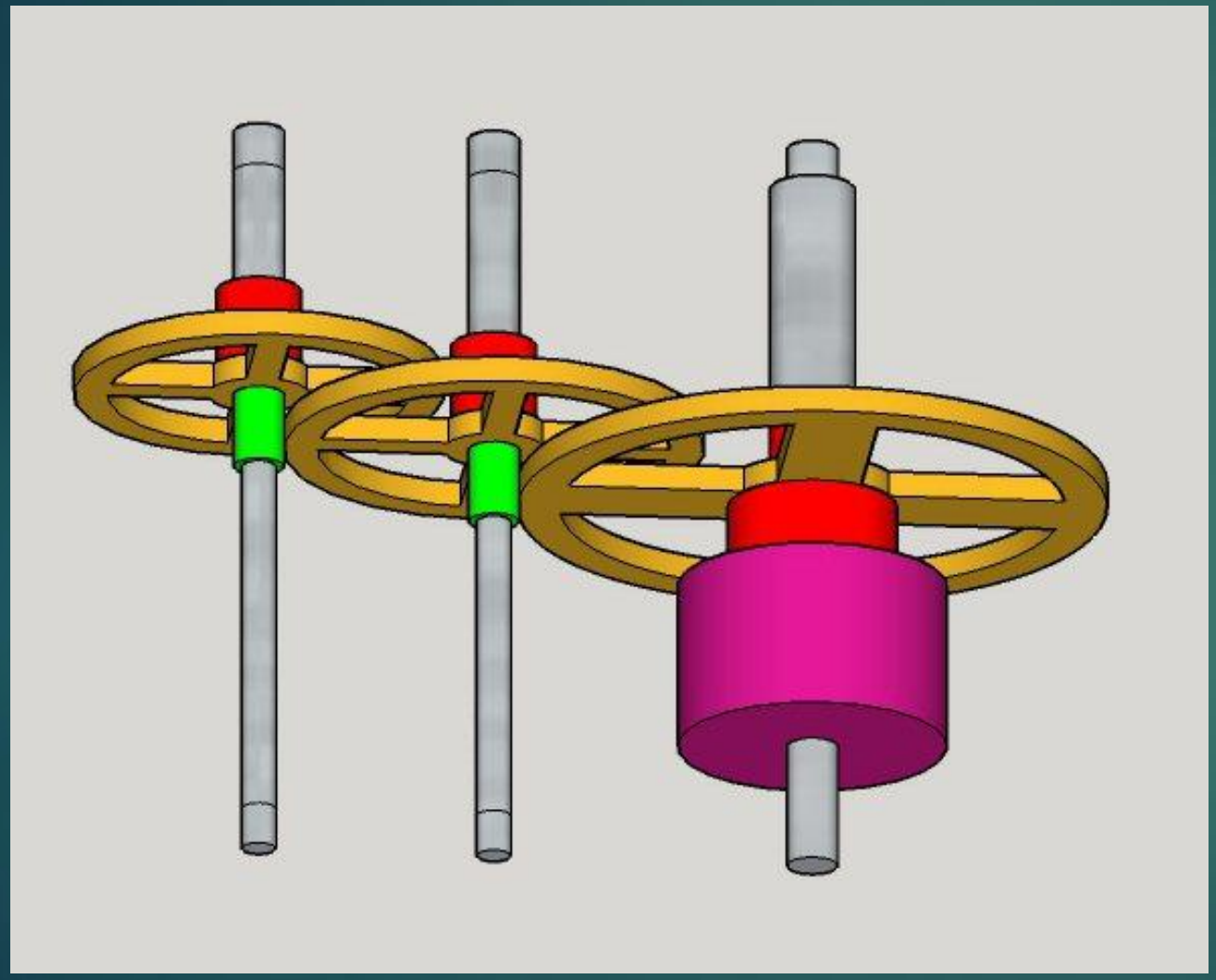
- Wheels drive pinions
- Reverse of the power transmission in most machines

Clocks are Simple



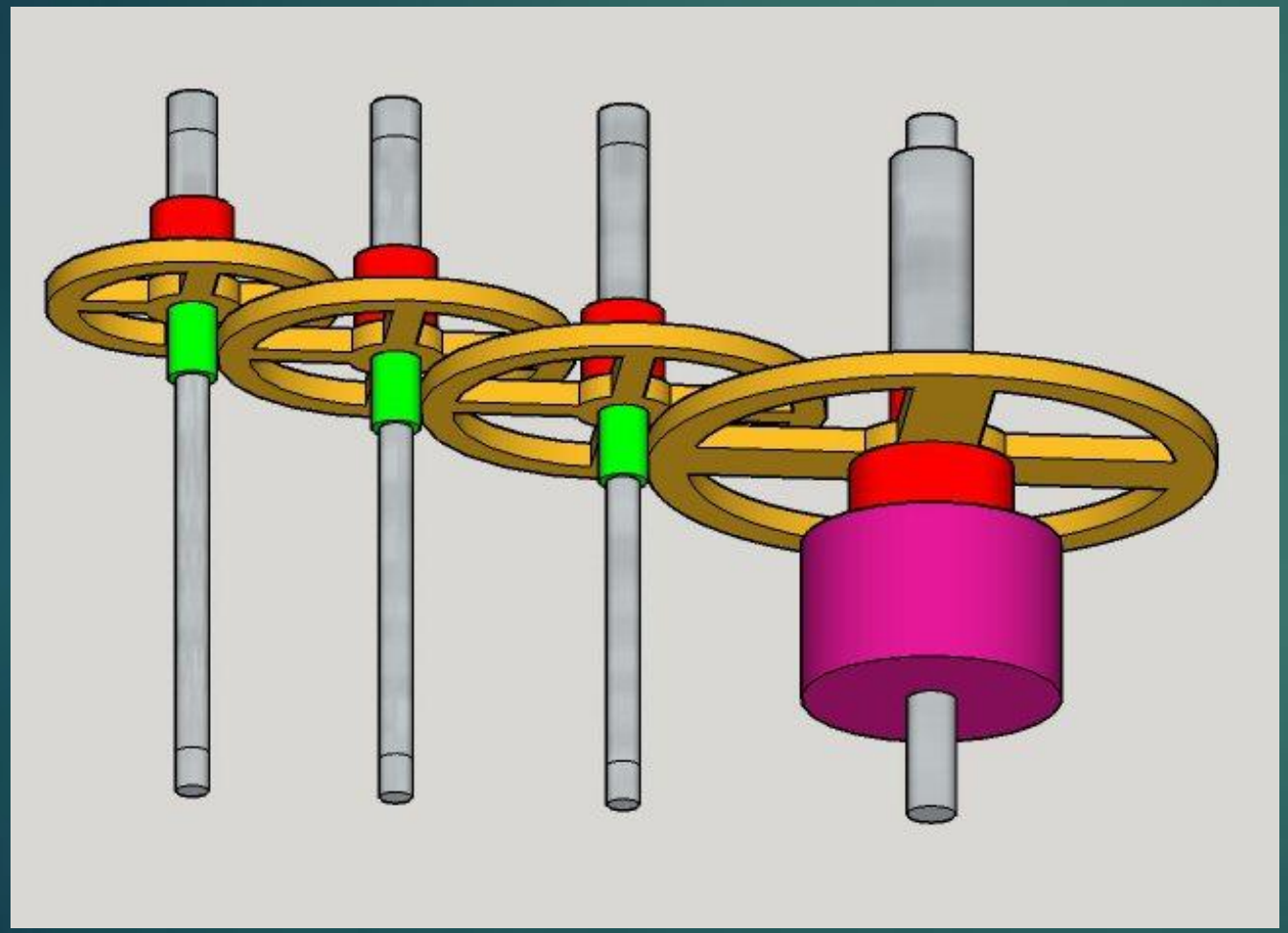
- Pinions attach to an arbor with Locktite.
- Arbor also has another collet and circle on it.
- Next wheel is the hour wheel and makes 1/12 turn per hour.
- Additional gearing attached to the hour wheel (not shown) translates this to 1/12 turn of the hour hand.

Clocks are Simple



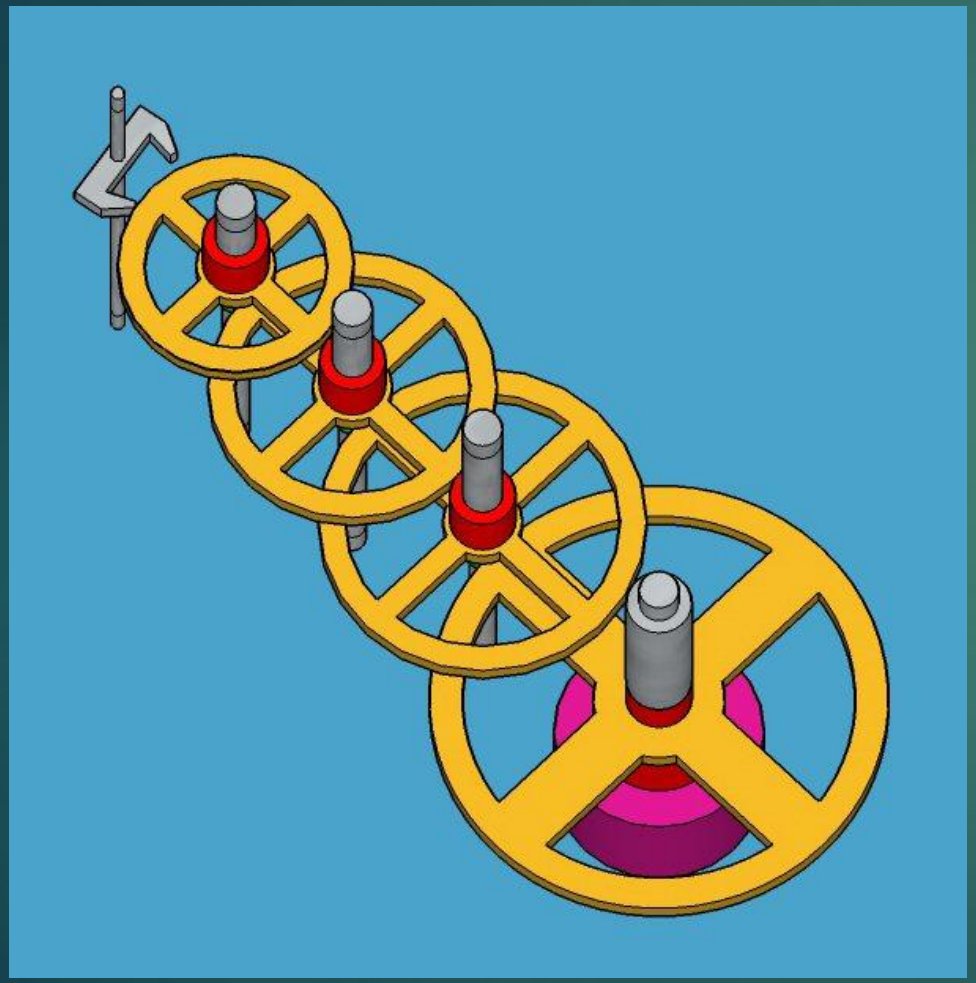
- Next pinion, arbor, collet drive the minute wheel.
- Minute wheel makes one complete turn per hour.
- Additional gearing off the minute wheel (not shown) drives the minute hand on the clock face to rotate once per hour.

Clocks are Simple



- Next pinion, arbor, collet drive the second wheel.
- Second wheel makes one complete turn per minute.
- Additional gearing on the second wheel (not shown) drives the second hand to make one revolution per minute.

Clocks are Simple

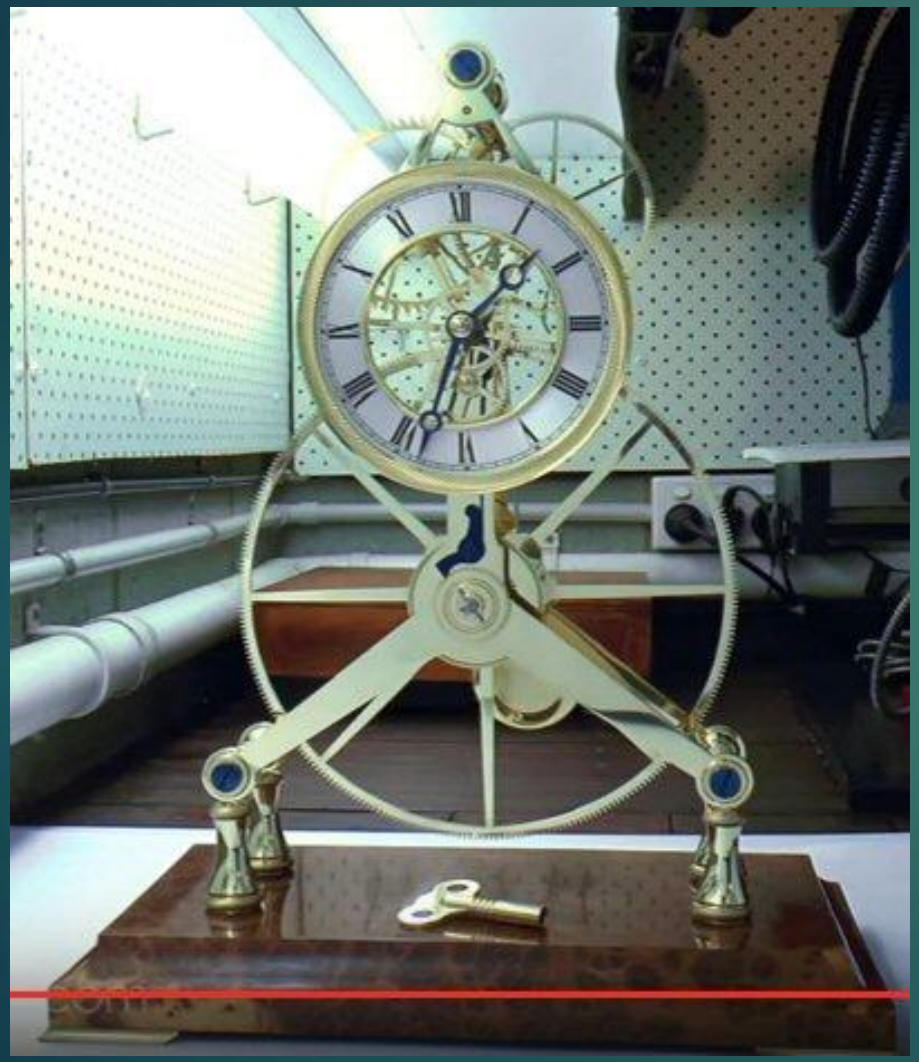


- Escapement is driven by a pendulum.
- Pendulumn has a period of 1 second.
- Each swing of the pendulum allows 1 tooth on the second wheel to slip by.
- Each swing of the escapement feeds a little bit of power back into the pendulum to make up for the energy lost through friction with the air.
- Through the gear train, the escapement keeps the big wheel from unwinding all at once.

Investigation Goals

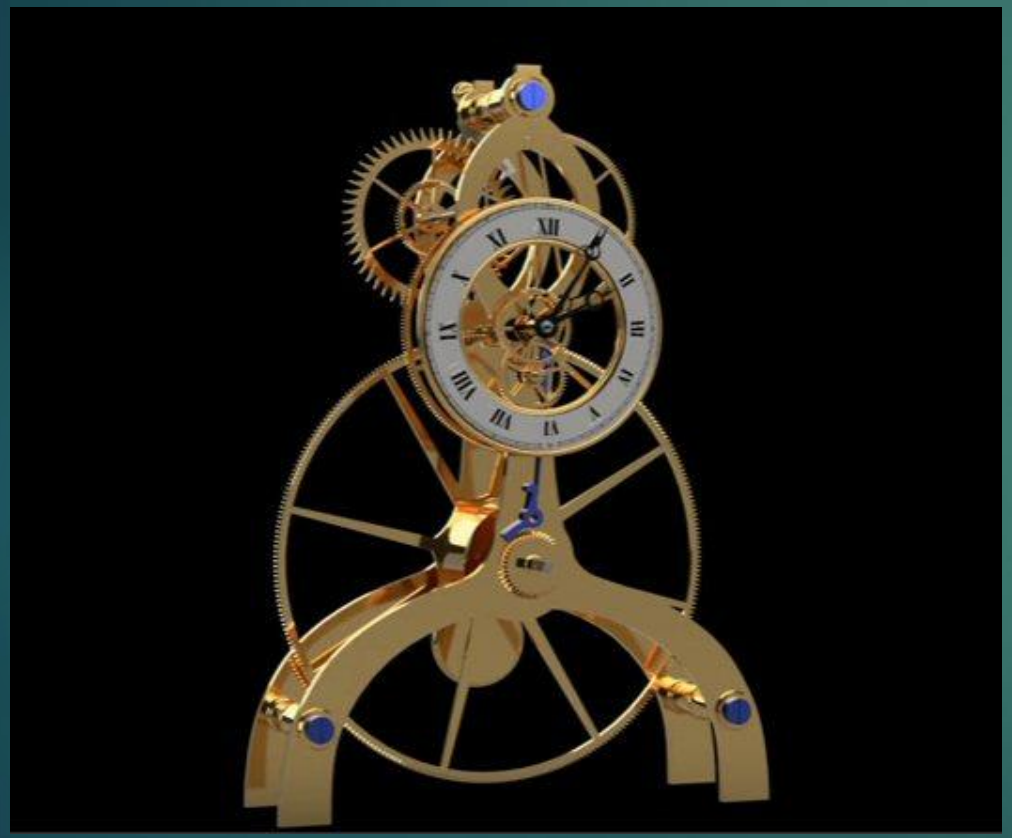
- What tools, techniques and materials are required to build a skeleton clock?
- What is the cost of building a skeleton clock?
- Only considering skeleton clocks… no watches.

Clickspring Channel YouTube



- Skeleton Clock
- 24 videos made with objective to encourage people to make their own clock.
- Many pages with a quarter million views and one with a half million views.
- Manual metal working techniques
- Main spring purchased rather than made
- Materials:
  - Engravers Brass C353 (Frame, Circle Gears)
  - Drill Rod (Larger Arbors, Pinion Gears)
  - Hardened Clock Arbor Steel (Smaller Arbors)
  - O-1 Tool Steel (Special Parts, e.g. Escapement)
  - Mild Steel (Screws)

Ken Toonz Channel YouTube

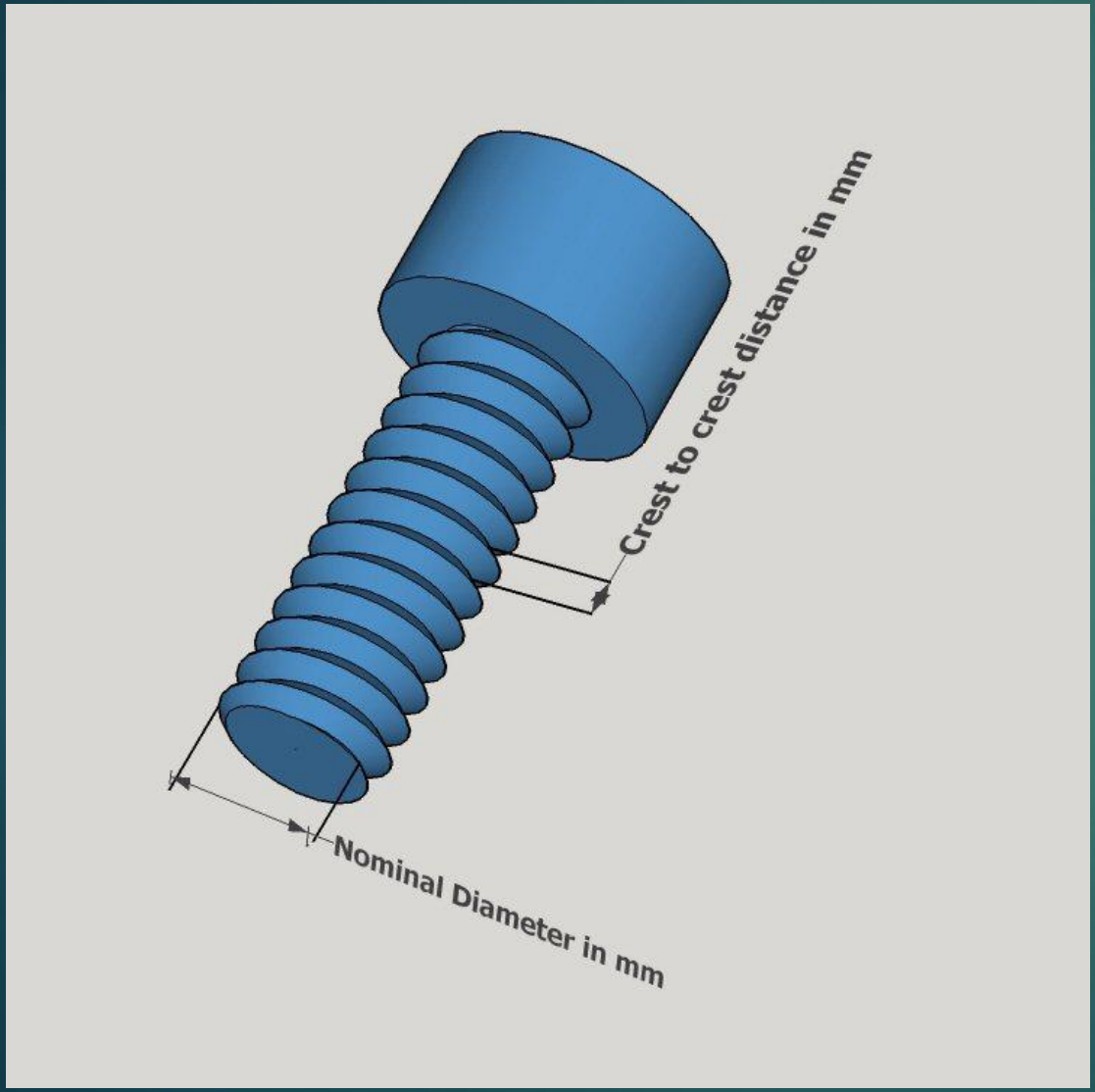


- Yet another skeleton clock only done with CNC
- Pinions purchased rather than made

Go Metric

- Clock parts, tools and accessories are nearly all metric based… as far as I can tell.
- U.K. seems to be the world center for amateur clock making.
- WW (Webster/Whitcomb) collet system, used in all horological lathes, was invented in the U.S.
- WW collets follow metric specifications… even those from Starret.
- It will be far easier to make a clock under the metric system than under the imperial system.

About Metric Threads



- Metric screws are specified in millimeters (mm)
- A penny is about 1.5 mm thick
- Metric screw specifications begin with the letter "M"
- First number is the nominal diameter in mm
- Second number is the crest to crest distance of a single thread (i.e. thread size).
- M3.0 x 0.5 means:
  - 3.0 mm in diameter
  - 0.5 mm is the size of a single thread

About Machine Tools

- Skeleton clocks = small parts
- Small parts = small tools
- Small tools = out of the garage and into the AC
- Only considering desk top sized tools

Bergeon Lathe

- Watch and Clock Makers Lathe
- Otto Frei vendor
- Only $37,797.00
- What's wrong with it?
- A manual tool made obsolete by CNC

Used Horological Lathes

- Because so many horological tools depend on the WW collet system, tool parts can very often be moved and used on machines from different manufacturers. There are a lot of "Franken-lathes" out there.
- Many used lathes have parts missing or, are themselves only part of a lathe. Or, in the case of collets, maybe the previous owners only purchased the parts they absolutely needed.
- It is often hard or impossible to tell the real condition, completeness, or origin(s) of a lathe from an EBAY writeup.
- Many EBAY sellers have inherited the tools and don't really know anything about them.
- Horological lathes are scaled for work on watches. You don't need one to make a clock.
- Horological lathes are only good for horological work or maybe some delicate instrument work.
- Niels Vrijlandt operates a used horological tool business.

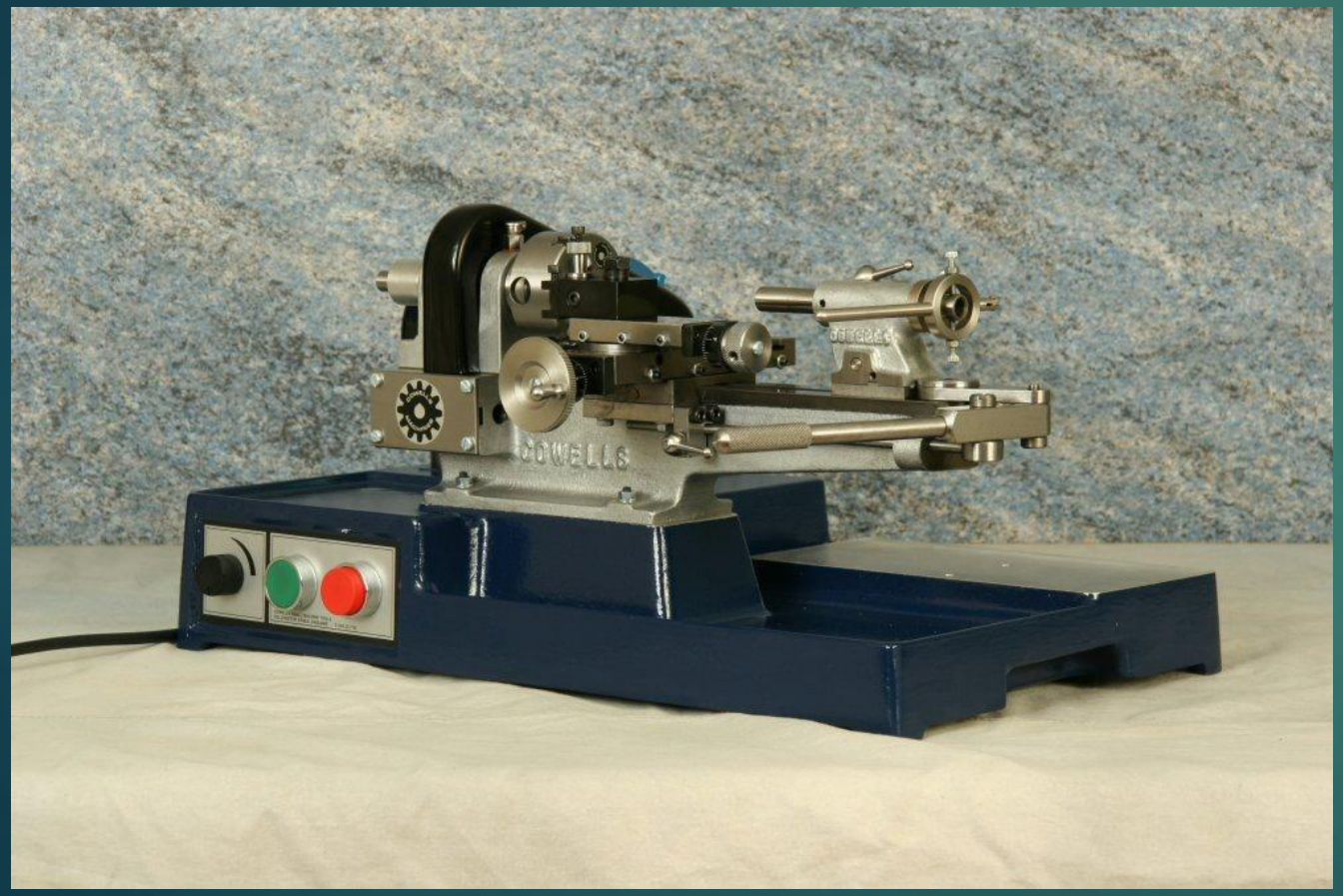
Tormach

- Lathe CNC, Tormach 15L Slant Pro
- Little Machine Shop
- $11,540.00
- Computer extra (Linux)

Tormach

- Milling Machine CNC, Tormach PCNC 1100
- Little Machine Shop
- $8,480.00
- Computer extra

Cowell's

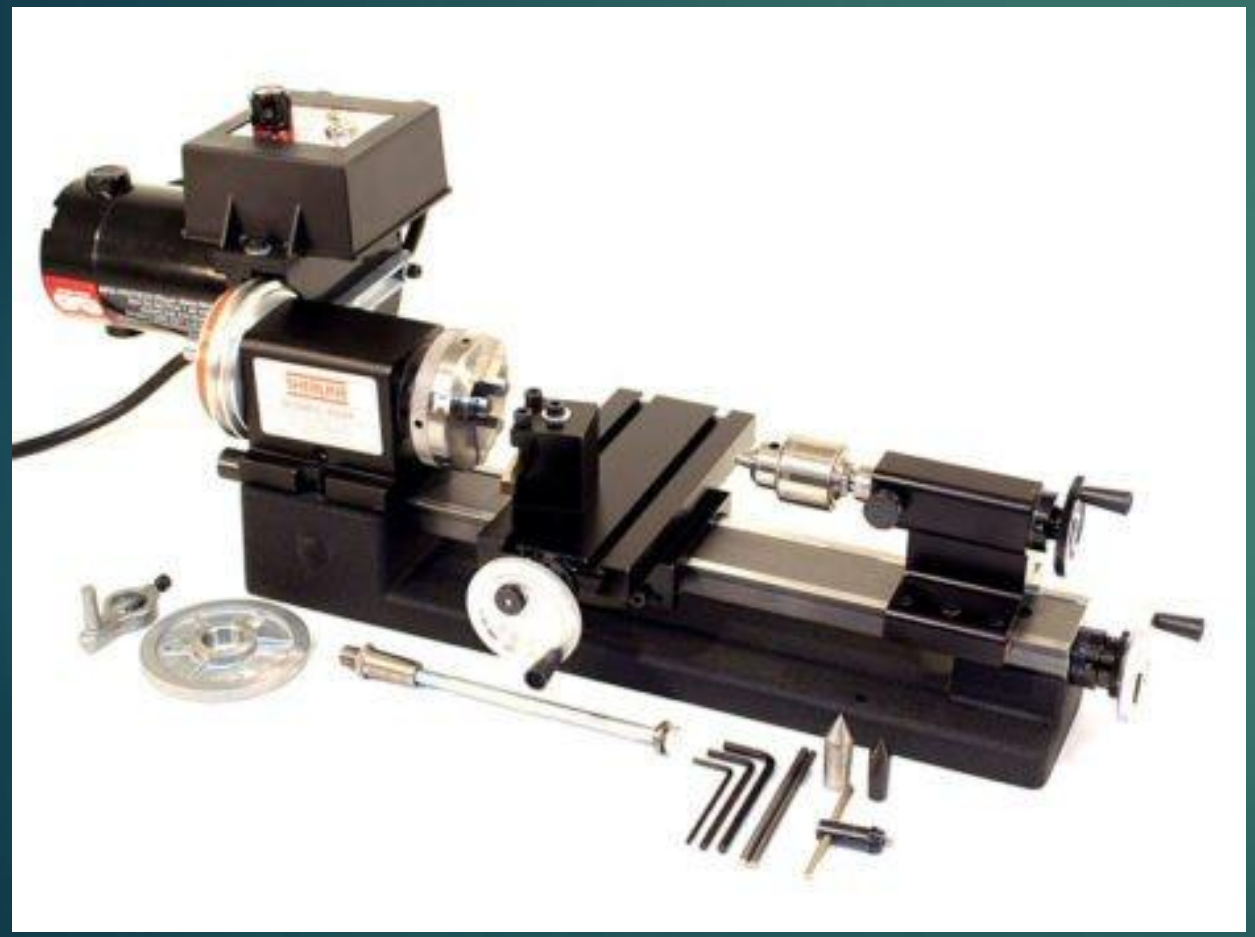


- Clock and Watch Makers Lathe
- Cowell's (UK)
- $3469.44
- Aluminum Base
- Cast iron bed, cross slide…
- Steel and Stainless Steel
- Many clock makers accessories
- Variable speed but not CNC
- Different lathe versions for Horology and Model Engineering
- Very high quality

Cowell's

- Milling Machine
- Cowell's (UK)
- $2968.73
- Aluminum Base
- Cast iron and steel
- Variable Speed
- Very High Quality

Sherline Lathe 3.5 x 8



- Clickspring used this lathe to make his Skeleton Clock
- $772.00
- Aluminum lathe bed
- Many clockmaking accessories available
- Metric version available
- Morse #1 taper in spindle

Sherline Mill

- Aluminum
- Variable Speed
- Many accessories available.

HiTorque 7x16 Deluxe Mini Lathe

- Little Machine Shop
- Actually a Sieg lathe (Shanghai)
- $1,249.95
- Cast Iron
- Variable Speed
- 500 watt brushless DC motor
- DRO, cross slide, compound
- Cuts imperial and metric threads

What I like about the HiTorque Lathe

- Cast iron construction
  - Bed
  - Headstock
  - Tailstock
  - Cross Slide
  - Compound Slide
- Variable speed DC (no gears)
- Tachometer available
- Metal change gears available
- Four Jaw Chuck available
- MT3 spindle and MT2 tail stock match my Jet lathe
- Taper bearings available for $14 (DIY install)
- Can cut left-handed threads
- DRO's can output in metric.

Sieg Mini-lathe Quality Problems

Tail Stock Flat Way

Tail Stock V Way

Sieg Mini-lathe Quality Problems

Carriage Flat Way

"It looks like the final way finish was done with a couple swipes with an angle grinder."

Some ways were concave. Others had only one or two points of contact.

Carriage V Way

Note the paint on the lower left of the V way.

Sieg Mini-lathe Quality Problems

- All Sieg Mini-lathes are manufactured in the same factory in Shanghai.
- Different resellers (Harbor Freight, Northern Tool, Grizzly, Little Machine Shop) request different quality options from the factory.
- Any reseller may receive Mini-lathes of varying quality. Gems and Lemons.
- Factory never rejects any machine for QC considerations. They ship everything they make.
- Rigidity problems with looseness in the carriage, cross slide and compound slide are very common. They seem to be the rule rather than the exception.
- Sometimes runout problems with the spindle.

Solutions to Mini-lathe Problems

- Every Mini-lathe has to be torn down and rebuilt before use.
- Rebuilding commonly involves:
  - Honing all the ways. Typically baby oil and 600 grit silicon carbide powder used
  - Replacing the saddle-to-bed attachments.
  - Replacing or reshaping all gibs. LMS offers brass replacement gibs.
  - Addition of lock down screws for the cross slide and compound slide.
  - Replacement of factory screws with at least hardware store quality screws.
  - Adjustment and alignment of all lead screws.
  - Cleaning.

Imperial Lead Screw and Cutting Metric Threads

	A	B	C	D	E	F	G	H	I	J	K	L
31												
32	Lead Screw 16 TPI											
33	A Gear	B Gear	C Gear	D Gear	Pitch mm	Should Be	Difference					
34	20	57	35	65	0.299932524	0.3	6.74764E-05					
35	20	80	50	57	0.348135965	0.35	0.001864035					
36	20	55	45	65	0.39965035	0.4	0.00034965					
37	20	60	55	65	0.44775641	0.45	0.00224359					
38	21	50	45	60	0.5000625	0.5	6.25E-05					
39	21	50	45	50	0.600075	0.6	7.5E-05					
40	35	55	45	65	0.699388112	0.7	0.000611888					
41	35	65	50	57	0.749831309	0.75	0.000168691					
42	40	65	45	55	0.799300699	0.8	0.000699301					
43	21	50	60	40	1.000125	1	0.000125					
44	35	40	45	50	1.25015625	1.25	0.00015625					
45	40	50	65	55	1.500909091	1.5	0.000909091					
46	40	35	55	57	1.750626566	1.75	0.000626566					
47	40	50	55	35	1.995714286	2	0.004285714					
48	60	55	65	45	2.501515152	2.5	0.001515152					
49	65	55	80	50	3.001818182	3	0.001818182					
50	65	21	57	80	3.501004464	3.5	0.001004464					
51	55	50	80	35	3.991428571	4	0.008571429					
52	55	21	65	60	4.50421627	4.5	0.00421627					
53	55	35	80	40	4.989285714	5	0.010714286					
54	50	55	80	21	5.497835498	5.5	0.002164502					
55	55	21	65	45	6.005621693	6	0.005621693					
56	57	21	65	35	8.002295918	8	0.002295918					

Metric Lead Screw and Cutting Metric Threads

71	Change Gear Setup for Common Metric Screw Threads											
72												
73	Lead Screw Pitch 1.5 mm				1.5*((B*D)/(A*C))	Gears	Modulus 1		Key 3 mm		Pressure Angle 14.5 ?	
74	A Gear	B Gear	C Gear	D Gear	Pitch mm		Bore 12 mm		Width 8 mm			
75						Teeth						
76	50	20	60	20	0.2	0	10	2 * 20	2 * 30	2 *40	50	2 * 60
77	40	20	50	20	0.3	1	11	21	31	41	51	61
78	50	20	60	35	0.35	2	12	22	32	42	52	62
79	50	20	60	40	0.4	3	13	23	33	43	53	63
80	50	30	60	30	0.45	4	14	24	34	44	54	64
81	60	30	60	40	0.5	5	15	25	35	45	55	65
82	50	30	60	40	0.6	6	16	26	36	46	56	66
83	50	35	60	40	0.7	7	17	27	37	47	57	67
84	40	30	60	40	0.75	8	18	28	38	48	58	68
85	50	40	60	40	0.8	9	19	29	39	49	59	69
86	30	30	60	40	1							
87	40	40	60	50	1.25							
88	30	30	40	40	1.5							
89	30	35	40	40	1.75							
90	30	40	60	60	2							
91	30	40	40	50	2.5							
92	30	40	40	60	3							

HiTorque Mini Mill

- Little Machine Shop
- Another Sieg product
- $1,499.95
- Fixed cast iron column
- Variable Speed (DC motor)
- DRO sends to Bluetooth Android, 3 axis

What I like about the HiTorque Mill

- Cast Iron
  - Column
  - Base
  - Work Table
- Variable Speed DC
- No Tilt Column: Tramming Easier
- Dove Tail Column
- Tachometer available
- Power Feed available
- Metric conversion parts available
  - X & Y lead screws
  - X ,Y & Z calibration bushings
  - Bronze nuts
- R8 collet chuck matches my Rong Fu

How do you grip small parts?

- ER collets can grip a *range* of diameters.
- ER16 collets are available in metric sizes from 0.5 mm and up.
- ER16 collets are available in 0.5 mm increments.
- Theory: 11 collets from 3.0 mm to 8.0 mm should be adequate for clock work.

How to afford ER16 collets

COLLET SET, ER16, 0.5MM, 15 PCS.

TECHNIKS | Zoro #: G0511135 | Mfr #: 08316MS

0.0 No Reviews | Write the First Review

$590.00 /EA Drop ship

qty 1 Add to Cart

Item ships in **5-10 business days.**

This item ships FREE. Details

Standard ground shipping

- This set goes from 3.00 mm up to 10.0 mm in steps of 0.5 mm.
- And it's *only* $590.00
- You can get Techniks ER16 collets on EBAY for less than half this price.
- On EBAY 1.0 mm to 10.0 mm at 0.5 mm increment (19 pieces) costs $256.50. That's $13.50 each.

ER16 Collet Chucks

MT3

Straight Shank

- MT3 chuck fits spindle in both lathes
- MT3 chuck fits rotary table
- Straight shank fits:
  - ¾ in. R8 collet in both mills
  - ¾ in. C5 collet in simple indexing device
- Flexible – I can use ER16 collets nearly anywhere
- Exhibits

Webster/Whitcomb Collet International Horological Standard

Body MD inch	Body MD mm	Body Length inch	Body Length mm	Tread MD Pitch (mm) inch	Tread MD Pitch (mm) mm	TPI	Brand
0.3147	8			0.2686	6.825	40.64	Boley
				0.2756	9.850635	40	Levin
				0.2756	9.850.625	40.64	Lorch
				0.27	6.8580.635	40	Wolf-Jain
				0.2686	6.825	40.64	Adams, Boley-Leinen, Coronet, Derbyshire, Pultra
				0.2696	8.2	0.625	40.64 Schaublin, Favorite II, Favorite III
0.3158	8	0.75	19	0.2756	9.850635	40	Moder n Starrett
0.3137.9502	8	0.75	19	0.2756	9.850635	40	Sherline WW
0.3158	8	0.75	19	0.2767	0.000.75	33.87	S-96 ATM-3

- The "standard" 8 mm horological collet is the Webster/Whitcomb (a.k.a. WW collet)
- Different manufacturers have built this collet to slightly different specifications.
- Some WW collets are interchangeable between machines; some are not.

Sherline WW Collets

Sherline WW Collet Part Numbers, Sizes and Decimal Equivalents

WW Collets—Available Inch Sizes

PART NO.	FRACTION SIZE	DECIMAL
116001	1/64"	.016"
116002	1/32"	.031"
116003	3/64"	.O47"
116004	1/16"	.O63"
116005	5/64"	.078"
116006	3/32"	.O94"
116007	7/64"	.109"
116008*	1/8"	.125"
116009	9/64"	.141"
116010	5/32"	.156"
116011	11/64"	.172"
116012*	3/16"	.188"
116013	13/64"	.203"
116014	7/32"	.219"
116015	15/64"	.234"
116016*	1/4"	.250"
116017	17/64"	.266"
116018	9/32"	.281"
116019	19/64"	.297"
116020*	5/16"	.313"
	OTHER	
2082	Special Order	to .320
2050	WW Blank	–
2083	WW w/ 1" blank	–

*Indicates sizes in standard collet sets

WW Collets—Available Metric Sizes

PART NO.	MM SIZE	DECIMAL
117803	0.3 mm	.012"
117804	0.4 mm	.016"
117805	0.5 mm	.020"
117806	0.6 mm	.024"
117807	0.7 mm	.027"
117808	0.8 mm	.032"
117809	0.9 mm	.035"
117810	1.0 mm	.039"
117811	1.1 mm	.043"
117812	1.2 mm	.047"
117813	1.3 mm	.051"
117814	1.4 mm	.055"
117815	1.5 mm	.O59"
117816	1.6 mm	.063"
117817	1.7 mm	.067"
117818	1.8 mm	.071"
117819	1.9 mm	.075"
117820*	2.0 mm	.079"
117821	2.1 mm	.083"
117822	2.2 mm	.087"
117823	2.3 mm	.091"
117824	2.4 mm	.094"
117825	2.5 mm	.098"
117826	2.6 mm	.102"
117827	2.7 mm	.106"
117828	2.8 mm	.110"

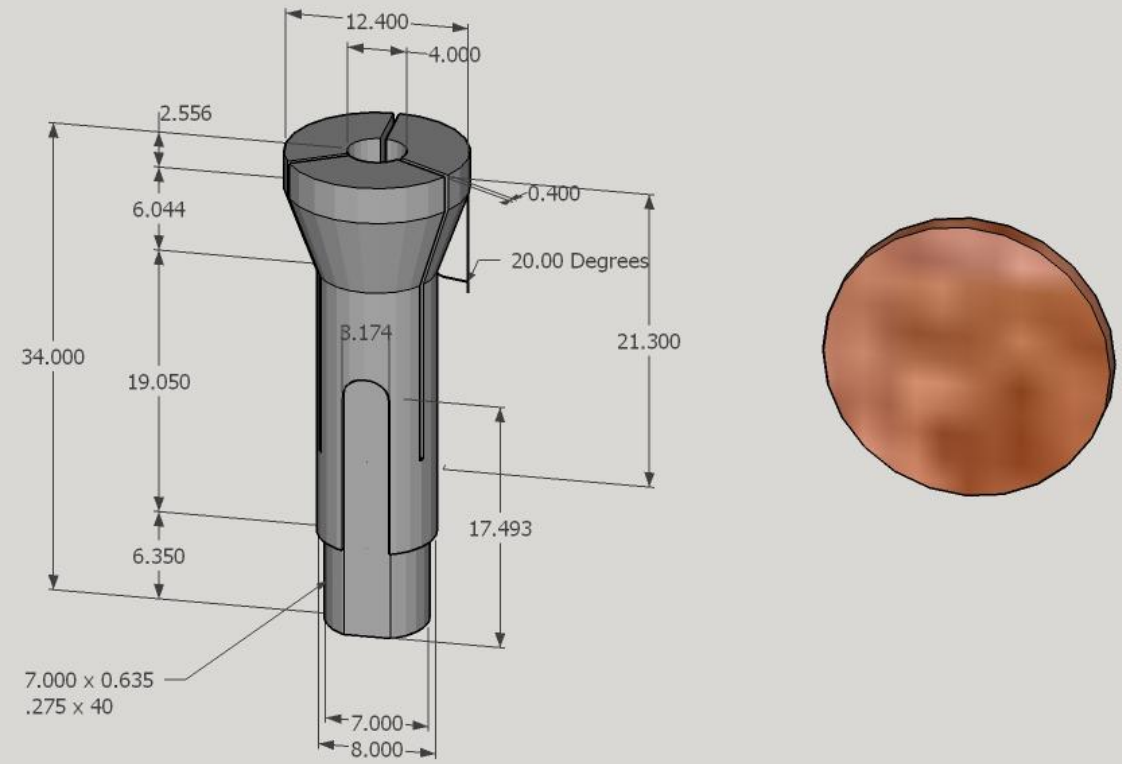
PART NO.	MM SIZE	DECIMAL
117829	2.9 mm	.114"
117830*	3.0 mm	.118"
117831	3.1 mm	.122"
117832	3.2 mm	.126"
117833	3.3 mm	.130"
117834	3.4 mm	.134"
117835	3.5 mm	.138"
117836	3.6 mm	.142"
117837	3.7 mm	.146"
117838	3.8 mm	.150"
117839	3.9 mm	.154"
117840*	4.0 mm	.158"
117841	4.1 mm	.161"
117842	4.2 mm	.165"
117843	4.3 mm	.169"
117844	4.4 mm	.173"
117845	4.5 mm	.177"
117846	4.6 mm	.181"
117847	4.7 mm	.185"
117848	4.8 mm	.189"
117849	4.9 mm	.193"
117850*	5.0 mm	.197"
117851	5.1 mm	.201"
117852	5.2 mm	.205"
117853	5.3 mm	209"
117854	5.4 mm	.213"
117855	5.5 mm	.217"

PART NO.	MM SIZE	DECIMAL
117856	5.6 mm	.220"
117857	5.7 mm	.224"
117858	5.8 mm	.228"
117859	5.9 mm	.232"
117860*	6.0 mm	.236"
117861	6.1 mm	.240"
117862	6.2 mm	.244"
117863	6.3 mm	.248"
117864	6.4 mm	.252"
117865	6.5 mm	.256"
117866	6.6 mm	.260"
117867	6.7 mm	.264"
117868	6.8 mm	.268"
117869	6.9 mm	.272"
117870	7.0 mm	.276"
117871	7.1 mm	.280"
117872	7.2 mm	.283"
117873	7.3 mm	.287"
117874	7.4 mm	.291"
117875	7.5 mm	.295"
117876	7.6 mm	.299"
117877	7.7 mm	.303"
117878	7.8 mm	.307"
117879	7.9 mm	.311"
117880	8.0 mm	.315"

Sherline WW collets

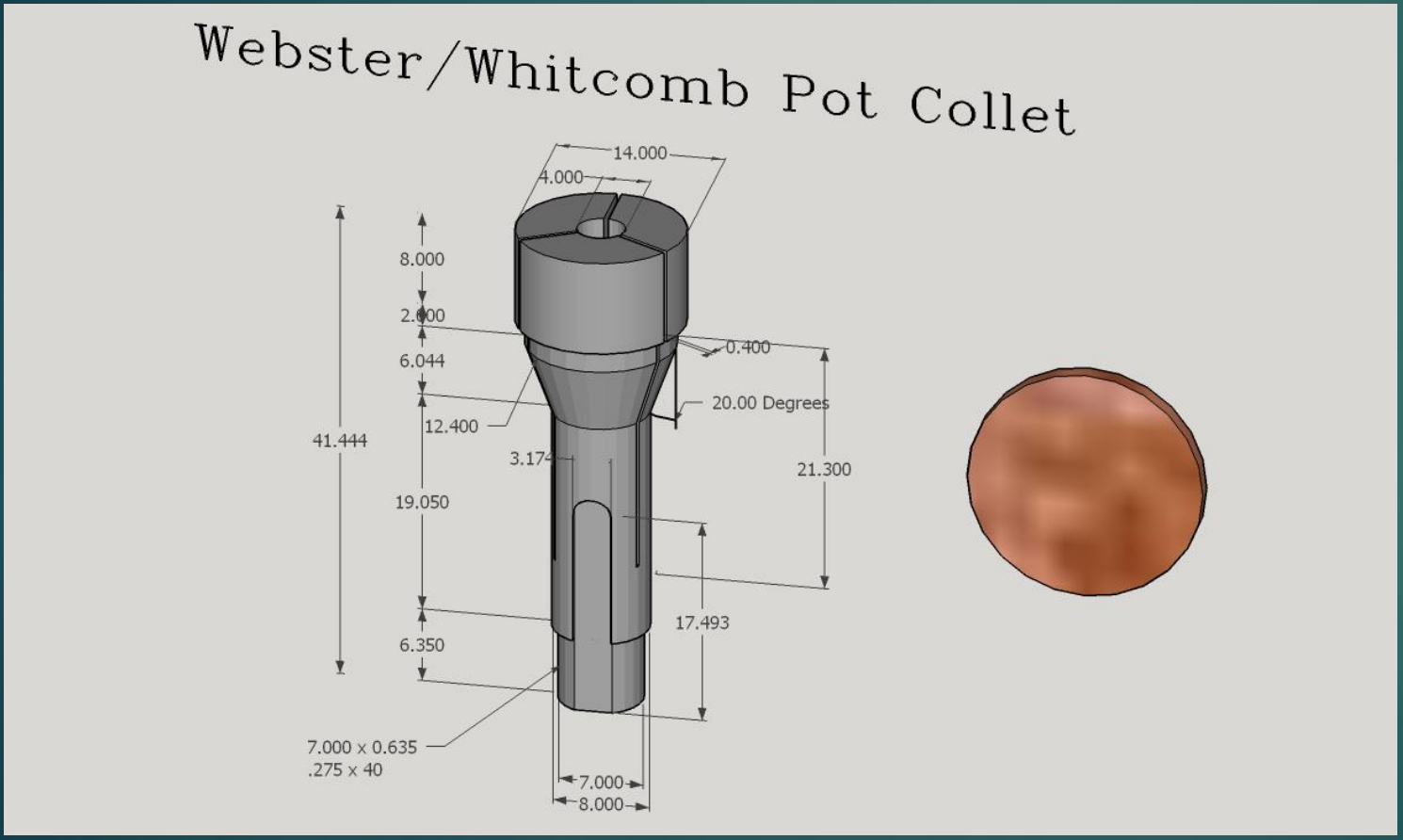
- Made by Starret
- Tool Steel
- Exhibit
- Sherline collet chuck has #1 Morse Taper
- Drawbar pulls them into a collet holder held in the jaws of a lathe… or other horological tool.
- $42 to $18 for Starret collets, $970 for complete metric WW set
- $106 and up for Cowell's WW collets.
- A complete set from Cowell's will cost in excess of $8,000
- What would it take to make you own WW collets?

WW as Norm sees it.



- Drawing based on mm
- WW collets are about 1.4 inches tall
- Penney size for comparison

WW pot collet as Norm sees it.



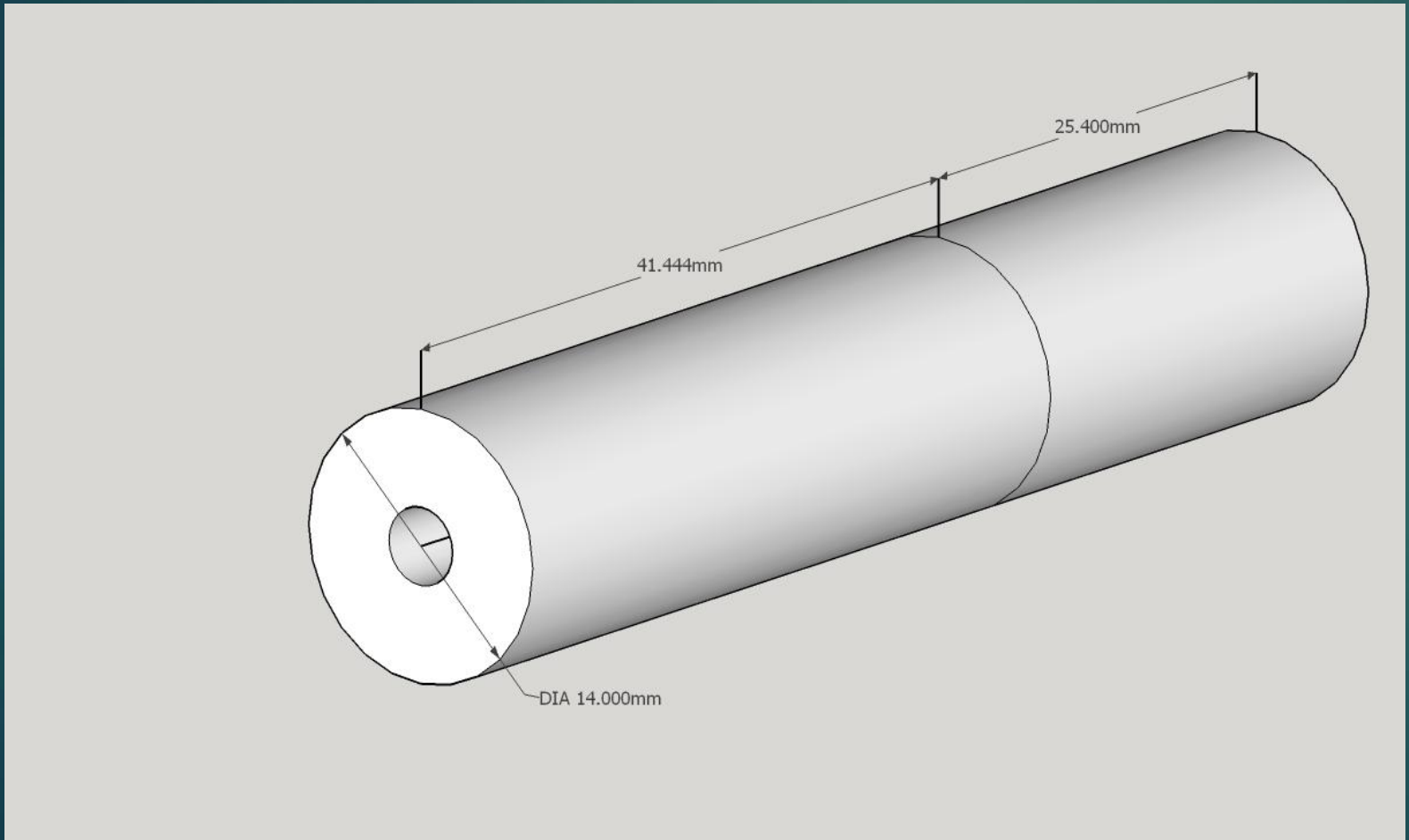
- No known specification for larger head on a pot collet.
- This head is 8.0 mm tall and 14.00 mm in diameter.
- Note the very non-standard threads:
  - M7.000 x 0.635
  - .275 x 40

AMAZON to the rescue

WW Size 0.275 - 40 Tap for Bergeon Levin Etc Watchmaker Lathe Drawbar
by Merlintools
$22.00 + $6.49 shipping
★★★☆☆ ▾ 2

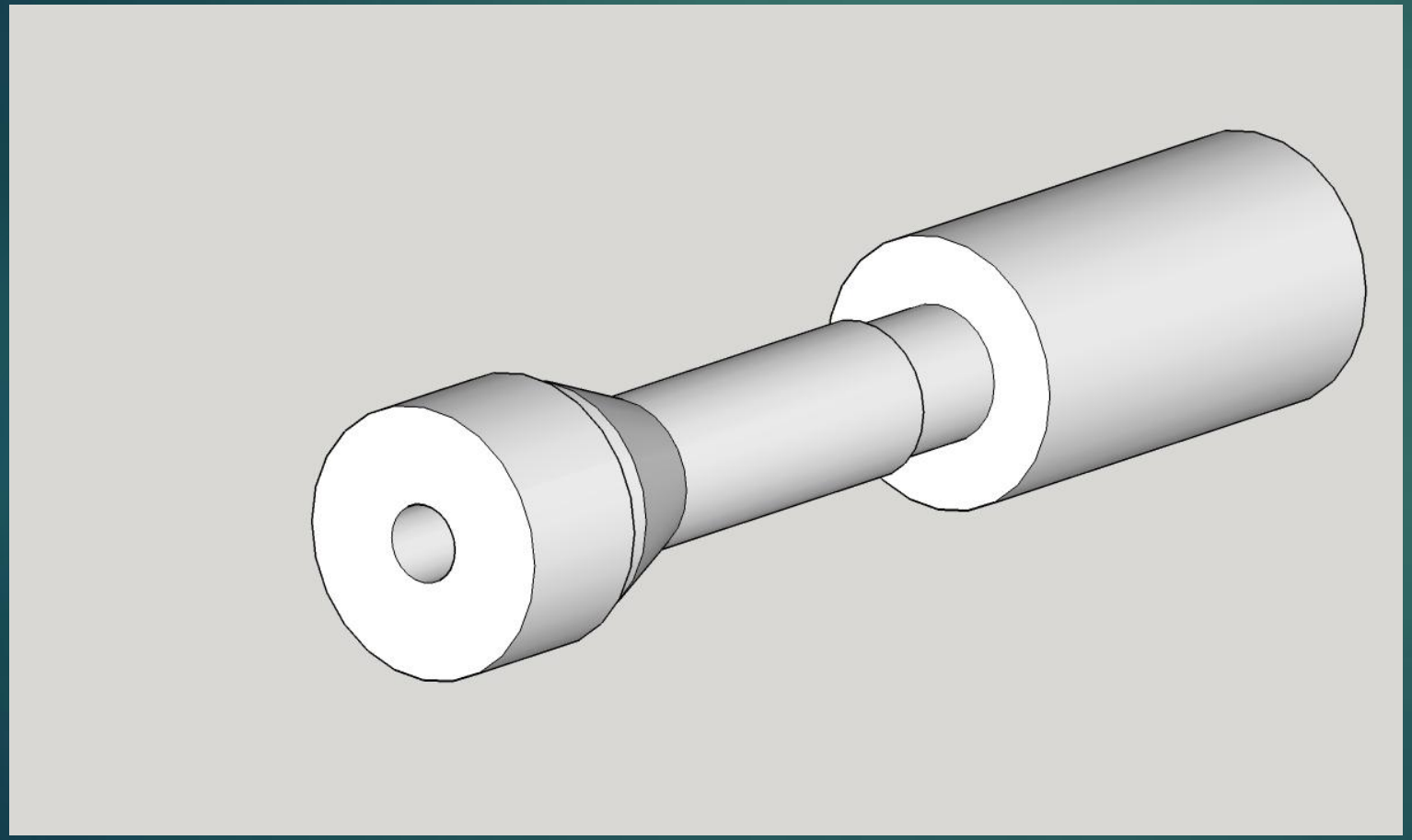
WW Size 0.275 - 40 Die for Bergeon Levin Watchmaker Lathe
by Merlintools
$20.00 + $6.49 shipping
★★★★½ ▾ 2

Making WW Collets Step 1



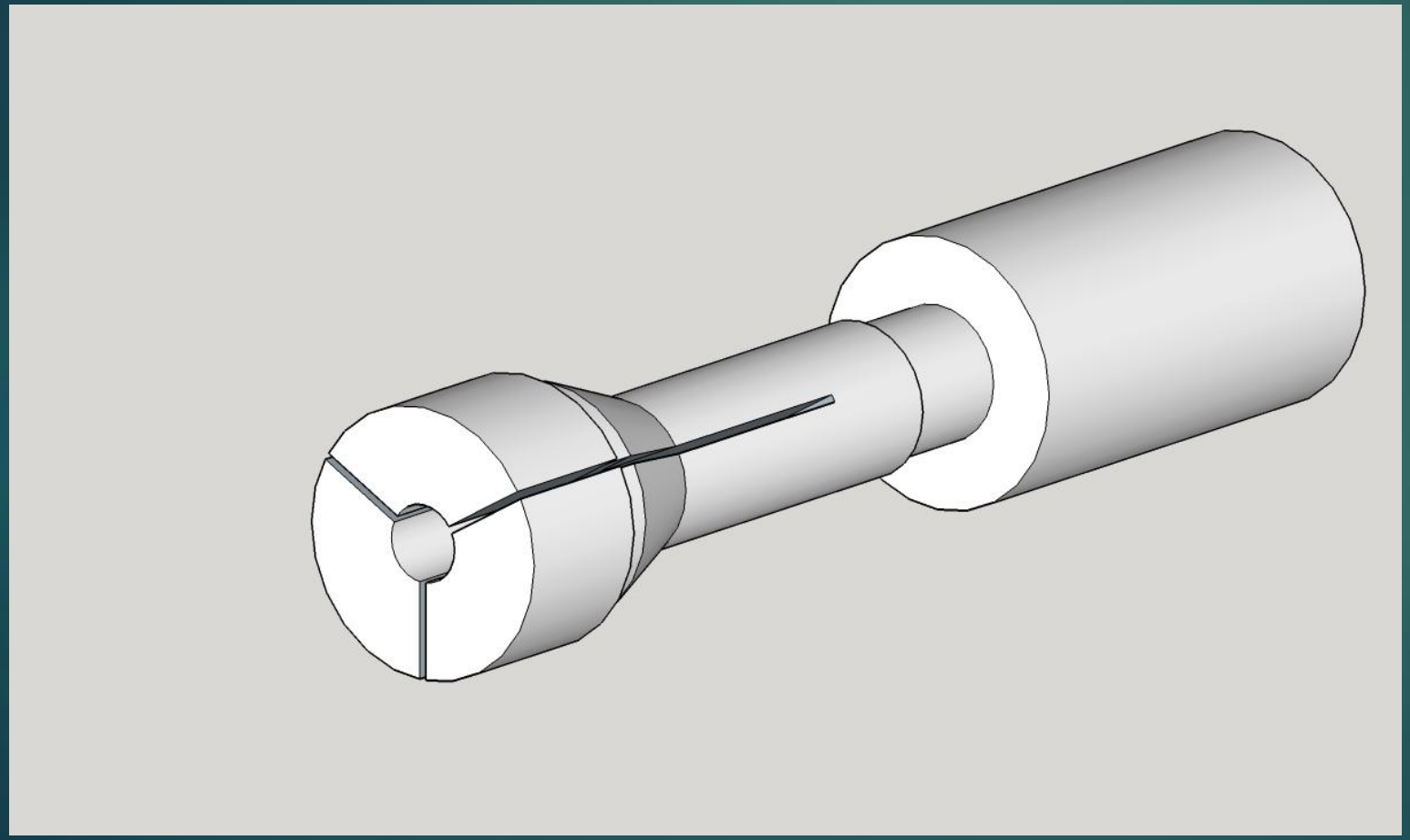
- Mount piece of 14 mm O-1 rod in lathe.
- 1 inch extra length for holding.
- Face off ends
- Drill hole and ream to required diameter.

Making WW Collets Step 2



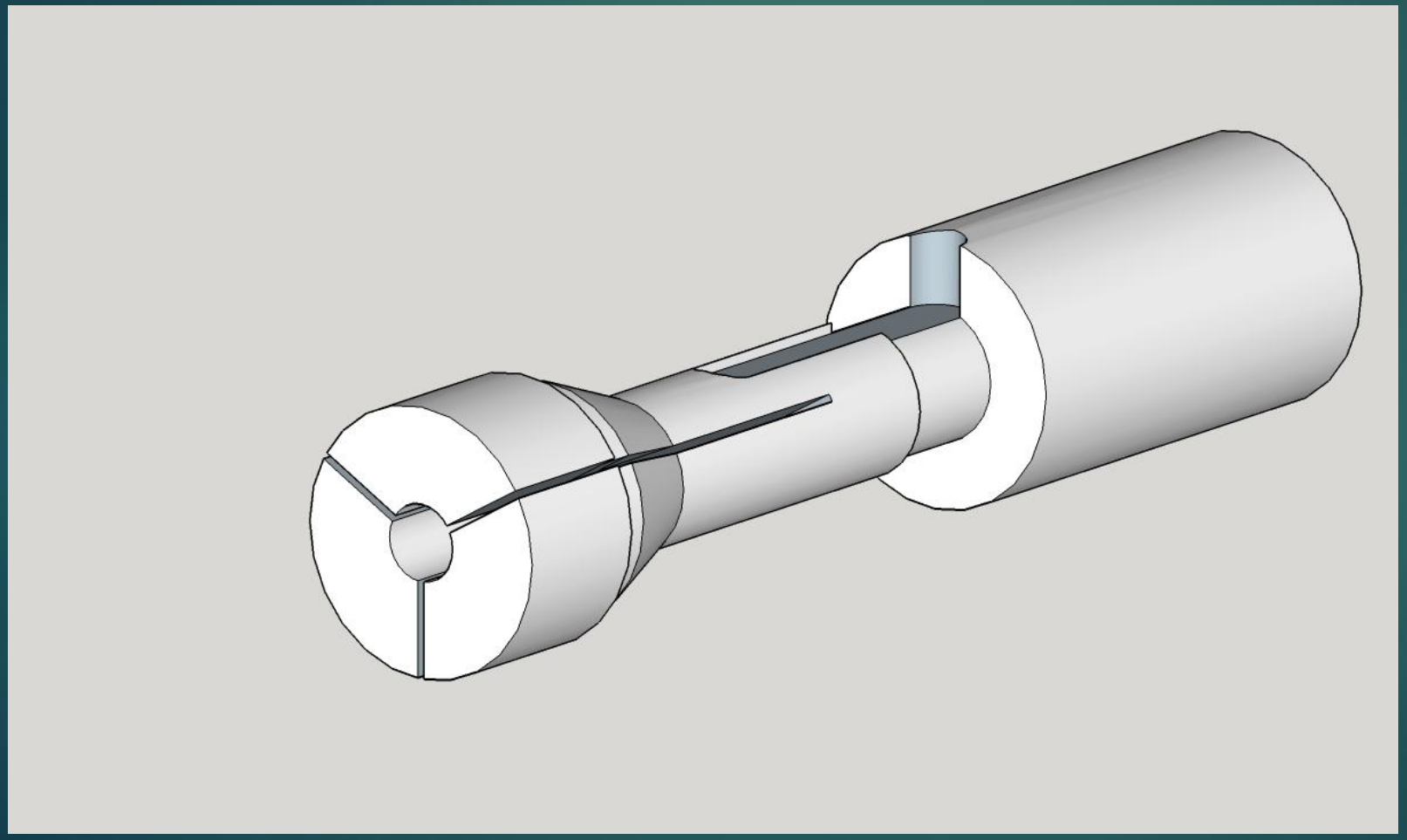
- Turn collet body.

Making WW Collets Step 3



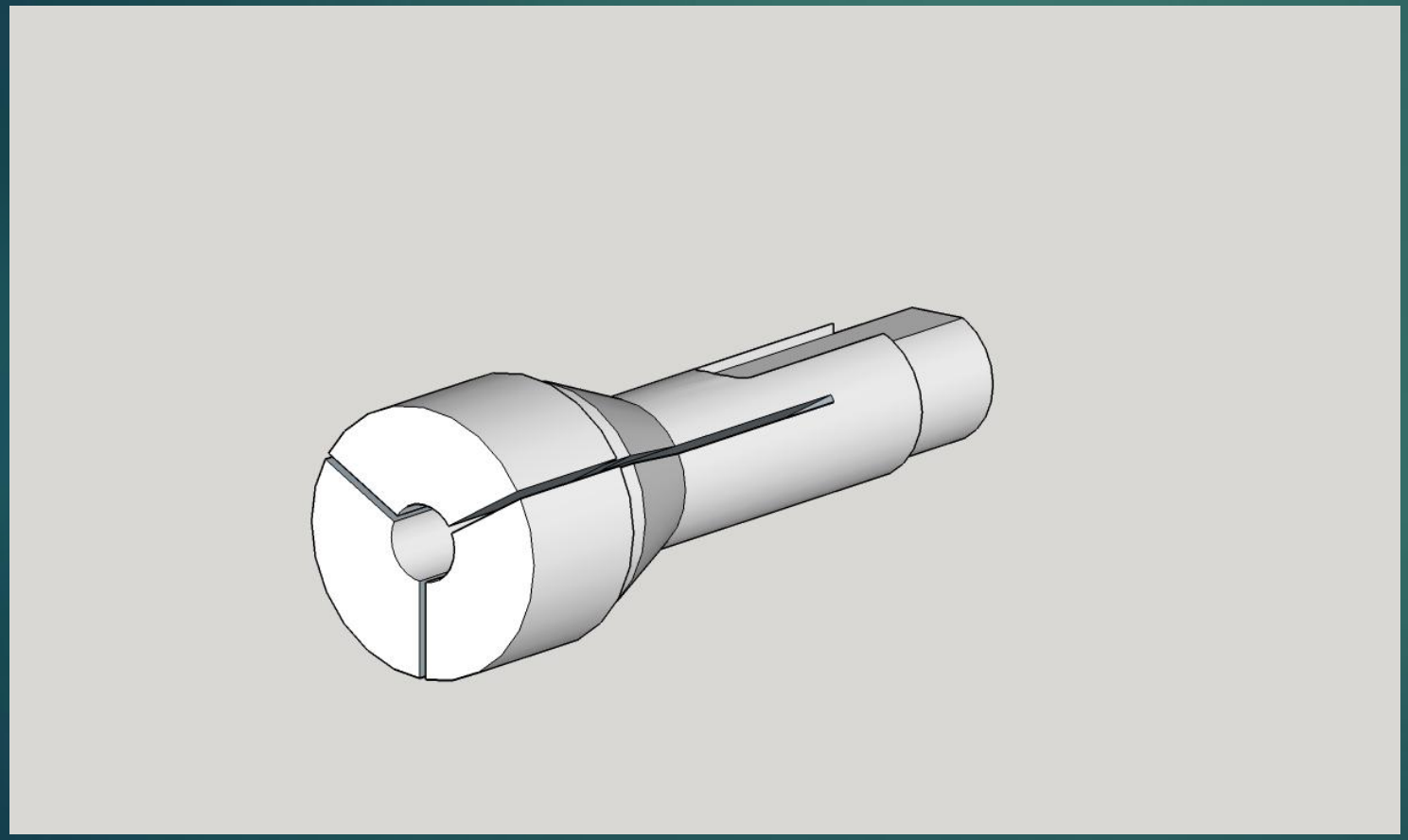
- Mount workpiece in simple indexing tool on mill.
- Exhibit
- Cut slits every 120 degrees.

Making WW Collets Step 4



- With work piece still in indexing tool, cut keyway slot.
- 2.0 mm end mill

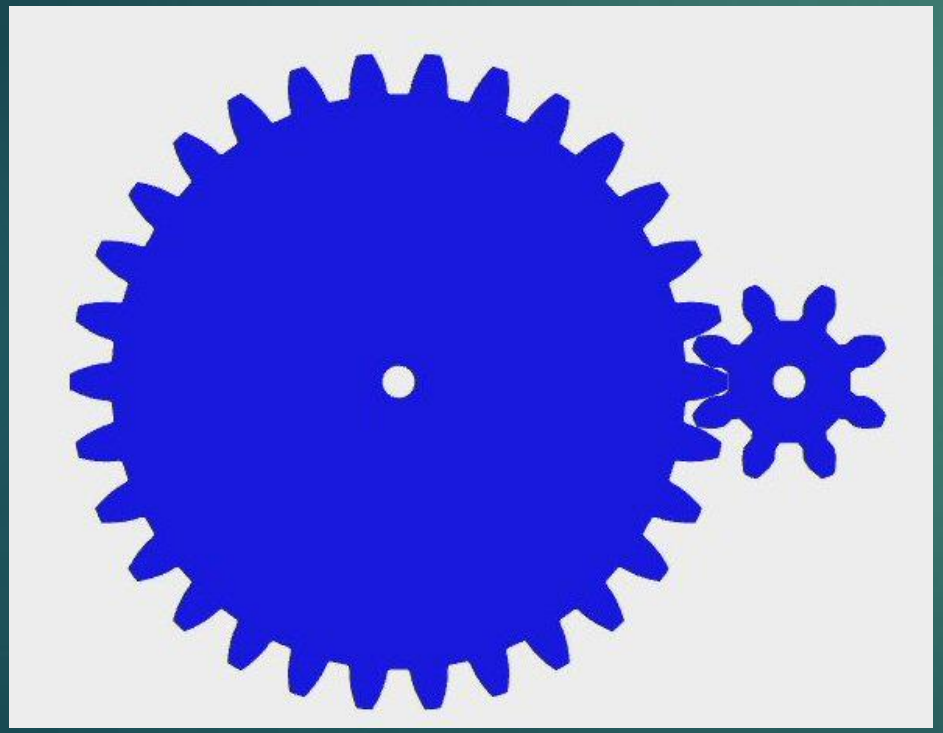
Making WW Collets Step 5



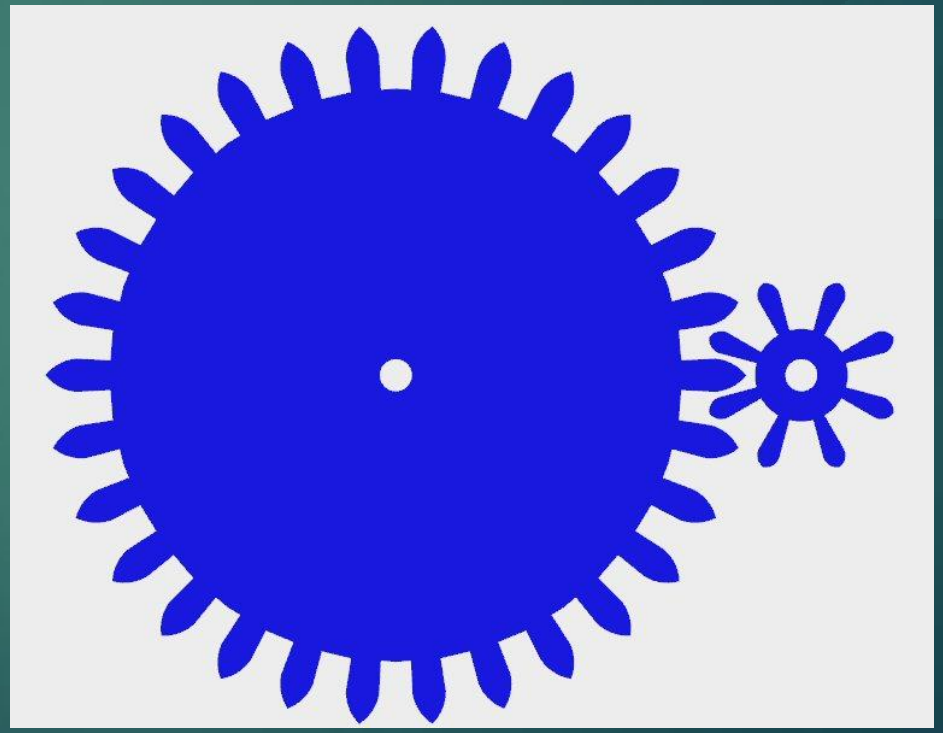
- Move work piece to lathe.
- Cut off excess stock and face base.
- Harden.
- Temper.
- Clean.

Clocks use Cycloidal Gears

Involute Gears



Cycloidal Gears



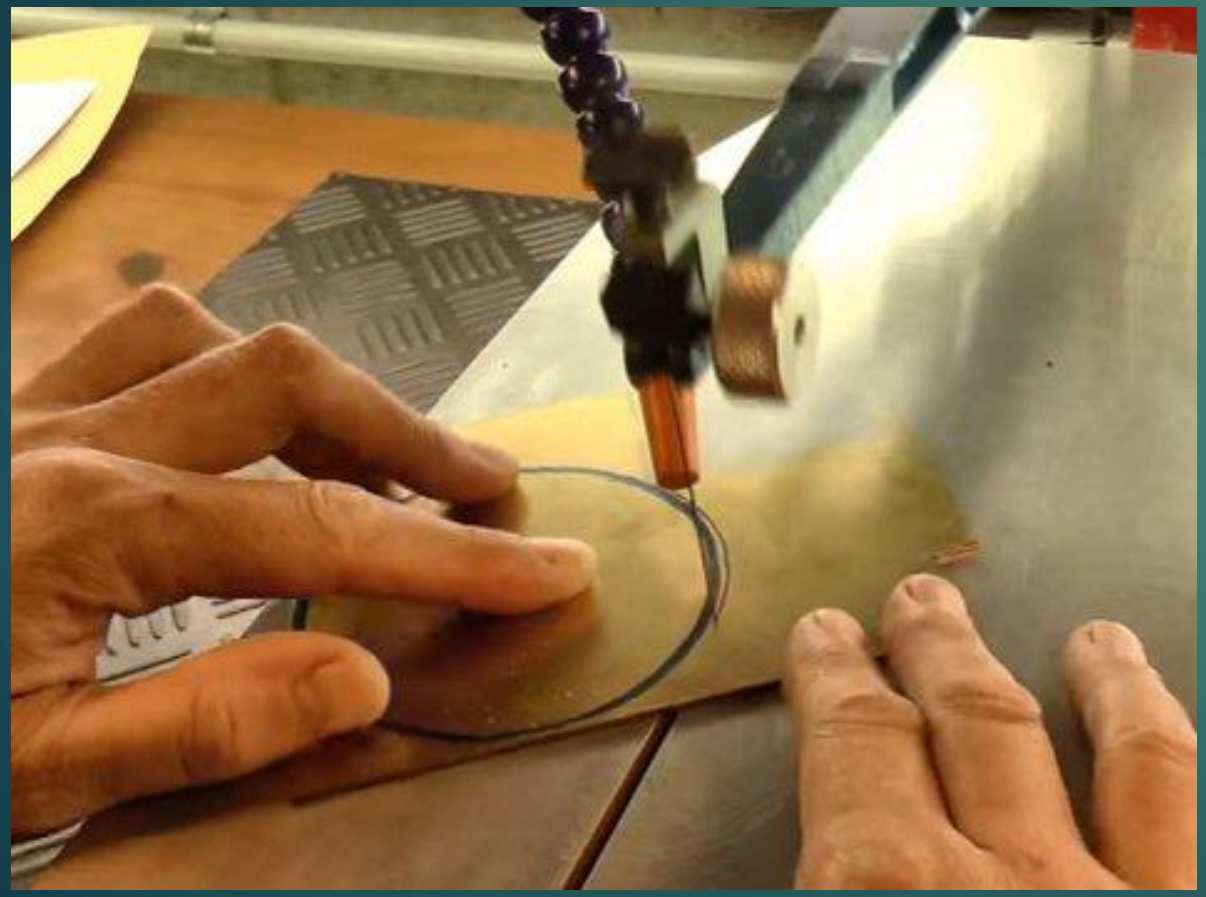
Cycloidal Gear Cutter

- P.P.Thornton in the U.K. is the best source for cycloidal gear cutters
- A metric tool
- Size specified as a modulus (reference diameter in mm / number of teeth)
- Two cutters needed for each modulus:
  - Pinions
  - Wheels
- Involute gears need a set of 8 cutters. Cutter choice depends on number of desired teeth in gear.
- Special cutters also needed for escapements and crank wheels.

Gear Materials

- Pinion gears are made of tool steel and are very hard on gear cutters.
- Wheel gears are made from engravers brass (C353). Clickspring uses plates that are 1/16 inches thick.

Making Wheel Gears: Clickspring



- Cut rough blank with scroll saw from 1/16 inch thick engraving brass plate.

The indexing problem

- Classical indexing needs an indexing plate with the proper number of holes in it.
- Skeleton Clocks often need gears having large or unusual numbers of teeth.
- Where can you get a dividing head plate for 290 divisions?

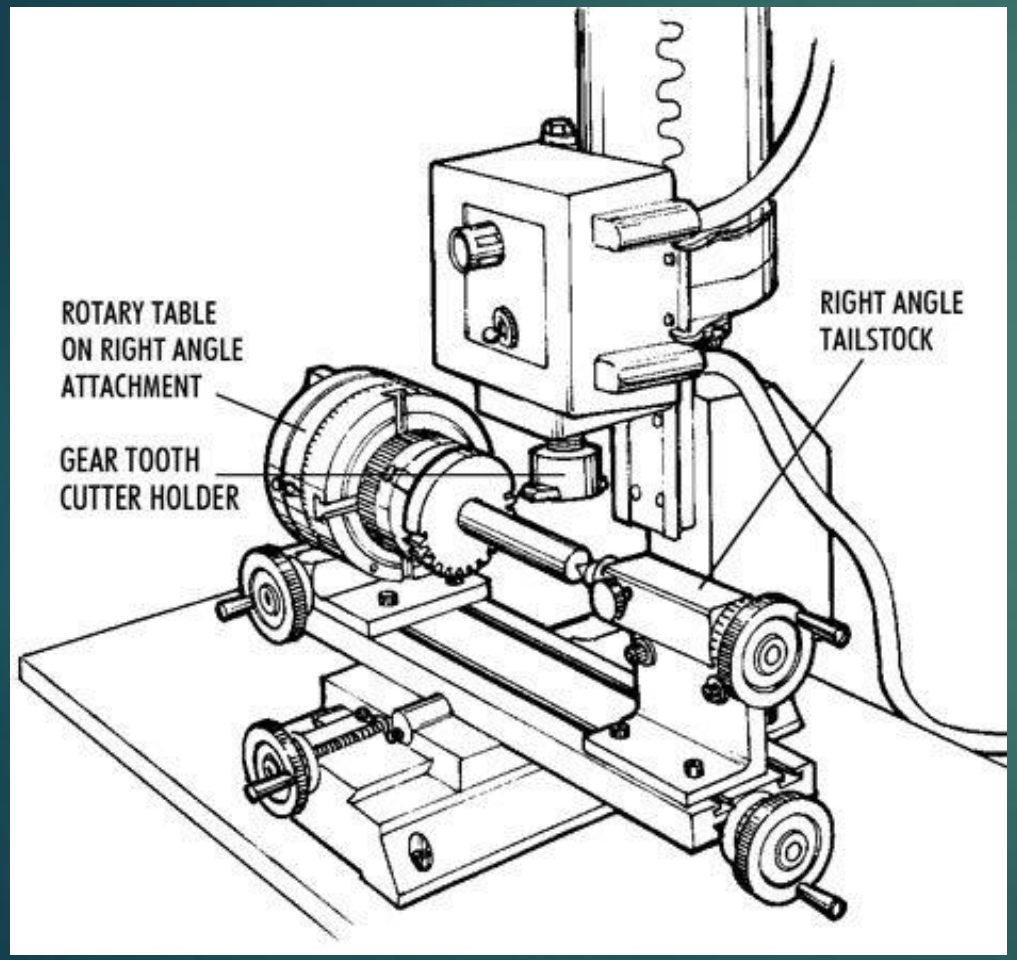
Digital indexing

- Sherline makes a 4" digital rotary table.
- $761.25
- Any number of teeth you want.
- However big gears can be a problem for a 4" rotary table.

Extended table tops available

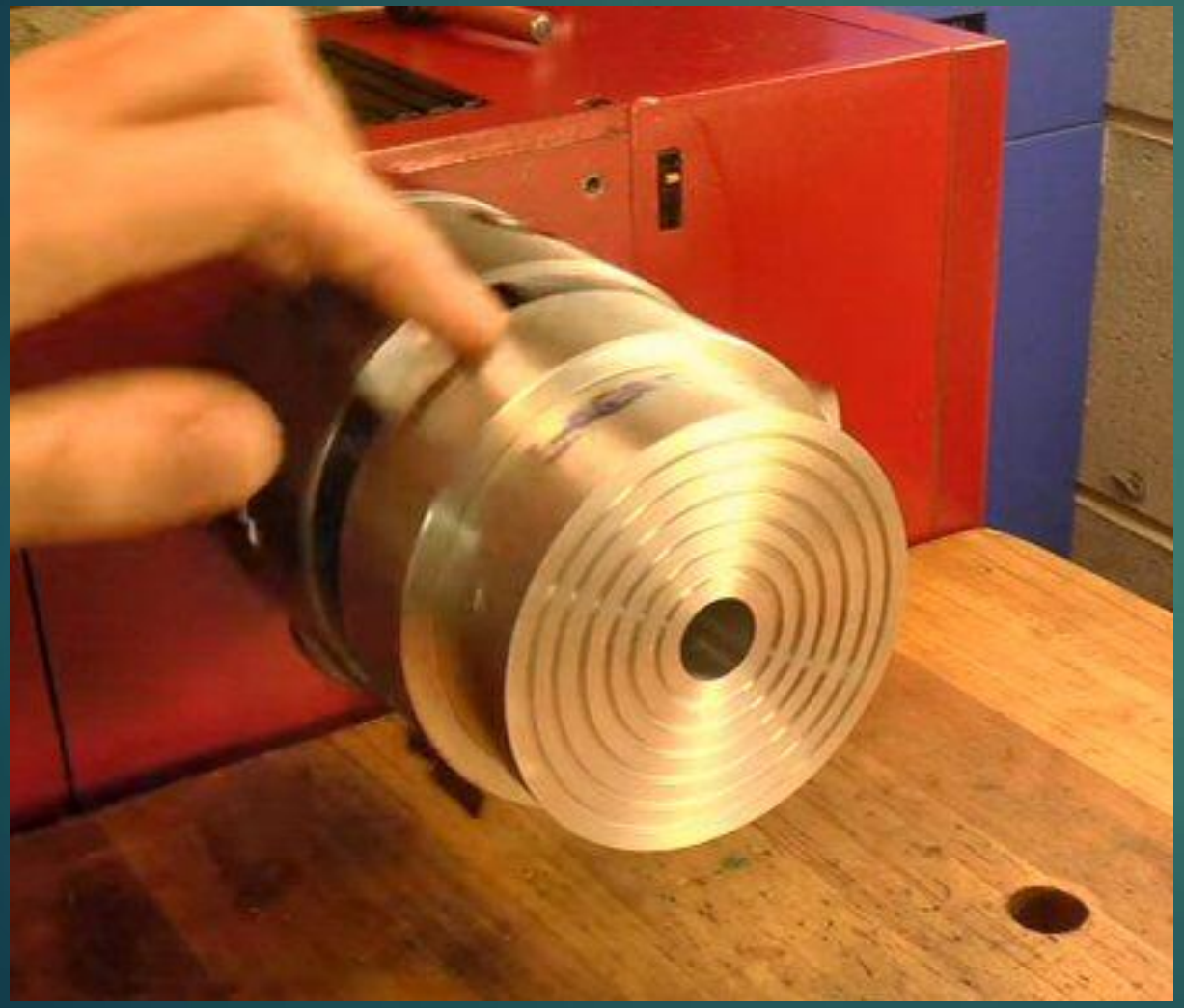
- Sherline makes larger table tops to fit their 4” rotary table.
- Clickspring’s 290 tooth gear was likely between 8 and 10 inches in diameter.
- Might need to use my Jet lathe and Rong Fu mill to make larger gears.

Also from Sherline



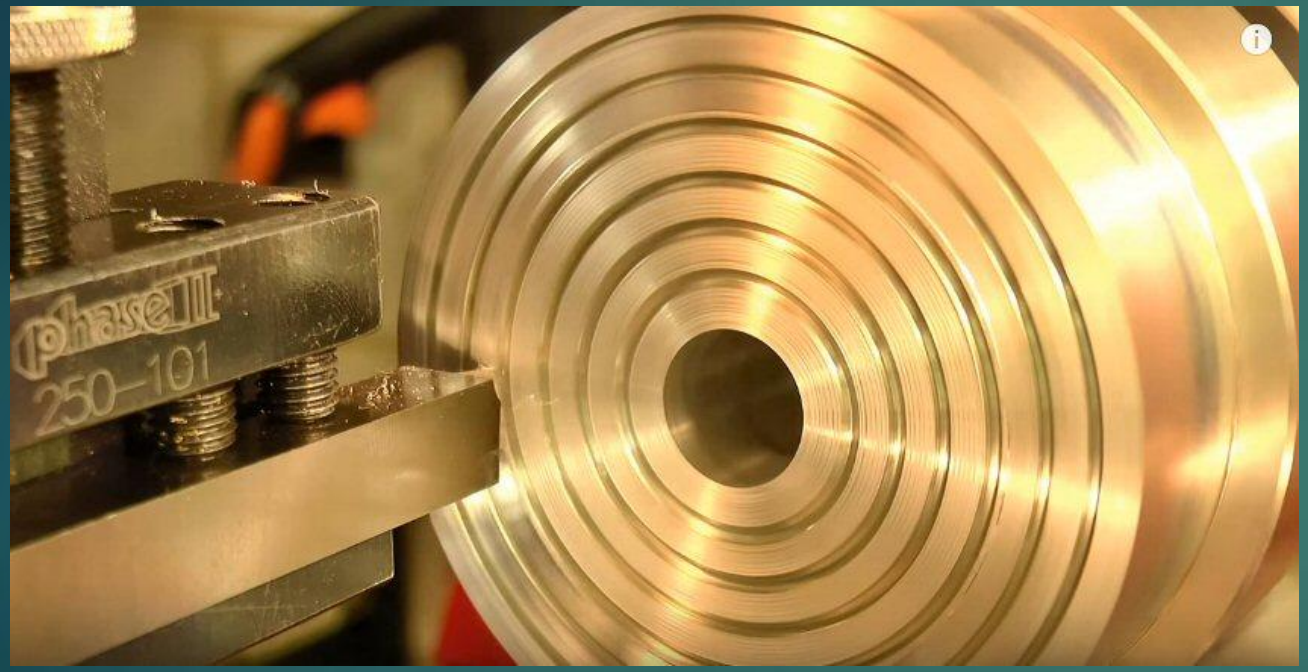
- Sherline makes an attachment that allows the digital rotary table to be set at a right angle on the work table of a mill.
- On a vertical mill the rotary table has to be oriented vertically to cut gears.

Super Glue Arbor



- Clickspring makes special arbors for mounting thin brass plate on a rotary table or lathe chuck.
- After sawing brass plates into a circular form, he glues them to the arbor with super glue.
- The blank can then be turned to size and the gear teeth cut.
- Arbor is made of aluminum and gets used up as you make more and more wheels.

Before and After



- Prior to gluing, the arbor can be turned to be in perfect alignment.
- After cutting the gear teeth, the gear is removed from the arbor by heating it with a propane torch.
- Residual super glue can be removed with acetone.

Crossing Out Wheels

- In a clock, the large wheels drive the small pinions.
- Movement of the wheel is done in a start-stop manner. The weight of the wheel is continually being accelerated and braked. This consumes energy at a higher rate than with gears in continuous motion.
- After teeth cut, wheel is a solid disk that needs to be "crossed out" to reduce weight.

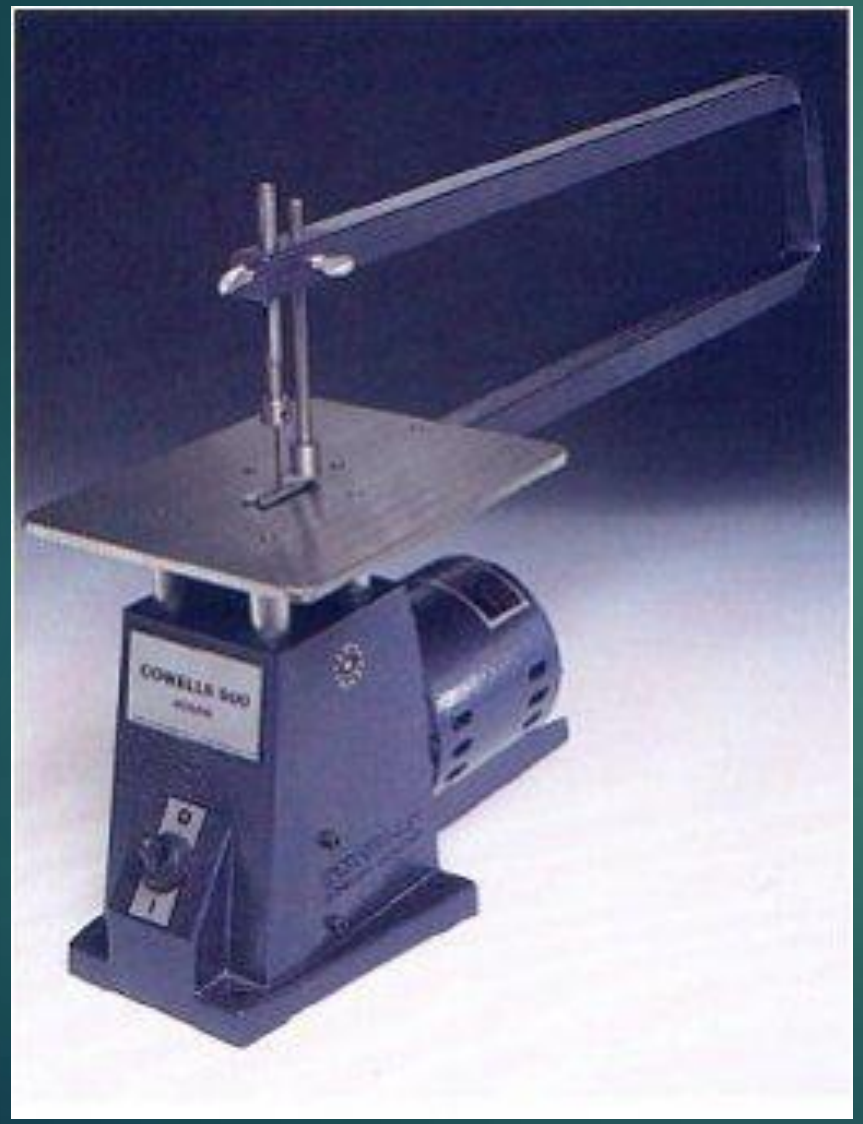
If you can afford one

- Stefan Gotteswinter uses a pantograph to cut out gear blanks… including crossing out.
- This pantograph is basically a highly specialized knee mill.
- A single wheel template can be scaled down to make any size wheel.
- Machine is made with cast iron.
- Pantograph greatly reduces amount of filing required to make a gear.

A cheaper way

- Mini scrollsaw available from Micro Mark.
- $154.99

Cowell's Scrollsaw

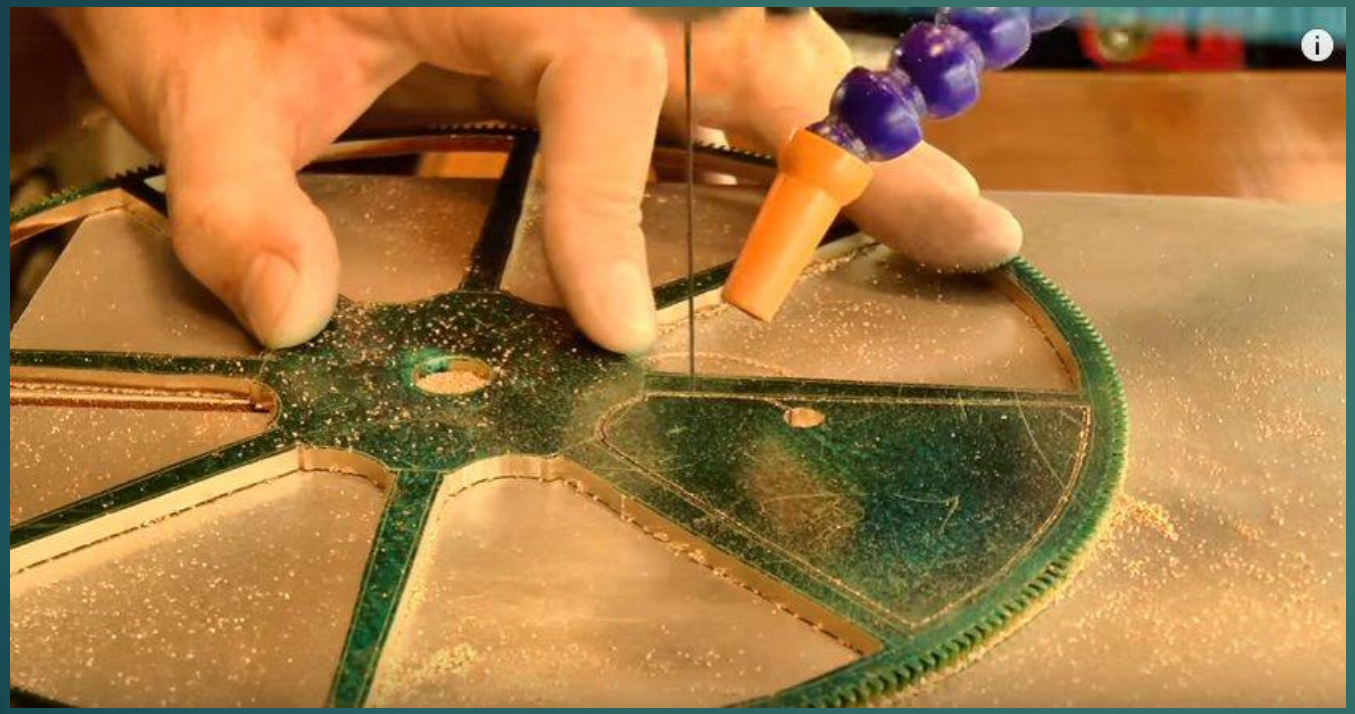


- $716 + shipping

DeWalt Scrollsaw

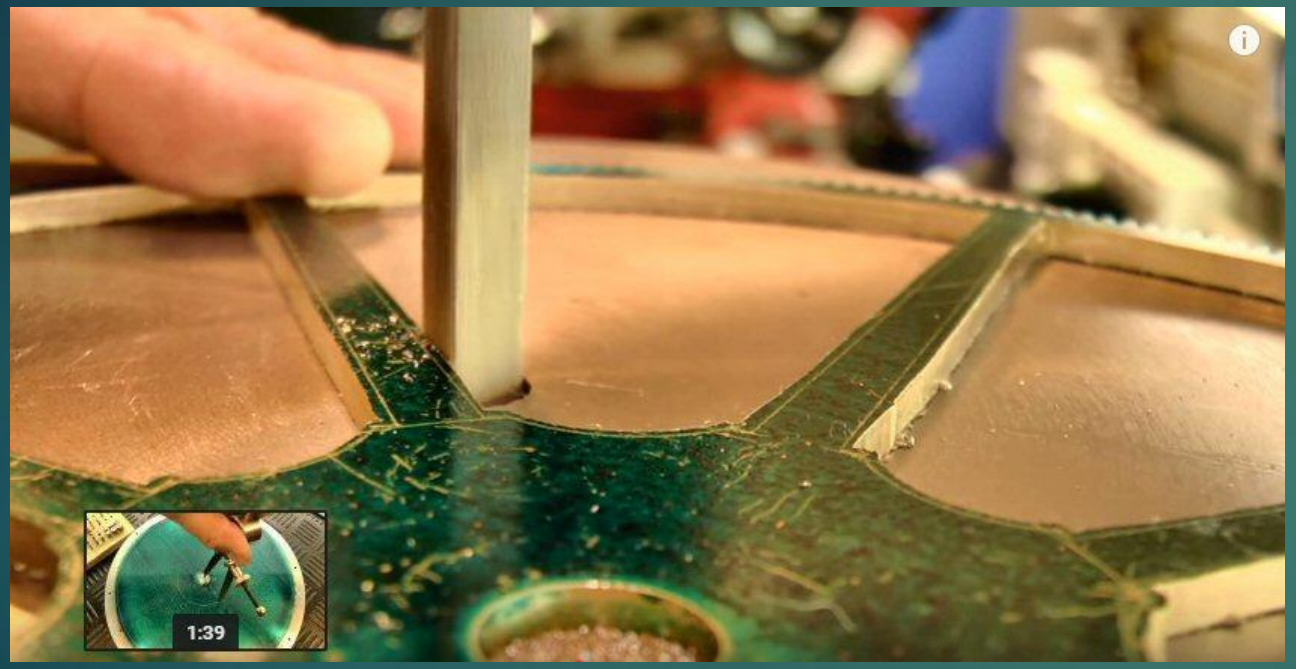
- $489.00
- 20 inch saw
- Not only cuts wheels for circle making but can cut the frame for a skeleton clock.

Scroll Sawing



- Clickspring using a scrollsaw to spoke cut his 290 tooth wheel.
- This is a rough cut only.

Power Filing



- Powered file used to remove more material from around the spokes.
- Powered file machines are obsolete and no longer manufactured.
- A motor drives the file up and down through center of cast iron work table.
- Castings and plans available to make your own powered file.
- Power Filing is not the final step.
- Just saves some work with a hand file. Also cleans and straightens the cuts made by the scroll saw.

Manual Finishing

- Clickspring made a special steel template to facilitate hand filing of wheel spokes.
- Final step in cutting a wheel.
- Still has to be polished.

Optics

- You can get eye loupe magnifiers
- You can get binocular microscopes
- All you need to make a clock is a cheap 3X pair of magnifying glasses

Make your own screws

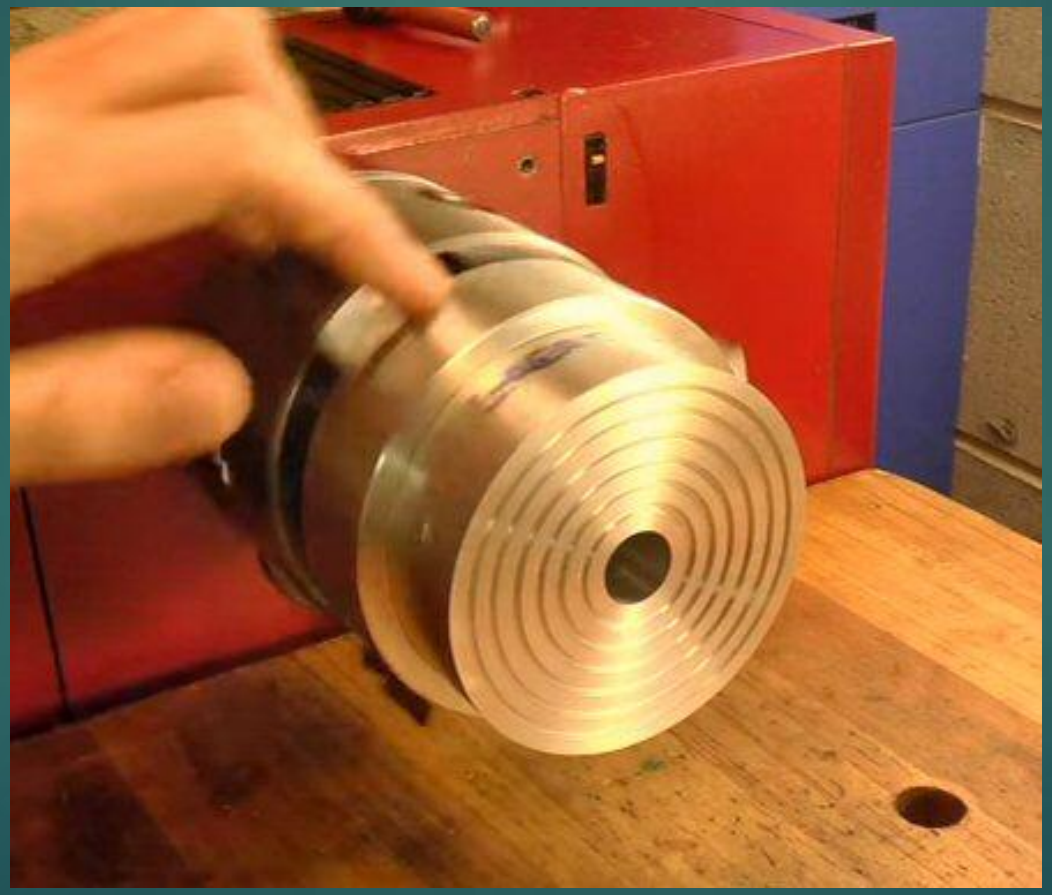
- Clickspring cuts his own screws from mild steel.
- Screws are very highly polished before bluing.
- Bluing done with brass shield over propane torch.
- Oxygen in the air creates the blue when the right temperature is reached.

Horology Abrasives

- Diamond
- Carborundum
- Aluminum Oxide
- Silicon Carbide
- Pegwood
- Clockmakers “burnish” their work.

Making your own horology tools

Super Glue Arbor

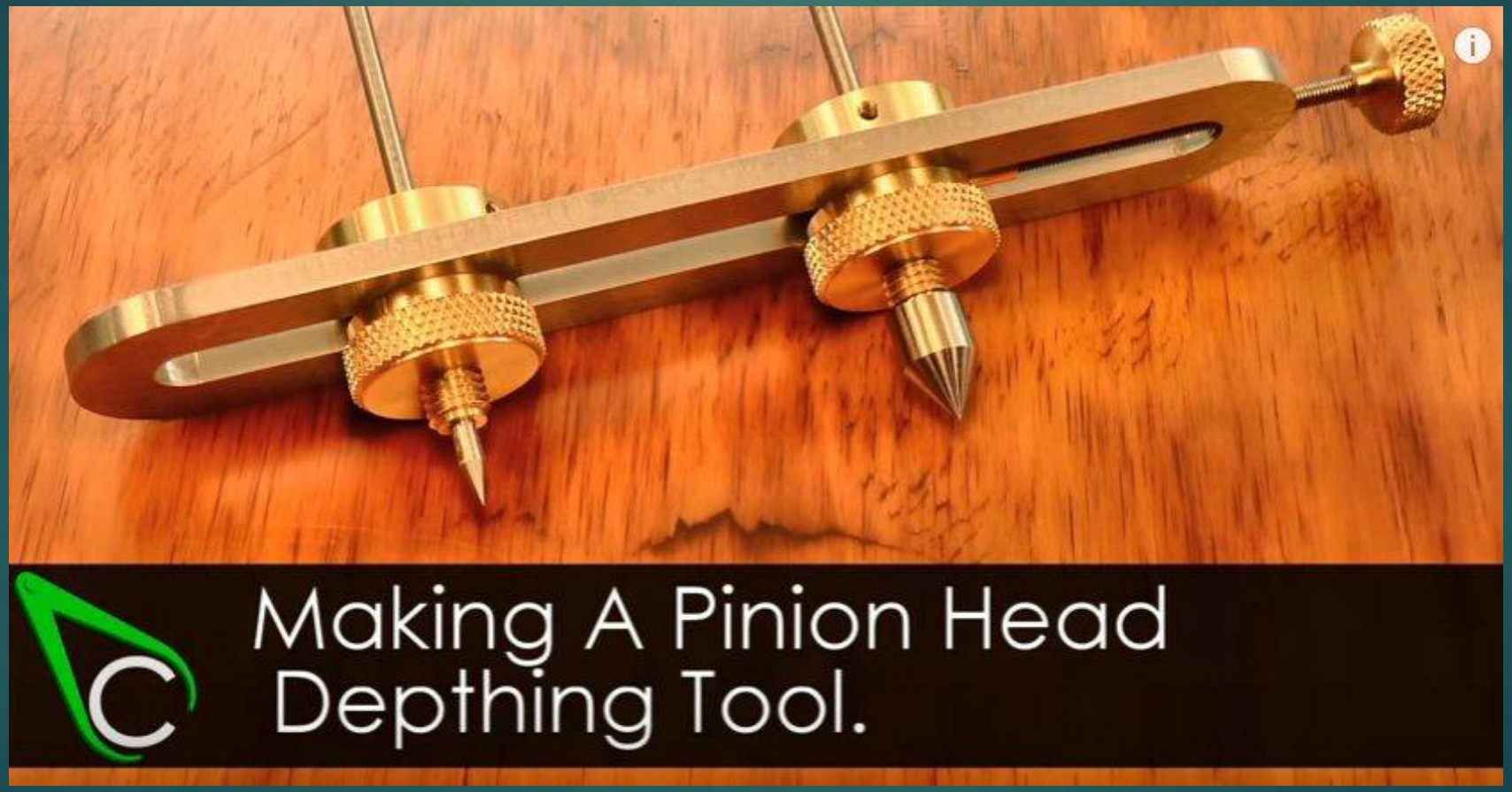


Power Filing Machine

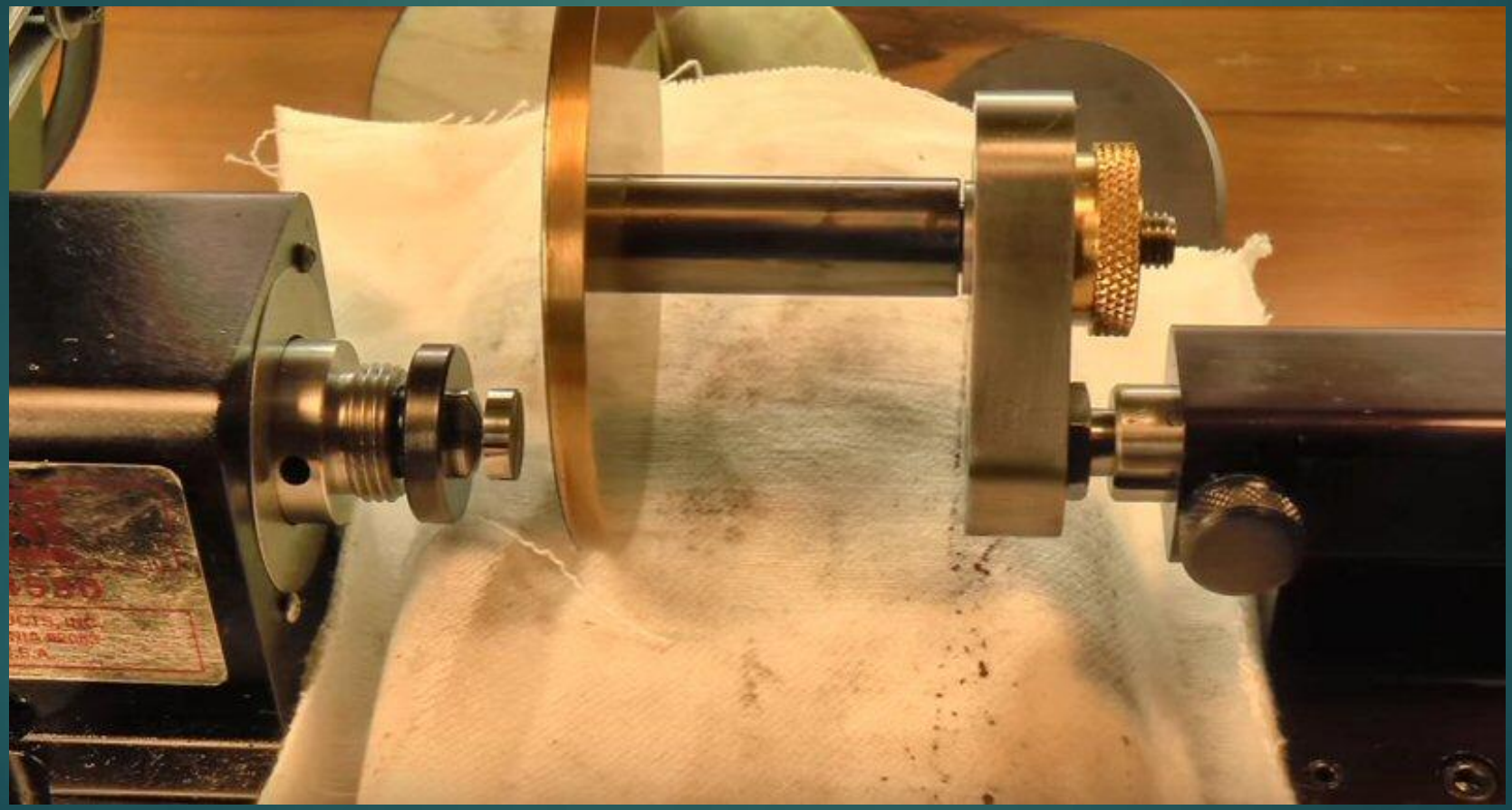
- http://www.statecollegecentral.com/metallathe/MLA-18.html
- This machine needs:
  - Motor
  - Pulley
  - Drive Belt
  - Wood Base
- Round hub is full of oil

Precision Filing Jig

Pinion-Gear Depthing Tool by Clickspring



Offset Polishing Tool by Clickspring



Lathe Die Holder

Alignment Tool by Clickspring

Bluing Tray by Clickspring

Techniques

Drilling Brass

- Ordinary twist drills have a positive rake.
- This causes them to dig quickly into brass. This effectively grabs the brass and attaches it to the drill bit.
- This causes ragged cuts, skewed holes, and safety problems with flying work pieces.
- Solution is to stone the cutting edge of the twist drill so that it presents a flat cutting face to the brass work.
- This means you have to keep a separate set of drill bits just for brass.

Controlling Hole Size

- Clockmakers use 5 sided broaches to enlarge holes.

Nice to Have Tools

Rotating Tailstock Chuck

- Little Machine Shop
- $59.95
- When a workpiece needs support because it is too long for the chuck…
- And too small to support with a rest or live center…
- Use a rotating tailstock chuck to hold it.
- Exhibit
- This is like a drill chuck but has a bearing that allows the chuck to turn freely with the work piece.
- It is a chuck for holding long but tiny workpieces rather than a cutting tool.

Sensitive Drill Chuck

- Little Machine Shop
- Fingertip control for drilling small holes
- Helps prevent drill breakage
- (0 - 3mm) Keyless drill chuck
- $109.95
- Exhibit

Desktop Drill Press

Miniature Drill Press Benchtop Multi-Speed Drill 8500RPM Max

Your Price: $79.95

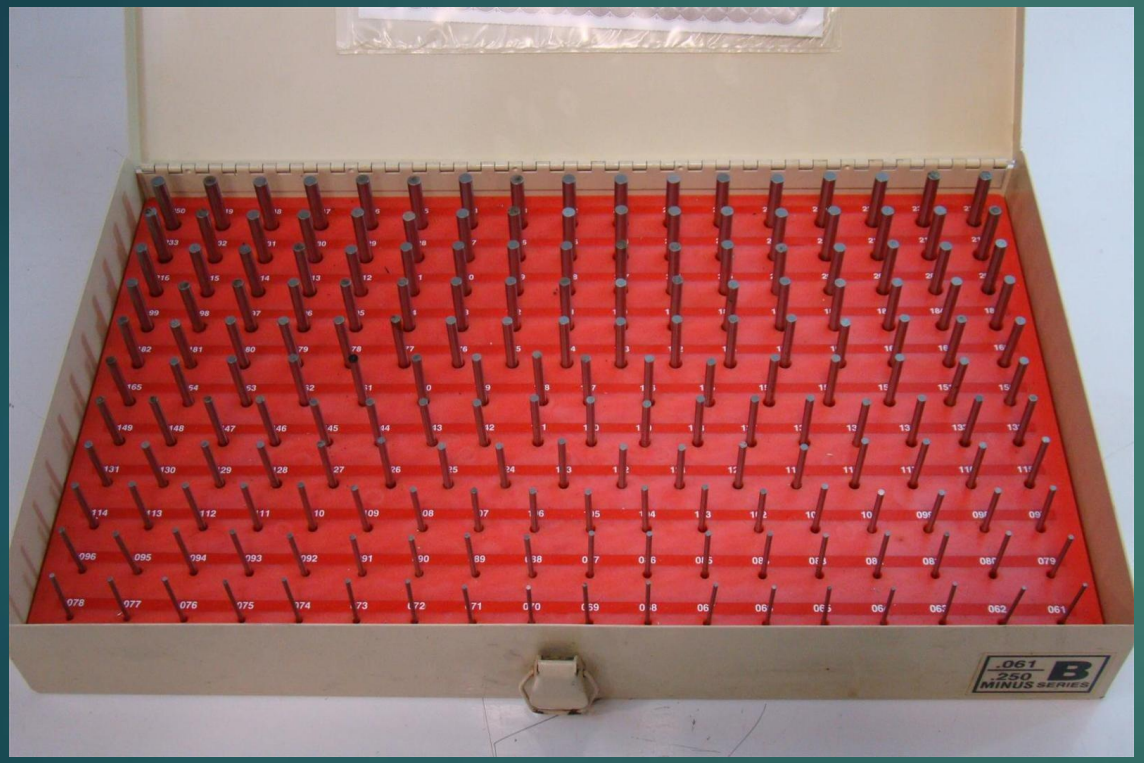
SKU: 28.300

Quantity: 1

Add To Cart

Add to Wishlist

Pin Gage Set



- Vermont Pin Gage Set
- 1.31 – 4.99 mm $156.00
- 5.01 – 9.99 mm $244.00

Have to buy tools

Description	Cost	Comment
Twist Drill Bit	$ 2.06	Metric-Tools.com M4 jobber drill Need two sets, Steel & Brass
Chucking Reamer	$ 14.36	Metric-Tools.com M4 chucking reamer
Swiss Needle File	$ 160.31	Amazon, 12 file set, 5.25 inch files
Thread Die	$ 43.03	Metric-Tools.com M4 x 0.75
Thread Tap	$ 10.54	Metric-Tools.com M4 x 0.75 Plug Tap
Cycloidal Cutter	$ 93.00	P.P.Thornton 0.50 modulus cycloidal gear cutter

Materials

Description	Cost	Comment
C353 Brass 24x36 sheet 0.187" thick	$ 713.40	Online Metals
C353 Brass 24x36 sheet 0.125" thick	$ 520.87	Online Metals
C353 Brass 24x36 sheet 0.63" thick	$ 160.31	Online Metals
C353 Brass 4x12 sheet 0.63" thick	$ 22.00	Timesavers
C353 Brass 36x48 sheet 0.25" thick	$ 985.13	Sequoia Brass & Copper
C360 Brass Rod 0.5" Dia. 72" long	$ 65.63	Sequoia Brass & Copper
O-1 Tool Steel Rod 0.25" Dia. 72" long	$ 6.93	McMaster Carr

The big brass problem

- Can brass clock frames be replaced with aluminum?
- Finish?
  - Anodize?
  - Powder Coat?
  - Common Enamel Spray Paint?

Big Ticket Items

Item	Cost	Vendor
HiTorque Lathe	$1,249.95	Little Machine Shop
HiTorque Mill	$1,499.95	Little Machine Shop
Digital Rotary Table	$ 761.25	Sherline
Scroll Saw	$ 489.00	DeWalt
	$4,000.15	

Bibliography

Making Clocks
By Stan Bray
Workshop Practice Series 23

How to Make a Skeleton Clock
By John Wilding

The End