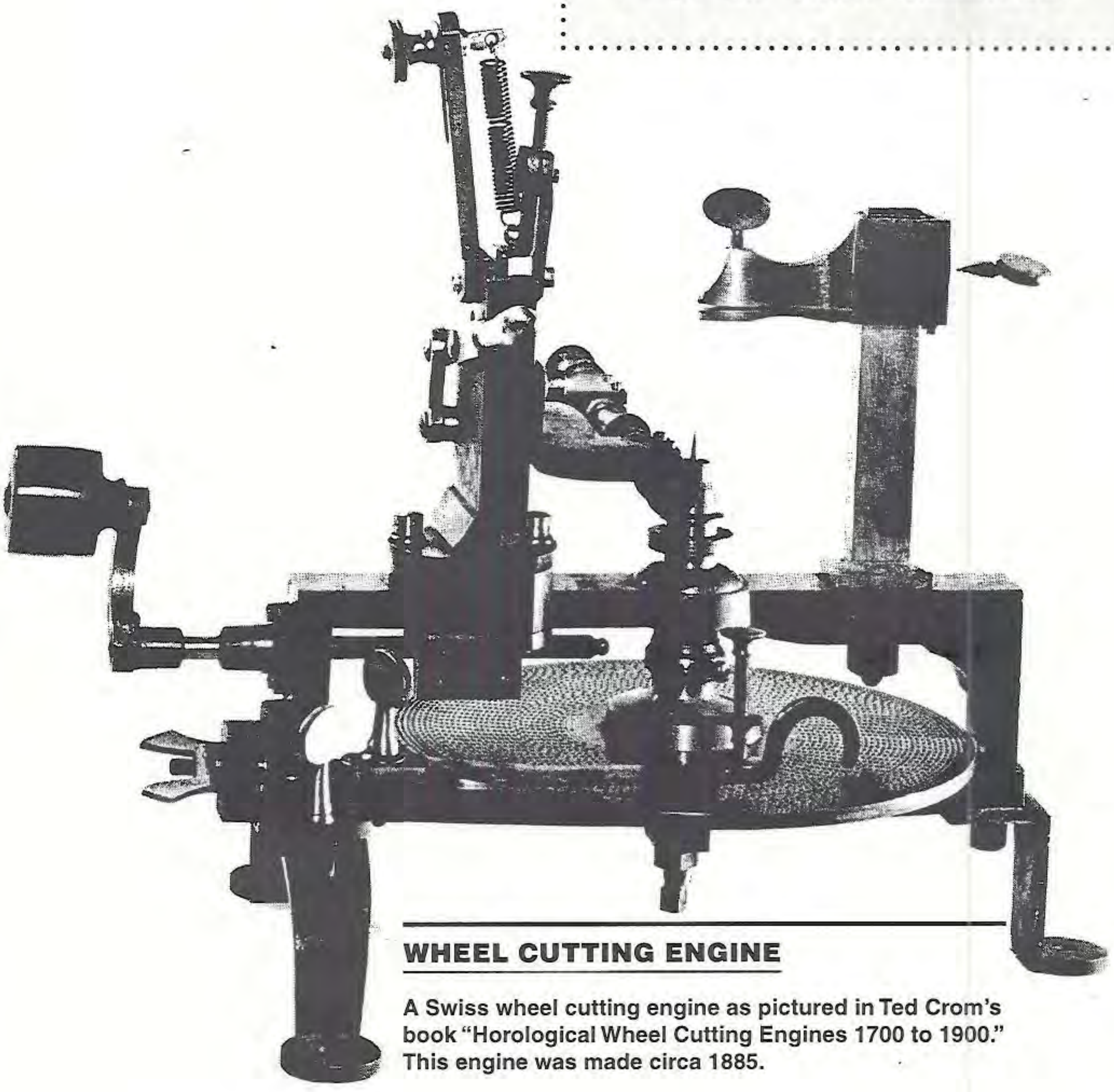
Tool Enthusiasts' Round-up

Volume I, Number I

Quarterly Newsletter: Fall 1997

Horological Tool Chapter #173 of NAWCC

In This Issue:



WHEEL CUTTING ENGINE

A Swiss wheel cutting engine as pictured in Ted Crom's book "Horological Wheel Cutting Engines 1700 to 1900." This engine was made circa 1885.

New Chapter of NAWCC:

Horological Tool Enthusiasts

This is the first issue of the newsletter for a new national chapter of NAWCC that is now formed. Already well over 50 people have expressed an interest in contributing to and learning from a chapter devoted to the understanding and collection of horological tools of all sorts. If you are interested in joining this chapter, which will meet at various large regionals and also at the National each year, please send your annual dues to the Secretary at the address below.

Tool Enthusiasts' Round-up is the quarterly newsletter of the National Horological Tool Chapter # 173 of the National Association of Watch and Clock Collectors, Inc., a non-profit educational organization. This is a national chapter, and open to any member of NAWCC.

Annual chapter dues of $10 will ensure that members in the Horological Tool Enthusiasts receive the quarterly newsletter and are included in the Membership Directory of this specialized chapter when it is published. Members also are entitled to one personal ad (see last page) in each issue.

For further information, contact one of the officers.

President:
Harvey Schmidt, 75-80 179th Street, Flushing, NY 11366; Phone 718-969-0847.

Secretary/Treasurer:
Dr. Bob Chapman,114 Sheffield Drive Knoxville, Tn. 37909 Phone 423-588-8848

Editorial Staff:
Harry Blair, 7 Hansom Lane, Marlboro, NJ 07746
Phone 732-536-5328;

John Grass,

Bob Leavitt, 8032 155th Place,
North Palm Beach Gardens, Florida 33418
Phone 561 744-0248

This chapter and its newsletter are intended to foster interaction among NAWCC members who share a common interest in the use and collection of horological tools. If you have an item you have researched, a book of interest, or notes on a project you have made, please consider sharing your knowledge with others through this newsletter. Editorial help and writing assistance are available to help you organize an article. Submissions should be sent to Harry Blair, Newsletter Editor, at 7 Hansom Lane, Marlboro, NJ 07746.

Chapter Meeting News

The Horolgical Tool Chapter will meet at each of the following NAWCC regionals. Look at the bulletin board at each event for date and location.

- October 30-November 1: Mid-Eastern Regional in Lancaster, PA at the Holiday Inn.

Mel Smith will talk on wheel cutting equipment. (Members, please bring your wheel cutting equipment to discuss at this meeting)

- February 19-22, 1998: Florida Mid-Winter Regional. (We're hoping to get Ted Crom on the program)

- June 24-28 1998: National of NAWCC in Portland, Oregon.

George Collard to talk on Waltham watch production and tools

What is it ?

Hints:

- *Used as a part of early wheel making, particularly chronometers.*
- *Invented in the early 18th century.*
- *Has a French name.*

Answer on page 11.

President's Message

BY HARVEY SCHMIDT

The first meeting of our newly formed chapter was held in Atlanta, Georgia at National meeting of NAWCC in June. Approximately 20 people attended and 14 joined chapter then and there.

Procedural matters were discussed and Bob Chapman was elected Secretary / Treasurer. $240 was collected in dues and donations. We thank all members who made generous donations above and beyond dues to the treasury at our Atlanta meeting. It was decided that the newsletter would be published approximately Quarterly, including both reprints and original articles on the subject of horological tools. Tool mart policies to be defined at a later date.

Chapter Activities

A brief meeting was held at the Syracuse Regional August 15, 1997. Approximately twenty people attended and new members were again signed up. Future meeting and chapter plans were discussed.

Mel Smith agreed to head up researching a list of U.S. Museums with good tool collections to publish in our newsletter

. Please contact Mel at: 2631 Amawalk Road
Katonah N.Y. 10536
914 232-5376

It was agreed that at a future meeting we would have a display and discussion of distinctive tools made by watchmakers. All members would be encouraged to actively participate .

In Coming Issues...

Topics for future issues of the newsletter include:

- Tools used in jeweling: Members Peter Grasso and Steve Lubduska agreed to contribute text and pictures and make input to this topic
- Wheel depthing tools
- Staking tools
- Wheel stretching tools and rounding up (Wheel Topping) tools including the Ingold Fraisse and Machine A Raboter
- Pivot drilling tools
- Modern jewelers lathes: Types, maintenance, accessories
- Tools and where to find them
- Mystery tools
- Tools made by watchmakers as graduation exercises and beyond.
- Polishing devices and techniques.

(Send in your ideas)

Wheel Cutting Engine Evolution

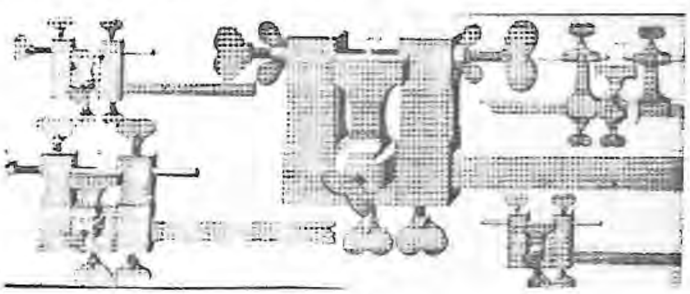
Looking at an eighteenth century watch, have you ever pictured some individual, hunched over a bench, slowly producing this old watch, piece by piece?

It probably didn't happen that way! Your single watch was produced by many hands: men, women, and children working in many shops and homes in the country and in cities.

There were many different crafts or workers involved in the making of a single wheel, involved only with the wheel, and many others who made the arbor and pinion and mounted the wheel.

The first worker, called the blanker, turned it to size and roughly crossed it out by stamping.

The lathes used in the process could have been driven by a bow, a foot or hand wheel. Shown below are a number of small lathes of the type many of the blankers might have used. The wheel, with its center hole open,



Turns used in cutting wheel blanks

was mounted on a turning arbor and placed between centers. Thus held in the lathe, it was quickly turned round. Removed from the lathe, it was put into the punch for blanking out

The second worker, the wheelcutter, cut the teeth, which were not rounded up at this stage. The dividing machine which he used for this was very simple; it consisted of a large divided plate with the wheel to be cut mounted on the axis of the plate. The spaces between the teeth were cut with a fraise, or milling cutter.

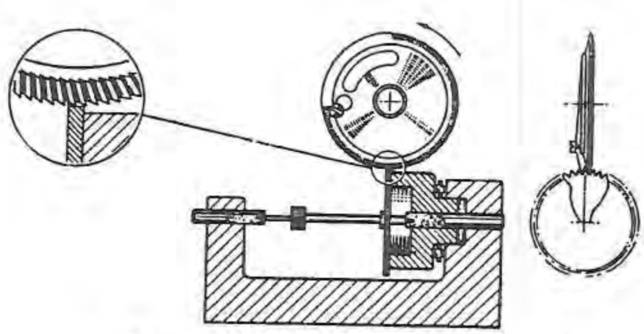
The wheel cutters used throughout the continent and in England from 1700 until after 1800 were generally of the same basic design. The cutters of this period were mounted on a cutting frame or arm that was pivoted so that as it passed through the wheel in cutting of the slot between the teeth it imparted a curved surface to the point and face of the teeth and the bottom of the slot.

This machine was very useful, and greatly shortened the work time of the horologists for cutting the teeth of wheels with exact division. The plate was made of brass of seven or eight inches in diameter, and of one-twelfth inch thickness, on which were drawn many concentric circles, divided into different even or odd numbers, with the higher numbers near the outer edge.

To divide a train wheel, for cutting by hand, the whole is placed on the arbor which is the center of the platform, and tightly fixed; a rule and a thin steel scribe are turned division by division.

The third worker was called the wheel finisher, and he did the finishing of the crossing-out of the wheel. He filed up the rim and the arms, and formed the angles. He was of necessity a good filer and the work was done with special small files called 'crossing files'. These files were extremely small and fine and in most cases were hand cut by experts who spent their lives, from childhood, doing nothing but cutting or making files. Although almost an exclusively handmade item, files may have been made by machine as early as the fifteenth century.

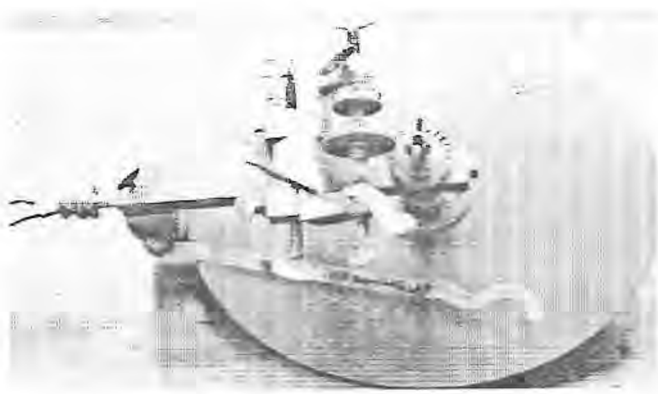
After the wheel finisher had done his job, the fourth worker was the tooth maker. His job was to round up each tooth and give it a shape somewhat approaching epicycloidal. For this he employed a 'recutting tool,' the predecessor of the rounding-up machine. Since the wheel had only been slotted on the cutting machine, the spaces had to be enlarged and deepened, and the teeth worked to the required profile.



Rounding off cutter, showing method of application.

Early Wheel Cutting Engine Background

Early clock and watchmakers, between the fifteenth and eighteenth centuries, made most of their own specialized tools. Some of their tools were made for other trades and modified for the manufacturing of clocks and watches. Many of these tools and horological tools were products of a cottage industry. The tool merchant would supply material and tools for the manufacturing and collect the finished products to sell.



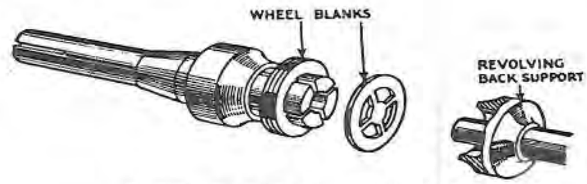
Wheel Cutting Engine ca 1789 Cutter just saws slots. Shaping, truing & rounding up were separate operations

Before the development of the wheel cutting engine, wheels were marked using a dividing plate and a straight edge or a pair of dividers. The wheel blank to be indexed was secured to the center of the plate by various means and a line was scribed on the circumference of the blank. This was done two different ways. One was to use a straight edge: The watchmaker would line up the proper hole in the dividing plate with the center of the wheel blank and scribe a mark for the center of each tooth. The other method was to place one leg of a pair of dividers in the proper hole of a dividing plate and scribe a line on the wheel blank for the center of each tooth. After the blank was marked, the teeth had to be filed to shape either by use of a hand file or with the machine-a-raboter.

The first known wheel cutting engine was by Robert Hooke, made between 1660 and 1670. Nicholas Bion wrote of a wheel cutting engine and had a drawing of it in 1709. These early engines only indexed and cut slots in the blank either with a circular saw or a vertical saw.

After slotting, the wheel still had to be finished by hand to the proper tooth profile. One of the earliest signed and dated wheel cutting engines to survive is one by Wilhelm Kober Eichstatt, dated 1709.

The wheel cutting engine evolved over the years with



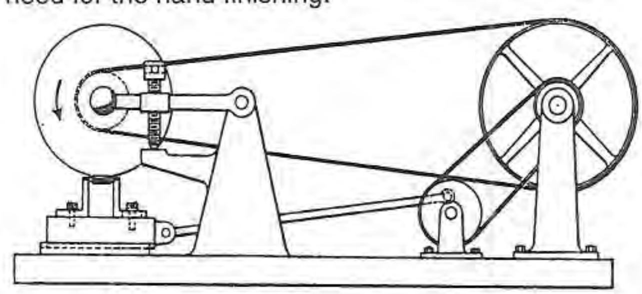
Mandrel for holding wheels whilst the teeth are cut.

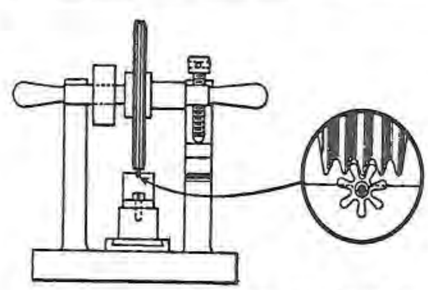
little change until the early twentieth century. The changes were mainly in the cutters used, the method of holding the wheel blanks and the invention of the dovetail slide.

Most eighteenth century engines used a horizontal index plate with a center arbor to hold the blank. Early engines used a screw or stud on the arbor to hold the wheel blank. Later models used a stump and cap to sandwich the blanks and a gallows was used to clamp the blank between the stump and cap.

About 1850 split chucks started to be used on the arbor, thus giving the engine more versatility.

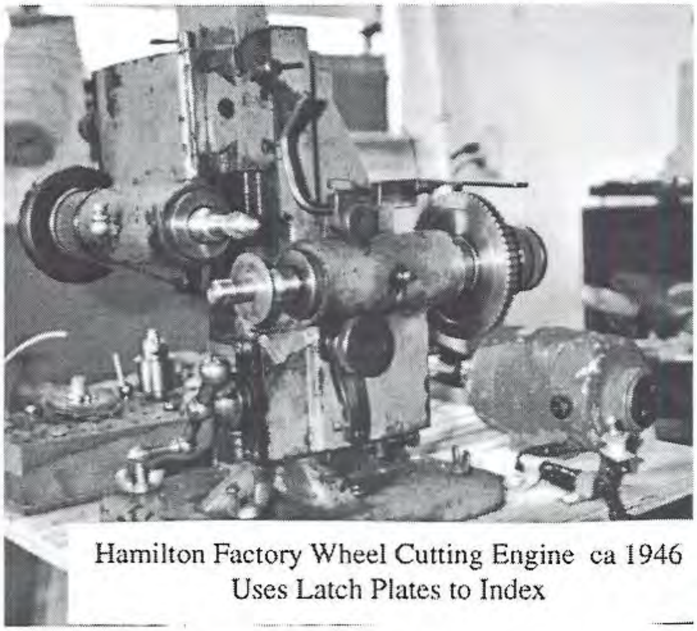
Early engines also used a pivoted cutter frame. This type cutter frame cut a curved tooth root on the wheel for added strength but had to be hand finished or cleaned up with a rounding-up tool. In the middle of the nineteenth century, with the invention of the dovetail slide, the engines were able to cut a better root and thus eliminate need for the hand finishing.



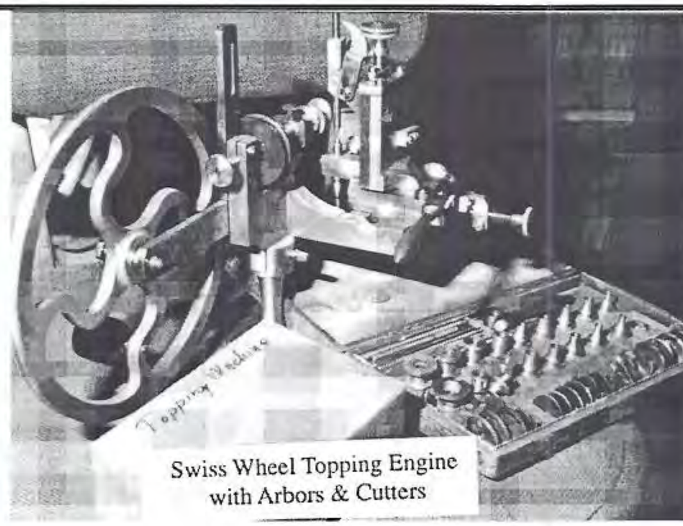


Lapping machine for polishing pinions.

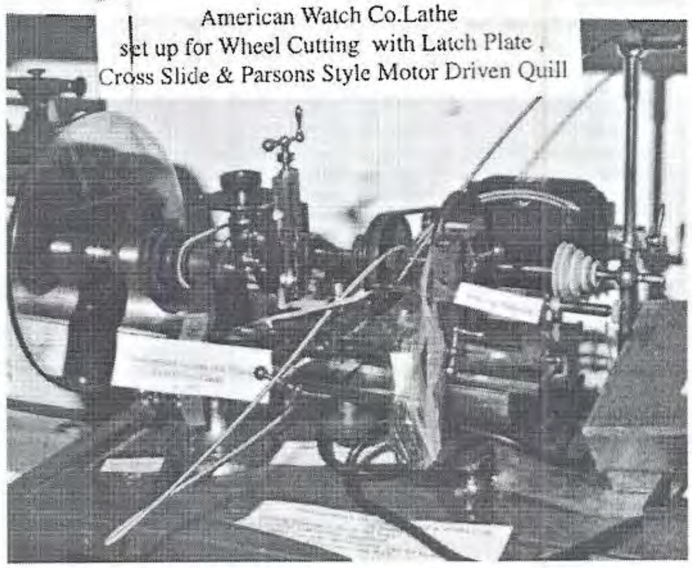
Various Wheel Cutting Approaches



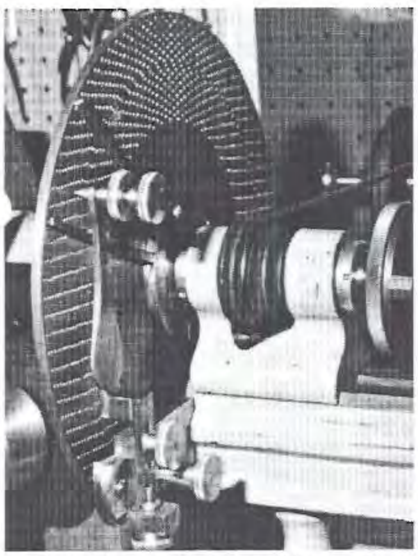
Hamilton Factory Wheel Cutting Engine ca 1946
Uses Latch Plates to Index



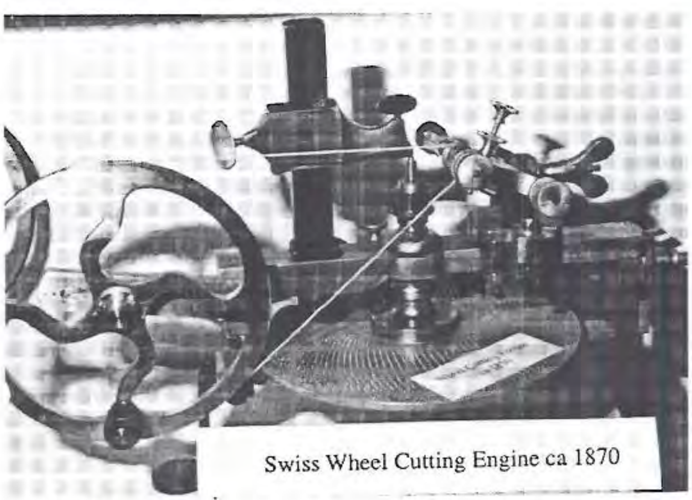
Swiss Wheel Topping Engine
with Arbors & Cutters



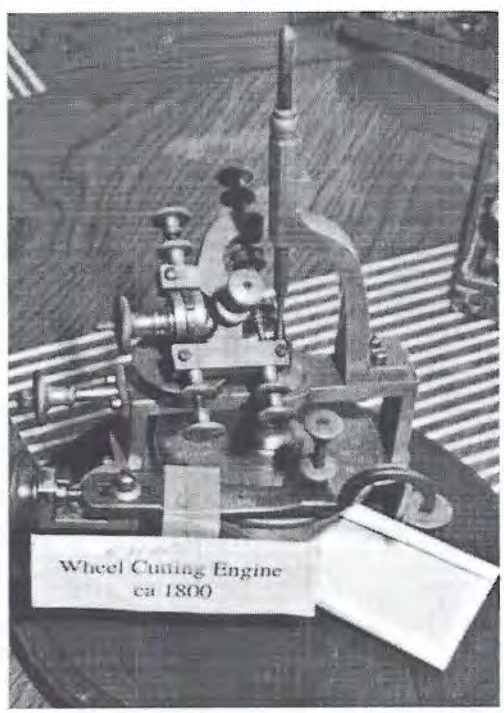
American Watch Co.Lathe
set up for Wheel Cutting with Latch Plate ,
Cross Slide & Parsons Style Motor Driven Quill



Sectoring of Indexing Plate on Lathe, tracks number of holes between wheel teeth thus avoiding errors



Swiss Wheel Cutting Engine ca 1870

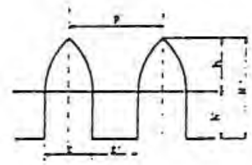


Wheel Cutting Engine
ca 1800

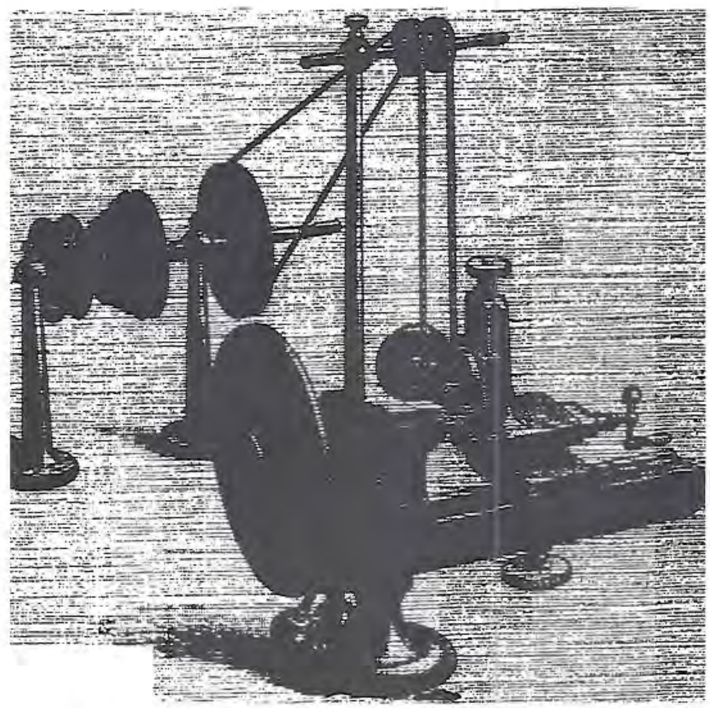
Watch wheel spoking punches circa 1820.
Wheel blank placed between two plates is hammered or pressed to punch out spaces between spokes.(Wheel blanks were also cast, hammered to harden and then filed for appearance)

CARPANO'S FORMULA FOR COMPUTING ADDENDUMS

The drawing and formula herewith, shows the Carpano method for finding the height of the addendum "h" on train wheel teeth of the epicycloidal form. The formula is self explaining, however we might add that, the addendum of any epicycloidal gear tooth as shown at "h" in the drawing, equals the module multiplied by 1.57 and by 1.10. Example: Module .20 X 1.57 X 1.10 equals 3,454 addendum.



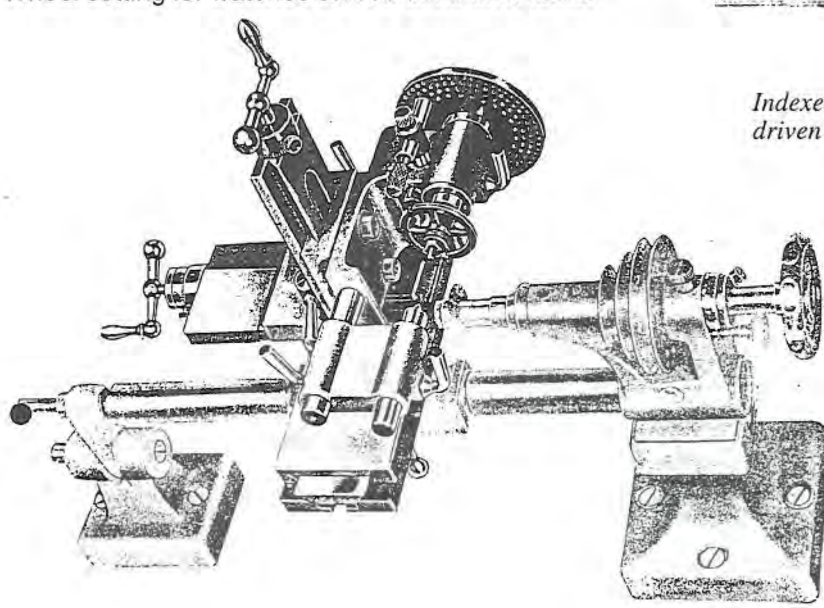
$$P = \text{Module} \times 3{,}1416$$
$$H = h + h'$$
$$h = E \times 1{,}10$$
$$E = \frac{P}{2}$$
$$E' = \frac{P}{2}$$

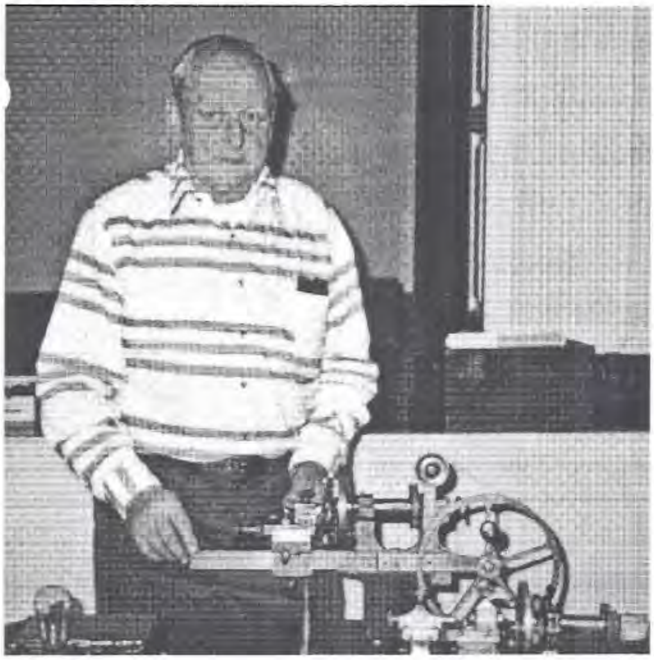


Indexed head stock on lathe, quill on milling attachment driven though countershaft.

WHEEL CUTTING TODAY

Wheel cutting for watches can be done on a lathe.





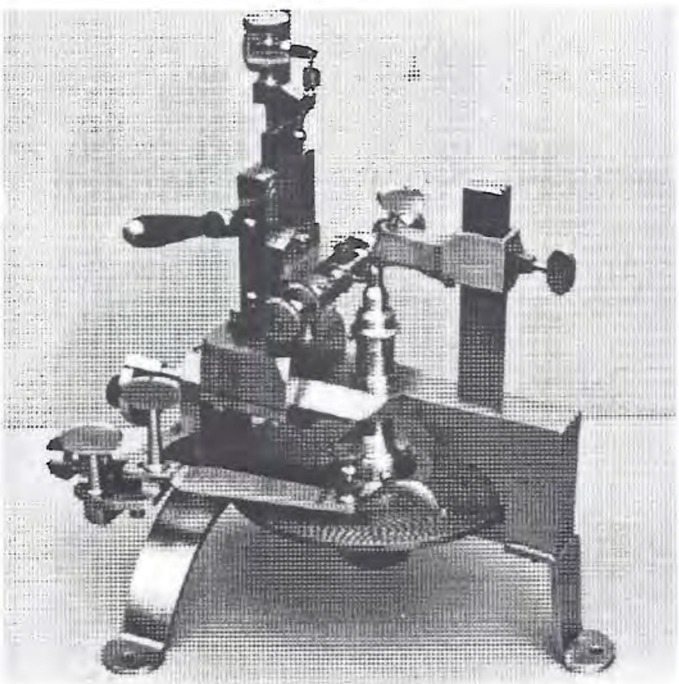
MEL SMITH

- NAWCC # 77079
- AWI # 22039
- Trained Machinist for the military
- Private Pilot (retired)
- Chrysler Corporation machinist and mechanic training
- 20 years as master mechanic and machinist on heavy construction equipment
- Presenter on the use of antique tools by watchmakers to various AWI and NAWCC groups
- Blue Ribbon Winner of 1996 NAWCC craft contest for wheel cutting engine

Mel Smith is retired now and lives in Somers, NY with his wife Helen. Together they raised three sons. Today they enjoys spending time with their grandchildren.

Mel is a voracious reader, but also has a skilled hand as evidenced by his woodworking and gardening skills. Mel has always loved the outdoors. He is still active with the Boy Scouts after being a Scout Master for many years. He also volunteers in his church.

Mel's greatest accomplishment is the recent construction of the wheel cutting engine pictured here, for which he received a Blue Ribbon at the NAWCC Craft Contest in 1996. It is a testament to his talent in the machine shop he maintains in the basement.



Completed Wheel Cutting Engine, made by Mel Smith: Blue Ribbon Winner in NAWCC Craft Contest of 1996.

Mel Smith working at milling machine.

Design of the Wheel Cutting Engine

This engine is a copy of a Swiss wheel cutting engine used in the 1800's, based on drawings prepared using pictures in Ted Crom's book "Horological Wheel Cutting Engines." page 57. This design also incorporated some of Mel Smith's ideas of what was done in the past.

Materials Used

- Cold rolled steel
- Brass
- Rosewood for the handles

Machinery and Tools Used

- Engine Lathe
- Drill Press
- Band saw
- Horizontal milling machine
- Vertical milling machine
- Universal dividing head.
- Miscellaneous hand tools

Dividing Plate

- 5 1/2" Diameter
- 26 Circles with the following holes per circle: 48, 56, 58, 62, 64, 66, 68, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 98, 100, 104, 108, 120, 128, 140, 144

Engine Operation and Swiss Wheel Cutting Engine ca 1885

- Horizontal & Vertical Dovetail Slides
- Fly Cutter

Use

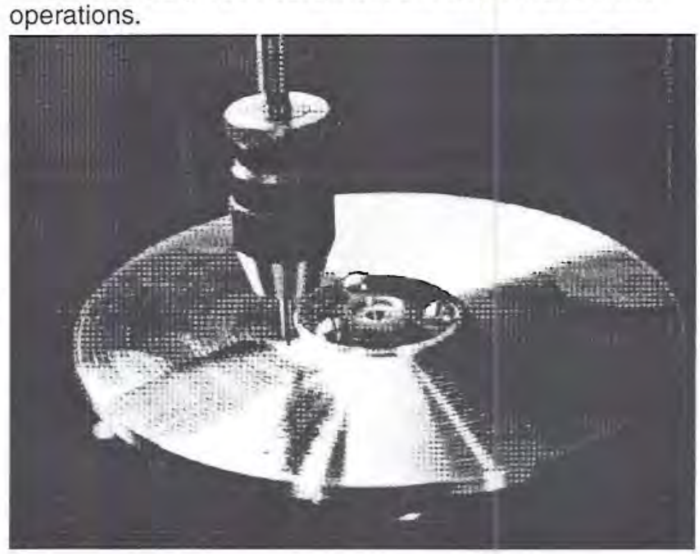
- Uses wheel supports (stumps) and also split chucks (collets) to hold wheel blanks and wheel and pinion arbors.

Mel at Drill Press

- Two cutting arbors for different wheel cutters.
- Engine is driven by a jack shaft, with a foot wheel for power.
- Accessory container includes cutting arbors, wheel supports, wrenches for cutting arbors and pin for retaining bolts.

Labor Expended

- Approximately 400 hours,most of them in hand work operations.



Drilling the Index Wheel (Dividing Plate)

HOROLOGICAL GEAR AND PINION CUTTING NOMENCLATURE

Addendum

The shape of a wheel tooth and how each part of it is formed is important and will affect its performance. The part of the tooth that portrudes above the pitch circle is referred to as the addendum. This shape is automatically induced when constant profile cutters are used. When fly cutters are being made, the shape of the addendum of the tooth will be a major consideration. Careful attention will have to be given to selecting a cutting tool with the correct radius to form a fly cutter capable of producing an addendum of a desired shape.

The addendums of involute and cycloidal teeth vary considerably. As involute teeth are usually employed in step-down applications and may need to reverse direction, their profile is different. Although the curve that makes up the face of the addendum may appear similar to the cycloidal tooth, it has been calculated and formed using an entirely different method.

The surfaces of the addendum of a cycloidal tooth are usually referred to as the faces. If the wheel was designed by a horological engineer, the curvature of this face will have been established from a drawing of the complete wheel and the arc that makes up this face will be part of an epicycloidal curve. The surface of the dedendum is normally referred to as the flank of the tooth.

Circular Pitch

The distance between the centerline of two consecutive teeth measured on the pitch circle is referred to as the circular pitch. In the American system the term diametrical pitch is used to designate the number of teeth for each inch of pitch diameter. Thus a gear with 60 teeth and a half inch diameter would be a 120 pitch gear. In European countries the dimensions of gear teeth are measured by a different system that is calculated using the number of whole teeth on the pitch circle.

Module

The height and the distance between each tooth play a major role in the identification, design and cutting of wheels for watches and clocks. We use the term module to designate the measurement and sizing of wheel teeth Basically, the module is the relationship between the pitch diameter and the number of teeth placed on it expressed as a decimal. The pitch diameter in millimeters divided by the number of teeth will provide the module. Once the module has been determined, a factor provided by the cutter manufacturer must be added to the number of teeth before the outside diameter of the wheel blank can be calculated. This factor usually ranges from 2.70 to 2.76. Pinions are computed using factors which are considerably different. Constant profile cutters are normally available in a range from 0.2 to 1.0 in the module system and are graduated in steps.

If the module is known, the width of the space between the teeth can be calculated. This technique is especially useful if a fly cutter needs to be made to reproduce a replacement wheel or pinion. Multiplying the module times 1.57 will provide the metric space between the teeth. The metric tooth height can be determined by multiplying the module times 2.92. The same cutter can be used to make several different wheels. The dimensions of the teeth and the width of the space between them will remain the same, but fewer will be placed on the wheels with the smaller pitch diameter. For example, the same cutter can be used to prepare an 84 tooth wheel with a pitch diameter of 68.859 mm, a 60 tooth wheel with a 49.120 mm pitch diameter or a 42 tooth wheel with a 34.442 mm pitch diameter.

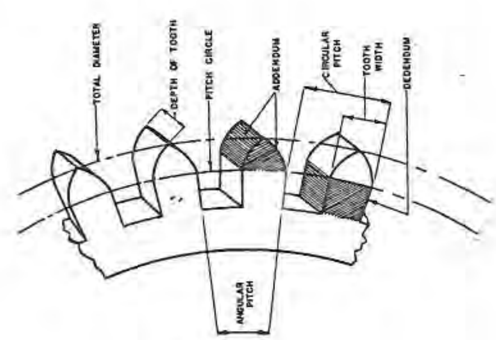
The metric module system sets a relationship between the number of teeth in a gear and its pitch diameter. The formula for calculating the module of a gear is:

$$\frac{\textit{Pitch diameter in mm}}{\textit{Number of teeth}} = \textit{MODULE}$$

Example:
A gear with a pitch diameter of 20 mm with 40 teeth would be .5 module and you would use a .5 module cutter. If you add more teeth of the same size to this wheel you must increase the pitch diameter. Gears and pinions cut with the same module cutter will mesh provided all the proportions are correct.

• The roots of wheel teeth are simply slots, they are not involved in the driving process. (They allow storing dirt)

• P.P Thornton provides wheel cutters from .1 to 1.0 Mod. One wheel cutter cuts all tooth counts with that mod .(Cutters are approx. $ 50 each)



Number of Cutter

When cutting a pinion you need a special cutter for each pinion. The table of cutters varies a little with makers. The following table is from a commercial cutter maker (and applies only to involute gears used on some clocks).

Cutter #	1	2	3	4	5	6	7	8	9	10	11
Cuts from	8	9	10	12	14	17	21	26	35	55	135
	to	to	to	to	to	to	to	to	to	to	to
	8	9	11	13	16	20	25	34	54	134	rack

To cover the full range of cutters 6 teeth to rack in a single Module size we would need to have eleven numbered cutters plus two special cutters.

Outside/Inside Cutter Diameters

Most cutter makers have standard outside and inside diameters for their cutters according to module size. The following table is from one well known cutter maker.

Outside Diameter	Hole Diameter	Module Sizes
12 mm	3.5 mm	.2 to .28 (watches)
14 mm	4.5 mm	.3 to .48 (clocks)
20 mm.	7 mm	.5 to .8 (tall clocks)

High Speed or Quality Tool Steel

High speed steel should be used for cutting steel pinions.

Epicycloidal or Involute

For most clock work, epicycloidal gearing is used.

Some Practical Thoughts on Cutters

1. For work on clocks the cutters most used range from .30 module to .8 module. You can turn out good work by purchasing in steps of 1/2 module, for example .35, .40, .45, .5, etc.

2. When we study the cutter numbers we see that certain numbers are essential for a start, for example numbers 1,3,9,10.

3. When work on older clocks is being carried out, epicycloidal cutters with square tops produce the traditional Gothic teeth. Modern clocks have a rounded top cutter which makes the teeth produced look modern.

Example:

You require a cutter to cut 120 teeth in a wheel which has a pitch diameter of 48 mm.

$\frac{48}{120}$ *= .4 Module, 120 teeth, number 10 cutter.*

You need one No. 10 cutter in .4 Module outside diameter 14 mm. Inside diameter 4.5 mm. High Speed Steel. Epicycloidal.

Module and Comparative D.P. Sizes

Module	Diametral Pitch
.2	127
.25	101.6
.3	84.7
.35	72.6
.4	63.5
.45	56.4
.5	50.8
.55	46.2
.6	42.3
.7	36.3
.75	33.9
.8	31.8
.85	29.9
.9	28.2

Wheels

To calculate outside diameter, add 3 to number of teeth and multiply by Module.

Pinions

Same as above, but instead of adding 3 add the following:

for 6,7,8 leaf—add 1.71

for 10—add 1.34

for 12 —add 1.61

What is it ?

Answer:

A Machine-á-Raboter, a rare tool from 1750–60 to allow consistently accurate filing of tooth shape and also resulted in faster tooth shaping than that done by hand.

ROUNDING UP CUTTERS

These cutters fit the Marco or any standard rounding up machine. Each is equipped with guide doing away with the necessity of changing guides.

No. 30814.	Sizes 0 to 20...Each,	$1.25
No. 30823.	Size 2/0........Each,	1.35
No. 30824.	Size 3/0........Each,	1.45
No. 30825.	Size 4/0........Each,	1.50
No. 30826.	Size 5/0........Each,	1.60
No. 30827.	Size 6/0........Each,	1.75
No. 30828.	Size 7/0........Each,	2.00
No. 30829.	Size 8/0........Each,	2.50
No. 30830.	Size 9/0........Each,	3.00
No. 30831.	Size 10/0.......Each,	3.25
No. 30679.	Set 12.	

The space between the teeth of train wheels of different makes of watches varies considerably. To assist the watchmaker in selecting suitable cutters, we give below a table of sizes together with the average cutter used with each:

Size of Watch...	18	16	12	6	0	10/0	10½L	6¾ to 5½L
Cutter No. for Center Wheels	16	10	9	7	4	3/0	3	3/0 to 6/0
Cutter No. for 4th Wheels	8	6	3	1	0	4/0	2/0	5/0 to 8/0

METRIC EQUIVALENT OF ROUNDING UP CUTTERS THICKNESS OF TEETH

No.	1/100 m/m	No.	1/100 m/m	No.	1/100 m/m
10/0	6	4	19	17	34
9/0	7	5	20	18	35
8/0	8	6	21	19	36
7/0	9	7	22	20	37
6/0	10	8	23½	25	43
5/0	11	9	25	30	50
4/0	12	10	26	35	55
3/0	13	11	27	40	61
2/0	14	12	28	45	67
0	15	13	29	50	74
1	16	14	30½	56	80
2	17	15	32	60	87
3	18	16	33		

WANTED:

Machine a Raboter . Any condition.
Harry Blair 7 Hansom Lane Marlboro N.J. 07746

Pieces of wheel cutting engines for parts / restoration
Mel Smith
2631 Amawalk Road Katonah N.Y. 10536

Faneuil / Rivett Lathes and other tools serial numbers as part of my study:
also looking to buy Faneuil / Rivett items.
Tom Hammond 3258 Forest Gale Drive
Forest Grove, Or. 97116

OFFERED:

Levin 8mm lathe with Levin collet holding tailstock , motor, speed control and 20 collet set $ 590.
Harry Blair 7 Hansom Lane Marlboro N.J. 07746

Each current chapter member can place one "wanted" and one "offered" ad in each issue at no charge. Additional ads placed are $25 per column inch per issue.
Send ad copy to:
Horological Tool Chapter #173 of NAWCC
C/O Harry Blair
7 Hansom Lane
Marlboro N.J. 07746
Include stamped self addressed envelope if reply is needed

General Information

The Henry B. Fried Annual Memorial Horological Tour has been putting a growing emphasis on horological tools and tool museums and will be visiting the Basel fair (many tool exhibits), Valle de Jour, Glasshutte and Prague. April 26 thru May 12 1998. For info. call Nick Lerescu (tool chapter member) and President of Advantage Tours 1 800 262-4284

Source material for this issue:

- Horological Shop Tools 1700-1900. by Theodore Crom
- Horological Wheel Cutting engines 1700-1900 by Theodre Crom.
- Clock wheel and pinion cutting by J. Malcolm Wild.
- Gears for small mechanisms by W.O. Davis.