The Parts and Processes of a Rose Engine in the Modern Shop

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Introduction

The many design possibilities of using a rose engine start with understanding the many techniques and processes available for the rose engine and to the modern designer and jeweler. Numerous accessories were originally designed and built for the rose engine during the 17th through 19th centuries. This paper will go into the details of how these tools and accessories are used in conjunction with the rose engine for making modern jewelry and objet d'arts, including details regarding the methods of cutting both the traditional metals and the modern metals, such as stainless steel, titanium and niobium. Also discussed will be the future of guilloché or mechanical engraving.

In my 2015 paper[1] I wrote about the history of the lathe, its evolution into the ornamental lathe, which was used for decorating wood and ivory beginning in the 16th century, and its further evolution into the rose engine designed for use on silver and gold in the late 18th century. This became known as the "trade rose engine." We also covered its sister engraving machine, the straightline, and saw many examples of the engravings that each could perform. This present paper will concentrate only on the trade rose engine, how it works, and what it can do for the studio jewelry designer and the manufacturing jewelry designer. It is almost impossible to find anything written on this topic throughout history. Very little was ever written down as this knowledge was kept amongst only those craftsmen who practiced the art. It is my goal to start disseminating the information that I have learned about engine turning over the last 20 years for the benefit of all artists and craftsmen, with the hopes of the creation of new and intriguing designs.

The Trade Rose Engine

The trade rose engine (Figures 1 and 2) was an evolution of the ornamental turning lathe and was developed for use on precious metals during the middle of the 18th century. It was rapidly deployed in the jewelry and watchmaking industries in the area of southwestern Switzerland. The trade rose engine was primarily used for the mechanical engraving known as guilloché, also referred to as engine turning.

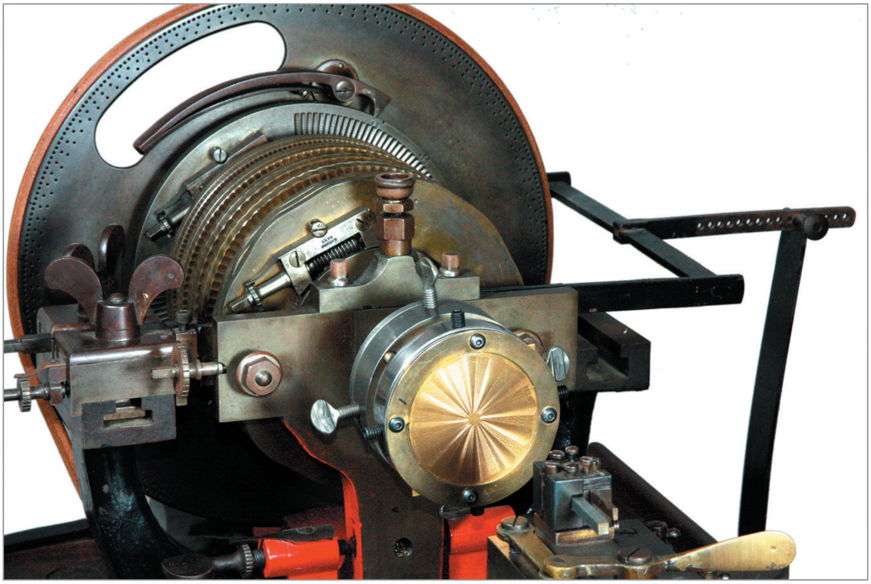

Figure 1 *Trade rose engine, circa 1885*

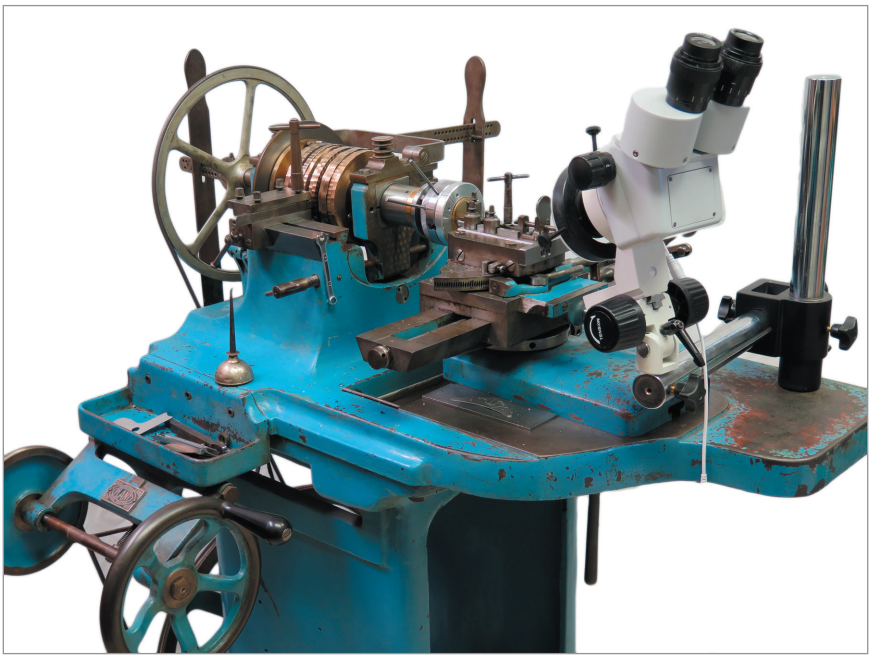

Figure 2 *Trade rose engine, circa 1930*

The key difference between the earlier rose engine ornamental turning lathe (Figure 3) and the trade rose engine is that the trade rose engine typically has low amplitude and high lobe-count rosettes.

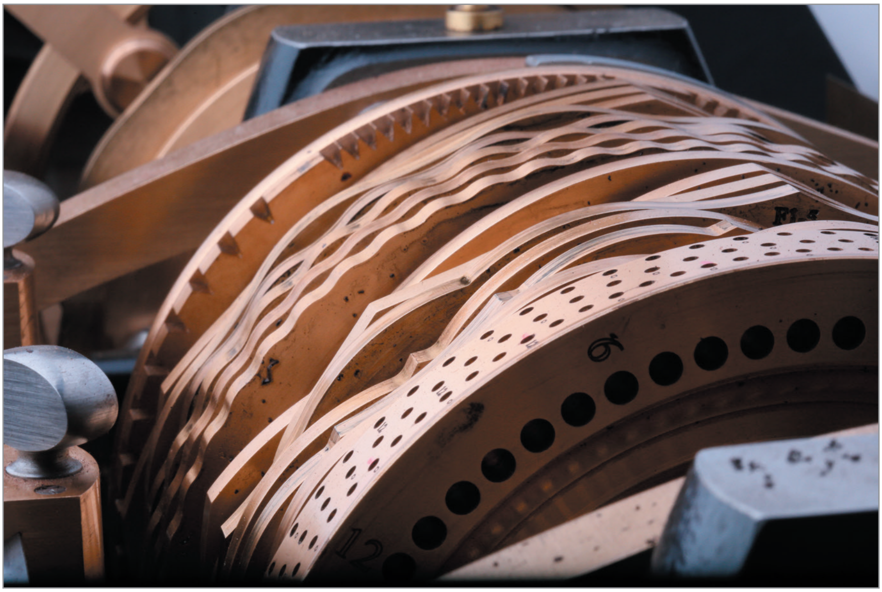

Figure 3 *High amplitude rosettes of an ornamental turning lathe*

Figure 4 *Low amplitude rosettes of a trade rose engine*

Amplitude is the distance between the peaks and valleys of a rosette. The lower amplitudes of the rosettes (Figure 4) were better suited to jewelry-scale items by minimizing the negative effects of amplitude (see also Figure 33).

The high lobe counts were also beneficial to the style and scale of jewelry items and were especially beneficial to those in the watch industry. Lobe counts of 120 or more allow the watch and clock makers to divide the minute hand arc with multiple cuts. High lobe counts are also very useful on large items such as picture frames and hollowware.

The Trade Rose Engine Machine

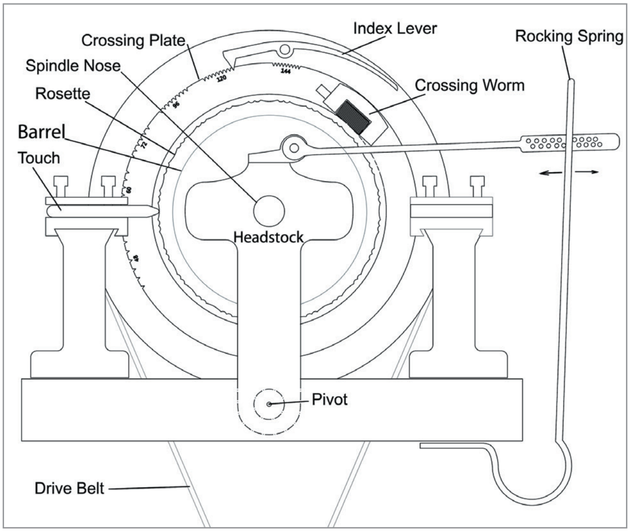

Figure 5 *The rose engine and its parts, front view*

How a Rose Engine Works

Figure 5 shows a graphic illustration of a rose engine in rocking mode, front view. Multiple rosettes are mounted to the barrel, which turns freely around the spindle and is locked to the spindle with the index lever. By rotating the barrel and rosettes around the spindle, the relationship of the rosettes to the workpiece can be changed. The barrel rotation is performed by using either the index lever or the crossing worm.

In this illustration the headstock is spring-loaded towards the left using the rocking spring. This forces the rosette against the touch, which is fixed, causing the entire spindle assembly, which includes the rosettes, barrel, crossing plate, worm and index lever, to rock gently left to right as the spindle is rotated by way of the drive belt. As the spindle is rotated, the rosette will pivot to the right when the touch reaches a rosette peak and, conversely, the spindle will pivot back to the left when the touch reaches a valley in the rosette. The workpiece is held in a chuck, which attaches to the spindle nose.

Axis of Cutting

The axis available for cutting on a rose engine is radially around the spindle axis. This can be utilized to cut concentrically on the face of a surface held perpendicular to the spindle, or axially around a cylinder held parallel with the spindle (Figures 6 and 10). The spindle can be rocked (Figure 7) or pumped when working on the face or sides of a cylinder.

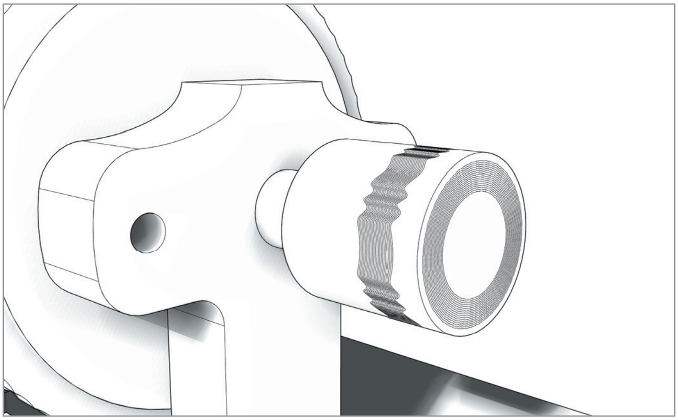

Figure 6 *The two surfaces (shaded) that can be cut with a rose engine*

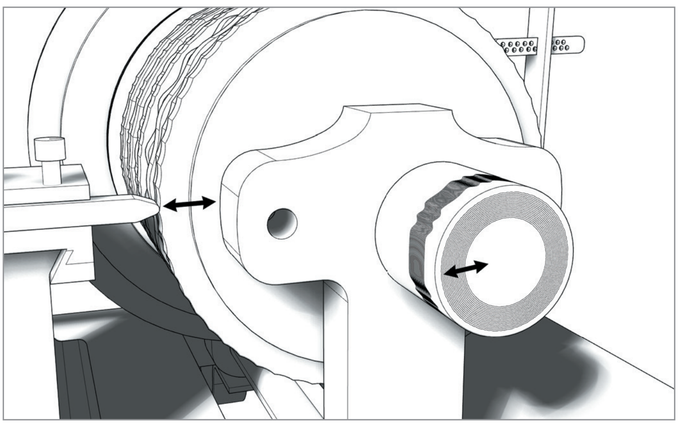

Figure 7 *Rocking motion*

When the spindle of the rose engine is set up for a "pumping" motion, the barrel and rosettes are held under spring tension and the touch is in contact with the side of the rosette (Figure 8). The rosette has a pattern of lobes machined along the side surface of its periphery. The pumping motion comes from the touch resting against the waves or lobes machined into the sides of the rosette (Figure 9). As the spindle is rotated, the cam action of the touch and rosette push the spindle in and out, or axially.

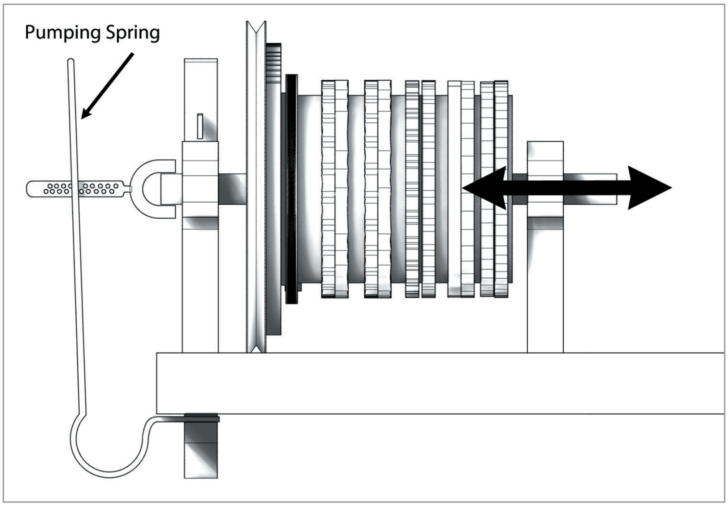

Figure 8 *The pumping spring forces the axial movement of the spindle*

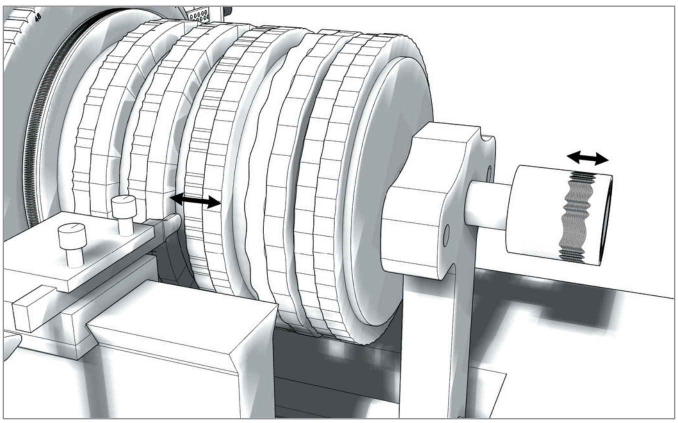

Figure 9 *The touch engaged on the side of the rosette*

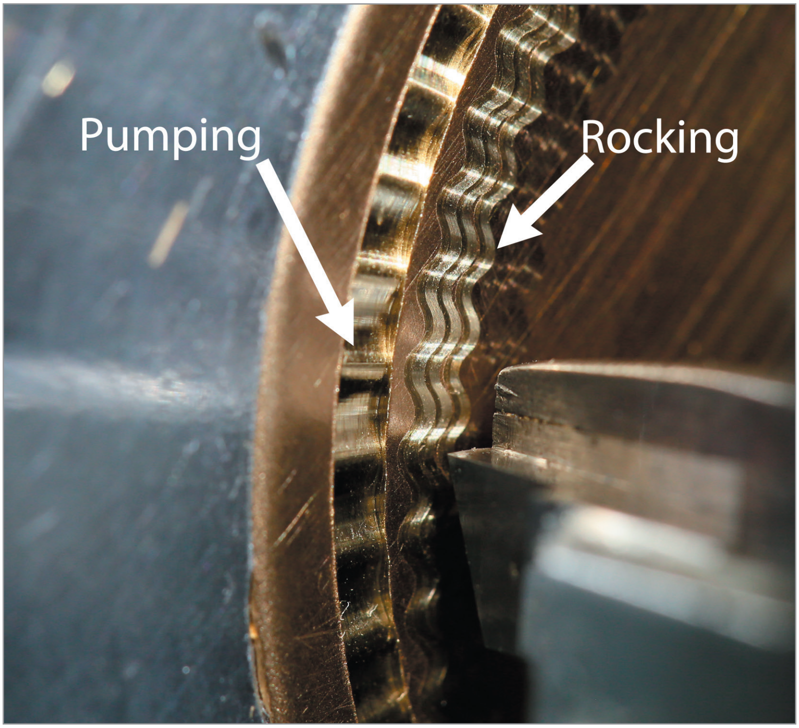

Figure 10 *Close up of pumping cuts (left) and rocking cuts (right)*

The Cutting Tools

There are two families of cutters used with a rose engine. The first family of cutters is the stationary or fixed-point cutter, primarily used for guilloché-style engraving. The second family of cutters is the flycutter and its cutting frame. Flycutters are typically used for high-relief patterns along with die-making processes. Their cutting frames hold the flycutter on a specified axis. These can be horizontal, vertical, or universal. The universal cutting frame allows for the flycutter to be set at any angle relative to the workpiece.

The Fixed-point Tool and Its Use

Fixed-point cutters are typically made from high-speed steel or carbide and are ground into many different shapes depending upon use.

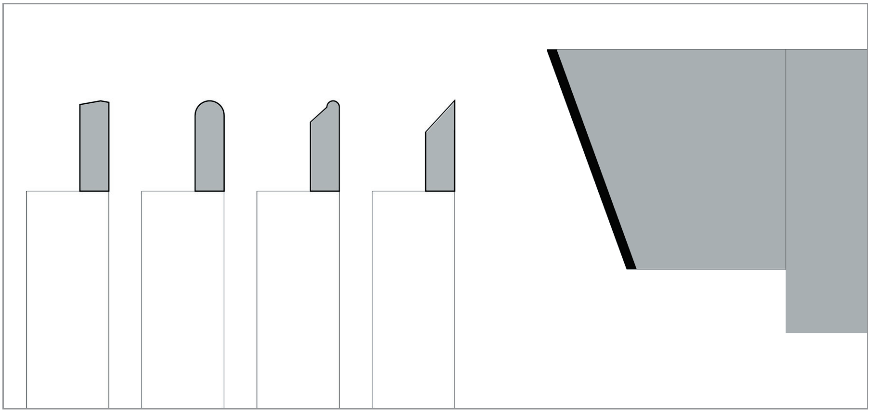

Figure 11 *Shapes of fixed-point cutters and the front relief angle*

The standard guilloché cutter for face and cylindrical work is shown in Figure 11, far left. It has a 150-160º included angle on its tip. The working relief angle ranges between 20-30º. When ground from carbide, a very slight negative relief is added to the cutting edge when cutting silver or gold. This negative relief helps with longevity of the cutter edge and leaves a bright cut in the metal. Greater amounts of negative relief are required for titanium and stainless steel.

Once the cutting is started, the cutter must remain in perfect condition until the work is completed. If the cutter dulls or chips, the work cannot be continued. It must be scrapped and restarted from the beginning as it will be visually obvious that the cuts do not match.

The quality and brilliance of a guilloché cut are highly dependent upon the quality of the ground tool. A highly polished cutter will yield a highly polished and brilliant cut in the metal.

The historic method of shaping and grinding the fixed-point cutters was with the use of a goniostat (Figure 12). The goniostat was used with sharpening stones and/or abrasive-charged glass or granite. The tool was fixed to the goniostat, the cutter and relief angles were set, and the entire assembly would then be slid over a plate charged with abrasive powder. Successively finer grits would bring up a pre-polish, and then a polishing powder would provide a high finish on the tool.

Figure 12 *The goniostat*

Modern methods of grinding carbide cutters to shape include universal cutter grinders and engraving tool grinding machines with diamond laps. The modern grinders all have one thing in common, which is a rotating abrasive wheel or lap. With these machines the angles are set for both profile and relief, and the carbide-tipped cutting tool is then brought into contact with the abrasive wheel or lap. The abrasive wheels and laps are impregnated with diamond grit, in the range of 260-600 grit, for roughing out the shape, then 1200 grit for pre-polish. The polish is accomplished using 50,000-100,000 grit diamond on a ceramic wheel or lap (Figure 13).

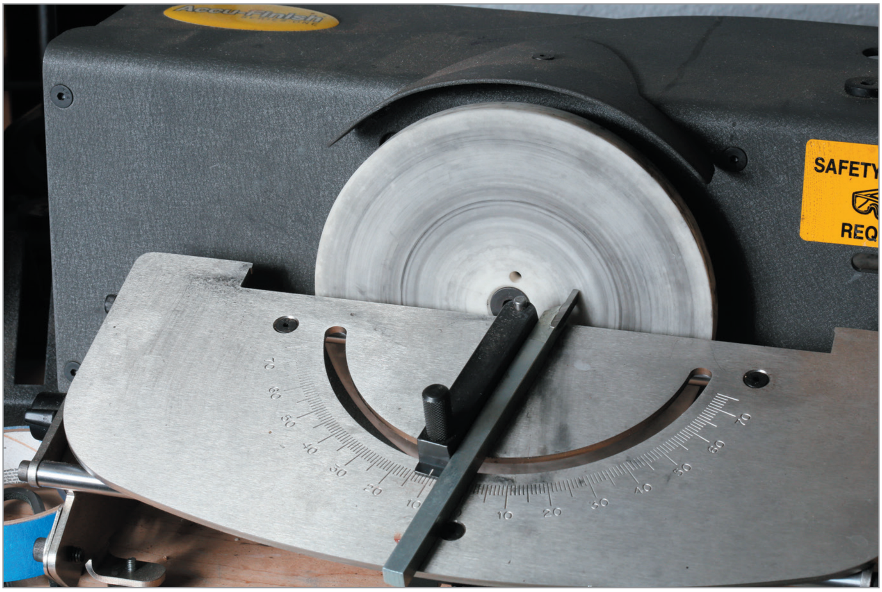

__Figure 13__ Polishing a cutting tool with a ceramic lap and 50,000 grit diamond

Once the cutter is ground and polished to the required shape, it is then mounted onto the cutter tool slide adjacent to the guide. The guide is a bull-nosed tool, which is also highly polished and designed to ride on the surface and burnish the workpiece while controlling the depth of the cutter (Figures 14, 15 and 16). The cutting tool and the guide are then adjusted for cutting depth.

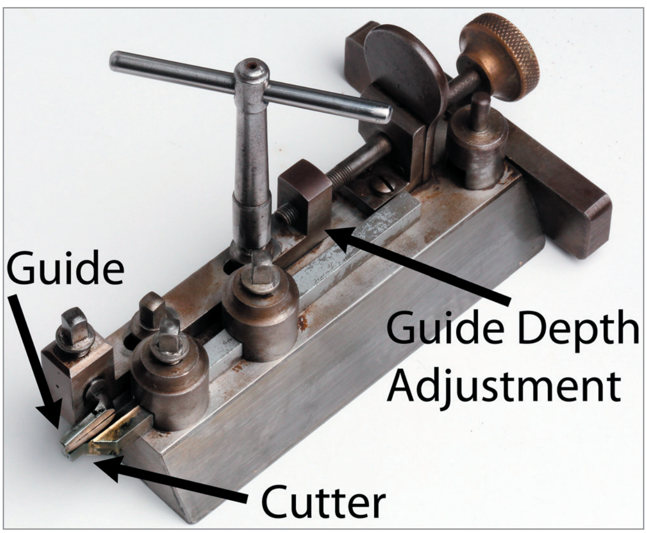

__Figure 14__ Tool slide

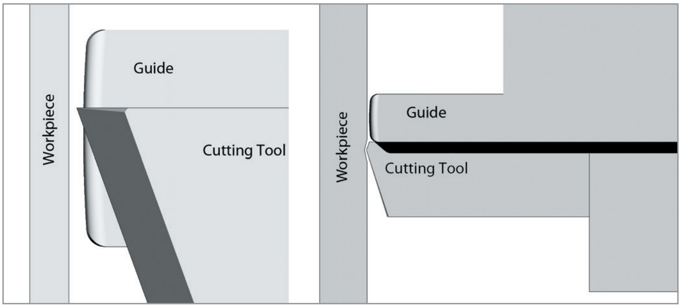

Figure 15 *Side view and top view of the cutter and guide*

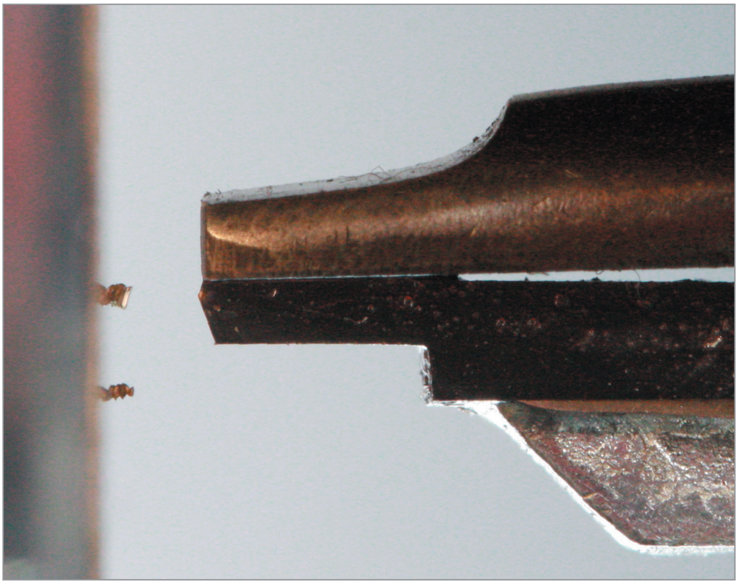

Figure 16 *Top view of cutter and guide*

The depth of cut is adjusted to achieve a specific pattern. For traditional guilloché engraving it is important to maintain the same depth of cut for each of the many successive cuts, otherwise the workpiece will need to be scrapped. Modern styles of guilloché engraving might include cutting to differing depths, in which case the guide is adjusted for each cut.

Given the broad angles of the cutting tool, it's apparent that a slight change in depth results in a greater width of cut (Figure 17). Both depth and width of the cut play major roles in pattern development.

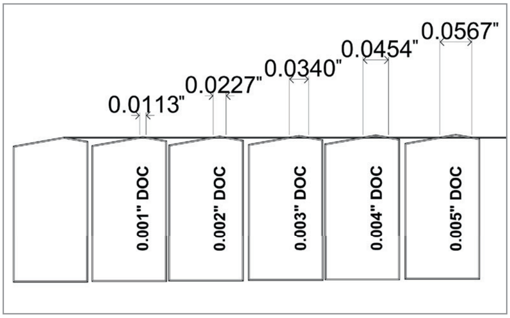

Figure 17 *Depth of cut (DOC) and its effect upon the width of cut*

Flycutters

Another commonly used method to cut metal in the rose engine is with the use of flycutters. Flycutters are milling devices which have the cutters attached to a rotating wheel, shaft, or spindle. There are many types of flycutters and their respective cutting frames. The cutting frames hold the flycutter wheel or spindle to a specific orientation relative to the workpiece. As such, the horizontal cutting frame will hold the flycutter in a horizontal position, the vertical cutting frame will hold the flycutter in the vertical position, and the universal cutting frame is fully adjustable through any angle of orientation relative to the workpiece.

The simplest type of flycutter is a drilling tool, also known simply as a drill, with an eccentric cutter as shown in Figure 18.

Figure 18 *Drill with an eccentric cutter*

Flycutter styles include single or multiple carbide-insert milling cutters in the shape of a wheel with the inserts around the periphery (Figure 19).

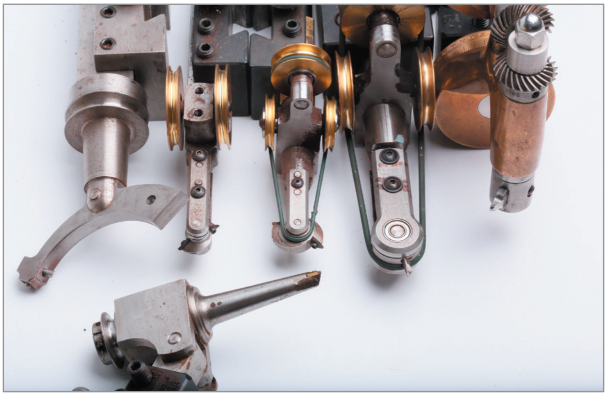

Figure 19 *Various flycutters with single and multiple carbide inserts*

Flycutters can be used to cut metal dies (Figure 20) which are then used to form the workpiece. The progression of cutting starts with light plunge cuts as the rose engine is put into motion. After each revolution the flycutter is moved in small increments into the die material until the desired depth is reached. Note that the rose engine can be operated in either the pumping or rocking mode for this process, which will yield different results on any given rosette.

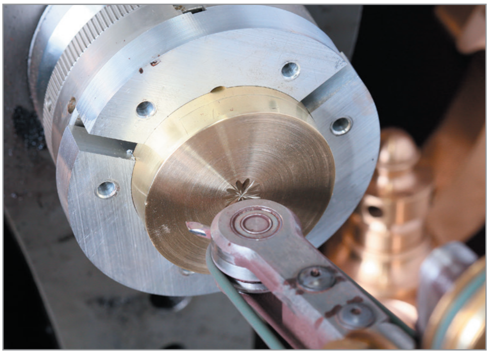

Figure 20 *Die-making with the use of a flycutter*

Upon completion of the die, a thin piece of metal (copper, silver, gold, etc.) is sandwiched between the die and the selected polyurethane and placed into a hydraulic press (Figure 21). The hydraulic press is then activated, which forces the thin workpiece metal into the die. The pressure required to form the metal depends upon the thickness of metal, type of metal and detail level of the die. Thick, hard metal requires higher forces to form the metal, whereas thin and/or soft metals form with lesser forces. Similarly, higher forces are required to form the metal into finely detailed areas of the die, whereas lower forces are used when the die has soft, flowing features with no fine details.

Figure 21 *Die made by pumping the rose engine and its results in niobium after forming in the hydraulic press*

Chucks

The workpiece must be securely held to the spindle nose of the rose engine. There are many methods and tools to accomplish this objective. The most common method used to hold the workpiece to the spindle is to use a multi-jaw chuck. Three- and four-jaw chucks are available with “pie jaws,” or full-circle jaws (Figure 22), which are capable of securely holding thin discs of precious metal. When properly made, these pie jaws allow for the full support of the metal from around and from behind the thin disc. Step jaws may be used for thicker, less flexible parts but will allow too much flex with thinner metals. This flex prevents the depth of cut from being maintained throughout all of the successive cuts.

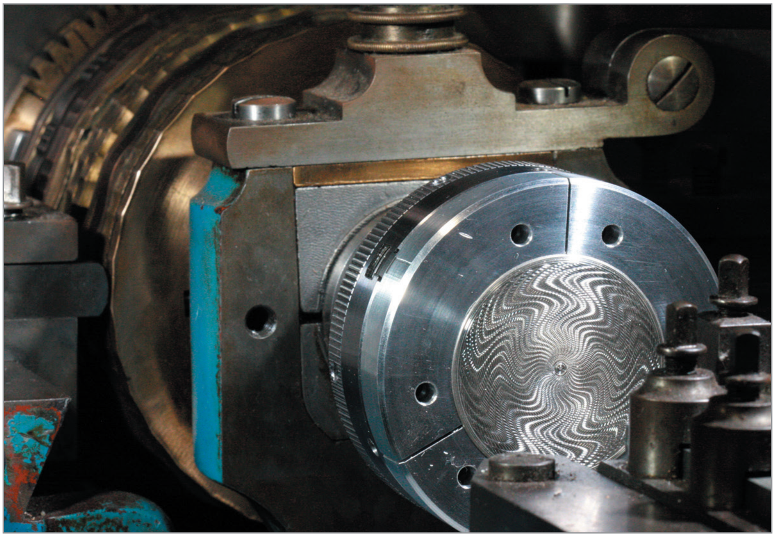

Figure 22 *Three-jaw chuck with "pie jaws" or full circle jaws*

Other chucks include two-jaw chucks (Figure 23) with interchangeable plates which are cut to fit a specific size or shape of workpiece.

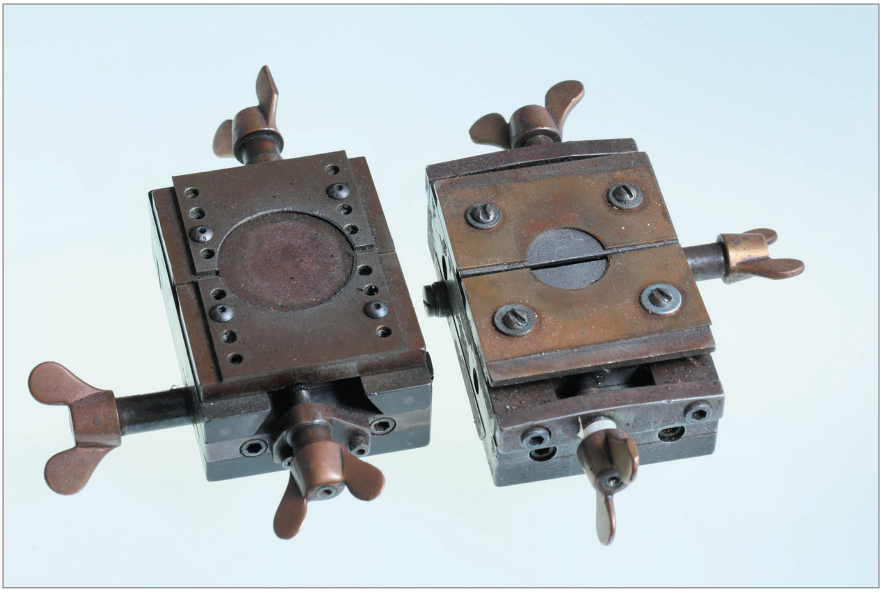

Figure 23 *Two-jaw chucks with eccentric slides*

Glue chucks or wood chucks with shellac are also commonly used to hold the workpiece to the spindle (Figure 24).

Figure 24 *Glue chucks or Jett Sett™ chucks*

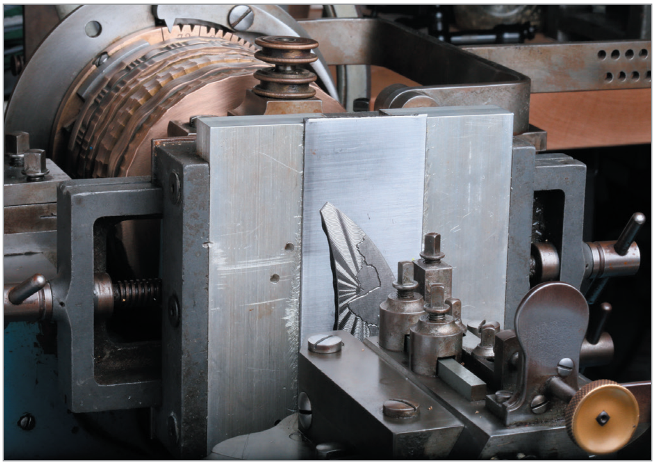

Figure 25 *Titanium workpiece on a glue plate held and adjusted to center with the two-jaw eccentric chuck*

Many of the two-jaw chucks allow for the off-center or eccentricity of the workpiece. (Figures 23 and 25) This can be utilized when creating patterns which overlap or have different centers.

Leveling chucks (Figures 26 and 27) are beneficial when the workpiece must maintain precise alignment. Some processes demand the face and sides of a workpiece be held axially parallel and radially centered, within a thousandth of an inch (a couple hundredths of a millimeter) or less. The leveling chuck allows for precise axial and radial alignment of the workpiece.

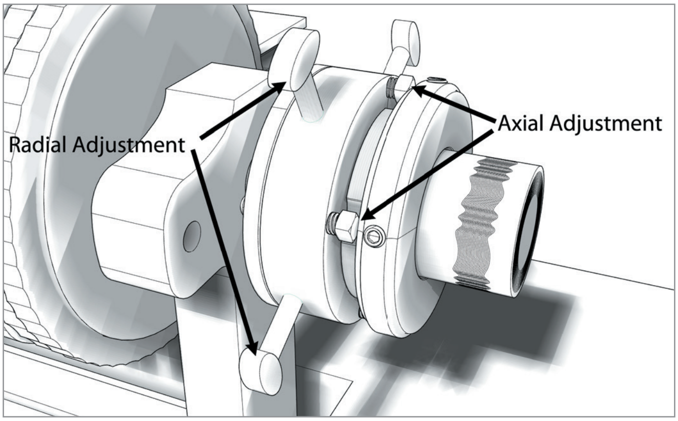

Figure 26 *Leveling chuck*

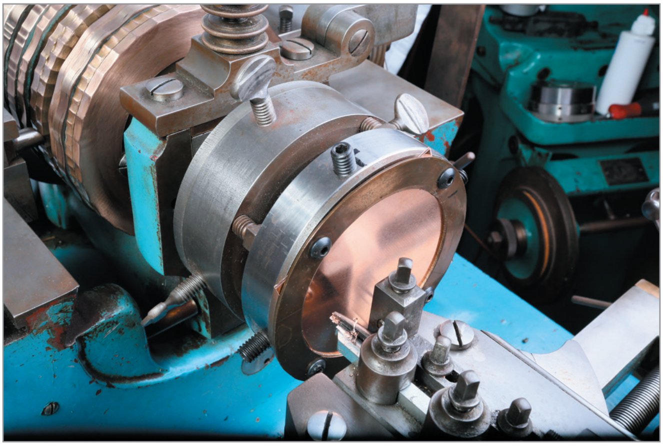

Figure 27 *Leveling chuck*

The Cutter Slide and Movements

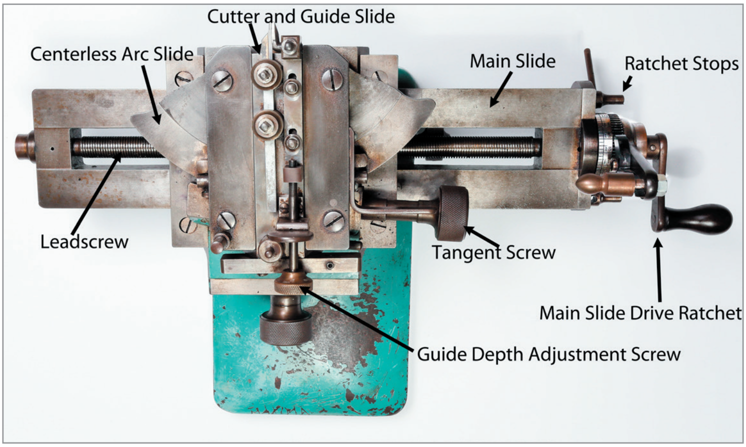

Figure 28 *The main slide and its parts*

The cutter and guide are held in a slide that is mounted to, and moves upon, a larger main slide that is traversed via the leadscrew. The leadscrew is turned via the main slide drive ratchet (Figure 28). This ratchet (Figure 29) is swung between stops which, when set, restrain the movement of the leadscrew to a specific and repeatable distance.

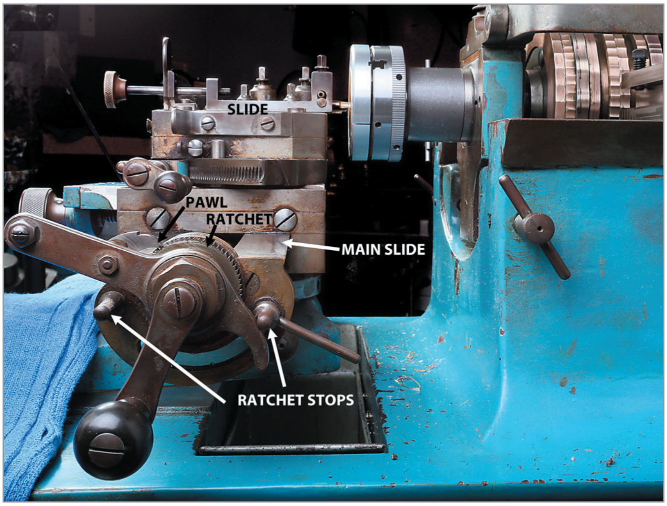

Figure 29 *Parts of the slide*

This distance is set dependent upon the depth of cut and the pattern required. Deeper cuts typically will be placed further apart whereas shallow cuts are usually placed closer together. When deep cuts are placed close together, the overall surface level will end up lower, which has advantages for enameling. When cuts are shallow and widely spaced, the result is a larger quantity of original flat-surface area between cuts. It's important to keep the backlash out of the slide by always moving the ratchet in the same direction while moving the cutter to the first and subsequent locations.

Starting the Cut

The slide is brought up to the workpiece and locked in position square to the workpiece surface to be cut. It's important that the tangent screw and its arc slide are also set perpendicular to the workpiece. If the cutter meets the workpiece at less than, or more than, a 90º angle, the cut will be imperfect (Figure 30). If the cutter and guide meet the workpiece at an acute angle the cutter will cut much deeper than intended. Similarly, if the cutter and guide meet the workpiece at an obtuse angle, the guide will touch the workpiece before the cutter and no cut will be made.

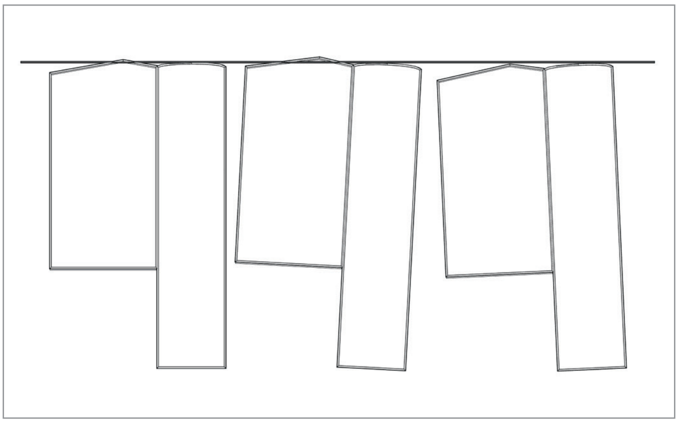

Figure 30 *Showing the correct orientation on the left, an acute angle in the middle which cuts too deeply, and an obtuse angle on the right where the guide touches the work and prevents the cutter from cutting*

When working on domed pieces, the cutter and guide are kept perpendicular to the work (Figure 31) by way of the tangent screw (Figure 28). The tangent screw swings the cutter slide through an arc of motion (centerless arc slide in Figure 28), which orients the cutter perpendicular to the workpiece.

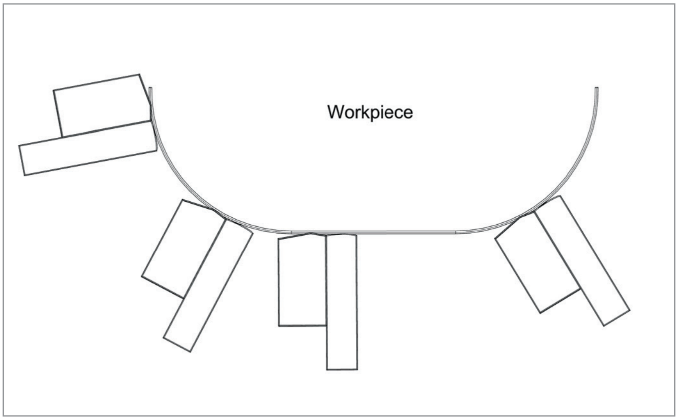

Figure 31 *Keeping the cutter perpendicular to the cut*

Cutting typically proceeds from the outside of the work towards the center (Figure 32), although it is not always necessary to cut in this direction.

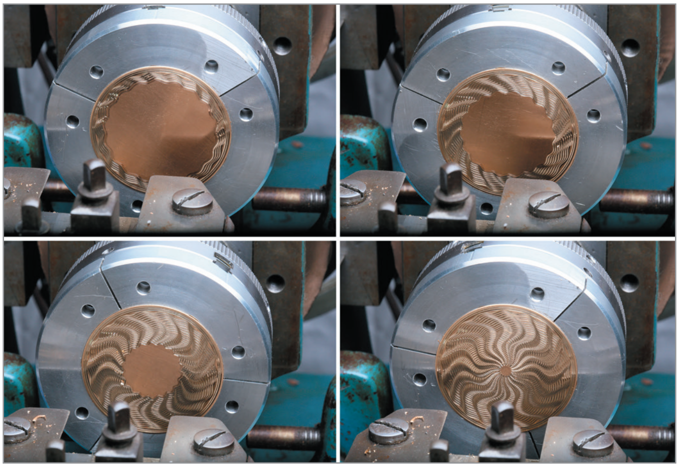

Figure 32 *Images of progress from outer edge towards center*

When the cutting has progressed to the final one-quarter inch (6.35 mm) of center, the common approach is to take the touch off of the rosette and cut simple circles. This is due to the effect of amplitude as the cutting gets closer to the center of rotation. As the cutting proceeds closer to the center of rotation, the ratio of the amplitude to the pitch (distance between peaks) of the rosette becomes extreme (Figure 33). This is caused by the fact that the amplitude stays the same while the pitch of the rosette becomes smaller with each successive cut.

Most rosettes will yield an extreme zigzag effect near the center of the workpiece, which appears as a less-than-ideal cut. Rosettes designed with very small amplitudes (<0.015″) are capable of engraving very close to the center of rotation, whereas rosettes with large amplitudes are unable to engrave close to the center of rotation.

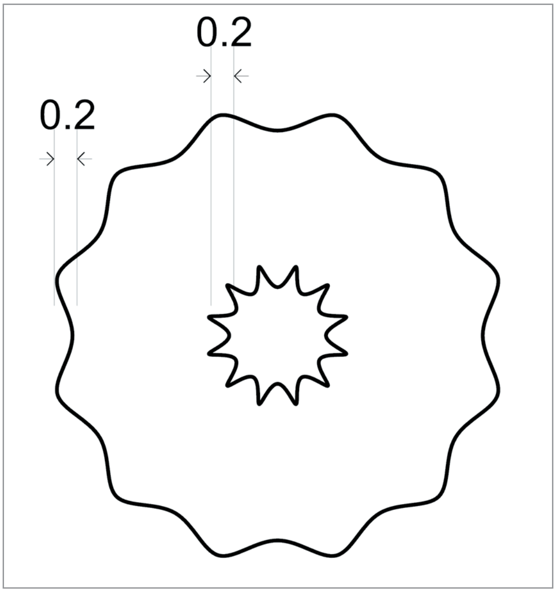

Figure 33 *Showing the effects of amplitude when approaching the center of rotation*

The Crossing Plate and the Worm

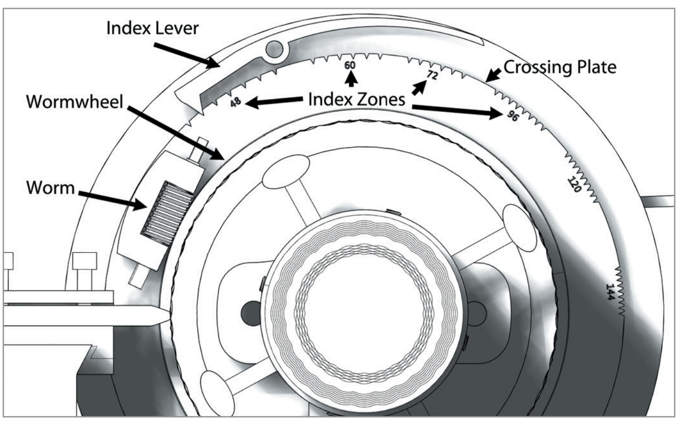

Figure 34 *The crossing plate and its parts*

There are many ways to change the relationship between the rosettes and the workpiece, thereby creating new patterns. Certainly, the most common method is the use of the crossing plate (Figure 34).

The crossing plate is also referred to as the division plate. It is fixed to the barrel of rosettes, which together are free to rotate around the spindle and which is locked to the spindle motion with the index lever. The index lever is fixed to the main drive wheel. Its role is to assist in the development of patterns by changing the rotational relationship between the barrel of rosettes and the workpiece. This is accomplished via two possible methods. The index lever may be used to index the crossing plate in prescribed amounts of rotation, or the worm may be used for any amount of rotational change not prescribed by the crossing plate.

The crossing plate has several zones of index notches on its periphery. The notches are located and indexed to the crossing plate with the index lever. The zones of notches are typically marked on the plate with numbers such as 48, 60, 72, 96, 120, 144, 192, 240, 300, 336, and 360 (Figure 37). These numbers denote the fraction of a circle between any two of the notches from the same series. As an example, in the 72 series of notches, rotating the crossing plate one notch is equal to a rotational change of 1/72 of a circle, or 5º of angular movement. This is called "phasing" and is readily applied to pattern creation. Phasing re-orients the rosette pattern relative to the workpiece. For example, using a 36-lobe rosette, starting from the outside of the workpiece the first cut is made. The cutter slide is traversed a set amount on the main slide; the crossing plate is then moved one index notch of the 72-index zone. The second cut is then made, after which the cutter slide is traversed a set amount on the main slide and the crossing plate is again re-oriented one notch of the 72-index zone. The cuts proceed in this manner, re-orienting the crossing plate after each cut. By moving the crossing plate one notch, the rosette is re-oriented relative to the workpiece by 1/72 of a circle, or in this example, half of the rosette lobe count, which has 36 lobes. The result is similar to that shown in Figures 35 and 36. This is traditionally called a barleycorn pattern.

Note that each cut in this example is a sinewave which is a single complete cut around the center of rotation. The perceived pattern when completed appears to be many interlocking or overlapping arcs.

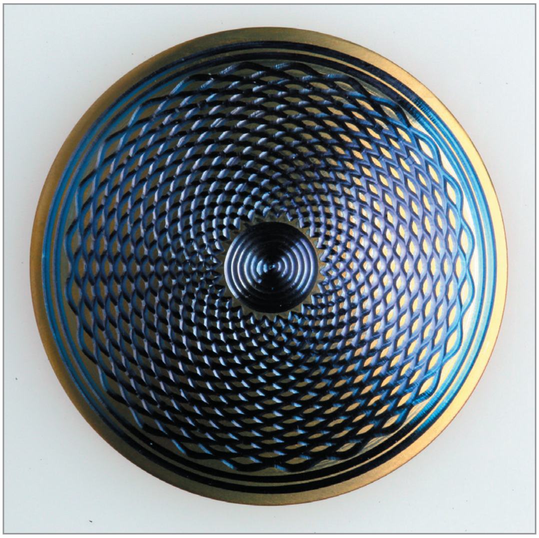

Figure 35 *Titanium cut with a 36-lobe rosette and phased with each successive cut, creating a barleycorn pattern*

Figure 36 *Barleycorn box, mastodon ivory with a barleycorn pattern cut into the side of the box (courtesy Daniel Brush, 1984)*

If the crossing plate is rotated two index notches in the 72-index zone, the physical change is equal to 1/36 of a circle or 10° of angular rotation. Similarly, when indexing one notch in the 144 series of notches, the relational angular change would be equal to 1/144 of a circle or 2.5° per notch. Two notches in the 144 zone would be 1/72 of a circle or 5°. See Table 1 for an example of notch zones and their relationships.

Table 1 *The angular movement in degrees of the barrel and rosettes relative to the workpiece when the index zones are used*

Notch Zone	1 Notch	2 Notches	3 Notches	4 Notches	5 Notches	6 Notches
72	5	10	15	20	25	30
96	3.75	7.5	11.25	15	18.75	22.5
120	3	6	9	12	15	18
144	2.5	5	7.5	10	12.5	15
240	1.5	3	4.5	6	7.5	9

The use of the worm is another method to change the relationship of the rosettes to the workpiece. It allows for any desired amount of rotation of the barrel. This way we can create patterns with non-identical movements. The worm is engaged to the barrel by way of a wormwheel. Most rose engines use either a 120- or 180-tooth wormwheel. This gives a rotational movement of 3^{o} or 2^{o}, respectively, for each full turn of the worm. It also translates into smaller angular movements when the worm is turned by fractions of a whole turn. As an example, a one-quarter turn of the worm would rotate the barrel and change the relationship between the rosettes and workpiece by three-quarters of a degree on a 120-tooth wormwheel or one-half degree on a 180-tooth wormwheel.

An example of a pattern which uses the worm would be the "Moire" pattern, also referred to as the "sine" pattern. These patterns are where the rotational relationship is changed between each successive cut in varying quantities. After each cut the worm would be adjusted by the following increments: ¼ turn, ½, ¾, 1, 1-¼, 1-½, 1-¼, 1, ¾, ½, and ¼. Continuing on, the direction of the worm would be changed and moved -¼, -½, -¾, -1, -1-¼, -1-½, -1-¼, -1, -¾, -½, -¼.

Another similar pattern uses a set of numbers such as the Fibonacci series. In this case the worm is first turned clockwise after each successive cut in the following amounts: 1, 2, 3, 5, 8, 13, 8, 5, 3, 2, 1; then the worm is turned in the opposite direction counter-clockwise -1, -2, -3, -5, -8, -13, -8, -5, -3, -2, -1. The result would look similar to Figure 37. Both Moire and Fibonacci patterns are almost identical.

Figure 37 *Titanium cut using the worm in a Fibonacci-like numerical sequence*

The Touch

One of the many variables to pattern creation is the radius of the touch in relation to the radius of the lobe on the rosette (Figure 38). Most rosettes consist of a series of shallow concave scallops around the periphery of the rosette. If the radius of the touch is half the radius of the rosette lobe, then the resulting cut in the workpiece is in the form of a sinewave (Figure 39). If the radius of the touch is less than half the radius of the lobe, the result will be a series of concave scallops similar to the rosette itself. Whereas, if the radius of the touch is greater than half the radius of the lobe, the result will be a series of convex shapes, in effect, opposite the shape of the rosette or the mirror image of the rosette.[2]

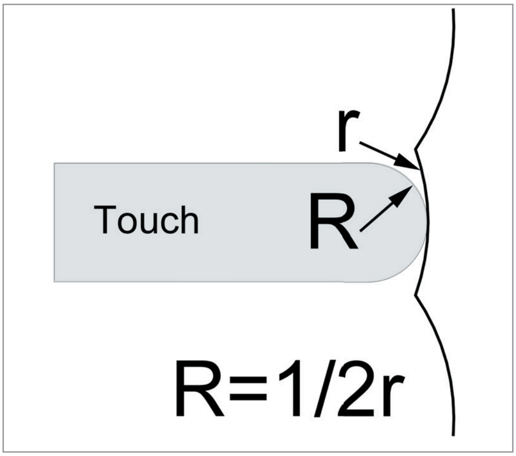

Figure 38 *The touch radius vs. the rosette lobe radius*

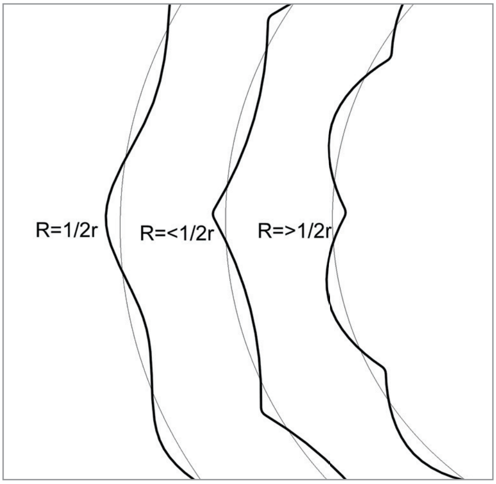

Figure 39 *Changing the radius of the touch and its effect on the cut*

Another variable, which again multiplies the number of patterns possible per rosette, is the location of the touch. Most machines have touch tool mounts on either side of the spindle. By placing the touch in the touch tool mount on the opposite side of the spindle, the cut will be a mirror image of the rosette (Figure 40).

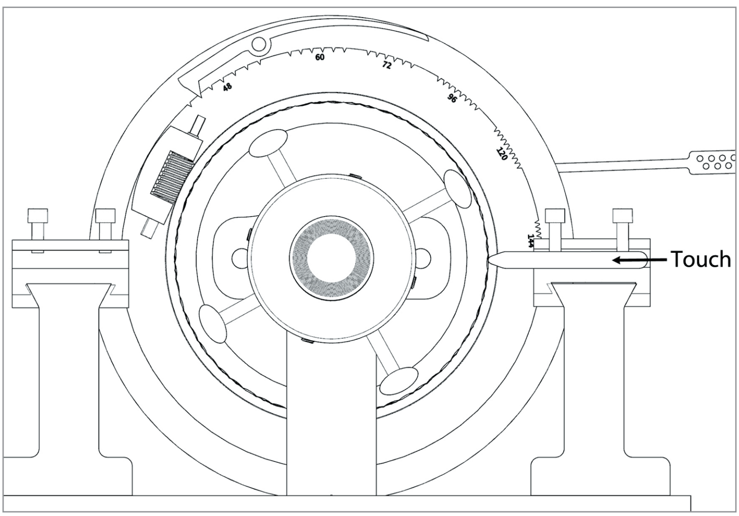

Figure 40 *The touch on the opposite side of the spindle*

The amount of engagement of the touch upon the rosette can also be altered to develop additional patterns. The touch can be accurately adjusted into contact with the rosette by using a leadscrew on the touch holder. This allows for incremental amounts of touch/rosette engagement. Setting the adjustable touch with zero amount of engagement, the pattern cut would result in a circle. By adding a small increment of engagement, the pattern cut would be mostly circular with small bumps where the touch engaged just the tops of the rosette. By continuing to add a little engagement after each cut, the full rosette pattern would eventually show in the cut. This process can be reversed to gradually fade the rosette cut back to a simple circle.

The use of a touch is not limited to only one touch and one rosette. Multiple touches can be utilized to engage multiple rosettes. This can enhance the cut pattern and yield a much more complex cut pattern.

Elliptical Chucks and Eccentric Chucks

The elliptical chuck (Figure 41), also referred to as the oval chuck, is capable of turning a wide range of ellipses with different axial proportions, from very narrow ellipses to very wide, almost circular ellipses. This chuck is attached directly to the spindle nose of the rose engine and can be combined with any of the rosettes on the barrel or run without the extra shaping of the rosettes. It can be used in both rocking and pumping modes.

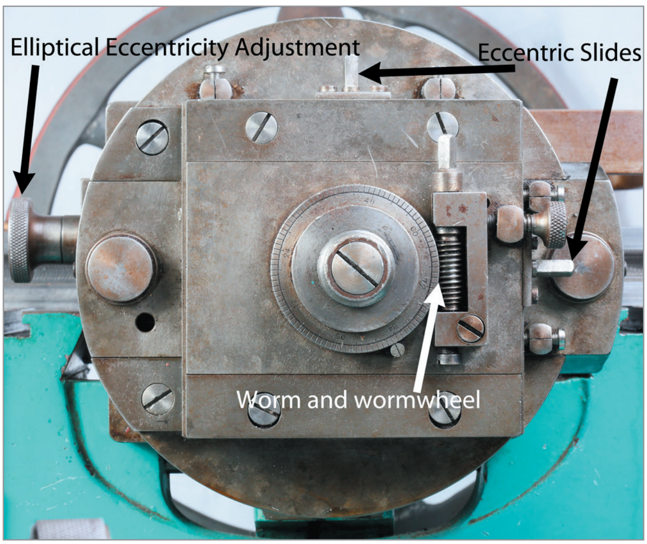

Figure 41 *The elliptical chuck*

An ellipse can be defined as a planar curve that surrounds two focal points. The distance between the two focal points defines the amount of elongation of the ellipse. The elliptical chuck has an adjustment thumbwheel used to set the elliptical eccentricity of the main chuck slide, which is, in other words, the distance between the two focal points. When the adjustment sets a small distance between the two focal points, an ellipse would be cut with a small amount of elongation to the ellipse (Figure 42). When the adjustment is made for more distance between the two points, the ellipse becomes more elongated.

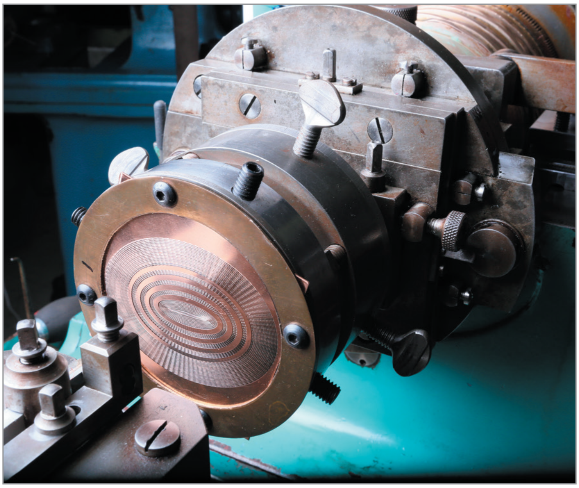

Figure 42 *Showing a moderate amount of elongation with the use of the 96-lobe rosette*

When engraving ellipses it is extremely important to set the height of the cutter to the exact center of the spindle and maintain the cutter at center, otherwise the ellipse will be slightly askew, or twisted, and successive cuts will interfere with the previous cuts.[3]

Most elliptical chucks also have the added advantage of having an integrated double-eccentric chuck. The double-eccentric chuck, also known as the compound-eccentric chuck,[4] allows the workpiece to be moved off-center on one or both axis slides. This allows the creation of numerous patterns with radiating circles or ellipses. John Holt Ibbetson explored this style extensively and published many examples and methods used in 1817.[4] Figures 43 and 44 show examples of elliptical and eccentric cutting using the compound-eccentric chuck.

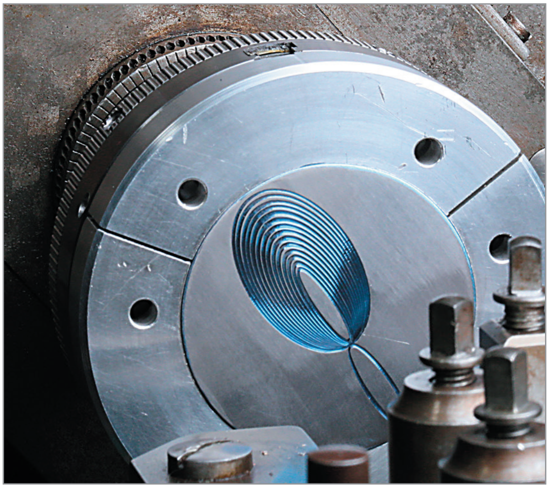

Figure 43 *The elliptical chuck in combination with the compound-eccentric chuck*

The orientation of the ellipse can be adjusted or changed with the worm and wormwheel on the elliptical chuck. This axis of change can also be utilized to create new patterns.

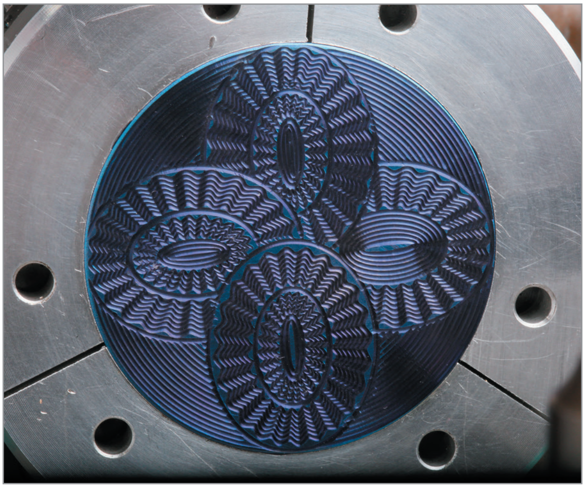

Figure 44 *The elliptical chuck used in combination with the compound-eccentric chuck and the index wheel on a piece of titanium*

There are many more styles of chucks and cutting frames far too numerous to cover and beyond the scope of this paper. That said, using the chucks, cutters, and variables described so far, the number of possible patterns is virtually limitless. A list of variables available for pattern development might look like this:

- Cutter style and shape
- Depth and width of cut
- Step-over of cutter slide
- Rosette or rosettes
- Touch radius
- Touch placement
- Touch engagement
- Crossing plate sequence
- Worm sequence
- Axial and/or radial eccentricity
- Elliptical eccentricity

With the numerous possible combinations of these variables, it is easy to see that the number of patterns is almost limitless (Figure 45).

Mass Production

During the beginning of the 20th century, the demand for guilloché items skyrocketed. This placed demands on the production of work to satisfy the marketplace. Several methods of speeding up the process and mass producing guilloché-like patterns were invented. The first was to use a diamond point to scratch the patterns into the metal rather than cut the patterns with a traditional engraving cutter. A benefit was that the diamond point was much easier to manage when engraving the patterns into metal. This meant that less training was needed for the machine operators. The drawback was that the diamond points cannot remove metal, only plow it aside, so depths are consequently very shallow. This, in turn, demands that the width of the engraved line had to be very narrow. Narrow cuts tend to be less bright than wide cuts so the optical effects on these pieces were less brilliant.

Die making was also a method of speeding up the process and mass producing a guilloché-like pattern in metal. Water-hardening steel was chucked up into the rose engine and engraved with a pattern. It was then hardened and tempered and used as either a hob, which would then produce a master die, or used as a die to coin directly into the metal, leaving the pattern raised (Figure 45). Again, this technique was effective towards the goal of greater production but failed at truly replicating the brilliance and optical effects of true hand-cut guilloché.

Figure 45 *Two hobs made to emulate guilloché*

Modern Methods and Materials, Future Developments

Modern CNC milling machines have been used to cut precious-metal pieces similar to what's available with the use of a rose engine. The modern machines succeed at some of the techniques but not all that are traditionally accomplished on a rose engine.

In the case of guilloché-type engraving, the rotary tools of a modern CNC mill or lathe will leave a very fine repeating mark in the tool's cut path. Under close microscopic inspection, the channels cut with rotary tools leave tool marks which appear as numerous radial marks across the kerf left by the tool. These marks reduce the brilliance of the cut. Pieces made this way can still look quite good, and some are so good as to be difficult to differentiate between one cut with a fixed-point tool and another cut by a rotating tool. In the best of cases, discerning eyes can see the difference as the properly executed hand-cut guilloché will always have a brighter cut due to its action.

A possibility in the quest to alleviate the tool marks left by a rotating tool would be the development of a CNC machine that could precisely mimic the rose engine. In this case the machine would be designed for use with a single-point fixed tool. This idea would require a table with X and Y axis movement, and a Z axis coupled with an axis of rotation concentric with the Z axis, which we might call the "C" axis. This C axis would keep the cutter always facing into the direction of cut with the tool's front cutting edge perpendicular to the direction of travel. The software would also need to be developed to allow for all of the variables of a mechanical rose engine. A few craftsmen and engineers have explored this area with interesting results. One engineer who has had success with this is idea is Leonardo Di Benedetto in Spain. He has designed a CNC machine with X, Y, Z, and C axes along with the control software specifically for engraving styles.

The software allows the user control of the depth of cut and entry/exit ramps to simulate hand engraving. The C axis keeps the tool edge perpendicular to the direction of cut while the Z axis is used for depth. Figure 46 shows two examples of the results on watch rotors.

Figure 46 *Examples of CNC cut engraving (left) and guilloché (right)*

One hardship of teaching this material, which has been made clear to me over the years, is the price of admission. Young designers who want to utilize these mechanical engraving machines sadly find that the rarity of the machines demand high prices for the few that come up for sale. The lack of easy access to these rare machines is partially to blame for an overall lack of new ideas and techniques by young designers. A modern version based on CNC controls could reduce the cost of entry, and may open new doorways of pattern development.

The recent use of the rose engine on modern metals, and with modern designs, is a new area of exploration which has yet to be fully exploited. A few designers are currently using the rose engine with space-age materials such as titanium, niobium, and stainless steel. Some have created new and unusual rosettes that generate interesting and unique patterns. One artist uses the rose engine to create intricate textures made by overlapping the cuts at differing angles to each other.

Several of the modern metals have the benefit of resisting tarnish. Tarnish and its effect upon precious-metal engraving has always been a problem. Tarnish reduces and impairs the beautiful optical effects of an engraved workpiece. Transparent enamels were developed in Switzerland around 1780 soon after the first guilloché was cut in silver and gold. The transparent enamels were needed in order to cover and seal the engraved workpiece and to preserve the optical clarity of the silver or gold, which would otherwise tarnish. Using modern metals such as titanium or stainless steel also solves the problem of tarnish and its ruinous effects on the engraved pattern. The anodized colors of titanium also add a dynamic element to the designs; as you move the piece the light reflects off of the different angles of the engraved lines, creating subtle shifts in color.

One contemporary craftsman who uses a rose engine with modern materials and styles is Peter Gilroy of Taos, New Mexico. The process used in creating his titanium bolo tie with 18K inlay (Figure 47) was as follows: the primary shape of the piece was cut out on a CNC mill, the part was then glued to a chuck and guilloché engraved on the rose engine with the workpiece far from the center point, thus creating an asymmetric composition. The titanium was then given a dark grey patina and polished, followed by CNC milling the slot for the gold inlay.

Figure 47 *Bolo tie in titanium with 18K inlay by Peter Gilroy, 2015*

The process used in creating the Gorget (Figure 48) was as follows: the workpiece was first chucked into a CNC mill, the Grand Teton Mountains were engraved and the peripheral profile machined. The engraved lines created an easy reference line to start and stop the guilloché engraving. The part was then glued onto a chuck and mounted to the rose engine, the eccentric slides were adjusted to locate the center of rotation (the circle describing the sun) and the sun's rays were then guilloché engraved and anodized gold. The mountains were masked off so that they could later be anodized blue. Similar processes were utilized in the titanium bolo tie with mountains and sunburst (Figure 49). After anodizing, the final assembly was done by laser welding titanium components to the pieces.

Figure 48 *Titanium Gorget by Peter Gilroy, 2015*

Figure 49 *Titanium bolo tie by Peter Gilroy, 2015*

Conclusion

By looking back and understanding the history of mechanical engraving machines and mechanical pattern making, we can better understand ways of approaching new designs. The rose engine has tremendous potential as a designing tool with its many possibilities of pattern development. A few craftsmen and artists have started to rediscover this machine tool and its vast potential to add value and intrigue to their jewelry designs. Further development of these processes might yield new machines with further design capabilities.

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