Introduction to Knotwork Construction

a tutorial

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Introduction

Tutorial Source

This instruction material is based on a class covering beginning Celtic knotwork construction (*Introduction to Celtic Knotwork*) I gave during Pennsic War XXII (the week of 20 August 1993). The Pennsic Wars are a long-running series of large yearly events held by the Society for Creative Anachronism (SCA, with URL: www.sca.org), a nationwide educational organization of those interested in pre-17th century activities.

background

This information should be considered introductory in nature, and assumes no experience in Celtic art or design; just a fascination with it! It does not cover what I would call "art" or "design" as such (I don't feel I'm qualified to teach in those areas), but is more "technical" in nature. This tutorial covers basic interlacing techniques, simple border and panel construction, analysis of existing patterns, interlaced corners, more advanced patterns (such as "doubled" knots), and provides links to other, advanced sources for your further research. Techniques from this tutorial can be (and have been) applied to both hand drawn and computer-constructed designs (for example, see my Celtic Computer "Art"--Images page (located at URL: mihaloew.guru/celtic). The techniques described in this tutorial did *not* originate with me. (Please see the Tutorial Bibliography for original sources.) I only *use* the techniques in my work, felt that they were not well-enough known, and hoped that the class (and this web site tutorial) would help them gain wider appreciation.

knotwork background and history

Where did what we call "Celtic Knotwork" come from? Interestingly, knotwork (and much of what we see as "Celtic Art" today) corresponds to only the latest style in a long tradition of Celtic art. Who were the Celts? Roughly, they were a non-Classical European society differentiated by language. They flourished in central and eastern Europe from (at least) the 7th C. BC, moved into the British Isles by about the 3rd C. BC, and remain there today. What, then, is "Celtic Art"? Besides the obvious definition ("art done by Celtic peoples"), Celtic art has several special features. For example, from [Megaw] comes a "minimal working definition" of Celtic Art:

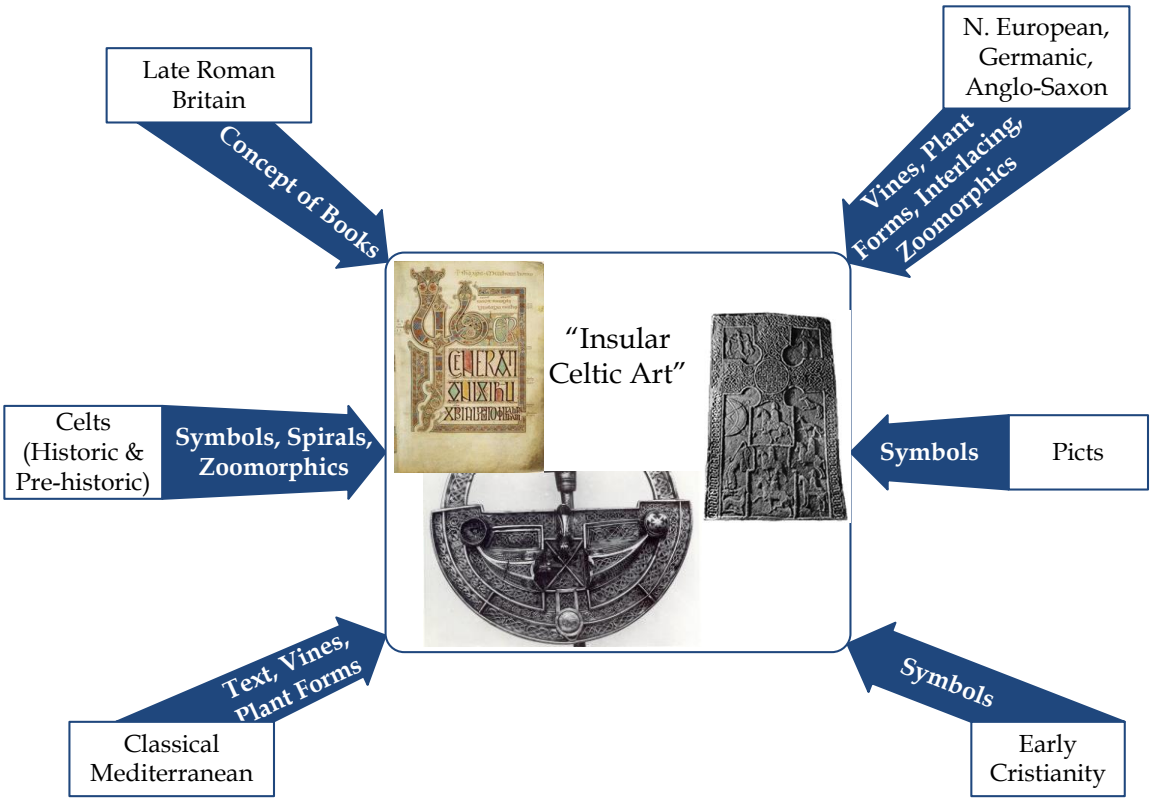
> ...encompasses elements of decoration beyond those necessary for functional utility, though these elements represent a form of symbolic visual communication which is only partially accessible to us.

From [Green] comes the concept that Celtic art was closely integrated with its society; that the Celts were used to seeing art as part of their everyday life. She maintains that "...in Celtic society it is virtually impossible to make a distinction between art and decoration."

The roots of recognizable Celtic art go back at least to the 6th or 7th centuries B.C. The earliest Celtic art seems to have been influenced by the existing Iron Age Mediterranean cultures. Some possible influences can be seen in art from Persia, Africa, Egypt, and other places (see [BainG], page 27 for some speculative examples). Celtic art went through a number of recognizable phases over time (see [Green], [Megaw], and [Laing] in the Bibliography for further details). The Celtic art phase I've concentrated on was a late development, sometimes known as "Insular Celtic", and exemplified by the illuminated manuscripts of the 6th-12th C. AD. This style was influenced by a number of sources:

- Christianity, by about the 3rd C. AD. It is interesting how the Christian influence, especially Roman and Irish monastic, seemed to enrich rather than replace the earlier pagan artistic traditions.
- Native northern British tribes ("Picts").
- Anglo-Saxons (from the 5th C. AD on).
- Vikings (from the 9th C. AD on).
- Others--For example, Thomas Cahill in *How the Irish Saved Civilization* notes that the use of red dots on manuscript initials (see *Knotwork Band Treatments* in this document for details), appears to have been introduced to Ireland by visiting Coptic monks, where that was a common treatment.

A view of these influences is shown pictorially in the following:



Sources for patterns used in this tutorial (and in the associated Celtic Computer "Art"--Images page (URL: mihaloew.guru/celtic/cel_images.html) are taken from illuminated

manuscript Gospels; *Durrow* (ca. 680 AD); *Lindisfarne* (ca. 700 AD); *Kells* (ca. 800 AD); and from carved stones (especially see [BainG] and [BainI]; also [Meehan2]). In the case of the great manuscripts, it appears that masters designed and initiated patterns, with students (monks?) completing the work.

Symbolism in Celtic Art

I've often been asked about the symbolism in Celtic knotwork, or in Celtic Art in general. Many visitors to my Web site ask if I have a list of knots and what they mean, or if I know of a knot that symbolizes a particular concept. I'm sorry, but my research indicates that the Celts probably had no such meaning attached to their work; and, if they did, we would not be able to interpret it today. Drew Ivan (among others) has studied knotwork symbolism, and says, on his site (URL: www.thinkythings.org/knotwork/knotwork-meaning.html) that:

> …Therefore, it's my opinion that the Celts did not use knots as specific symbols. They did not have different knots to represent specific ideas or concepts. Knots were just nifty ways to fill a space. The symbolism of connectedness and continuity seem apparent from simply looking at knotwork patterns. This may have been an intended effect, but I've uncovered no evidence to suggest that knotwork patterns mean anything more than that.

This is, alas, likely to disappoint a great many people. Ivan goes on to mention that: In "Brigit's Feast" (Vol. 2 No. 1, pp. 9, 11) Frank Mills writes...

> The interlaced patterns with their unbroken lines symbolize humankind's pilgrimage, both as a quest to return to our divine source and our spiritual growth as we move along in the quest. The pattern is to be mentally unraveled, which, while occupying the mind with a repetitive task, creates a deeper concentration enabling us "to see." In this it is akin to the use of a mantra or rosary beads.

...though in a footnote Mills says...

> It must be remembered that in our interpretation of Celtic art we cannot know the mind of the ancient Celts who developed these forms, thus the best we can do is to hopefully 'read between the lines' correctly and make some educated guesses.

This theme is reiterated, for Celtic art in general, in [Megaw], where they state:

> ...we cannot tell the precise meaning to a Celt of even some of the commonest motifs... Some may have been, like a three-leaved clover, a charm; others may be heraldic symbols like the American bald eagle or the Tudor rose; yet others may have a significance as profound as a crucifix has for a Christian.

This has *not* stopped some from assigning meanings anyhow! See, for example, URL: www.celticfolklore.com

Please read the fascinating works [Green], [Megaw], and [Laing] (referenced in the Tutorial Bibliography) for further information about the symbolism of Celtic Art.

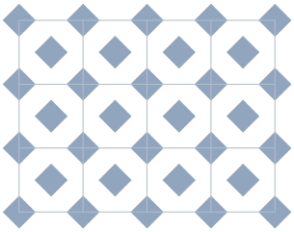
Now, on with the tutorial!

Basic Interlace Construction

Basic Interlacing

The most basic rule of interlacing is: "First under then over then under then...". Some early documented construction techniques (see [BainG]) involved drawing lines, then creating ribbon-like bands around these lines, and then erasing the interlaced areas. Later construction techniques (see [van Stone], [van Stone2], [Sherb], and [BainI]) involve generating a grid of cells using points laid out like "dice 5", and only drawing the lines needed, with little or no erasing required. From evidence on the manuscripts themselves (see [Hull] for details) this appears similar to the actual techniques used by the original Insular Celtic scribes.

One "cell".



These cells are repeated and grouped to give a "grid" (in this case of 4 cells by 3 cells) of dots, circles, or diamonds. That is, the dots, small circles or diamond shapes are drawn to give guidelines for the knotwork bands. The following table provides pros and cons for using the different pattern layout variations:

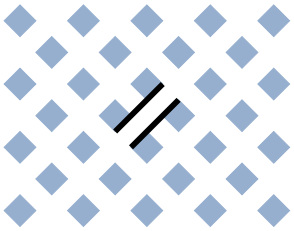
Layout:	PROS:	CONS:
Dots	Quick and authentic, little or no erasing required	Harder to keep constant band with
Small Circles	Easier to keep constant band width, and easier to hand draw	Some erasing may be required in corners and along walls
Diamonds	Most accurate and consistent band width	Hard to hand draw (but easy on the computer), and will always require some erasing

Bands are drawn at 45° to the original grid, between but not touching the dots. If bubbles (small circles) or diamonds are used, then the edges can touch the circles/diamonds. The bands "bounce" or "turn" off the edges and corners of the grid (referred to as the "walls" in this tutorial). Please see the following example:

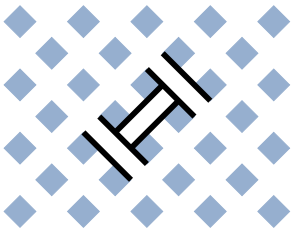
Basic Interlace Example

Try the following steps (use graph paper or a copy of one of the grids from this tutorial):

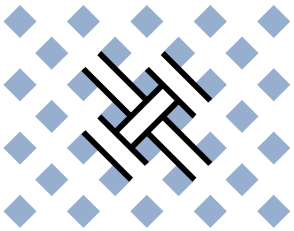
1. Build grid (example uses a 3 cell by 4 cell grid, and marks the centers of the grid points with diamond shapes).



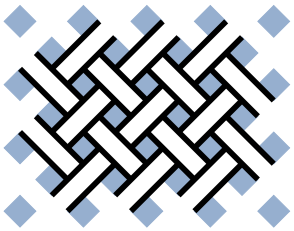
2. Draw 2 parallel lines starting at the edges of the circles, diamonds (or just off the dots), not the centers. Think of bands of ribbon placed between pegs.



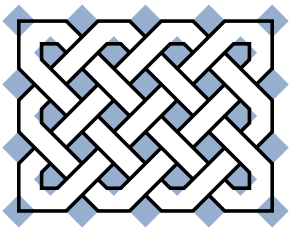
3. Now draw the perpendicular bands on either end...



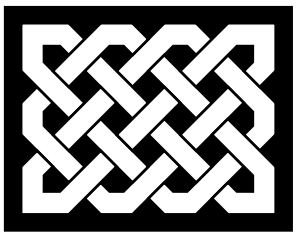
4. ...and bands running "under" the middle of the original band...



5. ...then continue with all bands until you run into a "wall" or corner.



6. For now, just "square off" the corners and wall turns (we'll get into curving these later).



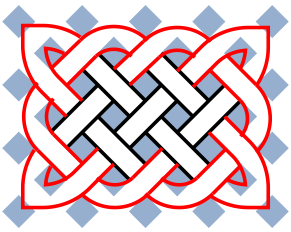
7. Finally, fill in the background with black to cover the dot/circle/diamond layout markers.

Please attempt this interlace on your own. Download a sample grid from the web site and work with it as is, print a grid from this document (in the *Sample Grids* section) and use behind tracing paper (or plain paper on a light table) as calligraphy guides are used, or use graph paper.

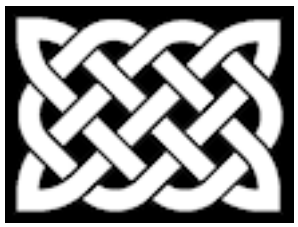
Curved Interlace Example

Most examples from actual artifacts use curved lines, not the angular corners we've done so far. Doing curves requires thinking ahead in the corners and walls. To get a smooth curve into the corner and against walls, you need to start back from the edge of the line that will hit the wall. Then smoothly curve the lines into the corners and walls. Try to keep the band a constant width, even though you may overrun the circles (or diamonds) in the centers of the cells. You'll see many examples of curved knotwork designs in the remainder of these instructions.

1. Start with the initial example, at step 5.



2. Smoothly curve the lines into the corners and walls, overlapping cell boundaries as needed. The new curves are shown in red.

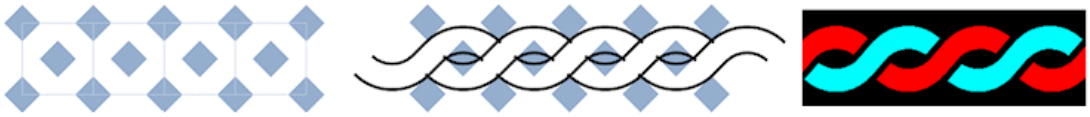


3. Clean up any stray marks “inside” the interlaced bands, and fill in the background with black as before.

Please attempt this interlace on your own as well.

Simple borders ("plaits")

A row of cells can be used to form a border. The simplest version is one cell wide. The example below shows the grid, a section of the plait, and the same section filled in:

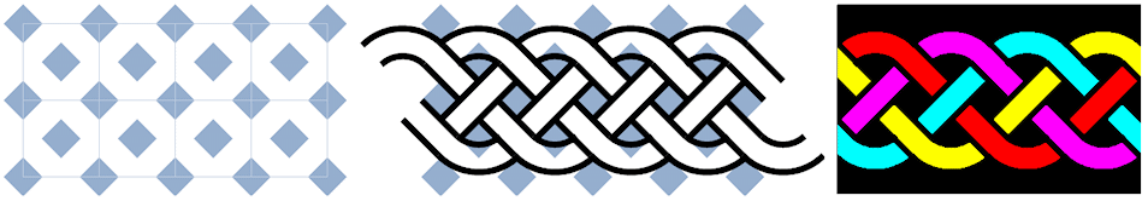


As the colors show, it uses two bands to form the border, which repeats every two cells.

A border "1 and ½" cells wide results in three bands, as shown by the colored example below:

This type of border is used as a basis for a number of Celtic knots, as will be seen in some of the examples. It repeats every three cells.

A 2-cell wide border (often used in Insular Celtic work) is initially four separate bands, repeating every four cells:



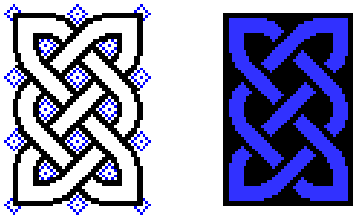
Please note that all these plaits are constructed in the same way as the simple interlacing example, except they have no "corners", just "walls".

Advanced Interlacing

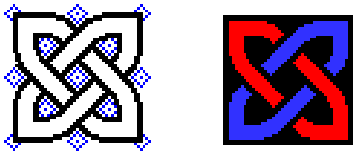
Interruptions and Interlacing Breaks

The original Insular Celtic artists usually devised patterns in single bands where possible. How was this done?

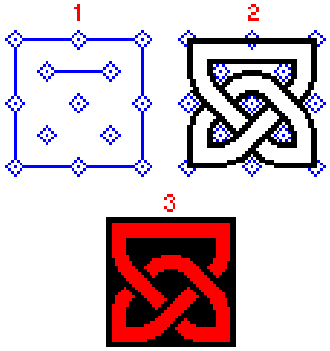
We see that Insular Celtic knotwork panels (and even whole pages or the sides of carved stones) are often designed to be formed from a single band. For simple interlaces, this only works when the ratio of the number of cell sides has no common factors (for example, in 2 cell X 3 cell templates, 3X4, 5X3, etc.).



An interlaced 2 cell by 3 cell panel generates a single band.



A 2 cell by 2 cell panel, when simply interlaced, results in 2 bands, colored red and blue in this example.



The same 2 cell by 2 cell panel, with one added wall, results in 1 band. The first part shows the 2x2 cell grid with the additional "wall" added. The second part shows the band generated by this template with the same rules and methods used in basic interlacing--over and under, changing direction ("turning", or "bouncing off") at walls and in corners. The third shows the band filled in with color.

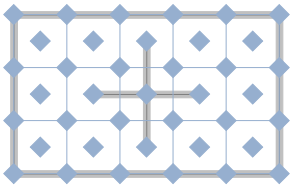
The trick is knowing how to add the "walls" into the panel patterns to end up with a single band in the end.

Interrupted Panel Construction

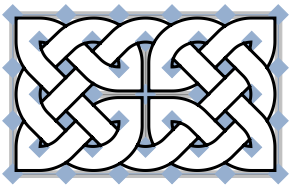
Most Insular Celtic knotwork designs can be seen either as connected panels (with a side partially removed) or interrupted borders (with extra walls and corners); the two concepts are very similar. The tutorial descriptions use the "panel grid with added walls" interpretation. The original Celtic designers used these breaks and interruptions to develop their striking patterns. They often broke down long rows of border cells into

areas like the 2X3 panel above, making designs that cover whole pages (or the sides of standing stones) using one long connected band.

The following example knot is taken from [BainI], pg. 43, using a pattern found in general use in *Lindisfarne*, especially on Folio 27:



1. It is formed on a 3X5 cell grid with additional cross-shaped walls forming four new corners.

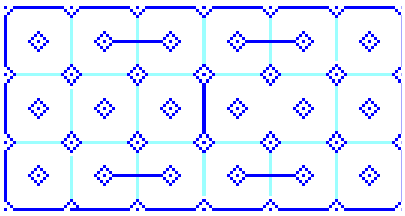


2. The bands are generated in the same way as for simple interlaced panels, "turning" at corners and walls.

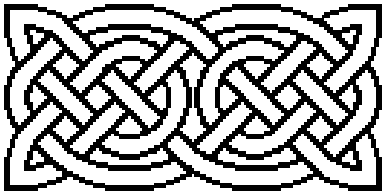
3. The bands can then be colored in, as with the other panels. For other ways of treating bands, see the section on *Knotwork Band Treatments*.

This pattern can be expanded into a border (as in the pattern below) as well as a panel filling pattern (see the associated Celtic Computer "Art" pages (URL: mihaloew.guru/celtic/cel_images.html).

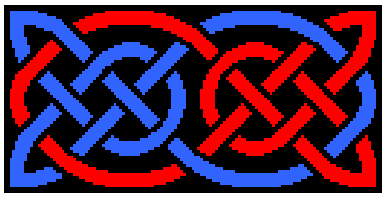
The second example knot panel is also taken from [BainI], pg. 107, using a pattern taken from *Lindisfarne*, folios 27, 95, and 211:



1. It is formed on a 3X6-cell grid with five additional walls.



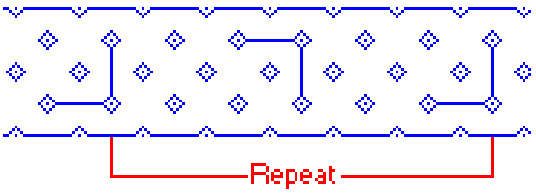
2. The bands are generated in the same way as for simple interlaced panels, "turning" at corners and walls, whether the original panel walls or the added walls. A new feature used here is the longer curve used above the short added wall. Note that the radius of this curve is made to fit "over" the shorter curve--it is not simply two short curves with a straight section between. For a better description of these curve types, see [BainI], Chapter 3.



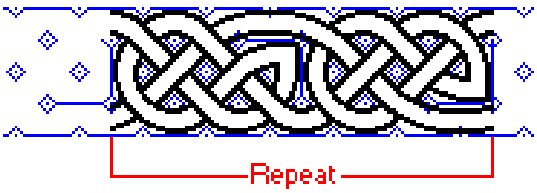
3. The bands can then be colored in, as with the other panels.

This pattern was originally used as a border and was designed to be "mitered" to fit around corners. See the tutorial section on *Mitered Corners* for more information.

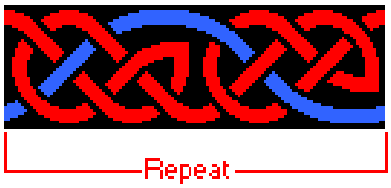
The third example knot is a border pattern taken from [BainG], pg. 40 plate E, originally from *Kells*:



1. The basic pattern is 2 cells wide, repeating every 6 cells, using four additional walls to make two extra unconnected corners.



2. The bands are generated in the same way as for simple interlaced panels, "turning" at corners and walls, whether the original panel walls or the added walls. This pattern also uses longer curve used above the short added wall.



3. The bands can then be colored in, as with the other panels.

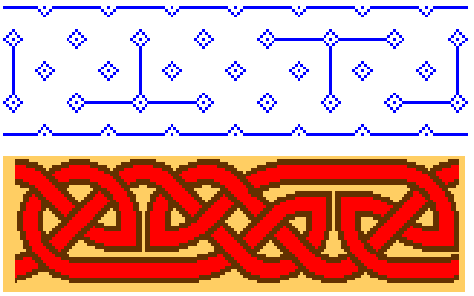
Knotwork Band Treatments

Introduction

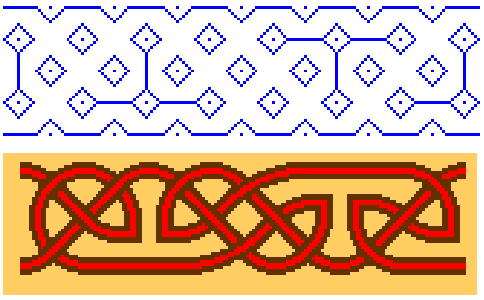
To this point we've been simply using black to cover up the construction marks (dots, circles, or diamonds at the grid points) and filling in the bands with colors. The Insular Celtic scribes certainly used this technique in the original manuscripts. They also used many other techniques to decorate the bands. Some of these are covered below.

Band Width

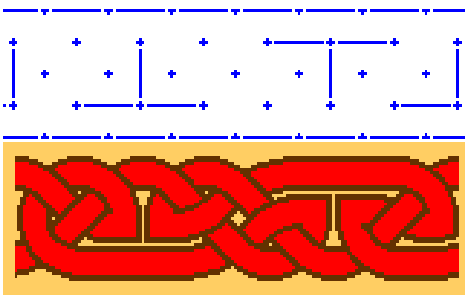
Try increasing the circle diameters/diamond widths without changing the grid spacing to construct thinner bands, and making smaller circles/diamonds to help get wider bands.



This pattern is from [Meehan2], originally from *Durrow*. Here is the original grid size, and a band generated using this template.



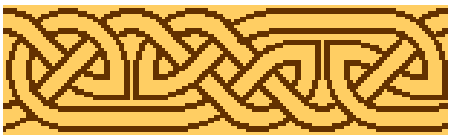
Here is a grid with larger diamonds generating a narrower band.



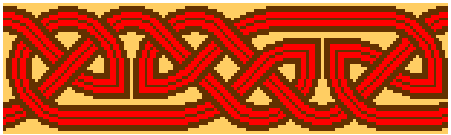
This grid uses smaller diamonds and, consequently, wider bands. Note that some spaces between bands disappear with wider band widths. Sometimes the bands will need to be adjusted to compensate for this effect.

Band Edge Effects

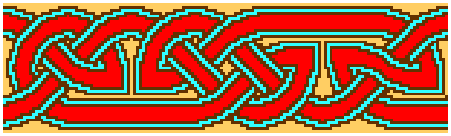
Besides changing the width, bands themselves were often decorated.



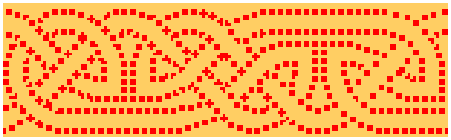
The band edges were often drawn in black, letting the background parchment show through.



Bands often had lines or dots running down the middle...



...or two narrow bands running on the sides of the band.



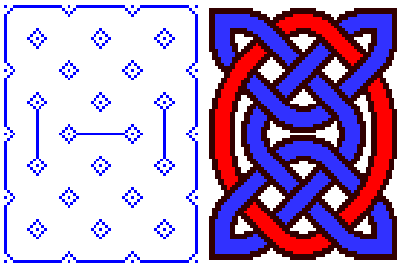
Finally, the knots were sometimes simply drawn with red dots alone against the parchment.

Colors

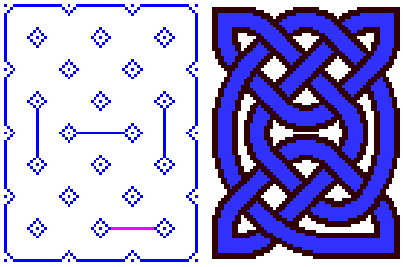
Celtic work was incredibly colorful. Some knots were light on dark (as most of the examples in this tutorial), but some were dark on light backgrounds. Colored areas were used on the bands and in the middle areas (between the bands) as well. Even if a band was continuous, often more than one color was applied.

Building Your Own Patterns

In designing your own patterns, aim for "interesting" work; make it pleasing to your eye. Study existing Insular Celtic and Northern European knotwork (see the references from the tutorial *Bibliography*) and attempt to reflect similar themes and overall designs (e.g., try for a single band running through the entire panel/border...) Watch out for "loops" and try to get "knots" instead.



Example of a pattern with a "loop". The left shows the underlying grid (3X4 in this case) and the right shows the bands. The "loop" generated is shown in red.



Similar pattern modified to make a "knot" instead. The left shows the added "wall" (highlighted). The right side shows the drawn and colored band, with the loop removed.

One way to begin (and my favorite method for doodling during meetings) is to sketch the underlying cell patterns and interruptions using graph paper. I then use the "bubble" technique (see the *Basic Interlacing Construction* section in this tutorial) to regularize the band width, then draw out the interlace by eye. This allows a quick review of the pattern and allows me to remove obvious loops and clumsy areas of the pattern before formally drawing it out.

Analysis of Existing Patterns

Translation from Existing Works

I've used the following techniques to determine the underlying cell templates for knots from a number of sources. The example below illustrates these techniques:

1. Find an original knotwork image to work with. Here's the original scanned image, taken from the *Book of Lindisfarne*, folio 211r:

2. Find the repeating pattern—outlined below:

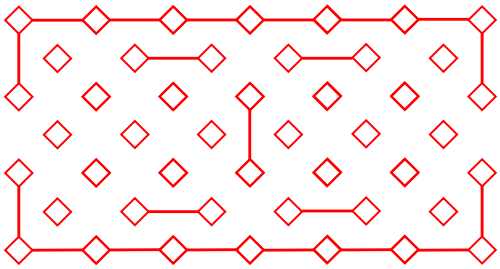
Note that the colors used in the original don't have to map with the repeats. We'll color in the bands later.

3. Isolate the repeating pattern:

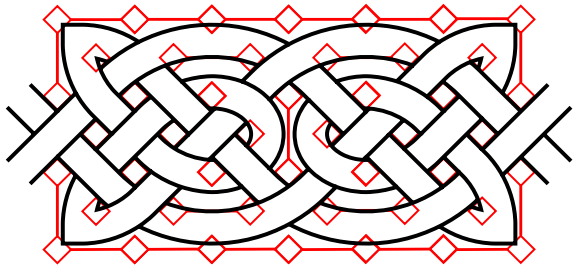
4. Try to find the underlying basic cell grid. To do this, focus on the "holes" between the bands:

5. Determine the interruptions (new "walls" and "corners" to be added):

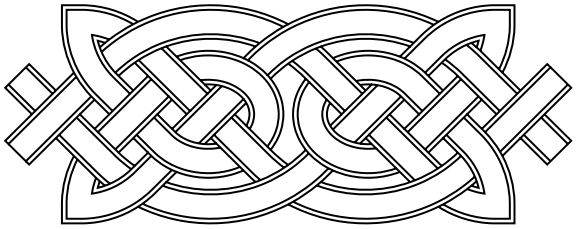
6. And then isolate the full template without the scanned knotwork:



7. Interlace the template using the usual techniques:



8. The original had a band edge treatment with two narrow bands running on the sides of the major band. So, here's a version with that treatment:



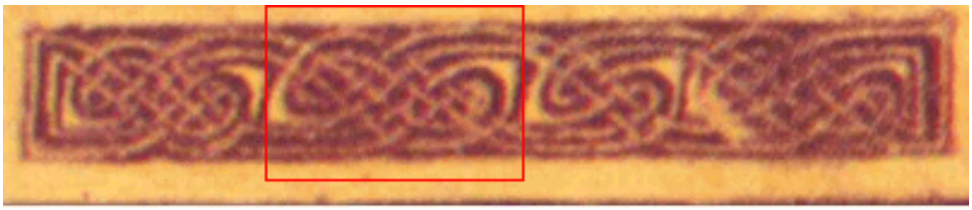
9. Here is a full version of the interlace, colored to match the original. Not bad! 😊

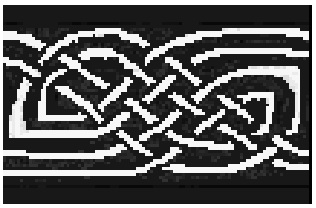
More Complex Analysis Example

Here's a more complex example that also illustrates these techniques:

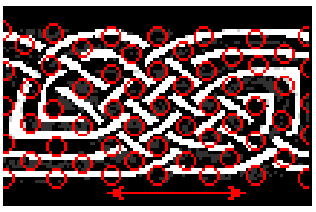
1. Here is an original scanned image, taken from *Book of Kells*, folio 124R, at the top of the border design:

2. Find the repeating patter (outlined in red below):

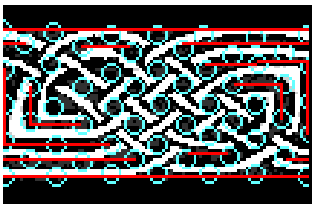




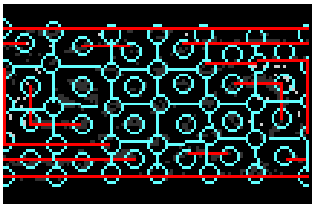
3. Here is the repeating group isolated. In this case, I've chosen to highlight the band using image processing techniques, as the original was lower in contrast.



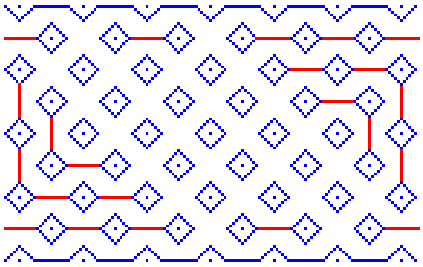
4. Look at the "holes" in the knots (outlined in red) to determine the underlying cell patterns. In this case, I started in the middle where the pattern was least broken (look for simple interlace patterns) and worked my way out. After the cell pattern starts to emerge, it becomes easier to complete it across the more complex areas. For borders concentrate on cell width; with panels the panel dimensions (width X height).



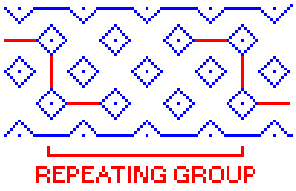
5. Determine how the pattern is interrupted by observing the breaks in the overall interlace design. These are added in red on the illustration.



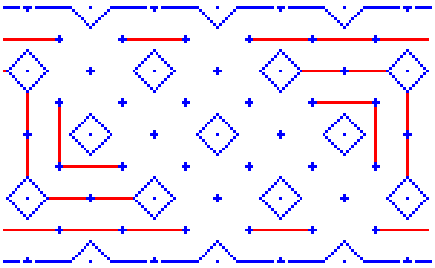
6. I've removed the original bands to more clearly see the underlying cell and wall pattern. This pattern uses 4X6 cells in the repeating group.



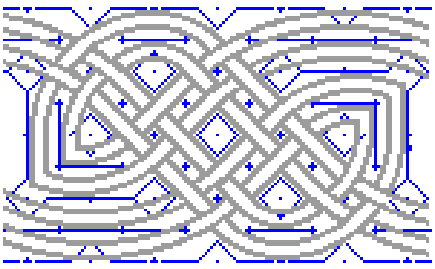
7. I've now placed the wall pattern on a regular grid, set up for a narrow band pattern.



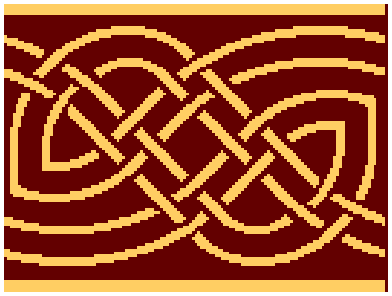
8. Reviewing the wall pattern, I observe that this is a doubled version of a 2X3 cell pattern, as shown in the figure. For information on drawing doubled knotwork, please see the "*Doubling" Interlace Patterns* section of this tutorial for details.



9. So, I now redraw the cells and wall patterns using the doubled grid. See the *Sample Grids* section for a view of this grid.



10. I interlace the design, just as the other knotwork examples in this class.



11. This illustration shows the pattern colored with band and background shades taken from the scanned original.

12. The template is extended to approximate the original panel design.

13. Finally, the generated panel is resized to match the original and compared.

14. Not bad, but the Insular Celtic scribes appeared to have used a variable width grid pattern and/or a pattern variance (the third repeat from the left does not have the same grid pattern as the other three). These are not unusual occurrences in the original materials.

Below is a slightly modified version of the generated design that includes the pattern variance. Closer yet...

limitations of Cell-based Interlacing

I'm sorry to report that some existing works will "resist" this type of analysis. Panels and pages based on triangular grids, grids warped or adjusted to fit a particular space, or freehand knots will be difficult (and frustrating--trust me on this!) to analyze. For triangular knot construction, please see the *Triangular Knotwork* section.

Some spiral- or circular-based knots are hard to reproduce using the rectilinear patterns found in cells. Some panels are based on circles rather than interlaces (especially some of the existing carved stones). Certain patterns need the cells turned 45° from the usual configuration.

In these cases, try to find the page/panel/border already analyzed-- see [Meehan2], [BainI], [BainG] from the tutorial *Bibliography*, and don't give up. Use the draw and erase techniques rather than cells but keep on trying until the pattern does what you want it to do.

And, Good Luck!

Borders with Corners: "Mitering"

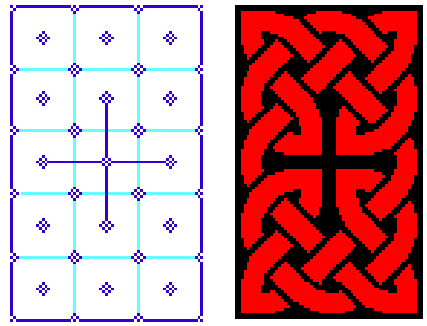
Introduction

Getting border patterns to properly turn corners is fairly tricky--to the best of by knowledge there is no consistent, pre-defined method for generating patterns that properly miter (that is, that turn corners) without drastically changing the underlying patterns, introducing loops or extra bands, etc.

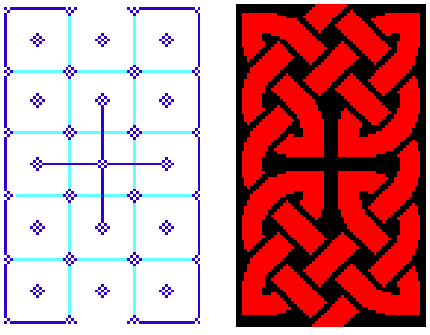
You can try to either "slide" or rotate existing cell patterns into the corner or try a different pattern that fits better into the corner space. Please expect some very strange bands (even those outside the cell boundaries) when a complex pattern turns a corner!

"Sliding" Pattern Into a Corner

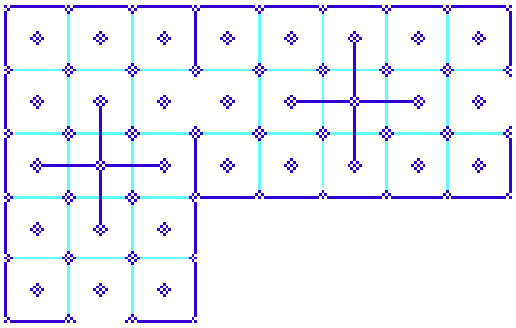
As an example of a "sliding" pattern, please see the border below (from [Bain] page. 35, plate 10 upper right).



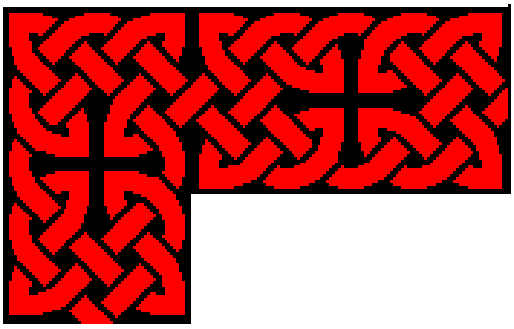
1. To the left is the underlying panel template and band treatment, from [BainI], page 43, based on a pattern found in *Lindisfarne*, Folio 27.



2. This figure shows the template extended (by removing parts of the two end walls) to form a border pattern.



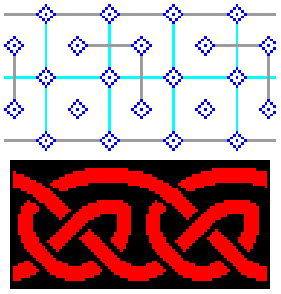
3. This figure shows the template shifted and rotated to allow the corner to be turned. Then walls were removed to keep the pattern constant.



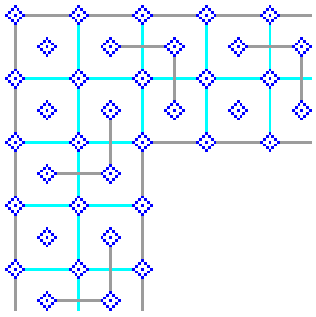
4. Finally, the bands were formed and filled in (as usual) to build the final panel. This can be further rotated and extended to form rectangular mitered panels of any desired size.

Pattern Modifications Into a Corner

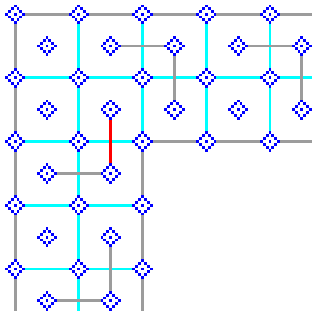
The second example, taken from *Kells*, shows a template modification allowing the pattern to "turn" a corner.



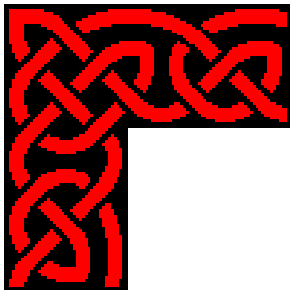
1. To the left is the underlying panel template and band treatment, from [BainI], page 103, based on a pattern found in *Kells*, Folio 124R. It is a 2X4 cell pattern, with the repeating group offset by a half cell.



2. This figure shows the original template flipped and used in a corner pattern. There is not a smooth way to shift and reconnect the pattern as in the first example.



3. This figure shows the wall to be removed (in red) to smooth out the corner turn. When doing these on your own, try to not add a loop, but keep the underlying pattern going as much as possible.

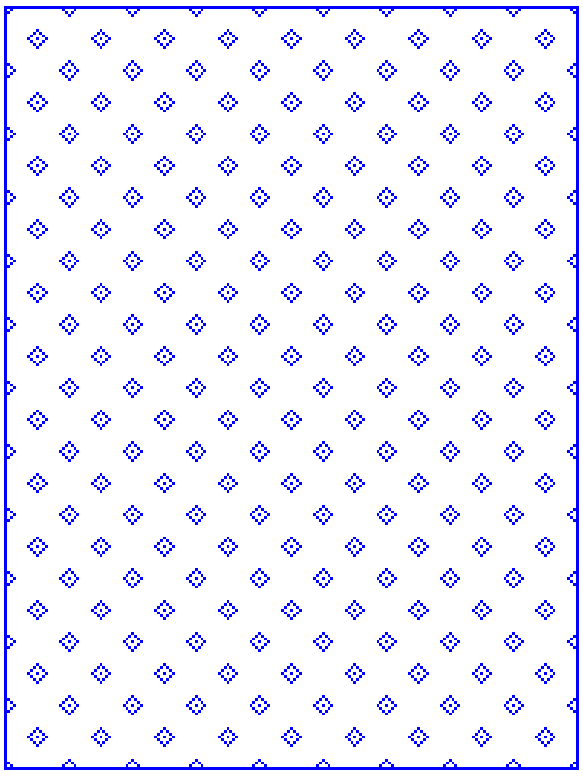


4. Finally, the bands are formed and filled in as usual to build the final panel. As with the first example, this can be further rotated and extended to form rectangular mitered panels of any desired size. Note that if you don't like the look of the interlace, change/add another wall and try again!

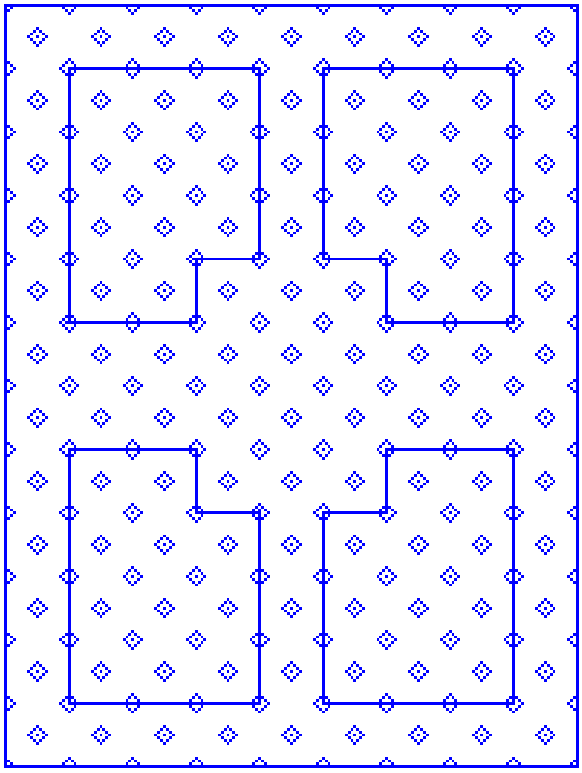
Filling Spaces With Knotwork Interlacing

Interlaced panels can be used to fill in areas of a page, like complex borders, between other forms, or inside of large initial caps, etc. The basic design concept is to divide the required space into cells of appropriate scale and add breaks to make things "interesting" (i.e., single band, no loops, etc.).

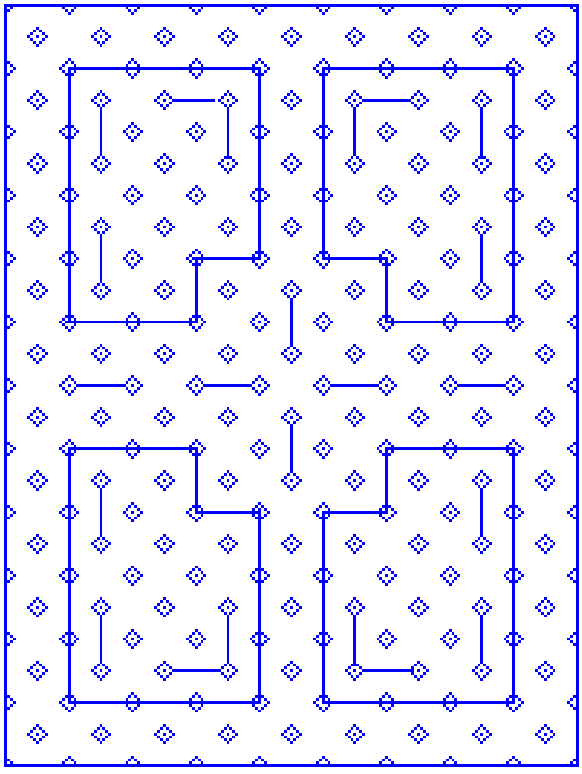
The following example approximates the look of *Durrow* in its use of knots only on a "carpet" page (pages containing patterns only, and little or no text). Most of these carpet pages from original sources use a broad mix of interlace, zoomorpics, spirals, keywork, etc.



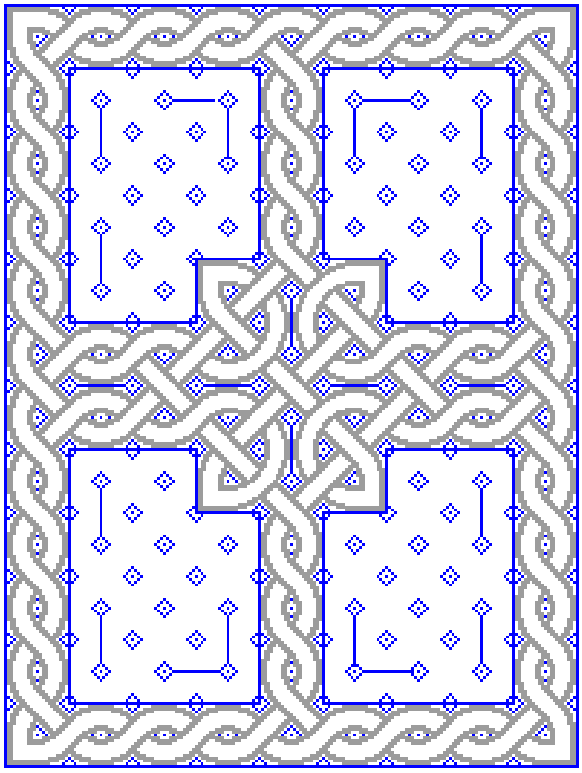
1. Divide the required page into cells--in this case into 9 cells by 12 cells. (Please note that on a real carpet page the number of cells used would be *much* greater.)



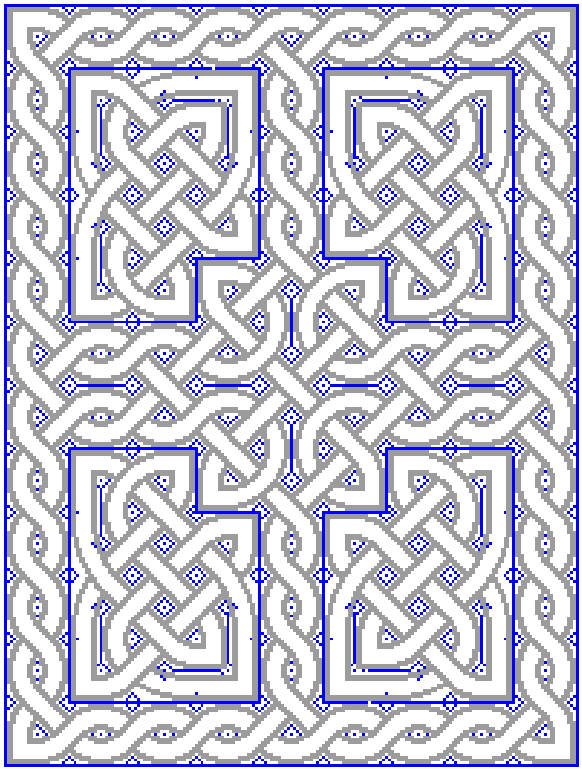
2. Break down the page into shaped panels. The remainder can be considered a border. A common division included a cross-shaped area (after all, the originals *were* Gospels, right?).



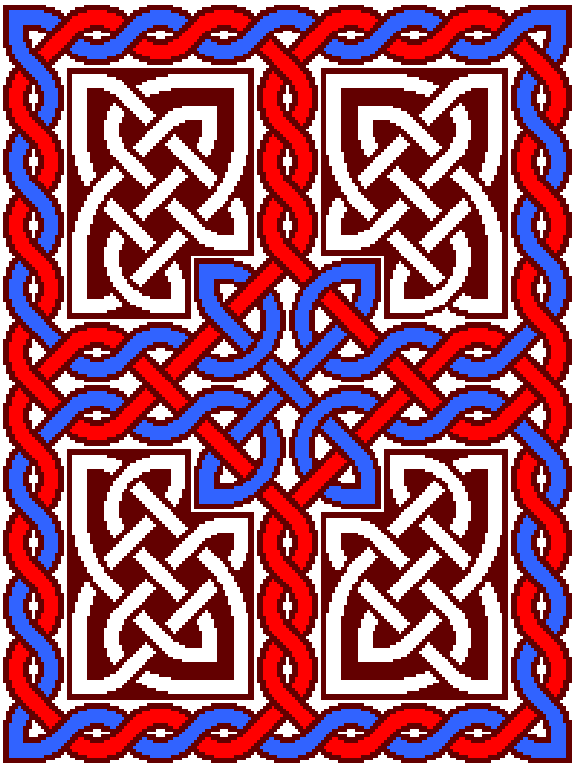
3. Add additional "walls" and "corners" to break up the design, add interest, and remove loops. In this design, I managed to get the panels to form a single band, but I failed to do this on the border.



4. Interlace the border area, using the same techniques as described in the tutorial sections on *Basic Interlacing Construction* and *Interrupted Interlacing*.



5. Interlace the panel areas. In this case I used the same band width throughout but could have changed it in the border or panels. For information on band width changes, see the tutorial section on *Knotwork Band Treatments*.



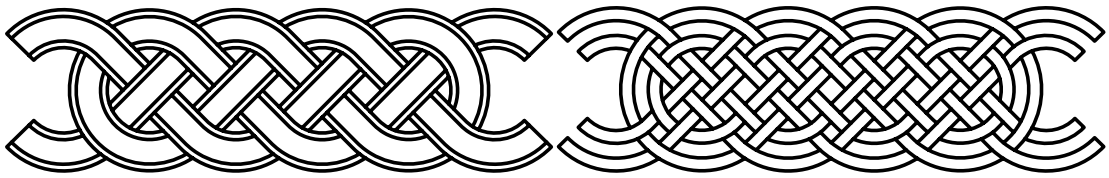
6. Finally, color in the bands. I've chosen to use two different band techniques here--one for the panels and a different one for the border areas. Please see the tutorial section on *Knotwork Band Treatments* for other ideas on how to decorate the bands.

You can also use pre-defined panels (see [BainG] or any of the other listed sources in the *Bibliography*), if the area you're trying to fill "factors" properly--that is, if the number of cells filling the space you need to cover is an even multiple of the number of cells in the original pattern. Existing examples used different interlace patterns on different sections of the same page. In fact, some examples use knots, key patterns, zoomorphics, and spiral patterns on the same page.
There are particularly good examples in [Meehan2] (pages 72-102), [BainI] (Chapter 10), [BainG] and, of course, any good facsimiles of the actual manuscripts. A (rough) example of a draft SCA-style scroll study using this technique can be seen in the following figure:

Also, please see other examples of space filling patterns provided on the Celtic "Art" pages (see URL: mihaloew.guru/celtic/cel_images.html).

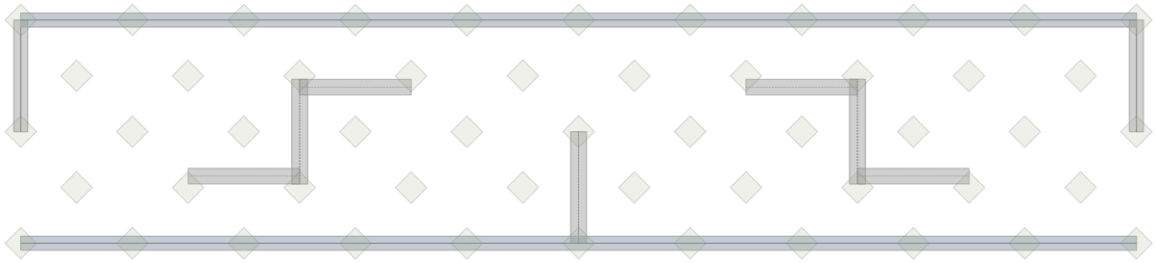
"Doubling" Interlace Patterns

"Doubling" can be considered a line/band treatment that forms a parallel double band from a broad interlace pattern; the two new bands do not cross except where the original broad band did. This form of interlacing was quite popular with the scribes and was extensively used in both *Lindisfarne* and *Kells*. It is as though the two narrow bands used as an edge effect discussed earlier have taken on a "life of their own" as independent, interlaced bands. The example below (taken from the *Book of Durrow*, folio 86r) compares the line treatment and full double knotwork patterns:

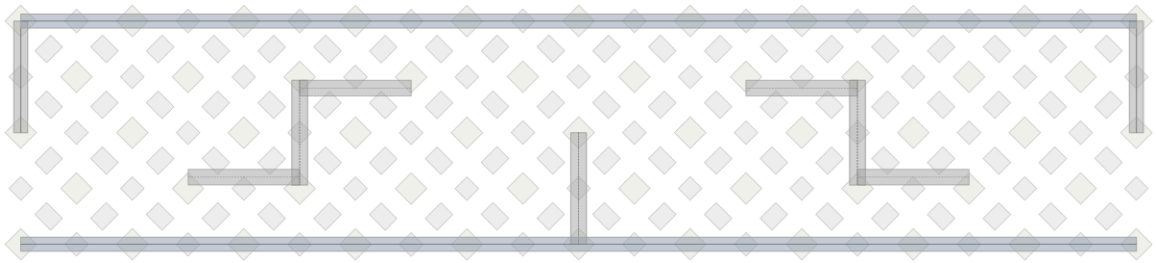


Construction techniques developed by George Bain (see [BainG]) involved building the original wide interlaced band, then converting the edges of these bands into new, narrow, parallel bands, and finally fixing up the interlacing. This requires a *lot* of erasing and fixing. Doubling can be supported with the cell structures we've been using by following the procedure below:

1. Draw original pattern on double-sized cells compared to the desired final result. This 10X2 cell pattern is taken from [BainI] page 101 and was originally from *Lindisfarne* Folio 11B.

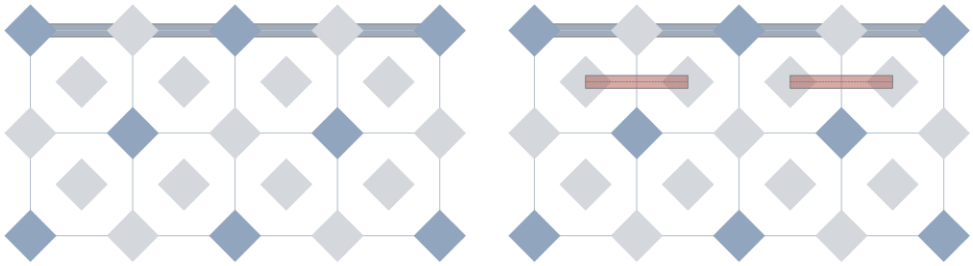


2. Build a set of "half-sized" cells between the original points. I used diamonds smaller than half-size for band spacing here to reflect the *Lindisfarne* style of doubling. See [BainI] pages 71-72 for further information and alternative construction techniques. On the illustration, the new cell diamonds are darker and the new cell sides are lighter. Add back the original interruptions (extra "walls"/"corners") to the pattern.



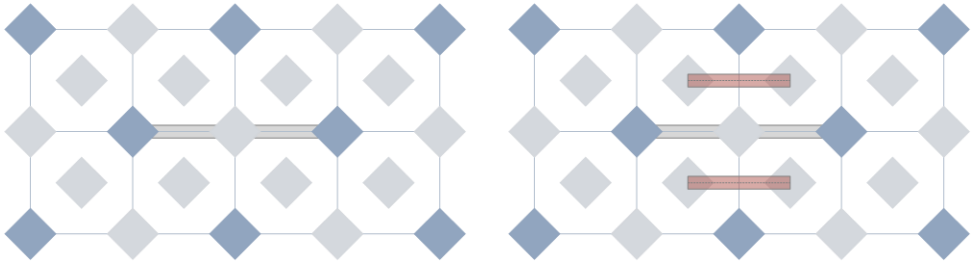
3. Add interruptions to the new patterns (in the half-sized cells) based on the original, full-sized cell patterns. When converting from single to double interlacing, there are eight possible cases to be handled. In all the case descriptions, the single knotwork cells are in dark blue, the doubled cells are light blue, edges are dark blue lines, the original (single) interruptions (walls) are in grey, and the new, added, doubled interruptions are in dark red.
    - **Case 1:** Uninterrupted cells along the edge of the original pattern.

Original Template | Doubled Version



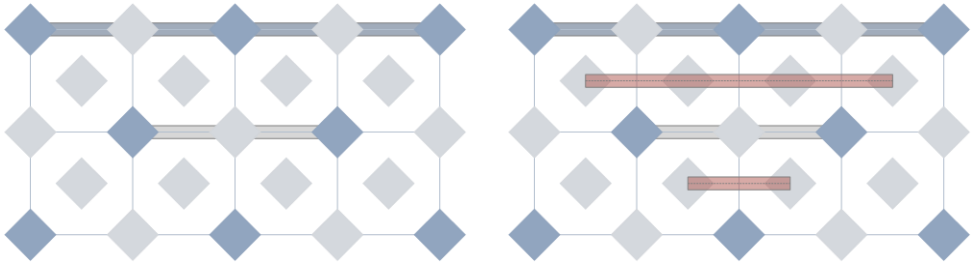
    - **Case 2**: The original template has an interruption in the border between two cells that is not on an edge.

Original Template | Doubled Version



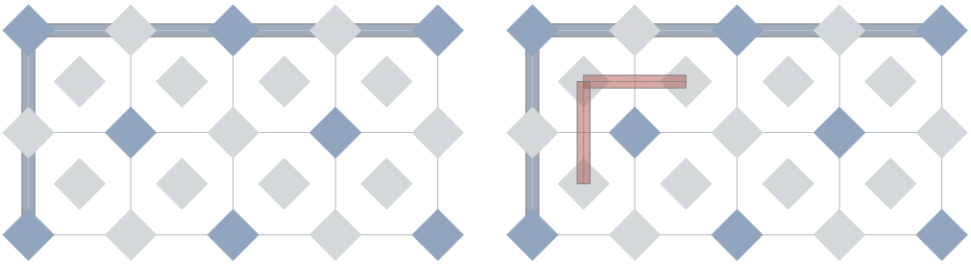
    - **Case 3**: The original has an interruption added next to a template edge.

Original Template | Doubled Version



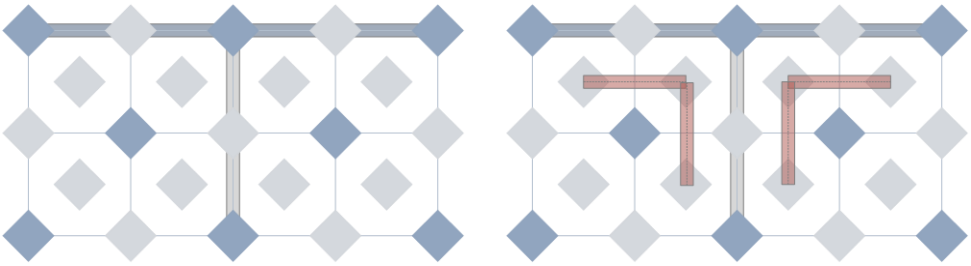
- **Case 4**: The original template has a corner along two edges (at the end of the overall pattern).

Original Template | Doubled Version



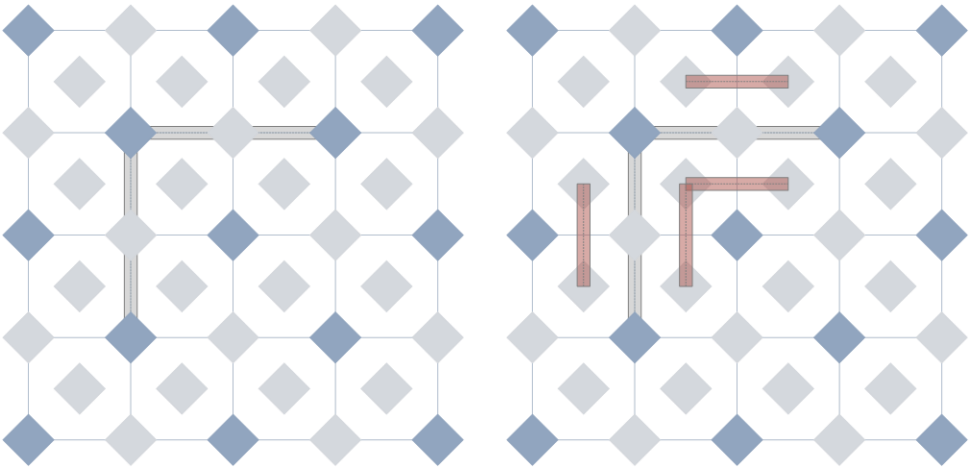
- **Case 5**: The original has a two-sided corner along an edge.

Original Template | Doubled Version



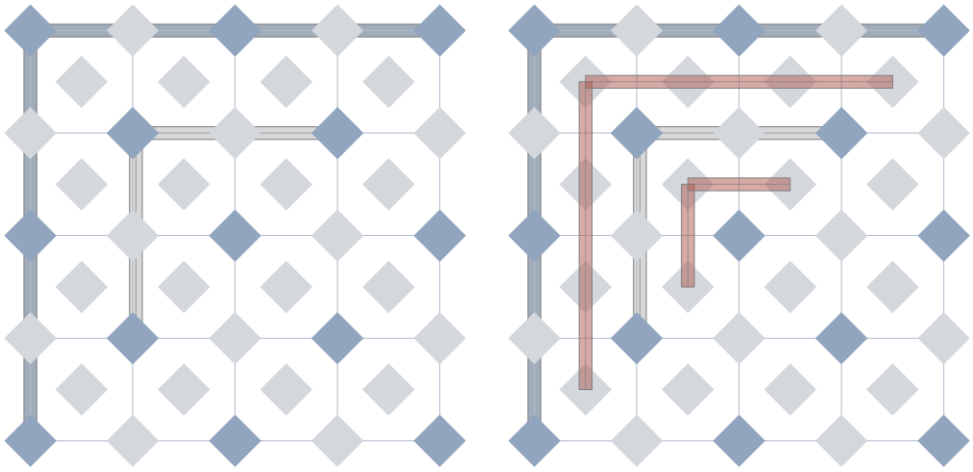
- **Case 6**: The original template has a corner not along an edge.

Original Template | Doubled Version



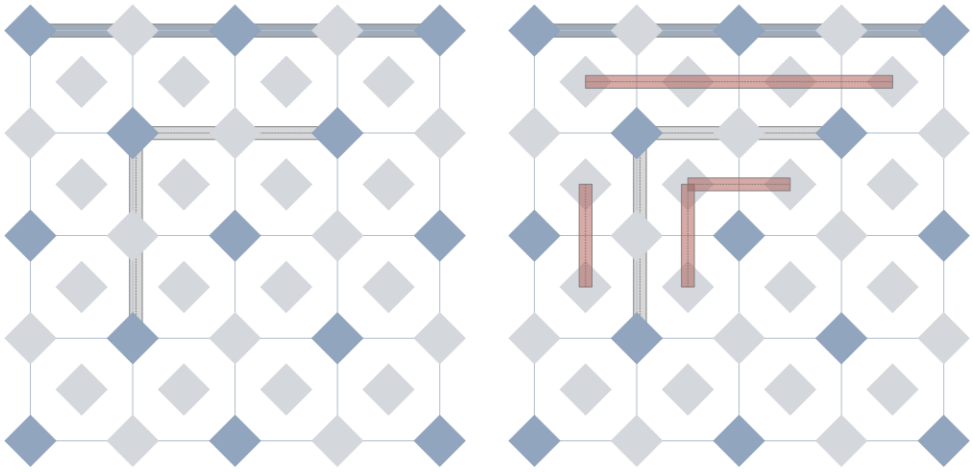
- **Case 7**: The original pattern includes a corner that crosses two cells (a nested corner) along an edge.

Original Template | Doubled Version

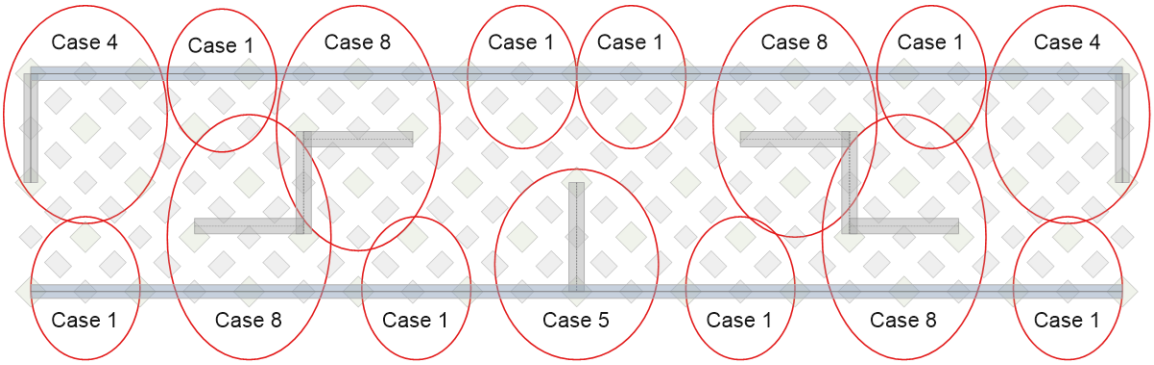


- **Case 8**: The original template includes a single cell corner next to an edge.

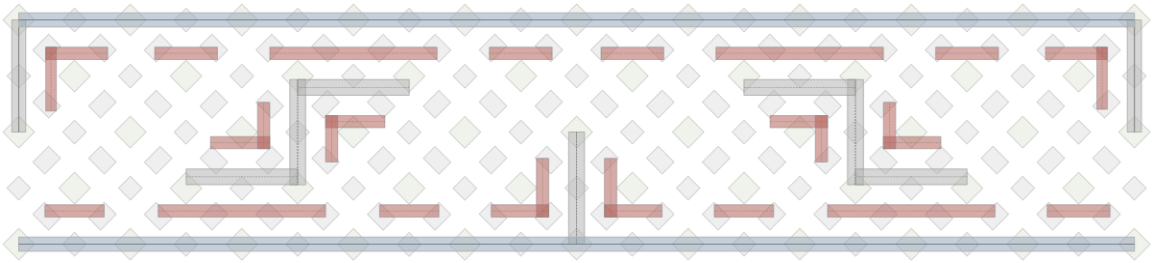
Original Template | Doubled Version



4. Determine, for each interruption and edge in the original, the doubled case that describes the interruption. For the *Lindesfarne* F11B pattern we're using as an example, the following figure shows the doubled case for each part:

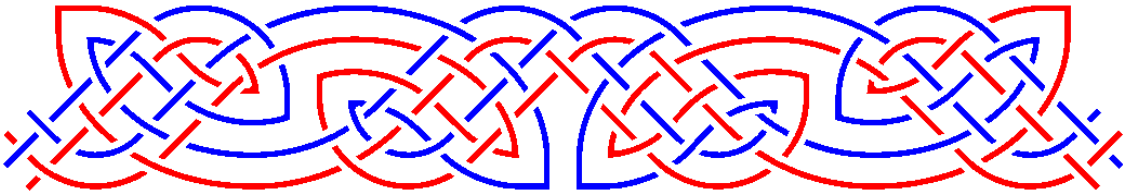


5. Add the new interruptions according to each case found. The added interruptions are shown in dark red.



6. Interlace as usual. Curves will take a bit of extra planning in order to keep them parallel and at a constant width.

7. Color the bands as desired. The illustration is colored to highlight the continuity of the bands across the repeating, doubled pattern.

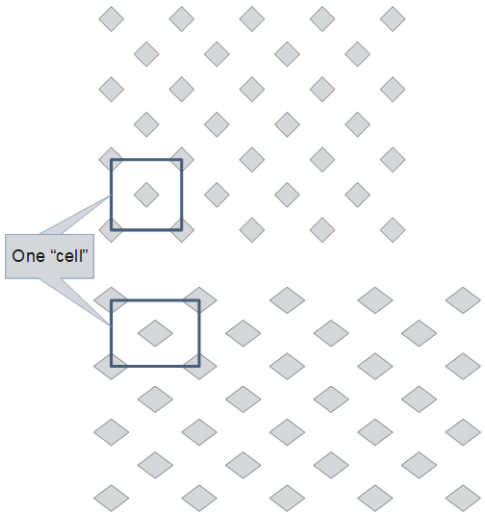


Also see other examples of doubling provided on the Celtic "Art" pages (see URL: mihaloew.guru/celtic/cel_images.html).

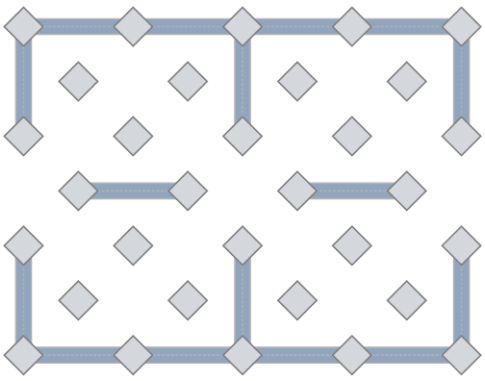
Alternative Grids

Non-Square Grids

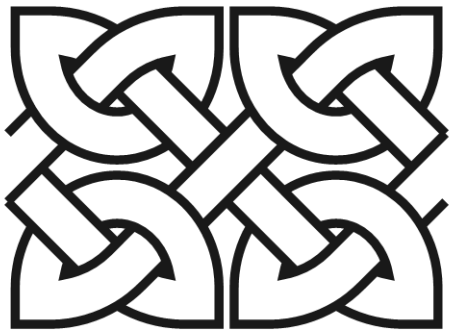
Many panels and borders are based on grids where the sides form a ratio of 4/3 rather than the square (1/1) grids used for the bulk of this class. George Bain (in [BainG]) calls this the "Pictish proportion". The example below illustrates developing an interlaced panel using a template with 4/3 proportion:

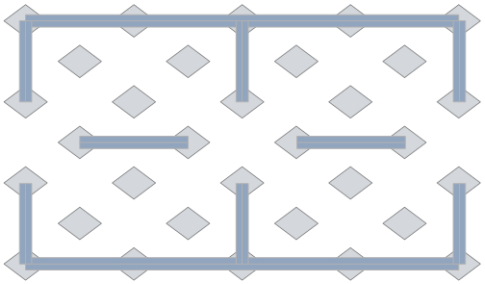


1. This shows both a square (top) and 4/3 ratio (bottom) grid, highlighting one "cell". Cells of either proportion are handled and interlaced the same way.

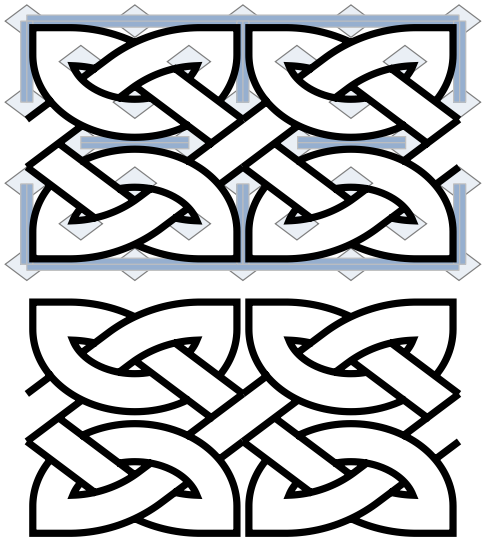


2. This illustrates the basic 1/1 (square) ratio proportion, using a pattern from the *Maiden Stone* (also called "Double Stafford Knot").





3. Here is the 4/3 ratio grid with the same *Maiden Stone* pattern set up.

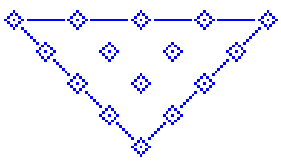


4. Here is the template above with interlacing added. The bands are interlaced just as in the square grids, but you need to watch the band angles so they meet up with the grid guides. Using 4/3 ratio grids can help if you need to squeeze in a certain number of grid squares into a space that is not *quite* big enough and more square grids are not working either. The original Insular Celtic scribes used this technique in several instances; they even used odd (neither 1/1 nor 4/3) grid sizes to adjust border spacing.

Triangular Knotwork

Many Insular Celtic patterns are based on grids based on triangles rather than squares or rectangles. These seem to be (for some reason) especially popular on the many carved standing stones in the British Isles--especially on those in eastern Scotland. The most common grid seems to be one based on a right triangle, though some are based on equilateral triangles, and-- inevitably--some are based on irregular triangles. It is the right triangular grid we will use for the class examples.

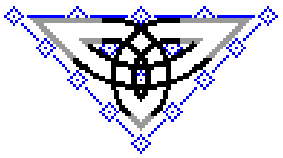
The following example is for a simple triangular knot taken from [BainG] page 47 and [BainI] page 86. The original source for the pattern is probably the *Ulbster Stone*.

1. 

This is the grid used for the knot. (Please see the *Basic Interlacing Construction* section for information on the grid patterns used...) [BainI] would refer to this as a ***4n*** grid--it uses four divisions across the long side of the triangle. You should experiment with different amounts of cells across the long side. The original artists used *just* enough cells to fit their pattern--a very tight grid. Four is about as small as one can go...

2. 

To build this simple pattern, first sketch in the corners of the triangle. Size the bands as you would for the usual knotwork pattern--watch the width of the band that moves across the top of the triangle as it can be tricky to size properly.

3. 

This view shows how the corners are connected for this pattern. Unlike the other knotwork patterns we've been using (see the *Basic Interlacing Construction* section for details), I've always had to draw the band edges first and then erase the overlaps while interlacing.

4. 

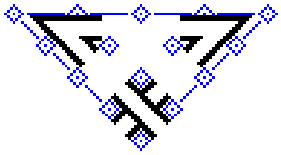
After interlacing the bands show the common over/under pattern of all knotwork.

5. 

Finally, the bands are colored in and the background darkened. As with any knotwork pattern, the bands can be treated in a number of ways; for example, using narrow or wide grid types. See the *Knotwork Band Treatments* tutorial section for details.

Triangular Knotwork Panels

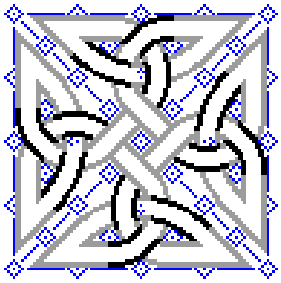
A simple square panel can be formed by slightly modifying the grid pattern used above and repeating it to form a square. An example follows:

1. 

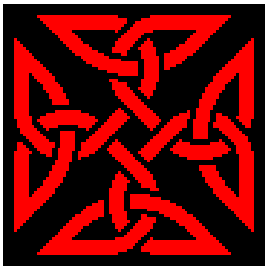
   This view shows the pattern sketched in. The "inside" corner pattern was changed to make the bands "flow" over and under rather than turn the corner as in Step 2 above.

2. 

   Connect the corners and interlace, as in Step 4 above.

3. 

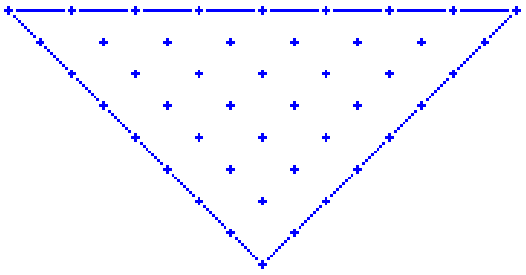
   This shows the pattern repeated to form a square. On the computer I simply copied, turned the copy 90 degrees, and pasted it back four times. By hand, one duplicates the grid and interlaces each of the four separately. Remember that the middle interlace constrains and drives the rest of the pattern, so do it first.

4. 

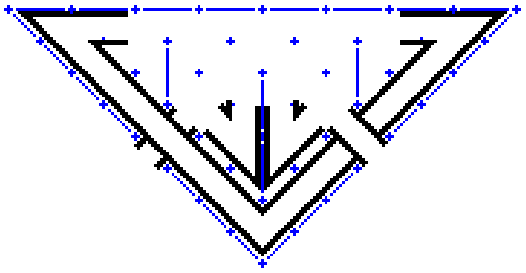
   Finally, color in the band and background, or use another band treatment of your choice. See the *Knotwork Band Treatments* tutorial section for details.

Advanced Triangular Panels

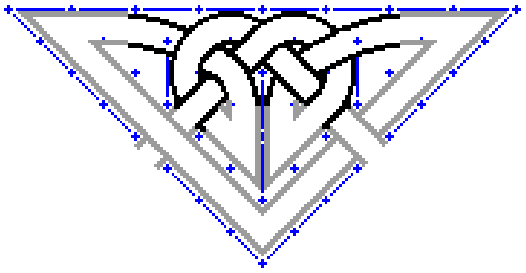
I've found that most of these types of patterns look better when originally built on a wide grid. Please see the *Sample Grids* section for more information. The following, more complex example (based on a pattern from the *Dunfallandy Stone*, found pre-analyzed in [BainG] page 41, Plate F.2) illustrates this technique:

1. 

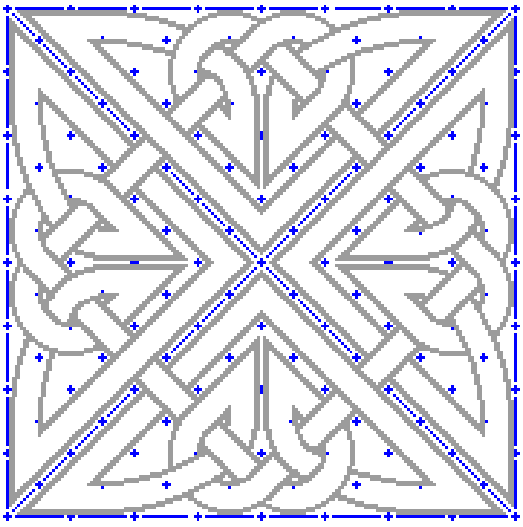
The grid for this pattern is 8 cells wide across the top.

2. 

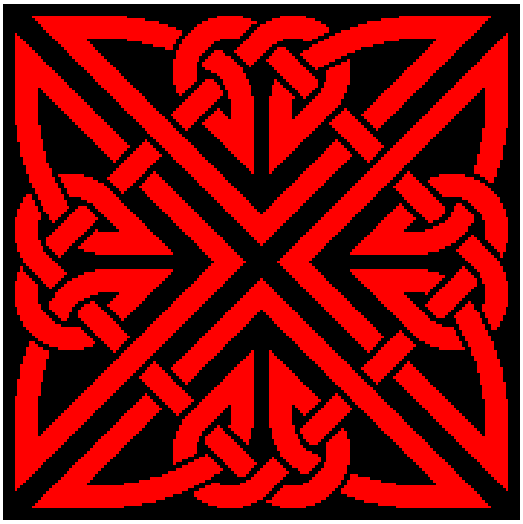
The *Dunfallandy* pattern is more complex, so I've used "walls" to represent the places where bands split and curve. This is similar to the techniques used in the *Interrupted Interlacing* section. I've also sketched in the corner bands. In this pattern note that bands go "through" the sides of the triangle.

3. 

As with the simple patterns, I've added the bands and interlaced. With this more complex design, you can see how the interlacing is related to standard, square knotwork--over-then-under, the bands "turning" at walls and corners. With wide bands like this, you need to really watch the width of the bands so they remain constant. Things *do* get tight!

4. 

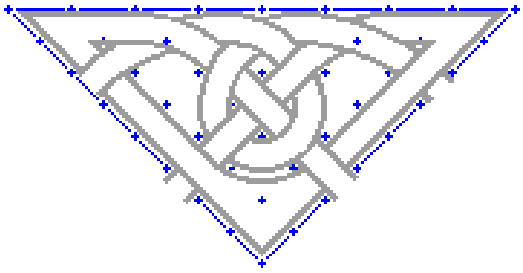
As before, I copied and repeated the pattern in Step 3 with 90 degree turns to form the square found on the original stone. Use the same techniques as in the simple panel above.

5. 

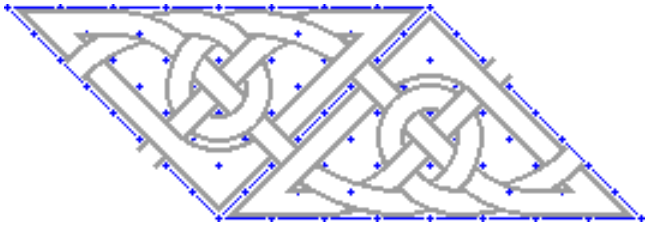
This shows the bands and background colored in.

Triangular Knotwork Borders

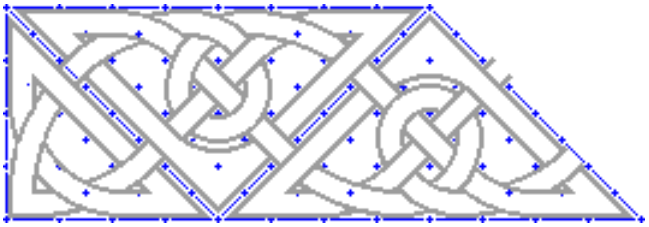
One can combine triangular panel sections into borders using the following technique (illustrated with a pattern from the *Britford Stone*):

1. 

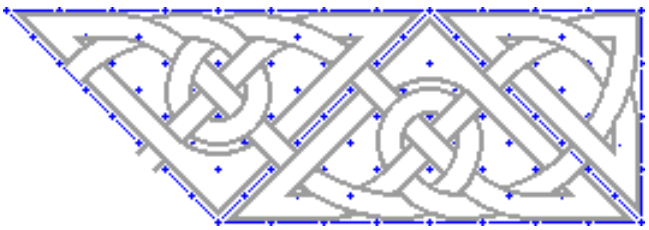
This shows one fourth of the total *Britford* pattern. This could be repeated and turned to form a square as with the *Dunfallandy* pattern used in the previous section.

2. 

In this view I've flipped the pattern over and connected it to the original. It was fairly easy to do this, since the band connections lined up. If they don't line up naturally, the pattern will have to be modified or shifted to make them connect.

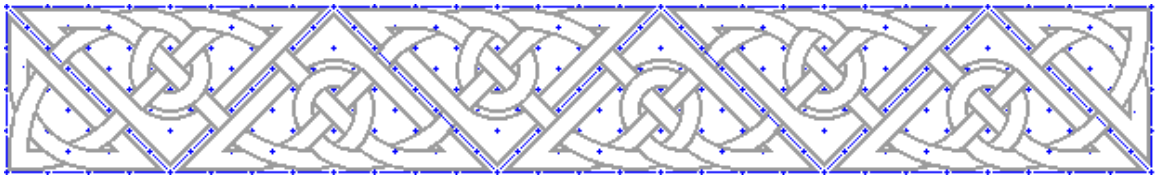
3. 

For this border I had to put in a little place-holder knot to make it come out square on the end. I should have worked harder on this, since it makes a “loop” in the pattern , alas. On some of the other triangular knotwork borders I put in a small zoomorphic "lizard" head and tail to complete the pattern. Please see my Celtic “Art” web pages for more examples.

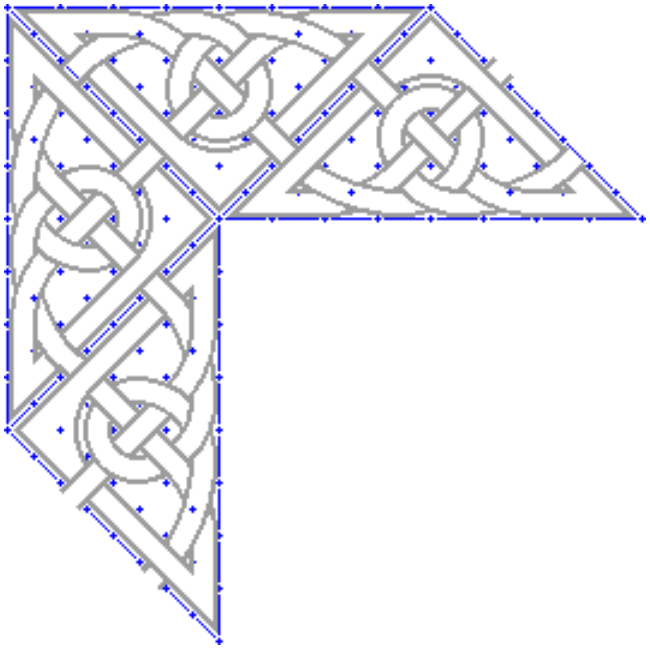
4. 

I added a free-form knot on the other end as well...

5. Starting with the pattern from step 3, I can add step 2 sections 'till the pattern gets as long as I need, then complete he border with a step 4 section. The result is shown below:



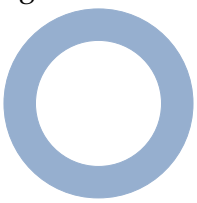
6. Finally, I colored in the bands and backgrounds. As usual, you can use any band treatment desired. See the *Knotwork Band Treatments* tutorial section for details. The result using simple colored bands is shown below:

7. 

Since the triangular patterns naturally turn 90 degrees, it is fairly easy to have a triangular knotwork border turn corners. A pattern for the corner is shown here. It can be combined (flipped and rotated as well) with patterns from steps 2-4 above to form a border of nearly any shape desired.

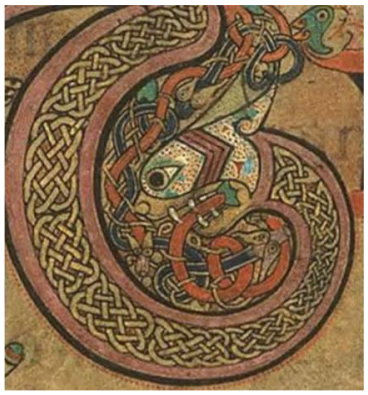
Annular Knotwork

An extreme example of "non-square" grids are those used in the construction of "annular" knotwork. An "annulus" is a fancy mathematical word for a doughnut- or ring-shaped two-dimensional region. That is, one that looks like:

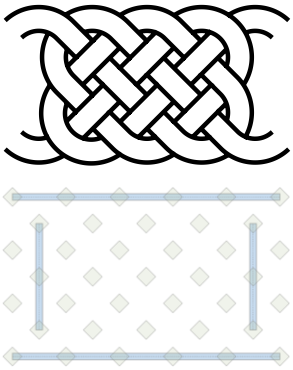


So, annular knotwork is based on the regular interlace patterns we've been using, adapted to fill in an annular ring. The following technique provides an example of adapting a linear knotwork pattern to an annular area:

1. Determine the starting pattern. In this case we'll be using a pattern from the *Book of Kells* Folio 124R that (appropriately) was used in an annular area filling in an initial letter:



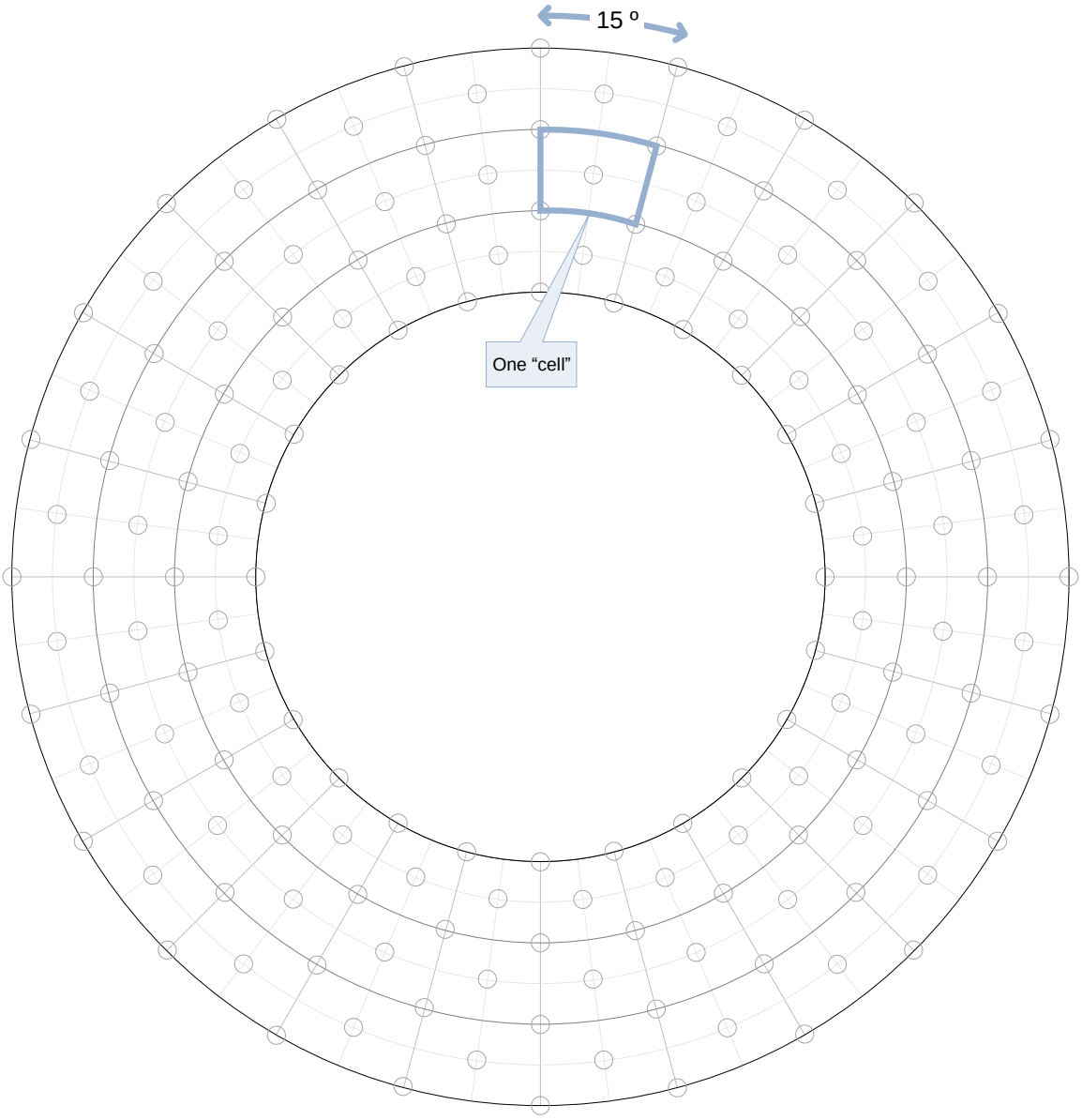
2. Develop (or look up) the underlying interlace and cellular pattern (a 4X3 cell design in this case):



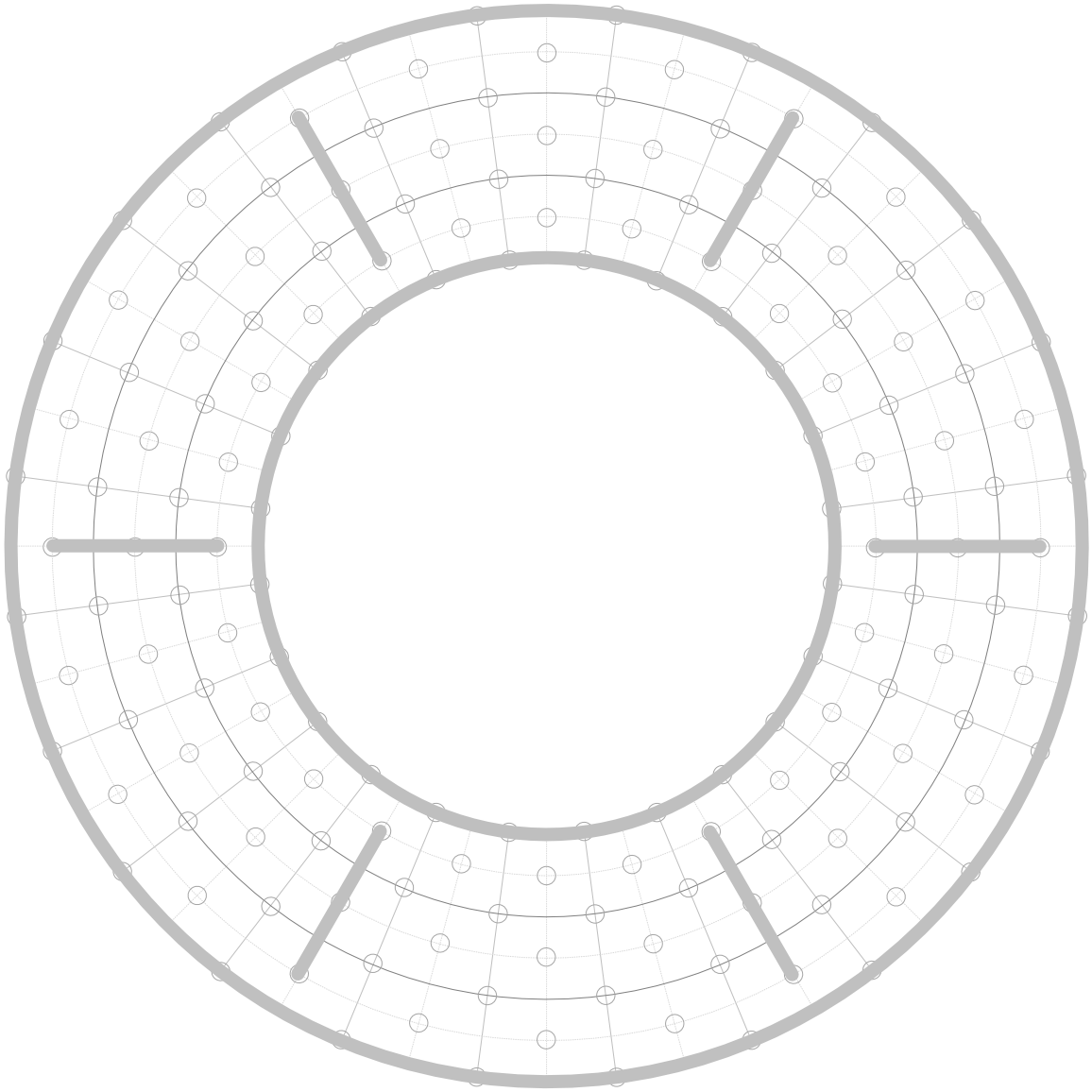
3. Figure out how many cells you'll need. Let's say we want six repeats of the pattern around the whole annular area. Since the pattern we're using is four cells wide, we'll need 6 (repeats) x 4 (cell width) or 24 cells around the whole.

   So, each cell will be 360 (degrees in a circle) / 24 (cells around) or 15 degrees wide.

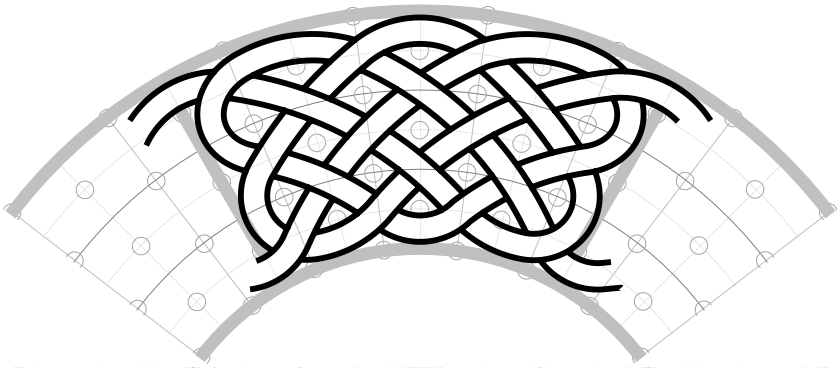
4. Draw the initial grid. It ***really*** helps to have a computer drawing package to perform this step, let me tell you! It might take a few tries to get the cells about the right size. You will need to adjust the radius of the inner and outer boundaries of the annular region so that the cells you'll be drawing are fairly "square" (that is the top-bottom distance is about the same as the left-right distance. The following shows the whole annular grid for this pattern, showing the 15-degree cell spacing and highlighting a single annular cell:



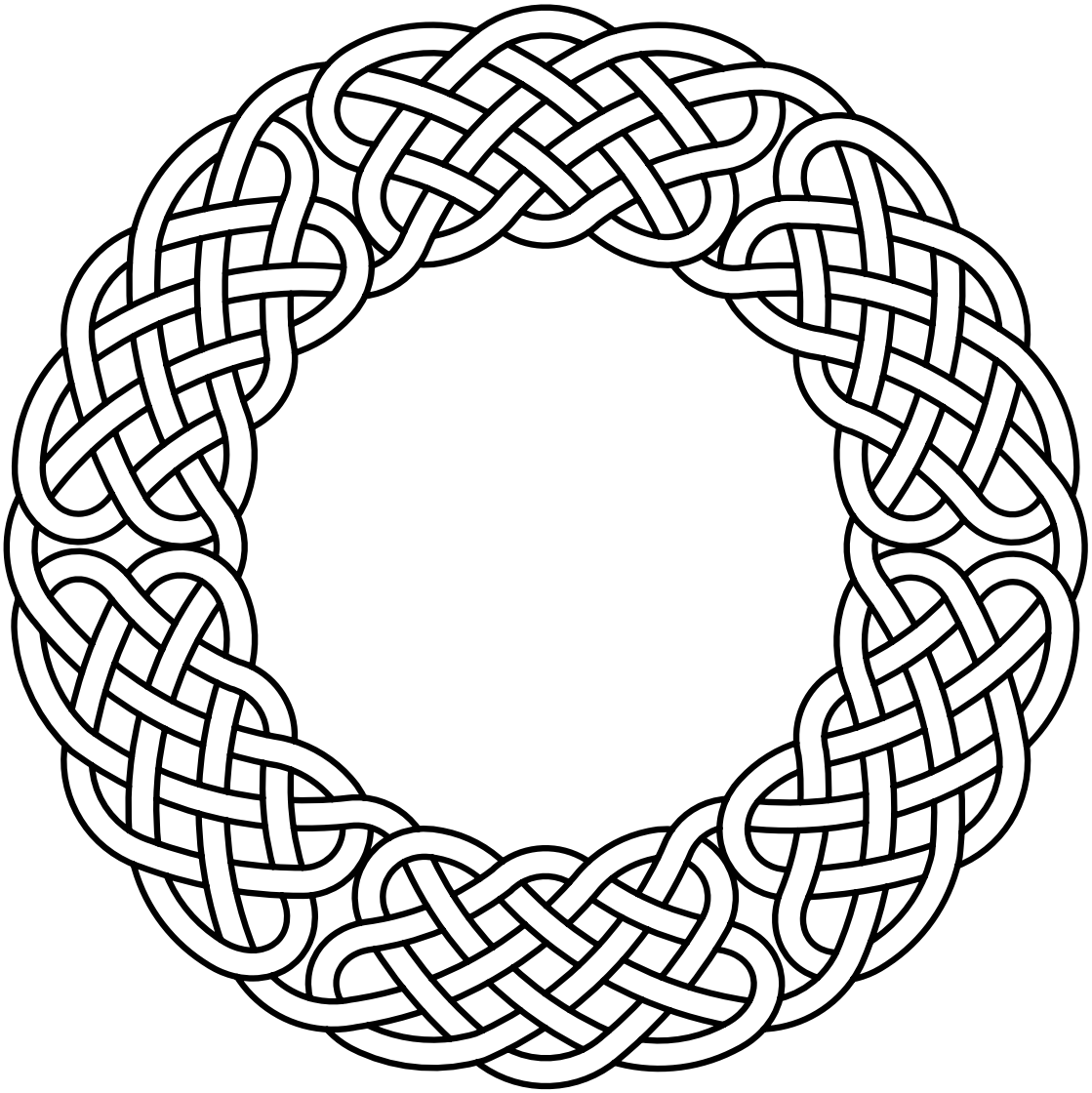
5. Now, add the cellular pattern walls and interruptions, repeating these six times around the circle:



6. Interlace one of the six segments (we'll start at the top center for this example). The interlacing is done just like the linear knotwork we've done before, though you'll need to curve the bands to fit into the annular area to be covered.



7. Finally, repeat the interlacing for the other five segments, using any band treatment desired:



Further Topics

(*not* covered in this tutorial)

There are a number of other topics in Celtic art that this class does not pretend to cover. Yet. 😊 These include:

- "Animal" shapes ([BainG] calls these "Zoomorphics", which I like!)--Many Celtic works (particularly *Lindisfarne* and *Kells)* use animal-like (birds, dogs, lizard-like things, even humans) drawings, interlacing legs, ears, necks, topknots, and whatever! Please see [BainG], [van Stone], [Sherb2], [Sherb3], and [Meehan3] for examples and instructions. Have a few experimental zoomophics out on my *Celtic Computer "Art"* page (URL: mihaloew.guru/celtic/cel_images.html).
- Keywork--Think of "Greek Key" shapes, done with the usual Celtic flair. See [BainG] and [Meehan1] for examples. I've also done a few of these on my *Celtic Computer "Art"* page.
- Spirals--Many Celtic shapes (starting in very ancient times!) are based on interlaced spirals, and just plain spirals too. See [BainG], and [Nord] for good examples. I've some of these of these as well on my *Celtic Computer "Art"* page.
- Figures--Many of the Gospels had human figures, sometimes mounted, done in a semi- realistic/semi-stylized mode... See [BainG] and [Nord] for examples ([Nord] has good color plates as well...) I'm not trained as an artist, so you're on your own!
- Page layout--Besides the quick introduction in the *Space Filling* section of the tutorial, [Nord], [VanStone2] and [Meehan1] have a number of possible layouts for Insular Celtic-style pages from various sources: these might be applicable to SCA use. A (rough) example of a draft SCA-style scroll study using a simple page layout technique can be seen in the figure in the *Space Filling* section of this tutorial.
- Lettering, Including Illuminated Letters--Many initial letters on the manuscripts were highly illuminated, often using combinations of the knotwork techniques shown here, keywork, animal patterns, and many more. See [BainG], and [Meehan4] for excellent examples, with [Harris] providing a good stroke-by-stroke tutorial.

Tutorial Bibliography

Basic Sources

- [BainG] *Celtic Art: the Methods of Construction*, George Bain, 1973 (reprint of 1951 work).
- [BainI] *Celtic Knotwork*, Ian Bain, 1986.
- [Hull] *Celtic and Anglo-Saxon Art: Geometric Aspects*, Derek Hull, 2003.
- [Nord] *Celtic and Anglo-Saxon Painting*, C. Nordenfalk, 1977.
- [Sherb] "Interlacing Without Erasing", M. Sherbing, from *Tournaments Illuminated* No. 53, Winter 1979.
- [Meehan1] *Celtic Design, A Beginner's Manual*, Aidan Meehan, 1991.
- [Meehan2] *Celtic Design, Knotwork*, Aidan Meehan, 1991.
- [van Stone] Wall hanging poster of Celtic Design notes, now out of print.
- [van Stone2] *Celtic Knots: Techniques and Aesthetics (Part 1: Basic and Intermediate Knots)*, Mark van Stone, Alphabet Studio, 1992.

Further Topics

- [Baker] *Celtic Hand: stroke by stroke* , A. Baker, 1983.
- [Harris] *The Art of Calligraphy*, D. Harris, 1995 (particularly pgs. 32-33).
- [Meehan3] *Celtic Design, Animal Patterns*, Aidan Meehan, 1991.
- [Meehan4] *Celtic Design, Illuminated Letters*, Aidan Meehan, 1991.
- [Sherb2] "Aviforms from Kells", M. Sherbing, from *Tournaments Illuminated* No. 83, Summer 1986.
- [Sherb3] "Drawing the Lindisfarne Dogs", M. Sherbing, from *Tournaments Illuminated* No. 88, Fall 1987.

General Celtic Art

- [Green] *Celtic Art: Symbols and Imagery*, Miranda Green, 1996.
- [Megaw] *Celtic Art: From its beginnings to the Book of Kells*, Ruth and Vincent Megaw, 1989.
- [Laing] *Art of the Celts*, Lloyd and Jennifer Laing, 1992.

Web Resources

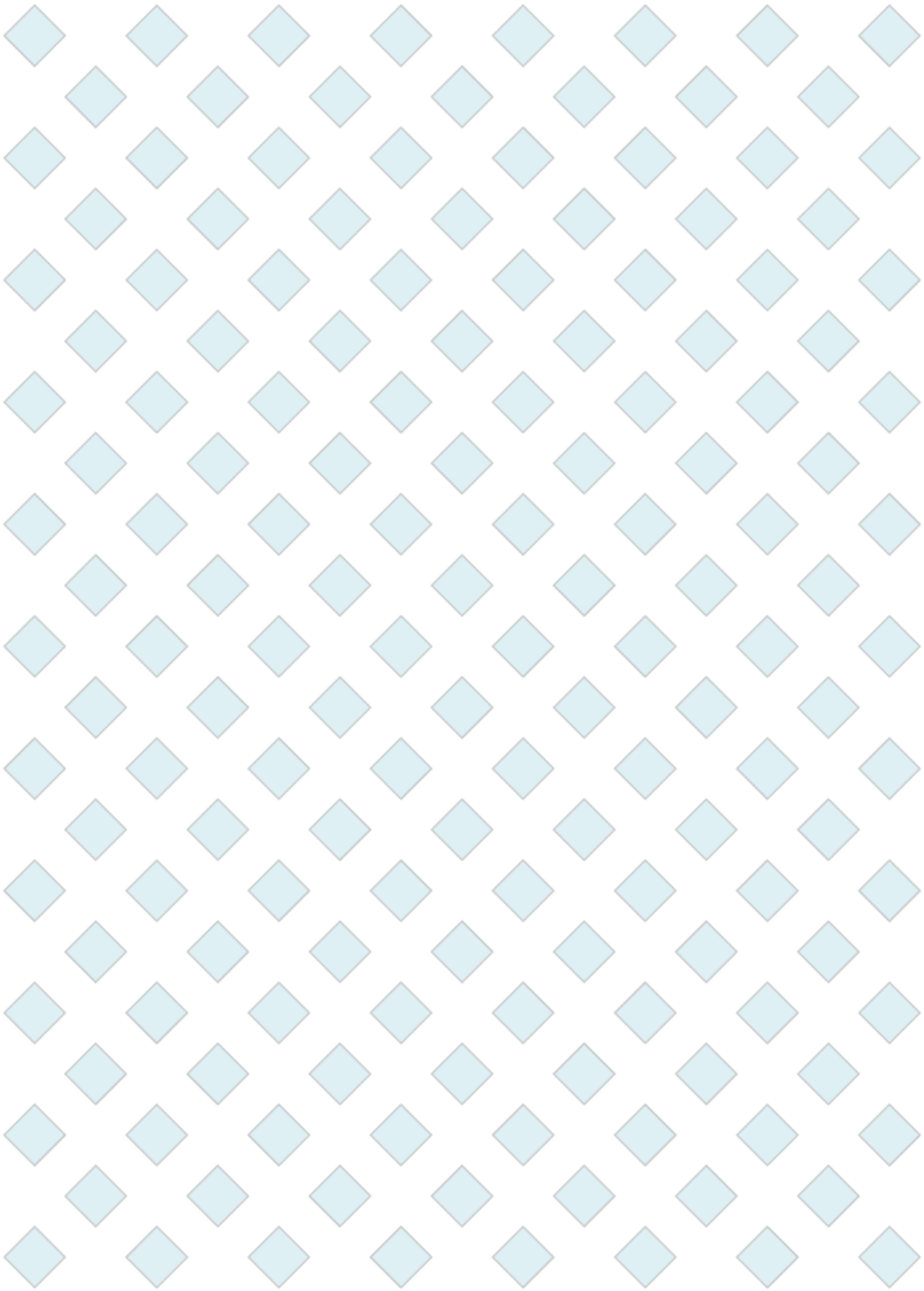
For other web resources, please see the Celtic "Art" links (URL: mihaloew.guru/celtic/cel_links.html) page.

Sample Grids

Below are a few grid examples, using various grid spacing and diamond sizes, plus one in the 3/4 ratio used in some knotwork. Feel free to download, and use them for computer-based knots, or print and use behind plain paper to allow for "invisible" grids (like calligraphy spacing guides). You'll probably need to double the grid size when printing to use them by hand, unless you have *excellent* eyesight and *really* good pen control). Light tables make these guides really handy.

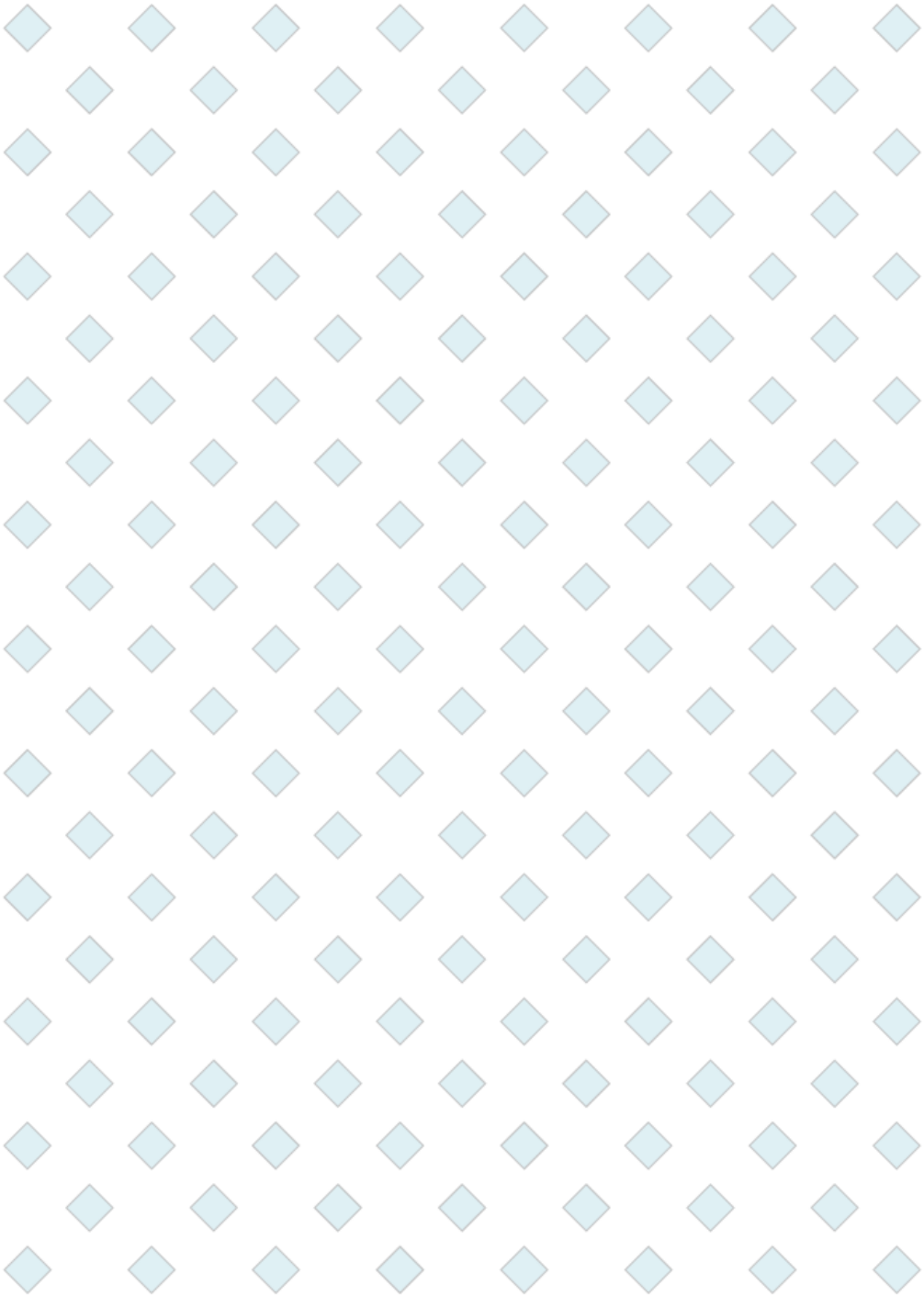
Regular Grid

This is the square (1:1 ratio) grid I've used for many of the samples in his tutorial, using a medium band width (no, this is *not* a computer networking pun!).



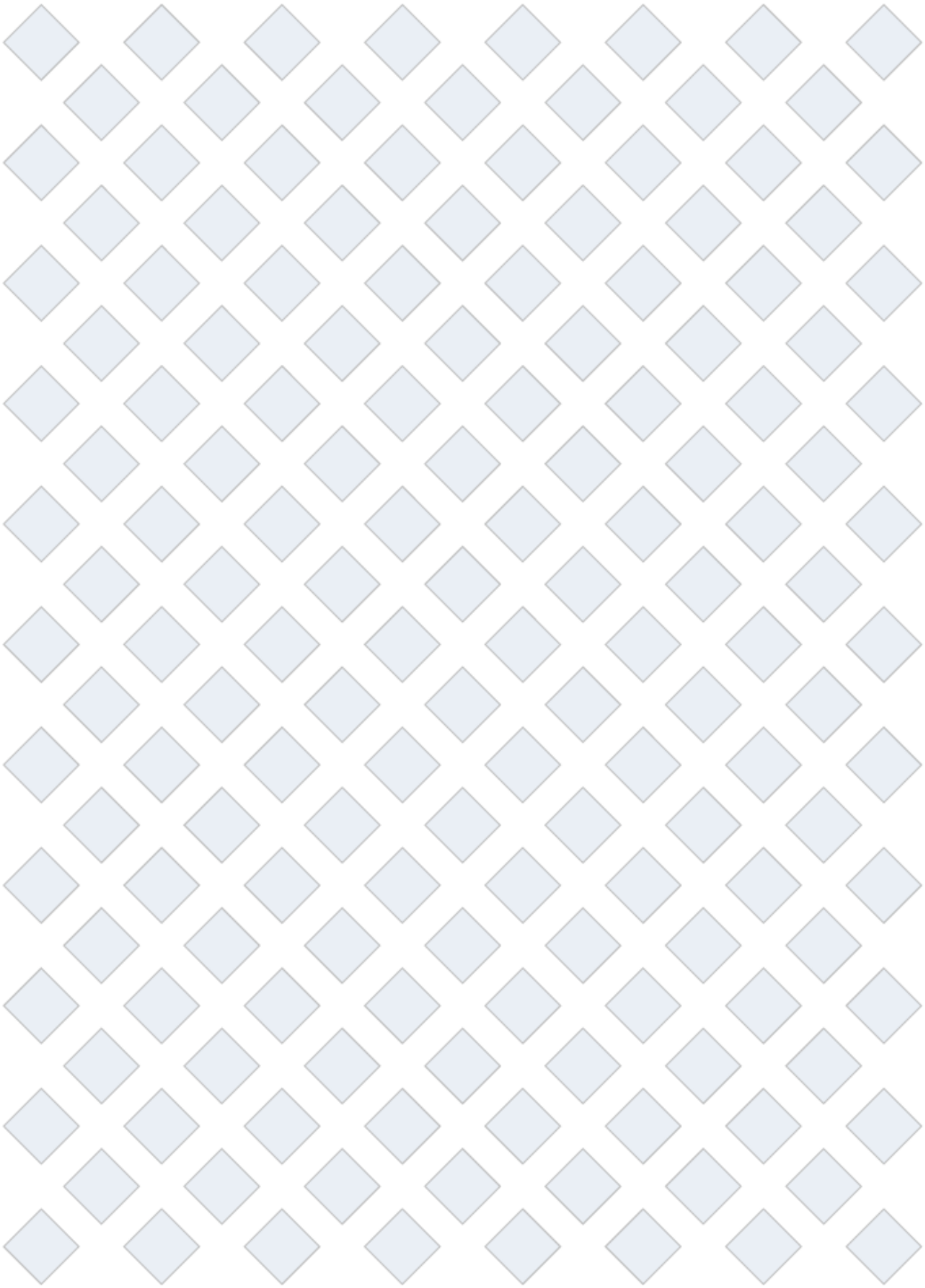
Wide Band Grid

This square grid uses the same spacing as the first, but smaller diamonds generating wide bands. See the *Knotwork Band Treatments* section for more information.



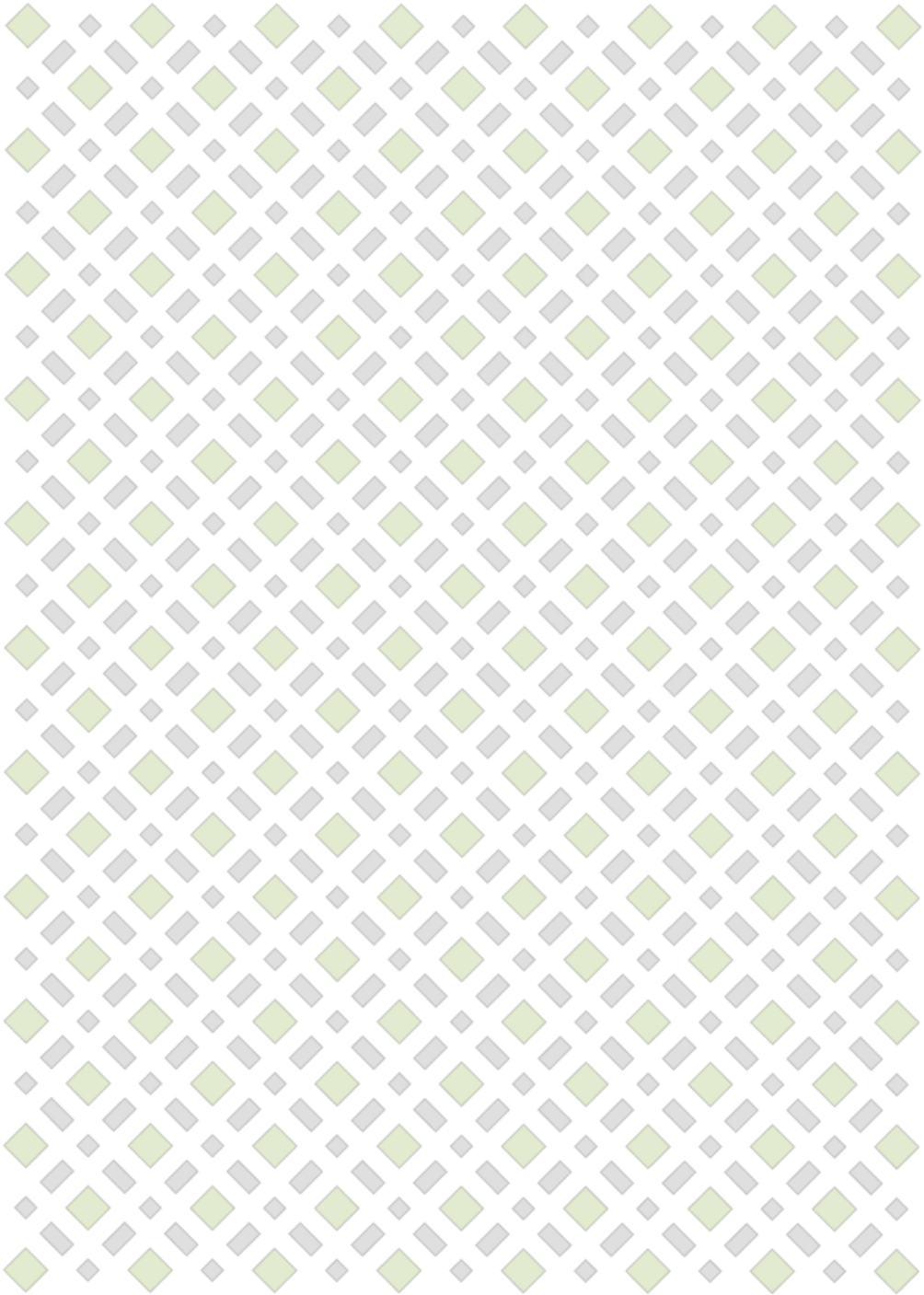
Narrow Band Grid

This 1:1 ratio grid uses the same spacing as the first, but larger diamonds generating narrow bands. See the *Knotwork Band Treatments* section for more information.



Doubled (Lindisfarne-Style) Grid

This is the grid I've used for experiments in "doubled" knotwork. See the *"Doubling" Interlace Patterns* section in this document for information and instructions.



"Pictish" Grid

This grid attempts to lay out a 3:4 ratio (called "Pictish proportions" by G. Bain) cell space.

have fun, and good luck!