12TH CENTURY
STAINED GLASS TECHNIQUES

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Stained Glass Techniques Theophilus style!

There is a story that was told by Pliny the Elder (23-79 AD) of a ship carrying a cargo of natural soda that made shore for the night. Having nothing to hold their pots and pans on for cooking, the crew took several blocks of the soda and placed them over the fire. The blocks, mixed with sand began to heat up and the crew saw a strange liquid begin to flow. This was the discovery of glass. Who knows if it is true or not, but it is an interesting tale. What we do know is that glass has been around for a very long time.

Colored glass has its roots as far back as ancient Egypt around 3000 years ago. The Egyptians pressed glass for perfume bottles, beads, and a wide variety of other uses. Glass was preferred over pottery. They discovered that by heating silica (sand, quartz) with potash, the silica could be fused. It wasn't until between 1554 BC and 1075 BC that the Egyptians discovered how to make clear glass. At this point in time they learned that they could cast this new glass into rods and while hot, mold them around sand cores to create vessels. The colors they created were more accidental than design due to the impurities in the materials they used. Color could be somewhat controlled by heating or cooling.

The blowing iron came into use somewhere in the second century BC. This allowed the artisans to attach a blob of glass to the end of a tube and blow air into it. The glass could be easily shaped by heating, blowing, rotating, and then repeating the process again until the desired shape was achieved.

By the first century AD, it was discovered how to make glass transparent and colorless. Color could be controlled by adding certain oxides.

The Romans had also been working with flat glass in the first century AD. They had inserted small pieces of colored glass into mounts for decoration. The Muslims used the flat glass to make mosaics in windows.

The earliest known pictorial glass is from records dating back to the 9th century. The oldest remnants were of a depiction of Christ's head from the Lorsch Abbey in the Rhineland (France) dated between the 9th and 11th century. Medieval stained glass was not used to pass light but more to capture and reflect it and really did not take off until the Middle Ages in Paris. The Abbot Suger commissioned the windows for the Abbey Church of St. Denis between 1144 and 1151, starting the stained glass trend. Soon after that windows were commissioned for the Charters, Bouges, and Le Mans cathedrals. Stained glass reached its peak in the Middle Ages between 1130 and 1330. Popular scenes were iconic and religious. Another popular style is called a "rose" such as the one commissioned at St Denis. Most rose windows use one of two themes: either the glorification of Christ and the Virgin or Christ as the apocalyptic judge. Sources of inspiration of stained glass come largely from the Bible.

Theophilus

In a book entitled *De Diveris Artibus*, a 12th century Benedictine Monk by the name of Theophilus, penned what is considered to be the "how to" book for the creation of stained glass.

Creating Stained Glass

So you want to make stained glass. It should be easy, right? Well… not in the middle ages it wasn't. Today we go to the store and buy our parts, we buy our tools and we can even buy a pattern. In the 12th century this was not possible.

Let's go over the basic steps of creating a modern stained glass window.

1) Decide what we want to make.
2) Make or buy a pattern.
3) Choose our colors
4) Choose the glass
5) Make a copy of the pattern
6) Cut the copy of the pattern up and glue it to our glass making sure we get the right pattern pieces on the right pieces of glass. One thing to note is if there are any patterns in the glass such as striations, bumps or streaks, we want to make sure that the glass patterns are oriented in such a way that enhance our overall project.
7) Cut the individual pieces of glass.
8) Use the original pattern as a reference for fine tuning the glass pieces. (I anchor the pattern to a board.)
9) Grind them down to shape.
10) Lead out the glass.
11) Solder the lead.
12) Repeat on the other side.
13) Use a whiting to fill in the gaps and spaces in the lead. The whiting adds structure to the glass as well.
14) Polish.
15) Put it in a window.

The process is very simple and straight forward. Unfortunately, in the middle ages there were no grinders, no glass saws, and no glass shops. Everything had to be made. So let's start back at the beginning of our list and put things into perspective. Remember, this is based on the methods used by Theophilus, so he will be referenced quit a bit.

What to make?

In the middle ages, deciding what to make was easy-something that would look nice in a cathedral or church.

The Pattern

We cannott buy a pattern so we have to make one. A common practice was to take a board and paint it white (called a white washboard). The pattern was then drawn on the white washboard. The drawing also included any images that might be painted on the

glass. Parchment could also be used instead of the white washboard.One advantage of using the white washboard was once you were done with the piece, the board could be re-painted and used again. Parchment could not. You cannot really make a copy of the pattern so this is a moot point. All of your work is done using the one white washboard.

Choose your colors

This is where it gets difficult. Your color scheme is limited to what was available.

The glass

In modern stained glass, we get a sheet of glass and start cutting. In the middle ages, it really gets difficult because before you can cut your glass you have to make it. Theophilus used two parts beechwood ash to one part river sand and heated it to about 2100° F. He came about this combination by trial and error, not by quantitative means.

There were two techniques to make a sheet of glass. The first is called the Muff Method. Here the glassmaker or glazier gathers a ball of molten glass called a parison, on the end of an iron rod called a pontil. He then molds the glass by rotating it. Then next step the glazier takes is to blow on the end the pontil, which is a hollow tube. What he creates is a hollow bottle shape known as a muff. He then cuts both ends of the bottle away to create a cylinder. While the muff is still hot, the glazier slices down the side of the muff length wise, and then flattens out the muff to create a flat sheet.

The second method is called the sheet or crown method. Here the glazier gathers a parison onto a pontil and blows shaping the glass as in the muff method. Once the desired shape is achieved, a second pipe is attached to the other end and the first pipe removed. The glass (crown) is rotated until it becomes flat and large. The crown is then removed from the second rod. The center of the crown forms an excrescence known as a bulls-eye. The resulting glass from both of these methods often had air bubbles and an uneven texture and thickness due to cooling and fabrication.

In northern Europe glass was made with two parts beechwood ash and one part sand. This is know as potash glass due to its high concentration of potassium. This glass can produce stronger colors but is also more subject to deterioration as the potassium creates a softer glass. In southern Europe they used sand and a soda rich vegetable ash (marine or desert plants). Since these were rich in soda it is known as soda glass. Because the vegetable ash has fewer oxides than the beechwood ash, the color ranges are not as good. However, the glass is more durable.

History texts tell us that the color could be controlled by adding metal oxides to the glass. Red was made by adding iron oxide, green with copper, blue with cobalt, yellow with manganese. Dr. Royce-Roll of the University of Alfred did research on this topic. His research centered around the methods of Theophilus to see if he could re-create the colors used in Theophilus' time. What he found is that the colors may not have all been created by adding different oxides as the history texts imply. He found that the impurities in the materials that were used in the creation of the frit caused the color differences in concert with heating the glass in either a reduced (oxygen poor) environment, oxidized (oxygen

rich) environment, or a combination (alternating) of reduced and oxidized environments. Beechwood ash contains a high concentration of manganese. It is these oxides of the manganese that produce the wide varieties in color. The manganese found in the ash can produce purple (oxidation), yellow (reduction), and pink (combination of oxidation and reduction). It was difficult to reproduce the colors the same from batch to batch because the concentration of manganese varied from tree to tree. With the addition of copper oxide you can produce red, green and blue glass.

Cut the glass

We now have our glass. The next thing we need to do is cut the glass. Sorry, but diamond points have not been invented yet. What we need to do is lay our glass on our drawing then trace the image on the glass with wet chalk. In order to cut the glass, the glazier took a glowing hot dividing rod and placed it upon the glass where it needed to be cut. When a small fissure appeared in the glass, the rod was drawn along the line, lengthening the fissure or crack until the piece was fully cut. To refine the shape of the cut glass, the glazier used a grozing rod to break away small bits of glass. A grozing rod is a piece of metal with slots cut into it matching the thickness of the glass. To smooth the edges the glazier used another piece of glass or a grindstone.

Staining

At this point if there is any painting to be done it should be done now. Once again we cannot just run to the store to get the stain. We have to make it. Theophilus used a combination of one third copper oxide, one third powdered green glass, and one third powdered blue glass. The glass we already have. The copper oxide was made by taking copper and placing it into a furnace, and then burn it. This yielded a black powder. All three ingredients are mixed together and bound by either urine or wine. (I am not sure what you want to do but I will go for the wine.)

We now take our glass and place it over our pattern. First, we do a lighter wash to create shadows. The glass is fired to adhere the enamel to the glass. Next, a darker wash is done to add body and the glass is again fired. Lastly, the detail lines are added and again the glass is fired. Depending on the effect that needs to be achieved, highlights can be created by taking a stick and dragging it through the enameling while it is still wet or sopping it up with a rag to create a texture. As a side note, not only can we obtain highlight lines with staining but we can also get highlight lines using a technique called flashing. In flashing we have a very thin piece of colored glass fused onto another piece of glass. The thin sheet is etched away using an abrasive. When light shines through, the bottom color is revealed.

Lead came

Now that we have our enameling done and our glass cut we need to start leading it. Oh wait!!! We have yet to make the lead cames! Lead cames are channeled pieces or strips of lead that hold the glass in place. To hold the inside glass we will use H channels, and for the outside pieces we will use U channels. The H channel cames are made of a heart (the center piece) and two leaves. The U channel is basically half of a H channel. Theophilus proposed two methods in making his molds for the lead. The first method is

to cast iron molds that are hinged at the end with an opening in the top. Molten lead is poured in the opening at the top. When full, the two halves are separated and you have lead came. The second method called for taking a flat piece of wood and marking it where the ends of the came should be. Then take a string soaked in ink and lay it across the length of the wood where you made your markings. Take a second flat piece of wood and press it down on the first. When separated a line will be drawn on both pieces of wood where you need to cut. Repeat this step with the second set of markings. The next thing to do is to take a knife and cut into the wood to the desired depth of your came along the lines you just created, on both pieces of wood. Next match the two sides up and bind them. Heat your lead and pour it into the mold. Let it cool and separate the two pieces of wood. You now have your H came. To create the U came, flip one of the boards around so that its flat side matches up with a cut side. Bind them together, melt your lead, and pour. Let it cool, separate the boards and now you have the U channel.

Solder

We have cut and painted glass, and we have lead cames. The next step is to permanently connect all the pieces together using solder. Solder is a low melting metal alloy composed of lead and tin, cast into sticks. Guess what? You got it. We have to make that too. Theophilus used one third lead to two thirds of tin. But it has been shown that this may have been a personal preference. Some artisans used a 50 percent mixture of tin to lead. This mixture is by percent weight. After each junction of the lead cames is cleaned, we use a hot iron to melt the solder into the joints between the cames, locking the glass into place. Then we carefully flip the assembled piece over and solder the other side in the same fashion.

Let’s finish this up

Once the soldering is complete, the last step is to cement the piece. This was done by creating a mixture of powdered whiting (calcium carbonate), and linseed oil then rubbing this mixture under the edges of the lead. After the excess was removed and the glass dried, the window became waterproof and had a bit more stability to it.

Depending on the size of the window, some stabilizers may have to be added to it. In order to install the window a little bit more work had to be done. The next step was to install the banding wires. These are copper strips about 4 to 5 inches in length, soldered onto the leading and are used to secure the window. There are two types. One is called a “division tie” and is used to connect adjacent panels of windows. The division tie has one long strip of copper that twisted around a division bar along with the tie from an adjacent panel, holding the panels together. The second type has two strips of copper called a “middle tie” and is used to connect the panel to a supporting bar. The copper strips wrap around the supporting bar, almost like a twist tie, adding extra support to the panels.

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