

The attached document was submitted in support of an entry into the SCA Arts & Sciences competition known as “Ice Dragon” held April 13, 2019, in the Barony of the Rhydderich Hael (see <http://www.ice-dragon.info/>).

Many thanks to the individuals who judged this and all entries and provided feedback on them, as well as to those who organized and staffed the event.

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A Heraldic Glass Window

“The 14th century was ... the period in which heraldry became a major element in the decoration of windows” (Crewe: 23).

Per chevron chevronelly Or and gules, and Or, in base a ship in full sail gules, all within a bordure embattled sable.

Project Goal

To make a period-style panel of colored glass suitable for display in my house, to appear in and completely fill a certain specific window opening.

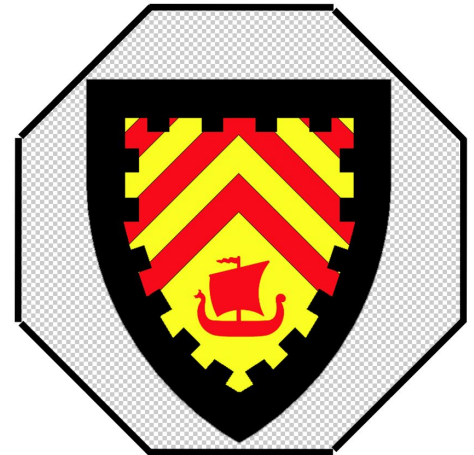
Long ago I learned to use modern tools and techniques in working with glass, but I have never made a leaded piece before, and I have not worked with glass in over a decade. I expect that researching this topic and then working with lead came will teach me about historical aspects of construction and also result in a window that enlivens the room it's destined to enhance.

Note that this project does not use any *stained* glass. The glass is inherently colored, rather than stained. The staining of glass, at least in England, did not occur until almost the Reformation (Marks, 1993: 38).



Artistic Considerations & Concessions

The shape and dimensions of the opening within the wall where this window will be mounted dictated its overall design, within which the heraldic device must fit. For my personal (modern) aesthetic sense, I chose to use the full octagonal space for the heraldry rather than forcing it to a standard escutcheon and then surrounding that with white or other filler glass (see image to right).



Despite searching high and low, I could find no instance of 14th-century glass displaying heraldry or arms in any shape except the escutcheon, although there are many of these (see images elsewhere in this document). When someone donated funds to a church, their arms could be on the glass, but always on a shield-shaped design. (Heraldry could also appear on surcoats of depicted figures, but not as a stand-alone depiction.)



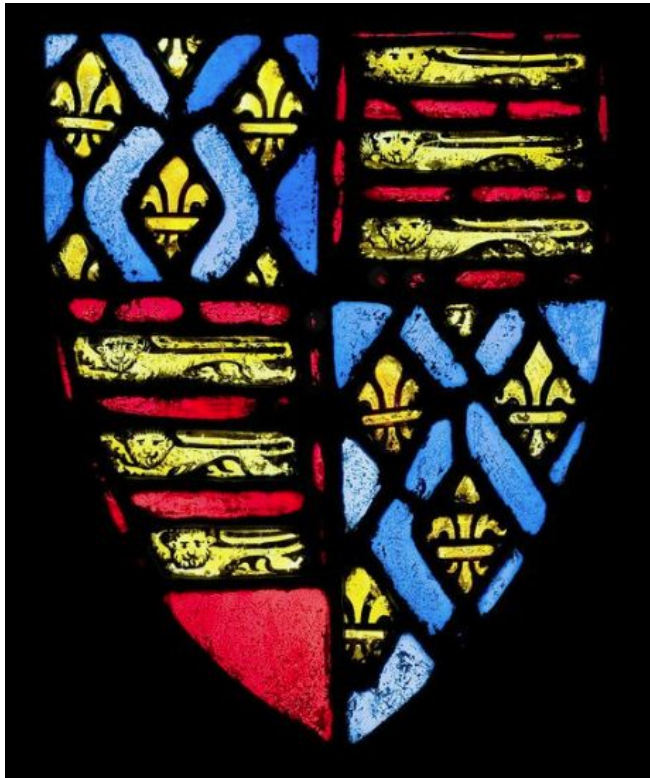
Heraldry on non-escutcheons designs. Left, seal matrix of the Villiers family, dated 1250-1450 (<https://finds.org.uk/database/artefacts/record/id/107629>); right, floor tile from Little Malvern Priory dated to the 15th century (<https://www.britainexpress.com/counties/worcestershire/churches/little-malvern-priory.htm>). Images not to scale.

Of course it is possible that someone had their arms depicted in glass on an arbitrary shape but the work did not survive the passage of time. At least one circular shape in a seal matrix survives, and at least one square floor tile, even though most heraldry in those media also use escutcheons (see images above).

Materials: Glass and Lead

The glass was purchased in sheet form, as typically done during this period by people making windows (Brown and O'Connor: 46; Marks, 1991: 265). Likewise, the lead came was purchased, rather than cast by me, although glass craftsmen usually cast their own (Brown and O'Connor: 64). Theophilus describes this process in detail, including the making of the molds (chap. 25-26).

Although I had some ruby and yellow glass on hand, there was not enough to complete the project. When trying to find additional glass online, it became clear that every merchant checked was out of stock in those colors - and only those two colors.



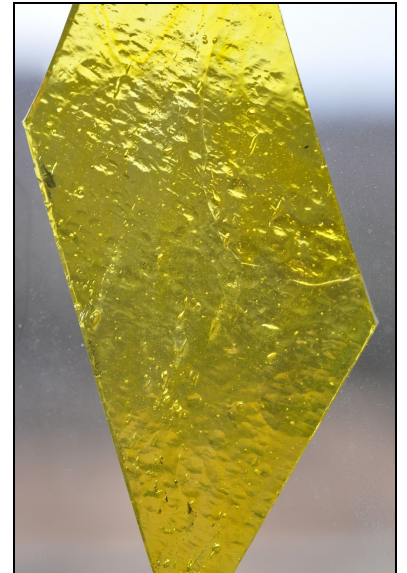
Ruby and yellow glass in a heraldic panel with the Coat of Arms of Edward III, King of England (reigned 1327–77), c. 1350-77. Height: 320.80 mm (12.62"); Width: 254.25 mm (10").
(https://commons.wikimedia.org/wiki/File:Artist,_maker_unknown,_English_-_Heraldic_panel_with_the_Coat_of_Arms_of_Edward_III,_

King_of_England_(reigned_1327%E2%80%9377)_-_Google_Art_Project.jpg and <http://www.philamuseum.org/collections/permanent/288431.html>).

On visiting a local glass shop, I learned that at least one glass-making company was recently penalized significantly for emissions violations for the heavy metals used in colored glass, especially ruby and yellow. I learned that other companies have taken note and ceased production until they can install scrubbers. As a result, there is a low stock of ruby and yellow glass and if it can be found there's a premium price tag on it.

Fortunately, the local shop had some spare glass in both colors. Unfortunately, the textures of the two did not match well. But beggars can't be choosers at this point in the project and I had to go with what I could get.

As for the texture and appearance of the glass, I believe that the yellow somewhat resembles the medieval material in its unevenness and inclusions such as small air bubbles (see image at right). The ruby, not so much, it being rather smooth and clear (Brown and O'Connor, 49; Nielsen: 15).



With an increased budget, I could have purchased hand-made glass to obtain a closer degree of authenticity for this project, but its cost is significantly higher, starting at \$50 per square foot. (This window has 391 sq. inches of glass, or about 2.7 square feet, but calculating the cost of the glass is not straightforward because of the way pieces must be cut and does not allow for wastage or mistakes.)

For the lead came, I choose 9/64" rounded because I believe it most seemly for the dimensions of this project. Medieval lead could be either flat or rounded, and varied in size even within a given work (Brown and O'Connor: 64). I chose rounded comes because I prefer their appearance over flat ones.

Fun fact: the word "came" in this context derives from "calmes," which in turn comes from Latin *calamus*, meaning reed (Marks, 1991: 274).

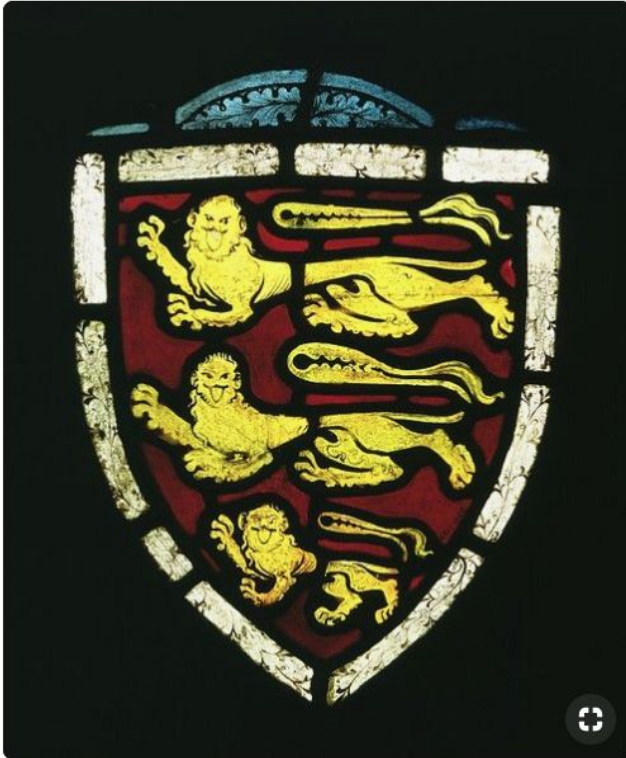
Glass Colors and Paint

Various surviving examples of 14th-century window glass prove that ruby and yellow glass existed at the time (see various images elsewhere in this document). See also Theophilus (chap.7) where he describes the manufacture of saffron yellow glass. Despite being available, it's almost certain that colored glass had to be imported from the Continent and would not have been made in England during the 14th century (Marks, 1991: 265; Brown and O'Connor: 47).

Yellow glass would have been made from an iron oxide as "pot" glass, having had all the ingredients mixed together during its formation. Ruby glass, on the other hand, was "flashed," meaning that a layer of colored glass was applied over - and fused to - a clear glass base. This was

necessary because the colorant, copper oxide, is very heavy and needed to be thinner to allow light to pass through it (Marks, 1993: 28).

However, if you seek black glass, you will not find it. To apply the embattled border in this device, then, it is necessary to paint it on the glass. Black and dark brown paints served as the basis for delineating many aspects of a scene on medieval windows, such as faces, garments, textures, architectural decoration, etc., as apparent from even a brief look at any book covering the topic.



Heraldic panel, ca. 1381, of clear, colored and flashed glass painted with brown/black pigment and silver stain. Depicting the arms, probably, of Thomas Holland, 2nd Earl of Kent. English, about 1381. Museum Number 6910-1860 (<https://www.pinterest.com/pin/355291858072796444/>).



14th-century heraldry in glass with a painted black border, just as in this project's solution. Moccas, Hereford. After <https://www.flickr.com/photos/amthomson/8527829608/in/photostream>.

After cutting the glass to the shape needed in the design, a painter would use brushes, pieces of wood, or a finger to apply the color to the inside of the glass (and, later, sometimes to the outside for added depth). The paint itself consisted of ground copper or iron oxide, powdered glass, and wine, urine or vinegar, and gum arabic. After applying the paint, the craftsman would usually fire the glass in a kiln in order to fuse it so that it would not flake or rub off (Marks, 1991: 271, 273; Brown and O'Connor: 56).

Occasionally, though, the paint could be applied cold, especially in smaller pieces, and it would be oil-based in that case (Brown and O'Connor: 61). Cold-painted oil was sometimes also used specifically for heraldry (Marks, 1993: 39). Because I do not own a kiln, I chose to apply a purchased oil paint for the ship's strakes, the figurehead, and the main cross beam as well as the embattled border. After constructing the whole window, the final step was to apply the paint and let it dry for several days.

Process

To make a window in the Middle Ages, various people with differing talents and skill levels would be needed: artists, designers, glaziers, painters. Sometimes an individual might possess several of these. I had to do them all, with more or less success at each step.

Design the Window

In the 14th century the window patron and artist would work together to produce a *vidimus*, a quick drawing or sketch of the design in order to ensure everyone was on the same page, so to speak.

The craftsman would transfer the design to a cartoon, at a 1:1 scale for the window on a hard, flat surface, that will be used to determine the shape of each piece of glass to be cut and, later, laid out for assembly. In the 14th century, craftsmen drew their design on a white table, using red or black lines and marking pieces with letters, and then built the window on top of it (Baker, 2; Brown and O'Connor: 52-53). Later parchment and then paper took the place of a dedicated table because those media offered portability (Marks, 1991: 267-270, 280; Nielsen: 17; Crewe: 9). See also Theophilus (chap. 17) on laying out windows.

Because I lack a large white table on which to draw the design, I printed out a copy of my cartoon onto paper and then used that during shaping the glass pieces and assembling them into the window (see photos below). This is much the same as them being glued together to make a larger sketching area (Brown and O'Connor: 54).

(For the modern reader, on a piece of this size, it will be necessary to output a tiled version across several pieces of paper. Various computer applications can do this, but Adobe Acrobat is a good free one, if the design can be exported to PDF first. I recommend ensuring that the output is set with an inch of overlap to help align the pieces of paper, which are then joined together with clear tape. Also, use the largest piece of paper the printer supports, such as 11"x14," in order to reduce the

amount of tiles and minimize errors during alignment and taping.)



The window cartoon, printed on six 11"x14" pieces of paper, taped together. The embattled border will be painted on. Additional lead lines were added as the glass was cut because of some risky curves and because certain large pieces could not be cut from remaining sheet glass.

Cut and Trim the Glass

Now for the scary part: cutting and breaking the expensive glass. Like many projects, the hardest step is often the one that commits your materials. The more you do it, however, the more comfortable it becomes. Keep in mind that even broken pieces can be used just by adding an (arbitrary) new lead line between them, or elsewhere in the same project, or in another one.

Medieval glass workers employed hot irons to cause the glass to break by applying intense heat along the lines defining the shape they wanted (Marks, 1991: 271). This was a highly skilled and difficult process (Crewe: 9-10). Theophilus describes it in chap. 18:

Next heat on the fireplace an iron cutting tool, which should be thin everywhere except at the end, where it should be thicker. When the thicker part is red-hot, apply it to the glass that you want to cut, and soon there will appear the beginning of a crack. If the glass is hard [and does not crack at once], wet it with saliva on your finger in the place where you had applied the tool. It will immediately split and, as soon as it has, draw the tool along the line you want to cut and the split will follow.

Because I do not have such a tool, and no experience at all using one, I employed a modern, diamond-wheel cutting tool. Although probably not known in England during the 14th century (Crewe: 9), it was used during the later Middle Ages, and in Italy at this time (Brown and O'Connor: 56).



Cutting the glass and testing how well pieces fit.

Because glass can break imprecisely, it's often necessary to trim it. For rough trimming in modern work, one can apply grozing pliers and then hold the piece to a specialized grinding machine to achieve very smooth edges. The grinding wheels on those machines are especially useful on inside curves, where attempting to trim often results in breaking the glass, although skilled medieval glaziers could make extremely delicate cuts, even removing circles (Brown and O'Connor: 56).

Medieval glass workers used grozing pliers too, but certainly not modern glass grinders. Thus, the edges of the glass are rather rough. Given that they lie inside the lead comes, though, this does not matter. (It's not clear to me whether or not they ever ground or filed their glass, with, say small metal files. None of my sources address the question one way or the other.)

I used grozing pliers to trim and shape all the glass pieces, using no modern grinding tools. This tool generally resembles a pair of modern pliers, but its top blade is flat along its length while its lower one curves upward to form a grip just at the end of the blades, both of which are flat. With patience one nibbles away at the glass to shape it, hoping fervently that an unseen stress line will not cause the piece to break unexpectedly.

Assemble the Pieces Between Lead Comes

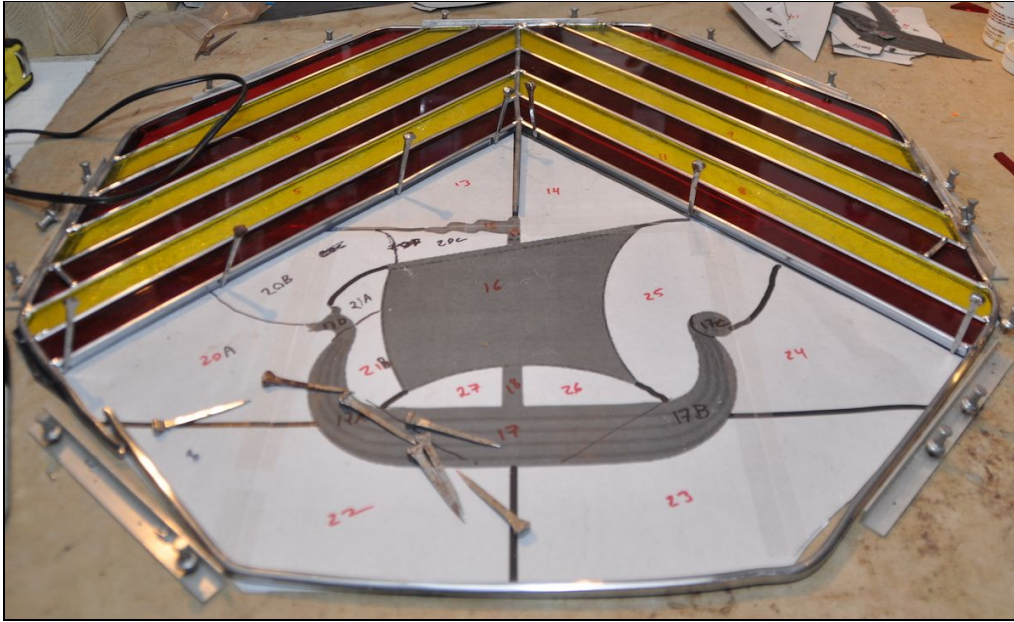
After cutting the glass and shaping the glass pieces to match their matching cartoon shapes, they are assembled into the window with lead comes holding each in place.

First, I placed metal brackets at the appropriate angles and dimensions to form a sturdy set of edges around the perimeter against which I could lay the U-shaped edging came.

Then, starting at the top I positioned each piece of glass, adding lead came as needed to enclose it, using square nails to hold them in place while soldering the joints each place different lead comes met. Sometimes I had to adjust the size of a piece of glass to better fit its assigned space.



All glass pieces cut and ready to lead.



Adding the lead and soldering it in place.

For soldering, I purchased and applied a modern 60/40 concoction and a modern soldering iron. See Theophilus (chap. 27) for details on this process, which does not differ much from my approach.



Leading complete, ready for putty.

Apply Putty and Clean Up the Mess

After placing all glass and lead comes and soldering joints on both sides, I applied purchased putty to fill the gaps between the glass and the lead in the channels. This provides stability and weather protection for the glass.

Putty is composed of linseed oil, mineral spirits, and whiting powder, although in the 14th century it sometimes also included tallow or cement (Marks, 1991: 274). It is applied by squishing it into the small gaps between the lead comes and the glass.



Putty in place, next step is cleaning off the excess.



Whiting powder applied as a way to clean the putty by brushing it off.



Cleaned glass and came, letting dry to solidify a bit.

Paint the Details

Finally, to add detail to the main heraldic charge, I brush-painted on the ship's strakes, its figurehead and aft decoration, and the main cross beam. In addition, I painted on the entire border.

See the earlier section on colors and paint for details on the materials used and a discussion of cold-painting versus fusing the paint into the glass.



Painted border and ship details.

It was necessary to apply one coat of paint, then allow several days in front of a heater and fan for it to dry before adding a second to ensure that light does not penetrate it. After the second coat, I used a very sharp knife to scrape some of the painted edges into straighter lines.

Learning Points

Although I learned to work with glass many years ago, I've only used the copper-foil technique to build panels. This is my first leaded piece, so there are some obvious defects with it. Specifically, some of the chevronell pieces came out a bit short on the left side, despite them all lining up properly on top of the cartoon. It's not clear to me why this happened, but perhaps I should not cut all the pieces ahead of time, and instead cut them as they are incorporated into the panel with the lead came.

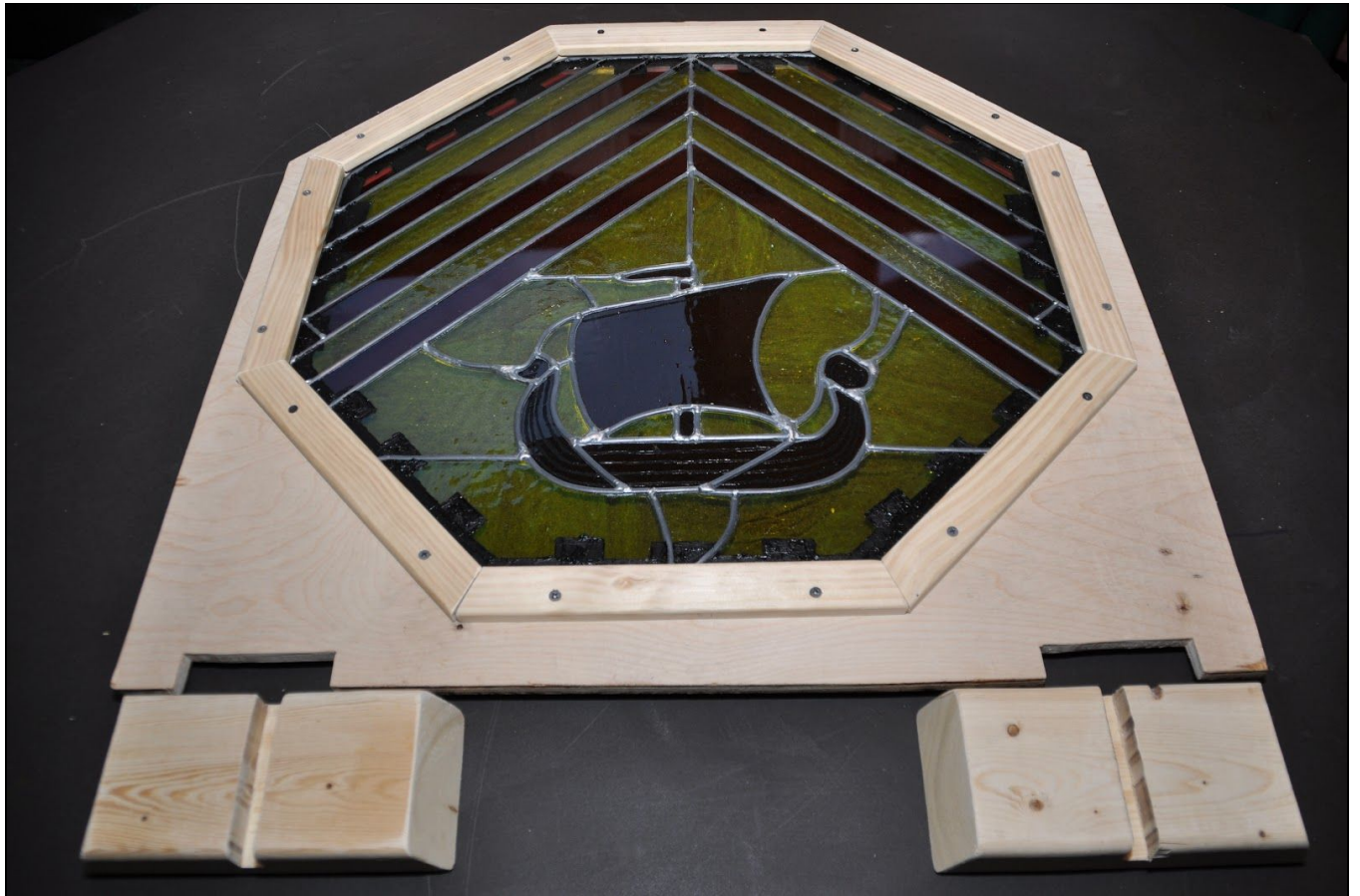
As mentioned, I've not worked in this medium for more than a decade, and thus was very surprised to learn about the current market limitations on glass, especially ruby. I believe the piece would look better if the ruby and yellow glass textures matched, so the next project will need much more preparation time for acquiring glass consistent across colors.

Using modern equipment to cut the glass to proper shapes and dimensions appears to be relatively easy compared to the period techniques described earlier. At this time I do not see a way to acquire the equipment or facilities needed to attempt those methods, but I would certainly like to see them being used in person in order to gain better understanding of them.

Adding unfired paint to the glass, as done in this project, may very well result in it flaking off. I am seriously considering taking classes at the local shop to learn how to achieve period-style painting results, both artistically and technically, in order to further develop my skills in working with colored glass. Having the design fused into the glass and having the proper stylistic depictions will improve further work in this subject matter.

The Display Frame

The window is displayed in a wooden frame so that light can pass through the glass and it can be examined from both sides. The wood frame also facilitates transporting the glass safely. Please forgive the use of modern screws that allow it to be taken out safely after the frame is no longer needed.



Window mounted in a frame, with feet, for display and transport.

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Additional Resource

Corpus Vitrearum Medii Aevi (CVMA) of Great Britain (<http://www.cvma.ac.uk/index.html>)

"The Corpus Vitrearum Medii Aevi (CVMA) is the international research project dedicated to recording medieval stained glass. In Great Britain, the CVMA is a British Academy Research Project, hosted by the Centre for Medieval Studies at the University of York. A Project Committee oversees the programme of activities, including our publications, which are undertaken by volunteer authors. This website has details of our Books and how to order them, and hosts our digital publications and conservation materials. Here you will also find free access to our digital Picture Archive, containing more than 25,000 images, most of them in colour."

This appears to be a treasure trove of medieval glass imagery, but when attempting use it I learned otherwise. The search feature either returns all records or none. No contact / feedback link was found to report this issue.

Further Examples of Heraldic Glass Windows



The Lucy Chapel east window of Christ Church Cathedral in Oxford, c. 1320. Crops from <http://www.therosewindow.com/pilot/Oxford-Christ-Church/Lucy-Frame.htm>



East window of Tewkesbury Abbey, c. 1340. Crop from <https://www.flickr.com/photos/paulodykes/41118046931>



Note the painted-on border.



The Arms of Sir John de Somery, of Dudley Castle, Worcs., dates to the early 14th century and uses a range of wonderful richly coloured glass.

<https://bopardconservationproject.wordpress.com/category/stained-glass/page/6/>