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## P A P E R S

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### IS STAINED GLASS A LOST ART?\*

BY LAWRENCE SAINT

#### An Age of Color

Today we live in an age of color. The invention of neon signs and kindred illuminated signs have made colorful the streets of our cities and villages. We find that color has invaded the kitchen and bathroom, with pink bathtubs and blue sinks, and all sorts of colored toothbrushes.

As stained glass is the greatest expression of color in any art, it ought to be the leader in this movement in which we find ourselves, and it is appropriate that we should study it.

Stained glass transfixes the myriad flashes of the diamond, the glory of the sunset, the iridescence of long buried ancient glassware, the splendor of a New England autumn, the richness of Venetian sails at evening, the gleam of a thousand jewels, the wonder of the rainbow.

The iron work used in stained-glass windows subdivides the weight of the lead and glass. It is made as nearly as possible like the iron work used by the ancients, because the eye and key system allows the panels to be easily removed if need be and put back. I use Swedish-charcoal wrought iron, the same type as the old, for its lasting qualities. I have seen much of this iron seven hundred years old.

There is an interesting unity of materials in a stained-glass window; for instance, the copper

of the wires (which fasten the tiny supporting bars to the window to assist against wind pressure) as one oxide, makes greenish blue and, in another form, red. Iron is also used as a coloring element in the glass. There is lead in the cement and glass as well as in the grooved leads which bind the window together. There is tin in the glass and in the solder. The building is limestone. There is lime in the glass. The materials pull together quite happily.

The ancients cut glass by running a hot iron over it, dampening the trail to make a fracture, and then "groising" or "chewing" it down in some way. By using the notches on the modern cutting wheel, I have reproduced the exact effect seen on the edges of old glass. It is quite likely this notched part of the tool has come down from ancient times. The tiny wheel used today when passed over the glass causes friction, making fractures in the glass. When tapped on the back the glass breaks where it has been scored by the wheel. This method is superior to the old.

Glass paint of the 13th Century is a most wonderful substance. I have seen examples on the outside of a window which had resisted the weather for 700 years; there is some 800 years old just beginning to come off the glass. With the sun shining through it under a microscope, it looks like a sunset. It has in it particles of pale lemon color, yellow, orange, deep red, brown, and black, and has a luminous quality like Rembrandt's shadows, which gives life and glow to the windows.

\*Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, March 30, 1936 (General Session). Received May 20, 1936. Copyright 1936 by Lawrence Saint.

See also Lawrence Saint, "Stained Glass Creed," *Bull. Amer. Ceram. Soc.*, 15 [6] 238-41 (1936).

### Color Glass Production

When I undertook the work for Washington Cathedral it was understood that I would make my own glass. I was expected to get colors like those in the old glass. Although I had collected a number of formulas from different countries, I found it necessary to have analyzed several pieces of 13th Century glass. Analyses by the quantitative\* and the spectroscopic† systems checked beautifully. I was surprised to learn that there were materials in the glass of which I had never heard. The reports showed silica, alumina, chalk, magnesia, copper, soda, potash, manganese, sodium sulfate, titanium, cobalt, bone-ash, iron, lead, tin, and borax.

In the piece which was analyzed, I discovered the secret of how to reproduce almost any shade of blue I wanted. Altogether I have made about 300 shades of blue. I took samples of my glass to Europe, many shades of all colors, to compare them with the old. About 75% of the samples closely approximated the best colors in the old windows.

I found that by combining manganese with other coloring elements I could produce soft Tokay-grape shades, used in drapery and flesh tones.

The old colors are never raw or garish or unpleasant. They are soft and poetic and beautiful, like the lovely colors of apples and banana skins and Tokay grapes, the sky and autumn leaves and old lace. To produce a fine yellow, for instance, we find it necessary to borrow a little from the red and a little from the blue, which makes purple. A slight amount of purple superimposed on the yellow produces the soft banana or topaz tint. This softened or slightly neutralized tint will harmonize with the other stronger colors about it.

The same thing happens to the red. It borrows a little yellow and a little blue, which makes green. And a little of the green with the red softens the red and makes it blend beautifully in the field with other contrasting colors. The same thing is true of the blue. A little yellow and a little red makes it harmonize with yellow and red. How this effect is achieved in the red will be described later.

I believe the system of color harmony used by the medieval artists to be fundamental. It is the basis of color harmony in oriental rugs, Japanese

prints, and Venetian paintings. The same principle was used in making tapestry and, in fact, in all forms of good art in all countries and all ages.

Soft shades of topaz yellow and attractive shades of red and blue result from mixing in small amounts of their complimentary colors.

### Effect of Color Layers

In a photomicrograph\* of the edge or section of a piece of ancient red, dating from 1225 (Fig. 1), the black streaks are the red layers. The ancient red, unlike the other colors which were and still are colored uniformly through their mass like gelatin, was made with a number of microscopic layers running throughout its body. Frequently

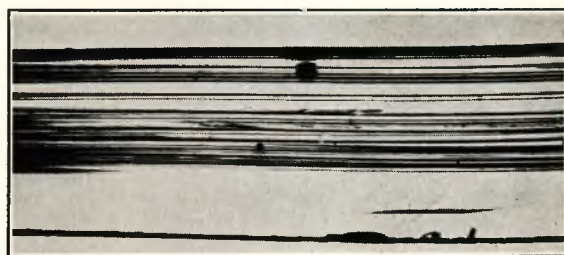


Fig. 1.—Photomicrograph of a cross-section of a piece of red glass made about A.D. 1225 showing typical arrangement of the red in layers. Magnified about 15 diameters.

it had amber-colored layers between the layers of red and on the back a layer of greenish white varying in thickness and tint. The variation of the greenish white and the amber as well as the amount of red determined the different shades of red. A red from my formula, which I think closely matches the old stained glass if allowance is made for the aging in the old one, has 16 layers (Fig. 2). The piece of red glass made about A.D. 1225 (Fig. 1) measures one-eighth inch thick. It has an irregular surface caused by the weathering of the glass. In cross-section its red layers appear black with amber layers between and greenish white on the back.

Ordinarily the layers run parallel, but in exceptional cases this is not true. I never had seen such an arrangement of layers until these were ground down.

One of the finest samples of glass made in ancient times has some patina (pit marks and corrosion caused by the weather) which makes it a

\* Frederick Wynkoop.

† Jacob Papish.

\* Howard A. Walter.



little gray. Along the clear edge the actual color may be seen; there are about twenty layers of red.

My red formula covers nearly eight pages of typewritten material and there are about forty ways it can fail. I arrange the layers in a little different way from the ancient, but the effect achieved is the same.

After 200 years, the art of making good red glass had practically vanished. "Flashed ruby" from the 15th Century is without streakiness or

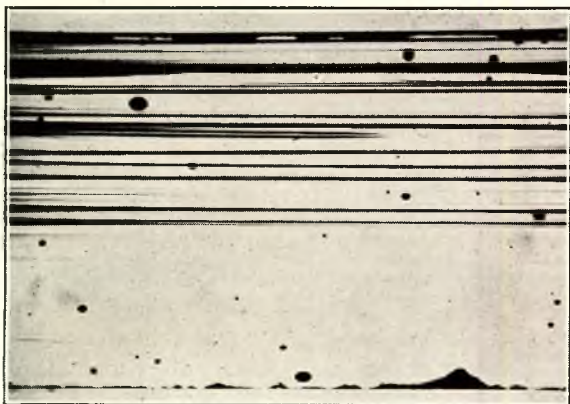


Fig. 2.—Photomicrograph of a cross-section of a piece of red glass made from Lawrence Saint's formula, showing the layers.

striations. One layer of red was flashed on a nearly white body of glass. By this time the glory of the early reds had departed; the entrancing loveliness was no more.

I tried all sorts of variations and combinations of the red made from my formula. Sometimes what should have been red came out black; sometimes no color showed. Sometimes I would find a lump of free copper about the size and shape of a lima bean in the bottom of the pot. By varying the amount of red and greenish white or amber layers, I can now produce an infinite variety of shades in the red.

#### Effect of Irregular Thickness

One of the interesting things about old glass is that nearly every piece varies in thickness. This irregularity of thickness bends the light rays in a way that is pleasing to the eye. On the principle of enlarging and reducing lenses, the rays of light change in all directions, giving a certain soft effect to the old windows. Not only does this irregularity of thickness bend the light rays, but it helps the beauty of the tint of the glass by making it light and dark in the same piece. In a

piece of old blue, rather the worse for wear, which has stood up against the rains and frosts and snows for seven centuries, the center of the glass is thinner and therefore lighter than the outside which is thicker and darker. In this particular piece of glass, the rays radiate as they do from a reducing lens.

One of the peculiar characteristics of 13th Century blue is that where it is thick it looks purplish-blue and where it is thin it has a greenish-blue tint.

#### Effect of Weathering

Some people think that glass lasts forever, but in time it is attacked by the weather. The weathering really enriches the vibration of the glass, if it has not gone too far, and gives it a delightful shimmering effect. To retain this sparkle or vibration, I have studied the corrosion and pitting to find some way of reproducing the effect by craftsmanship. The question is often asked whether the beauty of old glass is not largely due to the weathering or aging. This is true only up to a certain point. Glass that has too much weathering is almost rotted away. It is about one-sixteenth inch in thickness. Horizontal leads often make a miniature roof which keeps the rain off the glass immediately beneath; thus protected, it remains clear at the top.

#### Glass Painting as an Art

In painted glass of Medieval times, the lines taper in width and are light and dark in value. Edging the brown, painted lines is an almost invisible, horny-toned film which keeps the lines from looking too thin as the light pours around them.

When a rich color scheme was used it was necessary to paint the whites down by putting rich design work on them. Everything was done free hand. It is delightful to imagine the enjoyment the early artists must have had in their clever brush work. It has snap and life in it.

Textures are an important quality in art. The waves are a texture on the ocean; bark is texture on trees; clouds are a texture on the sky.

#### Examples of Glass Windows

In Europe I have climbed around on ladders and scaffolding studying and copying the windows to learn the character of the glass, the type and method of leading, painting, and so forth.

The west windows in the Cathedral of Chartres

are the greatest windows in all the world. Inside the cathedral is seen one thousand square feet of the most astonishing color, majestic design, and thrilling Christian story that could possibly be imagined. As a Christian artist I am happy that the greatest windows have as their theme the life of Our Lord.

The crucifixion window at Poitiers, France, is one of the greatest in the world. The figure of Our Lord on the cross is eight and one-half feet high. The colors are magnificent. A great glass development occurred in Poitiers dating from Roman times. A Grecian figure which was dug up there may have been eagerly studied when this window was made (in 1172). The treatment in the drapery on the statue and in the window is much the same. The reds are marvelous in striations and color tone. It was here that the idea of making windows sensitive to light first came to me.

It was when the early windows of the 12th Century were able to combine something "to keep out the birds and rain and yet admit the light," to depict the Christian story, and to embellish a cathedral architecturally that they caught the imagination of the people. The populace spent fabulous sums, relatively speaking, on their windows, and they were as enthusiastic about them as we are about radios and cars today.

In the west windows of Chartres, Our Lord is represented in several scenes. These 12th Century windows shimmer and glow and change somewhat with every passing cloud and shadow and every changing tint of blue in the sky. The paint on these windows has lasted for centuries.

Another part of the same series of windows shows Our Lord in large scale at the top of the window. A minister who looked at this window said that it was the most celestially beautiful thing he had ever seen in this world. This window is sensitive to light, changing with each passing mood of the sky behind it, because the colors are neither extremely dark nor extremely light.

The first glass I made was not well melted, but when I went abroad to compare it I found that the blues from the first dozen pots matched closely the blues in the Tree of Jesse Window at Chartres, perhaps the most famous window in the world. Once in a while we do have a good accident.

### Stained Glass Should Harmonize with Building Architecture

It is important to know that stained glass should accept the limitations of the architecture. It should fit harmoniously into the architectural scheme and seem to grow out of it. It should not fight the architecture, as many modern picture windows do. The windows in the Chartres clerestory feel naturally the shape, lines, and majesty of the great spaces of stone in this mighty House of God.

Some three or four years ago, James Sheldon of New York became so enthusiastic about the windows in the Cathedral of Leon in Spain that he, through Washington Cathedral, sent me over to see them.

The Spaniards used color in a different way from the French. They emphasized the reds, yellows, and greens and reduced the blues. This was quite a different view on color construction from anything I had had before. The areas of color in the window from Leon are divided about as follows: 23% red, 23% blue, 16% yellow, 12% white, 10% green, about 8% Tokay grape, and 3% flesh. The division irons and leading are not included. So large is the area of glass in the walls of Leon that they seem to be made of glowing color.

In the 14th Century someone discovered how to make a golden color out of silver. By dissolving silver in acid and firing it on the glass at a temperature of 1000°F or more, it becomes a transparent yellow. It is the only material used to stain glass after it is made. This discovery may have been a determining factor in 15th Century stained-glass work. It enabled the windows to have warmth of tone despite the cool colored glass used. Perhaps, too, the soft skies and weak light of England help to account for the English artists forsaking the rich color schemes of France and using so much white glass. No doubt the latitude, also, has a bearing on the type of windows used.

Some people think that patina or aging is what makes the old windows beautiful. If the patina has been ground off of old glass and compared with usual samples, those with patina have more depth, more grayness and softness, but the colors basically are delicate and beautiful. I have never seen an ugly one.

The whites of the old windows are very soft. They have a hint of moonlight in them. Makers



of automobile headlights should try this tint. It would take away much of the distressing glare.

Figure 3 is a drawing of a panel for my first window in Washington Cathedral. The value of symbolism should be emphasized, because symbolism is the language of stained glass. It is the "boiled-down" essence of an idea. In this drawing the wheat represents thirty-, sixty-, and one hundred-fold. The birds are treated in a decorative way. The thorns are shown growing up and choking the wheat.

In the "Ten Virgins" panel, I tried to show the spirit of the subject in the contrasting movement of the figures.

The old artists made their designs fit into the various limitations of space. The figures bend in the rounding space of a medallion. In designing the water, I studied the Japanese treatment of whitecaps and the medieval structure of waves.

The theme of the Rose Window (Fig. 4)<sup>1</sup> that I designed for Washington Cathedral is the Last Judgment. The window is 26½ feet in diameter, 256 square feet in area, contains 9000 pieces of glass, has 79 figures in whole or in part, and took twelve persons about a year to execute it. Frohman, Robb, and Little were the architects. I had less trouble with this window than any other. The red note in the Rose Window, about 19% of the whole, was determined by the Lake of Fire panel. I had considerable difficulty with this panel. Throughout the window all sorts of varying combinations of color are used, although the same general design elements repeat themselves. Everything is varied and is done free-hand; no two pieces are exactly alike. I learned much about this technique at Leon.

The Rose has in it eighty different shades of blue, unnumbered shades of red, fifty of warm and cool greens, fifty-three of greenish white, forty or more of yellow, twenty-three of flesh tone, and thirteen shades of lavender and purple. Primary colors dominate in area.

### Symbolic Simplification

One of the things essential to the stained-glass art is conventionalization, or symbolic simplification. We do not treat heads and figures in full form, naturalistically, as is done in photographs. We outline the boundaries—put strong lines

<sup>1</sup> This photograph by Gerald W. O'Connor was taken at a hazardous risk, and Mr. O'Connor is to be congratulated on the splendid result.

around the brow, eyes, nose, lips, ears, and chins. We try to interpret rather than imitate nature. I worked for several years to see if we could copy nature exactly and conventionalize it, but gave it up.

Bold lines running almost parallel at a great distance give the effect of real hair. At the same time the character of the glass is preserved.

In the figure of Jeremiah, I tried to show the melancholy sadness of this great servant of God. In making King David, I had trouble with the



Fig. 3.—Cartoon for Parable Window of the "Sower," Washington Cathedral by Lawrence Saint.

yellow in the robe. Finally I tried a yellow that was marked "not useful" and got the desired result.

The head of St. Paul in a panel of the Parmelee windows, three windows under the north transept Rose in Washington Cathedral, is shown on actual glass, full size, with artificial light behind it. It illustrates what I mean by outlining the boundaries and tapering the painted lines, making them light and dark in value. The panel is located 45 feet above the floor and is seen from a maximum distance of 179 feet. The striations in the red in the panel have design energy, mak-



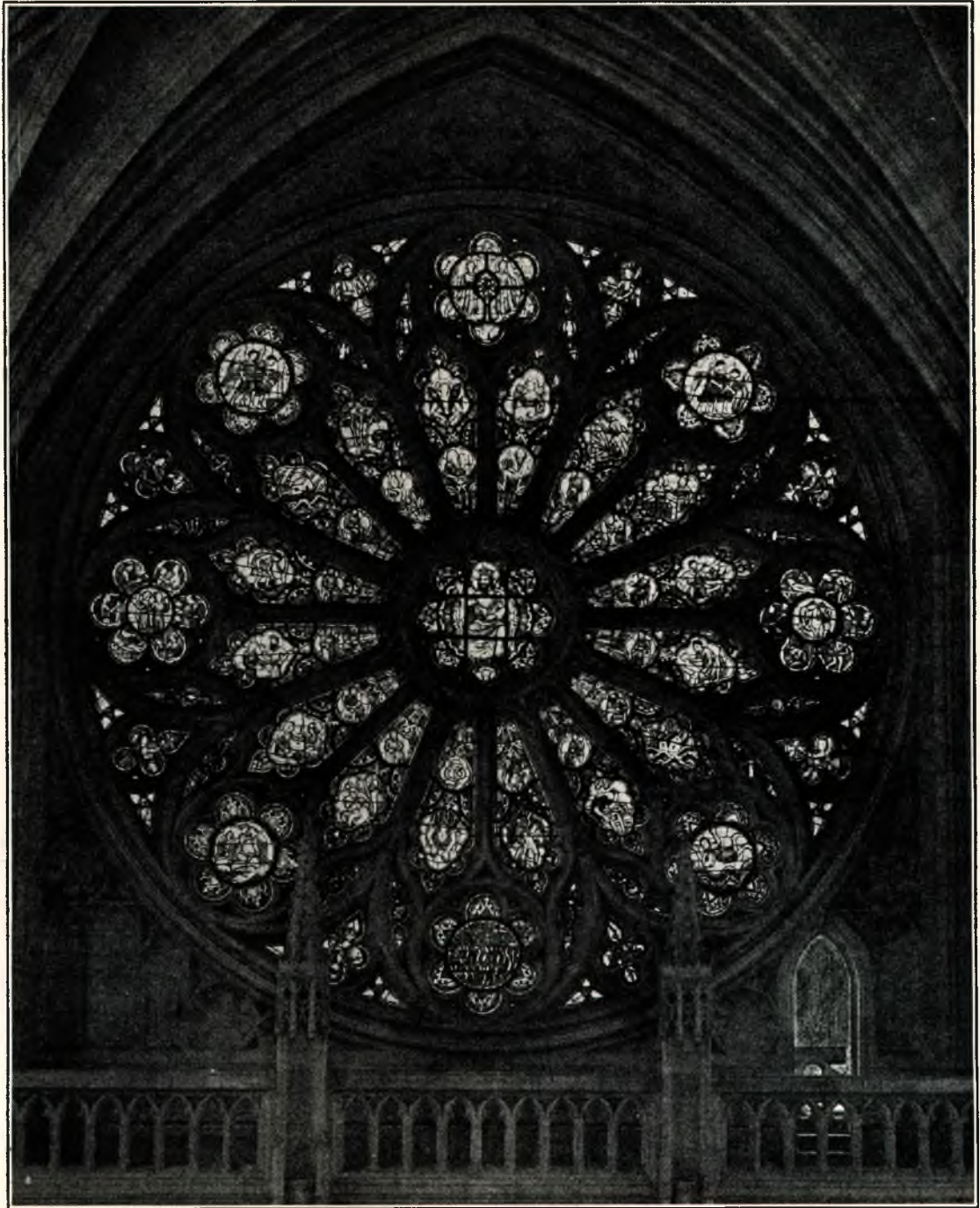


Fig. 4.—North Transept Rose Window, Washington Cathedral, designed by Lawrence Saint; Frohman, Robb, & Little, architects; photograph by Gerald W. O'Connor.

ing it necessary to choose each piece with great care.

One of the things I try to get in my windows is an "all-over effect," so that the whole window is seen at the first glance. All the great windows of the past have this wonderful quality.

I made many preliminary studies for the panel representing Isaiah, the prophet; after considering the criticisms of my assisting artists, I finally chose one which depicted Isaiah as the fiery prophet of God and lofty poet of Israel.

A window in Chartres Cathedral (Fig. 5)





Fig. 5.—Head from a window in Chartres Cathedral illustrating what is meant by archaic drawing.

illustrates what we mean by the term "archaic." The mouth protrudes farther than the nose; the ear is at the end of the eyebrow. From my standpoint this is delightfully refreshing. Many people today, however, are not pleased with this style.

To make windows as fine as possible it is necessary to test and change many pieces. The Parmelee windows have an area of 216 square feet, and out of the 6000 pieces in these three windows we changed 1200.

In the figure of Malachi, the red background is treated simply. Glass of this ancient type has a body and looks velvety at a distance.

In the figure of St. John, the streaks in the red in the halo had to be changed two or three times. At a distance the streaks run together, giving it a delightful, "juicy" sort of life and quality.

A figure of Our Lord enthroned was made for a window for a mausoleum in Norristown, Pennsylvania. The subjects treated, many of them not as large as a postage stamp, start at the beginning of the Bible and continue through the New Testament.

### Description of Work Procedure

The small furnace I use holds two pots thirteen inches high. We get eighteen to twenty-four roundels out of the two pots. Reds are made in sheets to keep striations from appearing like pin wheels.

The colors may be modified two or three times before the glass is finally melted. This is a great help in matching colors accurately.

It has been an advantage to me to have several pieces of old glass with which to compare the colors.

I work the color scheme and the design along together in transparencies, color on the back and the lines on the front, so that I know from the beginning how the color patterns are working out.

The transparencies are made on celluloid with ordinary artist's colors and give the same sort of reaction that the window itself will eventually give. When a design is made in water color on paper the effect is so different from the effect of glass that the same reactions can not be obtained. Some of the transparencies are painted on canvas.

We always keep in mind the shapes of the pieces of glass so they will not break after they are put into the window. Following early precedents I try to use as few lead lines as possible. Too many small pieces of glass increase the number of leads, greatly increasing the weight and harming the window generally.

Pattern drawings show the heart of the lead line. Two tracings from these are made. One of them is cut up into patterns (each pattern numbered) and the other is used by the glazier when he puts the lead around the glass.

The patterns are made with shears with three blades which cut out a little section to allow for the heart of the lead. I use leads about three-sixteenths inch wide. The heart, of course, is very narrow. Every pattern has to be tacked down in its place like a Chinese puzzle. Selecting the glass is a most important part. We have to use the irregularities of the glass to get the best effects possible.



Fig. 6.—Cross-furnace designed by Lawrence Saint. The burner and blower were designed by J. Wesley Lewellen.

The patterns are laid on the glass and then cut out where the artists have marked them.

### Glass Paint

The formula for paint-making is tricky. Sometimes we lose quite a lot of it. Temperatures, recorded by pyrometers, are closely guarded and carefully recorded.

Some of the oils I mix with my paint are stirred several thousand times covering weeks to get certain qualities necessary in the oil. Of course, in firing, the oil medium vaporizes and goes away before the point of fusion is reached. I use turpentine mainly.

The paint is mixed on a small glass slab and put in a thimble-shaped container into which the brush is dipped. As the weather changes the condition of the oil medium also changes.

A texture is put on both sides of the glass. Films make the light vibrate and add softness. Besides the reddish-brown, I make a brownish-black paint and a horny-toned white; admixtures make golden texture and olive, white, and warm-toned backing. The ancients used these first two colors mixed together in variations. The horny-toned white was never mixed with anything so far as I know.

In the muffle kiln used to fire the paint on the glass, the flames go up the sides through tubes. It takes several hours to fire this type of kiln to a temperature of 1160°F. After the glass is fired it has to be laid down on the drawing according to the numbers of the patterns.

The glass is kept or stored in small boxes. Every sheet carries the number of its formula.

For purposes of inspection the pieces of glass are fastened to a plate glass panel with beeswax and rosin. Black lines are painted on the back of the plate glass to imitate the lead lines.

We had to make the design of the north transept Rose in Washington Cathedral very bold so it could be seen at a distance of 179 feet. The top of it is about 85 feet above the floor. I took every section of that window to a huge barn about six miles from my studio where I could test it at distances up to 220 feet. My assisting artists conferred with me and criticized each section. All this troublesome testing and changing meant

a great deal to the finished work, for when the window was put in place everything could be seen as I wanted it. In its present situation the window can not be seen to advantage. The building is not yet completed, and there is a lot of surplus light on the inside surface of the glass. The building, however, is going forward again, and the windows will soon be seen under favorable conditions.

### Lead Procedure

In glazing the windows, we use lead with tin in it. The only lead which has survived from ancient times is of this type. This hardens the lead and makes it last longer. The old lead, usually three-sixteenths inch in width had a thick flange and thin heart, in contrast to much modern lead, which is just the opposite in construction. There is little of the ancient glazing that has lasted through the centuries. The paint and glass have lasted but almost none of the old lead. I have seen only two or three sections out of all the hundreds of windows made in medieval times that were still in the original lead.

The leads we use were worked out by the National Lead Company with assistance from the Bryn Athyn Studios. This is only one small instance of the many ways in which Raymond Pitcairn, Esq., has helped the art of stained glass. Mr. Pitcairn has done much for stained glass by encouraging a thorough study of the ancient, by sponsoring experimentation and research, but most of all by his artistic appreciation. I owe much of what I have accomplished to him.

Lead and various other things are mixed with linseed oil to make the cement used to fill in the space between the lead and the glass to keep out the rain. It also gives the glass a slight cushion.

In the cementing and cleaning operation, the panel is cleaned with plaster of Paris. It helps the oils to dry more quickly. We clean the glass very carefully, because even a little of the cement would affect the colors in the wrong way.

Home-made putty is put into the iron frame which in turn is fastened to the stone walls. The panel of glass is then set in this bed of putty, the covering iron is placed over the eyes, and the keys are put in place.

HUNTINGDON VALLEY, PA.