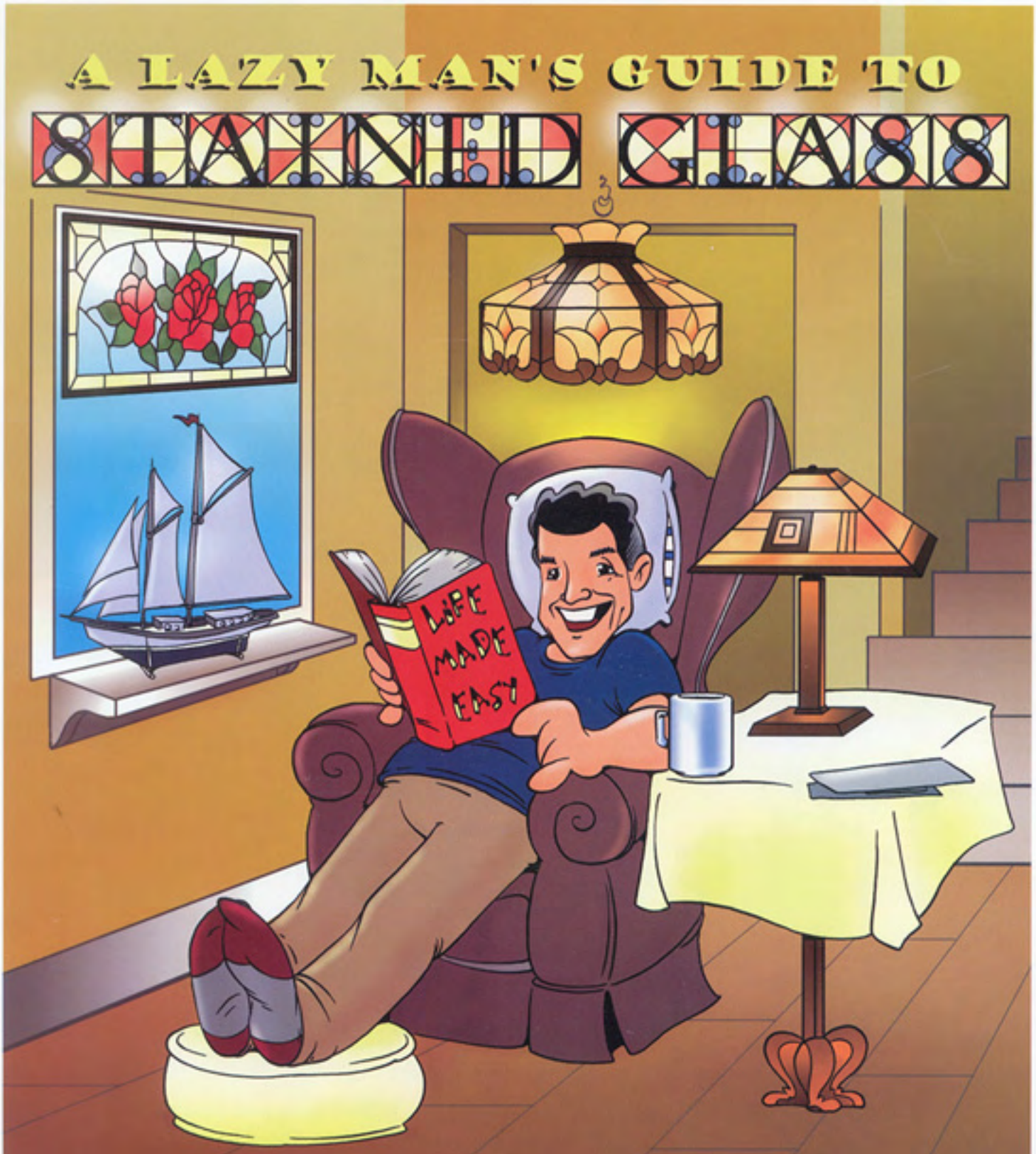
A LAZY MAN'S GUIDE TO STAINED GLASS



PROFESSIONAL TIPS, TRICKS, AND SHORT CUTS

BY DENNIS BRADY, DEBRADY GLASS STUDIOS
ILLUSTRATED BY LAR DESOUZA

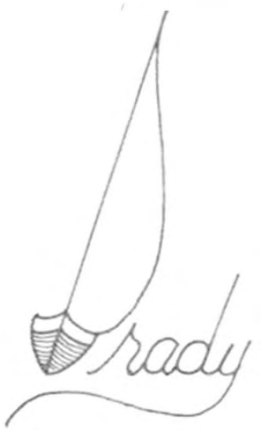
THIRD EDITION

A Lazy Man's Guide to Stained Glass

Professional tips, tricks, and shortcuts

3rd Edition

by Dennis Brady



Published by:

DeBrady Glass Studios
566 David St.
Victoria, B.C. V8T 2C8
Canada

Tele: (250) 382-9554
Email: info@glasscampus.com
Website: www.glasscampus.com

This book is dedicated to my son Brant.

He introduced me to stained glass and helped me start
DeBrady Glass Studios.

It's unfortunate he couldn't stay long enough to see what it became.

Recognition

Covers and Illustrations by:

Lar de Souza
4 Division Street
Acton, Ontario L7J 1C3
CANADA

Tele: (519) 853-5819
Fax: (519) 853-1624
Email: lar@lartist.com
Website: http://www.lartist.com/

Swag lamp and transom:

Inspired by designs from
Somers-Tiffany Inc

920 West Jericho Turnpike
Smithtown, NY 11787
Tele: (631) 543-6660

Email: sales@somerstiffany.com
Website: http://www.somerstiffany.com

Prairie table lamp:

Inspired by a design by Dale Grundon
305 Lancaster Ave
Mt. Gretna, PA 17064

Tele: (717) 964-2086

Email: dalel@paonline.com
Website: http://www.DaleGrundon.com

Acknowledgement

So many people helped me over the years that there wouldn't be space here to say thank you to all those it was due. Without the consistent support of all of them, this lazy old guy would never have written this book. A sincerely heartfelt thanks is due to everyone that contributed ideas, critique and encouragement – and steadily pressured me to finish and publish it.

All those people I talked with at different glass shows and the many, many more with whom I exchanged ideas and opinions on different internet stained glass forums supplied a lot of the questions and comments that directed me to where I should go with my writings. I hope I've been able to satisfactorily answer all of their questions with this book.

A special note of gratitude should go to all those antagonistic troglodytes on the internet exchanges that so persistently attacked dissenting opinions from behind aliases and pseudonyms. More than anything else, it was their "My way is the only right way" attitudes, along with their "It must be done this way because it's always been done this way", that gave me the resolve and determination to see this book through to publication and distribution.

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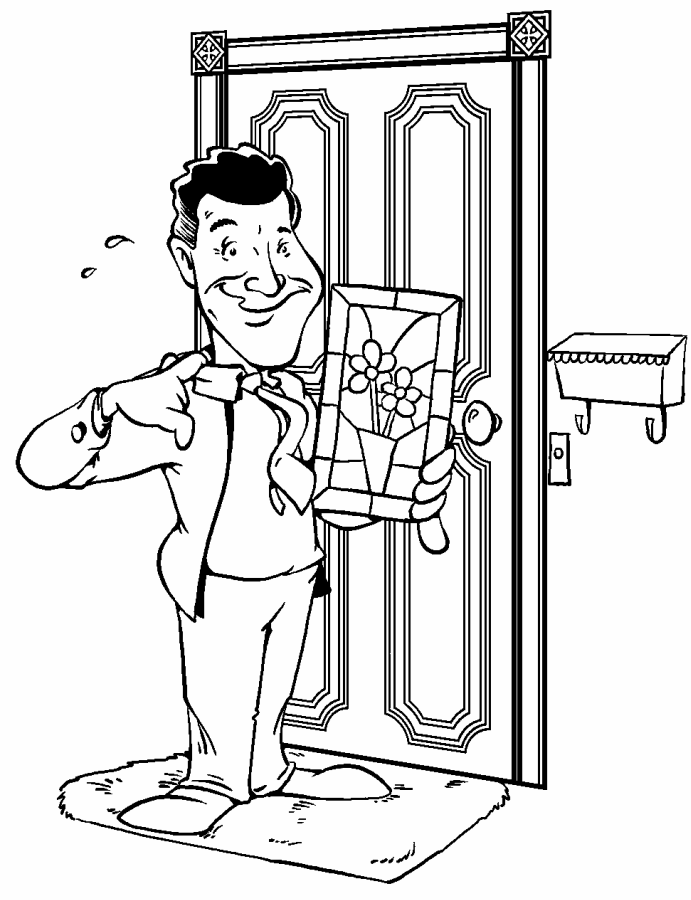
Introduction



Come on in. Sit down and we'll talk.

The Lazy Way

I'm lazy - a special kind of lazy. I don't mind working long or working hard, but I seriously resent working any longer or any harder than I have to. If there's an easier way, or quicker way to do something, that's my choice. From the first day I started commercially producing stained glass, I've been experimenting with quicker and easier ways to do the job.

A lot of these experiments were outrageous failures, but a few were a surprising success. I'd like to share some of those winners with you.

This is not a "how to" book for beginners. There's already lots of those. Instead, this is a "what's next" book. It's meant for someone that has already learned, or is working on learning, the fundamentals of stained glass work. Someone, perhaps like you, that's wondering "where do I go next", or "Is there an easier way?" If you're too lazy to slog through all the dead-end trips and all the error part of trial and error, this is the book for you. I hope it helps.

I wanted to put together a list of all the easiest and best ways to do everything, but such a list might not be much help to you. What's easiest and best for me, might not work so well for you. What I've done instead is suggest the alternatives and some of the advantages and disadvantages of each.

Instructors will usually teach their students the method that is the easiest to learn. That might not be the most efficient or easiest way to do something. More often, the easiest way to do it is the way that takes the longest to learn. You must decide for yourself how much time you're willing to spend learning and practicing these alternatives.

Often the best shortcut is getting it right the first time.

Introduction

The Easy Way

Here's a little story I'm passing on from J.K. Sinrod of Sinrod Studios in Lynbrook, N.Y.

It seems like I'm the only one that can supply this big Temple with large enough sheets of colored glass to go OVER existing window that are creating a lot of glare. They don't want to remove the old ones, some of which are deep sandblasted. I really don't care to do this, but before I know it I get them samples of cathedral colors that they can fight over. (you know these religious committees – trying to agree on anything is a chore). I gave them an obscene price, and don't you know, after 6 months they call up and are raring to go. I go through hell trying to get all this glass in 72 x 60 sheets in the right colors, delivered and cut up to fit. Most of the shapes are rectangles about 48 x 34 with a few oddball curves and trapezoids to add to the trouble. I shoot 'em in with points and caulking. I put in the first couple of rows by myself, and now I'm at the end of my 12 foot A-frame ladder. I simply cannot reach the 16' height – much less the top ones over 20' high.

I spend the next few weeks investigating scissor-jacks, lifts, scaffolds, cherry pickers. Trust me – none of these options will work, for many reasons. It's indoors on a wooden stage, with a large unmoveable piece of furniture in the middle. What to do? I call my closest "friendly" competitor and offer to hire him for the day to put these in with me. After explaining it all to him, and hearing him call me a wimp, he agrees. We meet the next week and he brings his 20' extension ladder and his burly macho attitude. He takes a look at the high, tall, wide window and says…"Two hours tops". An hour later we simply cannot get ONE sheet of glass up high enough. Picture us climbing up a ladder trying to carry a big sheet of 1/8" glass and maneuvering it in place? We are both experienced glass guys, but could not do it.

It's now another week later, and the customer is getting testy wondering why it's not finished. I've lost hours, nights, and days of sleep over this. My buddy comes into the shop and announces, "OK next week you, me, and my pal Chris and his helper (a mirror and glass installer) will all meet at 8 am with a series of 4 ladders and setup a series of handoffs with the sheets 'till we get them up to the top". As you can imagine, I don't get too much sleep that night.

All four of us meet at 8 am the next day. Glass, ladders, suction cups, hoists, standoffs, gear that isn't even in the CR Lawrence catalog! Chris walks in – 5'8" tall, about 140 lbs. He takes a look and says "Two hours." "Oh my God, not that," I say. My buddy describes the plan of 4 guys, 4 ladders, handing off, etc., etc. Chris says, "Just stand back and let me work". He tests the 20' extension ladder, walks up the 1st step and says, "hand me the biggest sheet". He has soooo much confidence in his manner that we all step away after doing what he asks. He kind of hefts the glass for size and weight, puts it on his shoulder, the entire sheet of glass by himself, and climbs one handed to the top, carefully turns if around and plops it in place. Done! My buddy and I, who are bid guys, look at each other in astounding amazement and roar with laughter and embarassment. "Of course, that's the way to do it….it looks so easy". An hour and a half later all the 18 sheets are in and completed.

Sometimes the easiest way is also the simplest. Nothing complicated, elaborate or fancy. Just do it.

Attitude

If you think you CAN do something, you're already halfway done.

If you think you CAN"T, you're completely finished.

Assume Nothing

Just because some "expert" tells you something won't work, don't assume they're right. It could be, and often is, that the expert just never tried it. Don't' assume that the way you were first taught, is the "best" way until you have tried some other ways. There are no "best" ways – just personal preferences. How can you decide which way you prefer and feel most comfortable with, until you have tried them all?

I've experimented with a lot of unconventional ideas – and even some thoroughly weird ones. Many unexpected things not only worked, but worked extremely well. Even the experiments that failed, taught me something. My attempt to cut tempered glass with a band saw produced a crystal explosion that scattered a quadzillion bits of glass into every crack and corner of my workshop. I've been finding these bits years later in the strangest places. But, other experiments produced interesting results and huge time savings. I tried soldering at increasingly higher temperatures to see what happened. The result was a superior quality soldering job in a lot less time. I discovered that as I increased the heat, the solder got smoother and it became increasingly easier to solder. The "experts" insisted that you can't cut a circle out of glass the way James Bond did it in the movies. I tried anyway. They were right! It won't work the way it's done in the movies. But, my attempts taught me a quick and easy way to cut a circle (or other shapes) out from inside a piece of glass. It also taught me a way to cut deep curves that worked better than the traditional series of fish scales.

The most important thing I learned was that just because a method worked well, doesn't mean there isn't another method that works better. Never assume – always experiment. Try new things. Just don't try cutting tempered glass with a band saw. Trust me on this one.

Fill Your Tool Box

Tools aren't just things you buy at a hardware store. They're also all the personal skills you learn from practice and experimentation. Each new technique you learn is another tool to add to your collection. No single tool works for every job, and no single skill is right for every application. The more tools you have, the more likely it is you'll have the one that works best for whatever you want to do.

Take the time to collect as many tools as you can for your tool box. Learn everything you can so you'll always have the right tool.

Attitude

What Kind of Experience?

There are two distinctly different kinds of experience. There's the really good kind where you're constantly learning new things at every opportunity, and using those new things to add to all your previous experience and knowledge. Then, there's the not so good kind where you learn a few things in your first year or so, and keep on repeating it over, and over, and over. What kind of experience do you have? Did you learn just the basics and keep repeating it without trying new things and learning some new techniques, or have you been constantly improving? Do you have ten years of the same experience, or is it one year you've repeated ten times? Are you saying, "I do it this way because I've always done it this way." Or, is it, "Of all the ways I've tried, I like this one best".

Amateur or Pro?

There's nothing wrong with being an amateur any more than there's anything wrong with being a professional. Each has different goals and each works in different ways. Some of the very best work is done by amateurs that make stained glass as a hobby. They enjoy the luxury of time and use it to good advantage. Amateurs don't care how long it takes to complete a project, but take pleasure in doing it. They have no reason to rush and can take however long is needed. The result is often work that's superior to that done by professionals.

The pro expects to be paid for his or her time, so must learn to work quickly. It's the speed at which they work that determines how well they are paid. They know that there is a limit to what a customer is willing to pay. If they demand too high a price, the customer will refuse to buy it. If they take too long to produce that work, they'll be poorly paid for their time. It's not that either the amateur or professional is superior to the other, but that each has a different goal. The amateur might often produce better work, but takes so long it would be impossible to make a living doing it. The professional tries to produce work to a set standard and work quickly enough to produce it at a price customers are willing to pay.

The greatest difference between amateurs and professionals is not in the quality of their work, but in how long it takes to produce it.

Good Enough?

Because a professional must worry about how long it takes to produce something, they must have a clearly defined goal as to what level of quality is required. It doesn't need to be perfect, but to be done to an acceptable professional standard. The amateur doing it as a hobby will often chase an elusive goal of perfection. The problem with trying for perfection, is that it's an unreachable goal. No matter how good it was done, it could have been better. Perfectionism can easily become a compulsive obsession.

When you make something, you might ask yourself, "Who am I trying to please?" If it's for yourself, you'll probably never be satisfied with the quality and be forever unable to overlook it's imperfections. Most of us have the same problem that whenever we look at our work, we see only the flaws and the "could have done betters". If you make something as a gift for a friend or for sale, the standard is different. It should be their opinion, and not yours, that determines acceptability.

If they're satisfied with it, it is good enough.

Attitude

The Best Way to Learn

There's no one best way to learn. Each of us is unique and learns in uniquely different ways. Some of us learn by personal experiments, while others prefer to watch others demonstrate it. You might prefer a personal structured lesson, while others do better working at their own pace with books or videos. Many people have found the internet to be a great learning source.

For a long time I told people the secret to learning was "Practice, practice, practice". This is the single most important factor in learning stained glass, but there is much more to it than that. Dale Grundon of Dale Grundon Stained Glass Designs, has suggested a formula for learning that I think describes it well.

Practice
+ do glass
+ read about glass techniques
+ ask questions
+ listen
+observe others
+ experiment
+evaluate your own work
+ work safe
+ discuss glass

Devotion = Learning to do glass

Maybe the best way to learn anything is to make a commitment to never stop learning.

The Best Technique?

A method or technique that works well for you might not for someone else. Something that is perfect for one application might be useless for another. Each of us has from our own practice and experimentation discovered the ones we are most comfortable using and when different alternative methods are most effective. It's foolish to reject anything you've never tried. Sometimes the least expected method will surprise you and end up becoming your favorite, or it may turn out to be the only thing that works right for that very special thing you're trying.

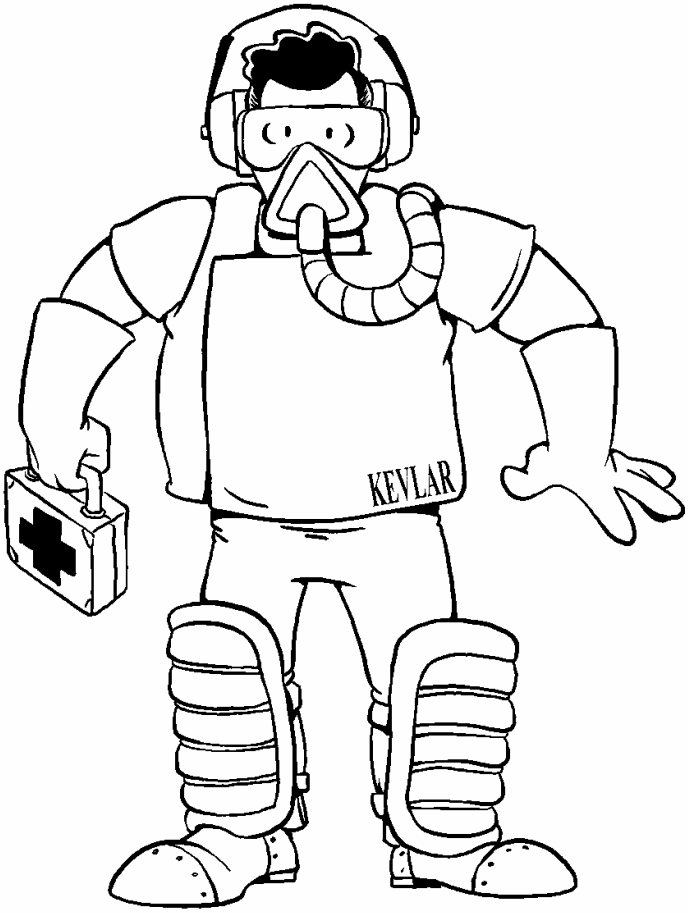
In the end, the best method for you is the one that you best like using.

If you spend all your time trying to do the very best work, you'll not have the time to finish a lot of satisfactorily good work. Best is the enemy of good!

Practice teaches you how to do something better. Experience teaches you how to make less mistakes.

Get the job done quick schemes don't work any better than get rich quick schemes.

Safety



Glass artisans don't break for coffee.
They break to congeal.

Keep Sharp

Most glass cuts result from not paying enough attention to what you're doing. Unless you think wearing dozens of band-aides makes you look sophisticated, staying alert is the smart way to handle glass. Razor sharp edges can slice like a scalpel, and thin slivered shards will impale like a spear. It's important to always be aware of the potential for serious damage when you work with glass. Complacency causes more injuries than anything else. Keep yourself sharp – always pay attention to what you're doing.

Safety Glasses

I'm sure that by now you've been told to wear safety glasses – probably several times. Well, I'm going to tell you again. This is so important, it can not be stressed too many times. Dozens of times I've had to rinse a glass bit out of someone's eye, or wait in the Emergency ward for a doctor to extract it. It gave me a serious respect for how easy it can happen - when someone thinks, "It's just a quick cut, it'll be okay." or, "Just a quick grind to this one piece. I don't need the glasses."

You can buy expensive glasses, or cheap ones – any kind is better than nothing as long as you do wear them. Cheap safety glasses work fine. They just won't last as long as the more expensive brands. Whatever kind you choose, it's a smart idea to get ones that have a bottom that sits against your cheek. When you break glass or grind it, shards can fly up, hit your check just under your glasses, bounce off the inside of the glasses, and go straight into your eye. This happens often while grinding, when the glass bits will be travelling fast enough to imbed firmly into your eye.

I mentioned this was important didn't I? Well, it's so important, I think I'll say it again.

ALWAYS PROTECT YOUR EYES.

Safety is a working attitude. Don't just do it the best way, do it the safe way.

Safety

Flux Fumes

If there has been too much fear about lead poisoning, there has been too little about the potential damage from flux fumes. Vaporized flux is both poisonous and corrosive. You know how irritating flux is on our skin. Imagine how bad it is inside your lungs. You might think it's enough to just use a fan to blow the fumes away from where you're working. It isn't! This just circulates the fumes around the workplace so you can inhale them later.

It's important to remove flux fumes entirely from where you work. Several small "fume traps" are available that vacuum the fumes and send them through a filter. To some varying degrees they all work. An inexpensive and more effective protection is to extract the fumes entirely with a ventilation system. This can be as simple as a cheap kitchen range hood over your work table that vents the fumes to outside. You can help protect the environment with a HEPA filter on the line venting to outside.

The more powerful your extraction fan is, the more fumes you'll remove. A fume trap will work best if it's close to your work to minimize the fumes that can escape around it. An external vent works best if you can create a booth to trap the fumes and force them out the exhaust. Installing three walls around your soldering area is an efficient way to do this. You should try a simple "dip" test to see how well you are removing flux fumes. Dip a hot soldering iron into liquid flux and watch where the fumes go. They should ALL exhaust out, and NOT drift back into your work area.

Lead Poisoning

Of course this is serious, but not near as much as has been publicized or as many people have come to believe. Fear of lead contamination has been fueled with an irrational paranoia that is often unsupported by scientific evidence.

The myth continues to circulate that lead particles will be absorbed through your skin while handling it, and that you will inhale vaporized lead while soldering. Both of these are unsubstantiated. Lead won't go through the pores of your skin and soldering won't vaporize it into a form that can be inhaled. However, it is possible to get lead into your blood through cuts or breaks in the skin. Covering these skin openings with a band-aide, or wearing gloves while soldering is enough to protect you.

There IS a serious risk from lead poisoning when cutting lead with power saws, or when repairing leaded glass. Fine particles of lead produced by the saw or when you scrape old lead, can easily be inhaled. Always wear a protective mask when doing either of these.

The most common way to get lead poisoning is by ingesting it. Protecting yourself is simple. Don't eat it, always wash your hands after working with it, and don't drop it on your foot. For peace of mind, have regular blood and hair analysis tests done to monitor the amount of lead in your body.

Glass and Children

There's no reason you can't introduce children to stained glass at a fairly young age. If they can hold a glass cutter, they can learn to cut. If their arm is strong enough to hold an iron, they can learn to solder. Children are fascinated with cutting glass and in the whole process of how stained glass is made. Even kids as young as six can be taught how to complete simple suncatchers.

With a little supervision, children can safely work with glass. The safety concerns for them are no different than for adults. Introducing children to stained glass can be a terrific opportunity to teach them safe work habits that they can later apply to many other things they do. It's also a wonderful pastime to share with your children.

Dust

Dust is a serious hazard that is too often ignored or overlooked when working with glass. Dust from whiting compound, or the fine particles of glass from grinding can be inhaled. When you clean up glass dust, or whenever you work with whiting, you should wear a dust mask. It can be as simple and inexpensive as a disposable drywall mask - but you should use one. When wiping up glass dust, do it with a wet sponge or cloth. Don't sweep or vacuum it.

If inhaled, glass dust can cause serious and permanent damage to your lungs. You can't just go to the hospital and have it removed. Once you breath glass dust in, like asbestos, it's there forever. Protect your lungs – wear a dust mask.

Tempered Glass

For those few that don't already know, tempered glass can NOT be cut. You can score it, but when you try to break it, tempered will explode into tiny pieces. Often these pieces will explode into your face. Tempered glass can be identified by a small "tatoo" in one corner of the glass. If you know it's tempered, do NOT try to cut it. If you suspect it's tempered, but aren't certain – take precautions. Wear gloves, full face protection and cover all exposed skin.

If you're very, very careful it is possible to grind a very small amount (about 1/8") off the edge of a piece of tempered glass. Sometimes this will work, but not always – so it's not a good idea unless you really, really have to do it. You can safely sandblast or acid tempered glass, but trying to carve or mechanically etch it will usually cause it to shatter.

Tempered glass is about 4 times as strong as regular window glass and will withstand much greater temperature changes without breaking. Most of the time it will break into small relatively safe pieces like tiny cubes. Not always! Some of these broken pieces are tiny needle-sharp spears capable of doing intense damage. Laminated safety glass won't do this. You might consider using it as an alternative to using tempered.

If you take the time to protect your ears whenever you cut metal or glass with a saw, you'll save the cost of a hearing aid later.

Designing

A glass design must be more than just an attractive drawing.
It must also be one that is possible to be made from glass.

I Can't Draw!

Everyone can draw. For some it's easy, for others it's more difficult. If you can write or print your name, you can draw. Learning to draw your own glass patterns just takes a little time and practice. If you could learn how to cut glass, you can learn how to draw. It's not a talent, it's a skill! You CAN master it if you try. Then you'll never again wonder where to find a pattern. You'll just draw it.

It's much easier to learn to draw simple patterns than to learn to produce stained glass. You already have the most important skill - knowing what shapes can and cannot be produced with glass. You may never become good enough to produce drawings like Michelangelo, but you don't need anything like that. Most patterns are simple line drawings than can be done quickly with pencil and paper. Even elaborately detailed ones can be made by just tracing over a photograph. All it takes is a little practice.

Resizing Patterns

Having exactly the pattern you want, but in the wrong size can be very frustrating. You could redraw it, using the traditional method of grid scaling and redrawing, but that takes a long time.

There are some easier ways to resize patterns. You can have it done at a commercial shop that has adjustable size photocopy or blueprint machines. This is advantageous if you want your pattern printed on unusually large paper so you can work full-size. Be careful when you have patterns enlarged by photocopy. They don't come out accurately sized. If precise size is critical, you should go to a blueprint copier.

The easiest way to resize a pattern is with a computer. Many glass designers store all their patterns in their computers, then just resize to whatever they want and print. These will print the pattern in sections that you can tape together to form the full-sized pattern. Sources for some of the free demo programs are listed in the back of this book.

You can also use an opaque art projector. These are used extensively by painters and are sold at art supply shops. Projectors are especially handy for producing a full-sized pattern from a photograph.

Designing

Drawing with a Computer

Some glass artists like to produce patterns with a computer, while others prefer to use a paper and pencil. Those artists that are skilled and experienced with computer drawing programs can produce near magical results. For many others, the process can be slow and frustrating.

A computer will produce a better quality printed reproduction, and will make it easier to resize the pattern. Many computer programs also allow for insertion of colors and even glass textures and patterns. These can provide a beautiful display for prospective clients and make it conveniently easy to compare different kinds and colors of glass in your design. Saving patterns in your computer allows you to print whenever needed and to resize to whatever you want. It also allows you to extract design elements to "Cut and Paste" as wanted.

Designing with a computer has many advantages, but it isn't always the "best" way. The computer is only capable of producing what you instruct it to. Drawing is much more than a simple mechanical process. It's the end result of the design you first imagine in your mind. If you can't imagine it, you can't draw it. It doesn't matter whether it's with a computer or with a pencil. Many artists still prefer to start with a hand drawing and use a computer only when they need a high quality finished pattern. If you just need a pattern for something to make once, why bother with a computer when a quick pencil drawing is all you need to cut from? You can draw by hand a lot faster than with a computer, and for many applications a lot better.

There's a time and a place for every tool. What's "best" will depend on what all you need it to do. If you use it only infrequently, you might not want to buy an expensive computer program. If you plan to use it extensively, the low cost ones might be inadequate. Perhaps you should start by experimenting with the ones that offer free demos. Some of the websites for these are listed on page 60 of this book.

If you've decided that you're willing to take the time to become proficient with sophisticated programs, you might look seriously at professional calibre programs like Adobe Illustrator or AutoCAD. Both of these are complicated enough to satisfy even the most avid computer fan, and to make everyone else crazy with the frustration of an almost endless learning process.

Think Like an Engineer

It's not good enough for you to design something that will look good. It must also work well. You must consider the structural engineering of your design. Will it be strong enough? Will it hold together? Does the design provide internal support, or will it require reinforcement? Does it have unnecessary "hinge points".

Designing for 3D glass projects is the greatest challenge. You'll need to consider how it should be built, as well as if it will be structurally stable when it's done. Will it fall apart under it's own weight? Can it be fabricated the way you designed? Where will it require reinforcment?

You'll need to create as an artist while thinking like an engineer.

Designing

Color Selection

Designing stained glass has been called "painting with light". A painting or photograph is expected to be viewed with color determined by reflected light. Stained glass is expected to be seen with light coming through it. This provides special challenges and permits unique effects.

The best way to understand color is to study a color wheel. Any art supply store has samples, or you can find one on the internet by entering "color wheel" on a search engine. If you understand the relationships between primary colors, secondary colors, and complementary colors, you'll better understand how different colors affect each other and can alter the appearance of other colors. This is important for all designers, but critical for stained glass. Some guidelines that will help you select colors are:

Complementary colors are opposites and will provide a powerful contrast.

Reciprocal colors are those in the same family (like blue and green) and blend well in groups.

Bright colors in a subject will make it stand out and draw the viewer's eye to it. Used in the background can be distracting.

Texture and pattern variance can provide additional appearance of depth.

Subdued backgrounds cause the viewer to focus on the foreground.

Light colors look larger than they really are. Dark colors look smaller.

Adjoining colors will blend. The human eye plays optical tricks with colors and is especially susceptible to being fooled with back lit colored glass. Your eye will often "blend" colors to interpret something that you may not intend. For example, placing bright red glass alongside bright blue glass will often cause the eye to interpret them both as slightly purple.

Texture attracts the eye. A textured or patterned glass will draw the viewer's eye, while avoiding plain or solid colors.

Use the lines

Stained glass will always have thick seam lines between each piece of glass. No matter how hard you try, you can't eliminate them. Trying to make them too small can seriously weaken a panel. If you can't lose them, use them. Try to make these lines part of your design. Lines need not be identical size. If you vary the size of foil or lead for different pieces, you'll have a more interesting and more realistic looking panel. Using flowing curves that connect smoothly from one line to another will almost always make a design more appealing.

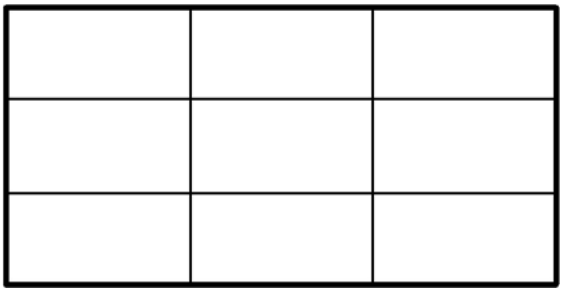
Know when to stop

One of the more common mistakes in glass design is putting in too much. Some artisans want to show off by demonstrating every one of their skills and techniques in a single piece. The result can be so overly complex it's hideous. A good designer always appreciates what is important and what is unnecessary decoration. Whether it's literature, music, or art, what's left out is as important as what's put in. You might use as a guiding rule for design, ***"Just because you can, doesn't mean you should".***

Designing

Composition

There are no firm rules about what you can or cannot do. It's your design, and you can do whatever you please. If YOU think it looks good, then it does indeed look good. However, there are some guidelines that can help you when composing a stained glass design:



- **An elaborately detailed subject** will draw the viewer's focus to that subject.
- **An elaborately detailed background** will cause the viewer's eye to wander around and not focus on any one thing.
- **A simple design can look elegant.** Many of histories greatest artists and architects relied on elegant simplicity.
- **An overly detailed design** can look cluttered and amateur.
- **A centrally positioned subject** looks artificially posed (like a portrait). Pro-painters and photographers are taught to position the subject in one of the "third" points. These are determined by dividing your panel into nine equal sections like the drawing on the upper right. The points where the lines intersect are where subjects should be positioned.
- **A low horizon** looks close, while a far one looks distant. This is also the case with the horizon line on a landscape image. If the horizon is placed one third up from the bottom, the subject will look close. If the horizon is placed one third down from the top, the subject looks far away.

The K.I.S.S. Principle

Keep It Simple Stupid.

The KISS principle applies for engineering, music, art , design and life in general. A simple elegance is usually the key to good glass design.

This isn't oil painting - it's stained glass. It's not possible to produce realistic intricate detail, so why try. Keep the design simple. A clean simple glass design often looks more attractive than one filled with complex tiny detail. If you want detail, restrict it to just a few important places. It'll show up more if you do that. Too much detail makes a design look cluttered.

If you use patterned or textured glass for a background, it will look better if you cut it entirely out of one piece so the pattern matches

Drilling

Anything this slow can get really boring.

With a Grinder

You can use your grinder to drill a hole in glass with a ¼ inch or smaller grinder head. Tilt the glass to be drilled on a 45º angle to the top of the grinder head and gently lower it onto the spinning head. Ease it steadily down until it grinds through the glass. Enlarge the hole by either grinding it out with the small bit, or repeat the process with a large head. If you're only drilling a single hole, it's often quicker to do it on your grinder than to set up a drill. If the position of the hole is critical, it's a good idea to drill holes before making the final cut on the glass.

I'm usually too lazy to change grinder heads, so I just mount the small head on top of the regular one. To lubricate and cool the small head, either wipe it with a damp sponge or spray it with water while drilling.

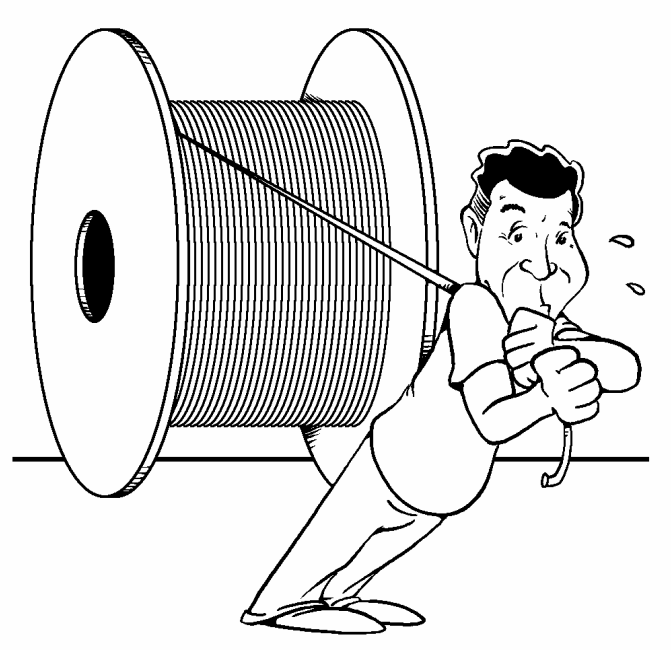
With a Drill

To drill a hole in glass, you can use a diamond bit on either an electric drill or a small Dremel type hobby tool. It works better if you use a drill that is stationary mounted on something like a drill press, but it can be done hand-held if you're careful. The important thing is to hold the drill steady, drill slowly, and be certain the diamond bit is kept constantly wet. There's a big range in price between different makes of drill bits. The most significant difference between the cheapest and the most expensive bits, is how long they will last. If you only need to drill a few holes, you can get away using the least expensive bits, as long as you're patient and drill slowly with them. Even with expensive bits, trying to drill too quickly will produce enough heat to burn off the diamond dust.

If the object you're drilling is small enough, immerse it completely in a bucket of water while you drill it. Or, you can build a dam around the hole to be drilled with putty or clay and fill it with water. For small holes, a neat trick is to use a metal washer. Wet the washer and set it in place on the glass and fill the hole with water. As you drill, keep refilling the hole as needed.

If you need to cut a square or rectangle out of a piece of glass, an easy way is to start by drilling a hole at each of the 4 corners. With your glass cutter, score a line on the perimeter of your shape from corner to corner, then diagonally across from corner to corner. Tap the scores to run the cuts and break out the pieces. You'll now have a perfect shape with the corner points restricted only by the size of the holes you drilled.

Wire



Untie your imagination.

A huge variety of special effects can be produced by adding wire to stained glass. It can enhance an otherwise simple design, or be used to create a whole extra dimension to your work.

Wire Sizes

Wire size is referred to as “gauge”. Gauge is a percentage of an inch, so the smaller the gauge, the thicker the wire. 10 gauge wire is 1/10th of an inch in diameter. If 10 pieces of wire were laid out flat beside each other, the row would be exactly 1” across. If you had 20 gauge wire, it would take 20 pieces of wire to be 1” across.

The thickest solid strand wire that is commonly available is 10 gauge. Thicker wire is multi-strand. It would have a number of wires braided or wound together instead of just one piece of solid metal. 12 gauge and 14 gauge wire is commonly used for household wiring. Most commonly available wire sizes are 12. Larger gauge wire is available, but usually as part of multiple line wire. For example: telephone wire contains 5 wires (each with its own distinctly colored coating) inside an outer coating. To use this kind of wire, you must first cut away the outer coating, then strip out the bare wire from each of the colored coatings the same as for heavier gauge.

Straightening Wire

Quite often wire gets a bit crumpled and needs to be straightened out. The best way to do this is to “draw” it. Hold one end in a vise or with a pair of pliers in one hand. Then take a firm grip on the wire with the other hand and steadily slide that hand along the wire towards you. Unless you’ve got fairly callused hands, you should wear a glove for this. The drawing motion is identical to the motion an archer makes when drawing back a bow before launching an arrow. Pull as straight back as possible, and as steady as possible. With a little practice, you can get pretty good at straightening even the most crumpled wire.

Heavy wire like 10 gauge, that is badly bent, can’t be straightened this way. It must instead be “rolled”. This is done by putting the wire on a hard smooth surface (like a concrete floor, a piece of plywood, or a tabletop). Then a piece of wood at least as long as the wire, and 6 to 12” wide, is put on top of the wire. (for example: if rolling 24” long wire, you will need a board at least 24” long and 6 to 12” wide). Pressing firmly down on this piece of wood, roll it back and forth to roll the wire beneath it. This is the same motion you would make with a pie roller, rolling back and forth on a counter. The firm pressure downwards, combined with the rolling motion, will straighten the wire. This method also works well for straightening copper or brass pipe.

Wire

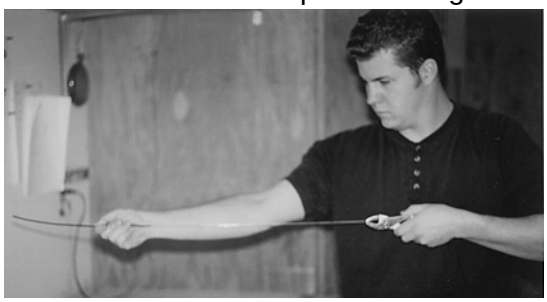
Stripping Wire

If you can't find a source for bare wire, you can buy standard electrical wire and strip it. Stripping the coating off electrical wire isn't difficult. It's not that you "strip" the coating off the copper inside – but instead you pull the copper out from inside the coating.

Cut the wire into 18" to 24" lengths. It's probably best to start with shorter lengths until you've had a bit of practice. If you have trouble with 18" lengths, try 12" ones until you've got the hang of it. Longer than 24" can be done, but it's very difficult and rarely necessary. With a knife or wire stripper, remove about ½" of the coating on one end of the wire.

With one hand, hold the exposed wire end firmly with pliers. With the other hand, take a firm grip on the outside of the wire about halfway down (wearing a glove for this is a good idea). Now pull the copper wire out from inside the coating. This doesn't take much strength. It does however take a little practice to get the technique down. The idea is to pull the hand with the pliers in it, straight back in the same motion an archer would make while drawing back a bow to load an arrow. At the same time, the other hand pulls straight away in the opposite direction. The "trick" is not to pull hard, and not to pull quickly – but to pull steadily.

If you pull straight, the wire will easily slide out of the coating. If you curve it at all, you will increase the friction on the wire inside and it will be almost impossible to get out.



Another easy way to strip the wire is to catch the coating in the "v" of a pair of snips. *(as shown in the photo below)*

Fluxing

When soldering wire, instead of brushing flux onto the wire, it's easier to dip the wire into the flux. Fill a small glass jar 1" or higher with flux. Then just dip the wire into the flux. If you're working with a long piece of wire, it's easier to wipe the entire wire with flux then to spot it on as needed. You can use a small piece of sponge to this.

Tinning Wire

To tin wire, it's easier to draw the wire along the iron than it is to slide the iron along the wire. Coat the wire completely with flux and load solder onto the iron. Start at one end and draw the wire steadily along the soldering iron to the other end. This will just tin one side. Turn the wire over, reload solder onto the iron, and repeat for the other side.

Soldering Same Size Wires

When soldering two or more wires of the same size together, load solder onto the iron tip and hold the soldering iron so that it is touching both wires at the same time. As soon as the solder flows smoothly – remove the iron quickly.

Wire

Soldering Different Size Wires

To solder a small wire to a large wire, load solder onto the iron tip and hold the iron on the heaviest wire (without touching the smaller wire) until the solder starts to flow. Then slide the iron over to contact the smaller wire until solder spreads onto it. Then remove the iron quickly. The larger mass of the heavier wire takes longer to heat up, so it must be heated before the smaller wire. The heavier the wire, the longer it will take before it heats up enough for the solder to flow. This is especially the case when trying to solder copper pipe.

Soldering Wire onto Lead

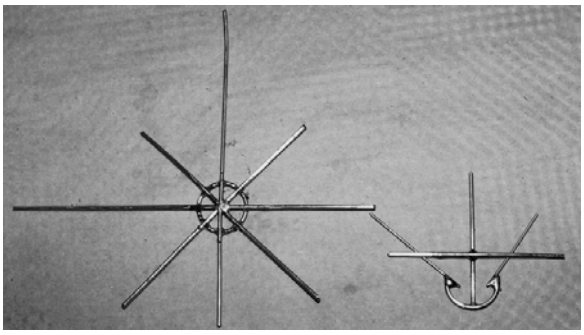
It takes very little time to melt right through lead came. You must be especially careful when soldering wire onto lead. Flux the wire and hold it in position on or against the lead. When the solder runs smooth, slide the iron to touch the lead – and remove it INSTANTLY. It is not necessary to reduce the temperature of your iron. With a bit of practice, you can easily solder wire to lead – even at high temperatures.

What if it Lets Go?

If the soldered connection lets go, it's either from too little or too much heat. If you don't hold the iron in place long enough, the heat won't spread enough for the solder to stick to both pieces. If there is too much heat, the solder might still be liquid when you let go of the wire and it will release. To prevent this, either hold the wire a little longer before letting it go, or if you're in a hurry, blow on the solder to set it instantly.

Use a "Heat Sink"

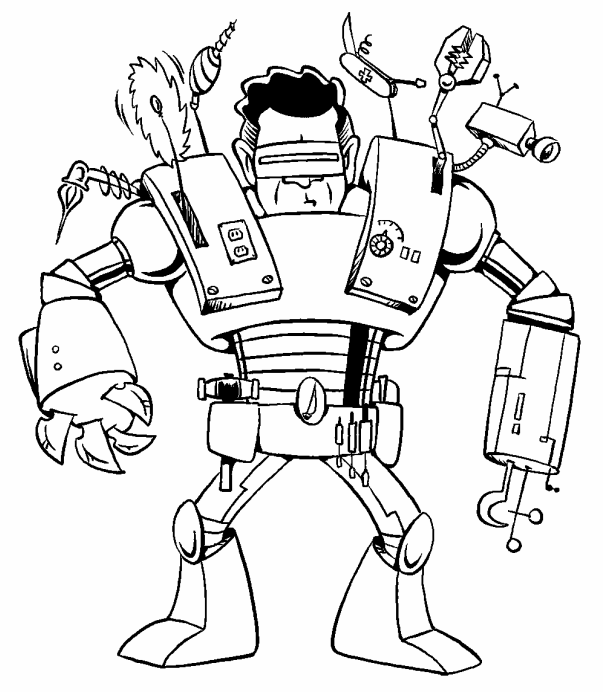
A "heat sink" is anything that absorbs heat. If you are trying to attach a piece of wire to a small wire with another wire already soldered to it, there's a good chance that when you heat it, the earlier soldered joint will let go. To avoid this, leave all the wires you are working with as long as possible. The extra lengths of wire will act as a "heat sink" to absorb enough heat to prevent releasing other joints. Also, by having extra long lengths of wire, you'll avoid burning your fingers by holding on to a hot wire. After you've soldered all the connections, you can cut the wire to the lengths you want. The photo below shows a helm and an anchor before the excess was cut off.



What is the Best Temperature?

Whatever you're comfortable with. It's a good idea to start with a relatively low temperature until you're familiar with soldering wire. But remember, the lower the temperature, the longer you must wait for the wire to heat up. The pros like to work with the highest possible temperatures, and learn to be quick with their motions. Using a temperature controller or rheostat is not a good idea. It takes a lot of time to keep changing temperatures. It's easier to learn to do all your work at the same temperature.

Tools



Half of everything you buy will disappoint you, but you have to buy everything to find out which half it is

What's the best tool?

What's best for one person might not be good for another. Each of us has personal preferences and favorites. What works great for you, might be something I'm not comfortable with. A tool that is perfect for one application, might be almost useless for another.

You might want to buy all the latest tools, devices, and gadgets hoping that they'll make the job easier and help you do better work. Sometimes they will, but sometimes you'll only be wasting your money. Often these tools not only don't help you, they harm you - by becoming a crutch that you come to depend on. Don't just spend your money on new devices, spend your time improving your personal skills. Your own skill is the best tool you'll ever have.

Glass Saws

There are lots of great uses for glass saws. I have one. It's a great monstrous beast that does lots of wonderful things, and it's enormous fun to play with. It's used for stack cutting, for cutting unusually thick glass, and for cutting marble and granite. But, it's rarely used to cut a single piece of glass. I believe that any shape that cannot be cut by hand is likely to be structurally unsafe. Cutting a deep inlet into a piece of glass, or into a peanut shape, almost guarantees that the piece will eventually crack at the small weak point created by this cut.

Ask anyone that owns a glass saw and you'll discover that the majority hardly use it at all and consider it a huge waste of money. Not because it doesn't work, but because they've discovered it has severe limitations. Saws are noisy, messy and slow – as well as useless for working on small pieces. In most cases you could have finished cutting and fitting the piece of glass in less time than it takes to set up your saw.

A glass saw will allow a skilled artisan to produce shapes that might be impossible without it. Unfortunately, saws are most often bought for the wrong reason. An expert artisan will use a saw to do something special. It's a tool to extend their skills, not to replace them. Beginners buy a saw because they think it will make them a better glass cutter. The saw might provide better cuts, but while doing so will prevent its owner from learning to produce these cuts by hand. It has then become a crutch instead of a tool. Think of a glass saw as a way to expand your skills – not as a way to replace them.

Tools

Toolaholicalism

It's time for me to be completely and totally truthful with you. My name is Dennis Brady, and I'm a toolaholic. Have been for years. If there's some new tool or trinket, or gadget or geegaw – I'll buy it. It's a sickness and I just can't help myself. Most of the stuff I've bought is useless for anything other than eating up space. Everyone has to have at least one bad habit and this is mine. Of course this is a very rare affliction and no doubt you have the will-power and strength of character to be unaffected by it. However, should you observe it in a friend or detect small early indications of its onset, I can offer some help. A friend posting as "Catglasser" on Warner-Crivellaro's internet glass forum, has provided a possible treatment for Toolaholicalism:

12 Steps to Recovery

1. *Burn checkbook*
2. *Remove and destroy all plastic cards.*
3. *Inform bank to hide all available assets.*
4. *Inform family and friends that you no longer can receive those handy little helpers as gifts.*
5. *Go to post office and stop all mail delivery (this helps with those unwanted monthly bills also).*
6. *Inform UPS that you no longer live at the same address.*

You're halfway there……

7. *Destroy all previous purchases that have no conceivable use whatsoever.*
8. *Just for kicks, drive by any local retailer that handles gizmos and toss a few water balloons, just for therapeutic reasons.*
9. *Make sure there is nothing in transit that you purchased before therapy program.*
10. *Inform your children that you're now very close to recovery, and ask them to kindly not upset you in any way so that you won't have a setback.*
11. *Inform your spouse…..see above.*
12. *You can now tell your counsellor that you are cured, but you can't pay him/her because of extreme financial difficulty, and get your hands off that catalogue you hid in the john a month ago…just in case*

Metal Cutting Saws

What tool you need depends on how much work you want it to do. If glass is a part time hobby and you only need something to cut metal for occasional projects, cutting by hand with a miter box and hack saw will work fine. Isn't it better to spend money on supplies, than on tools you rarely use?

If you cut enough metal that you think you need a power saw, there are several different small hobby saws that work well. If you want a multi-purpose tool, you might instead consider buying a carpenter's miter saw (also called a chop saw). It costs a little more than the hobby tools, but it's a lot more versatile and does the job better and quicker. By using different blades, you can use the same saw for cutting wood, iron, and all the soft metals (brass, copper, zinc) used for glass work. It can be set up in seconds and adjusts easily to any angle you want. You can cut one piece at a time, or stacks of dozens. You'll use a miter saw a lot more than a glass saw.

Of all the tools you'll ever try, the most valuable ones are your own personal skills.

Cutting

Cutting is the most important stained glass skill.
A good cut makes the rest of the job easy.
A poor one makes it impossible.

Glass Saws

There are 2 basic different kinds of glass saw – ring saws and band saws. The ring saw uses a metal ring coated with diamond dust. The band saws are like conventional band saws but have a diamond coating on the blade. Both types require the ring or band be kept constantly wetted with water – just like a grinding head.

Glass saws are becoming increasingly popular because they can produce other-wise impossible cuts. Some larger models can be used for "stack cutting" multiple copies of a piece. Saws are especially handy for thickly textured or difficult to cut glass. They can NOT be used to cut metal. Trying to do that just removes the diamond dust. There is a huge difference in quality and cost . Test drive before buying a saw.

Hand Held Cutters

Other than a few of the die-hard old-timers, most glass artisans use some form of the "Toyo" type oil filled cutters. Since the original pencil type, Toyo has introduced a pistol grip style that most artists prefer. There are also several other brands of oil-filled cutter now available. Each is different, and each has some advantages. The best guide for selecting a cutter is the same as for almost all other tools. Try out different ones to find the style that you feel most comfortable with - then buy the best one you can afford

Stationary Cutters

Several kinds of circle cutters are mounted on a fixed platform. There are also some kinds of conventional cutters that are stationary mounted. The most common are the "Score One" and the "Cutter's Mate". Both of these have a conventional oil-filled cutter head that is mounted so that it will always remain perfectly vertical. This allows the user to not worry about the cutter position, and concentrate just on maintaining a consistent pressure. This is a huge advantage for someone that has difficulty holding a cutter in their hand. These devices have allowed many people to continue cutting glass when they otherwise would have been forced to stop.

Stationary cutters are also especially helpful for production work when used with thick wood or plastic templates. The fixed position cutter head can efficiently be slid along the template guide to produce consistently accurate cuts by even an unskilled user.

Pneumatic Cutters

Some large production companies use table-mounted cutters that use a machine driven conventional cutting head, with air pressure to provide the precise pressure on the cutting head. This ensures that each score is machine perfect. The more elaborate versions of pneumatic cutters use a computer program to "steer" the cutting head so that each cut is also perfect.

Waterjet Cutters

For years waterjets have been used to cut metal to make precision machine parts. These machines use a high pressure jet of water containing an abrasive material. Recently, many glass producers have started using them for cutting glass. With a computer driven program, a waterjet will produce a perfectly smooth cut and cut each piece to extreme accuracy. This makes them ideally suited for high volume production work.

Cutting Oil

The 3 most commonly used oils for filling "Toyo" type cutters, are kerosene, diesel oil, and "cutting oil."

When Toyo first introduced oil-filled cutters, they specifically recommended kerosene. Most artisans consider it to be the best oil for cutters. It's inexpensive and flows smoothly. Second best is diesel oil. However, both of these have a pungent odor that some users dislike. Many glass shops now sell various products called "cutting oil". This is not something specially designed for glass cutters, but a lubricant that has for years been used in food processing machinery because it is free of taste and odor. "Cutting oil" might smell better (if smell is really important to you), but it's more expensive and doesn't work nearly as well as either Kerosene or Diesel. You should NEVER use anything heavier. It'll just plug up your cutter's wick.

Oil Advantage

For many years, professional glaziers have dipped their cutters in oil to produce better cuts. Even today, some glass artisans prefer to not fill their cutters with oil, but instead keep the tips oiled by dipping them.

Applying oil to your cutting wheel has two advantages. First, it allows the wheel to turn smoothly and ensures a more uniform cut. Second, it helps encourage the cut to break where you scored it. When glass has been scored, it immediately tries to heal itself. It tries to close the opening made by the score. Filling that score with oil, makes it harder for the score to close, and increases the probability that your score will break accurately. Whether you choose to dip your cutting head in oil before each cut, or to use one that wicks oil onto the head, keeping it oiled will always improve your cuts.

Cleaning Your Cutter

As you cut, small bits and shards of glass can get picked up by the cutter wheel and stick inside the cutter head. The easiest way to clean these out is by back-pedalling your cutter. If you usually cut by pulling the cutter towards you, start your cut by running the cutter backwards for several inches. Don't press hard enough to make a score – just enough to roll the wheel. The idea is to roll the cutting wheel several revolutions to clear out any debris.

Damaged Cutter?

It takes a lot to damage a cutter wheel, but it can happen. You might have dropped it, or hit it with something metallic. A good way to check it is to use it to score a piece of mirror. The mirror will provide a reflection of the score you make. If you see a perfectly uniform line, your wheel is fine. If there are any interruptions in the score, the wheel is nicked and should be trashed.

As tough as these cutting wheels are, they don't last forever. They will wear down. Because they wear so slowly, it's extremely difficult to tell if your cutting problems are something you're doing, or a well-worn wheel. The only way to accurately check is by direct comparison with a new cutter. Take your old cutter down to your local glass shop and try out a new one alongside it. If the new one cuts better, it's the wheel and not you. Keep your old worn cutter. A well worn cutter wheel usually works better for straight cuts and for cutting thick glass.

Storing Your Cutter

A common complaint with oil-filled cutters is that the oil stops running onto the wheel. There are 3 possible causes. A partial vacuum in the oil chamber, a plugged wick, or a dried wick. A partial vacuum can build up in the oil chamber from the oil wicking onto the wheel. To prevent this, it's a good practice to occasionally open then reseal the cap, to allow the air to re-pressurize inside the oil chamber.

Whichever oil you use, there might be small quantities of contaminant in it. These contaminants can build up in the wick's tip and clog it so that the oil no longer flows smoothly onto the cutting wheel. Remove the cutting head to see if your wick is contaminated. If it is, just trim about 1/16" off the end. Pull the wick out gently and cut it with a razor blade or utility knife

If you leave your cutter laying on its side, the wick might dry up and oil no longer runs onto the cutting wheel. Oil-filled cutters should always be stored standing up with the cutting head facing down so the wick is kept constantly oiled.

Cutter Position

The cutter should be held with the cutter head as vertical as possible. It should not be angled forward or back, nor should it tilt from side to side. It should be held firmly enough that you can accurately guide it, but no so firmly you can't maintain pressure.

Cutting Mirror

Mirror is cut the same as regular glass, but you must be careful when you break it. The silver back will chip easily if you don't snap it apart quickly. Intricate curves can be a problem. If you tap mirror to run the score, do it much more gently then you would for glass.

Special care must also be taken when grinding mirror. The silver backing chips easily. Use your finest grit grinding head and always grind moving against the direction your grinder head rotates. Be extra careful to use a gentle steady pressure when grinding.

To avoid scratching the back of your mirror, it's a good idea to put a clean piece of paper or towel under it while cutting.

Cutting

Cutting Methods

- **Template cutting**
  This requires cutting the desired pattern shapes out of paper, cardboard, or plastic to make templates to be held onto or attached to the glass with glue or tape. The cutting score is made by running the glass cutter along the outside edges of these templates. Template cutting is the easiest cutting method to learn and is the most common method taught to beginners.

- **Stencil cutting**
  For this you also cut out templates, but instead of scoring along the template, you draw the pattern shape onto the glass using the template as a stencil. You then score on the line drawn on the glass. Stencil cutting is the preferred method for cutting with a glass saw.

- **Trace cutting**
  To trace cut, place the glass over the pattern and make the score by using the cutter to follow the line on the pattern while looking through the glass. Just like tracing a drawing with one paper over the other but with a glass cutter instead of a pencil. Most glass is trans-parent enough to permit this. Opaque and dark colored glass that cannot be easily seen through, can still be trace cut by using a light box. Because trace cutting takes longer to master than template or stencil cutting it is usually not taught to beginners. Although many artisans don't use this method, it's usually preferred by professionals because it's considerably faster than other methods. If speed is important, you might take the time to master this technique.

- **Cutting guides**
  If you want to make several copies of the same piece, it might be worth making cutting guide templates. Cut a template from a piece of plywood or plexi-glass, that is slightly smaller on all edges than the piece you want to make. Set the cutting guide on the glass and use it as a guide to cut against. The time spent making such a guide can often be saved in being able to produce very fast and perfectly accurate cuts

Light Box

This could be an elaborate unit built into your cutting table, or something as simple as a sheet of glass propped up on bricks with a light under it. Anything that provides light will work. If you use incandescent lights, be sure to provide good ventilation to prevent heat buildup. Using fluorescent fixtures will eliminate that concern.

Perhaps the easiest to build light box is a simple 2' x 4' wood frame box with a 48" fluorescent fixture inside. Paint the inside white to reflect light, and place a sheet of ¼" thick window glass on top. Plex-iglass will work but might bend from usage. Safety or tempered glass would be the best choice, but isn't really needed. Simple window glass is strong enough – unless you plan to drop a hammer on it. Looking directly into the lights can be irritating, so you should do something to diffuse the glare. You can rely on the plastic diffuser cover that usually comes with the fixture, you can sandblast or acid-etch the glass, or you can place a sheet of opaque white glass underneath it.

A trick that will help you see through opaque or dark glass is to turn off all the lights in the room except the light box. That produces a clearer definition of the pattern lines.

Running a Score

"Running a score" is when you crack the glass along the score so that it will then break accurately along that score. Scores for straight lines and simple curves don't need to be run but can be just broken off. Deep curves or complex curves should be run to ensure the glass doesn't break away from the score. Some of the different ways to break glass, or to run a score are:

- **Two hand break.** The most common way to break glass. With the score facing up, hold the glass with each hand on either side of the score and sharply turn your hands outward to break the glass apart. As well as straight line scores, it will work on simple and gentle curves.

- **Table edge break.** For large sheets of glass, it's often better to snap the score on the edge of your cutting table. After scoring it, slide the glass to the edge of the table so that the score line is parallel to the table edge and about ¼" outside the edge. Lift the glass about 12 inches and press it down sharply against the table. It will break cleanly away.

- **Fulcrum break.** For running straight lines and simple curves, you can break by placing something like a pencil or old-fashioned glass cutter under the score as a fulcrum. Sharply press down the glass on both sides of this fulcrum to make it break.

- **Pressing.** After scoring, turn the glass over and with your thumb, firmly press down on the score. As it cracks along the score, keep moving your thumb along to chase the score it's full length.

- **Breaking pliers.** You can use regular pliers, or those specially made for breaking glass. For breaking off pieces that are too small to be done by hand, hold the piece with the pliers and snap it off the same way you would to break by hand.

- **Breaking & running devices.** Numerous devices are available to help you run a score. They work on the same principle as either the fulcrum or pressing methods.

- **Tapping.** Old-fashioned conventional glass cutters were all specifically designed to use the round non-cutting end for tapping glass. For cutting many shapes, tapping is one of the best ways to be certain the run stays on the score and doesn't stray. After making your score, turn the glass over and tap along the back of the score to chase the break along your score. This is called "running" a score. Start at one edge of the glass and tap with a continuous rhythm (like a woodpecker), following the score across the glass, until the piece breaks away along your score. Tapping will often cause the glass to chip along the break. If you tap very slightly to one side of the score line, the chipping will be only on that side of the score. The other side will break as cleanly as you would expect for a non-tapped break.

Cutting Problems

If your score fails to break accurately along the score, some possible causes are:

Score is not uniform. You may not have maintained a consistent pressure throughout the score. The break will then not follow your score but instead veer off. This is especially important, and especially difficult, with textured glass.

Score is too hard. You might have been pressing too hard. If your score produced tiny chips or shards, it's likely that you are applying too much pressure. A lot of textured glass cuts best with a fairly gentle score and will break poorly if scored too hard.

Score is too light. You may not have pressed hard enough. On most glass, you'll hear the score being made. If you didn't hear it, you may not have been pressing hard enough to make a proper score. Not pressing hard enough is rare for other than beginners. Pressing too hard is much more common.

Cutter is not vertical. You may have held the cutter on a slight angle. Perhaps a little forward or back, or to one side? This will produce an inconsistent score.

Cold glass. If glass is too cold it will often refuse to break accurately. Sometimes you will have to warm up the glass first. An electric heating pad or blow dryer works well.

Dirty glass. Dust or oil on your glass can cause the score to run erratically. If this is old glass that has been around for a while, that might be your problem.

Cutting Stance

When cutting glass, you should bend forward far enough that you look down at the glass in front of the cutter. Sighting one eye down the front of the cutter, in the same way a shooter would sight a gun, will give you a clear view of where the cutter is going. Use your body position to determine the pressure on the cutter. By leaning forward, you will increase this pressure - by leaning back you will reduce it. Do not try to use arm strength to do this. Instead shift your body weight backward or forward.

The cutter should be held firmly with the lower arm stationary and with the elbow held firmly against the body. The wrist and forearm should NOT move when scoring.

Move your shoulder, shift your weight, step back, or just shuffle your feet if you like - but don't move your arm any more than you absolutely must. The most important factor in getting a score that results in a clean break, is to be sure the score is made with a smooth flowing stroke that maintains a consistent unchanging pressure. This is best done by leaning over the cutter and keeping the arm as stable as you can.

It's the same idea as hammering nails. A beginner will swing the hammer with the wrist. A professional carpenter learns that it works much better if you lock the wrist and elbow in place, and swing with the entire arm. It's the same with scoring glass.

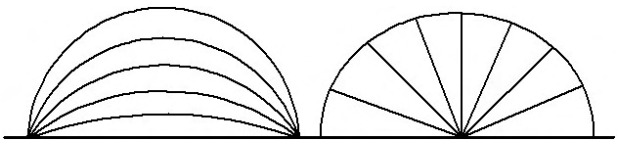
Listen to the sound the cutter makes. Try to have it produce a smooth and constant tone that does not start and stop, or change pitch. If you learn to cut by sound, you will always know when you have a perfect score.

Cutting out Arcs

There are 2 distinctive different methods for cutting a curved piece out of glass. The scale method, and the pie method. Everyone has their own personal preference. You should experiment with both methods before you decide which you like best.

With the scale method (shown below left) you score a series of "C" shapes and break them out one at a time.

The pie method (below right) is a bit more complicated, but is often preferred for deeper arcs. You first score the arc to be cut, then turn the glass over and tap to run the score. Then, turn the glass back to the original side and score a series of "pie" shapes – taking care to not score past the original scored arc. Now, turn the glass over again and tap to run these scores. Continue tapping to break out all the pie-shaped pieces. With patience, you can use this method to cut a circle out from inside a piece of glass without disturbing the glass around the hole you remove.



Cutting a "V"

Of course it's impossible to cut a "V" notch into glass, but there is a way to make what looks like one. Here's a trick compliments of Graham Muirhead of Cats Glass in Jordan, Ontario.

- *Go as deep into the shape as you can with your cutter, then grind more out with your smallest grinder head. You can do a pretty good job with a ¼", but if you're fussy the 1/8" will go deeper.*
- *The last step is cheating. Put a little extra foil at the head of the "notch" and trim it to a sharp point, then trim it to a notch on the abutting piece. Once the solder is on, it looks even sharper than you can cut with a saw. Use the same method to create inside cuts for "square" corners.*

Practice

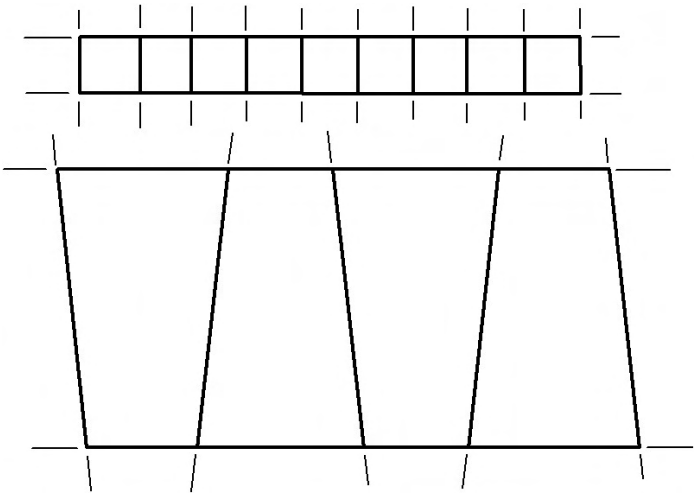
The best way to master glass cutting is to practice. Lots, of practice. For this you need a lot of scrap glass. You don't want to use up any of your beautiful art glass, so get a bunch of scrap clear window glass. Don't go to your art glass supplier. Find a shop that sells window glass and does glass replacement. They'll have bins full of scrap glass and will be pleased if you take a box of it home with you. This glass is perfect for practicing with – and it's the right price.

Cutting

Cutting Multiples

One of the most efficient ways to cut multiple copies of a pattern is to adapt the cutting pattern with extended lines as shown below. Using a pattern this way eliminates the need for complicated devices to set an angle. It also saves a lot of time by allowing you to quickly cut every piece with a straight edge.

The top diagram below shows how to adapt a pattern to cut out a series of squares. The lower diagram shows how to make simple trapezoid shapes form something like a panel lamp or a model lighthouse.



If you need to cut an inside curve, do it first and break it out before making the other cuts.

Cutting with a Saw

The higher the speed you cut at, the smoother the cut will be. You should use slower speeds only for doing small curves and for cutting material that breaks easily. Push the glass steadily into the saw but don't force it, and NEVER put any pressure on the side of the cutting band. Side pressure can produce enough heat to burn off the diamond dust and can even break the band. Do not back out of a cut with the saw running. Turn it off, then carefully back it out.

There are several ways to mark the pattern on the glass. You can cut out a paper or plastic template and attach it to the glass with glue or double-sided carpet tape, or you can draw the cut lines onto the glass with a waterproof marking pen. When the ink is completely dry, coat it with chap-stick or vaseline so the ink won't come off while you're cutting.

If you have a large enough saw, you can also cut layered stacks of glass. Hold the layers together with glue or carpet tape. Take care to position the glue or tape so that the band won't go through it when cutting. If not, you'll gum up the diamond dust on the band. When stack cutting, you must push the glass in at a proportionately slower speed than for a single piece. If cutting 3 layers, do it at a third the speed of one layer. Stack cutting won't be much faster than cutting one piece at a time, but it will ensure that each piece you cut is identical.

The three most important things for you to remember when learning to cut glass -

Practice……Practice…..Practice.

Grinding

A little bit off the top?

Grinder Heads

Diamond heads for rotary grinders come in numerous sizes and 3 different grits.

Coarse grit will very quickly remove a lot of glass. Using coarse bits is always messy and often disconcerting. They don't so much grind the glass away, as chew it out in chunks – often a lot faster than you want. They also produce a badly chipped and scalloped edge that will need to be finished with a finer grit head to produce an acceptable finish.

Regular grit is the most often used type. It produces a reasonably smooth edge that is usually acceptable for copper foil work, and more than adequate for lead.

Fine grit is only needed when you need to be concerned about even small chips (when using very thin foil), or when you want to leave the glass edge exposed. Few glass artisans buy fine grit grinder heads. Instead they just keep their old well-worn regular grit heads. When a regular head wears down, it becomes a fine grit head. If you want an exceptionally smooth finish, you'll need to use a belt machine instead.

Grinder Coolant

People often ask, "Why bother with coolant if you only use a teaspoon full"? I've heard some people recommend just putting ice cubes in the grinder water. That not only won't work, it'll make you miserable from grinding with freezing cold hands. Others have suggested that coolant is too expensive in those little bottles, so they use anti-freeze instead. That's just stupid. Anti-freeze is lethally toxic and doesn't work.

Even though it's called "coolant", it's inaccurate to think it "cools" the water by reducing the temperature. It would be more accurate to call it a "liquidifier". It makes the water thinner and more liquid. The water can then more effectively cool the grinder head by running faster and smoother around the head. Even though it only comes in small bottles, you use very little, so it's inexpensive. Coolant does perform an important function. You should use it.

Some glass artisans change the water in their grinder after each use. Others leave it until the reservoir has so filled with glass dust there's almost no water left *(That's what I usually do. Did I mention that I'm lazy?).* It's your choice, but it definitely isn't necessary to change the water if there is enough left to do the job.

Grinding

Finger Protection

We all complain about shredded fingertips from grinding. There are a few things that can help. Most grinders now come with different devices for holding the glass while you grind it, and numerous other gadgets are offered for sale to protect your fingers. They all work to some degree. There are also numerous devices offered for sale to "hold" the glass while you grind it.

Probably the most versatile, and most commonly used, protection is rubber thimbles. You can buy them in different sizes from stationery stores. They work fine for fingers but, for most people, are too small for thumbs. You can buy "thumbles" (hard plastic thumb covers designed for quilting). They're heavy enough to be used to push a large needle through a quilt, so they do a fine job of protecting your thumb while grinding glass.

If none of the devices or gadgets work, you might have to fall back on the "old favorite" solution of just buying band-aides in industrial size packages.

Belt Sanders

Commercial glass shops, and some glass artisans, use an electric belt sander instead of a rotary grinder. These are large machines with the belt mounted vertically. You can also adapt a small hand-held electric belt sander to do the same work. A variety of grit size glass belts are available for most size sanders.

You can hold the sander in your hands and run it along the glass edges. If you work this way, you must constantly spray the belt with water or a light oil to prevent friction heat from building up. Too much heat, and the glass will break.

With the large commercial belt machines, you instead hold the glass up against the machine just like you do with your rotary grinder. These machines are built so the belt runs constantly through a tray of water. You can make something similar. You can't run the belt through water, but you can rig it so that water is kept running constantly on the belt. Many small shops have mounted a sander under a hose that provides a constant drip of water onto the belt. If you do this, take care to not drip so much water it gets into the workings of the machine. That can produce "shocking" results.

Do it by Hand?

The two basic reasons for grinding glass are to either remove burrs and spurs left from the break, or to resize it for a better fit. You can do this on your grinder, or often you can just as well do it by hand.

Rotary grinding machines that use diamond-dust heads are one of the most valuable tools for a glass artisan, but are also often overused. If you've made a good cut, it's often not necessary to grind on the machine. Sometimes, all that's needed is to quickly wipe the glass edge with a hand-held carborundum stone to remove burrs and spurs. Many artisans that work with lead use their machines very little – preferring instead to work by hand with grozers and carborundum stone. Doing it by hand can save a lot of time.

Grinding

Grinding Problems

Chips in the glass

- **Inconsistent pressure** while grinding can cause the glass to chip. Practice wiping the glass across the grinder head with a smooth steady uniform pressure. Try to have the same pressure against the grinder head at all times. Running your glass against the direction the head spins will remove glass much quicker and is more likely to cause chipping.
- **A new grinder head** will usually cause glass to chip. It's a good practice when you install a new head, or you reposition one, to first do a few swipes on some scrap glass. Wait until it stops chipping before doing the good stuff.
- **A worn out head** will in time loose some of it's diamond dust and can cause chipping. If you've always been grinding using a steady pressure, this won't happen. Instead, the head will just wear down to a finer grit. If your grinding pressure has been uneven, you can produce uneven wear on the head. This will always cause chipping.
- **A defective head** sometimes slips through the manufacturer's quality control. There might be parts with not enough diamond dust. If you get such a defective head, return it and complain as loudly as you can.

Takes too long to grind

- Your head may have become worn to a finer grit and should now be replaced. Don't junk it. Keep it for when you want to grind a smoother than usual finish.

Head wearing too fast

- Grinding with insufficient coolant will cause your grinding head to wear out quickly. Heat causes the diamond dust to come off the head. Make sure you have enough water in your grinder, and ALWAYS use coolant.

Grinding head stuck on machine

- You should always oil the shaft when installing a new grinding head. Almost always a stuck head can be removed by liberal application of WD40 or "Liquid Wrench". If this fails to work, the safest way to remove it is with a mechanics "valve puller". These will hold the grinder head while pushing down on the shaft. You can also do it by holding the grinder head with a pair of pliers (preferrably vise-grip) and by using a hammer to tap a screwdriver down on the shaft.

NEVER sweep or vacuum glass dust. Wipe it up with a damp cloth or sponge.

It's not necessary to wipe and dry glass after grinding. Just rinse it off and stack it to air dry. Dish drying racks work great for this.

Bits of glass will stick to your clothes. Be careful to wipe yourself off when finished grinding.

Grozing

Chewing glass can be fun.

The Old Fashioned Way

Grozing is when you trim the edge or corner of a piece of glass with a tool called grozing pliers. These have serrated edges that allow you to "nibble" or "chew" the glass. Some glass artisans insist that you should never groze, because it can produce microscopic stress fractures. It probably can, but so can grinding, cutting with a saw, or just about any kind of handling. The vibrations from cutting a piece of glass with a band saw is as likely to produce stress fractures as grozing. More common causes of stress fracture are fitting pieces too closely together, holding your iron in place too long, or cutting an unstable shape with a saw.

Grozing has been successfully used to trim glass for several hundred years. It's an old technique that still works well and is frequently used by most commercial glaziers and many production artisans. Classic studios, like LaFarge and Tiffany, grozed all of their glass. Their work has stood the test of time without damage.

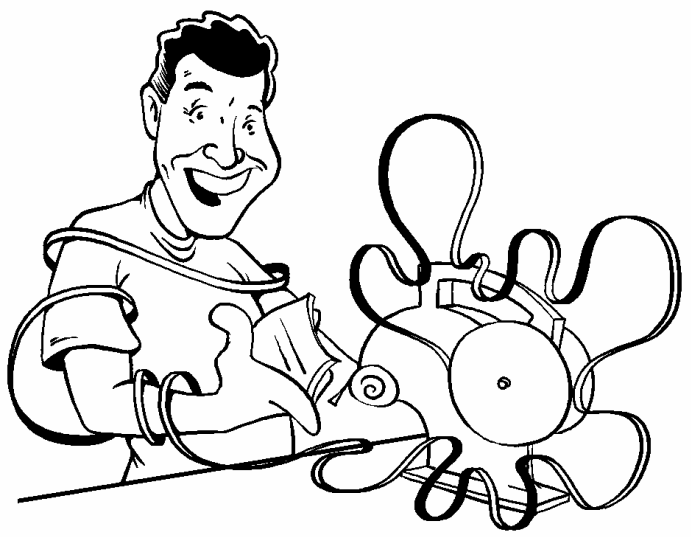
Although a well skilled grozer can produce a smooth edge, it will take some practice for you get past "a little bit rough". For copper foil work, it might not be as smooth as you would like, but if the piece is to be installed in lead came or metal channel it will be easily concealed.

Grozing is a handy skill that you should master to add to your "tool kit" of personal skills. If you're called on to do a field installation or a repair job, you'll often need to "nibble" a little bit off a piece of glass. You can't be running back to the shop to do it on the grinder. If you need to take any amount off by hand with a carborundum stone you could be hand grinding for hours.

Grozing can be a great time saver for lead work, or for just knocking corners off a piece of glass. Those that have mastered it, can quickly produce a perfect fit without grinding or recutting. If I need a piece with rounded corners, I just cut it square then groze the corners off to the finished shape. It does a perfect job - and it's a big time saver.

Many old-time artisans will cut a square and groze it into a perfect circle in less time than beginners can set up a circle cutter. You might not be so quick, but you should practice grozing until you've mastered it. Once you know how, you'll be surprised how often if comes in handy for just chewing off a little bit of glass.

Foiling



The Tiffany legacy.

Foiling Machines

There are lots of devices to make applying foil easier. Everything from small hand-held tools like potato peelers, to table mounted double-wheel applicators. There's even an electric foiling machine. I don't know how well the electric one works, but this old toolaholic finds just the idea of a power foiler irresistibily appealling. I want one!

To varying degrees, all these devices can help apply the foil. Some even help burnish it. Some artisans insist they can foil faster and better by hand. Perhaps they can, but it's more likely they just never took the time to master using a foiling machine. Like everything else we do, it takes some time and practice to get the hang of it. Those that do prefer to use foiling machines, insist that they are always considerably faster and usually more accurate than foiling by hand.

You should give them a serious try before deciding for yourself.

What Size Foil?

Copper foil comes in a range of widths from one eighth to half inch wide - with plain copper back, or black or silver back. You can even get it in 12 inch wide sheets and cut it to any shape or size you want. A good guideline is to use foil that is 3 times the thickness of the glass you put it on, but there's no fixed rule. Use whatever you think works and looks best. Most instructors start their students off using ¼" wide foil because it's easy to work with and will fit almost all glass. As the students get better at applying foil, they start using increasingly smaller size foil. Unfortunately, some of them too often don't know when to stop doing this. They mistakenly think that extremely thin foil indicates extremely good skills. It doesn't! If the foil is too small, the soldered bead will not be strong enough to hold the glass work together.

The size of foil is determined by both the thickness of glass you put it on, and by how you want it to look. For thicker glass, you will obviously need wider foil. Generally, it should cover at least 1/16" of both the front and back. If it's thinner than this, your work is likely to be dangerously flimsy and need extra reinforcement. You don't have to use the same size foil throughout your panel or lamp. Some artisans will intentionally use varying sizes of foil to produce a special effect.

Copper foil is available .001, .00125 and .0015 mm thick. Thinner foil is easier to apply but will tear easily. Thicker foil is stronger and less likely to break, but is more difficult to apply. Most artisans compromise by using .00125 for everything except special applications.

Foiling

Foil or Lead?

Neither is significantly better or worse than the other. It's your choice to use whichever you prefer. The only exception is for lamps and 3D work that must carry any weight. Those should be foil. Lead is soft and will stretch if any weight is applied to it. Lamps made with lead will fall apart. That's why Louis Comfort Tiffany introduced copper foil.

Foiled panels or windows usually have more internal structural strength and need less reinforcement than those done in lead, but not always. It depends entirely on the design. Generally artisans prefer foil if it's a very intricate design and lead for long smooth lines, but you can mix the two or use whichever you prefer to work with. Because solder oxidizes quickly when outdoors, lead is usually preferred to foil for windows exposed to the outdoors.

Perhaps the best explanation for the difference between foil and lead was offered by Graham Muirhead of Catsglass Studios when he said,

"Equate it to painting. Some people start with watercolour and some start with oils. At some point artists will try both, but prefer one to the other. Either method produces a pretty picture when done by a competent painter; and spectacular results when executed by a real artist."

Storing Foil

Some users think that you can't use old foil and that storing it in a cold place will help preserve it. I don't know if keeping your foil in the freezer will preserve it, but I very much doubt cooler temperature makes any difference. Sealing it from air exposure makes a huge difference. It's the oxygen that cause foil to tarnish to where it will no longer take solder. You can increase the life of your foil by storing it sealed from air.

I also don't accept that you can't use old foil. I've used foil that was over 10 years old. It worked perfectly. What's the secret? It had been kept in wrapped packages.

Old CD containers are handy for storing foil.

Fitting Foil Work

Some beginners work hard to be sure they cut and grind each piece of glass to an almost perfect fit. They'll try to get them to fit snugly against each other like a jigsaw puzzle. Don't do that! Instead you should leave a gap between each piece. That will permit some solder to form a seam between each piece, like the heart on lead came. It will also eliminate the problem of your project "expanding" after foiling and no longer fitting.

Fitting pieces too firmly will increase the likelihood they will later develop stress fractures and crack. Leave a gap to strengthen your work and to cushion against stress fractures. Don't worry if your gaps aren't perfectly uniform. A little difference in spacing won't be noticed after you solder. Some glass artisans intentionally vary the spaces (often dramatically) to produce an attractive artistic effect.

Foiling

Foiling Nuggets

Unless you have incredibly small fingers, foiling nuggets can be a frustrating experience. The most important thing is to start by washing them. Nuggets come with an oily film that causes the foil to slide off. Wash them in hot soapy water and rinse them off. A salad strainer works great for rinsing.

Don't just wrap the foil around once. Go all the way around twice, and the foil is more likely to stay in place. A handy "trick" for burnished foil is to "tumble" them instead of pressing the foil by hand. After foiling, put them in a round plastic container like Tupperware. Roll the container around and gently shake it – like a low motion paint shaker. The motion of the nuggets bouncing against each other will burnish the foil for you.

Foiling Problems

Foil won't stick

- **Soldering too slow** and holding the iron in one place too long can melt the glue off the foil back and cause it to peel away from the glass. You must learn to solder quickly and not hold the iron any longer in one place than is necessary.
- **Oily hands** while foiling can transfer body oil to the glass and prevent the foil from properly sticking. It's even worse if you use some kind of hand lotion. Always wash your hands before foiling.
- **Dust on the glass,** whether from grinding or other sources, can prevent the foil from sticking. Always wipe the glass before foiling.
- **Cold glass** will often not allow the foil to stick. Try to warm the glass up to room temperature before foiling - even if just to keep from freezing your hands.
- **Foil is too narrow.** If there is not enough foil on the face of the glass, flux can creep under it and cause the foil to peel away.
- **Foil is defective.** This does happen, but it's very rare. Most often when someone complains their foil is defective, it's instead one of the above reasons.

Foil breaks while being burnished

- **Pressing too hard** or with an irregular pressure can tear the foil. It's important to use an even pressure when pressing down the foil.
- **Inside curves** can be especially susceptible to foil breaking if you've pulled the foil too tight before pressing it down. It's easy to fix. Patch a small piece of foil across the break, press it down, and trim it off to line up with the original foil.
- **Foil too thin.** Some applications require thicker than usual foil.

Foil tears on glass edge

- Sharp burrs or shards on the glass edge can cut through the foil. If this is happening, you should check more carefully to see if the glass needs to be ground before foiling.

Lead

Nothing like a good stretch to start the day.

Why Stretch Lead?

Lead is stretched to stiffen or straighten it. Stretching lead will NOT strengthen it. Stretching any metal weakens it by making it more brittle. The more brittle a metal is, the more likely it is to break. Try bending a piece of iron back and forth until it breaks. Now try that with a similar size piece of copper wire and see how much longer it takes to break.

Lead is used for making stained glass windows because it's easy to work with and it stands up to weather exposure. Unfortunately it's so soft that it will easily bend out of shape. Stiffening lead will reduce the amount your windows can flex out of shape. Such flexing was a problem when stained glass panels were installed as exterior windows and exposed to the wind and weather. Today, stained glass panels are rarely installed this way.

Lead came is so soft, it usually gets twisted and mangled while it's being handled. Stretching it is an efficient way to straighten it out. Straightening lead is needed less today because we get lead neatly boxed in 3 foot or 6 foot lengths. If you're careful, you won't twist or mangle it and just use it as it comes from the box without stretching.

How to Stretch Lead

Anything that holds onto one end of the lead while you pull on the other, can be used to stretch it. Many artisans use a table mounted vise to hold the one end while pulling on the other with pliers. This works fine, but takes a little practice to learn to control how much and how far you stretch the lead. Several different lead stretching tools are available that make the work easier and allow for more precise control.
Be careful to not overstretch the lead. That would make it brittle and very susceptible to cracking. Probably the most commonly needed repair to leaded glass is cracked lead. The old time artisans learn to go by "feel". They know when it's stretched enough by how firm it has become. Until you master that trick, a good guideline is to not stretch 3 foot lead more than 3 inches and 6 foot not more than 6 inches. If you're not sure, it's definitely better to understretch than to overstretch. Better it's a little too soft, than too brittle.

Lead

Why Not Stretch Lead?

It's often unnecessary to stretch lead. Stained glass panels that are built into multi-glazed sealed units, or installed on the interior of a building against another window, are subject to much less flexing that those exposed to the exterior. Designs that have only short pieces of lead, or are thoroughly reinforced, are much less likely to need protection from flexing. An increasing number of glass artisans completely avoid stretching lead by using pre-hardened instead of pure lead. Most manufacturers of lead came now make it with 2% or 4% tin or antimony content. This is considerably stiffer than pure lead and does not need to be stretched.

Putty

You can use many different things to putty or caulk your windows. Packaged window putty, or commercially produced caulking is the most common. I've known artisans to use plaster-of-paris, and even cement. Commercial caulking compounds work, but are a mess to clean off the glass. Plaster is a poor choice because it will quickly break down. Cement is so durable it will be impossible to ever remove it for repairs or restoration. Both plaster and cement absorb moisture and are NOT waterproof.

Many artisans prefer to make their own. It's inexpensive and easy to do. Just mix whiting with boiled linseed oil. Raw linseed oil will also work – so will kerosene, diesel oil, paint-thinner, or turpentine. Mix your putty to the consistency of peanut butter. You can stir it by hand or get a mixing paddle for your electric drill. Your arm will appreciate that. You can make black putty by adding black mortar dye (for ceramic tiles) or mixing in stove black.

When to Putty?

Windows are puttied to weatherproof and strengthen. In the previous century, art glass was not nearly as uniform in thickness as it is today. Lead came had to be wide enough to accommodate the thickest glass used. That left the thinner glass sitting loose in the lead. Windows would have drafts blowing through and doors would constantly rattle. To prevent this, the gaps between the glass and the lead would be filled with caulking or putty. This waterproofed and strengthened the panel.

Modern art glass is a fairly consistent thickness, and machine produced lead came is perfectly uniform. Most glass fits snugly with very little movement in the lead. We still putty stained glass panels but don't have as much need to do so as in the past. Where and when it's needed is your personal judgement call. It's unusual today to install a stained glass panel exposed to the outdoors. If it's sandwiched inside a multiple-glazed unit, or if it's installed on the inside of a building with separate protection from the outdoors, caulking may not be needed. Sealing a panel on an entry door is advised, but might not be necessary for small cabinet doors. Caulking a small, or even medium sized, suncatcher is probably completely unwarranted.

It's your choice. If you think it's needed, do it. If you think it's okay without, leave it out.

ALWAYS wear a dust mask when working with whiting.

Assembly

It must fit somewhere.

Incrementalism

Everyone has difficulty controlling the incremental expansion as you fit pieces together. You've cut and ground each piece to a perfect fit, but when you foil or install the lead, your panel somehow grew. The best way to keep growth under control is to assemble directly onto a copy of the pattern so you can instantly see if you're expanding too far off the lines.

If you're building a window and the finished size will be important, it's wise to make a frame for you to assemble it. Start by fitting all the outside pieces and work your way in towards the center. When pieces aren't fitting the way you want, just resize them. If a piece doesn't fit right, lift it to sit on top of of the other pieces. This allows you to see exactly where it doesn't fit so you can make adjustment only where it's needed.

Fitting Foil

Don't try to fit the pieces too tightly together, and don't worry too much if the gaps between the pieces aren't perfectly regular. It won't show after you solder it. For suncatchers or anything where the outside dimension isn't important, it's easiest to fit from the inside working outward. For panels or windows, it's better to make a corner frame and work fitting from one corner out towards the opposite corner.

Fitting Lead

When fitting lead came on the pieces of glass, bend and insert inside curves first. Hold the lead inside the curve with one hand and use the other hand to bend it into the other shapes.

It's sometimes tricky to lift the glass to slide lead came onto it. It'll help if you cut up small pieces (about 1 inch square) of thin cardboard to put under each piece of glass. Small "skyhook" suction cups are also a handy way to "lift" pieces of glass to allow you to slide the lead onto them.

Preparing to Solder

If you're careful, you need not tack or nail the pieces of glass in place. For foil work it's enough to just position everything then gently tack solder enough of the seams to hold it together until you finish running the beads. For lead, you can just sit something heavy (like a roll of solder) against the pieces as you work fitting your way out.

If you decide to nail it in place, regular carpenter's finishing nails work as well as horseshoe nails – and cost a lot less.

Flux

The "agent" that brings it all together.

Applying Flux

Most glass artisans use standard metal flux brushes. They're cheap, easily available, and work fine. Some use bits of sponge, art brushes, or wick dispensers. For large projects, I've even sprayed it on. How you apply it depends on how you work as well as the kind of flux you use. Some flux can be spread on liberally and will be fine while you finish soldering. Other brands evaporate quickly, so you need to keep applying small quantities. Generally, it's better to apply small amounts as you work.

Too much flux can cause numerous problems. An old "trick" to avoid putting on more flux than you need, is to cut the bristles on your flux brush. Take a pair of scissors and cut them to half the original length. It will then only pick up half as much flux. Flux brushes were originally designed for paste flux and for liquid flux they absorb too much.

Kinds of Flux

Most of the flux used by glass artisans is either organic (based on Oleic Acid) or inorganic (based on Zinc Chloride)

- **Liquid flux** is the most widely used for stained glass work. It's easy to apply and spread with a brush and it washes off easily. Most brands contain detergents so you can clean it off by just rinsing with water. This is especially helpful in 3D work where you might not be able to reach everything to properly clean it. The drawback of liquid flux is that it'll get into all the cracks in came or channel and be difficult to wash out. Any uncleaned or unneutralized flux residue might come out later to contaminate your work.

- **Gel flux** is becoming increasingly popular because it stays in place where applied and won't run all over your work like liquids. You'll use less flux and it will produce less fumes while soldering. Gels fluxes are however a lot more difficult to clean than liquids and can be a problem to clean off some work.

- **Paste flux** has been used for many years and is still preferred by many artisans for working with lead. Because it's the most difficult to clean, it's rarely used for foil work. It can be cleaned from lead work by scrubbing with whiting or sawdust.

- **Tallow** is perhaps the oldest kind of flux used for lead work. Tallow is often considered the best choice for repairs on old lead.

Flux

What's Best?

Obviously there's no one flux that works the same for everything. You might prefer liquid for 3D, gel for flat foil work, and paste for lead. You can use the same flux for everything, but it'll be easier to clean (and less work) if you use the one best suited for what you're doing. One brand of flux might be very strong and just the thing you want for soldering copper, brass, or zinc but produces vicious fumes. Another brand might be almost odor free but be almost useless on metal - or it might evaporate so fast you must keep reapplying more as you work.

You might prefer the convenience of using one flux for doing everything, or using a different flux for each application.

Generally, you'll find that if a flux is corrosive enough to work extremely well, it will produce some extremely nasty fumes. If a flux produces little or no fumes, it will often be too weak to be a really effective flux. If it's easy to work with, it might be difficult to clean off. The flux that is easiest to wash off, might smell horrid when you solder. You'll have to compromise. Test drive as many different kinds and brands as you can before deciding which you prefer.

If you're lucky enough to discover one that works pretty good for everything, please let me know so I can try it. All this compromising can get irritating.

Flux Fumes

Carefully read the article on flux fumes on page 7 in the Safety chapter. These fumes can be the most serious health risk from stained glass work and you should take precautions to protect yourself. The level of fumes produced should be an important consideration when deciding which flux you want to use.

Flux and patina can seriously damage septic fields. If you're draining into one, you should carefully neutralize with ammonia or baking soda before washing off the flux.

Flux will irritate an even small scratch and cause infection If you don't like to wear gloves, either apply "liquid skin" or use a band-aide for even small scrapes.

Rubber & vinyl disposable gloves can be bought in most drug stores. Don't buy too many until you've tried them. Many people are allergic to latex, and some vinyl gloves will dissolve in contact with liquid flux.

Flux is a corrosive acid that will damage any tools it comes in contact with – even the most expensive ones. It's a good idea to buy cheap disposable hand tools for when they will get covered in flux.

Soldering

The best part. It not only holds everything together, it hides all the mistakes.

Kinds of Solder

Pure lead melts at 621º F. Most solder used by glass artisans is a mixture of lead and tin. The melting temperature of solder depends on the amount of tin it contains. The lower the melting temperature, the quicker the solder will set. Solders that melt at higher temperature will stay molten longer. These allow you more time to work with them before they re-solidify. Solders that melt at a lower temperature will set quicker. Some common compounds, and their melting temperatures are listed below:

30/70 30% tin 70% lead melts at 496º F 258ºC
50/50 50% tin 50% lead melts at 421º F 216ºC
60/40 60% tin 40% lead melts at 375º F 191ºC
63/37 63% tin 37% lead melts at 361º F 183ºC

There's very little difference between brands of solder. Just be sure you use a brand that uses 100% virgin lead. Some brands contain recycled materials. This will contaminate your work.

Lead-free Solder

Some glass artisans prefer to work with lead-free solder. Either because they're concerned about working with lead, or they're worried about something becoming contaminated by the lead. Lead-free solder comes in a variety of compound mixtures and melts at approximately 430º F (221º C) Not all lead free is non-toxic. Some brands contain highly toxic elements like cadmium or antimony. If you decide to use lead-free take care to select one that contains only tin, copper and silver. Many users of lead-free solder complain that it doesn't take patina as well or finish as smoothly as lead compound solder. It also requires working with a hotter iron to produce a smooth finish.

Soldering Iron Tips

Some of the older irons, and a few of the very large wattage irons, use a bar of solid copper for soldering tips. These must be kept constantly tinned as you use them. Most of the irons we use for stained glass work are made pretinned. It's still a good practice to keep these tips retinned. Your soldering iron tips will last much longer if you clean them and recoat them with solder just before turning them off.

Some models of soldering iron use a tip with a built in temperature controller. These tips ensure that the temperature will not exceed the preset temperature setting. If you want to work at a different temperature, you must change to a different tip. Other models rely instead on an external device to control the temperature level. This allows you to change your working temperature without changing the tip. If your iron uses tips with built in temperature control, you should NOT use an external controller.

Soldering

What Size Iron?

That depends on how much soldering you do and how fast you need to work. If you're only doing a few small projects as a hobby, a small 80 watt iron will be enough. If you're a professional artisan concerned with getting the job done quickly, you might want a 250 watt monster.

The biggest difference between different size irons is how long they maintain power. A small 80 watt iron will only be able to maintain temperature for a minute or so of soldering. A 100 or 120 watt iron will keep going for several minutes before losing temperature. The really big ones can go for almost as long as you can hold one of those heavy beasts.

A smart guideline is to get the biggest iron you think you might need, not the smallest you think you can get away with. It's a lot easier to work with an iron with too much power than deal with the frustration of one with too little power.

Temperature Control

Many people like to use external temperature controllers for soldering. It allows them to set a lower temperature for working with lead, a slightly higher one for soldering beads on foil, and a still higher one for wire and zinc. Others prefer to avoid changing settings and do everything at the same temperature. Instead of varying temperature, you can learn to vary the speed at which you solder. To solder lead, just make a very quick contact. To produce solder beads on foil, run the iron steadily along the seam. For zinc, brass, or copper hold the iron in place until the solder runs. Even thin lead can be safely soldering at over 1000º F. It just takes practice

It's best for beginners to start by learning to work at lower temperatures, then gradually work their way up by experimenting with higher temperatures. Like everything else, it's a matter of personal choice. However, there is one important difference. Soldering at higher heats definitely produces better beads on foil work. At higher temperatures, your beads will be smoother and more consistent. You'll also be able to produce a finished bead with a single pass.

When soldering, heat is your best friend. Let that friend work for you.

Keep Your Tip Clean

Perhaps the most common problem people have when soldering is the buildup of crud on the soldering tip. Some clean it by dipping the hot tip into flux. This works, but the thermal shock will damage the tip, produce vile fumes, and contaminate the flux. Not a good idea! Some like to clean the iron tip with a block of Sal Ammoniac. This works, but when used straight it can also damage soldering iron tips. A better way to use Sal Ammoniac is to cut off a piece about the size of a sugar cube, dissolve it in about 2 ounces of water, and dip the tip in that solution.

A simpler and equally effective way to clean your tip is to frequently wipe it with a damp paper towel. Doing this regularly will avoid crud buildup and increase the life of your soldering iron tip.

Soldering

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Soldering Methods

There are three basic methods for soldering. Each method has advantages. Whichever method you choose to work with, don't forget that strength is more important than looks. The most effective way to get both strength and good looks is to learn to solder as quickly as possible. Whether it's spot soldering lead together, or running a bead on foil, your goal should be to finish it with your first effort. The more times you go back over it to correct or adjust the solder, the more likely you will produce defects. Try to get it right the first time.

- **Dab method** is using the hot iron to pick up solder than dropping it onto where you want to solder. This is used for soldering seams on lead came, zinc channel and for attaching wire. It's also a great way to fill in gaps. Dabbing is also used by some artisans to deposit blobs of solder on foil seams to be spread out with the trowel method.

- **Trowel method** is using the iron to push molten solder along like a trowel is used to push plaster. The iron can be held vertical (straight up) or horizontal (sliding sideways). This is one of the easiest ways to learn to solder but is extremely difficult to control the amount of solder applied. It usually requires several passes to produce a finished bead. Whenever you have applied too much solder, you'll have to trowel it out of the way. You can vary how you trowel by using different positions on the soldering tip. That flat face is hotter than the edge or tip.

- **Draw method** uses the iron to pull or "draw" the solder. The iron is slid flat along the seam on its flat face while the solder is melted onto the opposite side. The hot iron draws the solder as it deposits it. This is more difficult to master than trowelling, but is quicker. By properly co-ordinating the flow of solder with the draw of the iron, you can produce a finished bead with your first pass.

Soldering Mirror

The major problem with soldering mirror is that the flux can creep in behind the silver backing and damage it. To prevent this, you can paint a strip along the back with clear lacquer or nail polish, or you can spray the entire back with clear lacquer. Be sure this painted strip is wide enough so you don't spread flux past it. You can avoid scratching the back of the mirror while you're soldering it by placing a clean piece of paper or cardboard under it. Paper towel or newspaper works great.

Edge Beading

When first learning to solder, edge beading probably gives beginners more frustration than anything else. It requires dabbing on small quantities of solder, then spreading it out to produce a smooth finish that looks like a soldered bead. It's tricky and takes patience and practice. One thing that can help, is to wrap a piece of wire around the outside of the suncatcher. Spot solder it in place, then rotate the piece, while soldering a bead over the wire. It will be easier to produce a clean edge bead if you solder at a low temperature setting, or use a fast setting solder. Another alternative is to not edge bead at all. Doing it produces a rounded edge. There's no reason you can't leave the edge square and just tin it, or wrap it in thin lead came. It's your choice – there are no rules.

Soldering

Electrical Tape

The more 3D glass work you do, the more you'll love this stuff. It's without compare, the best material for holding glass together while you solder it. Scotch tape won't stretch and it leaves a reside. Duct tape will stretch but also leaves a residue. Masking tape will release as soon as it comes in contact with flux. Plain old black cheap electrical tape works the best. It can be easily removed without leaving a residue, it will hold even when soaked in flux, and it stretches as needed.

Filling Gaps

Don't be too worried if your pieces don't fit perfectly together and you have some gaps. Foil work should NOT fit snugly together. Ideally, it should have about 1/16" to 1/8" gaps between each piece. The solder between each piece will provide both a cushion and a bond with the other side. Most gaps can be filled by dabbing bits of solder into them. Be patient when doing this. Wait for the first dab to set before applying the next one. Blowing on it helps it to set quicker. If it's a really big gap, you might first fill it with something before soldering. A piece of lead or wire will work great. To prevent molten solder from pouring out the other side, place a damp paper towel, or piece of electrical tape underneath.

Prebeading

When soldering copper foil, some artisans like to first run a flat bead of solder, than go back after and run the finished bead over it. If you have large gaps, you must fill them before you can run a bead. Otherwise, prebeading is just a waste of time. Your goal should be to produce the finished bead with your first pass.

Cleaning

When you've finished soldering, you must thoroughly clean your work. If you used liquid flux, you usually only need to rinse it off. More thorough cleaning is needed for gel or paste flux.

To clean foil work, wash carefully with detergent. Of all the brands I've tried, "Dawn" liquid or "Simple Green" has worked the best.

For lead you can clean off the solder by scrubbing with whiting (Calcium Carbonate) or fine sawdust. You can scrub and wash carefully and still leave some residual flux in cracks. This may come out later to produce unattractive oxidation. To avoid this, you must neutralize the acid in the flux. Whiting will do this, but it's messy to clean off. There are several brands of liquid compound "Neutralizer" sold for glass work, but an increasing number of people have discovered that liquid Ammonia works very well as a neutralizer. It's just too bad it smell so awful

Wearing Gloves

Some artisans like to wear gloves to protect their hands while soldering. Latex or vinyl are the most common choices, while a few use cloth gardening or painting gloves. Many users are allergic to latex. Cloth gloves are better protection from hot solder, but will become quickly soaked in flux. Latex or vinyl protect against flux, but are likely to melt on contact with molten solder drops. The majority prefer to work without gloves. Try working with and without gloves – then decide for yourself.

Soldering

Soldering Problems

- **Flux splatter**
  If your flux splatters, or if you're getting geyser-like air bubbles while soldering, you might be applying too much flux. If you use a flux brush, cut its bristles to half the original length. You'll then only pickup and apply half as much flux.

- **Solder is rough instead of smooth**
  Your soldering iron is likely not hot enough to melt the solder and make it run as smooth as it should. Increasing the temperature of your iron will make the solder run smoother.

- **Solder is running too much**
  This could be because your iron is too hot, but it's more likely that you're holding it in one place for too long. Practice soldering faster.

- **Solder is not bonding**
  This could either be that you haven't applied enough flux, or you're not holding the iron in place long enough for the solder to adhere.

- **Crud in solder**
  Contamination in either the solder or the flux can produce black crud in the solder. Check to see if your solder uses virgin lead and if your flux is dirty.

- **White dust on solder**
  This is oxidation, usually resulting from inadequate cleaning.

- **Glass cracks while soldering**
  You're probably holding your iron in one place too long, or you're getting cool drafts on the glass while soldering.

The "trick" to soldering is getting the hand holding the iron to work in partnership with the hand holding the solder. The object is to have this team so well co-ordinated that you complete the job on your first effort.

When soldering a bead on foil with a chisel tip, don't stop soldering at seams. Instead turn the tip sideways and keep going through the seam.

Whichever method you prefer using to solder, remember that you're NOT working with a paint brush. It's an iron for melting metal. Hold if firmly in place. A gentle touch makes messy solder.

Small stained glass items can be safely washed in your dishwasher.

A garden hose with a soap-filled car washing brush works great for cleaning large stained glass panels or lamps

When soldering foil overlay, be extra careful to not solder so much at a time in one place that you heat up the glass enough to crack it. Keep the iron moving steadily and do just a little bit at a time.

Patina

Bold, black, and beautiful

When to Patina?

Whenever you want to. There are no rules - use it or not as you like. Some people like the look of natural lead, while others prefer it darker. Lead will by itself darken with age, but applying patina will make it turn dark immediately. Using patina on solder will make it look more like lead. A dark patina will also make the colors in the glass stand out. You can patina zinc, but it almost never comes out a uniform color unless you first tin it with solder. If you want to tin zinc, it's a lot easier to do it with a propane torch than a soldering iron. Either way is a lot of work just to make zinc appear darker. Many artisans prefer instead to just paint it.

Applying Patina

Patina produces its color by causing a chemical reaction between the metal and the patina. It's critical that you thoroughly neutralize and wash off any flux residue before applying patina, or the flux can contaminate this reaction. If you apply the patina within a few days after soldering, it's not necessary to clean the solder. If it's been sitting long enough for the solder or lead to begin oxidizing, you should first polish it with either fine (0000) steel wool or with a nylon scrubbie pad.

It's important to scrub the patina on quickly, then wash it off as fast as you can. Some glass (Spectrum white and most irridescents for example) will become stained with what looks like an oil slick if the patina is left on for more than a few minutes.

A good way to quickly apply it is with a piece of sponge or a brush. You can cut cheap kitchen sponges into one inch cubes. These sponge cubes are great for scrubbing the patina on, and they're cheap enough to junk after each use. As soon as you've completely applied the patina, scrub along all the lead or soldered seams with a soft bristle brush (old toothbrushes are perfect). Then thoroughly rinse off all the patina.

Making Your Own Patina

You can make patina by dissolving Copper Sulphate crystals in Muriatic Acid. It works fine but smells horrific. It's also dangerous stuff to work with. Patina is not very expensive. If you're worried about the cost, buy it in gallon jugs instead of making your own. The ingredients are toxic and corrosive. The potential for harm from working with them is too great to be worth the small savings from making your own patina.

Patina

Waxing Patina

Many glass artisans apply wax over the patina to protect it. Several varieties of wax are sold at glass supply shops, or you can use any carnuba wax. "Turtle" car wax is one of the most popular. Just brush it on with a toothbrush and polish with a soft cloth or soft bristle brush. Before deciding to apply wax, remember that if the solder underneath it oxidizes, it'll be a lot of work to remove the wax to clean it.

Neutralizing

It's essential to thoroughly neutralize before and after applying patina. You must remove any residual flux before you patina, and neutralize the acid in the patina after applying it. There are several brands of neutralizer solutions on the market that all work well. You can also make your own neutralizer by using either baking soda or liquid ammonia.

To neutralize with baking soda, first rinse off the patina, then while it's still wet, liberally sprinkle baking soda over it. Scrub it thoroughly with a soft bristle brush – taking particular care to scrub along the lead and solder seams. Now wash it off with soap and water. This is messy and a lot of work. That's why so many artisans prefer to use ammonia. Wash with a diluted solution (about 4 parts water to 1 part ammonia). This can be a tear producing experience (like peeling onions), so it's best to do it as quickly as possible. Ammonia is usually the most effective and thorough way to neutralize both flux and patina.

Black Patina

There is no truly black patina – only gray. Some brands are darker than others, but none are actually black. If you want your patina slightly darker, add a small amount of salt. Black patina will work well on solder or lead, but poorly on zinc. To patina zinc, you should completely tin it then apply the patina. Alternatively, use black paint or stove black.

How long you should leave patina on varies between different brands and where it's applied. On solder, the color sets almost immediately. On lead, it often must be left for 24 hours to fully set, or you'll remove much of it when you wash and wipe. This can be a problem when working with some of the types of glass susceptible to damage from patina, as described in "Applying Patina".

Copper Patina

Copper patina is finicky. Almost everything seems to affect it in some way to spoil the color, but there are a few things you can do to improve your chances of a good looking finish.

Before applying copper patina to a panel or lamp, it's essential that you thoroughly neutralize it then wash it clean with nothing else but soap and water. Don't wipe it off, but allow it to air dry instead. Put the patina on with a small brush or a Q-tip – try to avoid stopping between solder seams. When it's completely dry, polish it with a soft cotton cloth or a buffing wheel. Be careful to not press too hard - it's easy to rub off. Leave it to set for 24 hours then wash clean with warm soapy water.

Patina

Stove Black

An attractive alternative to black patina on lead is Stove Black. Some glass shops carry it, or you can find it at shops that sell wood stoves. It comes in both paste and liquid form and can be brushed on. An old toothbrush works great. Just scrub it on, making sure you get it into all the cracks and corners. Allow it to thoroughly dry, then polish it with a brush (an old shoe brush is great) or with a small buffing wheel on a Dremel. When you're satisfied with your polished shine, wipe off the excess with a damp cloth.

Stove black is filthy to work with. Wear old clothes. If you're using textured glass (like glue chip) cover it with masking tape to avoid having to clean it out of all the cracks.

Gun-blue

You can produce an attractive gunmetal color finish on lead or solder by applying gun blue. If you plan to work with this stuff, do it outdoors or somewhere extremely well ventilated. The fumes are vicious. Brush it on carefully in small quantities, and buff it to a shine as you go. Don't slop this stuff on and spread it around the way you can with patina. Gun blue dries fast and will be very difficult to polish if you don't do it quickly.

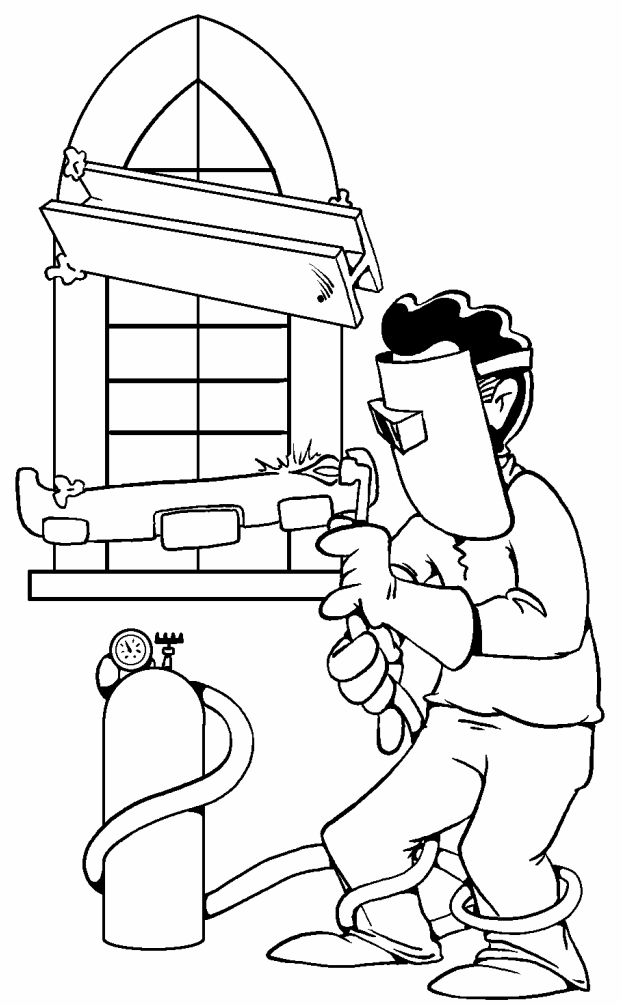
Patina Problems

- **Rust stains** can result from traces of water left on the glass or under the seams. It's important to thoroughly dry before applying patina.
- **Oil slick stains on glass** are usually from leaving the patina on too long.
- **White powder on patina** is oxidation. It's common, and can usually be polished off by scrubbing with a soft bristle brush. High mineral content in your water can cause severe oxidation. You might consider washing with bottled distilled water.
- **Uneven colored patina** is usually because you didn't rub it in sufficiently. You should scrub or rub it vigorously as soon as it's on.
- **Old patina.** Patina is a compound of copper sulphate crystals dissolved in a solution of water and nitric or muriatic acid. In time, these crystals can separate and settle to the bottom. If you think this has happened, or just think your patina is fairly old, all you need to is stir it before using it.

Patina is nasty stuff. Wearing some form of apron when applying it is a good idea. ALWAYS wear gloves when applying patina.

Waxing patina will slow down oxidation, but it won't stop it entirely.

Reinforcement



Sometimes it just needs a little extra help.

Types of Reinforcing

Reinforcement for stained glass windows is called “rebar” - a short form “nickname” for reinforcing bar. It can be anything that is used to strengthen, stiffen, or reinforce a window. Iron, steel, copper, brass, or zinc is often used. Rebar can be installed outside the window and attached to it, or it can be built into the window panel itself.

Saddle bars are flat or round bars placed across a stained glass window and attached to it with lead or copper wire. Saddle bars are usually set right into the window frame. They don’t strengthen the window, but are used to stiffen and prevent it from bending. Saddle bars are rarely used today for installing windows but were common when stained glass panels were installed as single-glazed windows exposed to the effects of wind and rain.

Flat bars can be ran across the window and soldered to each seam. Thet are often mounted right into the window frame. For small and medium size windows, usually these bars are all that’s needed for reinforcement. The disadvantage to using such bars is they are usually unattractive Having a bar run across the window in the middle of a section of glass can be pretty unsightly. For windows that are installed in sections, flat bars are an excellent way to reinforce at the seams between each section.

Fins are thin strips of copper, brass, or even lead, that are bent to follow the lines of the lead or soldered seams. These are soldered direct to the window and will stiffen and strengthen a window. Because the fins follow the seams, they don’t interfere with the appearance of a glass panel by running across a section of glass.

Internal reinforcing can be either wire or thin strips of metal (like fins). These strips can be inserted inside lead came or between pieces of foiled glass to stiffen a panel. Brass or copper wire can also be soldered onto lead or soldered inside the solder bead on foiled panels.

Reinforcement

When to Reinforce

It depends on the design as much as the size. Some factors that increase the need to reinforce are:

- **Hinge points**. Even relatively small panels should be reinforced if the design has some part that is likely to bend or hinge. A long straight seam would be a likely hinge point. The greater the likelihood of hinging, the greater the need for reinforcement. To determine if you have a hinge point, imagine the way a bifold door folds at its hinged seam. Do you have any place in your panel where the glass could hinge in this way?

- **Leaded panels** usually requires more reinforcement than those made with copper foil. The soft lead allows the panel to flex and bend more easily.

- **Sturdy frames** reduce the need to reinforce. The stiffer and stronger the frame, the less reinforcement will be needed. The heavier the frame, the less reinforcment will be needed. For panels with one dimension 12 inch or less, all that is usually needed is to frame it with zinc channel.

- **Long lines** in the design increase the need to reinforce. Even gently curves can produce hinge points.

- **Exterior exposure** increases the need to reinforce. If a panel is installed as a single glazed window, it will need a lot more reinforcement than if it's installed sandwiched inside a multi-glazed sealed unit window. If it's installed on the outside of a building, it'll need more than if installed on the inside of an existing window.

There are too many variables to have any fixed rules for reinforcement. The final decision as to were reinforcement is need is up to the individual artisan. A rough guideline that might help you make this decision is to provide some form of reinforcement every 12 inches for windows installed outdoors, and every 24 inches for those installed inside.

It's a smart idea to plan for reinforcement needs when you design a window instead of after it's built. Often a very small design change can save a lot of time and materials in reinforcement.

It's easier to avoid having hinge points than it is to reinforce them.

Instead of having to protect dangerously shaped pieces from stress fracture, eliminate them from your design.

Take care when soldering on reinforcement to not apply so much heat you crack the glass.

Wire will work well to keep a panel from pulling apart but will do almost nothing to keep it from bending or flexing.

The more places reinforcement is attached to the panel, the stronger the panel will be.

Installing

Now that you've built it, who's going to put it in?

Thermal Shock

When the temperature at one point in the glass is different than at another point, it produces "thermal shock". If there's enough difference, the glass will crack. A slight breeze on glass that has been heated while soldering, can cause this. Soldering cold glass is a quick way to discover the effects of thermal shock. Installing stained glass where it will be warmer on one side than another is almost guaranteed to produce thermal shock. A good example of this is a fireplace screen. One made from stained glass will look great, but if you light a fire it'll probably crack. Where glass will be subjected to thermal shock, you should use either tempered or pyrex glass.

Multiple Glazing

Commercially made stained glass windows often sandwich a panel between panes of clear glass in a thermally sealed unit. This is not a job to undertake yourself. Far too many things can go wrong. If you want your panel installed this way, take it to a skilled professional with the right equipment to do it properly, but first you might consider the potential drawbacks of multiple glazing.

- **Heat build up** inside these windows can cause small amounts of putty, flux, or patina to drip down and discolor the glass. It can also melt the glue behind copper foil and cause it to run down looking like an oil slick. If anything like this happens inside that unit, you can not clean or repair it.
- **Condensation** can build up inside sealed units. Even in outrageously arid Arizona, this can be a problem.
- **Glare** from the clear window pane will distract from the appearance of the stained glass panel. It will look fine when viewed straight on, but when seen from an angle, you're more likely to get a glare reflection from the interior glass.
- **It's not removeable**. Once it's installed inside a thermal unit, you can't remove it for repairs or if you move to a new residence and want to take it with you.

Expansion

Glass will expand slightly as it warms, and contract when it cools. If you install a glass panel too snug without allowing for this expansion, it's likely to break. You should leave a MINIMUM 1/8" on ALL edges when installing a panel.

Installing

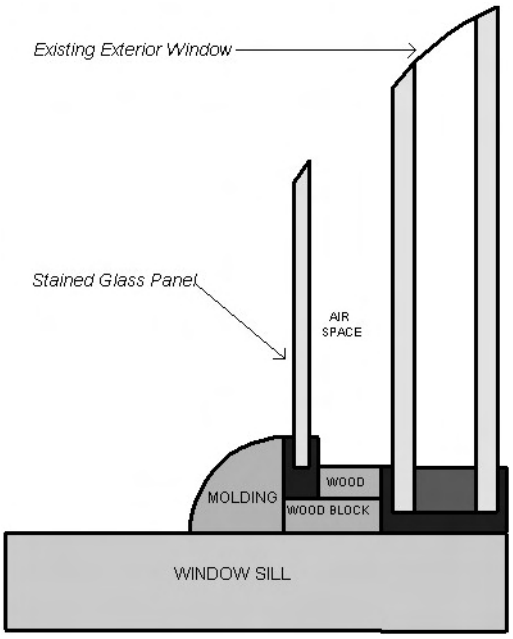
Installing a panel

Installing a stained glass panel into a frame opening is simple. Just position it in the frame opening and hold it in place with either mechanical fastenings or molding. Anything that keeps it in place works. It's not a good idea to glue or caulk it in. You might someday want to remove it for repairs or take it with you when you move.

Unusually large windows are usually fabricated and installed in sections. The seams between sections is a convenient place for reinforcment.

Installing a stained glass panel into a window frame against an existing window is more difficult. It should be AT LEAST ¼" away from the other window and should not be caulked or sealed in place. To ensure that condensation won't build up between your panel and the other window, you must provide for ventilation between them. The panel can fit fairly snug on both sides, but should be AT LEAST ¼" up from the bottom sill and ¼" down from the top. This will allow for air to flow in the bottom, up behind your panel, and out the top. The easiest way to finish off a panel installed this way is with wood molding. Drill holes or cut saw kerf notches in the molding on top and bottom to provide the needed ventilation. I suggest either drilling ¼" diameter holes every 3 inches, or make a 1/8" wide x ½ inch deep saw cut every 2 inches.

The diagram to the right shows a cross-section of how you might install a panel against an existing window. The wood blocks shown in the diagram need only be about 1 inch wide and spaced about 12 inches apart.



If you aren't positive about the correct size of the opening, or if you suspect it's not perfectly square, it's a good idea to use "H" or "Y" lead for the panel frame so you can trim it if needed.

If you're confident of the correct size, it's always better to frame a stained glass panel with zinc.

When you install a panel, you should always remember that it might someday need to be removed.

Repairs

If you can build it, you can fix it.

Bowed Windows

Single-glazed windows without adequate reinforcement will often bow. They are drawn towards heat. Windows facing south will bend outwards towards the summer sun. Those installed facing north will bend inwards towards the interior during the winter. Often these bowed windows must be completely dismantled for repair, but sometimes you can straighten them back out. Remove the window and lay it flat with the bow facing up. Place a heating pad or electric blanket over it with a sheet of plywood on top. Leave if for 24 hours (or longer if needed). The heat will soften the lead, and the weight of the plywood will straighten it. When it's satisfactorily straightened, re-solder any cracked seams, re-caulk as needed, and reinstall it. Don't forget to add reinforcement so it doesn't bend again.

Repairing Scratches

Scratches can be polished out with Jewellers Rouge. It takes a LOT of polishing to remove even a shallow scratch, and will always leave a distortion in the glass. It's almost always much less to work to replace the piece than to polish out the scratch. If you can feel the scratch with your finger, it's not worth the effort to repair. Replacing the piece will be much less work.

Foil Repair Methods

- Remove the damaged piece. Score it with a "starburst" shape (that's an x on top of a +) to divide it into small pie shaped pieces. Turn it over and tap to run the scores. Gently remove each piece. Heating the foil at the end of the piece will dissolve the foil glue and allow it to come out easily.

- Remove any leftover foil. Hold an end of the foil with tweezers or needle-nose pliers and pull it gently away while heating with the soldering iron. Use the iron to melt the solder so the foil can pull away without displacing the foil on adjoining pieces. Don't worry if you accidently remove some foil from an adjoining piece. Just clean it off, and patch on a bit of foil as needed.

- Use the opening from the piece you removed to draw the pattern for a replacement piece. Cut and fit the replacement piece.

- Solder the replacement piece.

Repairs

Lead Repair Problems

Removing old dried caulking or putty can be tedious and time consuming. It helps if you first soften it with liquid ammonia. In the past some strange compounds were use to caulk windows. Even cement. If the ammonia doesn't work, wrap it with clothes or newspaper soaked in kerosene. If that doesn't work, you're screwed.

You should keep in mind when repairing lead, that it's always a lot more work to replace lead than to repair it. It's often easiest to dismantle a window and rebuild it with new lead. If you decide to dismantle the window, make a careful tracing of the pattern, and number each piece of glass as you remove it. That'll help you remember where each goes when you reassemble the window.

Lead Repair Methods

Foil back method

- Remove the damaged piece.
- With a sharp knife, slice the lead in half down to it's heart and remove the part of the face that holds in the replacement piece.
- Cut and fit the replacement piece. Foil this piece with a foil size that the face of the foil will match the size of the lead you've removed.
- Solder the piece in place. The back of the piece will have a soldered bead to approximate the look of the lead on the front.

Insertion Method.

- Remove the damaged piece.
- Without disturbing the lead came, draw a pattern of the piece to be replaced. Make the replacement 1/16" larger in all dimensions than the opening in the lead
- Install a thin strip of caulking inside the lead this is to go into. Slide the replacement piece into one corner of the came - as far in as it will go. You should now be able to drop the replacement piece into the opening.
- Gently slide the piece towards the opposite side until it is the same distance in on all sides. The idea is to "jiggle" it around until it is inside the lead the same amount on all sides. The caulking will hold it in place.

Replace lead method

- Remove the damaged piece and cut away the lead the same as above.
- Cut and install the replacement piece.
- Cut pieces of lead to replace the face parts you removed. Solder them in place.

When scraping out old putty, ALWAYS wear a dust mask. Your scraping will also be producing fine lead dust for you to inhale.

It's often less work to dismantle and rebuild a panel than it is to repair it.

Handling

Try not to break it after spending all that time building it.

Transporting Glass

Whether it's just a few sheets of art glass or a large finished panel, you'll want to take precautions to ensure it arrives at its destination unbroken. If at all possible, glass should always be carried on edge and braced so it can't move. If for any reason you must carry it flat, be sure to lay in on something solid (like a sheet of plywood) to spread its weight over a large surface area. That way the impact from any bounce or bump will be spread over a large enough area to not break the glass.

Glass is strong but it's brittle. Sometimes it takes a lot to break it, but other times the slightest impact will crack it. I've dropped a piece of glass onto a concrete floor and watched it bounce and not break. Other times I've had a piece fall over onto the wood top cutting table and break into a dozen pieces. Whenever you're handling glass you should take precautions to prepare for the worst.

Don't forget that glass is heavy as well as brittle. I once lost two full cases of glass because I forgot about the weight. I'd unloaded all 110 sheets of 24" x 48" glass and stood it neatly in the back of my van. To be sure the load couldn't move, I tied it tightly in place with 3/8 inch rope. There's no way I wanted that load to move.

About the 3rd or 4th corner I took, produced an enormous noise from the load of glass. I'd forgot that 110 sheets of glass weighs over 1800 lbs. When that much weight shifted, it snapped the rope as if it was thread.

Turning a Panel

When you've completed soldering one side of a panel, and want to turn it over to work on the other side, you must be especially careful. The best way to do this is to set it on a piece of plywood so you can tilt up the plywood with your panel attached. Hold them together and tilt them up to vertical. Holding the panel vertical, remove the plywood and place it on the other side of the panel. Then, with your panel firmly held against the plywood, tilt it down to horizontal with your panel on top of the plywood.

An alternative method that is okay for small panels, is to slide it halfway off the edge of your work table, then "teeter-totter" tilt it vertical. Turn it around and lean it back against the table at midpoint of the panel, and tilt it back down.

Handling

Packing to Ship

When you ship glass, you MUST remember the following:

It must not bend

Glass won't bend, it'll break instead. To prevent this, you should "sandwich" it between two sheets of some rigid material. Plywood will work, but sheet styrofoam is the best. It's strong, rigid and lightweight. I recommend either 1 ½" or 2" thick. It comes in 2' x 8' and 4 'x 8' sheets.

Styrofoam can be cut with a saw, or it can be scored and broken the same as glass. Make a cut in it with a utility knife as deep as you can. Place the sheet on a table or counter top with the cut facing upward and along the edge of the table. Then quickly press down and crack it off at the score. This is the same way a glazier breaks a scored sheet of window glass, or a drywaller breaks a cut on a sheet of gyproc. With smaller pieces, you can also just crack it over your knee.

It must not be hit

If you hit glass, you'll break it. To ensure this doesn't happen, pack it with shock absorbing material around it. I found the best material for this is the kind of soft foam cushioning used for pillows and mattresses. You can buy it by the sheet, but the shops that sell this foam often have scraps for sale. These work just as well. Take your "sandwich" and pack it in a carton large enough that there is at least 3" of cushioning on all 6 sides. You don't have to fill the entire side with a sheet of soft foam. A strip every foot or so will be enough. This will be very much like the 2x4 framework used for building houses. Just so that there is something to absorb any force that hits the outside of the carton. Shredded newsprint (excelsior), soft styrofoam chips, or "bubblewrap" will also make excellent packing material. Styrofoam peanuts have a habit of moving off to one side of a carton, and should be used only if you have your cargo firmly braced inside.

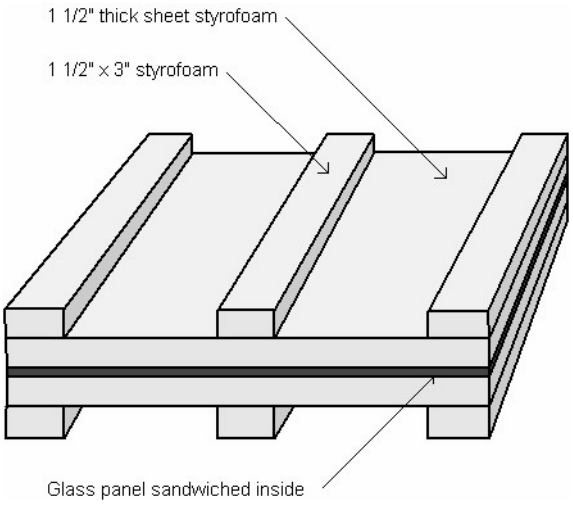
It will get dropped

The Post Office and all the freight companies use mechanical conveyor belts to handle packages. It is not uncommon to have packages drop as much as 12 feet down off the end of one of these conveyors. Your package must be able to survive this drop without damaging the glass inside.

It won't be insured

The company you ship with will probably be happy to sell you damage insurance on your shipment. But, if you ever try to collect on it, they'll probably refuse. Stained glass is usually not covered by insurance. The ONLY real insurance you'll have is the way you package it.

This diagram shows how you might build a styrofoam "sandwich" to ship a glass panel.



Teaching

A good teacher can inspire a student for life:
A poor one can destroy interest forever.

Why Teach

By now you might think you're ready to start teaching stained glass to others, or maybe you've already been giving some lessons. It's time for you to ask what makes a good teacher, and how good you'll be at it. We all know most of what makes a teacher effective. We think of such things as enthusiasm, commitment, experience, and personal skills. But, we often overlook the importance of attitude and motivation.

Why do some people teach? If you want to teach stained glass, you should carefully and honestly consider your motives.

If you operate a retail glass shop, providing classes will create new customers for your business. This is good for you and your students. But, it's a disappointing reality that about 80% of students abandon stained glass as soon as the classes are finished. If you expect all your students to buy a full compliment of tools and equipment, that 80% will have a lot of stuff they'll never use again. Is that fair? Maybe it's better for beginner students to buy only the essential hand tools (such as a cutter and breaking pliers) and whatever supplies they use for their projects. All other tools can be provided by you for the class. You'll still have the other 20% that will become steady customers after the classes, and many of these student/customers will become your friends.

Will you teach everything you know about stained glass, or do you want to keep the "good stuff" as your "trade secrets". Will you try to explain all the alternative methods and techniques you know to your students, or will you insist that they learn only your personal favorites? Will you demand they do everything your way, or encourage them to experiment with different things? Will you teach them to go out and fly on their own?

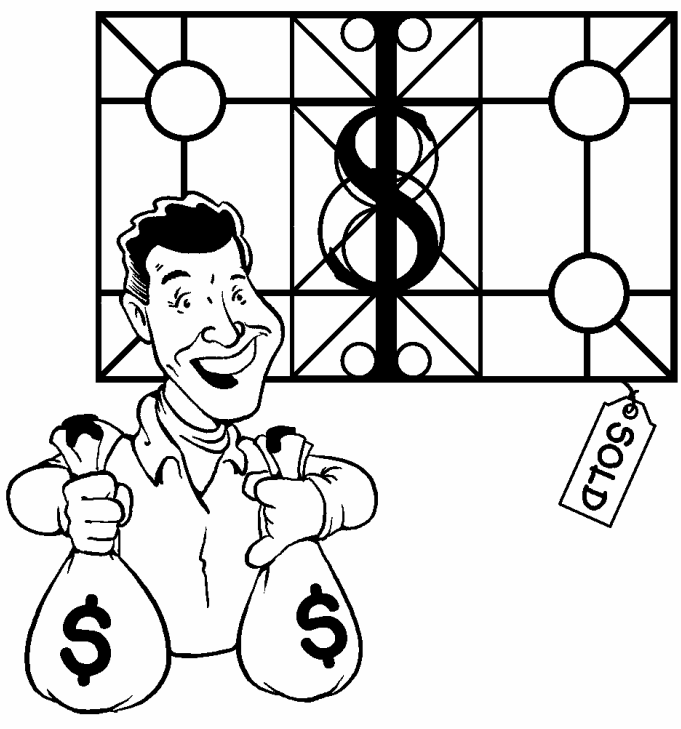
Perhaps the mark of a good teacher comes down to two simple guidelines:

Teach first - sell second.

Teach everything you know.

There are many stained glass teachers whose primary motivation is greed. I hope you never become one.

Selling



Buying your work is the highest compliment someone can pay you.

Selling Your Work

Few things are as personally rewarding as selling something you made. Another person is willing to trade their hard-earned money for something you produced. They didn't just tell you how much they liked it, or how good they thought it was. They bought it! Could any praise be higher, or any critical comment be more meaningful than that?

Each of us needs to feel that what we do has value. Selling your work fills that need. It's unfortunate that selling your work can become habit forming. You might start with a few small suncatchers sold to friends, then it's a small window commission, then it's a Craft Show, then before you know it – you're addicted.

Some glass artisans argue that selling your work is prostituting your art. Maybe it is, but so what! Everyone works for pay, but not everyone gets to be paid doing what they like.

I started stained glass as a hobby and loved it so much I decided to make it a profession. At first, I planned to become an artist so renowned that people would come to throw roses and $100 bills at my feet, just to look at my work. It turned out I wasn't that good, and the best I could expect was an occasional posy and a rare $10 bill. Then, I decided to become a crassly commercial hack and make enough money to be richer than God. It turned out that Bill Gates had already done that.

The only choice left for me was to earn enough to comfortably support my family, live anywhere in the world I wanted to, work only when I choose, travel extensively, take LOTS of time off, and love what I did. Third best isn't that bad. It worked okay for me and I'm lazy. It's likely to work even better for you.

Commissions

Most of us start selling our work when a friend asks, "Can you make me a ……? It's a good friend, so you just charge a few dollars. You didn't earn much, but it IS your first commission sale. Many of the glass artisans that produce elaborate and expensive windows started by just such small commissions. Doing these can both personally and financially rewarding. Unfortunately they're usually not steady and consistent enough to provide a reliable income. Commissions are fine if you just do them part-time, but if you plan to make stained glass a full-time job, you'll need something else to fill in the between commissions time.

Selling

Pricing for sale

Learning to accurately price your work will take longer than learning to cut, solder, or any other glass skill. But it is a skill that you can learn like any other.

It's surprising how few "professionals" have not learned how to price. Many calculate their prices per square foot. They might charge $80 for a simple design, $120 for average designs, and $150 for something complicated. This is a dumb formula. It's okay for a rough guess, but it's never accurate for a final price. Such "estimating by average" might be okay if you have no competition and will get every job you bid on, but you won't. Your competition will get the jobs on which you price too high, and when you price too low you'll get the job but wish your competitor had.

Practice and experience will teach you the many variables that affect the cost of different projects. The kind of materials, techniques used, design, how fast you work, your expected income, and many other factors will contribute to deciding the final cost. It's complicated, but there is a simple costing method that will help you get started. Instead of pricing per square foot, price per piece of glass. The labor to cut, fit, and solder a small piece is as much as for a large piece. Often it's even more.

A more accurate, but still not precise, costing is to estimate the total materials cost and add a fixed price per piece of glass. For example if pricing a 24" x 24" panel with 120 pieces of glass, your estimate might be this:

Glass cost	*4.5 square feet*	*$ 40.00*
Other materials cost		*$ 10.00*
120 pieces @ $4.00 per piece		*$ 480.00*
	TOTAL COST	*$ 530.00*

If you're just starting off and work out of a home studio, you might be satisfied doing the job at this price. If you have overhead expenses from running a shop, you'll want to add a percentage to cover this. If you want to improve your income, either add a fixed percentage to the total cost, or increase the per piece price.

To demonstrate how inaccurate costing per square foot can be, compare the different costs for the same size panel, but with different numbers of pieces in the design:

40 pieces	*cost $ 210.00 = $ 52.50 per S.F.*
60 pieces	*cost $ 290.00 = $ 72.50 per S.F.*
80 pieces	*cost $ 370.00 = $ 92.50 per S.F.*
100 pieces	*cost $ 450.00 = $112.50 per S.F.*
120 pieces	*cost $ 530.00 = $132.50 per S.F.*

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Wouldn't it be better to know EXACTLY what a project costs then to just guess at it?

Craft Shows

I love Craft Shows. They're fun, exciting, educational and inspirational. You get to see lots of beautiful work and meet the people that did it. You talk to the public and learn what they like and what they want. This "first-hand" market research is invaluable in helping you decide what to do and what to make. Your creativity is energized with a barrage of new ideas and you make wonderful network connections. If that alone isn't enough, you make money selling your work.

Not all shows are great. Some are stupendous, while others a waste of time. There's no advance guarantees. I've often been surprised. A show that I expected to be terrific turned into a dud, while one that I did only as a favor to help a friend produced

incredible sales. The best way to decide if a show is worth doing is by asking somebody who has done it before. If you can't find someone to ask, the following is a rough guide to whether or not a show is likely to produce good sales.

Christmas shows are almost always the best. That's when people spend lots of money on gifts. That's when you'll sell the most of your work.

High rent shows usually produce higher volume sales than those with cheap rent. That's why they can charge you more to exhibit. If the rent is cheap, usually so are the products that are offered for sale.

Juried shows usually sell higher quality and more expensive goods. Customers come to juried shows expecting to find such work and expecting to pay accordingly for it. They don't bargain.

Admission fees to shows usually attract more serious buyers. If it's free to get in, the show is more likely to just get lookers.

Entertainment venues usually produce poor sales. The people come for the entertainment, not to buy stuff.

Church bazaars might be a good way for the church to raise money, but are rarely any good for artisans trying to sell anything but extremely cheap goods. The people who come to these shows are usually looking for bargains – not quality.

Theme shows with a special focus will often produce very good sales. For example, it you take an assortment of suncatchers and panels with cowboys and horses to a Western theme show, you'll sell them. I've had wonderful success selling my model ships at boat shows……but I doubt they'd sell well at a Western show.

Consignment

I'm generally opposed to consignment selling, but there are times when it can be useful.

You can't expect a shop owner to buy very large, expensive works, or unusual works that might take a long time to sell. They will also hesitate buying until they know your work will sell. Placing your work where a lot of people will see it, can be very good advertising. It might sell there, but even if it doesn't, a lot of people will see it.

More often, consignment is a poor idea. If a store buys your work outright and sells it, the store's markup is 50% or more of the sale. If the goods are on consignment, the sales commission is usually less than that. Often a lot less! A shop makes less money selling goods on consignment than it does buying and reselling them. Why would a store do that? Either they take consignments because they don't have enough money to buy stock, or they don't know what to buy. They take whatever they can get just to fill the shelves. The end result is very limited sales. With limited sales, these shops are often unable to pay you even after they've sold your work. Consignment shops are notorious for going broke leaving behind a collection of unpaid suppliers.

Your only advantage to consignment selling is to get a higher percentage of the retail selling price. You will be taking a huge gamble hoping to get a slightly higher percentage of a much lower sales volume – especially with the risk that you'll end up getting paid nothing at all. If you do place your work someplace on consignment, be certain you know the owners extremely well and have a written agreement with them.

If a prospective wholesale customer is nervous about trying out your product for the first time, it's perfectly reasonable for them to want the first order on consignment. Maybe a better way for you to respond is to instead offer the first order "on trial". Tell them that the first order is on a 30 day trial. After 30 days, if they aren't satisfied, they pay for whatever they sold and return the rest to you. If they are satisfied, they pay for the total order - and you now have a permanent customer. You'll find that your prospective customers rarely refuse a trial.

Selling Wholesale

For most people wanting to sell wholesale, the biggest problem is accepting that the wholesale price is half the retail price. The retail store expects to sell your work for twice what they pay you for it. You might think it's unfair that you buy all the materials and do all the work, while all the store does is leave your masterpiece on a shelf, then sell if for twice the cost. It's not unfair! It's the way business works. The store-owner has an overhead for rent, wages, utilities, etc. An overhead that continues relentlessly even on days when nothing sells. If you think retailers have a good deal, open a store.

The disadvantage to selling wholesale is obviously the lower price. The advantage is the higher volume of sales. It's hard to sell much retail, but easy to sell everything you can make if you deal with a few good shops. Selling more of your work will allow you to buy materials in larger quantities. That will reduce your costs.

If you're selling work retail while selling wholesale, it's important that you sell for the same retail price as does your wholesale customer. You can't sell something for a lower retail price than you expect them to. That's unfair competition, and it won't be long before they stop buying from you.

If you want your business to succeed, don't think of the shop owner as a customer, but instead as a partner. You make the product, and they sell it. That's a pretty nice partnership arrangement. If you help your partners with their problems, they'll help you with yours. Remember that the store owners want to buy stock and resell it as quickly as possible. Their greatest fear is that they will buy something and can't sell it. They are afraid they will have spent their money and filled up shelf space while the stock just sits there. You should understand that until they have had some experience with your product, it's natural they'll be afraid this might happen. Why not make it easy for them and eliminate that fear? Offer them a return option. Just tell them that anything that is unsold can be returned to you for full credit. You can then sell it somewhere else. Doing this builds trust. Then, whenever you introduce a new item, your "partner" will be quite willing to buy it from you. Because they trust you.

Another important consideration is credit. The store owner expects to not pay you for 30 days. They will usually agree to pay C.O.D. for the first order (or for small suppliers from whom they only buy infrequently) but they will expect their regular wholesale suppliers to grant 30 day credit. This should not be a problem. By the time you are granting credit to your customers, you should be getting it from your suppliers.

Didn't I tell you it was all about being partners?

Websites

Aanraku Stained Glass
http://www.bayareastainedglass.com
Jeffrey Castaline's San Mateo teaching studio. A fun glass forum with some truly inspiring examples of student work.

Art Glass Art
http://www.artglassart.com
Glen Copeland's site with a terrific collection of finely detailed technical tutorials.

Cole Sonafrank
http://www.elbesofester.com
Lots of great technical information, plus links to all the glass forums and over 500 terrific glass sites.

Contemporary Warm Glass
http://www.warmglass.com
Brad Walker's outstanding site. The best forum for hot and warm glass questions.

Dale Grundon Stained Glass Design
http://www.dalegrundon.com
Lots of Dale's terrific tutorials and some of his beautiful Prairie lamps.

Delphi Stained Glass
www.delphiglass.com
A good collection of tips and guides for beginner stained glassers.

Dodge Studios
http://www.dodgestudio.com
A good collection of free patterns and really helpful technical tips.

Dragonfly Software
http://www.dfly.com
Free trial version of Glass Eye 2000 computer drawing program.

Glass Notes
http://www.glassnotes.com
Harry Halem's superbly technical site on warm and hot glass.

Inland Tools
http://www.inlandcraft.com
A good collection of beginner's tutorials and helpful tips.

Mailgate (Usenet)
http://www.mailgate.org.rec/rec.crafts.glass/
Glass forum with the most comprehensive glass archives on the internet.

Silicon Folly
http://www.dmentd.com/folly/
Great tutorials and tons of unique tips for stained glass and stones. THE top internet site for stones.

Storefinders
http://www.storefinder.com
A glass forum, with a worldwide listing of stores and studios.

SG Designs
http://www.sgdesigns.com
Free trial of Rapid Resizer and Pattern Wizard computer programs.

Spectrum Glass
http://www.spectrumglass.com
One of the most comprehensive stained glass sites on the internet. Terrific technical articles and some inspiring examples of glass art.

Stained Glass Canada
http://www.stainedglasscanada.com
Great forum for exchange of ideas and collecting information.

Warner-Crivellaro
http://www.warner.criv.com
Extensive technical tips and the most popular stained glass forum on the net. Ask here and it shall be answered.

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Biography

My son Brant took stained glass in High School Art class and introduced me to it. I fell in love. Within a year, my hobby grew constantly to demand increasing amounts of my time until I had no choice but to start doing it professionally to pay for it. Along with Brant, I formed DeBrady Glass Studios. The name means “by the Bradys”. After 20 years, it’s still a family business that now includes my younger sons Jason and Dane.

We started with a few private commissions, then travelled as “gypsy crafters” from craft fair to craft fair. After a couple of years of this, I decided to put the business into overdrive. We went into production and started selling wholesale. The more stores we sold to, the more we needed to expand our ability to produce stained glass. We hired some help and kept expanding. Today we have a crew of 20 skilled artisans and ship our stained glass into more than 20 different countries around the world.

The greatest challenge was not in selling our work, but in finding ways to produce it on a commercial scale. At that time, stained glass was mostly just a hobby, with a few artisans doing personal commissions. All the techniques we could learn about had been developed for them. We couldn’t find anyone that did it on any scale other than with extensive and expensive machinery. The equipment available was either for hobby use, or for huge commercial production. The axiom “Necessity is the Mother of Invention” became our motto. We needed, so if we couldn’t learn, we’d invent. Each possible method of doing something was tried, no matter how strange it seemed. Every traditional approach was analyzed, questioned and tested. We experimented constantly with new ideas. Always our goal was to find the most efficient way to produce the finished product. We learned a lot. Now we can pass on some of what we learned to you.


THE BEST SHORTCUT IS
GETTING IT RIGHT THE FIRST TIME!