The Stained Glass Handbook

By Sam Halstead

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THE STAINED GLASS HANDBOOK

BY SAM HALSTEAD

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.

In Appreciation.

Thanks to Herald Publications of Auckland, New Zealand, who printed and published the first and second editions of The Stained Glass Handbook.

I also owe overdue thanks to Janet Matthews who typed out the original back in 1981 (before PC's), and was uncredited in the first editions.

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INTRODUCTION

Throughout most of the history of stained glass, designers have concentrated on a pictorial approach where the glass was used as a "canvas" to which paints and stains were applied. In medieval times, before the printing press, windows were designed as Bible illustrations. Nowadays, visitors to famous gothic cathedrals come away dazzled by the light, the feeling, the colors, and the hour by hour changes in effect. The subject matter becomes secondary to the architectural effect of the glass. Many contemporary designers understand that the main effect of stained glass is the way it changes the light and mood inside a building and they allow it to be abstract enough to invite interpretation and reflection. They try to be true to the inherent qualities of stained glass rather than forcing it to be something it is not.

While stained glass has plodded along behind popular art movements for centuries, there has been a resurgence of interest over the last few decades. Even so, there still remains a danger of craftspeople abusing the medium through lack of understanding of its true nature. The natural beauty of the material can often hide or outshine bad design and workmanship.

If stained glass is going to regain a standing amongst the arts, our work must show a higher regard for composition, be a significant vehicle for self-expression, show a spirit of innovation, and demonstrate that we have a full understanding of the medium. The temptation to use exotic glass and a range of "gee-whiz" techniques must be tempered by the desire to do justice to the buildings in which our work will be installed. There is no reason to perpetuate dated styles or copy from pattern books when there is so much else we can do with glass.

The first step to becoming a stained glass craftsperson is obviously to learn the rudimentary construction techniques. If you desire to be an artist, this should be accompanied by a study of other art and design, including glass art, and a personal search for relevance. The more you develop your creativity, the more joy you will receive from your finished products.

Learning the techniques and discovering the potential of stained glass are exciting experiences and I am delighted to be able to share in them with you.

Dig deep, extend yourself, express yourself, and have fun with this book.

Sam Halstead

1. GLASS SAFETY

- Carry glass vertically with both hands. Hold the top edge.
- If glass falls, do not try to catch it.
- Don't hold glass above your head.
- Keep the bench-top clear of glass scraps and splinters. Sweep it often.
- Vacuum the floor - do not sweep dust around.
- Keep young children aware of safety needs or away from the workspace.
- Keep pets out of the studio area - glass chips, fumes, and dust are not good for them either.
- Change your shoes before moving into living areas. Have separate shoes for your workspace. Wear closed-in shoes rather than sandals.
- Wear safety glasses when cutting, breaking, and grinding glass. Get immediate professional help if you do get a splinter in your eye.
- Do not eat, drink, or smoke while handling lead. Lead enters the body through ingestion or inhalation. Be especially careful with lead if you are pregnant because high contamination levels can cause miscarriage. Have your blood tested for lead levels every year if you work with lead a lot.
- Scrub your hands with soap and a nailbrush after lead work.
- Wear rubber gloves when working with patinas and other chemicals.
- Wear a facemask on dusty jobs like cementing and blackening.

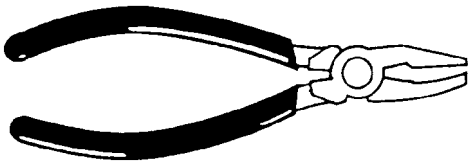
Disclaimer: There is a little danger in working with glass and lead but it can be minimized by keeping the work area clean and through the careful handling of materials. While the techniques introduced in this book are widespread and time-tested, we can in no way be responsible, or in any way liable, for any injury sustained by any person involved in stained glass design and construction. We have no control over any workspace but our own. We urge caution but advise that you undertake all stained glass craft activity at your own risk.

2. TOOLS AND MATERIALS

Glass cutter

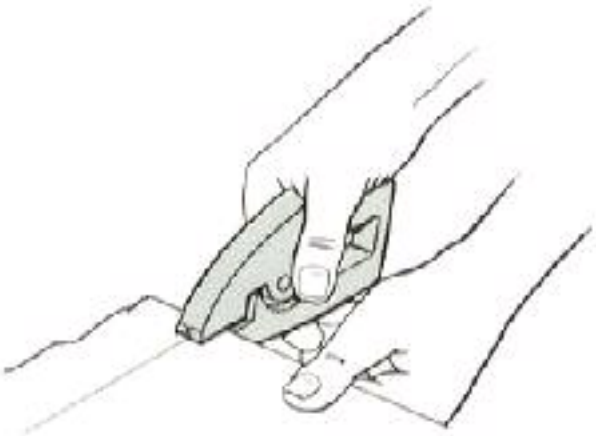
Use a single-wheeled cutter that is designed for stained glass work (rather than for general use.) The wheel should not be too large as this can hinder maneuverability. If there is a large variety available locally - ask for the most popular and buy one with a lubrication reservoir if possible. All pictured glass cutters have an oil reservoir in the handle and a slightly swiveling, pattern-cutting head. Many people find the "pistol grip" model on the left to be comfortable and easy to steer.

Glass pliers



These are used for breaking and grozing (chewing) glass. Typically you will make a score and immediately use these pliers to break the glass or "run" the scoreline (see glass cutting section). Any rough edges can be grozed smooth. A glass grinder can then be used if necessary.

Running pliers

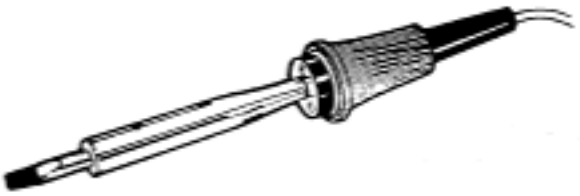


These are not absolutely necessary but you may prefer to use them to start off scores that will be "run" by hand (see glass cutting section.) They are most useful for small pieces of glass that are hard to grip with fingers. The inexpensive plastic running pliers pictured are spring loaded and grip the glass softly.

Lubricant

The wheel of the glass cutter needs to be lubricated for ***every*** score. Your supplier may sell a proprietary brand of lubrication – often it is colored to make it easy to see in the reservoir. Otherwise keep a small amount of kerosene (or 50/50 kerosene and "3-in-1" oil) in a jar and dip the wheel into it before scoring. Place a small wad of kitchen sponge in the bottom of the jar to cushion the wheel.

Soldering iron



An 80 to 100-watt soldering iron with a removable ¼" or 3/16" tip is ideal for both lead and copper foil work.
To "tin" the iron tip when it is new and whenever it gets dirty:

- Heat it
- cover it with flux
- melt solder over the end
- cover it with flux again.
- Wipe it clean on a wet cellulose sponge.

Remove and clean the tip regularly. Use anti-seize lubricant on the shaft of the tip to make it easier to remove and to prolong it's life.

Lead knife

Lead knives usually have a curved blade balanced by a lead-weighted handle. The blade accentuates the rocking motion used to cut lead and the handle can be used for tapping glazing nails in. Lead knives come in different styles so try them for feel. I recommend the style pictured because force can be applied directly down the shaft to the blade.

Lead Nippers

Many people prefer lead nippers (or lead "dikes") over lead knives. Nippers are usually spring-loaded and are designed to not crush the lead when cutting. They do not require as much brute force as lead knives do.

Straight edge

A strip of wood or a builder's wooden ruler can be used for guiding the cutter on straight scores. Always do a sight check along the length to make sure the piece of timber is not curved.

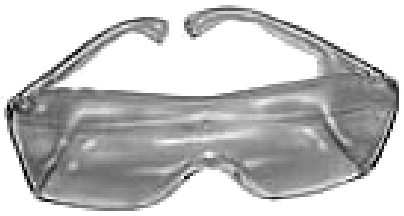
Square

Use a large metal or plastic square for squaring up the corners of cartoons (the full size patterns.) The square should be used to check window frames for square-ness also. If a frame is out of square and cannot be fixed, you may need to build the window out of square too.

Bench brush
A brush and dustpan will help to keep the work area free of glass scraps and splinters. Use often.

Pattern paper
Use strong Kraft or butchers' paper for drawing the full size patterns. Once glass has been cut to fit, the window or panel will be built on top of the pattern.

Safety Glasses
Use goggles or shielded spectacles with clear plastic lenses to prevent splinters in your eye. Ordinary glasses do not give enough protection so you will need to buy goggles that will fit over them.



Newspaper
Use a few sheets of newspaper to create a soft backing for placing glass on when scoring. There must be a completely flat surface for scoring on as any little irregularity can create an unwanted pressure point.

Fid (Lathekin)
This is a simple wooden or plastic tool for opening up the channels of soft lead if they are deformed when cut. It can also be used for smoothing foil prior to soldering.

Glazing Nails
Horseshoe nails are used to hold glass pieces in place as the leaded window is built up over the pattern. These nails have long flat sides which create less of a pressure point.

Lead vise / Lead stretcher
All lead needs to be straightened and stretched before use. The lead vise grips one end while you pull on the other end with pliers.
(Note: A cam cleat from a boating supplier will also make a great lead stretcher. Both serrated cams are spring loaded and will grip the lead tightly.)

Brushes

- For cementing and blackening lead you will need two stiff bristled brushes. A “wet” one to force cement under the lead and a “dry” one to brush the excess cement away. This second brush can be used for blackening lead as well.
- You will need a small wire brush for cleaning lead joints before fluxing and soldering.
- Old toothbrushes can be used for applying flux to copper foil and to “antique” the solder.
- An artist's paintbrush with long bristles is needed to apply blackening to lead.
- Have a bench brush and dustpan handy at all times.

Glazing Hammer

This is a double-headed hammer with one hard plastic head and one softer rubber head. The hard head is used on glazing nails and the soft head for tapping pieces of glass into place when leading.

Laths/Battens

Purchase some straight wooden battens/laths at least 3/8 inch (10mm) thick to use as a temporary frame when leading up a window over the pattern. Keep a variety of lengths on hand.

Grinding / sharpening stones

Use a carborundum, or silicon carbide, stone for grinding rough edges of glass. The stone is often handy for shearing off slivers that do not quite need a glass grinder. A separate sharpening stone will be needed to keep your lead knife sharp.

Glass foiler

The glass foiler dispenses foil and wraps it onto, and around, the edges of each piece of glass. The foiler can dramatically increase accuracy and speed up foiling time.

Glass Grinder

If you mostly produce detailed copper foil work, you will need one of these. Glass does not always break with a smooth edge and these machines make short work of tidying up rough edges. Smooth edges make foiling easier and produce tight, even joints. Glass is held on the flat top surface and moved against the wet, spinning, diamond-coated, spindle to smooth off jagged edges. Use a spray guard to protect the surroundings and - WEAR GOGGLES.

Glass Saw

You probably do not *need* one but they do save time on intricate cuts – in fact there are some cuts you can not do without one. A glass saw is a small bandsaw with a continuous diamond-coated wire or blade.

Glass is moved against the water-cooled blade which cuts a thin, smooth, slot through the glass.

In this door panel, a glass saw has been used for the reamy clear glass along the bottom and for the internal curve in the larger blue shape at right.

Checklists

If you are just starting out and have no equipment, these checklists will help you to select the basic essentials. A full kit can cost less than $200 and a basic kit will cost less than $100.

Copper Foil Only

- 100w Soldering Iron
- 60/40 Solder
- Copper Foil
- Flux
- Flux brush
- Patina
- Facemask
- Grozing pliers
- Fid
- Glass Cutter
- Cutting oil
- Safety Goggles
- Foil pattern scissors

……..plus glass to suit first projects.

Lead Only

- 100w Soldering Iron
- 60/40 Solder
- Flux
- Flux brush
- Small wire brush
- Grozing pliers
- Glass Cutter
- Lead vise
- Glazing hammer
- Glazing nails
- Fid
- Cutting oil
- Safety Goggles
- Facemask
- Lead pattern scissors
- Cement
- 2 cementing brushes
- Black lead polish

……..plus glass and lead to suit first projects.

The above lists contain the bare necessities for stained glass work. The following checklist is a *recommended* starter kit for someone working with both foil and lead. The most expensive items are the grinder, soldering iron, lead knife, and controller. All other items are relatively inexpensive.

Recommended checklist for both Foil and Lead

100w Soldering Iron	Soldering iron controller
60/40 Solder	Glass Cutter
Cutting oil	Glass grinder
Grozing pliers	Flux for foil
Flux for lead	2 Flux brushes (lead and foil)
Small wire brush	Copper Foil
Patina	Fid
Safety Goggles	Lead pattern scissors
Foil pattern scissors	Glazing nails
Glazing hammer	Cement
2 cementing brushes	Scrap glass for cutting practice
Facemask	Whiting (for cleaning lead windows)
Black lead polish (stove polish)	Glass and lead to suit first projects.

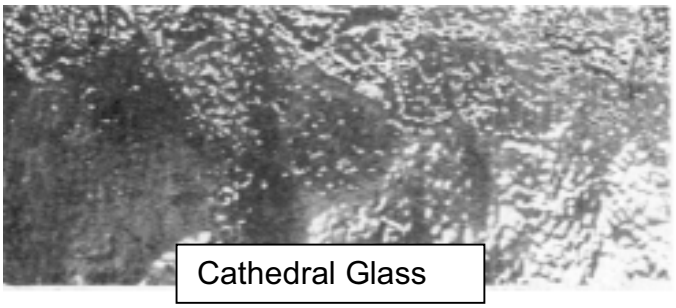
You will also need newspaper, a dustpan and brush, boxes for lead and glass scraps, a sharpening stone, a straightedge, a square, pencils, pens, and some pattern paper.

Materials

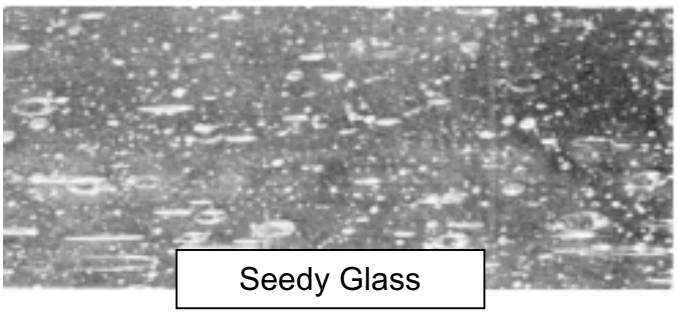
Glass

All glass used for lead and foil work is about 1/8" (3-4mm) thick.

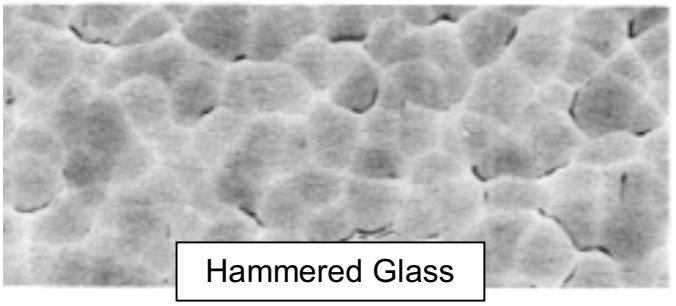
Cathedral glass. This is the most common colored glass on the market. It is machine made in large sheets and has a uniform texture on one side. It comes in a wide range colors. Some companies also supply cathedral glass with a "hammered", seedy, or smooth texture.


Cathedral Glass

Antique glass: Large hand blown glass bubbles are cut open and flattened out to produce antique glass. This is the original method of producing glass sheet - hence the name. It varies in thickness (and therefore intensity), texture, and price. A typical sheet has a network of fine "straw marks" on one side which crinkle up daylight in a subtle and beautiful way.

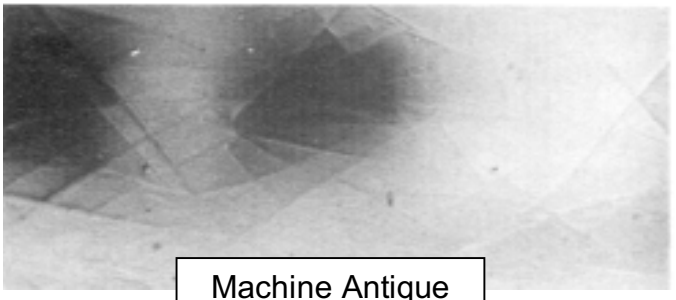

Seedy Glass

Machine antique: This glass is made to look like antique glass with "straw marks" and all. A wide range of colors is now available. Being machine made, it is all the same thickness and intensity and it does not have quite the same randomness of genuine antique.


Hammered Glass

Flashed glass- A very thin layer of one color is bonded to a thicker base color. The flashing can be etched or sandblasted off in places to let the base color show through. Always cut it on the base side, not the flashing. Look at it edge-on to see which side is flashed.

Opalescent glass: An opaque glass that reflects, as well as transmits, light. It is machine-made and often features variations of intensity and a swirly design through it.

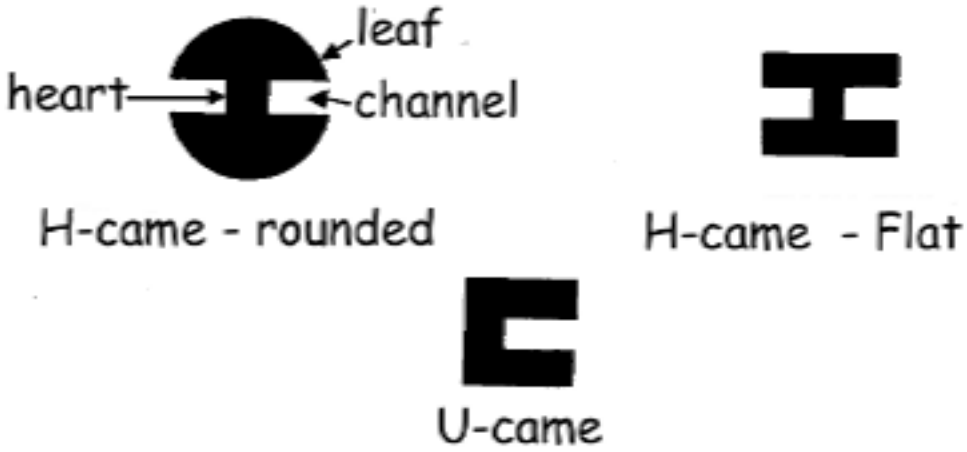

Machine Antique

Streaky glass: Either antique or machine made glass with two or more colors swirled through it. Can be very overpowering if used too much.

You will also find other specialty glass types at your local glass dealer. There may be opal, opak, variegated, enamel, dichroic, waterglass, and iridescent colors to delight and confuse you.

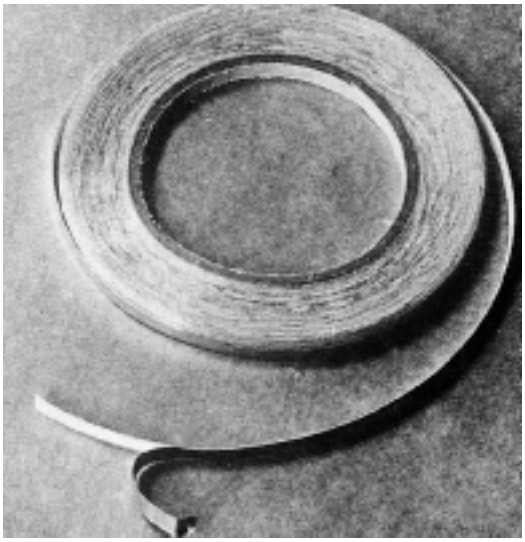
Lead Came

The lead used for most stained glass work is called medium heart lead. Narrow heart lead is only used for thin glass in cabinet doors. High heart lead is used for very thick glass (such as some English antiques) or when two pieces of glass are sandwiched together. Lead comes in 6' (1800mm) lengths and is called came. It is normally H-shaped but there are U- shaped cames for the borders of hangings. The widths range from 1/8" to 1" (3mm to 25mm) and the most commonly used sizes are 3/16" and ¼" (5mm and 7mm). H came of 3/8" or 1/2" (10mm or 12mm) width is used for bolder lines and as border leads. Some companies make soft and hard cames with a choice of flat or round surfaces. Soft lead is easier to bend around shapes but the hard lead is more sturdy and smooth and definitely prolongs window life. The "leaves" of the came do not buckle under so easily either. Lead must be stretched before use.



Copper foil

A variety of widths of adhesive copper foil is available. The standard sizes are ¼", 7/32", and 3/16". The thinner foil requires accurate glass cutting and can provide for a very delicate effect. Each roll contains 100' (30m) of foil with a peel-off paper backing protecting the adhesive. The back of the foil will show through clear or light colored glass so consider selecting foil with a black or silver backing if it suits your project.



Solder

Solder is made of tin and lead. 60/40 solder has 60 per cent tin and 40 per cent lead and has the lowest melting point. It also has a small "plastic" range which means it sets solid immediately the soldering iron is taken away. Some people use 50/50 solder because it is slightly cheaper and the difference in strength is small. It is often preferred for copper foil work because it has a wider plastic range and gives a nice "bead". Try leadless solder if you can find it.

Flux

Flux cleans and de-oxidizes metal prior to soldering. For lead there are two traditional fluxes - oleic acid and tallow (stearine) candle. Oleic acid is an oily liquid and can be applied with a brush. Tallow candles are rubbed onto the joints to be soldered. There are now a number of proprietary brands of flux for lead and foil and, because stocks vary, you should take the recommendation of your stained glass supplier.

For copper foil, the flux is normally a "killed" acid. Some brands can give off uncomfortable fumes but there are also good water-based fluxes now available that do not splutter and are easy to clean off the glass.

Cementing

For cementing and waterproofing leaded panels you can use a premixed glazing compound or make your own (recipe in lead technique section.) If you only make small panels, you can thumb normal linseed oil putty under the leads instead. This method becomes laborious on larger windows.

Finishing Agents

For copper foil work you can use copper sulfate crystals to obtain an "antique" copper effect or black patina to darken the solder. There are proprietary products available for blackening lead but the best results seem to come from using liquid stove and grill polish

3. WORK SPACE

If you have space to set up a permanent studio, think carefully about your work habits, and design the area so you have room to handle the type of projects you envisage working on. As with kitchen designing, you need to make sure everything is within easy reach. The glass rack, light box and easel should be near the cutting bench for instance.

Work bench

The bench needs to be high enough so you do not have to bend over while standing. Three feet from floor to tabletop is comfortable for most people. The top should be at least a couple of inches lower than your elbows when you are standing. The bench must be strong and stable and large enough to handle moderately sized windows. Something between 3ft by 6ft (900 x 1800mm) and 4ft by 8ft (1200 x 2400mm) is ideal. The top can be made from plywood or flooring-grade particleboard around ¾"(18mm) thick. A 36" (900mm) solid-core door can also make a good ready-made bench top. If you have no room for a bench, you can work on a project board made of plywood or soft particleboard.

Glass racks (Fig 3.1)

Racks are usually made of wood and must be very solid and well braced. If timber is used on the floor of the racks, the grain should go into the rack rather than across it.

Try to site the rack so that it is on a wall at right angles to one with a window in it. As you pull the glass out, the light from the window shines through it, making it easier to see the color.

The divisions should be spaced at 6" (150mm) or less and never filled with so much glass that you end up scratching pieces as you take glass in and out. A smaller rack can be built on top to store off-cuts.

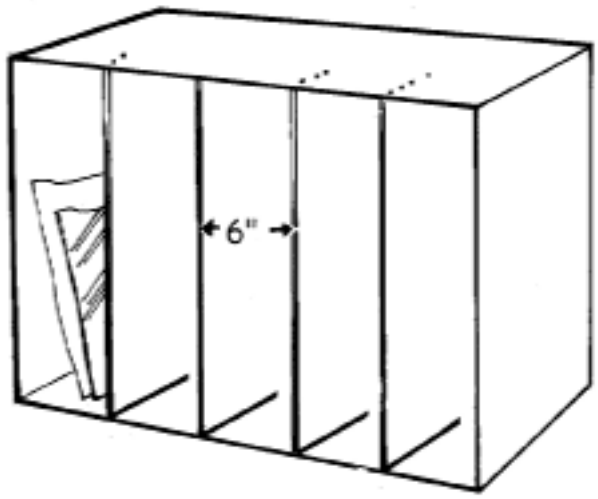


Fig 3.1

Light box (Fig 3.2)

The light box is used for tracing, selecting colors, and cutting dark glass over the cartoon (pattern.) The top can be made from recycled 3/8"(6mm) plate glass from broken shop windows – cheap or free from glass merchants. A sandblaster can quickly and cheaply frost the underside for a diffused effect. The interior of the box can be painted white and a "daylight temperature" fluorescent light wired inside. If you are building a studio, consider rebating the light box into the end of a bench top so that the glass is flush with the bench surface.

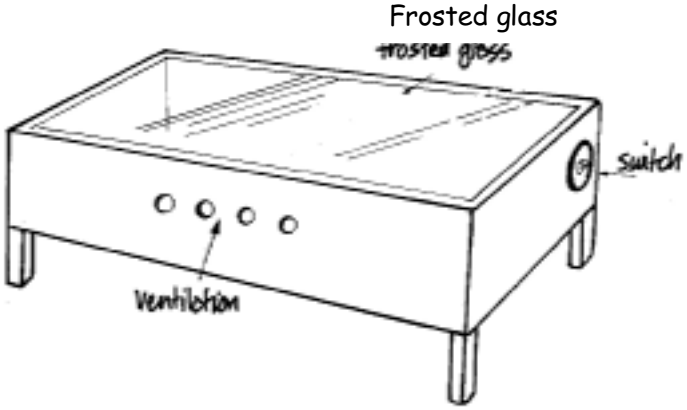


Fig 3.2

Lead Storage

Leave lead in the wooden, or heavy cardboard, "coffins" if you are buying in large quantities. To store fewer lengths, make up a partitioned wooden tray so each size can be kept separate. Store lead so it can be lifted out from the side. If you pull it out from one end of the box, it will get tangled and scratched.

Easel

An easel is not essential but you may gravitate towards it. As each piece of glass is cut to the pattern, it can be attached, using small knobs of plasticine, to a sheet of clear plate glass. When all the pieces have been fixed in this way, you are able to change any color that no longer looks right and preview how your window is eventually going to look in natural light. This can save potential disappointment at the end of the project when the window might be discovered to be "not quite right". Some artists paint the lead outline onto the easel first so that clear light does not shine between pieces.

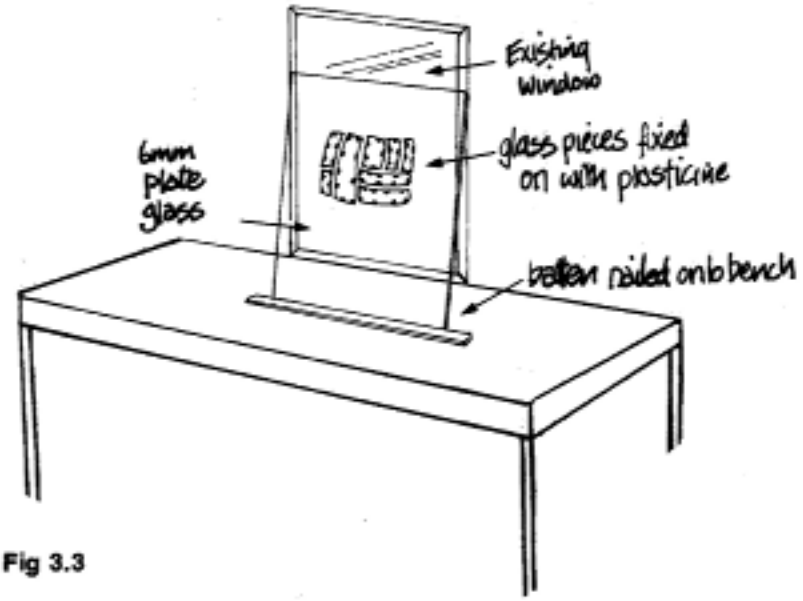


Fig 3.3

Any old piece of 3/8”(6mm) plate glass will do for an easel. Try your glass company again for some re-cycled shop windows. The glass must be solidly supported in front of a natural light source - you really do not want this falling over. A permanent wooden frame is best but you can stand the easel on a bench in front of a window and restrain it with a batten nailed in front of it (fig 3.3). The glass should slope backwards slightly but do spend some time making sure it cannot be accidentally knocked over. If you are only making small panels, you can use a smaller piece of glass or stick pieces straight on to a fixed window in your work area (See chapter 5 on Lead Techniques for methods).

Waste bins

Have solid, separate, containers for glass and lead scraps. The glass may have to be dumped (some potters might take it off your hands) but the lead can be sold to a scrap metal merchant for good money.

Cementing room

It is advisable to do the cementing and blackening in a room separate from the studio. These processes generate a lot of dust which will get everywhere. If it is impractical to do it outside or in a separate area, cover the floor and bench with newspaper and try not to be too vigorous. Vacuum the area when finished. A cementing room should be well ventilated, preferably with an extractor fan. Wear a facemask – even a disposable paper one is better than nothing.

First aid kit

Bandages, burn cream, tweezers, eye bath and rinse, morphine, crutches, ……..

4. GLASS CUTTING

Glass cutting skills are the main foundation of stained glass work and this chapter has been written as a series of consecutive steps by which you will learn all the basic cutting and breaking techniques. Learning from a book can be difficult because glass cutting has to do with feel, sound, and pressure. For this reason, we have posted some videos of glass cutting and breaking on the handbook website at: http://learn-stained-glass.com

It is worth spending a couple of hours practicing on scrap glass before attempting your first projects. Visit your supplier or glazier and try to solicit some clear scrap glass from them. If you cant get scrap glass, buy some single strength (less than 1/8"/3mm) or double strength (1/8"/3mm) clear glass which is cheap and easy to learn on.

The Nature of Glass

A saw or a knife will cut material by slicing through it but a glass cutter does not cut or slice through glass. When you score glass and break it, you are not "cutting" it so much as disturbing the molecules along the scoreline and breaking the surface tension. This action splits the molecules apart and creates a weak path right through the glass. The glass is more likely to break under the score. If you try to break a scoreline that is a few days old it will be harder to break and is likely to shoot away at an odd angle. This is because the constantly moving molecules have settled and "healed up" beneath the cut. It is a good habit to break glass immediately after it has been scored.

A project will take longer if glass is cut poorly because you will have to compensate all along for a bad start. Lighter pressure is better – do not try to cut a trench across the glass, that is not what it is about. Lubrication and gentleness are the key.

Holding the Glass Cutter

(i) This is the classic textbook grip (fig 4.1). In truth, not many people cut glass like this. This grip works best on steel handled glasscutters with a wide finger grip. If you spend all day cutting like this with a wooden handled cutter you might end up with blisters between your first and second fingers.

Fig 4.1

(ii) Holding the glasscutter like a pencil is a popular grip (fig 4.2). Hold the handle - not the head - and keep your wrist up so the cutter stands upright. Your elbow should be higher than your wrist for a smooth action. Stand on a box if the bench is too high.
Long-handled reservoir cutters will be held like this.

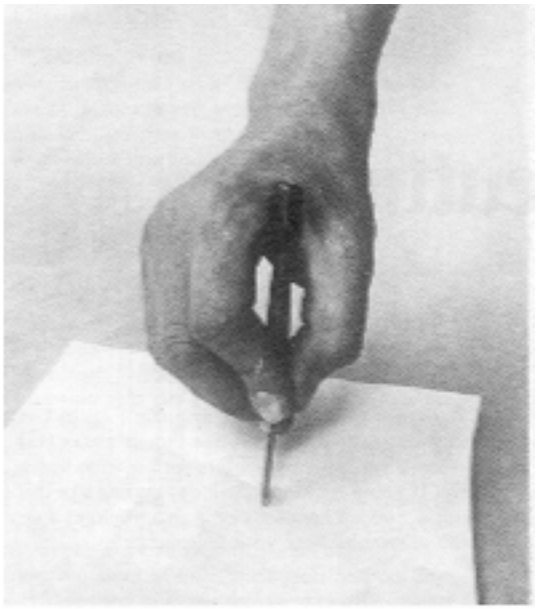


Fig 4.2

(iii) If you have long fingers, or find that your hand slips down the handle in the previous two grips, try this variation (fig 4.3).

The grip is basically the same as (ii) but the handle is tucked into your palm. This gives a four-point grasp of the cutter and automatically raises your wrist over the cutter. Cutting pressure goes straight down your arm and through the handle to the wheel. Try to imagine the cutter as an extension of your forefinger. It is easy to vary the pressure and maneuverability is good.

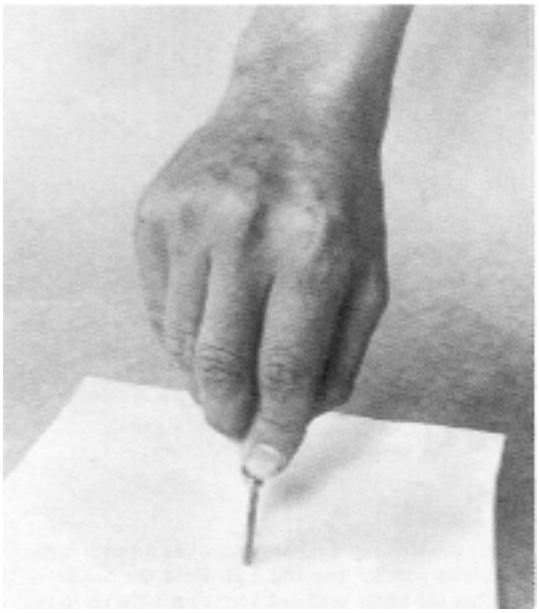
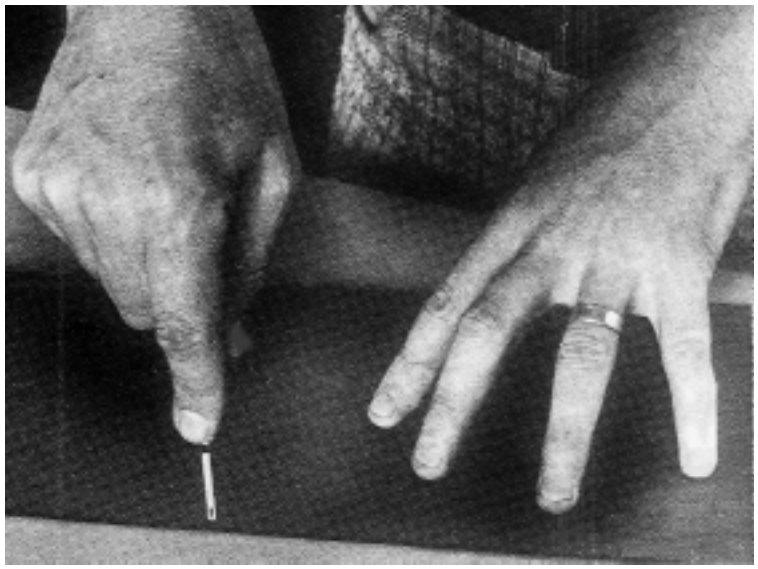


Fig 4.3

In all cases, keep the cutter vertical or lean it slightly back towards you when scoring.

The first cut

- **Lay newspaper on your bench top**
- **Stand up**
- **Wear safety glasses**
- **Clean the glass if it is dirty**
- **Make sure the cutter is well lubricated**
- **Score on the smoothest side of the glass**
- **Never go over a score line twice**



Stand with your body close to the table and relax. Let your forearms do the work – not your back. Start with freehand straight lines across a piece of glass which is about 8 to 12 inches (200 to 300mm) wide. Hold the (lubricated) cutter so the wheel is just inside the furthest edge (fig 4.4). Apply a firm pressure and draw the cutter smoothly towards you. Do not speed up, slow down, stop or falter. Keep the pressure and speed constant until the wheel has gone off the edge near you. It is important that the score is well defined at this front edge because that is where you will begin the break.

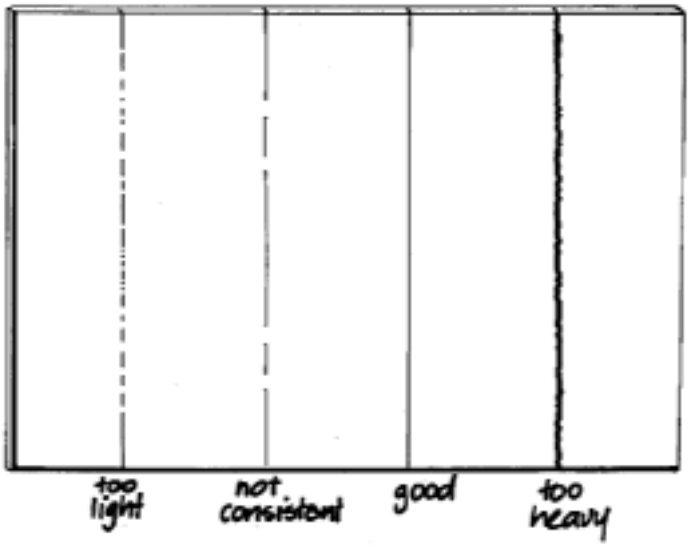


Fig 4.5

It is hard to describe how much pressure to put on. I have seen it described as 15lb which is far too much. It is nearer 2 to 51b (1 or 2 kilograms). The right pressure will not require force; the cutter will make a "hissing" noise as it moves; the scoreline will be visible but not dry, chipped, or flaky.

Do not move too fast at this stage. Take about 3 seconds to score 1 foot (300mm). Check your scoreline to see if it is too heavy, too light or inconsistent (fig 4.5). Keep scoring and experimenting to discover the workable range. If you mess up, just move along and start again. **Going along or across a previous score will damage the wheel.** If the line will not break, it is either too lightly scored, uneven (does it disappear then reappear?), or not constant to the front edge (did you slow down or ease the pressure off as you came to the edge?). Visit the website for a glass cutting demonstration video - http://www.learn-stained-glass.com

That's it - the basic method. Every other technique of scoring and breaking is a variation on what you have just learned. The rest of this chapter describes some variations and when to use them. However impatient you are, do not move on from here until you are confident that you have the feel of the basic technique.

Breaking by hand

Glass is always broken by applying pressure from underneath the scoreline. To break a typical score, hold the glass as in fig 4.6 - thumbs on top and either side of the line, fists underneath with knuckles touching. Put on a slight outward pressure and then quickly roll the wrist outward and downward to break the glass. The forefingers will provide an upward pressure to help this to happen.

Hold the glass above the bench so that if it slips, it will not fall far. Throw your glass scraps into a bin as you break them and keep the cutting surface swept clean.

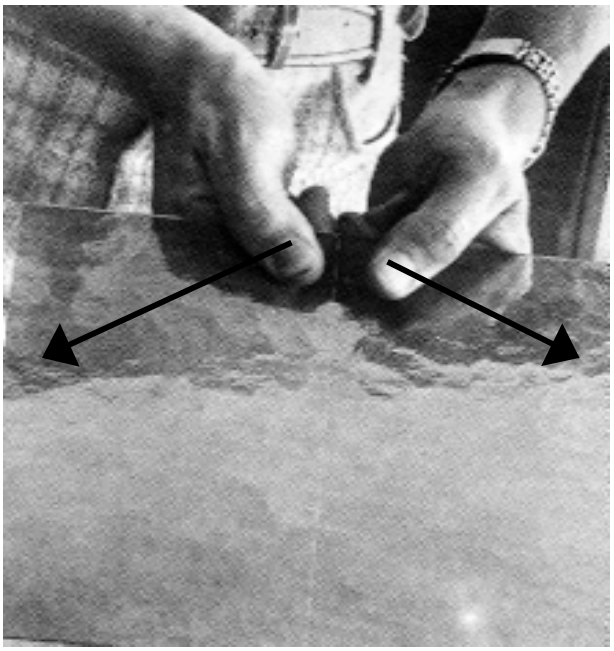


Fig 4.6

Cutting forward

If you score forwards when cutting to a pattern you can see where you are going and better judge the wheel's relationship to the line. The only problem is controlling the cutter so it does not skid away forwards faster than you want it to.

A two-handed operation can regain the necessary control (fig4.7). Your cutting hand should hold the cutter and provide both the weight and direction for the score. The fingers of the other hand should hold the glass down and the thumb should fit behind the cutting hid to provide forward movement. As you move along, the fingers holding the glass can "crab" along in front of the score.

Fig 4.7

Cutting shapes

As you get more proficient at straight lines, start to curve them gently and see if they break any differently. Try the cuts in fig 4 .8.

You should find that gentle curves (A and B) break well but sudden changes of direction (C), convoluted lines(D), thin edges (E), deep curves (F) and cuts to a point (G), may not break properly.

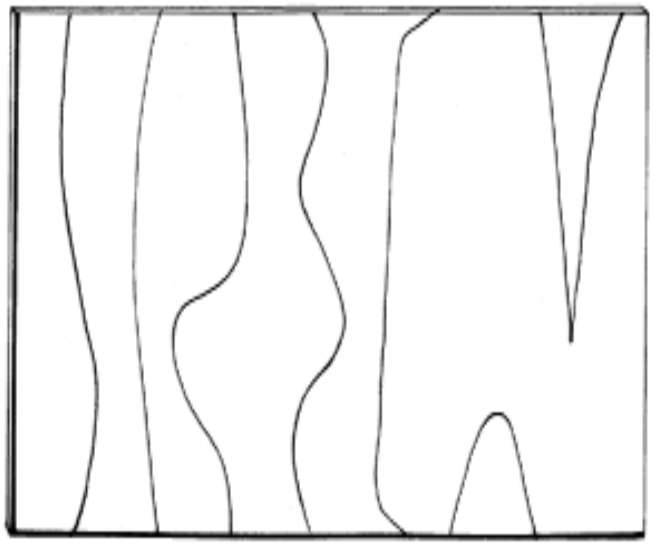


Fig 4.8

There are other breaking methods that help to overcome these problems but the fact is there are some shapes that cannot be cut by conventional means. When they are finally worked out, they are more likely to break apart in assembly, installation, or high winds. Example E is difficult and inherently weak. Example G is not possible because one of the score lines will run to the far edge. (This cut could be achieved with a glass saw or a by drilling a very small hole drilled at the apex, then scoring the two lines. It will almost inevitably break up at the some later stage, however.)

Tapping

Deep concave cuts or sharp curves can be scored and then broken out by tapping from underneath with the metal head of the glass cutter (not the wheel!!).

Each tap should be an *accurate* swift "poke" at the underside of the scoreline with the cutter (or the ball head of a metal or reservoir cutter) held at right angles to it (Fig 4.9). A crack should appear in the glass and advance with each tap. The temptation is to flail away madly at the glass to get it broken out quickly. The drawback to tapping is that every time you tap the glass, it cracks through on a slightly different angle. Once the waste is broken away you will discover a very rough edge to the glass. To partly overcome this, make each tap gentle and accurate rather than erratic and heavy. Tapping usually results in the use of a glass grinder.

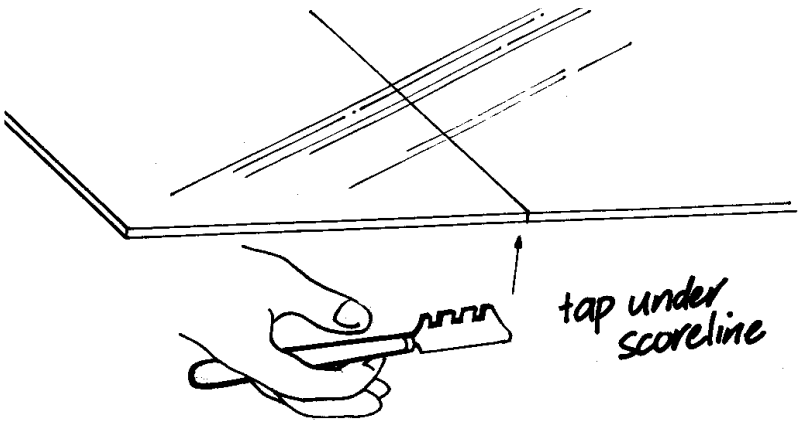


Fig 4.9

Because this method is almost infallible, it is tempting to tap out nearly everything that is not a straight line at first. It is not a very risky technique but it does produce rough edges, gets used far too often, and needlessly uses up valuable time and glass. However, it **is** useful for small sharp curves that cannot be broken out by any other method.

In a case such as fig 4.10, the main line should be scored first and then the "waste" area divided up with smaller lines. The whole area should then be tapped and broken out. Tap the main line before all the others - remember not to go over a previous scoreline with the cutter - only up to it. When all lines have been tapped, begin breaking and grozing beginning with the outside edge.

The jagged edges produced by this method can be cleaned up by rubbing with a carborundum (or silicon carbide) stone, using a glass grinder, or with grozing pliers. Once you get the feel of glass cutting you will “run” cuts rather than tap them and will find that you achieve smooth scores with much less effort. Tap the glass as a last resort rather than as a first choice.

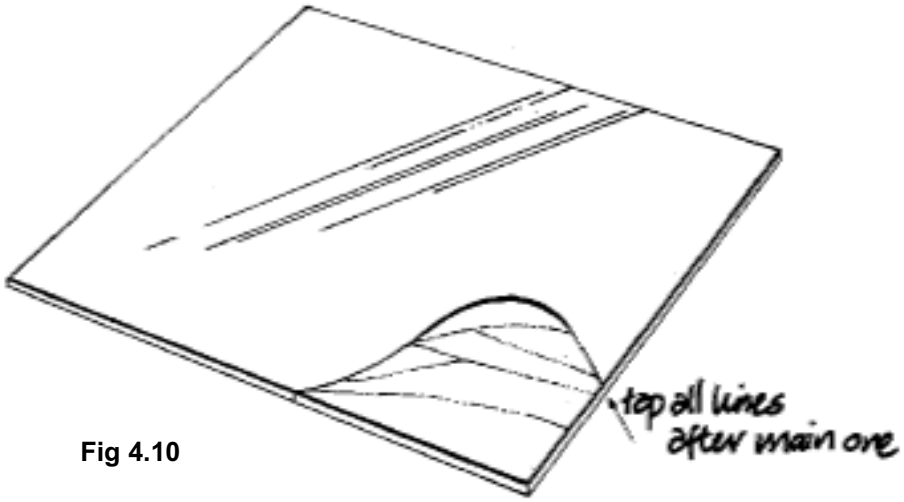
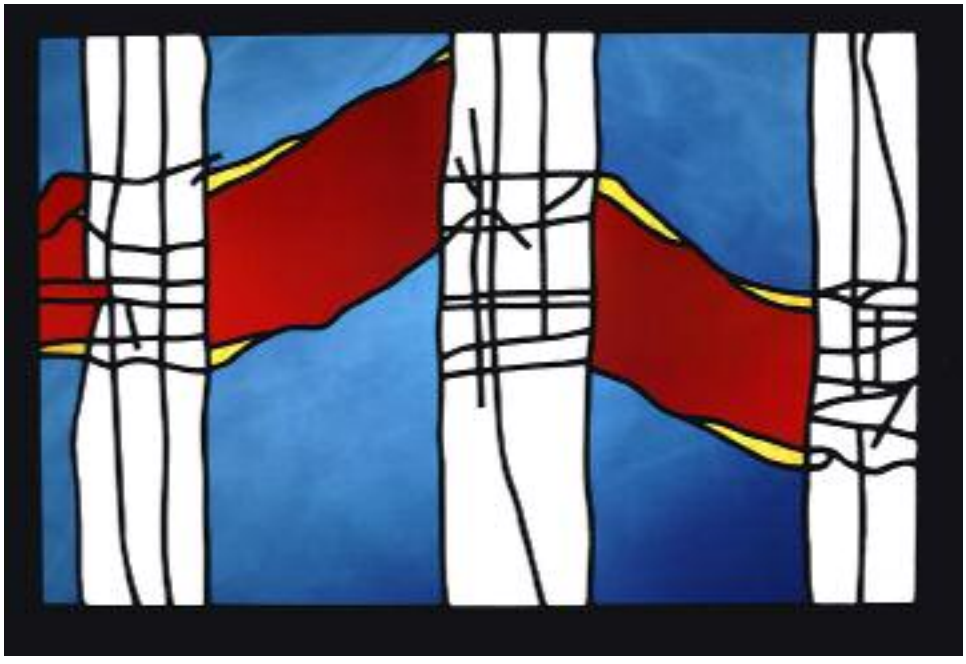


Fig 4.10



Running a cut

A scoreline can usually be cracked by applying a gentle pressure from one end and creating a crack which will "run" along for an inch or two at a time. The advantages of this simple method are that the glass will part with clean edges, no tapping out or smashing up of glass is necessary, and both long and short scores can be broken easily. In other words, this should be your basic preferred method. For your trial "run", take a piece of scrap glass about 16' (400mm) long and make a smooth, constant, well lubricated score along it such as in fig 4.9. Instead of tapping all the way along, tap once at each end of the line to start the crack and then run it by hand.

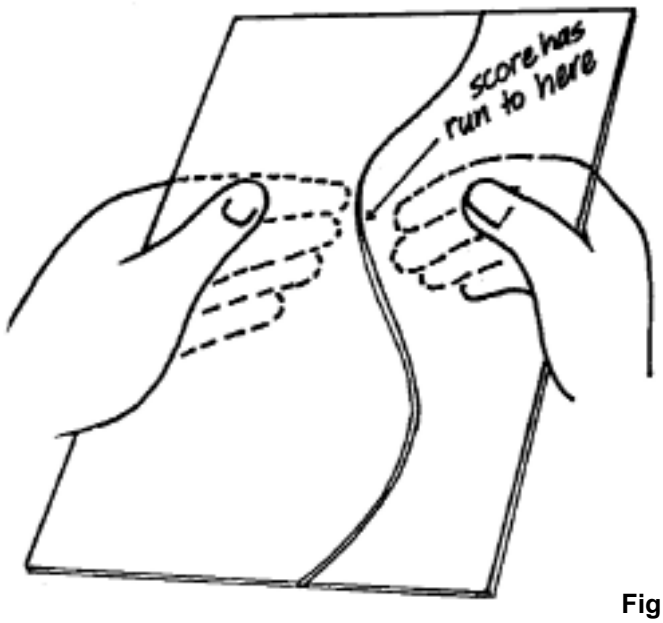


Fig 4.11

Take the glass in your hands and, starting from one end, apply the gentlest possible bending pressure on either side of the scoreline from underneath. Carefully increase the pressure until the crack runs along for a couple of inches. Move your fingers up to just behind the end of this crack and gently increase pressure until it runs again.

The crack will run slower around corners but works well even on fairly tight curves when you are practiced at it. If you have trouble getting the crack to move, start from the other end and work back from there. Try a gentle tap from underneath with your finger if the run becomes stubborn. Always have a hand on both sides of the score in case the crack goes faster than expected and the pieces fall apart. Again, check the website for a demonstration: http://learn-stained-glass.com/

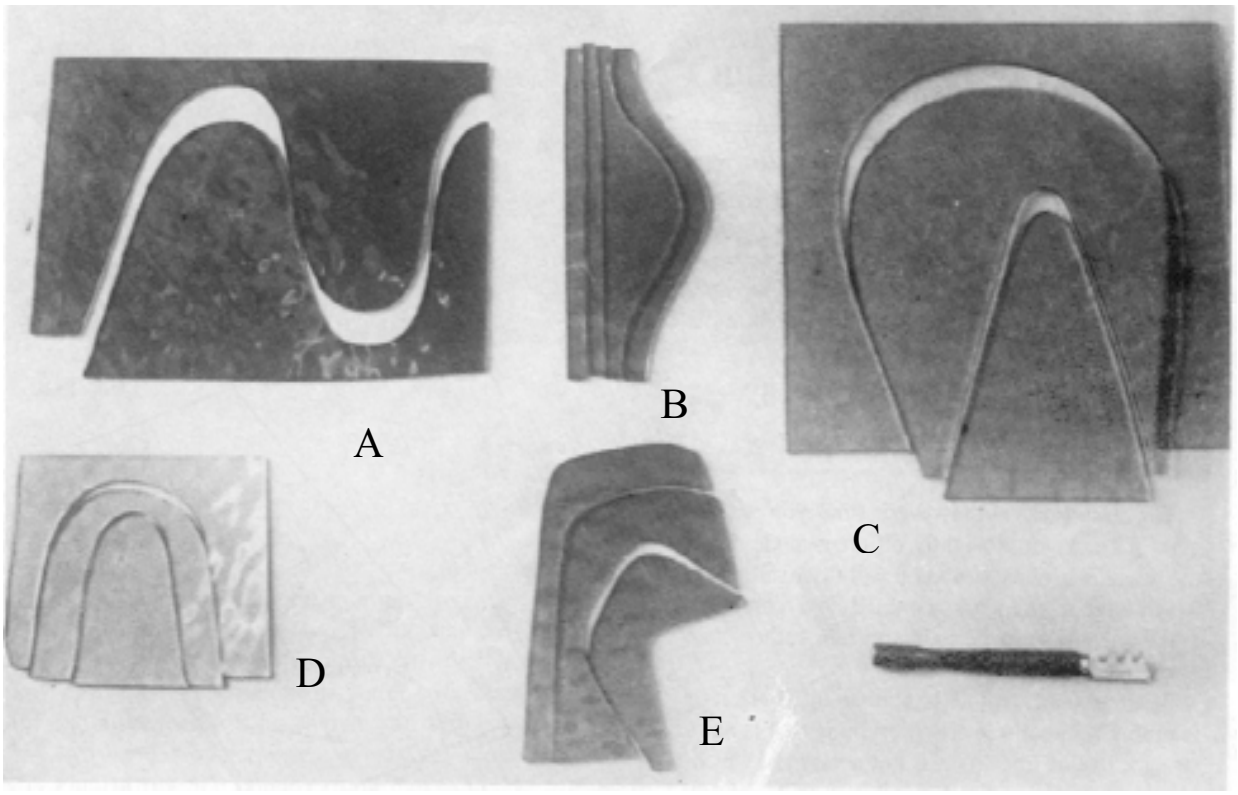


Fig 4.12

Fig 4.12 shows shapes that can be run either by hand or by using pliers. No lines were tapped.

A. A curved line was scored and run without tapping. Straight lines cut last (otherwise the curved line might crack to the outside edge).

B. Lines were run with pliers as the glass pieces are too small for fingers to grip

C. The large curved line was scored first and carefully run. The straight border lines were scored and broken next. Then the large inside shape was carefully prized up and out by gently springing the "arms" outside of the shape. The deep inside shape was scored and run and "wiggled" out in a similar manner. These breaks would not work on all kinds of glass. This particular color and brand of cathedral glass was found to be softer than others.

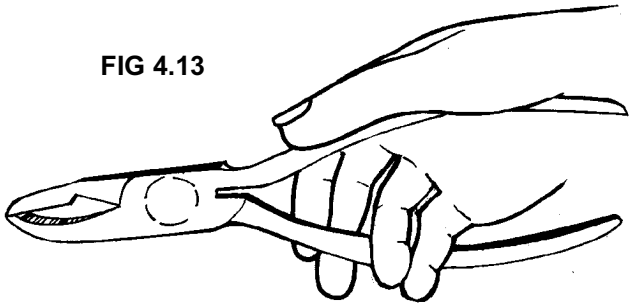
D.&E. Scored and run in a similar manner to C.

Using glass pliers

There are three uses for glass pliers in stained glass work – breaking, grozing, and running. Combination pliers have small jaws and are made of soft metal. They can break and groze and their job is to chew glass into shape and clean up ragged edges.

Hold the pliers as in Fig 4.13 with one or two fingers under the lower handle to provide a repetitive action. The flat-edged jaw is always uppermost. The lower jaw is curved so that it only touches the underside of the glass in one place – directly below the scoreline.

FIG 4.13



Grozing

To groze with pliers – chew at the edges and bite off small pieces until you can get to the shape you want. Score the line you want and tap it if you have to. Start at one end and work your way along, grozing the excess away.(fig 4.14)

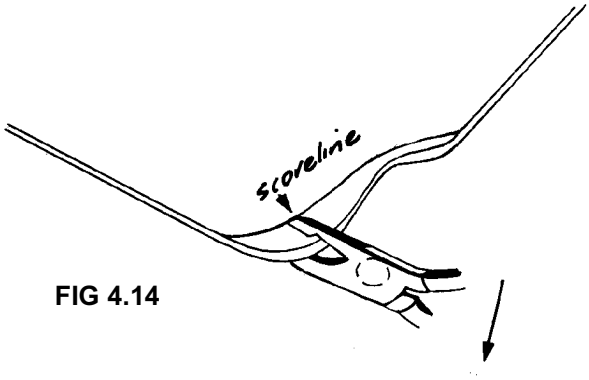


FIG 4.14

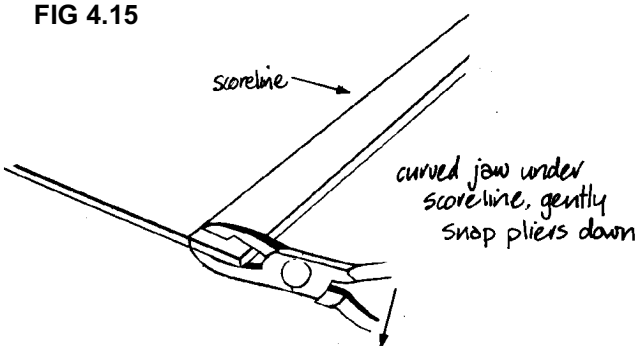
Use this method for scorelines that are near to an existing edge and for difficult internal curves that have been tapped and divided up (fig 4.10.)

When cutting to a pattern you should get into the habit of scoring and breaking glass and then automatically using the pliers to trim off any small irregularities. Practice some difficult cuts to see what the pliers are capable.

Running with Pliers **(yes, you're allowed)**

To run a cut with pliers, score it and tap one end, then gently bend the glass from that point (fig 4.15) Move the pliers along as the cut runs (fig 4.16). Use this method in preference to tapping and only when the piece to be broken away is small enough to fit into the jaws of the pliers. Anything wider than that can be run by hand.

FIG 4.15



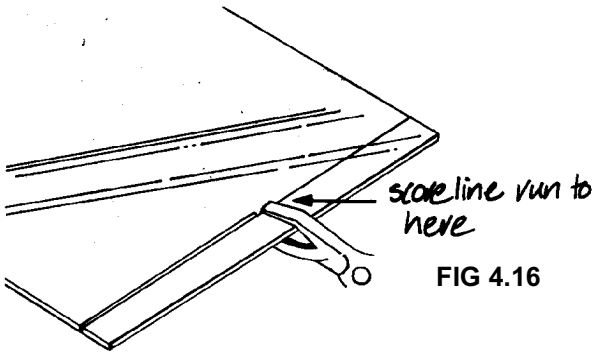


FIG 4.16

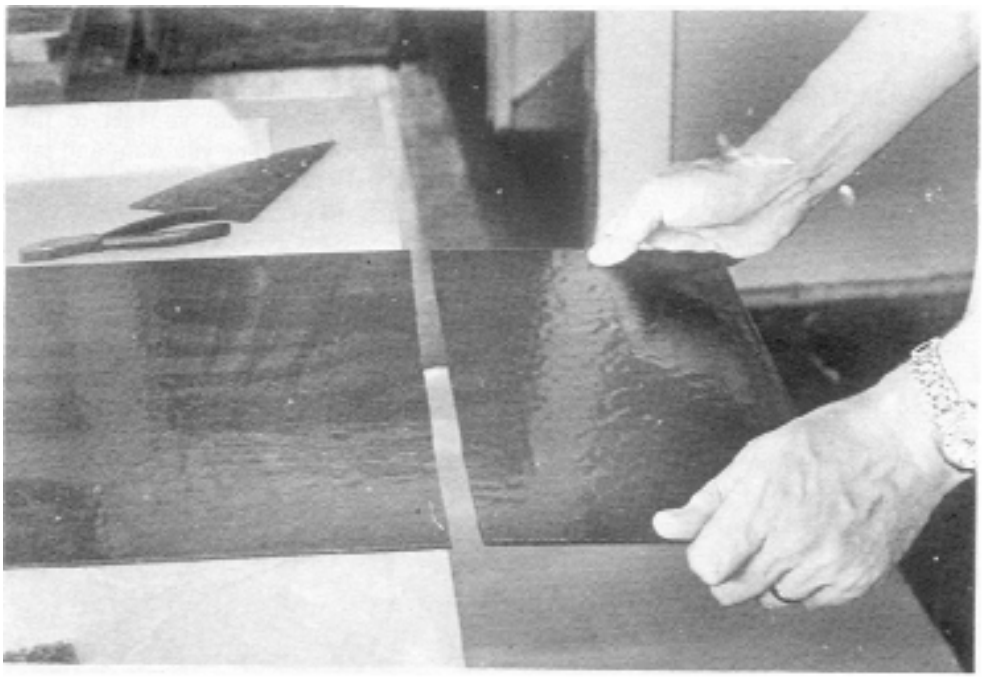


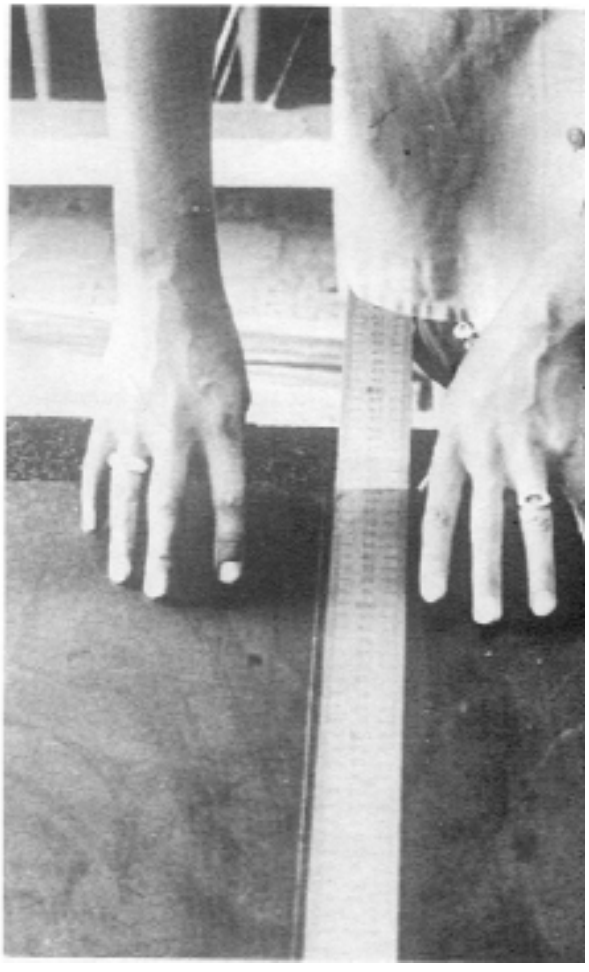
Fig 4.17

Other Breaking Techniques.

To break large pieces, score the line and slide the sheet so that the score is just over the edge of the bench. Lift the glass slightly and gently snap the overhang downwards. Make sure you have a good grip on the glass (fig 4.17).

The same type of score can be broken by sliding a wooden ruler or straight edge under the glass and slightly to one side of the line. Place one hand on either side and press downward (fig 4.18). I really don't recommend this method too much – I much prefer pressure that is applied from under the scoreline.

Fig 4.18



If your bench top is even and well padded, you can turn the glass over after scoring and press with your thumb along the back of the line to run the cut. Some colleagues swear by this method but there is a heightened risk of pressure points under the glass. Preferably, always break glass above the bench with the scoreline facing you.

Flashed Glass

Always cut flashed glass on the thicker base side. To work out which this is, hold the glass edge-on to the light and the thicker base will be distinguishable from the thin flashing.

Seedy Glass

When glass has small bubbles or "seeds" in it you will find that one side is slightly smoother than the other. In the course of scoring, the cutter may get stuck in one of the bubbles. When this happens, lift the wheel and continue the score from right beside the "seed". Run the cut from opposite ends towards the seed.

Cutting circles

A circle cutter is invaluable for scoring circles where accuracy is important. When you have the cutter set exactly to the size circle you require, place it on the glass with the suction cup in the center of the area. Hold the center of the spindle with one hand and cross the other hand over your wrist to hold the cutting head. This will enable you to complete the score in one continuous movement without changing hands.

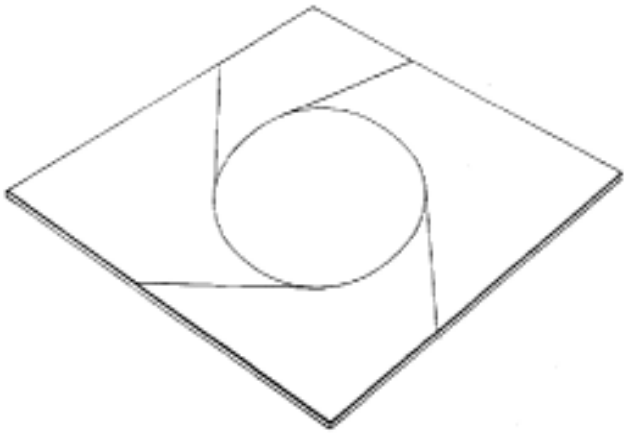


Fig 4.19

When the score is complete, remove the circle cutter and score some tangent lines to the edges of the glass (fig 4.19). Break these outside pieces away by hand until only the circle is left. You will inevitably have to groze/grind off some lumpy edges where the tangent lines meet the circle.

Cutting holes

To cut a hole in glass – score it in the same manner then carefully run the cut by hand, tapping it with a finger or by placing the glass upside down on the padded bench and pressing around it with the thumbs. Score across the circle in the pattern shown on fig 4.20

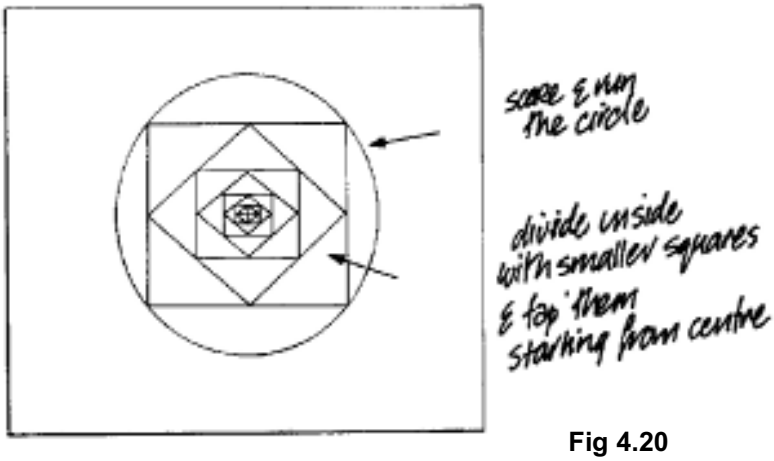


Fig 4.20

Take special care not to go over the edge of the circle. When the glass has been scored in this fashion, hold it over a waste bin and tap from behind, starting with the small pieces in the middle until you "hole through." Continue to enlarge the hole until the final few pieces fall out.

Holes can also be made with glass grinders that have a suitable grinding head on them. The cutting edge of the head MUST be kept well lubricated with water and this can be achieved by holding a very wet sponge against it while boring through. Wearing goggles is especially important when doing this.

Fig 4.21 - ***Bathroom*** *window.*
This window contains antique, and machine-textured, clear glass. The reamy glass is German hand made "antique" glass, the central fluted glass is common bathroom glass, and the glass with the larger fluted pattern was salvaged glass purchased from a demolition yard.

Chapters four and five cover the construction of this window.

Cutting to a pattern

Cutting shapes to fit a pattern is the main skill required in stained glass work. Having mastered the basic cutting skills you will find you have to make your scores a lot slower to stay on or beside the line of your design. The distinctive hiss of the cutter may disappear, but as long as you know that you are applying the right action and pressure, it will not matter.

To practice cutting for lead work, draw some simple shapes on to paper with a medium felt pen (like a “Sharpie”.) The width of the line should be about 1/8”(3mm). Glass has to be cut inside this line which represents the heart of the lead that goes between all pieces of glass. Place the glass over the pattern so you can see the line showing through the glass (fig 4.22).

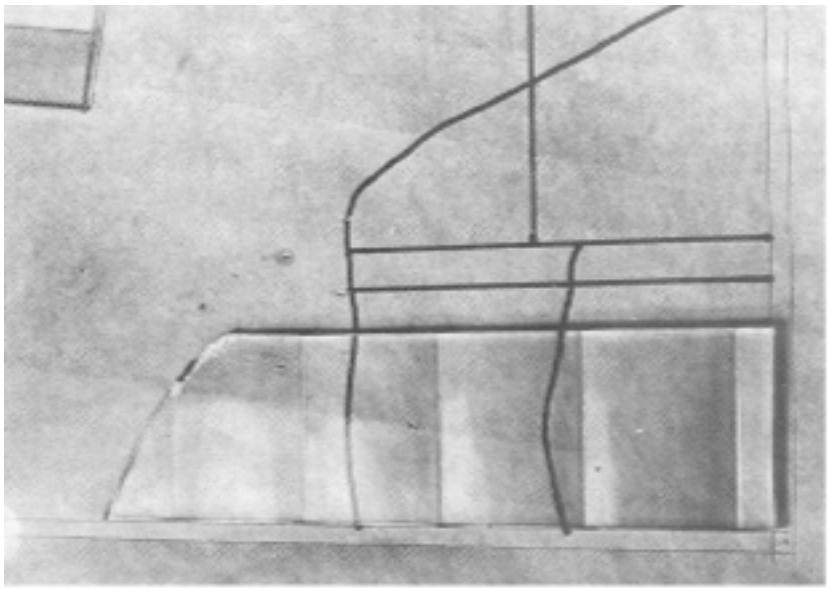


Fig 4.22

Place the wheel of the cutter on the inside edge of the line and score smoothly along the line and off the other edge of the glass. Break the line and replace the glass onto the pattern with the newly cut edge back in its place. Score and break each successive line until the whole shape has been cut. The pen lines should be visible all around it (fig 4.23). If the glass encroaches over the line, just trim it back with grozing pliers or a grinder. If the glass is cut short of the line, the lead came may not cover it’s edge so another piece must be cut. There is not much leeway in cutting to a cartoon - it has to be precise.

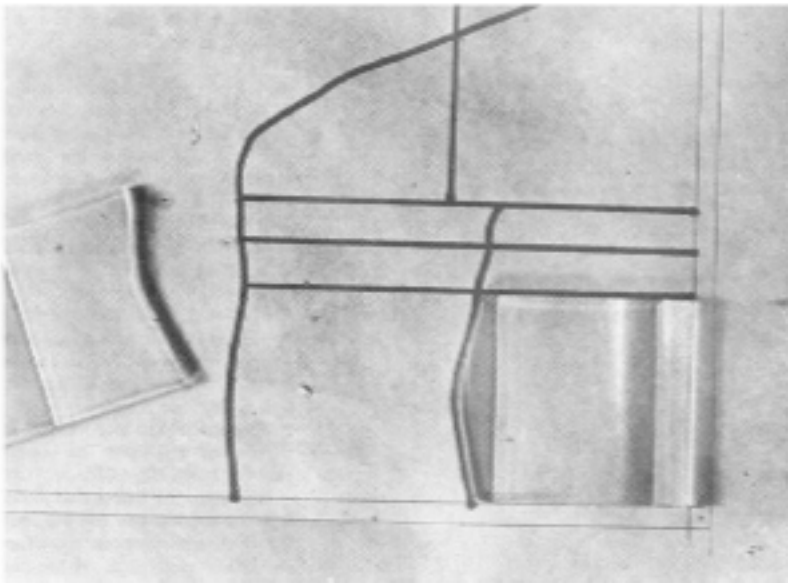


Fig 4.23

Use your glass economically by cutting your shape from a corner or near an edge of the sheet you purchased. You can cut a "blank" from the sheet first and then cut and trim that to size. Always leave about ½” (12mm) of glass to be broken away from around the shape

Note: the cut piece shown is at the bottom right-hand corner of the window in fig 4.21. The two thin pen lines around the border on this cartoon are the Final Size (outer) and Cutline (inner.) See Chapter 5 -Lead technique for explanation.

Score the hardest line of the piece first so if it breaks badly you will not have wasted much time or glass on making the easy scores. Where a curved line meets a straight line, cut the curved one first. The straight line will be easier to break (fig 4.24). It is easier to follow a pattern if you score forwards (fig 4.7) because you can see the relationship of the wheel to the line and also where you are heading. To avoid duplication, checkmark each piece on the pattern once cut.

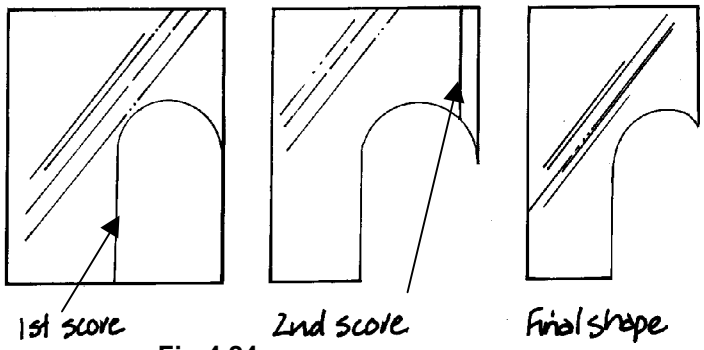


Fig 4.24

Light box

If the glass you are cutting is too dark to see through, lay the cartoon on the light box with the glass on top of it. The extra light should enable you to follow the scoreline. This is often quicker than making a card template.

Templates

It is necessary to cut cardboard templates for very dark or opaque glass because the line will not be visible through the glass. Place cardboard under the pattern with carbon paper in between and trace over the lines to produce the identical pattern on to the cardboard

A 1/8" (3mm) (or less) line will have to be cut away between each template to allow for the heart of the lead between the glass. This can be done by using pattern scissors that cut out a thin strip of cardboard, or by two razor blades taped together with a spacer between them (Fig 4.25).

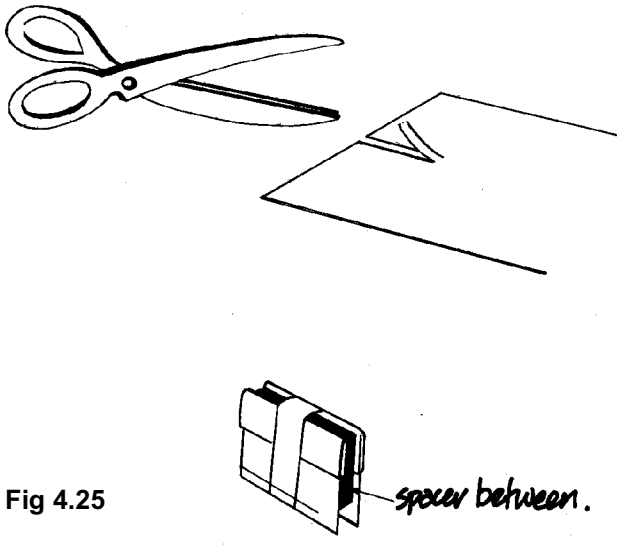


Fig 4.25

Once all the templates have been cut, check them against the original pattern for accuracy. Number the templates and each respective shape on the pattern for easy reference. Place a template on top of the glass to be cut and hold it firmly so it will not slip as you score along the edges (fig 4.26). Check the glass back to the original pattern again.

Many people cut templates for every piece of glass in a window because of the greater accuracy that can be achieved. An advantage is that the cardboard shapes can be shuffled around on a sheet of glass to gain the maximum economy from its shape. It is however a time consuming extra step in the process that is not always necessary.

To start with, use templates only on dark or opaque glass and get into the habit of cutting transparent glass by sight.

5. LEAD TECHNIQUE

Almost any room, in any house, can be enhanced by a carefully designed and manufactured stained glass window. The series of logical construction techniques is the same for every window and has not changed since it was devised. Each stage is equally important and there are no shortcuts. In this chapter we will follow through the standard construction sequence and end with a few notes on the design constraints of glass within architecture. I recommend you consider using the metric system for all stained glass work and measure everything in millimeters (forget centimeters and meters). It is so much easier to measure, record, and divide 974mm than to work with a mixed measurement like 3 foot, 2 inches, and 5/16 of an inch.

Measuring the frame

Every leaded window should have around 3mm (1/8") of the outside lead showing once installed. This is to provide a good waterproof seal round the border. An H-shaped came is normally used as a border lead as it can be trimmed in places if necessary (some artists use zinc border came to provide more rigidity in transportation and installation.) For example, if a 10mm (3/8") wide H came is used, 8mm of it will be fixed in the rebate and 2mm of it will show out of the rebate.

Daylight Size = the inside measurement of the window frame (literally the amount of daylight you can see through the window)

Final Size = Daylight Size plus 8mm added to all sides. This is the size of the window to be constructed. It will be calculated, not *measured.*
Measure the Daylight Size of the window and then add 8mm to all sides to determine the Final Size of the leaded panel (fig 5.1).

Take the daylight measurement in two or three places horizontally and vertically and also check the corners of the frame with a square. If the window is out of square or varies in width you can either build the panel square and trim the border lead or actually make the window out of square as well. Double-check your measurements. If the window is divided into two or more sections, measure the distance between them so you can match any lead lines that flow across the divisions. If the window has a shaped top you will need to make a template of the shape or press heavy paper into it and mark the daylight size with a ballpoint pen. Make sure you completely understand the following example before continuing:
The Daylight Sizes of a window are 382mm wide and 620mm high. The Final Sizes will be determined as follows:

Width		**Height**	
Daylight Size	= 382mm	Daylight Size	= 620mm
Plus 8mm each side	= 16mm	Plus 8mm bottom and top	= 16mm
Final Size	= **398**mm	Final Size	= **636**mm

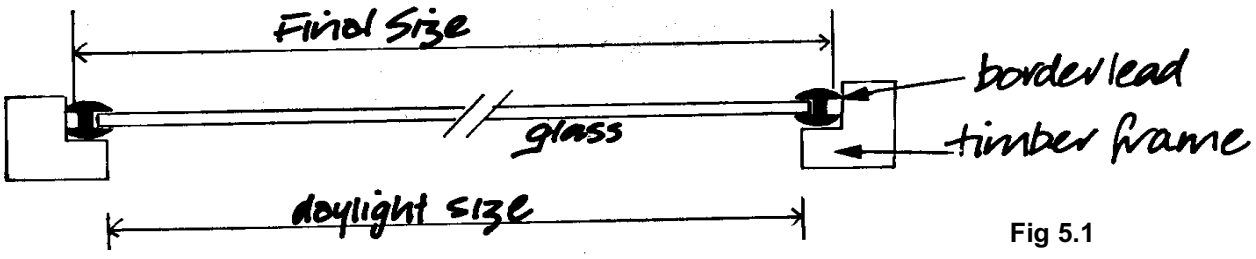


Fig 5.1

The "final size" (not the daylight size) dimensions will be used to draw up the cartoon. Always notate your measurements to save confusion later. If a distant client measures a frame and gives you their measurements, make doubly sure you know exactly what they have measured. They must give you the Daylight Size and rebate depth. Be VERY careful with measurements. A good rule of thumb is: Think twice and measure three times.

When measuring a window you will have a chance to start thinking about the design and can take stock of the surroundings. Look at the existing window from inside - what can be seen through it? What direction does it face? Does it get direct sun at all? Is it the only window in the room? What happens in this room and when does it happen? How will changing the window change the room? You may start getting ideas for the design so take notes while on site. You can mentally weigh up the balance of the room and the outside world and decide whether to be subtle or bold, colorful or restrained, transparent or translucent. Feel for a design, search for a hint of what might work.

2. The cartoon

The cartoon is the full size working drawing from which the glass will be cut and upon which the window will be assembled. The paper that is used should be Kraft or butcher's paper - something tough. It should be at least 2 inches (50mm) bigger all around than the Final Size of the window.

Final Size

Using a long ruler or straightedge and a square, draw the Final Size of the window on to the paper. Use an extra-fine felt tip or ballpoint pen for a sharp line.

Cutline

Inside this line must be drawn another line called the Cutline, which is where the glass comes to inside the border lead. If you look at the end of a piece of H-came you can see where the glass will fit on one side. On border leads, the other side (the outside) will remain open.

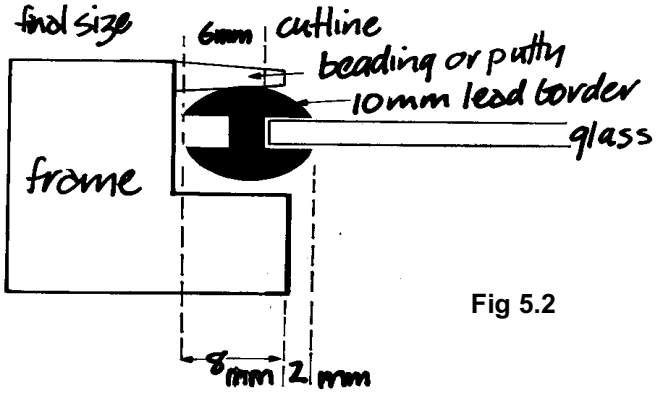


Fig 5.2

The distance from one side of the heart to the opposite outside edge is the distance between Final Size and Cutline. For 10mm lead, this is 6mm (see top of fig 5.2). If you are using a 10mm border lead, the Cutline (fig 5.3) should be drawn 6mm inside the Final Size line.

Design Lines

Now you can draw in the lines of your design. Use a soft pencil to start with. Once you are happy with the lines, go over them with a felt pen (such as a "Sharpie") that leaves a 2mm wide line on the paper. The 2mm line represents the heart of the lead which will be between each piece of glass.

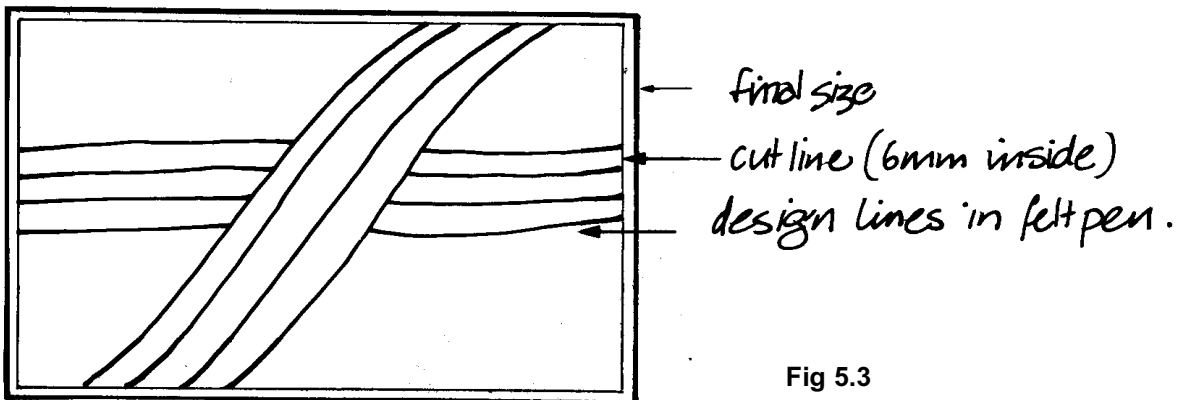


Fig 5.3

Once your design is complete, check that is possible to cut every piece and that they will not be likely to crack. If you have time, hang the cartoon up on the wall for a few days and live with it. You may be able to refine it slightly or notice something that requires change. It is better to discover minor design faults before a window is made rather than after. You may not have room to lay out all the cut glass beside the cartoon so you could number each shape and then each piece of glass as it is cut. If you know which colors you will be using, you can note them on the cartoon as well.

If you are going to use reinforcing bars (see section 9), mark their position on the cartoon and design them in if possible. Most people do not even notice reinforcing rods so there is not too much need for camouflage. The mind is a pattern-making organ and while the eye is exploring the design of the lead and glass it tends to exclude everything that is not part of that pattern.

Cut templates for any dark or opaque pieces. If you prefer, you can cut these shapes from scrap clear glass and trace round them with a felt pen on to the glass you are going to use for the window. Do not be impatient at this stage - make sure you are 100% happy with the whole cartoon before continuing.

3. Selecting and Cutting Glass

Let us assume you have already chosen the colors and bought the glass and can now proceed to cut out each shape. Remember to be economical, to check each piece back to the cartoon, and to checkmark each shape on the cartoon once it is cut.

Try out different colors on the light box or up against the window for effect. It may be difficult to choose the right shade of a particular color or to tell what a small piece of one color will look like beside larger pieces of other colors. This is where an easel is handy (see chapter 3 - workspace).

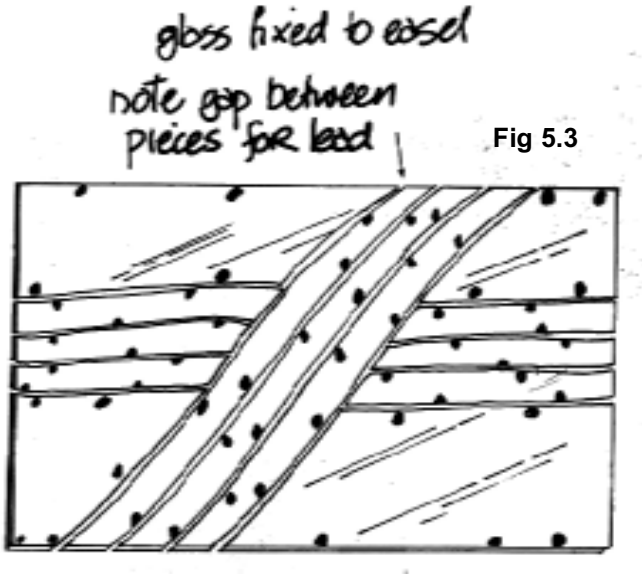
4. Using an easel

Each piece of glass, as it is cut, is attached to the front of the easel with three or more pea-sized knobs of plasticine. The plasticine can be scraped on to the back edge of the piece and will flatten out when pressed into place (fig 5.4). Use more "knobs" for larger pieces of glass.

Fig 5.4

The easel can be used in various ways. You can start with the colors you are sure of and attach them first. Other colors can then be held in front of the easel to see how they relate.
Another method is to cut out the window using your first choice for each piece and then, when all the glass is easeled, it can be reviewed, and any unsuitable colors re-cut. The easel gives you the opportunity to judge the effect of the finished window before it is even built (fig 5.5).

Fig 5.3



Some artists add extra realism by first painting black "lead-lines" on the back of the easel. This will stop light shining through between the pieces. For ultimate effect, dark curtains can be drawn around each side, top and bottom of the easeled glass so that the only light seen is coming through the window. The lengths you go to will obviously depend on how important it is to you and how much you are getting paid.

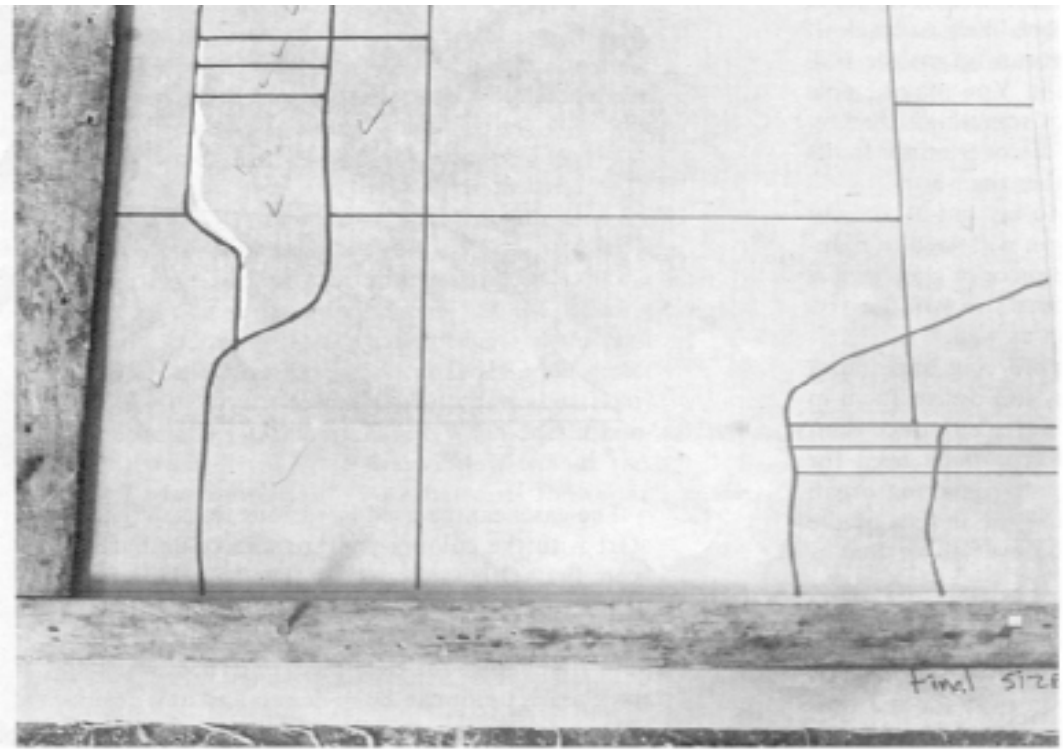


Fig 5.6

5. Assembly

Lay the cartoon on the bench and nail two battens along two adjacent final size lines to form a right angle (fig 5.6) You will be assembling the window starting from this corner and working away from it, tucking each piece against the previous ones. Choose the corner of the cartoon that seems the most logical one to work from.

Take the first length of border lead, straighten it if it is twisted, place one end in the lead vice, and pull the other end with pliers to slightly stretch and straighten it (fig 5.7). When you feel it firm up, do not pull any further. Always keep one foot out behind you in case something goes wrong.

Fig 5.7

Cutting lead

Keep the lead straight, place it on the bench, trim off the end where it was crimped, and cut it to length along the bottom edge of the cartoon.

Whichever type of lead knife you use, always apply a firm rocking motion as you slice through (fig 5.8). If you force the knife hard down you will squash the leaves of the came. German-styled lead knives have a blade with a sharpened, curved, edge to them. The rocking motion can be achieved by moving the handle up and down.

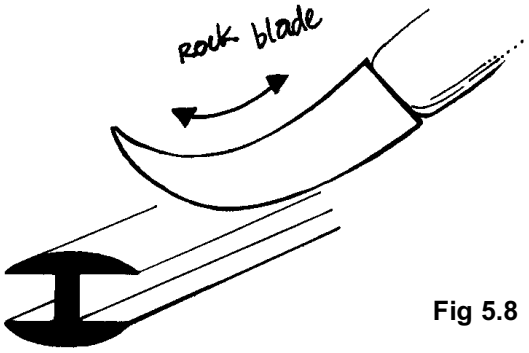


Fig 5.8

If the blade is has a sharpened lower edge, wiggle it slightly from side to side as well as rocking it (fig 5.9).

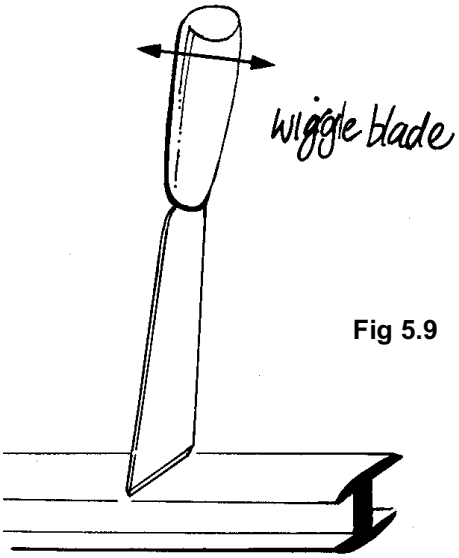
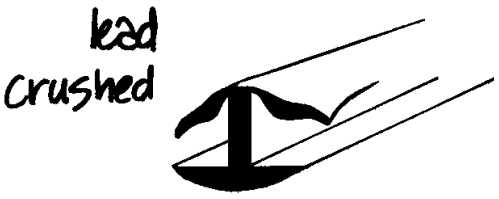


Fig 5.9

Practice cutting on a few scraps to get used to the action. The lead will crush slightly (fig 5.10), even with careful cutting, so always ease it back with the knife blade before using it. Keep the knife sharp.

Cut a second border lead for the adjacent side and butt them together in the corner - there is no need to miter the corner joints (fig 5.11).

Fig 5.10



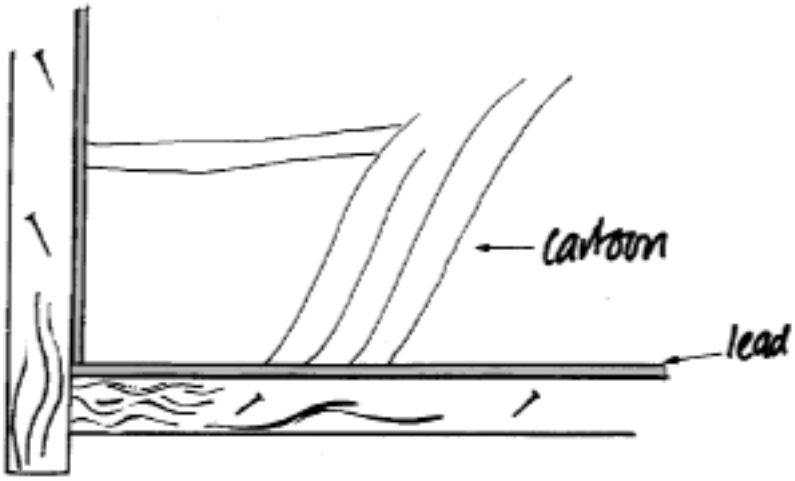


Fig 5.11

Think ahead and arrange the surrounding timber so that none of it needs cutting to length or else you will need to keep buying longer lengths for subsequent windows. You can use ordinary nails to hold the laths/battens in place (fig 5.12)

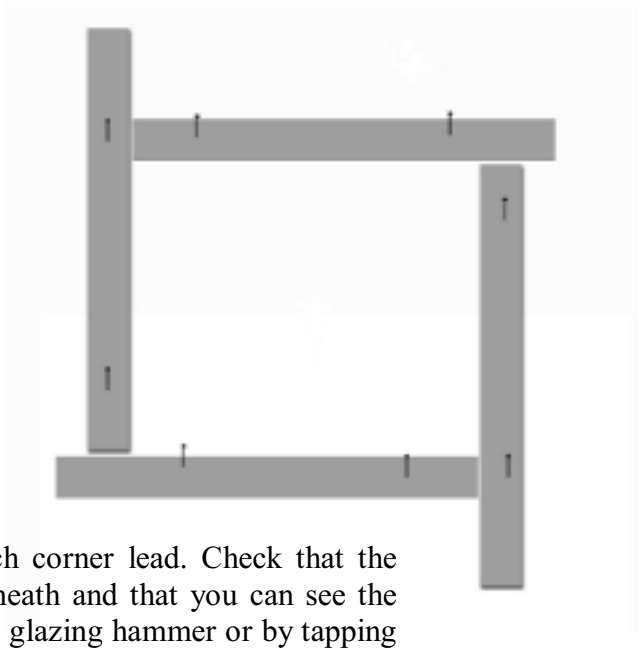


Fig 5.12

Place the corner piece of glass into position inside each corner lead. Check that the exposed glass edges are aligned with the pattern underneath and that you can see the Design Lines clearly. If need be, tap it into place with the glazing hammer or by tapping it with a small block of wood held against the glass (fig 5.13).

Straighten and stretch all lead came. Fit a piece of this lead against one side of the glass and trim it so it is short of the other edge side to allow for the overlap of the next piece of lead. It is a good idea to have a few small scraps of lead on hand to place on the adjacent glass edge help you judge where to trim to.

Continue fitting the pieces against each other and trimming each lead to allow room for others that butt against it.

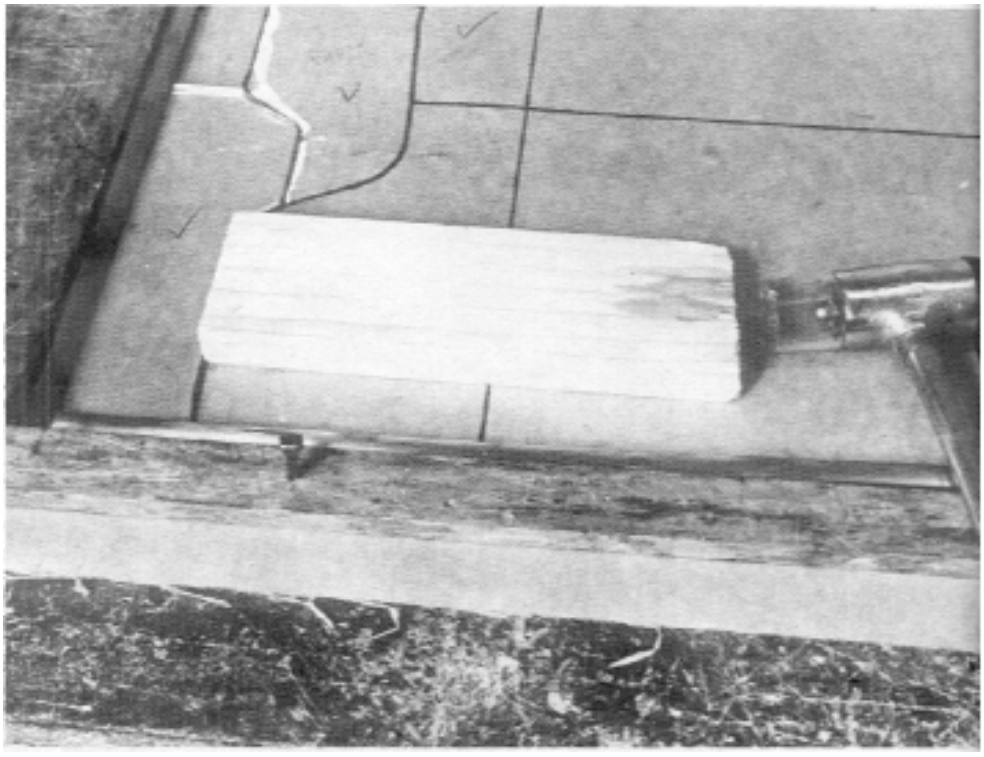


Fig 5.13

Lead ends cut short to allow room for this piece of lead which is being moved into position.

(The scrap lead at top was used to help to determine where to trim the three short leads)

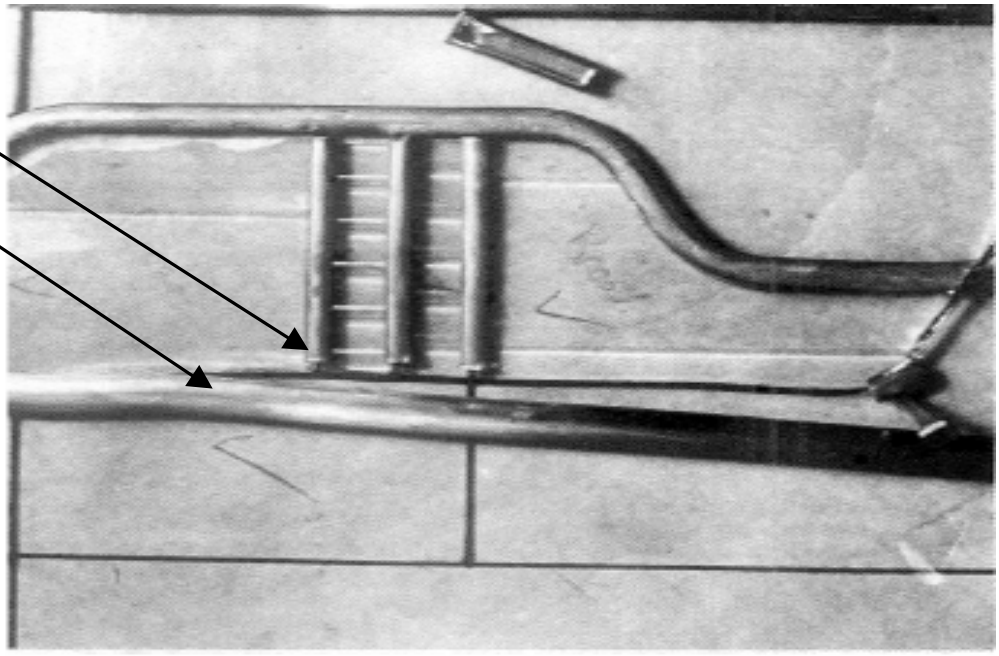


Fig 5.14

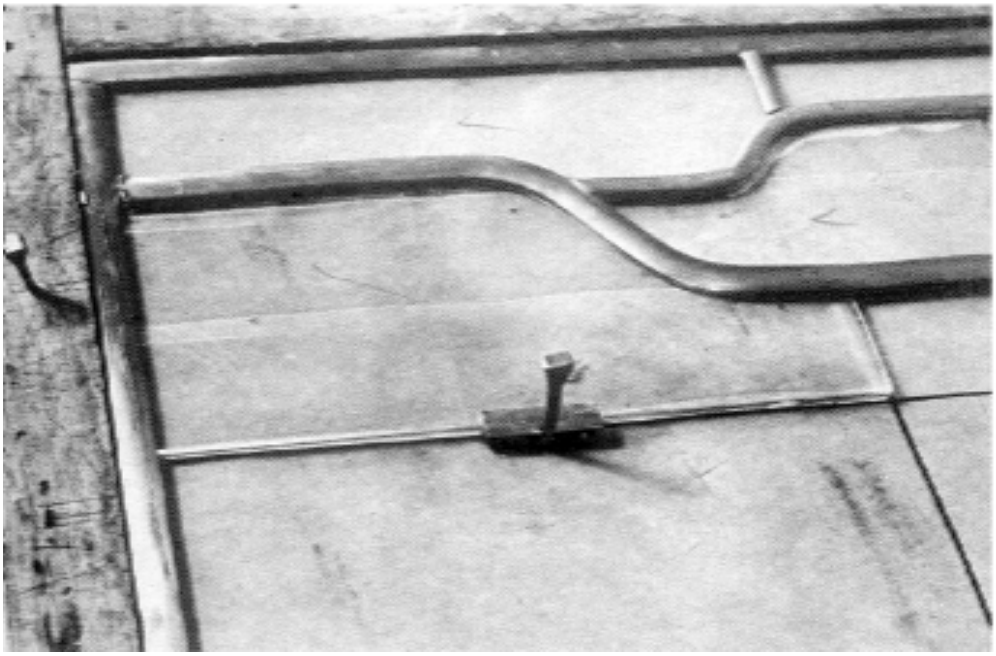


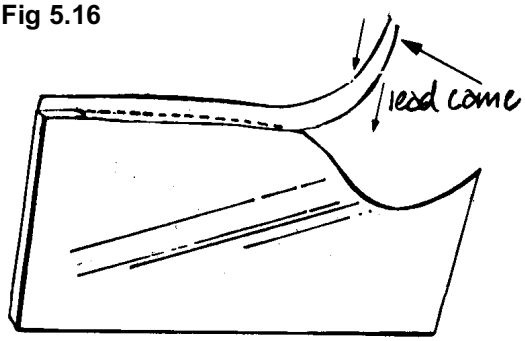
Fig 5.15

It takes practice to be able to judge where to cut the ends so you should cut them too tight at first and then trim them back. Try and trim leads so that they butt tightly against each other because that will make soldering much easier and faster (fig 5.14).

You can decide when to run length of lead along two or more pieces of glass and when to cut it short if you think ahead as you build a window. Use a glazing nail with a scrap of lead held against an edge (fig 5.15) to hold the glass in place.

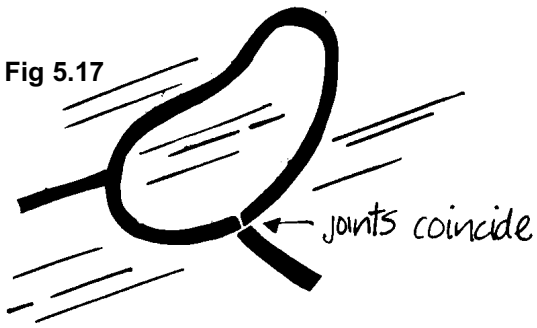
Pre-bend the lead against any curved edges before trimming and always cut the end short on the exact angle of the adjacent edge. To ensure the lead fits tight along an erratic edge, over-bend it and press it on to the glass a short section at a time (Fig 5.16).

Fig 5.16



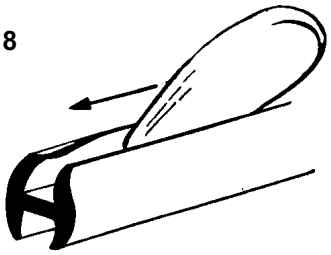
If any piece does not fit to the cartoon beneath, check that the lead is not crimped up and obstructing it. Tap it into place with the glazing hammer and if it still does not fit, it will have to be trimmed. Before you trim, take a closer look at the previously leaded pieces to ensure they are all tucked tightly into the leads, especially if you are confident all the glass was cut correctly. If one length of lead goes completely around a glass piece, position the start/end join so that it meets where another lead will be soldered to it (fig 5.17).

Fig 5.17



Soft lead may crinkle and crimp up but can be straightened out with a fid. This is a short piece of shaped wood (or plastic) that can be run along inside a lead channel to push the flanges out straight (Fig 5.18). It can also be used to force lead tight against the glass edge. You can make your own by shaping the end of a broken wooden ruler or sharpen a dowel to a blunt point.

Fig 5.18



Of course, different widths of lead can be used in panels and there are no rules as to when to use them. Very small windows or hanging panels can look too heavy if larger sized lead is used. Large windows will lose some strength if only narrow lead is used.

Once all the glass has been fitted, cut the border leads for the remaining outside edges and hold them in place with battens. Hold each batten against the lead and tap it with the hammer until it is sitting right on the Final Size line.

The soldering iron can now be turned on and while you are waiting for it to heat up, make a final check of the whole panel. Straighten up any leads that have shifted slightly out of position, lift crushed corners at the joints, and, if some of leads have been cut too short, cut small scraps of lead to fill the gaps. Be very careful doing this as you could break the glass.

If you look at your hands after leading, you will notice a gray film of lead dust over your fingers. That must be completely scrubbed off before you eat or smoke. Scrub your hands before leaving the workroom as you will otherwise leave lead dust deposits on everything you touch.

6. Soldering

You will need an 80 to 100 watt soldering iron, 60/40 or 50/50 solder, and a flux that is suitable for lead. Keep a damp kitchen sponge handy for wiping the soldering iron tip clear of any impurities collected from the lead and solder.

The joints need to be cleaned before they can be fluxed and soldered. Use a small soft wire brush that is about the size of a toothbrush and gently scrub until the lead on both sides of the joint is shiny. Flux is used to further clean the joints of oxidation and provide a clean area for the solder to bond to. If you use candle flux, rub it liberally over each joint. Liquid flux can be painted on with a small brush**.**

Before soldering the panel, practice on some scrap lead to get the feel of the action. Wire solder (10 or 13 gauge) is easier to handle than bar solder. Try soldering lead that has not been fluxed and also see how long it takes before the iron will melt through the lead. Obviously that must be avoided on the panel itself.

The action of soldering lead, and any other metal for that matter, is to flow the molten solder over the base metal which must also be heated up enough to produce a good bond. You cannot just "drop" the solder on - the iron has to rest on the joint just long enough to heat the lead, but not so long that it burns through.

Hold the iron so that the tip is vertical and pointing at the center of the joint. Bring the solder over to the iron tip and wipe about 3mm on to it. Press it gently into the joint for about a second or as long as it takes for the solder to flow out to the edges (fig 5.19).

Alternatively, the solder wire can rest on the joint and the iron can be pressed into it. The coil of solder can be pulled away as soon as enough has melted.

Use a small amount of solder at first. You can always add more but it is difficult to take it back off. A well-soldered joint should be smooth and flat, tapering off almost to a feathered edge.

If, the joint is craggy and bumpy, the iron is not hot enough or was not held in place long enough. If the solder just sits in a ball in the middle of the joint then there is either no flux present or else the lead is old and dirty. Use the wire brush to scrub the joint, re-apply flux, and re-solder.

Should you happen to burn the lead, cut a small scrap of lead to size and solder over that to bridge the gap. You might need to hold your knife blade underneath to lift it up off the glass. Stop soldering the panel if the results are not too good and practice again on scrap lead. When all the joints have been soldered wipe up the excess flux with a paper towel and remove the battens. Check each joint before turning the panel over. It is very easy to miss one. Check the soldering video at:
http://learn-stained-glass.com

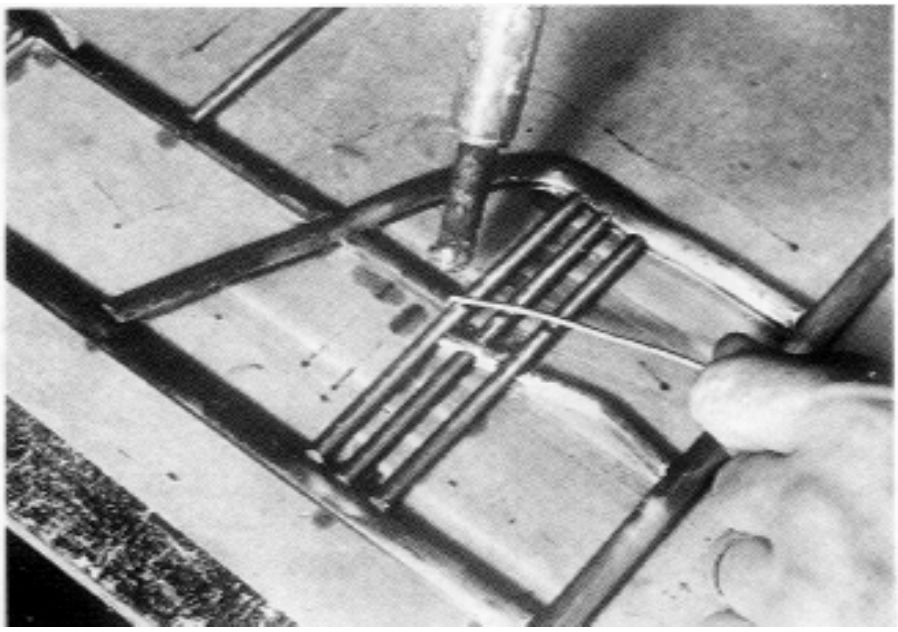


Fig 5.19

7. Turning the Panel Over

Fig 5.20 Slide half the panel off the table supporting it with one hand.
Fig 5.21 Raise the far edge using the table edge as support for the center.
Fig 5.22 Stand the panel upright on the bench, soldered side leaning towards you.
Fig 5.23 Push the bottom edge away, lower the panel, supporting it in the middle and holding the near edge.

The joints on the second side can now be soldered.

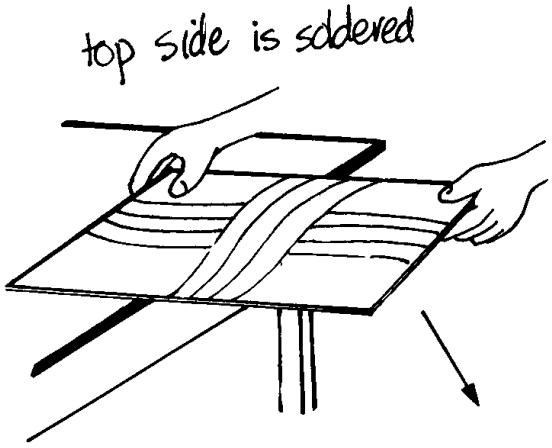


Fig 5.20

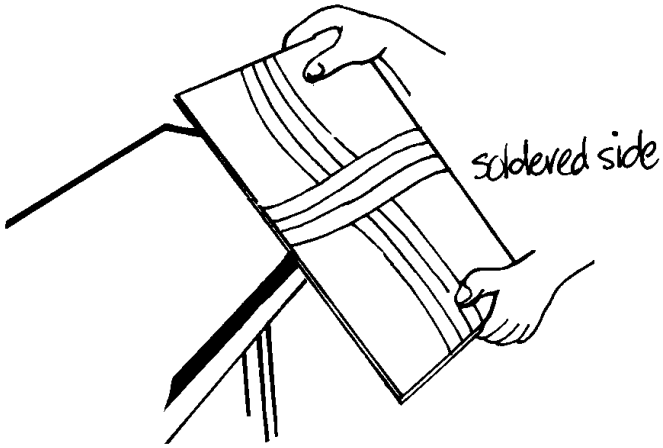
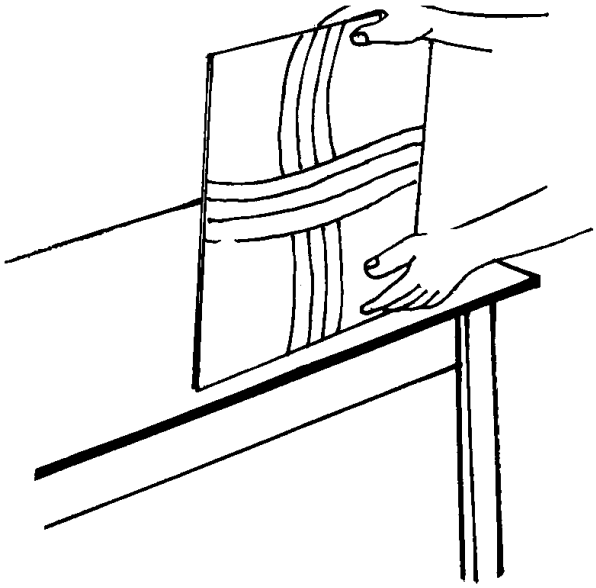
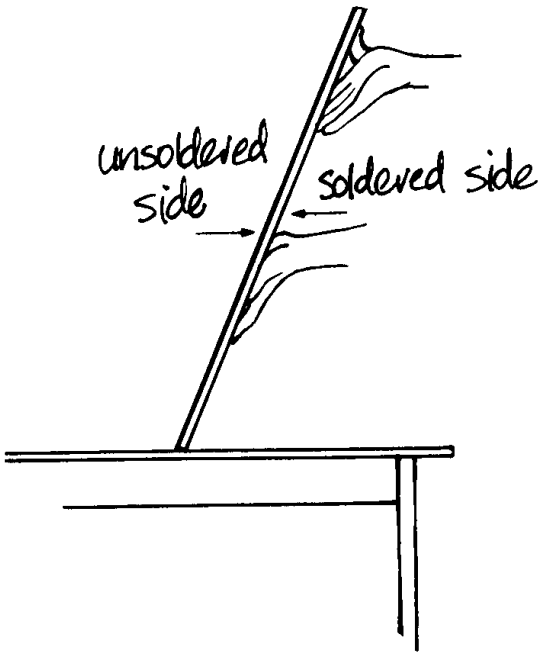


Fig 5.22

Fig 5.22

Fig 5.23





8. Cementing

The purpose of cementing is to strengthen and waterproof the panel by forcing a putty compound into the lead channels where it will seal and harden around the glass. For small panels you could force some ordinary linseed oil putty under the lead with your thumb. For larger panels it is better to use proprietary stained glass cement or make up one of the following mixtures and brush it into the leads.

Mixture "A"

Mix together equal parts of whiting and plaster of paris in a small container.

Add a teaspoon of black oxide (you can add more later if necessary).

Mix together equal parts of turpentine and boiled linseed oil in a jar or bottle.

Add the liquid mix to the powder mix in trial doses, stirring in between, until you have a very thick dough consistency. If you make it too sloppy just add more powder mix.

If you have nowhere else to do this but in your workshop, spread old newspapers around and wear old clothes or an apron.

Take a firm-bristled brush, like a dishwashing brush or a soft scrubbing brush, and pick up some cement on it. Scrub towards the lead so that the bristles force cement under the flanges (fig 5.24). Do not use a circular “scrubbing brush” motion because you may gouge out as much as you force in. Go around every piece of glass, brushing towards each section of lead. Be careful not to deform the border leads away from the glass.

Double check that all lead is full then turn the panel over and repeat the process on the other side.

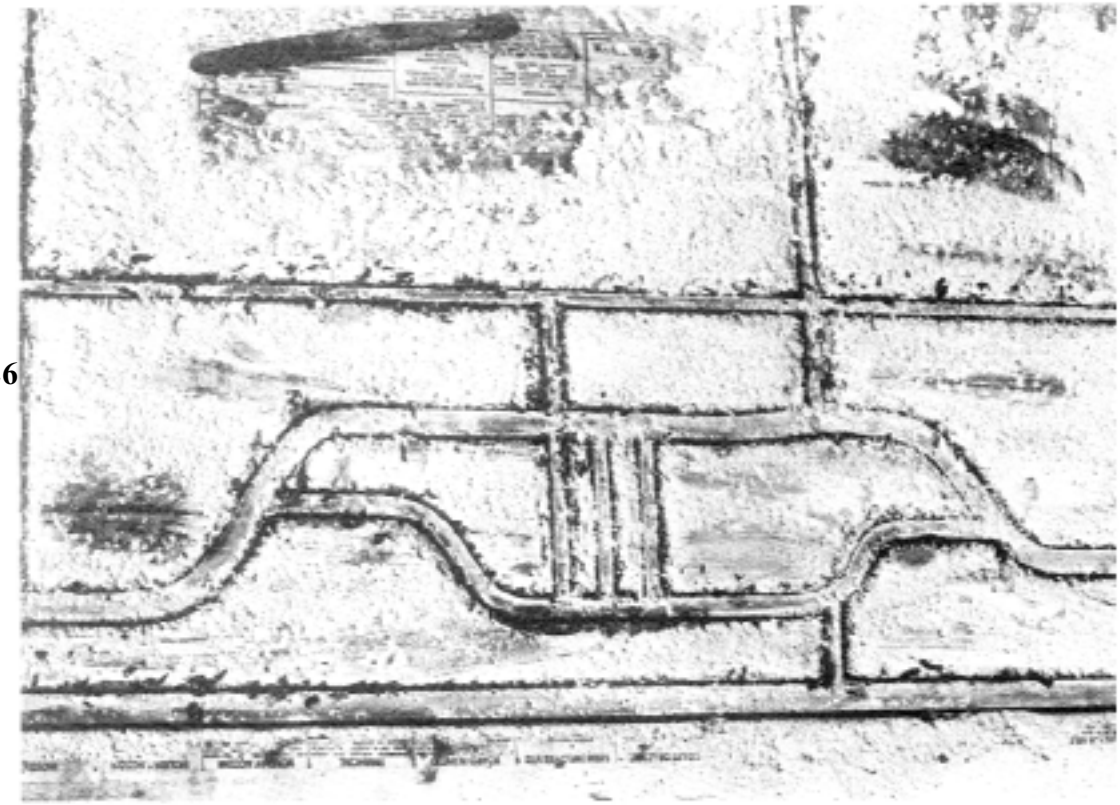
Make sure that the mixture covers all the lead and solder because it will help to darken them slightly and provide a good "key" for the blackening to adhere to.

Fig 5.24

Fig 5.25

Sprinkle whiting liberally over the whole side and rub it around (fig 5.25). The whiting will become absorbed into the cement under the lead and start to stiffen up. At the same time, it will absorb the excess moisture and mixture on the glass surface.
Take a pencil-shaped piece of wood (a sharpened dowel works well) and gently run it around the edges of the leads to shear away the excess cement and leave a clean edge (fig 5.26).

Fig 5.26



Take another brush and go over the whole panel with it but this time brush carefully *along* the leads to take the material away. Wear a cheap disposable facemask as it can be a dusty job. You can be fairly vigorous but make sure you are not scraping the cement out from under the leads. The whole side of the panel *must* be absolutely spotless so brush over all the glass, not just around the leads. Use a brush and pan to move large piles of whiting and to give the panel a final dust-off. If any cement looks like oozing out, firm it up with a few pinches of whiting and clean it again with the pointed stick.

When the whole side is clean, stand the panel on edge, change the newspaper beneath it and turn it over to repeat the process on the first side. If any residue is left on the lead or glass it will prove very difficult to shift once it has dried. Leave the panel lying flat for a few hours then come back to it and shear off any further seepage with a stick or a nail. Make sure the corners are not rounded with cement - pick it all out.

The panel should be left for at least two days to dry out and harden.

9. Blackening

It is not necessary to blacken the lead and solder before installation. The dull gray finish of un-blackened lead will suit some designs and a dark black shine will suit others. In any case the technique is simple:

Take a bottle of lead blackening (I prefer Liquid Stove Polish) and give it a good stir. Merely shaking it will not disturb the heavy sediment on the bottom. Paint the polish over the lead, the solder, and the cement under the lead. It does not matter if some goes on to the glass. The polish will dry out to a black powder within a few minutes and can then be brushed off with a stiff brush. If your polish dries to a fine black dust, wear a face-mask during the brushing operation to keep it out of your mouth and nostrils. The lead and solder should both shine up to the same degree of blackness and polish. If the dry polish is difficult to remove from the glass, try a household glass cleaner and paper towels. Metholated spirits will also work but may remove the polish from the lead as well if you are not careful. Give the whole panel a final buff up with a soft rag (old tee-shirts are good).

10. Reinforcing

There is no infallible rule as to when a window needs reinforcing. Some people say anything over .5 sq. m (5.5 sq. ft) or where the smallest dimension is greater than 600mm (2 ft). Many windows are inherently strong by nature of their design. Take everything into account and if in doubt - reinforce.

The normal method of reinforcing is to solder copper wire "ties" to the window and wrap them around a steel or brass rod that is fixed into the frame. Cut the wire into 75mm (3") lengths and apply a suitable copper flux (such as is used for copper-foil work) to the center of each wire. Attach a blob (technical term) of solder to this area and the ties can then be placed on the window. Solder the ties by scraping the "blackening" from the leads, or existing solder joints, where the bar will cross them.

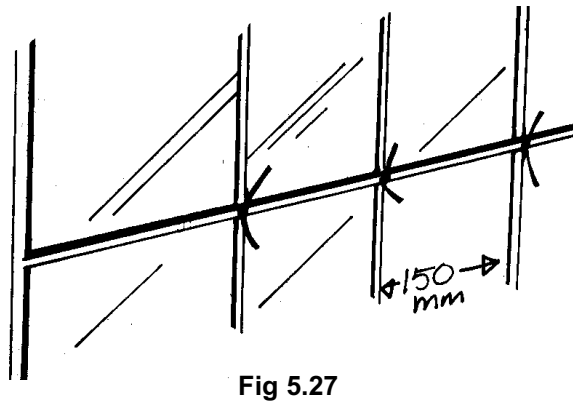


Fig 5.27

The ties should be spaced about 150mm apart (fig 5.27). Apply flux to the scraped lead areas. A press with the soldering iron will melt the solder and affix the tie. The fresh solder joint can be darkened with black patina or left to dull over in its own time. It will be hidden by the bar in any case. The bars are usually 8 or 10mm (3/16 to 3/8") steel, zinc, or brass rod or box section. They should be cut oversize, and primed and painted before installation. Reinforcing bars always cross the shortest dimension whether it is vertical or horizontal

Another method is to solder a 10 x 4mm (3/8 x 3/16") brass or zinc bar directly to the lead and check it into the frame on installation (fig 5.28). This results in a very strong window because the bar is part of the window, not just part of the frame. It is a slightly more time-consuming method since the face that shows through the glass to the outside must be painted before soldering. The soldering itself requires plenty of heat to give a bond and the joints can look quite messy. However, it does present a very low profile as you look through the window.

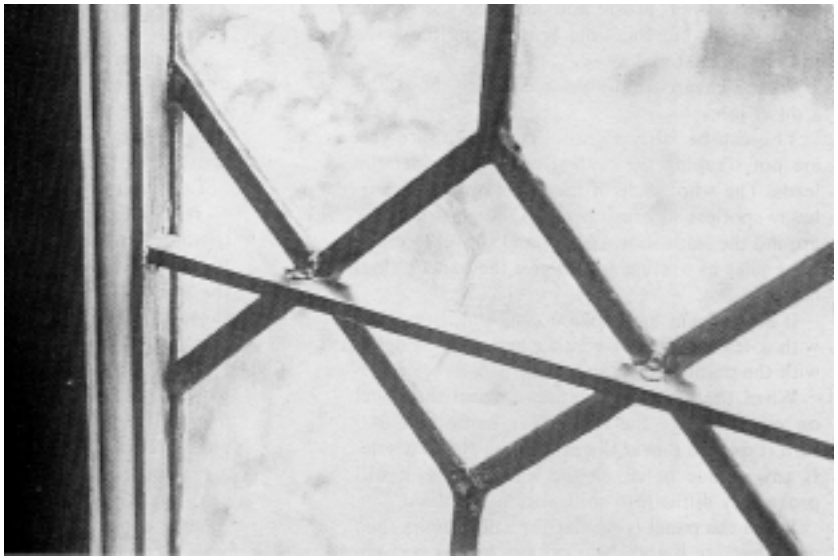


Fig 5.28

11. Installation

On an existing wooden window, hack out the old pane of glass using a chisel on the hardened putty. Clean the rebate so it is smooth and even all around. Prime the rebate with a quick-drying wood primer to stop the wood from absorbing oil out of the fresh putty. Check the leaded panel to see how it fits and trim the border leads if they are tight anywhere.

If the panel needs packing up to center it, use thin strips (or shavings) of wood under the bottom lead. Mark the position of any reinforcing bars onto the inside of the frame.

If you are using 10mm (3/8") reinforcing bar, drill a 10mm hole into each side of the frame (fig 5.29). Make one hole about 20mm (3/4") deep and the other one about 40mm (1 ½") deep. The rod can be cut just under 40mm longer than the daylight size and pushed into the deep hole first then back into the shallow hole.

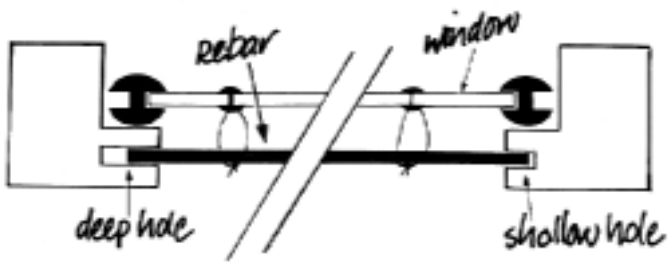


Fig 5.29

When the primer has dried, thumb a small film of glazing putty around the inside edge of the rebate and very gently press the leaded panel into it. Too much pressure in one place can crack one of the outer pieces of glass (that is REALLY annoying), so go around the border a few times easing it in. The putty should ooze up on the inside of the window. To hold a panel in place while the putty dries, use carpet tacks and angle them into the corner of the rebate so that the large head overlaps the edge of the border lead (fig 5.30).

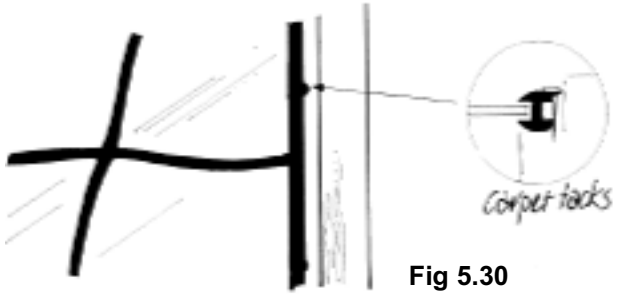


Fig 5.30

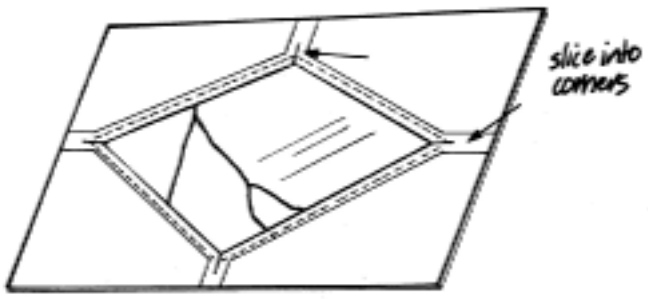
Use a nail punch – carefully! Finally, thumb some putty around the outside and use a putty knife to smooth it to a taper on the border leads. Clean away all the excess putty and give the whole window a final polish. Twist the wire ties around the bar. Snip excess and fold the short ends along the bar. Some windows will have timber glazing beads that can nailed in around your panel in lieu of putty.

12. Repairs

It is hard to repair windows on site because they need support from behind while being worked on and because it is difficult to resolder a vertical joint.

The quickest way to repair a crack is to hide it by soldering a false lead over it. Just slice one face of an H-came away from the heart, cut it to length and solder it in place. Scrape back and flux the old lead to get a clean surface for the solder. If a piece or glass is broken and the lead came is flat and fairly soft you might be able to slice into the corners with a utility knife and fold the leaves out (fig 5.31).

Fig 5.31



The glass can be broken out, the channels cleaned and a new piece cut and fitted. Fold the lead back and re-solder, thumb some putty in, and clean up.

If the lead has a rounded face it will be difficult to bend back. In this case you can slice the lead away until the glass edge is exposed and can be taken out. If too much force is applied you can break some of - the surrounding glass. Scrape back- the surrounding lead and replace the glass. Cut some leaves off some new lead, trim them to fit, and solder them back in place. This type of repair can look very messy when finished and might attract attention to itself.

For most repairs the window should come out and be worked on in the studio (fig 5.32). Measure the window as well as the Daylight Size so you can be sure to rebuild to the correct size. Use your lead knife to carefully cut back the lead, then ease out the glass and lead until you get to the part that needs repair. Clean out the old lead channels, replace the glass and lead as necessary, and rebuild it back to the original size (figs 5.33, 5.34). Check the whole window thoroughly for other cracked solder joints. Scrape them back, flux, and resolder.

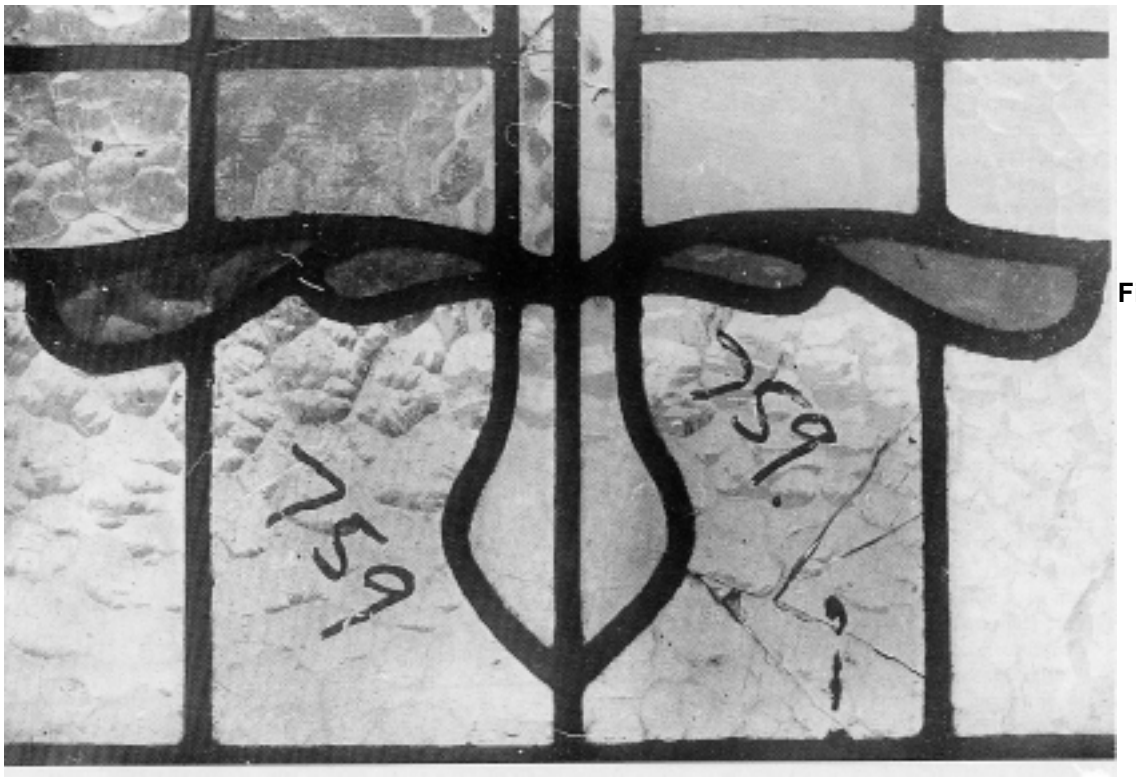


Fig 5.32

The bottom half of this window has been dis-assembled, the exposed lead channels have been cleaned out, and it is ready for the new glass and lead which will build it back to full size.

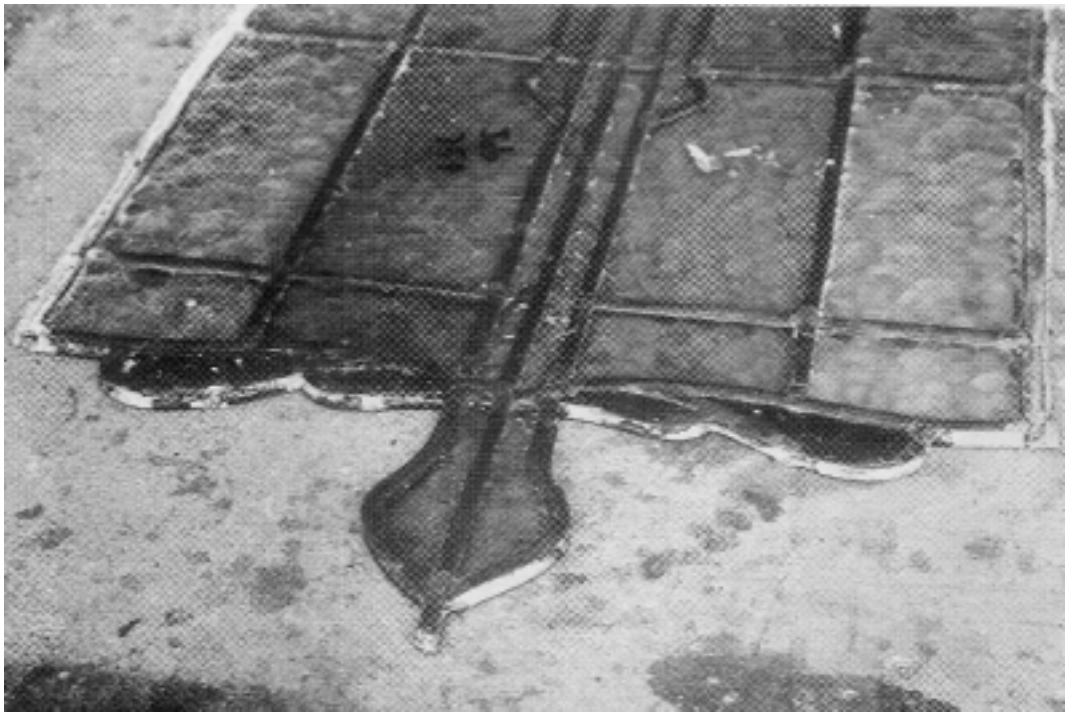


Fig 5.33

Note the fresh lead and glass, and the scraped-back joints ready for soldering. The new glass is the nearest match that could be made to the very old original glass. Sometimes unbroken pieces will also be replaced for the sake of balance.

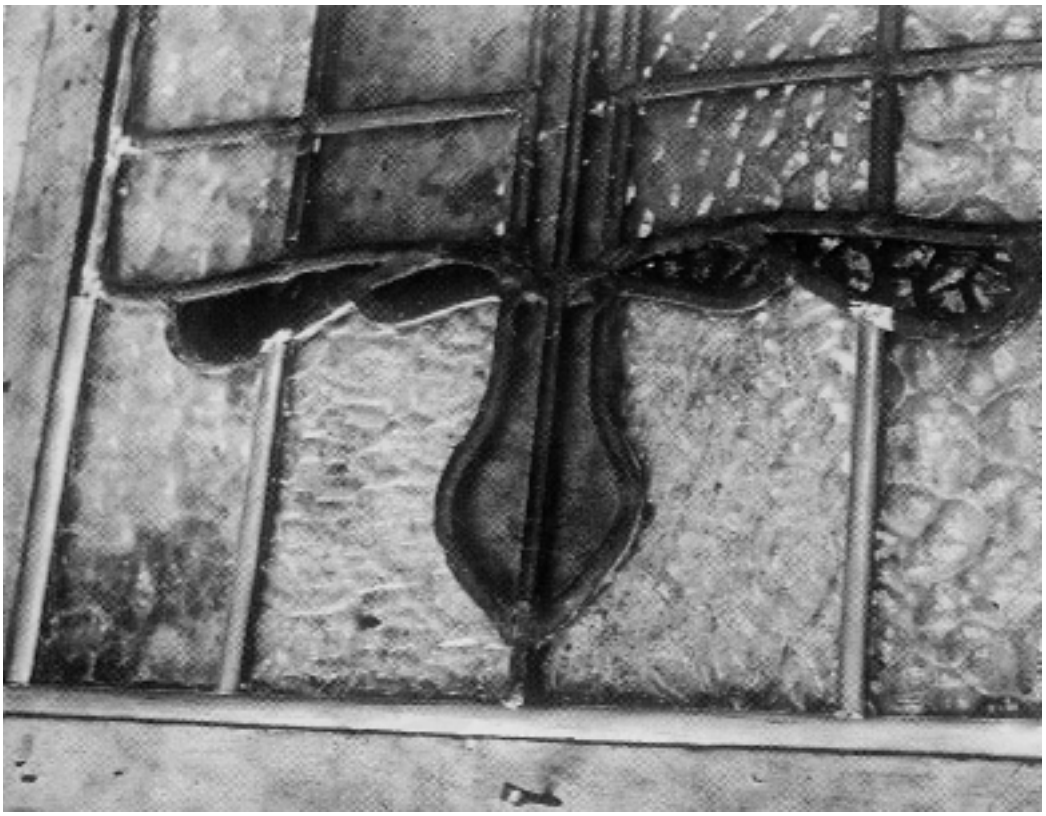


Fig 5.34

6. DESIGN CONSIDERATIONS FOR LEAD

Design is the most important component of a stained glass window. A clumsy design, however perfectly executed, will not produce a memorable window. Because design is far too large a subject to be discussed here in any depth, I suggest that, if you feel your knowledge of color and composition is limited, you should undertake some private study through night classes, the internet, or the local library. There are some very good guides to drawing and composition on the Internet and a search using phrases like "principles of design", or "art composition" should prove fruitful.

Designing for stained glass requires an understanding of the basic principles of color theory and composition along with an appreciation of the unique qualities of the medium. Stained glass is better at doing some things than others. For instance - it is not a great medium for figure studies because the leadline tends to harshly divide up areas of the body and it is difficult to suggest texture, shadows, volume, skin variance, and 3-dimensional form with lead and glass. To say nothing of the problems of depicting separate, unconnected, components such as a mouth or a navel. Artists that have risen to this challenge have often resorted to awkward compositional devices which have, more or less, dictated the flow of the composition. In other words, the medium imposes its own constraints (I prefer that word to "limitations") and in many instances, pushes an artist away from realism and towards abstraction. The only thing a stained glass window can "realistically" represent is something that has shapes that are bound by sharply defined lines. To a medieval glass painter, the leadline was a necessary evil - the structural skeleton that held the painted glass pieces in place. To the contemporary glass artist, lead and glass have become two primary, complementary components. When we "draw" a window design - we draw the leadlines. That is why developing our drawing abilities will have a huge impact on our window designs. It is easy to draw; that is, to make marks with a pencil or pen, but to draw *well* requires one other thing; the ability to observe and record the relationships of visual components in space.

The following are some of the important qualities of stained glass that provide both its discipline and its uniqueness:

Size

Some designs look fine as a sketch but wrong when scaled up to full size. Others seem to have a natural size and do not seem to work whether scaled up or down. Try to visualize the impact the window will have on its surroundings and exercise enough control in the design so that it does not become too overpowering.

Light transmission

Glass is a unique medium in that its primary effect is achieved by light traveling through it rather than being reflected off it. One important aspect of this is that the immediate outside world affects the way the window looks from inside.
For instance, trees near a window could tinge it green in summer and brown in autumn. As the
sun moves around during the day the appearance of the window will change noticeably. Stand back and take a long look at some of your glass against a window. Come to terms with the outside and inside world and how glass can change the appearance of both.

Brightness

An easy way to impress other people is to use the most amazing glass you can get your hands on in the boldest, most dramatic fashion. Designers and observers alike can be captivated by the "punch" and

excitement of exotic glass and may not notice the lack of good design or thoughtful architectural integration. Novelties wear off quickly though and there must be more to glass design than the use of obvious or blatant technical effects, especially in windows that will become part of people's lives. The contrasts of color and intensity in stained glass are far greater than that of any other medium and as such need to be treated with respect and control.

Line

In contemporary glass design the lead line has taken on a far more important role than in the days when it was merely suffered as a necessary evil. Lead is the major graphic tool available to a stained glass designer. With it we can suggest strength, direction, speed, grace, balance, harmony, decay etc.. Line must also somehow convey the pure essence of the subject whether it is abstract or representational.

Stained glass roses never look like real roses because you cannot produce the texture and shading of a rose very well with glass and because, in nature, rose petals do not really have black lines around them. If you have to design a rose you need to use line to suggest the feeling and essence of a rose rather than attempt a literal translation. The conclusion from all this is one that is not often realized: by its very nature stained glass is and has always been a truly abstract medium and this is mostly due to the insistent and inescapable presence of the lead line. The realization of the graphic potential of lead has really been the savior of the medium, as a look at any of the post-war German glass design will clearly show. Because line is the prime compositional tool, it is important to learn its special language. Become aware of the lines around you, the edges of things, the interface between shapes, and the divisions of large forms. Try to discover what makes line interesting to you.

Form

Designing a window is not merely a matter of filling up a given space. An equal intensity of color and intricacy of design over the whole area will lack focus and interest. A good composition must incorporate forms, in color and line, that provide a balance of contrasts. There should be areas of rest as a complement to the areas of activity. The whole space must be composed to obtain the required effect through the careful use of the inherent qualities of the medium.

This window is on the side wall in a crematorium chapel. The design concept was to use vertical lines to emphasize the movement from earth to heaven. The upper floating colored shape has a reflected version below. These two shapes are suspended in air - almost as if floating outside of the frame. They enter from the left and exit "stage right", interacting with numerous events along the way. The combined aspects of movement, parallelism, suspension, interaction, and entrances and exits, all hint at the temporal and spiritual nature of life.

Architectural Integration

Stained glass is an integral component of a building and is tied to architecture as much as any other art form. When designing for a building, you should be searching for the design that the building needs rather than one that you are dying to try out. I like this comment from German glass artist Ludwig Schaffrath. "The building is not there as a frame for your window. You must play your part in the orchestra of the architecture. In one building play the flute, in another the cello." Many feel this integrative approach is the true discipline of architectural stained glass design. In truth, windows can complement the architecture, contrast with it, or completely integrate with it.

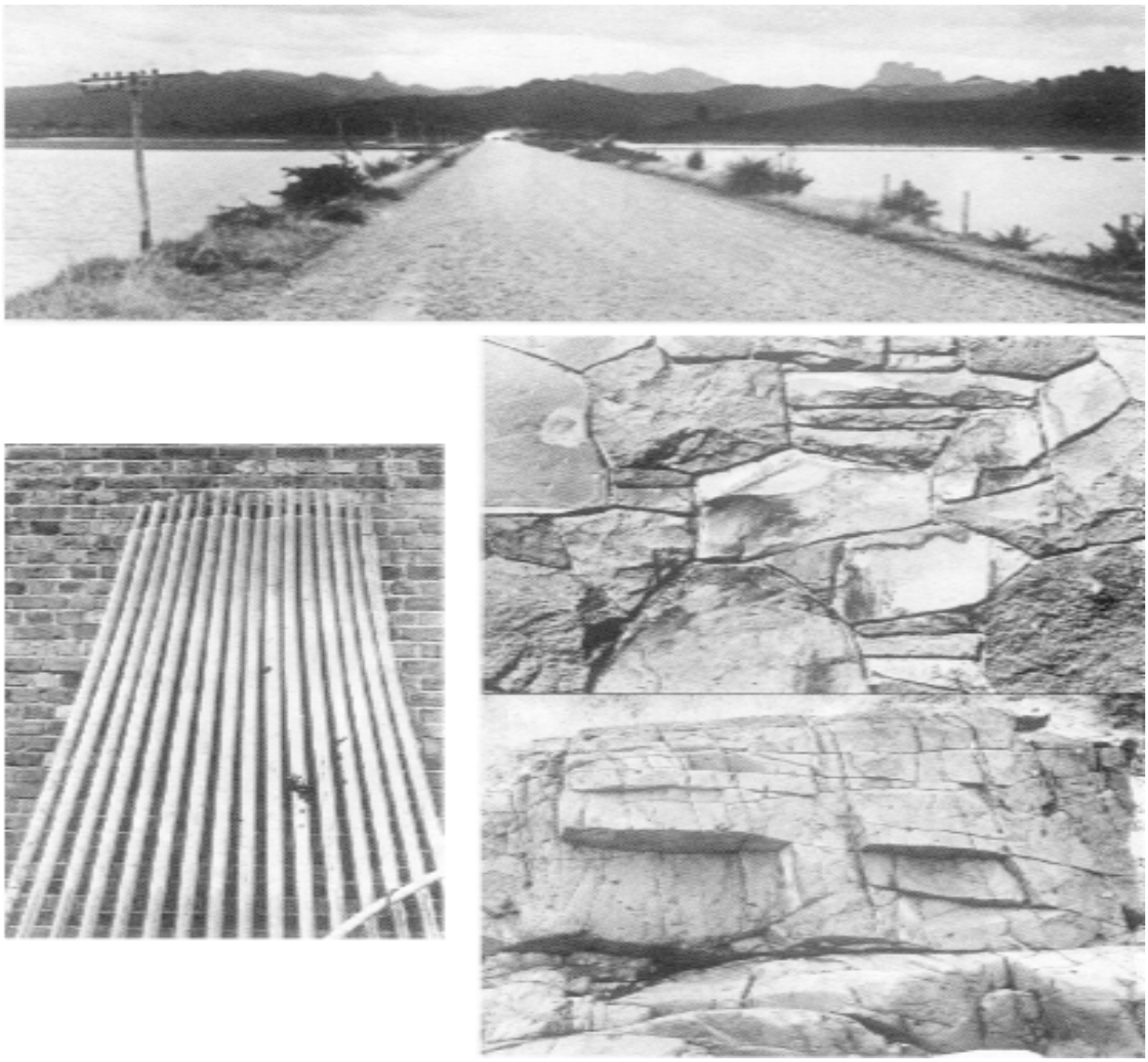
Autonomous Panels

Glass is not only architecturally oriented. There is an exciting field of design that concentrates on free-hanging stained glass panels which are self-contained works in their own right. These have become known as independent, or "autonomous", panels and can be hung in front of existing windows. The attraction of designing like this is the complete lack of any rules and restraints. Because the autonomous panel is not made for a specific building and customer, every decision about style, size, color, techniques, framing etc, is the designer's alone. You can experiment with ideas for future commissions or just make up the design you most want to do next. This sort of work is usually a far more personal "statement" than architectural work can be. While there is tremendous satisfaction in doing what you want, there is not as yet a huge market for autonomous panels. I feel that should be seen more as a challenge than a drawback.

Fig 6.1

The trunk of this "fruit salad" plant has shapes and lines with clearly defined edges – making it an ideal subject for interpretation in stained glass. The autonomous panel on the right is not a strict copy but attempts to capture the creeping aliveness of the plant. The leaden lateral roots appear to have burst out of the frame.

The above points are offered only as a start point for your own ideas. I am quite sure there could be a healthy argument about some of them and that is great. It has been pointed out that we react to things as we perceive them to be, not as they actually are. The way you perceive things could be your personal contribution to contemporary glass design. While you are quite likely to gain some insights into the peculiarities of the medium through studying other glass designs, do not fall into academic imitation of other artists and then try palm off the results as your own. That would cheapen both you and your mentor and would point to an absence of originality. Every creative person knows how it feels to "go blank" occasionally. The worst thing to do is worry about it or give up. The best thing to do is to just keep on searching ourselves and our world – to keep drawing and freely interpreting what we experience and see.



Look around you for design ideas - plants, landscapes, stones etc all have shapes and forms that can be adapted for stained glass work. Take particular note of the linear qualities of the edges of shapes.

7. COPPER FOIL TECHNIQUE

The development of the copper-foil technique is generally (and wrongly) attributed to Louis Tiffany who used to make intricate lampshades with as many as 2000 small pieces of glass. The foil method was ideal because it produced a joint that was stronger, lighter and more delicate looking than lead. Foil is also cleaner to work with because no cementing is necessary.
The technique is by no means limited to lampshades. In fact, the very qualities of strength, lightness, and delicacy make it ideal for windows, hanging panels, and three-dimensional objects such as terrariums, jewelry boxes, and glass sculptures. The secret is in the tin content of the solder that holds everything together. Tin is lighter and stronger than lead and not prone to stretching as lead is. Another bonus is that copper foil will not burn through like lead does when you are careless. If you are not happy with the surface of your soldering you can keep playing around until it is right.

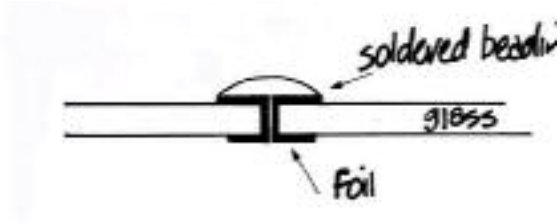


Fig 7.1

The edges of each piece of glass will be wrapped with copper tape that is less than 1/10mm thick. The glass will have to be cut with almost no gap between the pieces at all so the cartoon lines must be drawn as thin as possible. Do your initial drawing in pencil and, once it is satisfactory, draw over the correct line with a steady smooth action. Use a ballpoint or fine felt pen.

If you are making a large window in copper, design it with an H-lead border for ease of installation. Copper foil is not completely weatherproof or waterproof.

Score each piece just on the edge of the line - try a few practice pieces with scrap glass. Your glass cutting will have to be very accurate. Break the glass without resorting to tapping which causes rough edges. Check all pieces against the pattern and against each other. Trim any irregularities by grozing, rubbing with a carborundum stone, or using a grinder.

Wrapping Foil

Foil is sold in 30-meter (100') rolls and a variety of widths. 6mm (1/4") foil is used for most work. Make sure the glass is clean from dust and moisture or the foil will not adhere properly. Peel away some of the paper backing from the foil and center one edge of the glass along it. Press the foil tight on to the edge and fold the sides over on to each face of the glass. Continue around the piece, first sticking the foil to the edge, and then the sides (Fig 7.2).

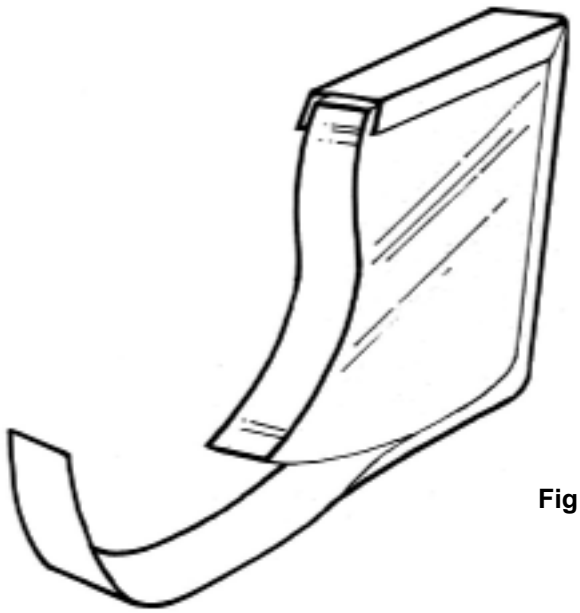


Fig 7.2

When you finish, overlap the start by 5 to 10mm and cut the foil. It is important to have an even amount of foil folded over each edge all the way around. Try and get neat tight corners by crimping the foil into lugs that can be folded tight as you foil the next edge (Fig 7.3).

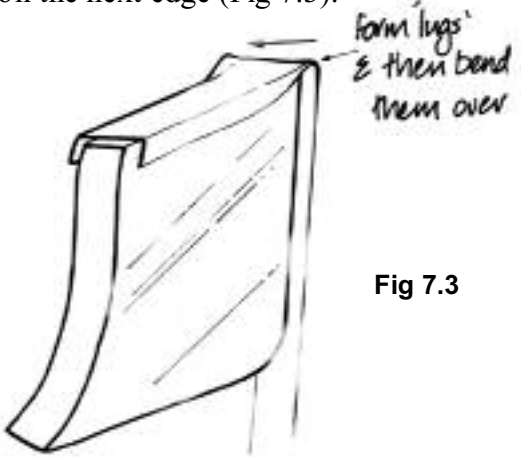


Fig 7.3

Internal curves

On severe internal curves the foil will split if you are not careful. This can be avoided by burnishing the overlaps with a fid or a pencil. Run it along alternately on either side, gradually tempering and stretching the foil round on to the glass (Fig 7.4). (See website for burnishing demonstration.)

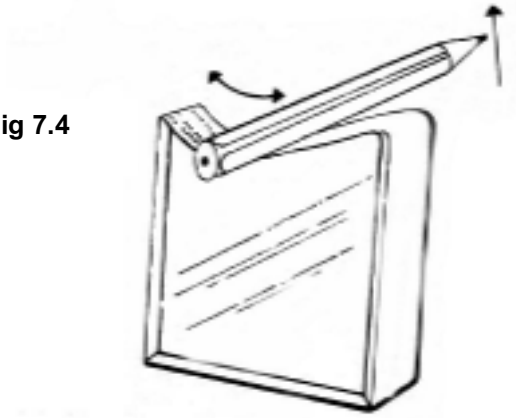


Fig 7.4

Place the piece on the bench and further flatten the foil to the glass by rubbing it with a fid. Always start foiling on an edge that will butt against another piece so the join will be hidden in the center of the panel and not on an outside edge.

Try holding the glass so that the edge you are foiling is the furthest away from you and you will be able to see if the foil is evenly protruding out each side of the glass. You may be all thumbs at first but the final effect relies on this part of the job being done right.

Assembly

A frame of laths/battens will be necessary for a square or rectangular panel but free-form hangings can just be built up on the cartoon.

If you try to place all your glass on to the pattern at once you may find that, as you press the last pieces into place, you are dislodging some of the earlier ones. It is better to heat the iron and tack pieces over the pattern, two or three at a time.

Foil must be fluxed before soldering but do not do it all to start with. Instead just flux pieces at their corners and tack them together with a small amount of solder (Fig 7.5). If you have trouble in a later stage of assembly it is easy to unsolder your way back to where things had been right. Coil up some wire solder and have one end sticking up like the raised head of a snake. This will make the solder accessible to the iron tip and will free your other hand to hold the pieces in place as you solder.

If every piece is pressed tight against its neighbor and tacked into place, the design should follow the pattern. If a piece will not fit at all, trim it and refoil it or leave it out completely and recut a new piece once the whole panel has been built. One piece of glass that is oversize will throw the remainder out of position.

Soldering

When all the pieces are tacked together, check again that all the foil is tight on to the glass. Apply flux with a small brush to all the exposed copper and cover it with solder.

The best way of achieving a good raised "beading" such as fig 7.6 is to lay the solder wire along the joint in the path of the soldering iron. Hold the iron so the tip is vertical or lean it slightly in the direction of movement and float it through the solder, gently touching on the foil surface underneath.

It does not take much practice to perfect this movement providing your iron is hot enough and the tip is kept clean.

If you are not happy with the finish of the beading, just go through it again as smoothly as possible. The foil cannot burn away.

Turn the panel over and flux and bead the other side. If you go over a joint too much on this side there is a risk of over-heating it enough to melt through and disturb the beading on the first side. Leave any rough areas to cool down and return to them a little later.

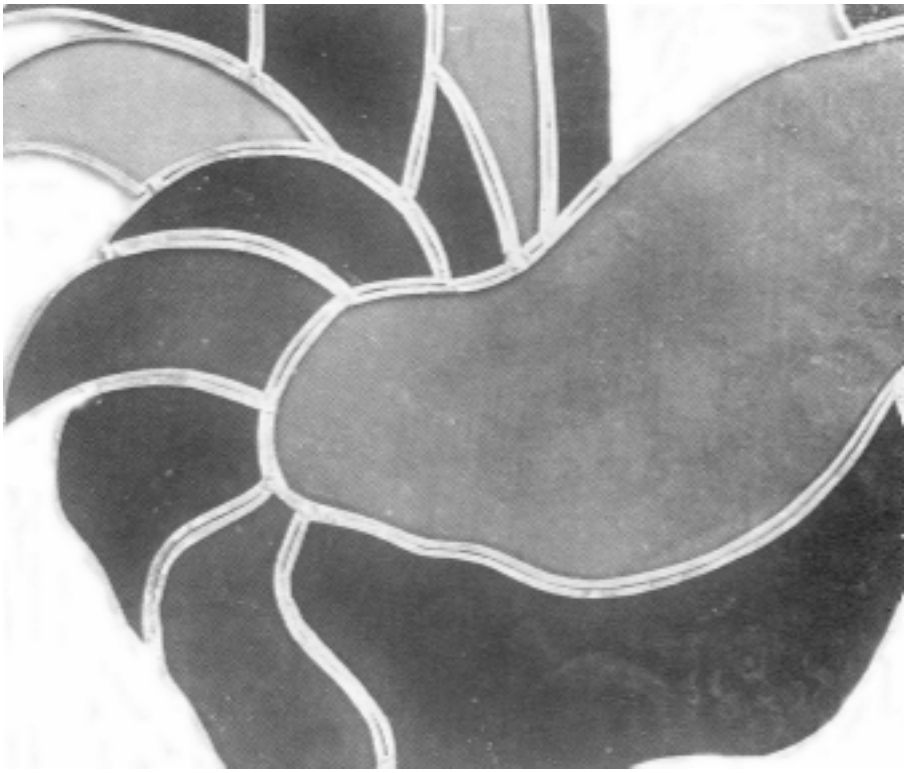


Fig 7.5

Note that attention has been given to accuracy of glass cutting. When soldered, all joints will be of even width.

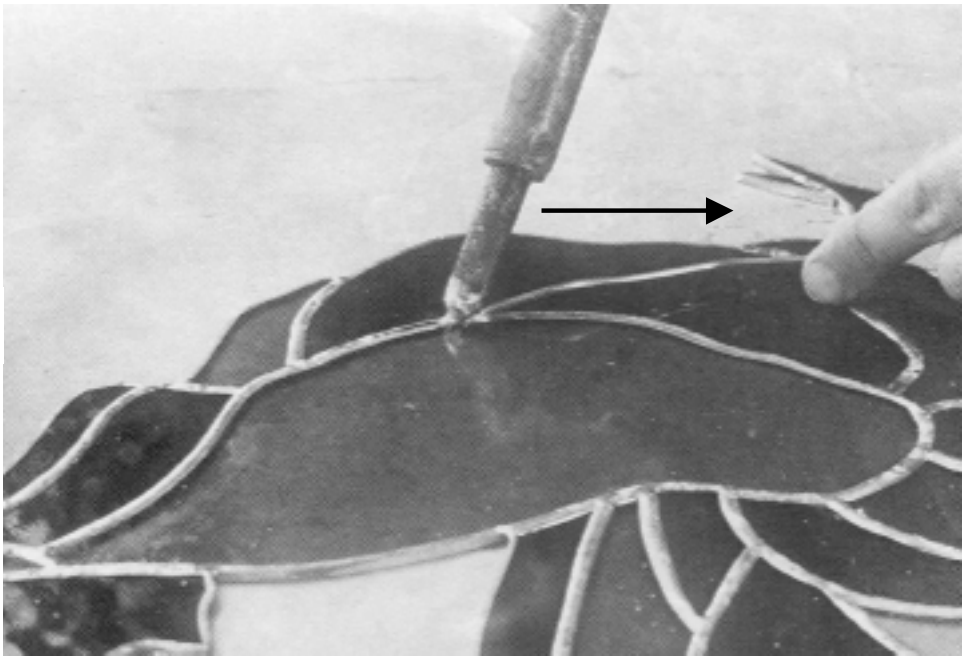


Fig 7.6

The soldering iron is moving onto the stationary solder, melting it, and leaving a raised beading behind.

When all the beading has been done, the outside foil edges of the panel can be covered. It is impractical to get a raised beading on these edges so they should just be "tinned" -- fluxed and then coated with a flat layer of solder.
On circular or rectangular panels, a U-shaped lead can be fitted to create a more definitive border. It should be soldered to each joint where it touches them. On free-form panels that will hang inside an existing window, spaces can be left open between pieces or filled solid to stop light completely.

Hanging loops

These can easily be made by folding a short length of copper wire into a staple shape. Flux and tin the ends and solder them into one or two strong points of balance at the top of the panel (fig 7.7). Do not solder a loop to the outside edge of foil. Bed it into a joint where it can take the weight.

Finishing techniques

The solder can be treated in various ways to darken it. This should be done as soon as possible after soldering or else oxidation will form a barrier on the surface and the chemicals will not be able to penetrate it.

Should that happen you can scrub the solder with a soft wire brush, such as a suede shoe brush, to take the oxidation film away. Do not wash or clean the project yet as this can retard the darkening process.

i. Copper finish: Copper sulfate crystals and water will act on the tin content of the solder and, in effect, copper plate it. Either mix the crystals with warm water and wipe the solution over the work, or sprinkle dry crystals on to the panel and rub them into the joints with a wet rag or an old toothbrush (Fig 7.8). The latter system gives more consistent results because the copper sulfate is always used fresh. An aqueous solution becomes contaminated each time you dip the rag or brush back into it. The solder should have an "antique" copper brown color to it. When the piece has been cleaned and dried you can polish the coppered solder with a domestic brass polish to obtain a more shiny effect. If you purchase copper patina in a bottle, apply as directed.

ii Black finish: Most stained glass merchants stock “black patina” which is a commercial preparation that will give anything from a gray to a black finish. Repeated applications will result in darker joints. Apply with a toothbrush or as directed.

iii Natural finish: The solder can he left as is or polished after cleaning with a domestic silver or brass polish.

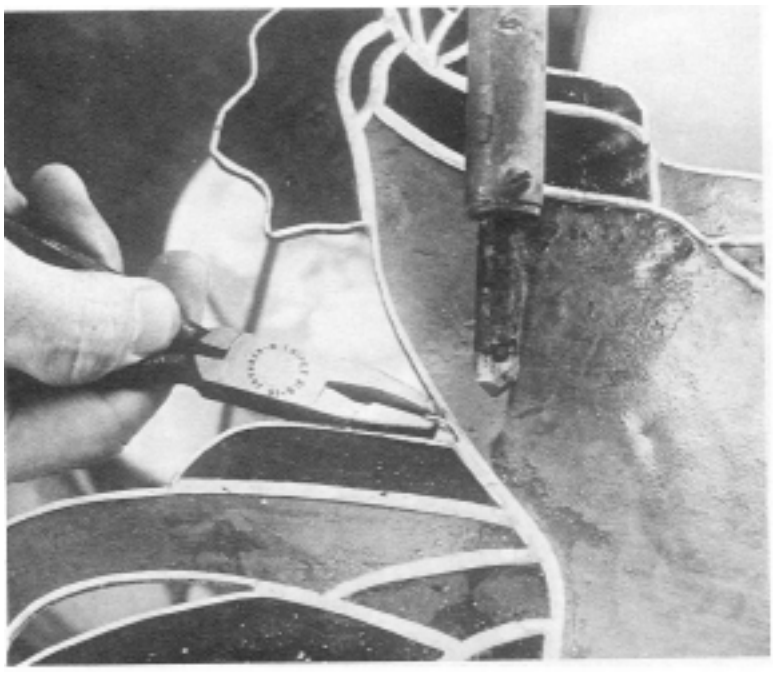


Fig 7.7

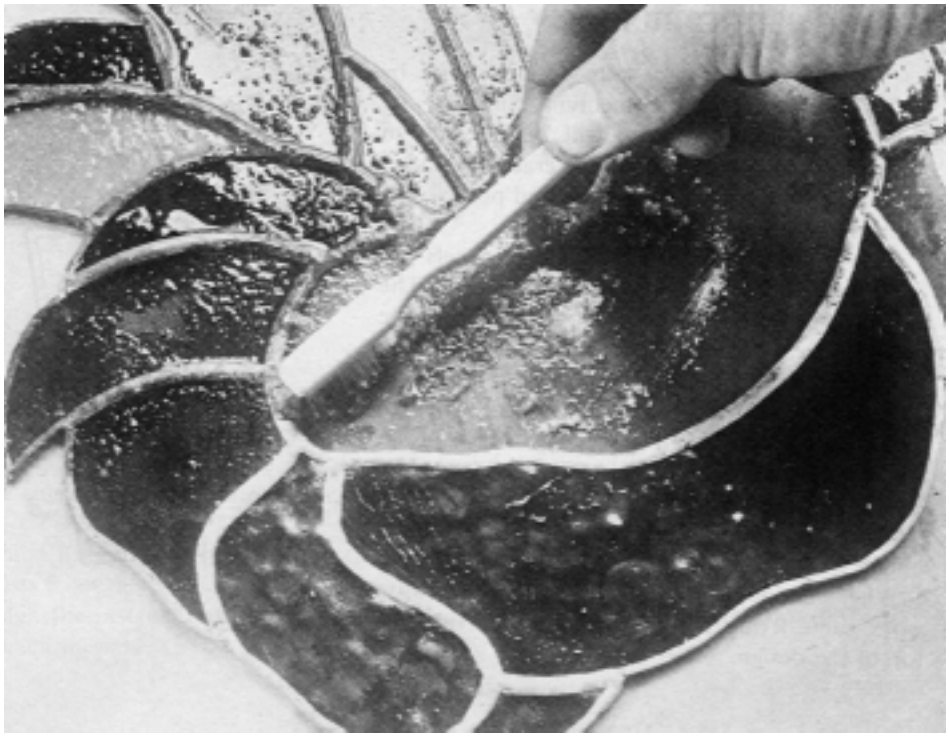


Fig 7.8

Cleaning

There will be grease, flux, patina and dust all over the project and a vigorous cleaning will be needed. Use a liquid dishwashing detergent in warm water and scrub the work all over with a nylon-bristled brush or similar. Be very careful to not disturb the thin foil around the border (fee 7.9). A final rinse with clean water will remove the detergent and the work can be dried with a clean rag or paper towels.

If the glass still looks grimy, brush it again or try some domestic glass cleaner. Do not clean your work in an enameled bath or basin which might get scratched. Use a large plastic basin or even a baby's bath that has been discarded. Alternatively you can fill a bucket with soapy water, scrub the work outside, then hose it down.

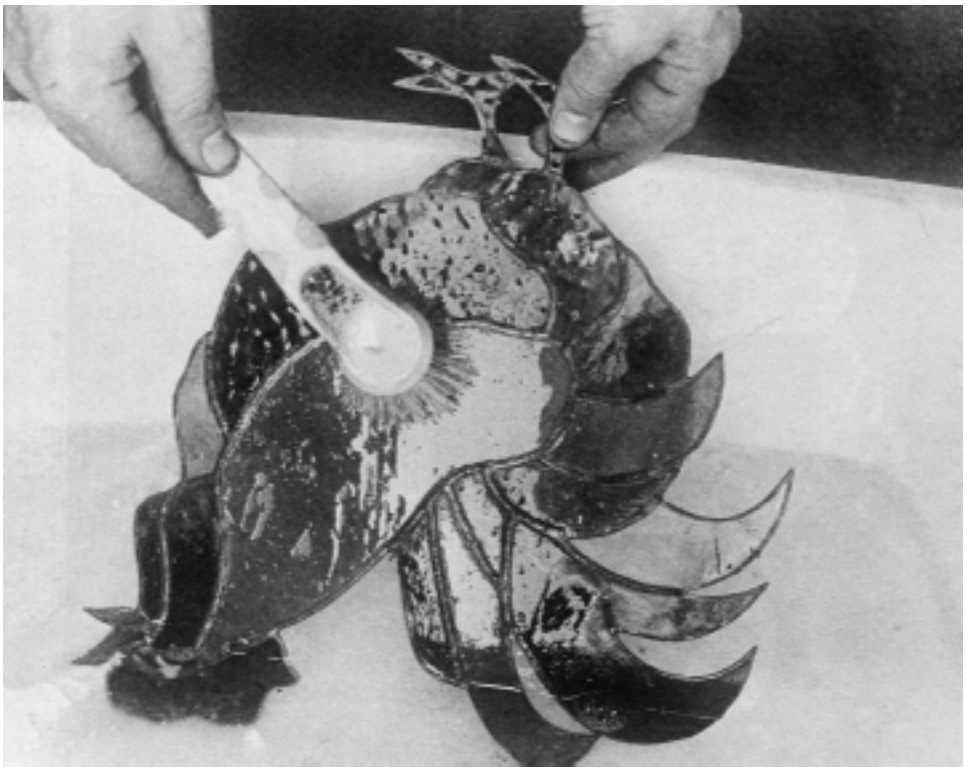


Fig 7.9

8. DESIGN CONSIDERATIONS FOR FOIL

As with lead work, your designs must be within the limits of the medium. Showing off your glass cutting abilities might result in weak points which will inevitably crack. You may be able to find excuses for cracks and poor workmanship – other people will not.

Care must be taken with hanging panels because gravity will be working against them. The hanging hooks must hold on to a solid part of the panel and each piece of glass in the design must be locked firmly into others.

Do not have large pieces of glass attached to others by only one small length of joint which can not take the weight (fig 7.10). A curved joint is always stronger than a straight one which could flex and bend like a hinge. When designing free-form hangings, always work some fixing points for the hooks into the top of the design.

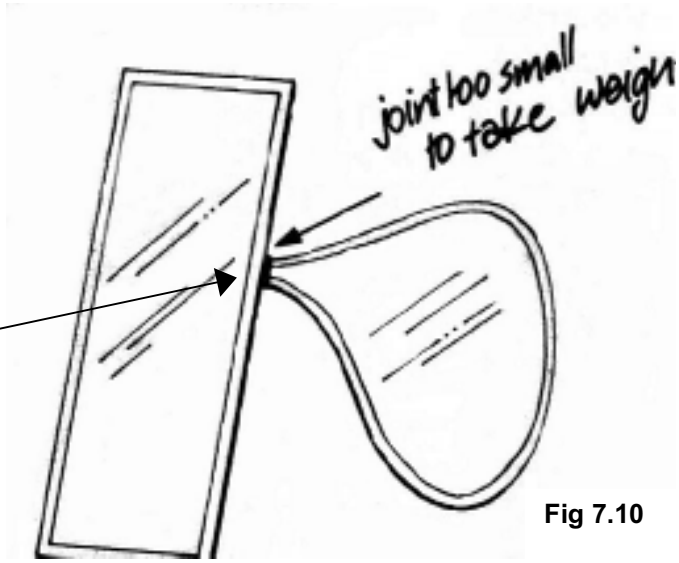


Fig 7.10

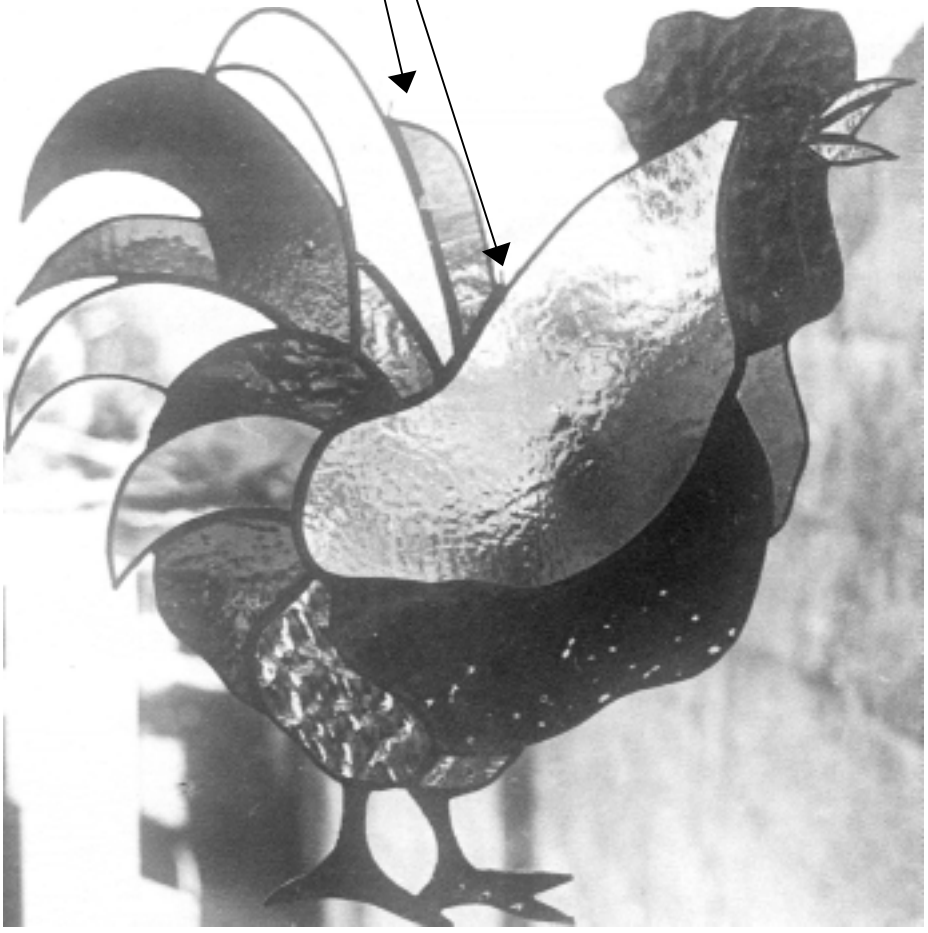


Fig 7.11

9. PROJECTS

The following projects are included merely to introduce ways to apply the foregoing techniques in a logical sequence. It is not necessary to make each or any of these projects (in fact – please don't), but it really is essential that you know how they are made. Reading through the projects will be a good refresher of the ideas contained in the first part of the handbook and will also introduce you, for the first time, to the techniques three-dimensional work.

I suggest that your first endeavors be limited to items of similar simplicity. Definitely make something flat before you attempt a three-dimensional project and follow your own interests from there on. At least read through all the following instructions to gain a fuller understanding of the technical possibilities of the medium.

I strongly urge you to make a small practice lead panel and be prepared to throw it away if it does not turn out right. Instead of being nostalgic about the "very first thing I ever made", consider it to be a rehearsal for the first thing you make - like a preparatory sketch for a painting.

Soldering might be the most frustrating part of your first projects – it does take some practice to get smooth joints in lead work and nice rounded beadings on foil. Practice on scraps. Practice on scraps.

Project 1: Hanging Lead Panel.

This is a typical first project in lead because it takes you through all the steps without taking up much time or costing a lot of money. You will learn much more than you think by putting a project like this together. Read the chapter on lead techniques before starting. Make up your own design with a similar complexity to this one.

DIMENSIONS:

280mm high x 200mm wide.

MATERIALS:

Scrap glass, one length U-came, one length 5mm (3/16") H-came, 50g solder, cement mixture, lead blackening (stove polish), 75mm (3") of copper wire.

INSTRUCTIONS:

1. Draw up a rectangle of the finished size of the panel (about 200mm x 300mm or 8" x 12") on paper. Draw the outer lines with a fine ballpoint or fine felt pen and use a square for accuracy.

2. Sketch the design inside this rectangle with pencil. When you have refined the lines, go over them with a standard felt pen (like a "Sharpie") leaving a 2mm wide line (Fig 8.1).

3. Select and cut the glass. Cut to leave the line showing between each piece. Check pieces back to the pattern. If the edges are too far inside the line, cut another piece. If they are over the lines, trim them back. At this stage you may think you can cover up any bad cutting with lead. While that is sometimes true it is far better to be accurate in case the mistake can not be covered. Start as you mean to carry on. Easel the glass or spread it on a light box if you are uncertain about the colors.

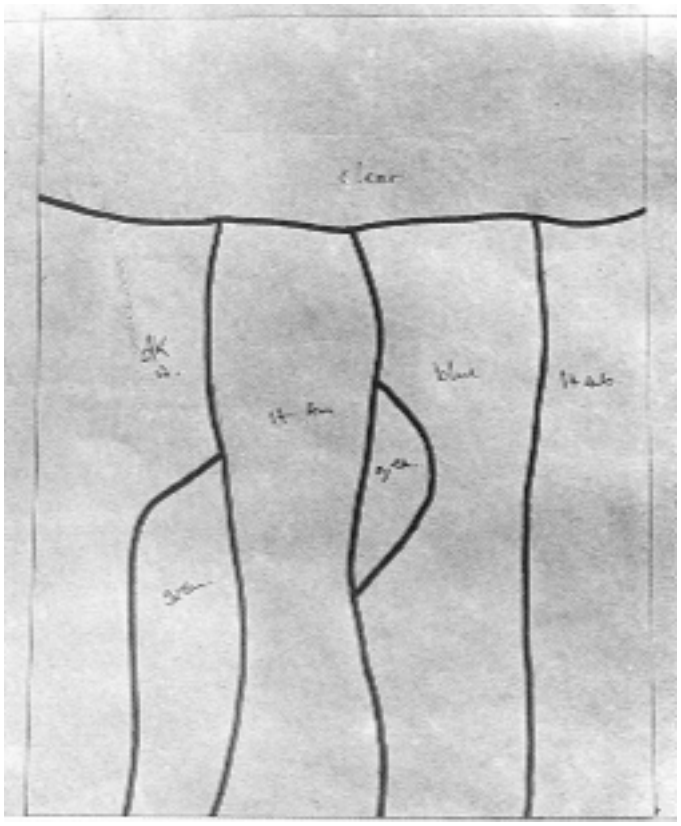


Fig 8.1

4. Stretch a length of U-came and 5 or 7mm H- came. Before the laths are nailed to the cartoon, place a border piece of glass into some U-came and move it into position. The lath can then be nailed alongside this U- came (Fig 8.2). You will find that the laths end up 1 or 2mm outside the original line.

5. Miter two lengths or U-came into the first corner.

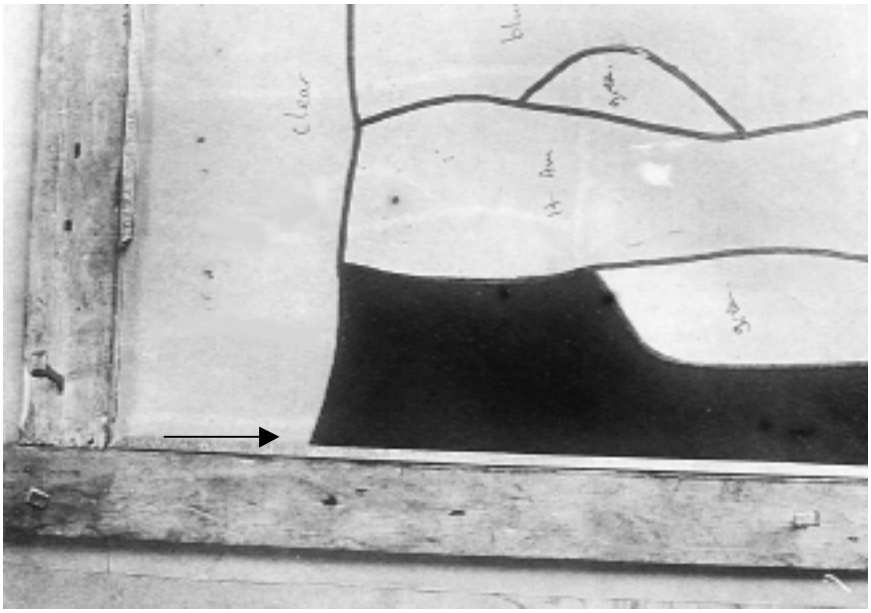


Fig 8.2

6. Place the first piece of glass into position. Shape, trim and fit a length of H-came along its edge. Secure it with a piece of scrap lead and a nail (Fig 8.3).

7. Add the subsequent pieces and H-came until all are in position. The outside cutline should be visible under the free edges of glass around the border.

In this panel, the clear piece on the left was placed first, then the dark piece on the bottom, then the dark piece immediately above it. Note how the lead has been trimmed short of the glass edge to allow room for the next piece of lead. Also note how the horseshoe nails hold everything in place.

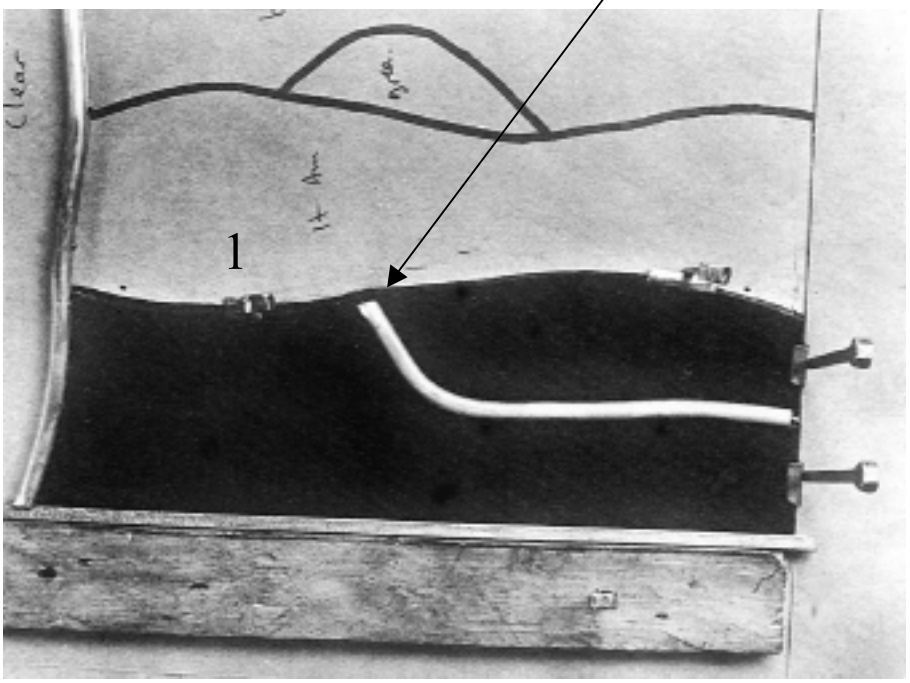
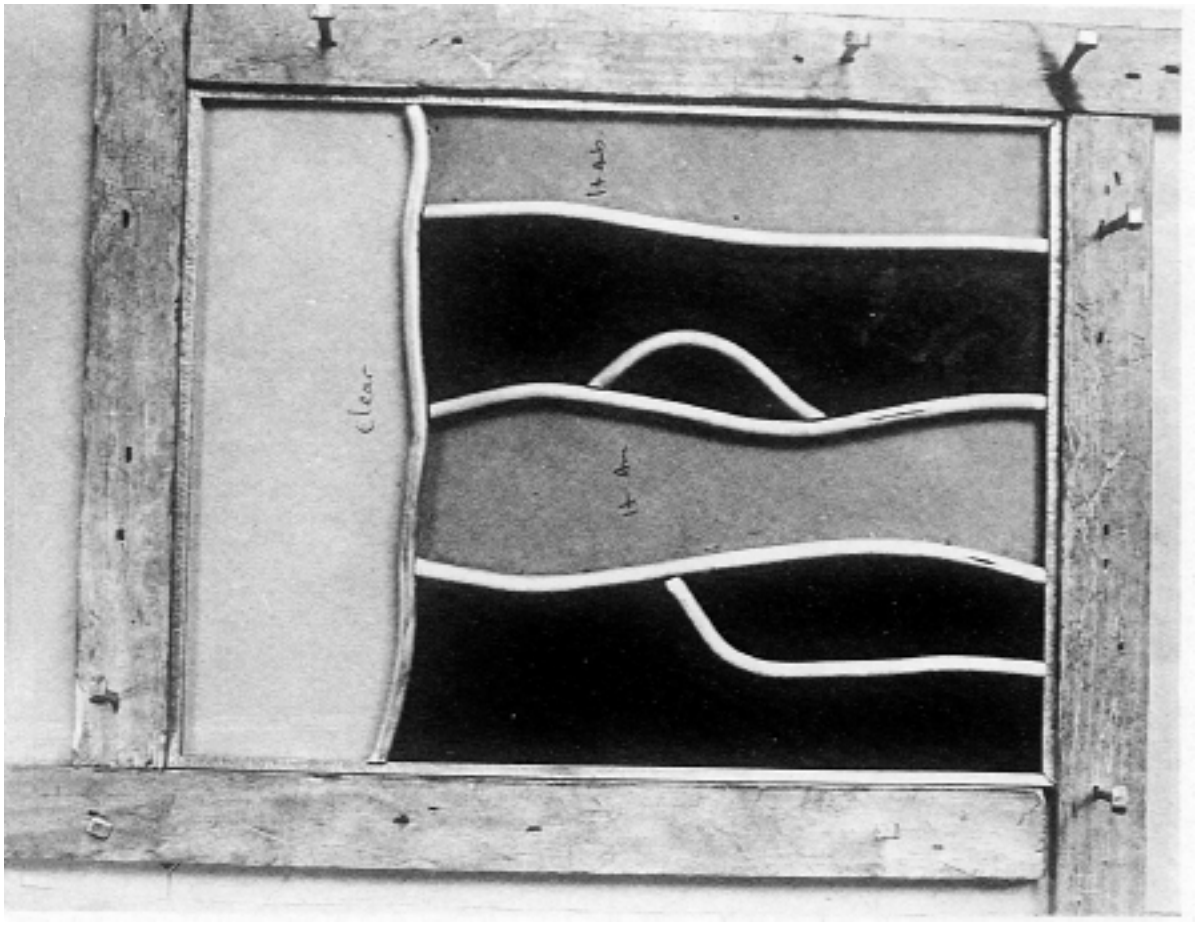


Fig 8.3

Fig 8.4

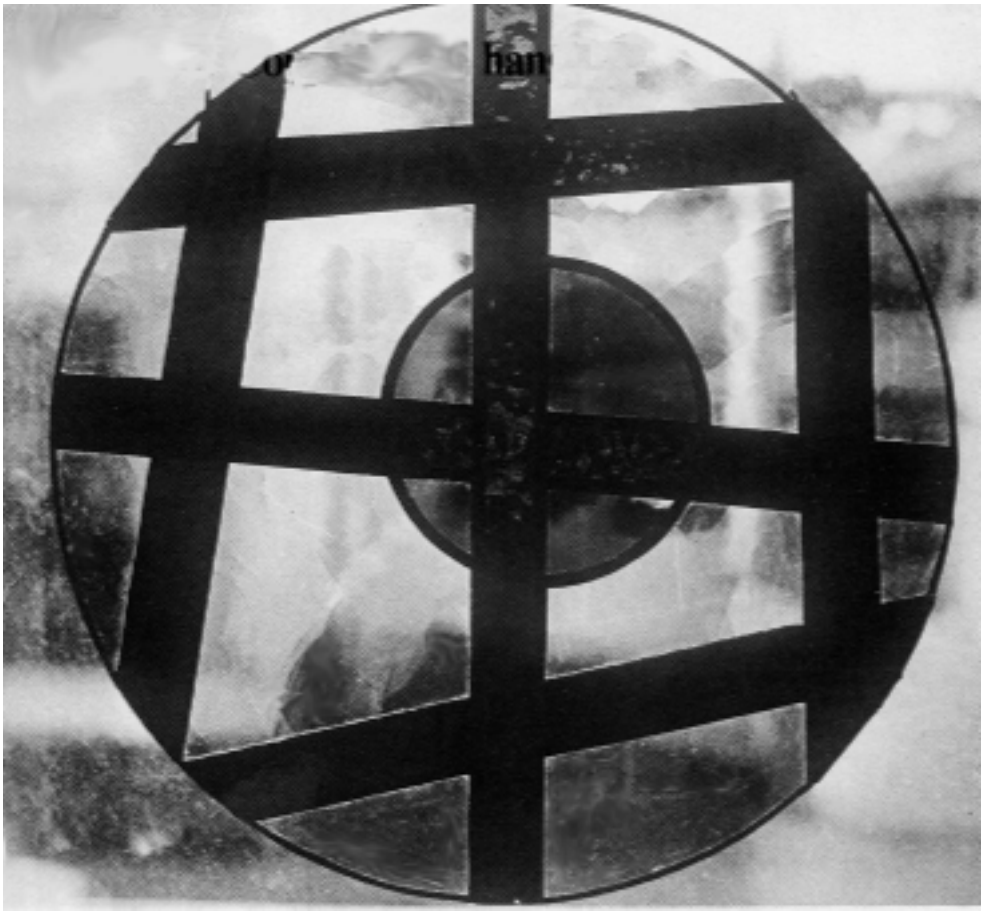


8. Mark and cut the miters in the other ends of the first border U-came. They will have to be slid out slightly to do this and then slid back. Cut, and fit the last two border leads and nail the laths in position (Fig 8.4). Remember to sequence the laths so none need to be shortened (fig 5.12.)

9. Flux and solder the panel, then remove the laths. Flux and solder the other side of the panel.

10. Attach copper wire hooks to the top corners. For maximum strength, effect, and practice, the panel should be cemented and blackened. Reinforcing is not necessary on small panels.

Project 2: Copper Foiled Hanging



Create a design of similar complexity and size to this. Remember to design in a fixing point or two in the top and make all component pieces lock together rather than hang from each other. Very small pieces are an exception. Read chapter 7 before starting.

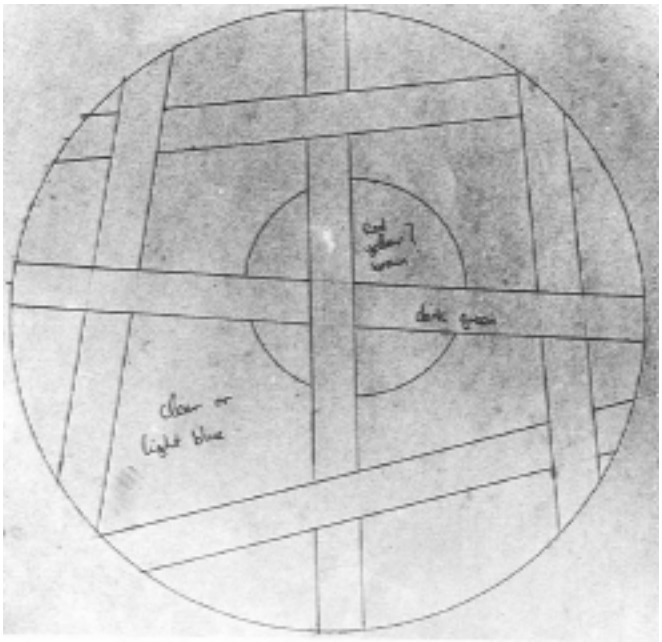
DIMENSIONS:
280 mm diameter.
20mm wide strips.
100mm diameter smaller circle.

MATERIALS: approx. 1 square foot of colored glass scraps, copper foil, 200g solder, 50mm of copper wire, copper sulfate or patina to darken.

INSTRUCTIONS:

1. Draw your design with fine dark lines. Mark the suggested colors onto the cartoon (fig 9.1)
2. Cut glass over this pattern allowing for the smallest possible gap between pieces. Groze or grind all edges smooth and avoid tapping the glass.

Fig 9.1



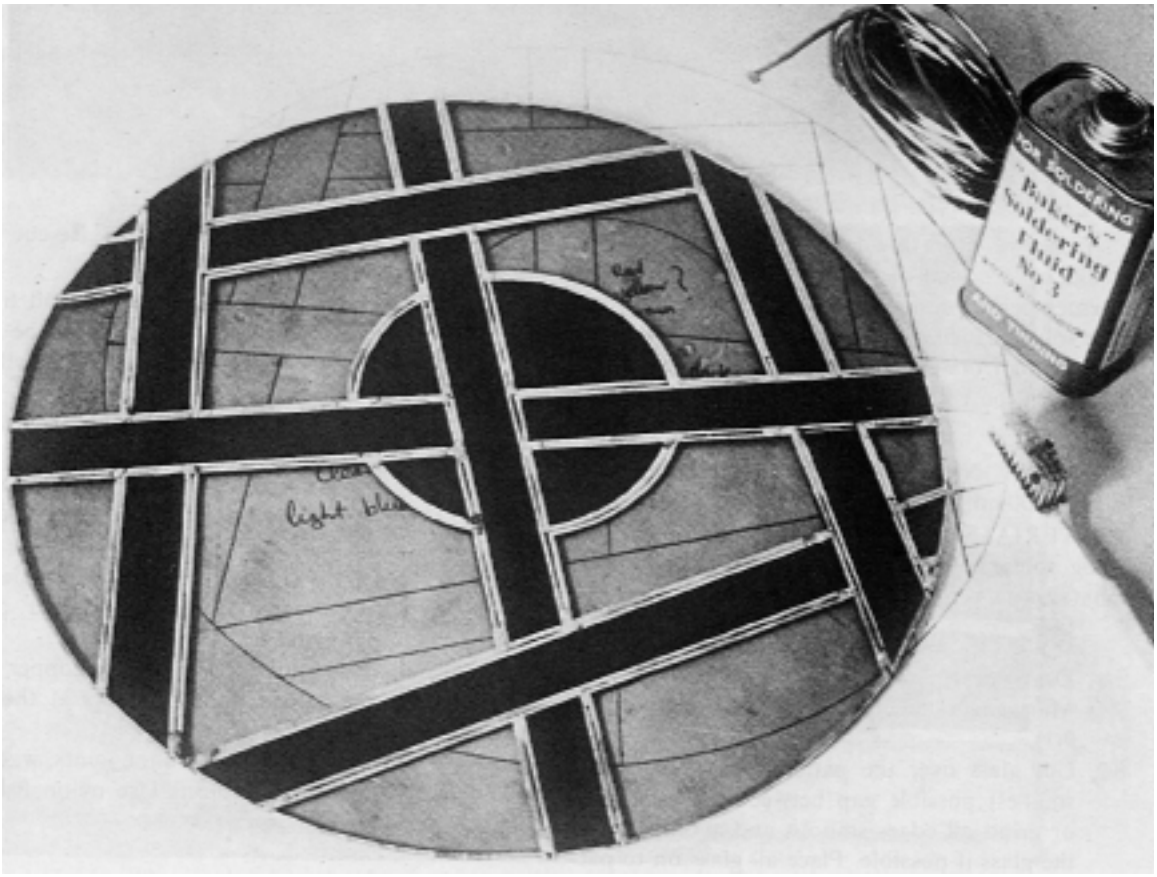
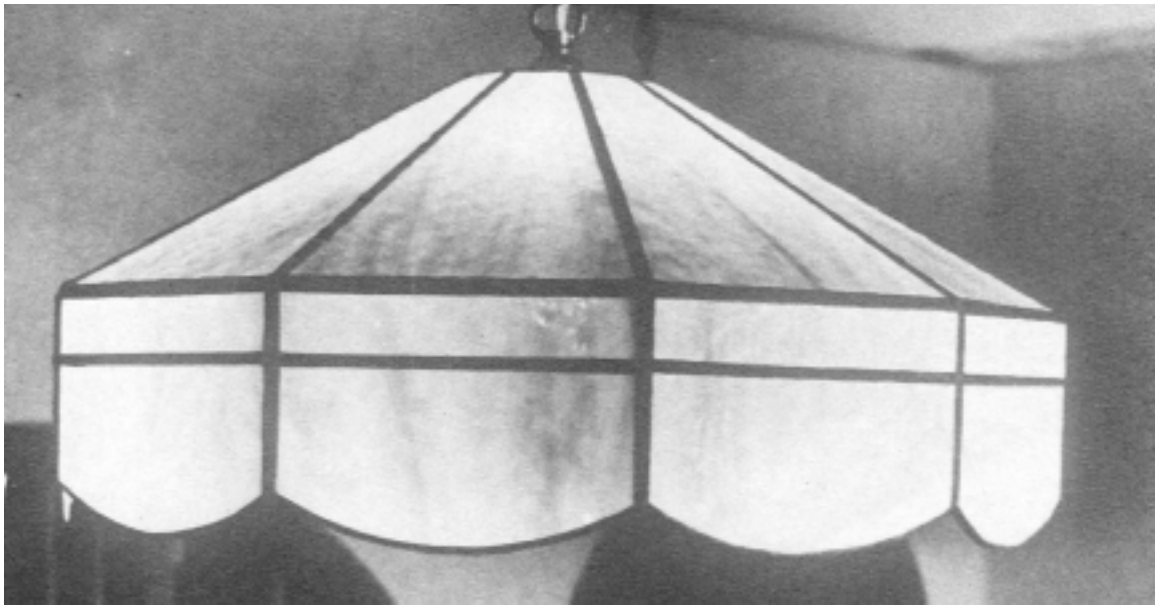


Fig 9.2

3. Place all glass onto the pattern and check for fit. Re-cut or trim as necessary.
4. Foil all glass. Try to start and finish foiling each piece on one of it's sides that will be attached to another piece rather than a side that will be on an outside edge of the hanging. Make sure the foil is evenly wrapped onto the edges so the beaded lines will have an even width.
5. Place all foiled glass back on cartoon and press pieces tightly together.
6. Flux and tack pieces together until whole hanging is assembled (fig 9.2). Flux and bead all joints front and back. Tin all outside edges. (if the hanging is circular, a length of' U-came can be soldered around the perimeter.)
7. Flux and tin one or more copper wire hooks and attach them into joints at the top of the hanging.
8. Antique or blacken the joints, wash and clean the whole project. Use nylon fishing line to hang it.

Project 3: Simple Panel Lamp



DIMENSIONS
This lampshade is 4OOmm wide across the bottom, 75mm at top diameter, and 10 panels around. The width of panel B is the same as the bottom dimension of panel A (132 mm).

MATERIALS:
Glass - A panels. One strip 900mm x 190mm
- B panels. One strip 132mm x 300mm
- C panels. One strip 132mm x 750mm

Copper foil, 400g solder, 75mm spider, chain, lampholder with hook, patina.

1. Draw the panels (accurately) on graph paper to the dimensions in Fig 10.1. (See Appendix for details on how to determine the size of panels for any lamp.) The arc across the bottom of panel C has a 135mm radius.

2. If opalescent glass is used for any of the pieces, cardboard templates will have to be made for scoring around. Use a strong thin cardboard such as a manila folder. Use carbon paper to trace the patterns on to the cardboard and cut out the templates carefully.

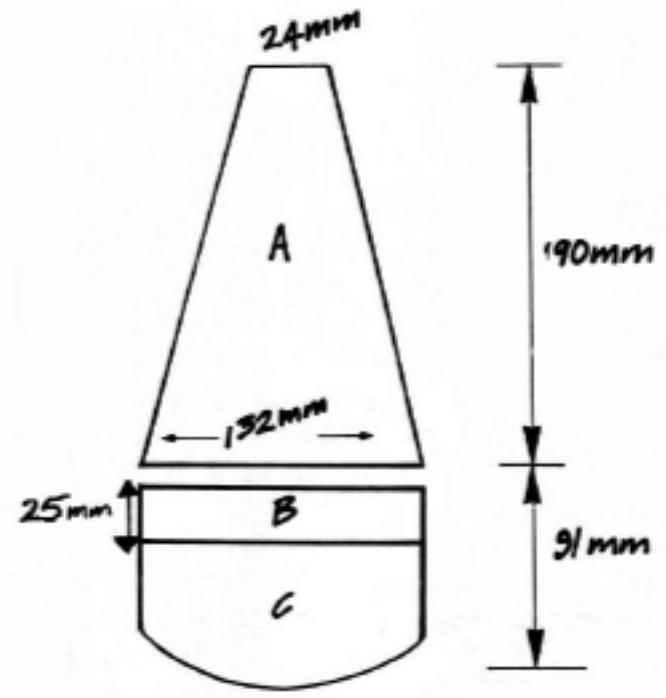


Fig 10.1

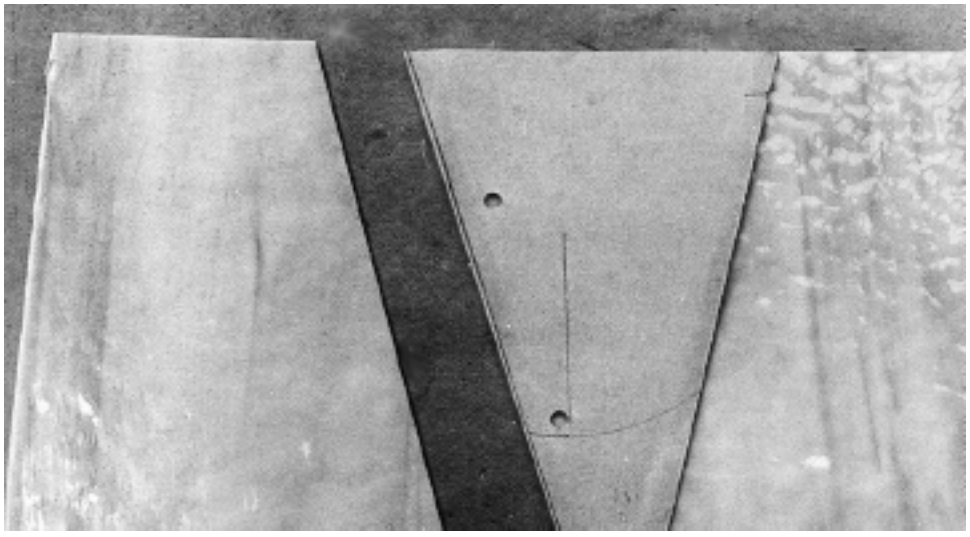


Fig 10.2

3. For the A panels, cut a strip 190mm wide, lay the template on it, and cut the panels as in fig 10.2. Cut B and C panels from a strip 132mm wide. Foil all pieces.

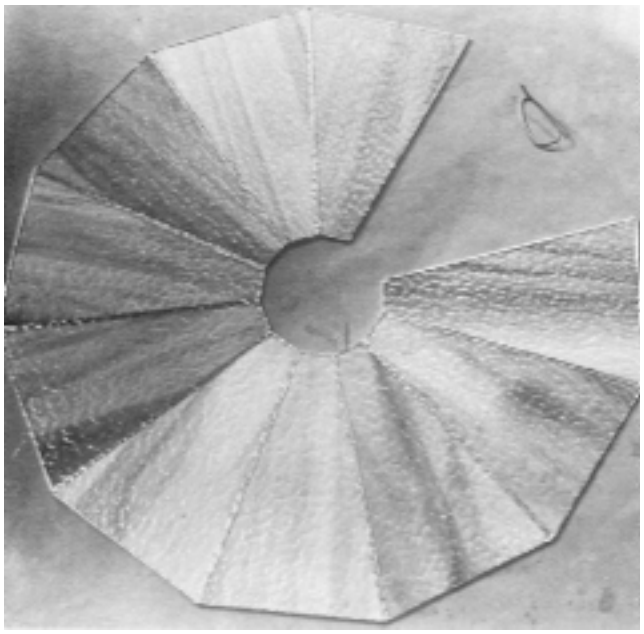


Fig 10.3

4. Tack all B and C panels together to form the "skirt" of the lamp.

5. Lay out all A panels in an incomplete circle (fig 10.3) with the side that will be inside the lamp facing up (normally the textured side). Flux and lightly tack the pieces together in the corners. Do not use too much solder as it will only rip the foil when the whole layer is bent up into shape. A surprisingly small amount will do it as long as it has a good bond.

6. Lift the two free ends together to close the gap. Tack solder them top and bottom. All corners must meet accurately. Strengthen all corners with more solder. Be careful not to un-solder as you do this.

7. Tack two complete skirt (B/C) panels together at approximately the correct angle. Place these on the assembled A panel layer and line them up exactly. Do not tack these on at the corners this time as that could unsolder the previous joint. Instead, tack them about 15mm in from the corners (Fig 10.4). Use only a small amount of solder because if subsequent panels do not fit properly you will have to unsolder some joints to adjust.

8. Add the remaining skirt panels one at a time, tacking each one twice to its aligned A panel and, at the top corner, to its neighbor. If all panels are placed accurately the last will fit snugly. If you can see them getting out of position, untack them back to where they did fit right, and replace them more carefully.

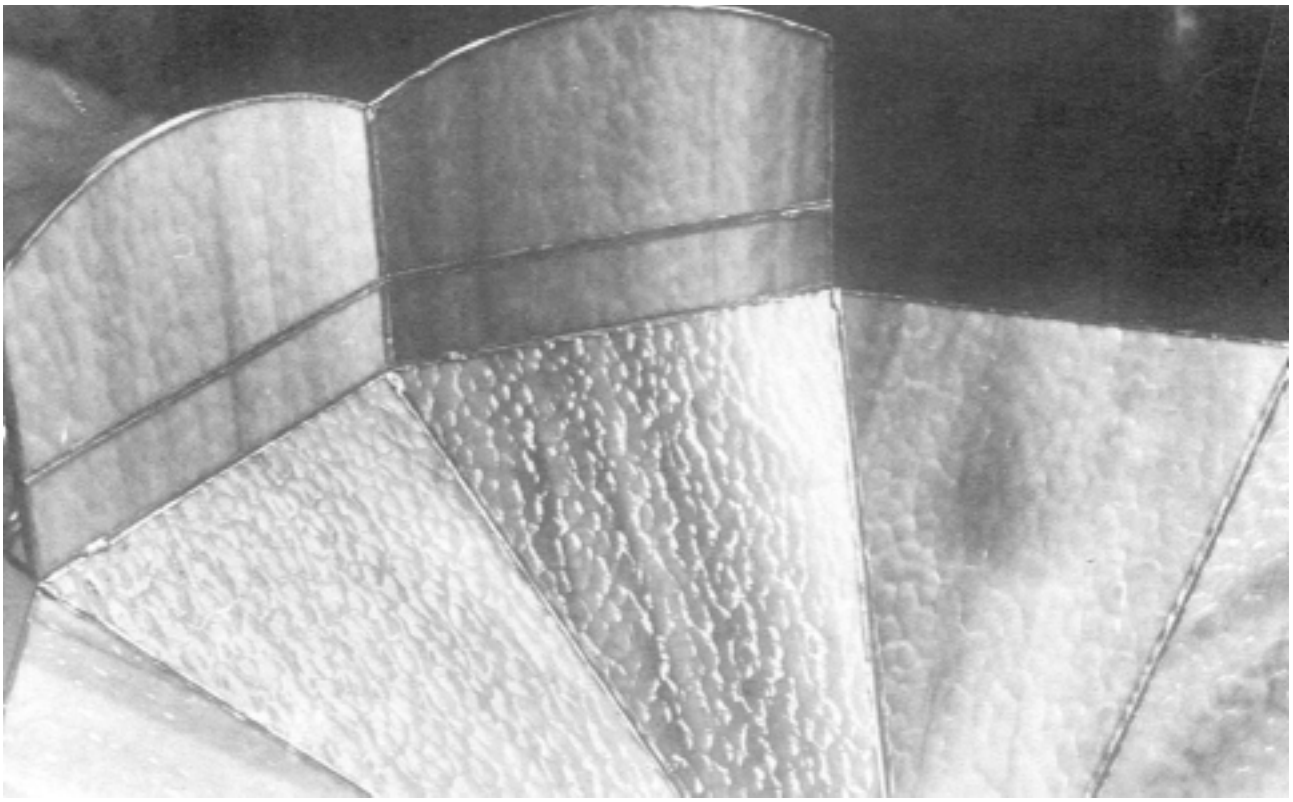


Fig 10.4

9. Solder over all the inside joints of the lamp. A raised beading is not necessary. The outside joints should be beaded, however. Tilt the lamp up to get the joint horizontal as you work on it (fig 10.5). Tin the foil edges around the bottom of the skirt and solder a 75mm (3") wire spider into the top opening (fig 10.6).

10. The lamp can now be darkened and cleaned. A chain should be used to hang it and a lampholder with a hook on the top will provide a fixing point for this.

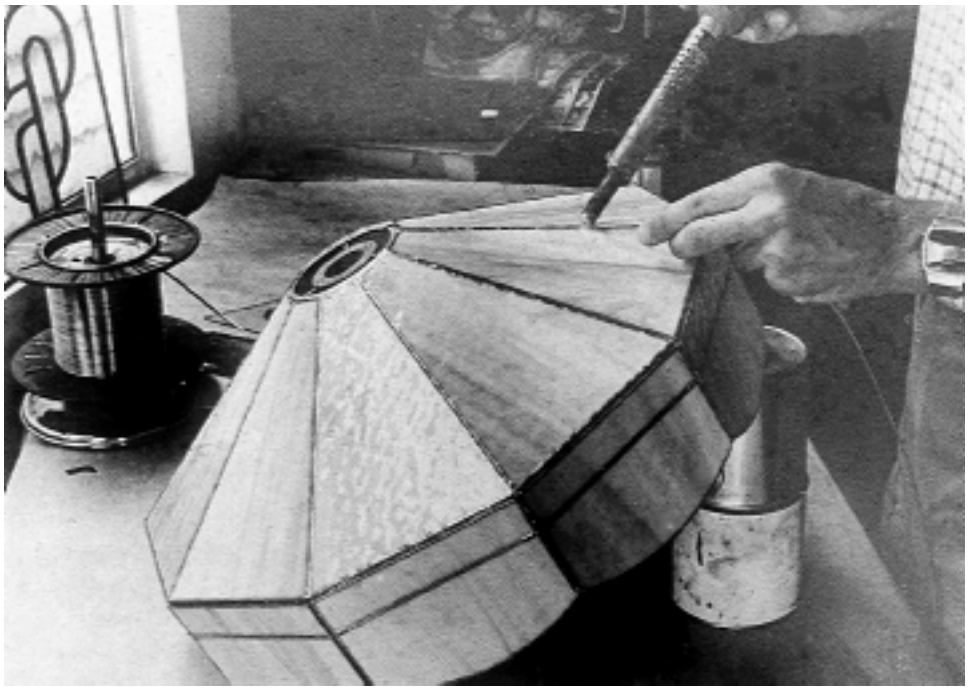


Fig 10.5

Footnote: The "knot" panel in the top left background of this photo was once considered to be a glasscutter's challenge. In fact, only one score is a little difficult to break and that is the tight internal curve of the "n" shape at the top of the panel. Glass saws would make quick work of such a cut these days but the panel is a little trickier to lead than might be expected.

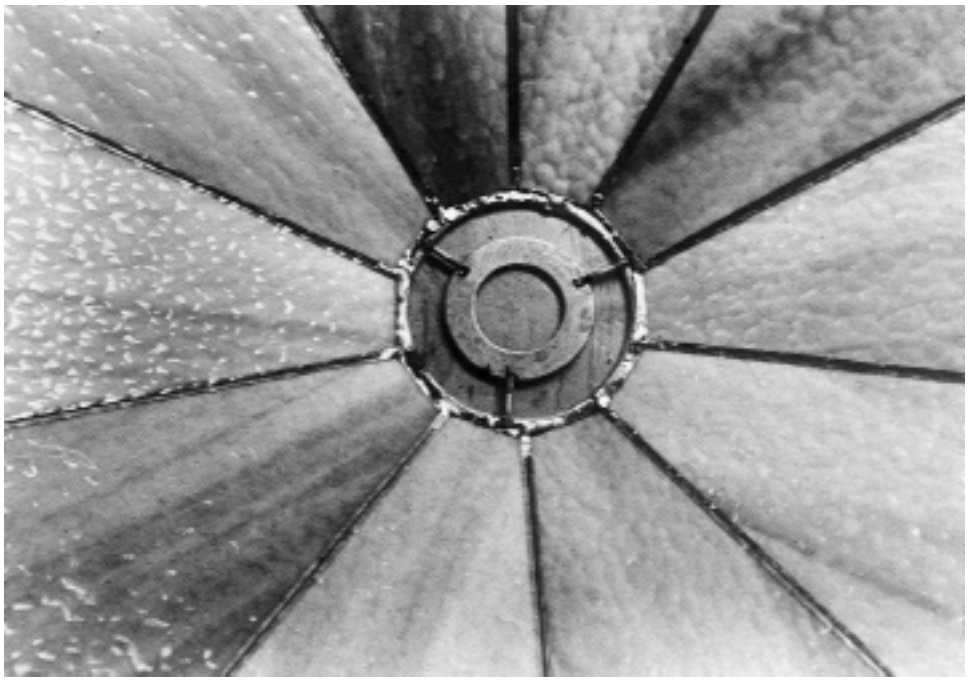


Fig 10.6

Project 4: Simple Terrarium

DIMENSIONS:
Top - 80mm wide
Middle - 225mm wide
Base - 180mm wide
Height - 310mm

MATERIALS:
Glass - A 'and B panels - 9OOrnm x 260mm
Base - 200mm x 200mm.
(order one piece of glass 1100mm x 260mm or slightly larger), copper foil, 4OOg solder, 120mm of copper wire, chain, patina.

INSTRUCTIONS:
1. Draw up panels on graph paper, to the dimensions in fig 11.1, using a very fine line. Six pieces are cut from each shape.

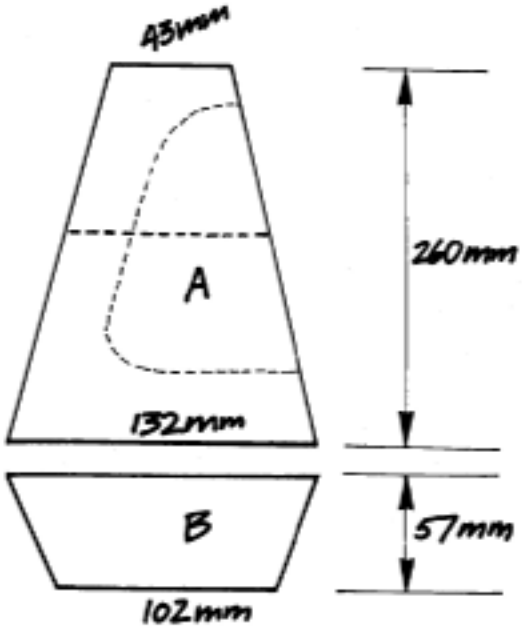


Fig 11.1

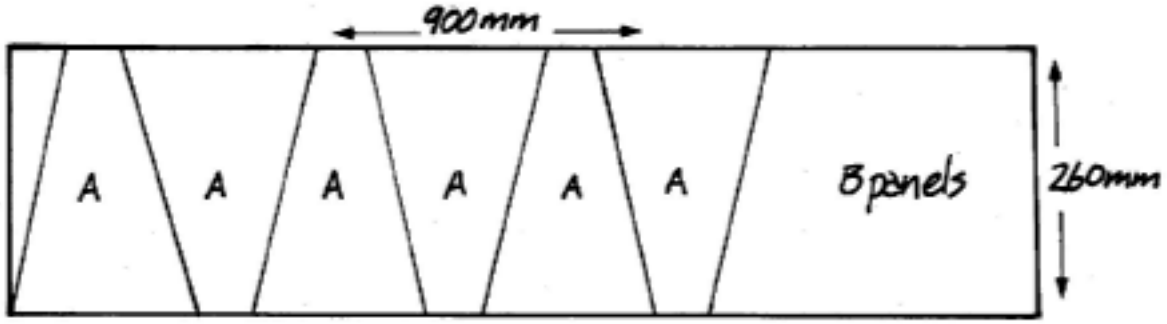


Fig 11.2

2. Cut a strip of glass, 260mm by 900mm.
   Place it over the A pattern and cut 6 identical pieces from as in fig 11.2.
   Use a straightedge to guide the cutter. The rest of the glass can be used for the B panels.

3. To create a side hole in the terrarium, two of the A panels must have an identical section taken out of them and be joined together. One will be an exact reverse of the other. Carefully draw a curve on to the pattern as in fig 11.1 Score this curve on to one panel and then score a straight line across near the center to divide the panel in half (score up to the curved line, do not go over it.) Break this line first and then "run" the two curves. If you are using clear glass, repeat this step. Reverse the glass once it is cut so it will join up to the first panel and create the opening. If you are using a textured glass, reverse the pattern paper and trace the curve through from the first side. Once the piece is cut it will match correctly.

4. Foil up all the glass (A and B panels).

5. Begin assembly by tacking two of the base panels together. Stand them up at an angle as in fig 11.3. Solder them together at the inside corners only-. Add the remaining B panels one at a time until the circle is complete. Make sure the joints are tight and accurately lined up.

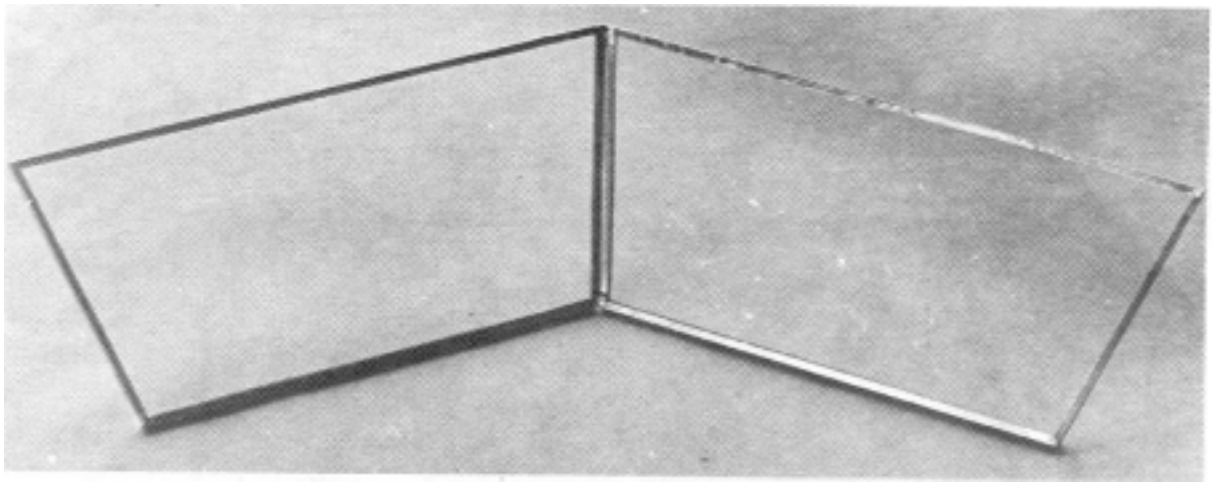


Fig 11.3

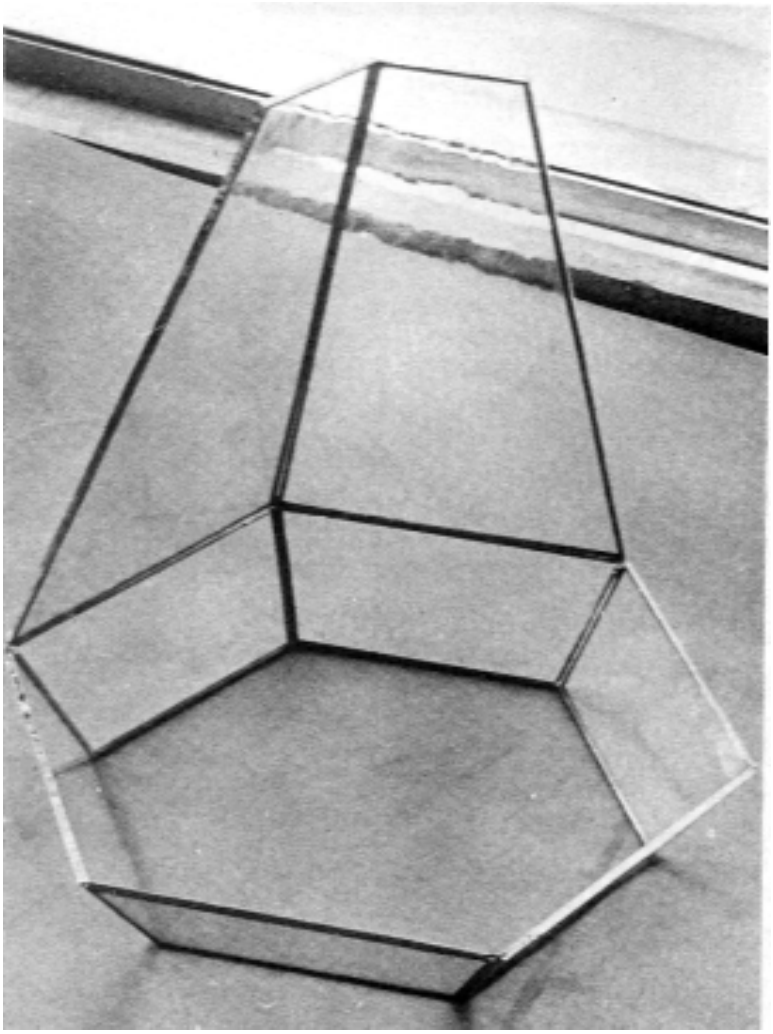


Fig 11.4

6. Tack two of the A panels together at the correct angle and sit them on top two of the assembled B panels. It is vital that all edges and corners line up exactly. Do not tack these on at the corners because you may unsolder the previous joint. Instead tack in about 15 to 20mm from each corner. The first two top panels are the most critical and difficult to place (fig 11.4). Add the remaining A panels one by one. Hold the last panel in position, check that each corner fits exactly and solder the two top corners before the bottom two.

7. Strengthen all the corners, taking care not to unsolder anything, then completely solder all the internal joints - there is no need to raise a beading on them. The soldering iron will have to reach in through the open base or the side hole while the terrarium is lying on its side. Tin the foil edges around the side opening, the top, and the base.

8. Stand the base on another piece of glass and carefully draw around inside it with a felt pen to get the size of the bottom piece. Mark one side panel and its adjacent edge so the piece will go back in the same way. Before you move the construction from this bottom piece, judge where the score line will need to be in relation to the felt pen line.

9. Foil and tin the bottom piece once you have checked it for Fit. Solder it into position.

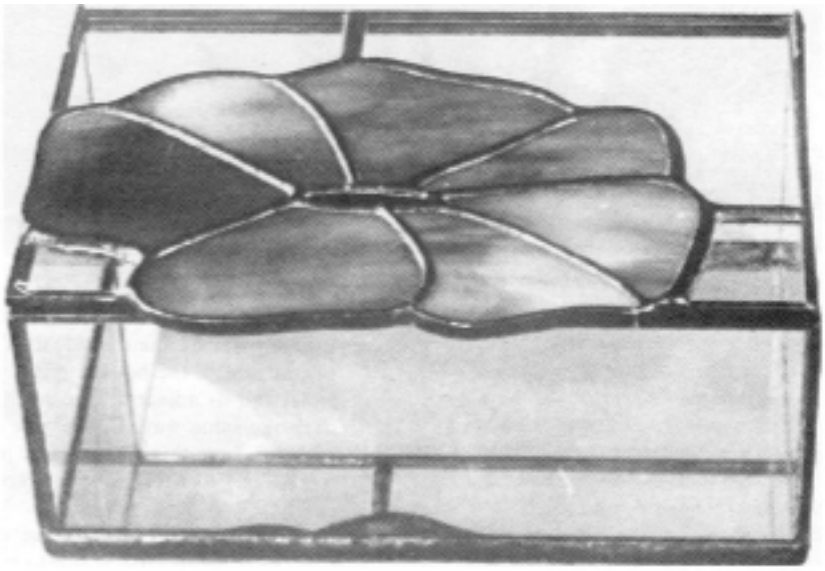
Fig 11.5

10. Solder all over the outside joints. Prop the terrarium up so that each joint is horizontal as you solder it. The joints will be wider, and require more filling in, than flat foiled work.

11. Solder two or three copper wire hooks into the top joints. The hooks should be about 30mm (1¼") long once bent. Solder one strand inside and one outside of the joint (fig 11.5). Raise a beading over the wire to hide it.

12. When all foil is soldered and the outside joints beaded, an antiquing solution can be applied to darken the joints. Hang the planter by a small chain.

Project 5: Jewelry Box



(Design and construction by Juliet Bamford)

DIMENSIONS:
130x80x50mm

Box lid	130 x 80mm
Front and back	130 x 50mm
Two sides	75 x 50mm
Base	130 x 80mm

MATERIALS:
Clear glass 150x300
Opalescent glass (petals)
Mirror glass 130x80

INSTRUCTIONS:

1. Draw up all patterns on graph paper.

2. Cut sides out of 2mm clear glass. Cut base from 2 or 3mm mirror glass. If opalescent glass is used, make cardboard templates for flower petals and arrange them on glass (fig 12.2). Score and break each petal.

3. Foil all petals with 6mm foil and tack them together. Cut and groze/grind a small center for the flower, check it for fit, foil and solder it in place. The flower is complete.

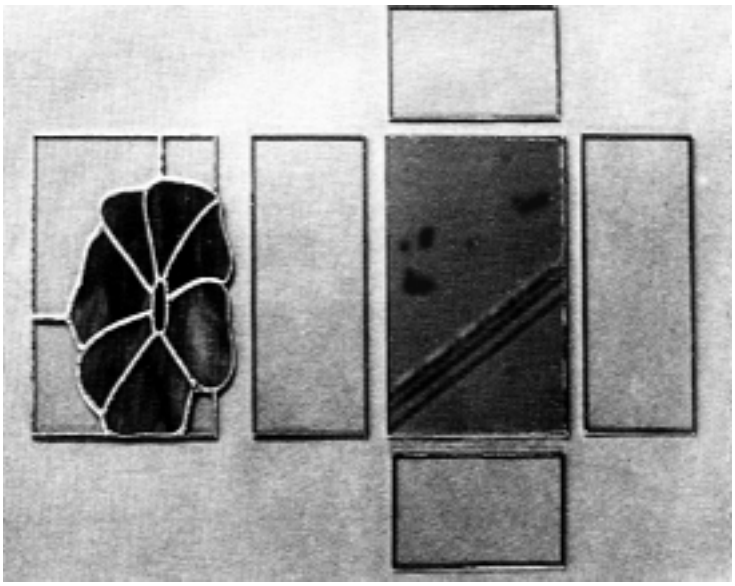


Fig 12.1

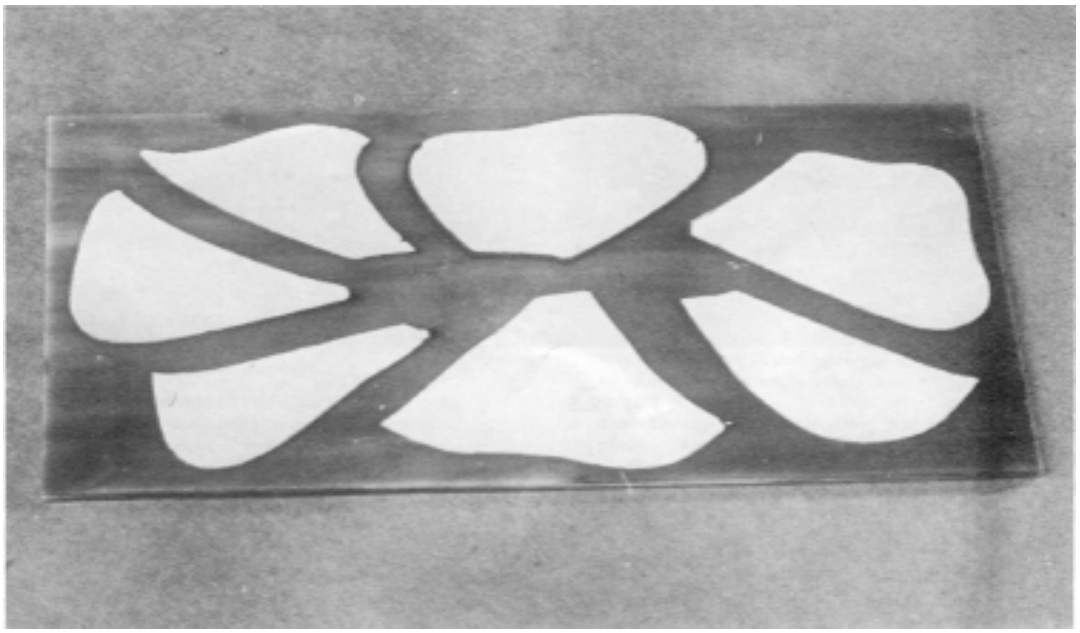


Fig 12.2

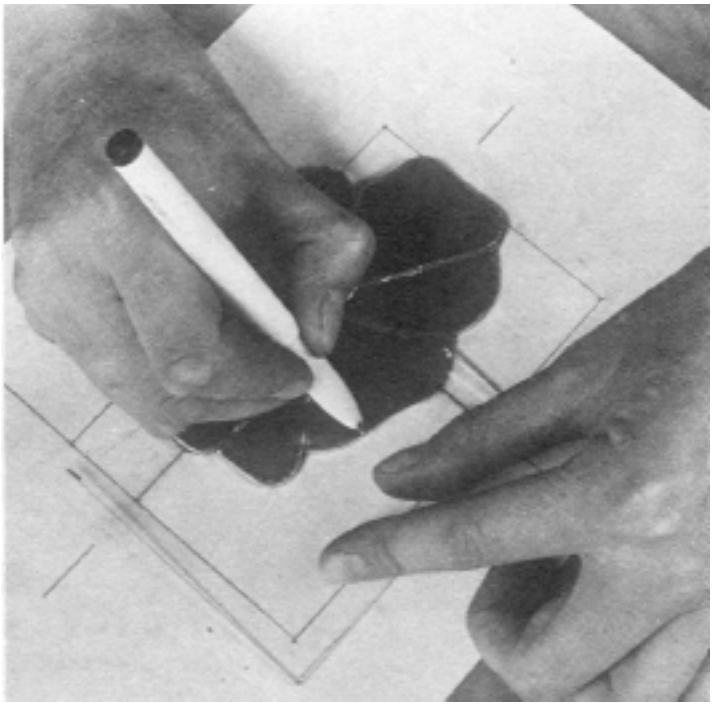


Fig 12.3

4. Place the flower back on to the pattern. Hold a piece of 2mm clear glass over the flower and mark the cutline on the glass with a felt pen (fig 12.3). Mark, score and break the four back- ground pieces in this manner. When they have been checked for fit, foil them with 5mm foil and solder the whole top together. The upper side of the lid should have beaded joints but the inside needs only to be tinned.

Hint: Don't cut the outside edges of the lid until last. It is better to first get a tight around the petals and leave the easy cuts to last.

5. Foil the sides and the mirror base of the box. Use 5mm foil for all thin glass. All the foil should then be tinned (covered with a thin coating of solder) because, once the box is together, it is almost impossible to get the soldering iron into the internal corners.

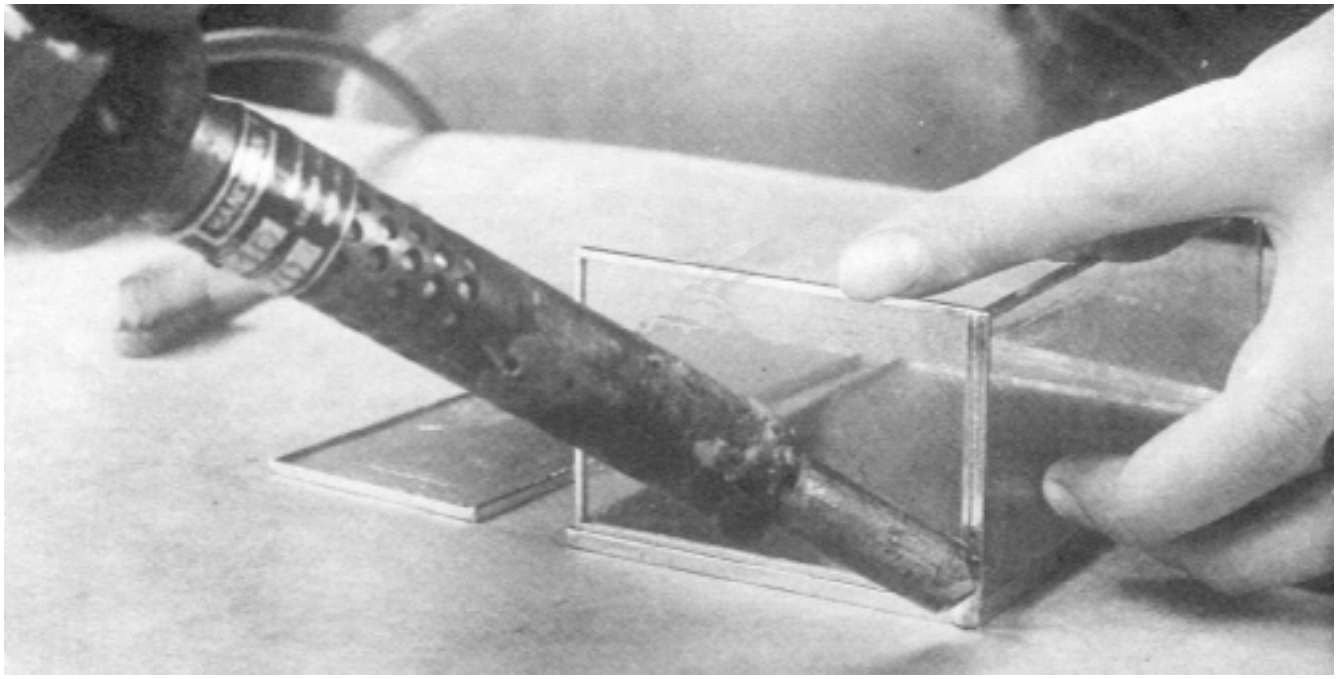


Fig 12.4

6. The sides all sit on top of the mirror - the short sides fit inside the long ones (Fig 12.4). Tack the box together and if everything fits well, cover the outside joints with solder.

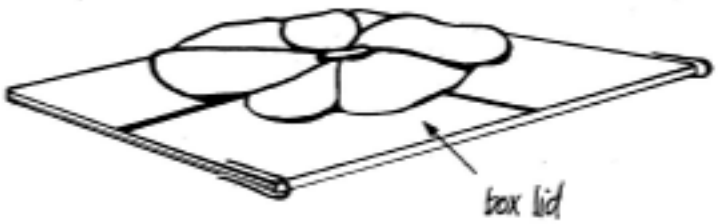
7. Bend four lengths of thin copper wire into staples (fig 12.5) and tin the ends. Solder two on to the rear sides of the box lid as in Fig 12.6. The other staples should be crimped tight except for the loop at the end. Slip them through the loops on the box lid.

8. Place lid into correct position on box and hold it Firm while you tack the base loops to the foil on the rear corner of the box. Check that the lid functions properly then solder the rear staples more firmly. Cover the wire completely but take care not to move it.

9. Check the whole box to make sure everything has been done then antique or blacken it. Wash it in warm soapy water and rinse it under a tap. Once it has been dried, cut a piece of adhesive felt and stick it to the back of the mirror. Trim it with scissors. (Felt is available from some paint, hardware and wallpaper shops.)

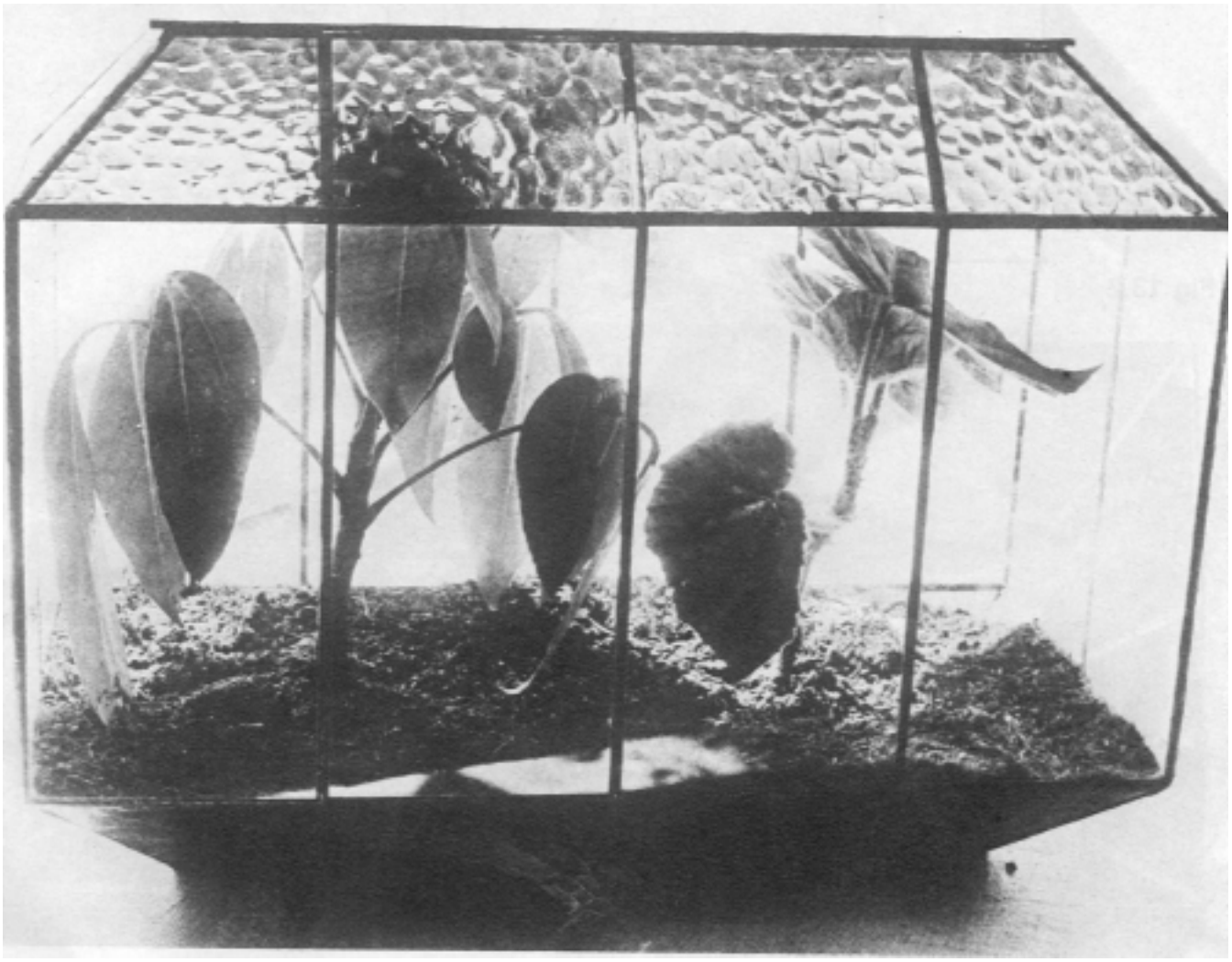
Fig 12.5

Fig 12.6



Footnote: Check out other hinging methods at your stained glass supplier.

Project 6: Terrarium



This is a true terrarium because it is a self- contained ecosystem. Once planted, it should need very little attention. Contact a local plant shop for advice on which plants suit this type of environment.

DIMENSIONS:
400mm long,
200mm wide
300rnm high.

MATERIALS:
1200mm x 200mm 3mm clear glass
700mm x 400mm colored glass
Copper foil
600g solder
Patina.

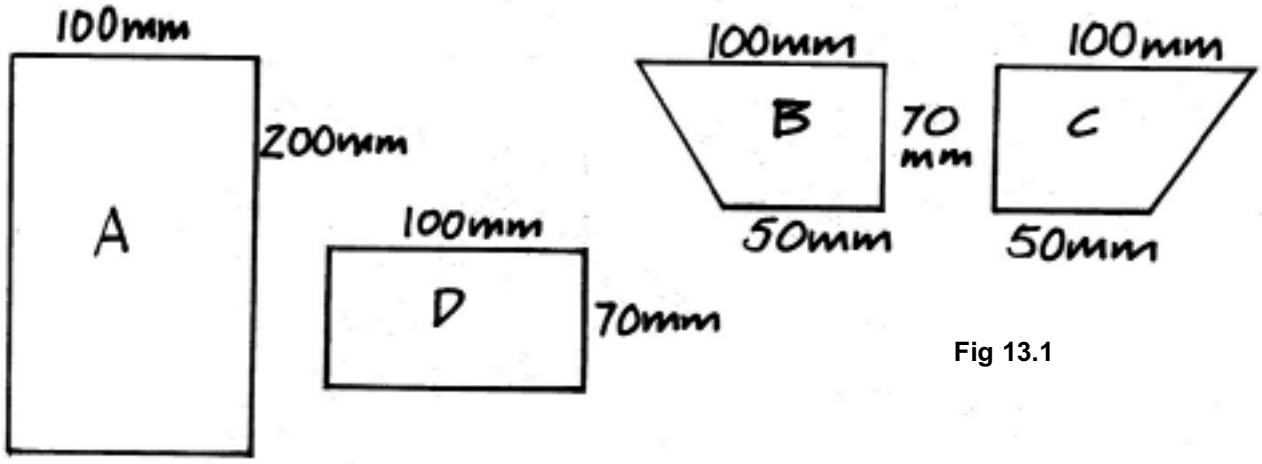


Fig 13.1

INSTRUCTIONS:

1. Cut panels to shapes and sizes as shown in fig 13.1. Cut 12 pieces of shape A from 3mm clear glass. Cut 8 pieces of each of the other shapes (B, C and D) in glass the color of your choice. The top and bottom of the terrarium can be measured and cut during construction.

2. Foil all glass.

3. Assemble the base section by tacking together four each of B, C and D panels as shown in fig 13.2. If you wish you can assemble top section now as well.

4. Place base over pattern paper or selected glass and trace around inside to determine the size of bottom piece. Make sure it is cut with true right-angle corners. Foil this piece and solder it in place.

Fig 13.2

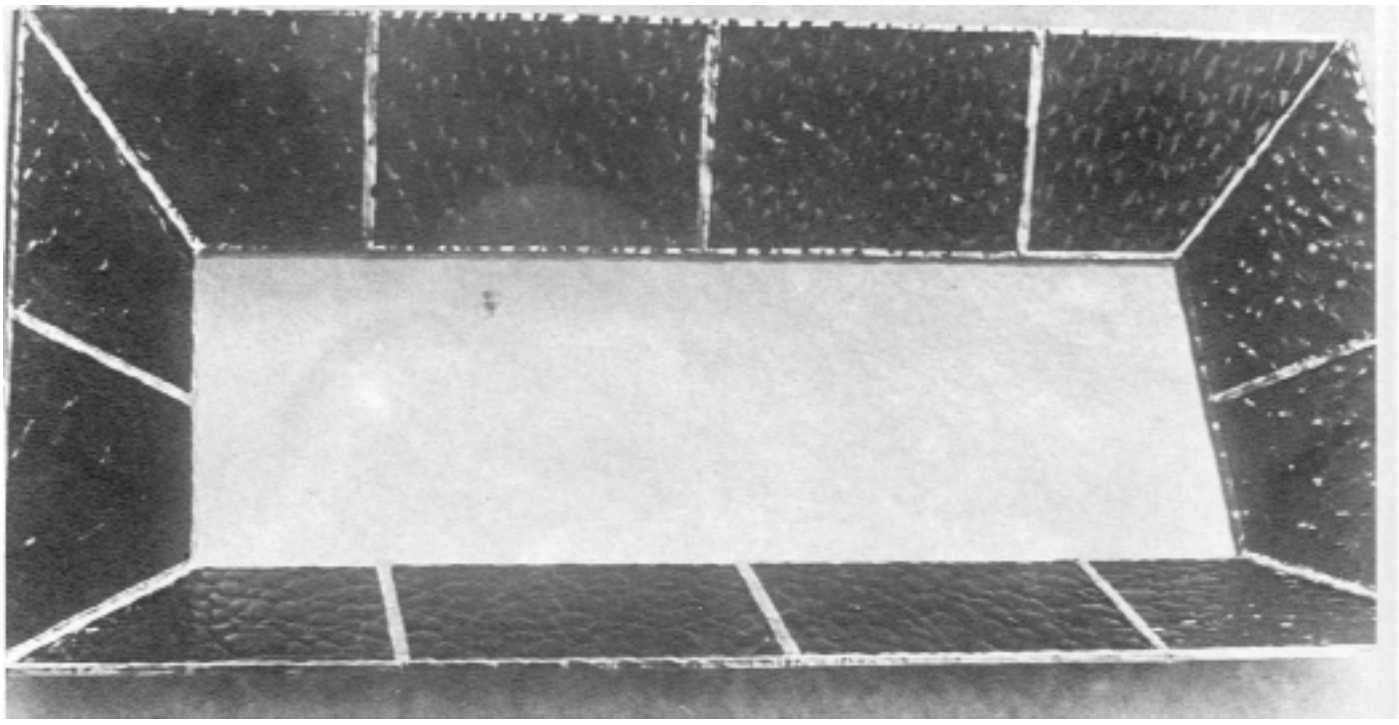
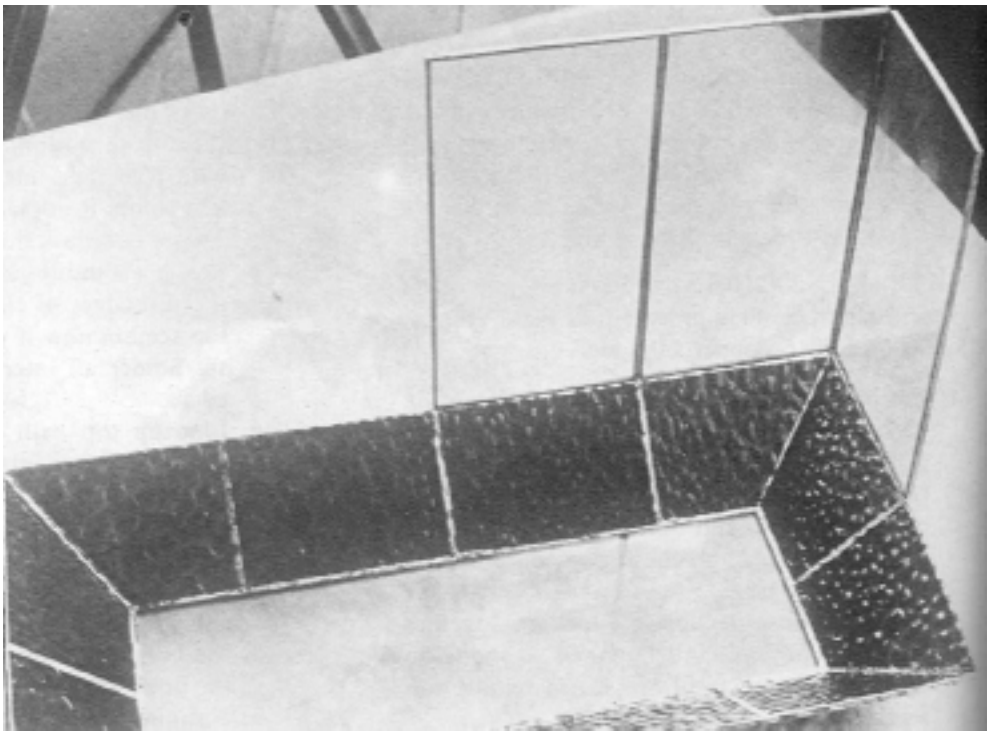


Fig 13.3



5. Tack clear glass side panels to the base (fig 13.3). Solder all inside joints so far created and tin the top edges of clear glass pieces. Assemble top section now if you have not already done so. Solder all internal joints and tin all foil edges.

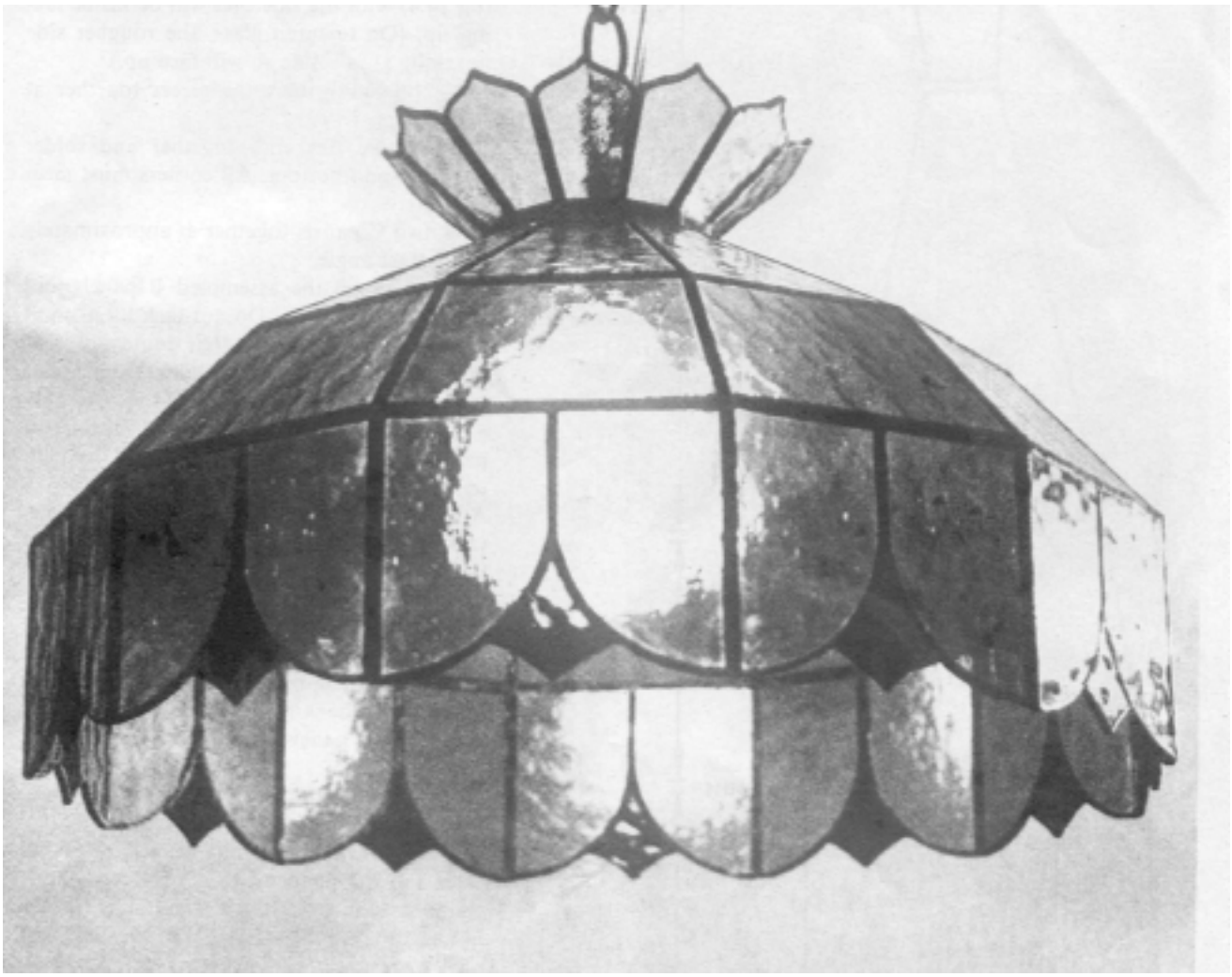
6. Line up top with clear sides and tack into position when centered.

7. Completely solder the outside of the terrarium. The inside should already have been soldered or at least tinned.

8. Cut a piece of glass (the same color as top assembly) to size. Make it slightly bigger than the hole in the top. This "lid" will just sit on the opening.

9. Antique and clean it. Add suitable plants. Talk to your local plant shop about the best plants for this kind of close environment.

Project 7: Lampshade

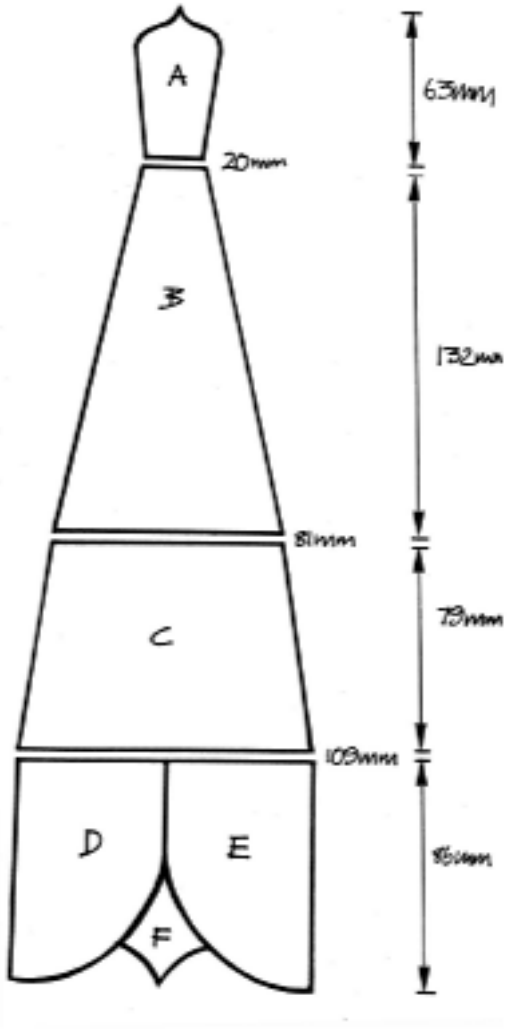


DIMENSIONS:
400mm wide across the bottom and 300 high

MATERIALS:
Glass - A panels 400mm x 70mm.
B panels 700mm x 132mm.
C panels 1200mm x 79mm.
D and E panels 1400mm x 95mm. F panels scraps/offcuts.
Total glass .4M2. If all glass is of one color order one 750mm x 550mm piece and a small scrap for F panels.

Copper foil	650g solder
75mm wire spider	Chain
Lampholder	Copper sulfate.

Fig 14.1



INSTRUCTIONS:

1. Draw up all panels on graph paper using the dimensions in fig 14.1 Use the full-size drawing (fig 14.2) for the crown panel.
2. Cut the A panels from a strip 70mm high. Cut the B panels from a strip 132mm high. Cut the C panels from a strip 79mm high Cut the bottom panels (D and E) from a strip about 95mm high in the method shown in fig 14.3.
3. Cut F panels from scraps.
4. Foil all glass with 6mm foil.

Fig 14.2

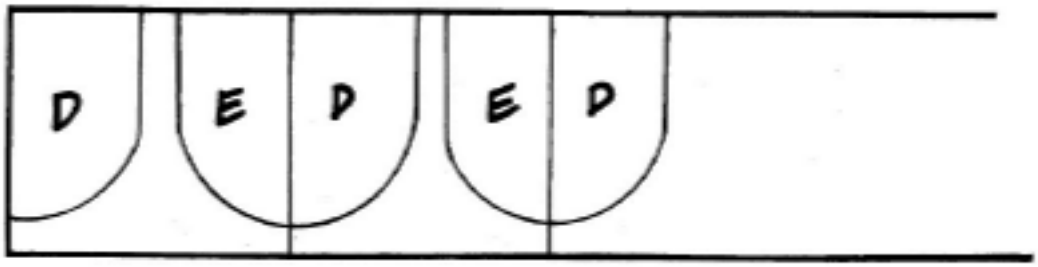


Fig 14.3

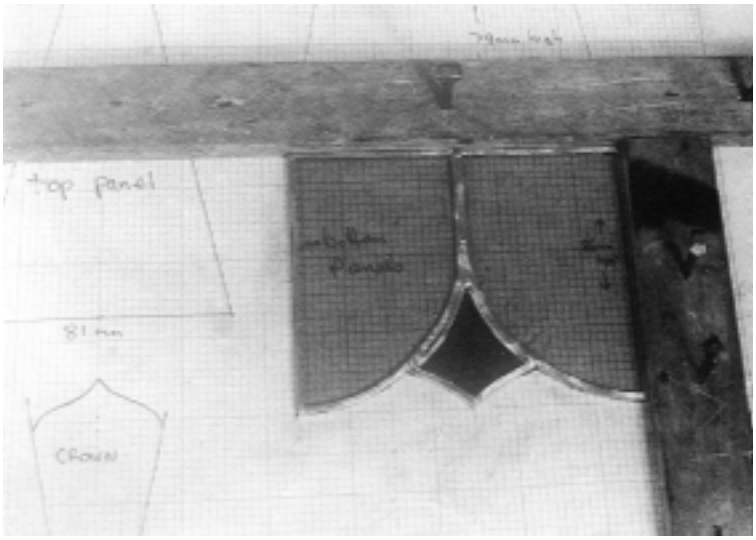


Fig 14.4

5. Tack D, E, and F panels together over the pattern or a copy of it. Use battens as a jig to ensure each set will be the same width (109mm). Solder over the back of these panels and then raise a beading on the front which will be on the outside of the lamp. These pieces can be handled as one panel from now on (fig 14.4).

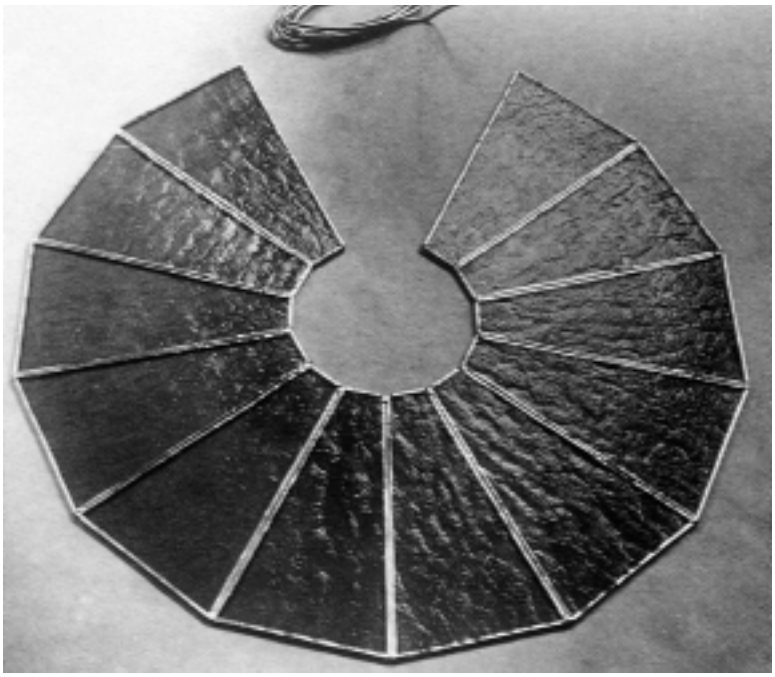


Fig 14.5

6. Lay out all B panels in an incomplete circle (fig 14.5) with the side that will be inside facing up. On textured glass, the rougher side normally goes inside the lamp, so will face up. Flux and lightly tack the pieces together at the corners.

7. Lift the two free ends together and solder them top and bottom. All corners must meet accurately.

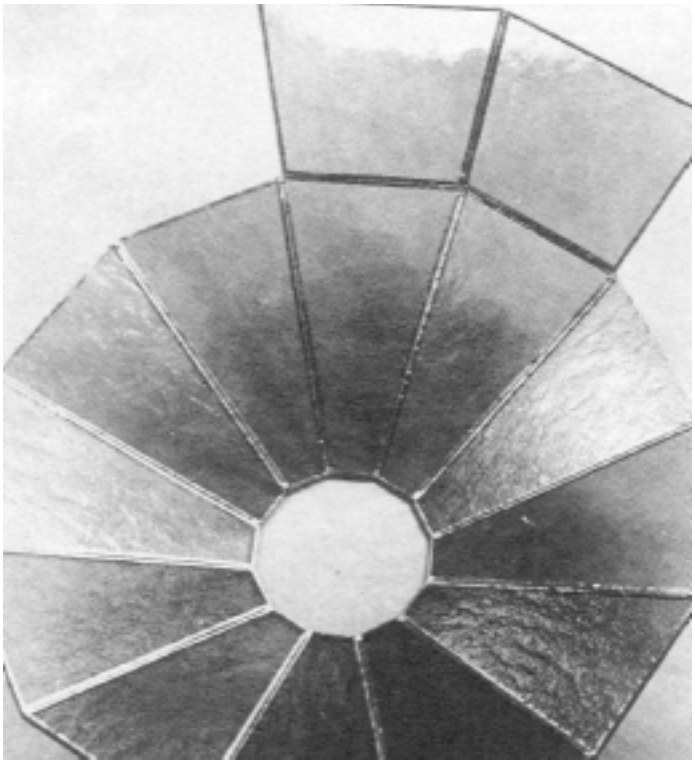


Fig 14.6

8. Tack two C panels together at approximately the correct angle. Place these on the assembled B panels and line them up exactly. Do not tack these on at the corners this time as that could unsolder the previous joint. Instead tack them about 15mm in from the corners (fig 14.6). Use only a tiny amount of solder because if subsequent panels do not fit properly, you will have to unsolder some joints to adjust.

9. Add the remaining C panels one at a time, tacking each one twice to its B panel and at the top corner to its neighbor. If all panels are placed accurately the last will fit snugly. If you can see them getting out of position - untack them back to where they fitted exactly and replace them more carefully.

10. Add all skirt panels (D, E, and F) in the same manner.

11. Solder over all the inside joints of the lamp. A raised beading is not necessary.

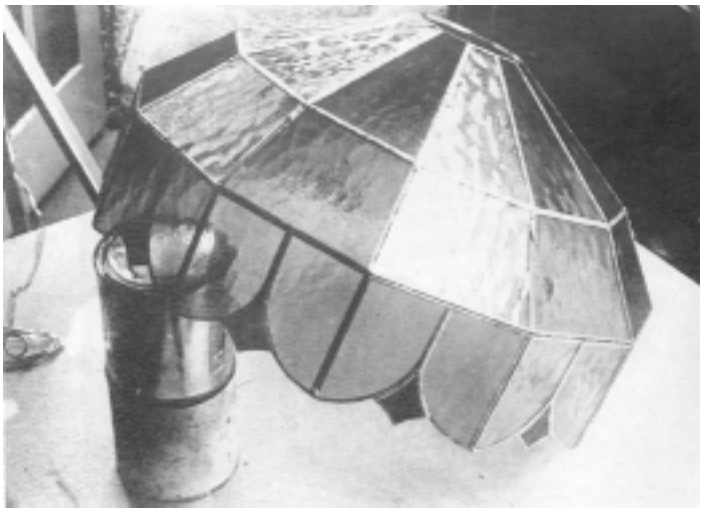


Fig 14.7

12. The outside joints should be beaded. Prop the lamp up to get the joint horizontal as you work on it (fig 14.7). Tin the foil edges around the bottom of the skirt and fit a wire spider into the top (see project no 3).

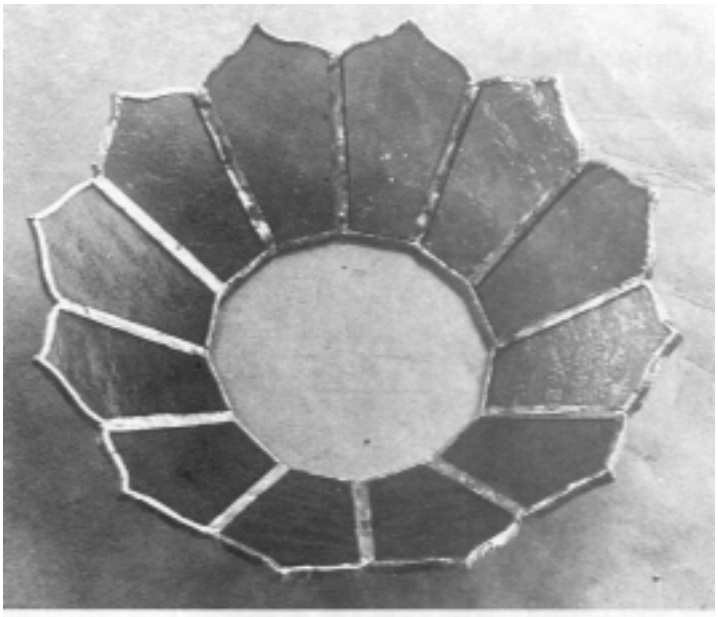


Fig 14.8

13. Make the crown (A panels) separately in the same way the B panels were assembled (step 4). When the crown is complete (fig 14.8), bead all the joints and solder it on to the top of the lamp. "Tin" a length of foil and wrap it around the join between crown and lamp to tidy it up (fig 14.9).

14. The lamp can now be cleaned and darkened. A chain should be used to hang it and a lampholder with a hook on the top will provide a fixing point for this.

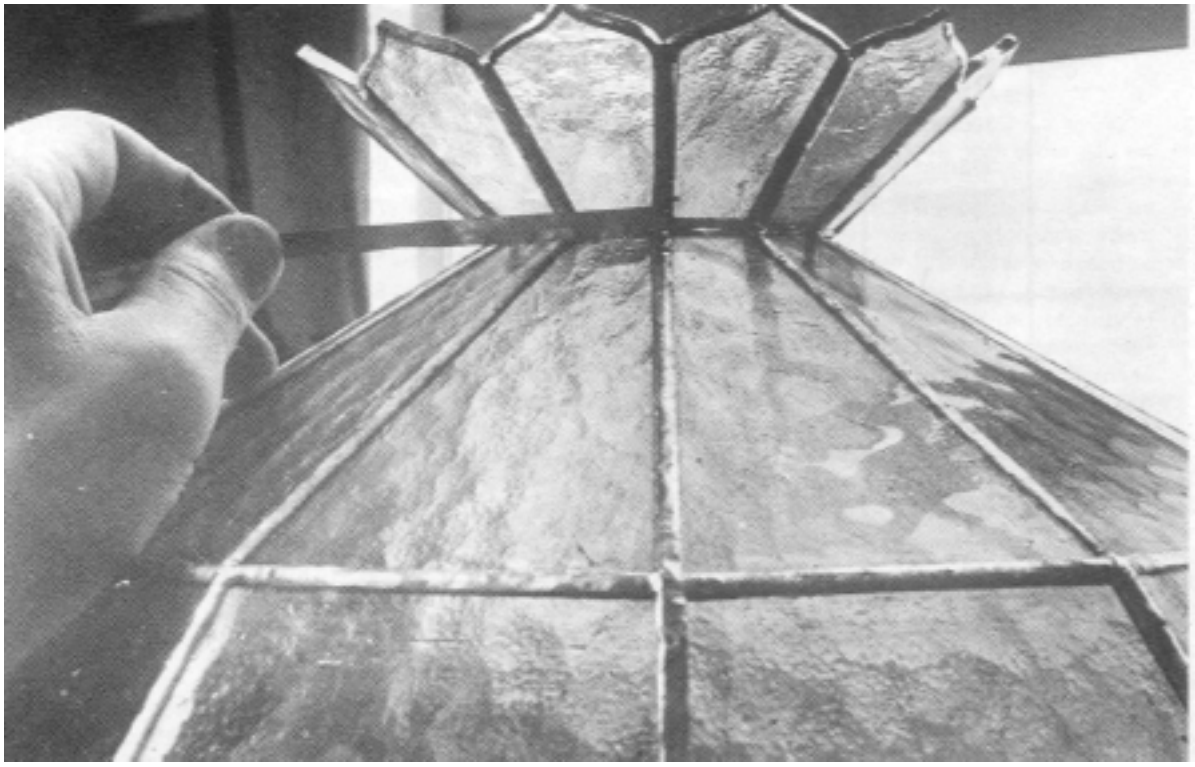


Fig 14.9

10. LAMP PANEL SIZING

I highly recommend a software program by Dale Grundon that is small, simple, 3-dimensional, and quick. It is called Tiermaker and is MUCH easier than the method here. We have made Tiermaker available as a free download from The Stained Glass handbook site at: http://learn-stained-glass.com

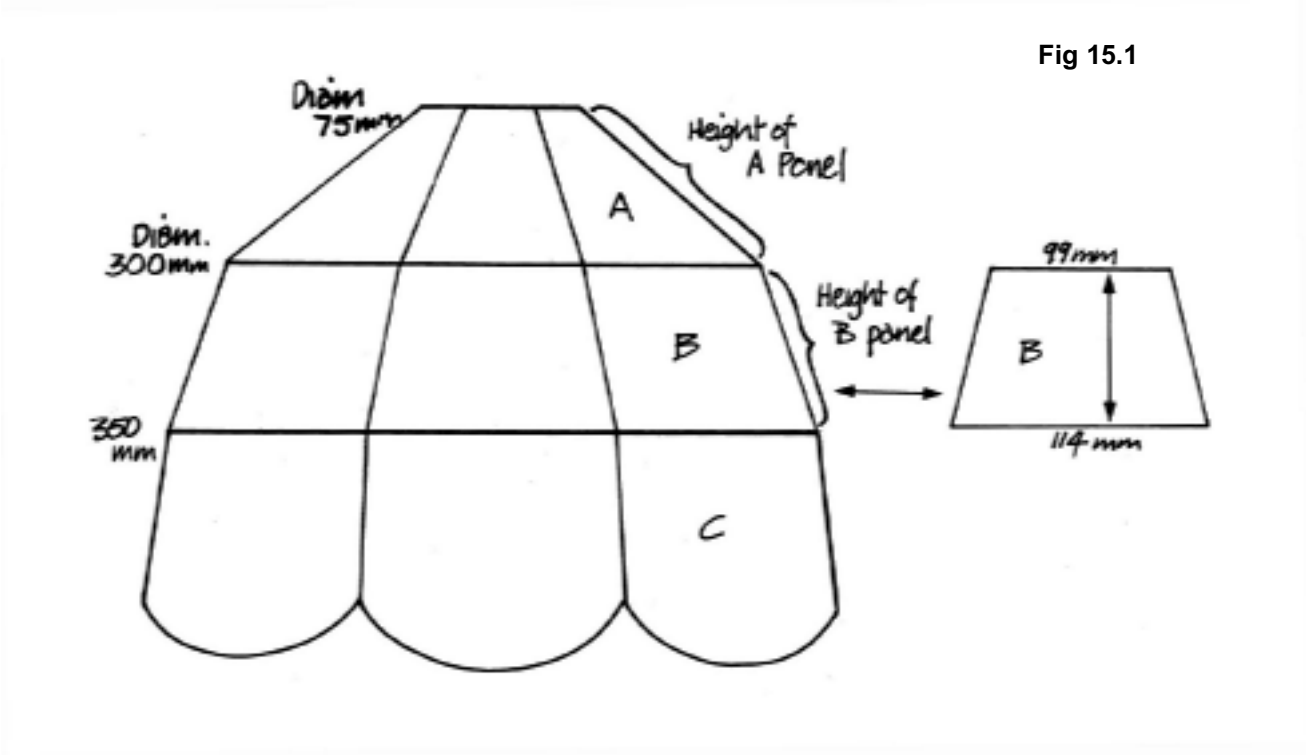
To determine panel sizes for any lampshade:

Draw the lampshade accurately to half scale on metric graph paper. This is when you decide how it will look, what angle there will be to each layer, etc..
Measure the height (along the slope) of each layer from this drawing and double it.
The width of the top and bottom of each shape can be determined from the chart below once you have decided on how many panels the lamp will be divided into.

For example: in a 10-panel lamp of the dimensions illustrated in Fig 15.1, the width across the top of panel B (and the bottom of panel A) would be 99mm because the diameter is 300mm
The bottom of panel B would be 114mm because the diameter there is 350mm.

Diameter	Number of panels							
	6	8	10	12	14	16	18	20
50mm	30	20	15	13	13	10	10	8
75mm	43	30	24	20	18	15	13	13
100mm	58	43	33	28	23	20	18	15
125mm	74	53	41	33	28	25	23	20
150mm	89	64	48	41	36	30	28	25
175mm	102	74	58	48	41	36	30	28
200mm	117	84	66	53	46	41	36	33
225mm	132	94	74	61	53	46	41	36
250mm	147	104	81	69	58	51	46	41
275mm	163	117	91	74	64	56	48	43
300mm	175	127	99	81	69	61	53	48
325mm	191	137	107	89	76	66	58	53
350mm	206	147	114	97	81	71	64	56
375mm	221	157	124	102	86	76	66	61
400mm	234	168	132	109	94	81	71	64
425mm	249	178	140	117	99	86	76	69
450mm	264	191	147	122	104	91	81	74
475mm	279	201	157	130	109	97	86	76
500mm	292	211	165	137	117	102	89	81
525mm	307	221	173	142	122	107	94	84
550mm	323	231	180	150	127	112	99	89

Fig 15.1



11. PHOTOGRAPHING GLASS

Use a camera which allows you to set the exposure manually (turn off the auto-exposure). Whichever sort of light-metering system you use, always get close up to the window to read the exposure. Take a reading from a typical section of the composition and do not be concerned that when you step back you will get a different reading. You are photographing the intensity of light coming through the window and that is the same no matter how near you are. From further back, an automatic reading would be influenced by the dark interior of the building. With a digital camera you may be able to preview the photo on an LCD screen and make manual adjustments visually.

If the window has a wide range of intensities take another photograph 1 or 2 F-stops either side of the reading. Record the exposures for later reference and comparison. Use a tripod and cable release to eliminate vibration.

Take color slides in preference to prints because you can always get duplicates or prints from them plus the quality will be better and they can be used in slide shows. Most importantly, with slides you get exactly what you take. If you use color negative film and take perfectly exposed photos of stained glass, they will probably be printed too light. That is because prints are usually put through a machine designed to compensate for bad photography. Before each print is made, the machine reads the intensity of the negative and adjusts the print exposure time to suit. When it reads all the dark background area around the window it assumes the negative is under-exposed and does not give it a long enough light burst to register the colors of the window properly. You can, however, get these negatives redone by hand and even cropped down to just how you want them. Make a note on the order form with the film explaining what you want and check the prints before you pay for them.

A high-resolution digital camera gives a lot of versatility. There will be no loss of quality over time, adjustments can be made on the computer, photos can easily be printed in brochures and advertising, posted on the web, emailed, included in digital videos, and projected via presentation software.

12. COMPUTER AIDED GLASS DESIGN

Throughout the centuries, not much has changed in the way stained glass windows are constructed. Electricity was the biggest change as it streamlined glass and lead manufacture and allows the studio artist to use electric soldering irons, kilns, bandsaws, and grinders to speed construction.

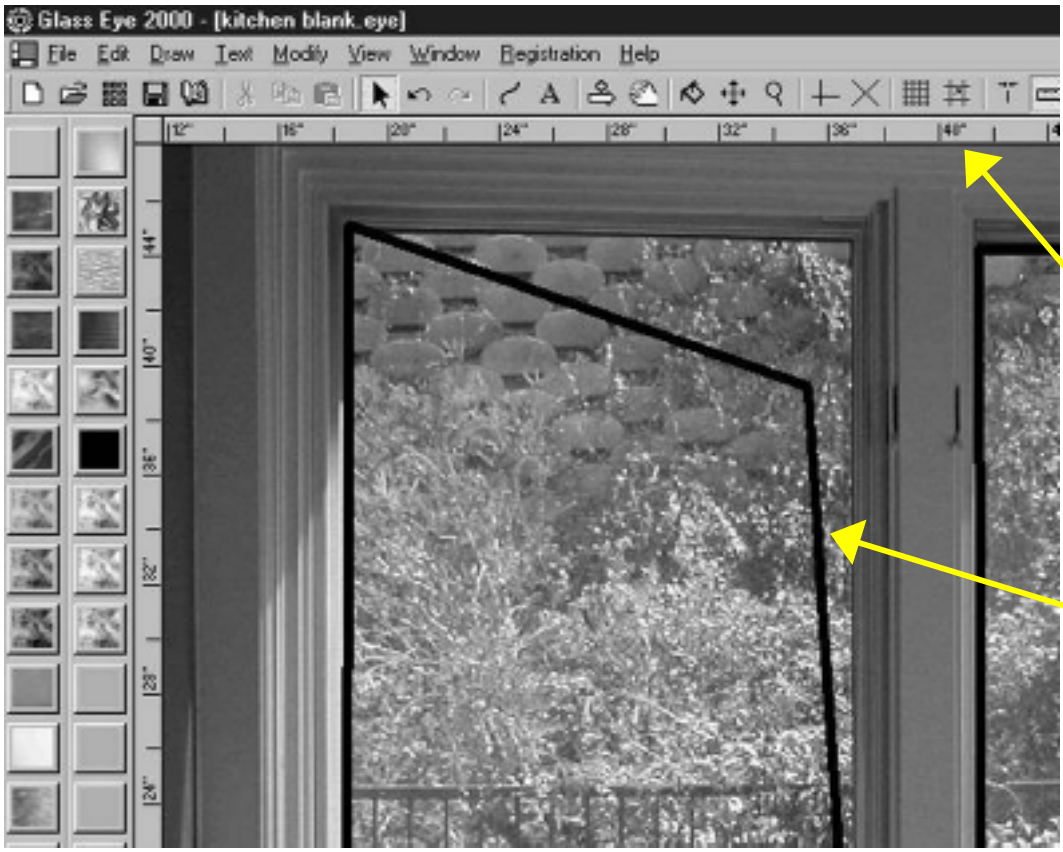
The computer age has also ushered in a most welcome change. Until recently, artists had to draw or paint the design proposals for their clients. While this often resulted in beautiful watercolor renditions, some imagination was still needed by the clients to be able to picture the window in place and the effect of light coming through it.

We can now use computer programs for designing windows and panels. Some people use drawing and photo-editing programs but there are also programs like *Glass Eye 2000* and *Designer II*, which are specifically made for stained glass design. Both are available as trial downloads from their respective Internet sites. Just connect to the Internet and click on these links:
Glass Eye 2000
Designer II

The only one I own is *Glass Eye 2000,* but they both work much the same way. The following screenshots show parts of the process of designing a window with GE 2000. They simulate a finished window by layering lead-lines and digitized glass pieces over a background photo. The process enables the designer and clients to better visualize the finished window in its setting, and easily make adjustments for final approval. A photo of the existing window can be imported into the program and the window can be designed on top of that photo.

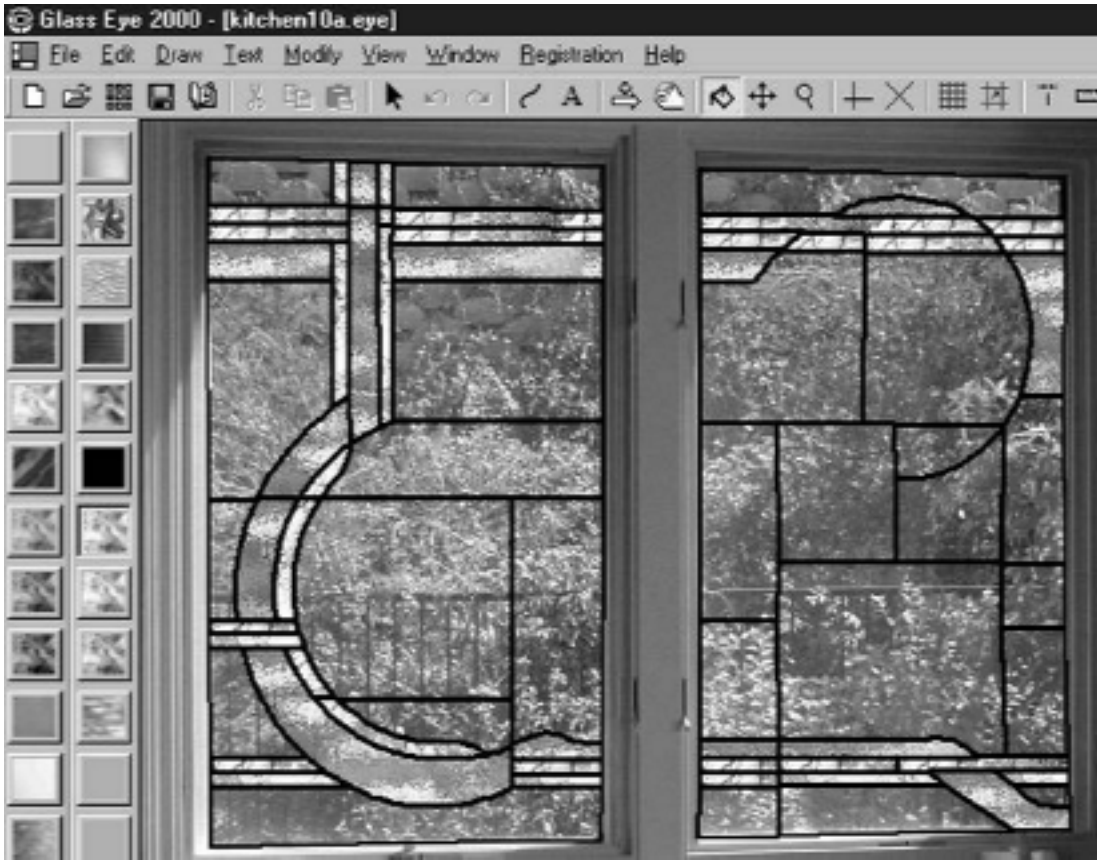
Step 1.
Photograph the existing window and discuss potential design ideas with the clients.

This kitchen window looks out on to a retaining wall, some bushes, and a few plants. There is some greenery there and that is highlighted by the sun for most of the day.



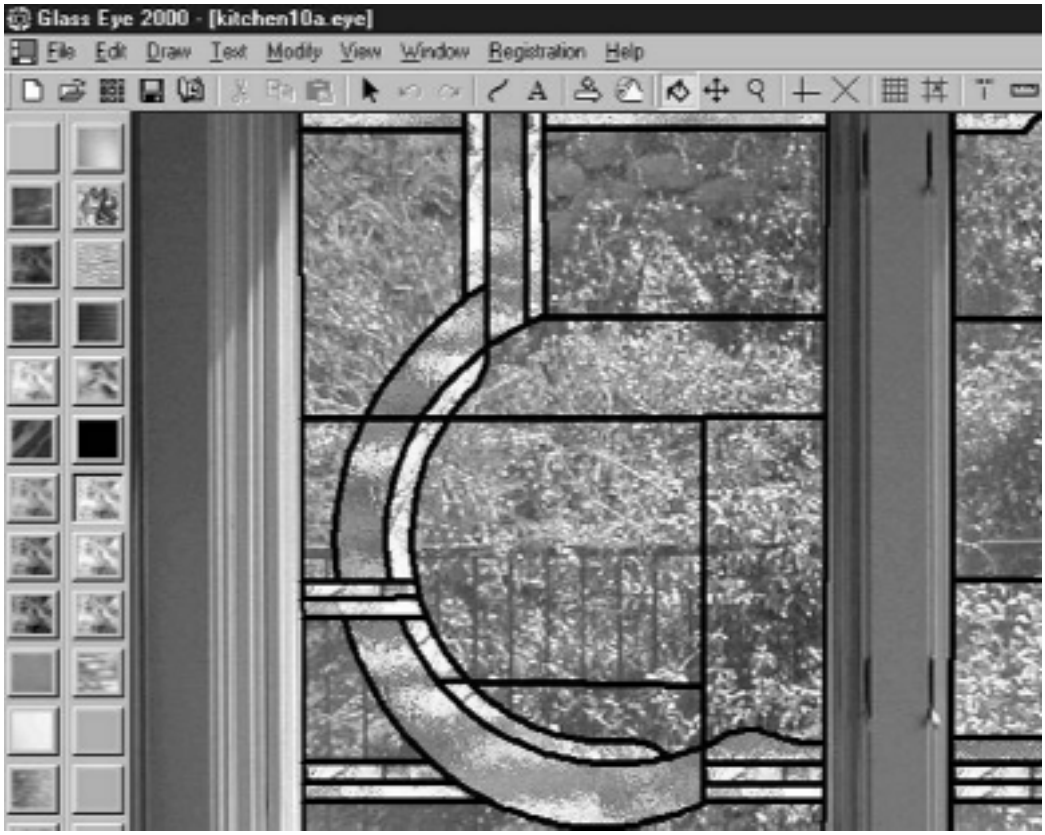
Step 2.
The photo is placed in ***Glass Eye 2000*** and scaled to size (note the inches below the toolbar).

Leadlines are drawn onto the picture. In this screenshot, the border lead has just been placed by drawing an oblong inside the window. The oblong's corners are then dragged into place.



Step 3.
Once the border leads are placed, the internal lead lines, in their varying widths, can be drawn in. They can be bent, moved, deleted, and altered at any stage.

Glass samples are added to the palette at the left of the screen and can include glass from all the major manufacturers.



Step 4.
We can zoom in on any portion of the window to attend to detail.

Glass is filled in by selecting a sample from the left and using the "paint" tool (shaped like a tipping bucket) from the top menu.

The background is able to show through where no colored or textured glass is placed.

The program accurately estimates quantities and materials costs. Designs can be printed as photos or emailed to a client, and full-size patterns can be printed for glass cutting and window construction.

The final presentation to a client may include optional treatments and prices.

The main advantage of programs like this is that nobody has to imagine what the finished window will look like.

13. GLOSSARY

Antique glass - hand blown sheet glass.
Beading - the raised solder joints in foil work.
Blank - the working piece of glass from which a shape is cut.
Came – lead, zinc, or brass extrusion - H shaped or U shaped.
Cartoon - full size working drawing.
Cathedral glass - machine made glass, patterned on one side and smooth on the other.
Cementing - lead windows are sealed and strengthened by forcing cement/putty between lead and glass.
Cutline - line on cartoon showing edges of glass.
Daylight size - inside measurement of window frame
Dutchman - a false-lead repair.
Easel - large sheet of plate glass upon which cut glass pieces can be fixed for previewing.
Fid - a small, shaped wooden or plastic tool for opening out lead and smoothing foil.
Flanges – a term sometimes used for the "leaves" of lead came.
Flashed glass - glass with a thin layer of color fused onto a thicker base color.
Flux - a substance that cleans metal surfaces in preparation for soldering.
Foiling - Wrapping of adhesive foil tape around glass edges.
Glazing hammer – a double headed hammer with one rubber surface and one of toughened plastic.
Groze - to nibble excess glass away with special-purpose pliers.
Grozing pliers - glass nibbling pliers.
Heart - the thin central upstand in H came.
Lathekin – see Fid
Lead vice - a clamp for holding lead during stretching.
Leading - the assembly process using lead cames between glass pieces.
Oleic acid - a flux for leadwork.
Opalescent glass – machine-made opaque glass.
Score - line made by glass cutter wheel.
Seedy glass - glass with small thin bubbles in it.
Solder - 60/40 or 50/50 solid wire solder.
Spider – a wire ring soldered into the top of lamps to hold the lampholder (lightbulb fitting)
Tacking - temporary soldering.
Tallow – animal-based flux for lead. Manufactured in candle form.
Template - cardboard pattern piece for scoring around.
Tinning - coating copper foil or wire with a thin layer of solder.
Translucent - light transmitting but blocking out detail.
Transparent - able to be seen through.
Whiting - Calcium carbonate. The main constituent of stained glass cement.

Suppliers:

Stained glass suppliers usually advertise in the Yellow Pages under "Glass – stained and leaded". You will find a number of large mail-order suppliers on the Internet as well. Go to a search engine, type in "stained glass", and stand well back.

Websites:

Remember to check out the Stained Glass Handbook website where there are links and free instructional videos of glass cutting, breaking techniques, leading, foiling, and soldering.

Book site:- http://learn-stained-glass.com
Studio site:- http://samhalstead.com

Send suggestions, corrections, feedback, additions, and comments to: sam@samhalstead.com