*Proceedings*

*The Sixtieth Annual*

# Symposium
## on the
# Art of Scientific Glassblowing

Sponsored by
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THE
AMERICAN SCIENTIFIC GLASSBLOWERS SOCIETY
*Machias, NY*

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# Contents

## Papers



## Other Information



* These two papers were presented and the authors were unable to submit them for publication.

# Papers

# A Few Tips That Could Be Helpful

**by**

**Joseph S. Gregar***

## ABSTRACT

*This paper will highlight a few of my favorite hints, tips, tools and tricks that I have learned and used throughout my scientific glassblowing career. Hopefully some of you are already using them, but everyone should pick up something new and helpful.*

I have written this paper with the idea of sharing some of my more interesting tips that use tools or fixtures that have helped me over the course of my 49 years as a scientific glassblower. It is my wish that you will find these techniques interesting and helpful. Hopefully, if you do not have an immediate use for these tips and techniques, they will come in handy in the future.

## NATIONAL HAND TORCH TIP WRENCH

A very useful tool is a ½" "deep socket" wrench for removing hot tips off the National hand torch nozzle (Photo 1).

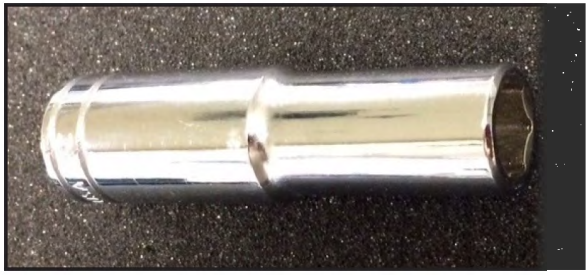

**Photo 1**

Because of the length of a "deep socket" you can get a strong grip on the socket and unscrew the hot tip from the nozzle without burning yourself. The National tips have a 1/2" hex shank that a 1/2" "deep socket" fits perfectly. I want to give credit for this tip to Ian Duncanson, ASGS Past President and fine scientific glassblower from Notre Dame University. It was from Ian that I first heard of using the "deep socket" for this purpose. I will add that it also is a great tool for mounting the tips onto the nozzle, hot or cold (Photos 2, 3, & 4).

**Photo 2**

**Photo 3**

**Photo 4**

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## RIGHT ANGLE SPLICE FIXTURE

The right angle splice fixture is made by using a 6” long section of 1” stainless steel angle iron and a 5” length of ¾” stainless steel tubing (Photo 5).

**Photo 5**

The ¾” diameter stainless tubing is welded onto a ¾” x 2” long stainless steel angle iron. That assembly is bolted to the backside of the 1” stainless steel angle iron.

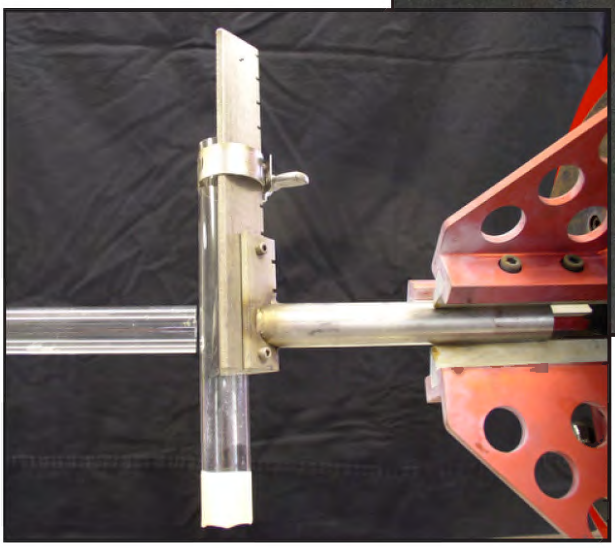

**Photo 6**

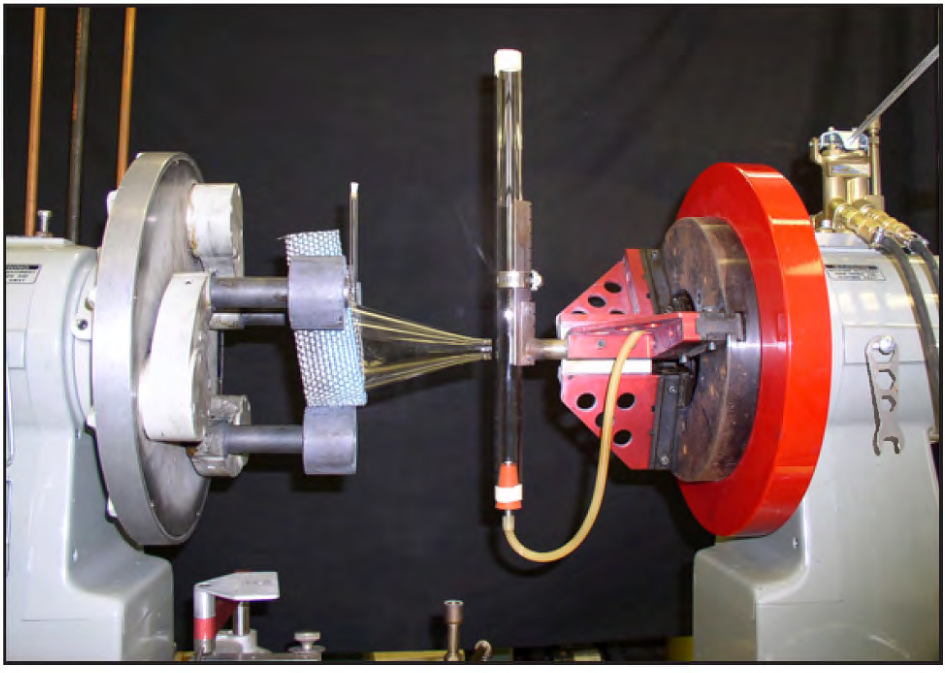

**Photo 7**

The top end of the 3/4" stainless tubing is machined to have a "V" that will sit nicely onto the smaller angle iron and is then TIG welded exactly at 90 degrees to the smaller angle iron section. It is critical that the 90-degree be very accurate. Small grooves can be cut into the edge of the angle iron around which bailing wire can be wrapped to hold a glass tube in the angle iron. I prefer to use small diameter stainless steel band clamps also known as radiator hose clamps (Photo 6).

You can then place this assembly into the tailstock of a glass lathe. Add your blow hose to one end of your mounted glass tube and close the second end so you can blow into the tube. Place a second glass tube into the headstock and begin to make your tee seal in the lathe. All the parts are held securely in the lathe with the vertical tube at a perfect 90 degrees to your tube in the headstock. Here is an example of the complete lathe setup (Photos 7 & 8).

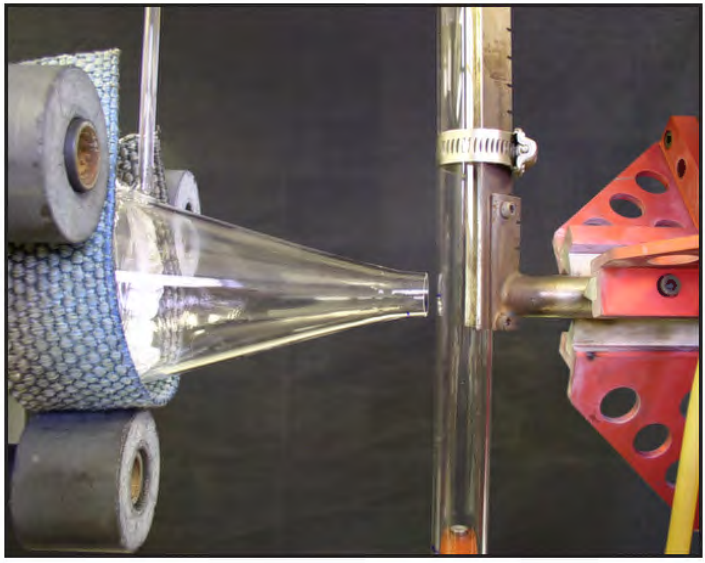

**Photo 8**

With the lathe turning, hold your torch at the "on center" location of the vertical tube and gently blow a bubble where you want the hole (Photo 9).

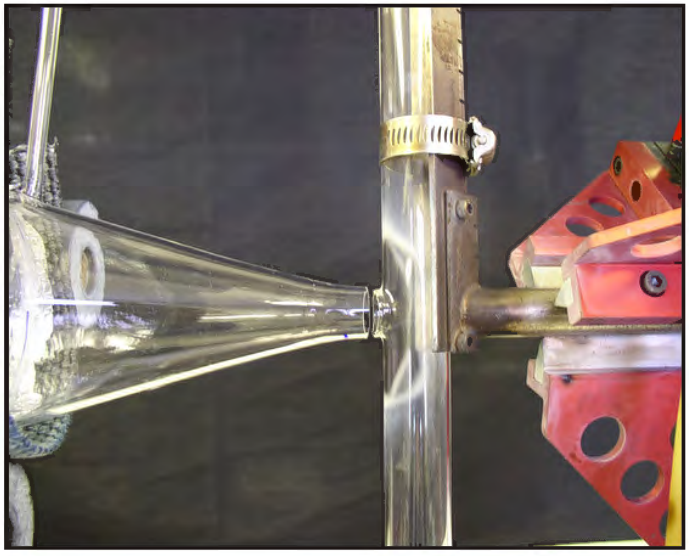

**Photo 9**

Eventually blow and pop the hole open and ream with a graphite rod to the matching size of the horizontal tube to be spliced. If the hole does not come out with a straight edge, stop the lathe and carefully pull off the high spots with a tack rod. You will generally find the high spots to be at the top and bottom of the hole when it is stopped in the vertical position.

Here are some examples of tee splices that I have made using this method (Photos 10, 11 & 12).

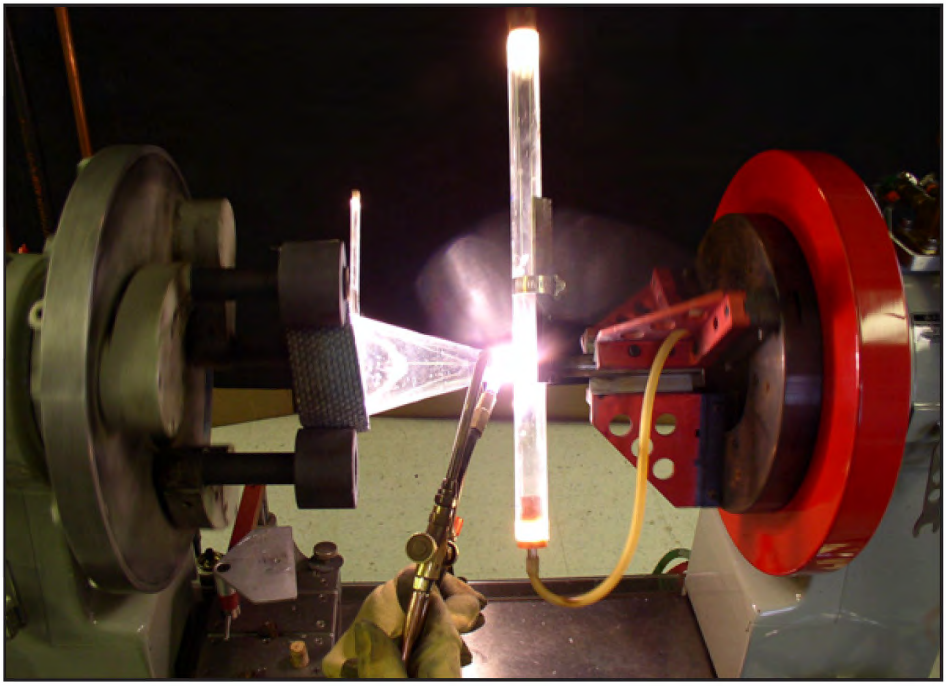

**Photo 10**

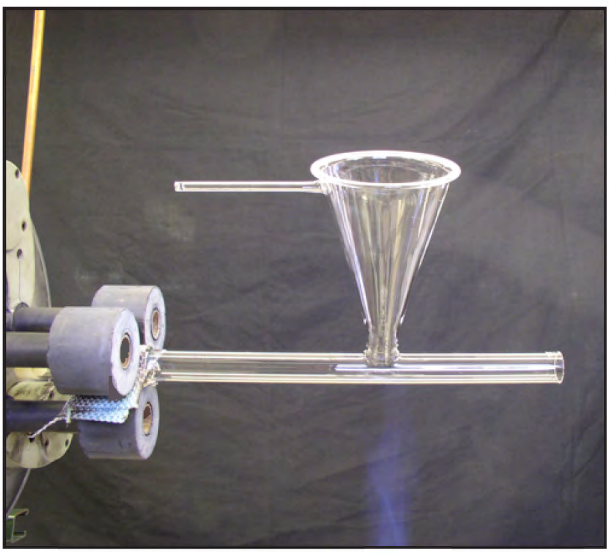

**Photo 11**

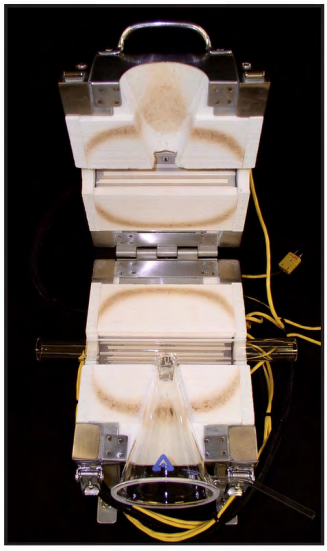

**Photo 12**

## ROTATING VACUUM SWIVEL

Scientific glassblowers have utilized the rotating vacuum swivel for many decades. They are used most often to hold flat glass discs by the use of vacuum. The disc could then be spliced on or into the end of tubes (Photo 13).

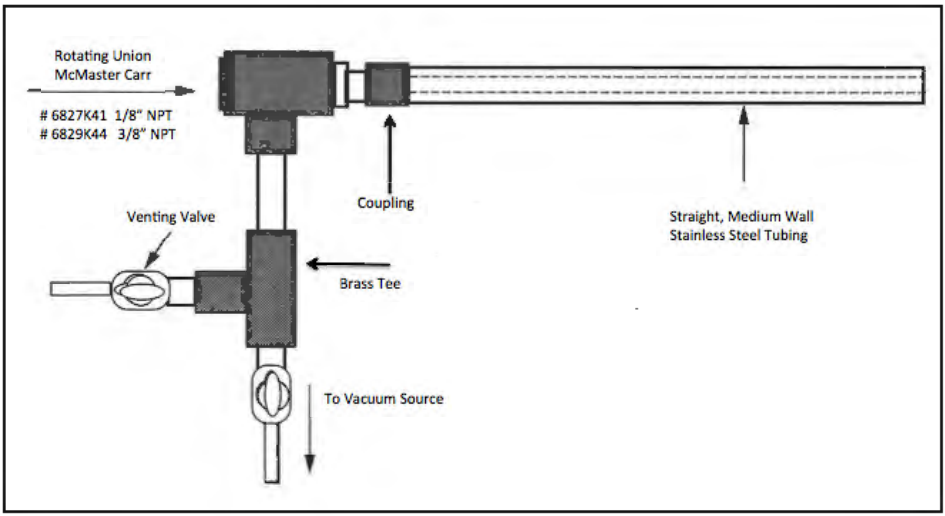


**Photo 13.** *Vacuum rotating union*

I tried using the swivel from our glassblowing hoses, but the leakage is too great to hold the parts without slipping or falling off. The swivels I found are common in the hydraulics industry. They call them "rotating unions" and they can be purchased from McMaster Carr. There are two sizes that I use. A small union, Part #6827K41, has 1/8" NPT size thread connections. The larger one, Part #6829K44, has 3/8" NPT thread size connections. I incorporate a simple two-valve system allowing me to isolate the vacuum source that holds the disc and a pressure release valve that allows for a quick and simple removal of the disc after the seal is completed. A stainless steel tube is fit to a pipe by means of soldering a pipe coupling with the matching thread size to the connection on the rotating union. Care should be taken to select a pipe coupling and stainless tube that are very straight so that they run true when turning in the glass lathe (Photo 14).

**Photo 14**

This rotating vacuum swivel is unique because of the graphite accessories I make for holding glass discs and other glass parts. The first piece is a small graphite holder for small diameter discs and other shapes (Photos 15 & 16).

The second graphite holder is slightly larger and holds larger diameter discs securely.

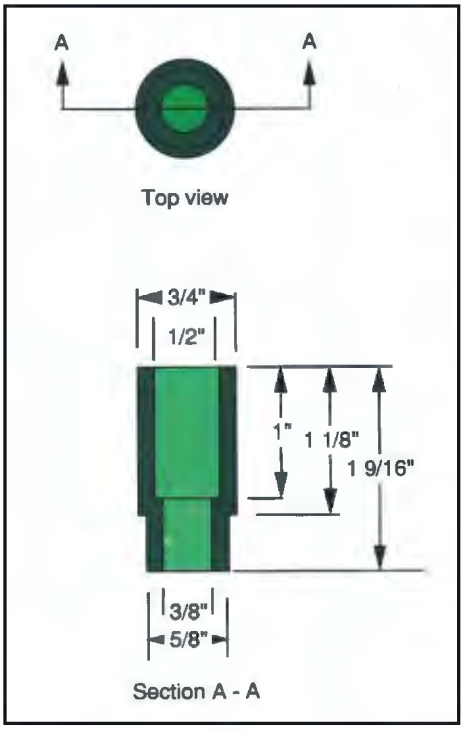


**Photo 15**

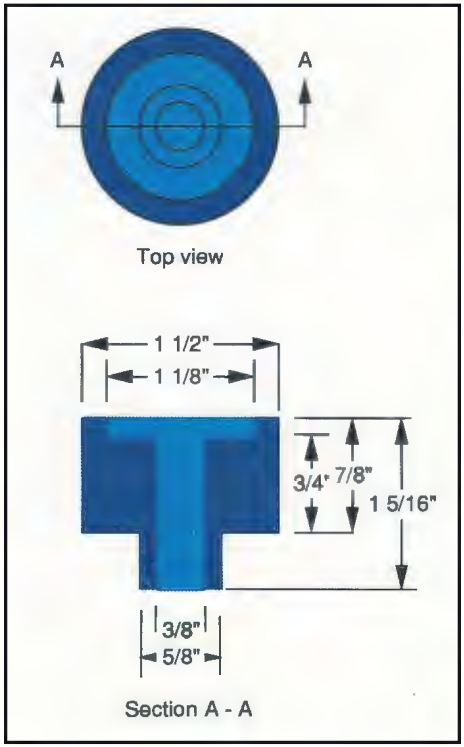


**Photo 17**

**Photo 16**

There is a recessed well machined into the face of the holder creating a larger vacuum space (Photos 17 & 18).

The third holder has very sophisticated tunnels machined into it for holding discs that have a hole drilled in their center and looking like a doughnut. I make a lot of tubes with flat bottoms and a hole in the center of the bottom. Trying to drill the hole after the tube is made was a big hassle and many broke during the drilling. I drilled the holes into the discs first, held them with this graphite holder, and then sealed the disc into the end of the tube to complete the job. It is much easier to drill the hole in a flat disc sitting on a flat sur-

**Photo 18**

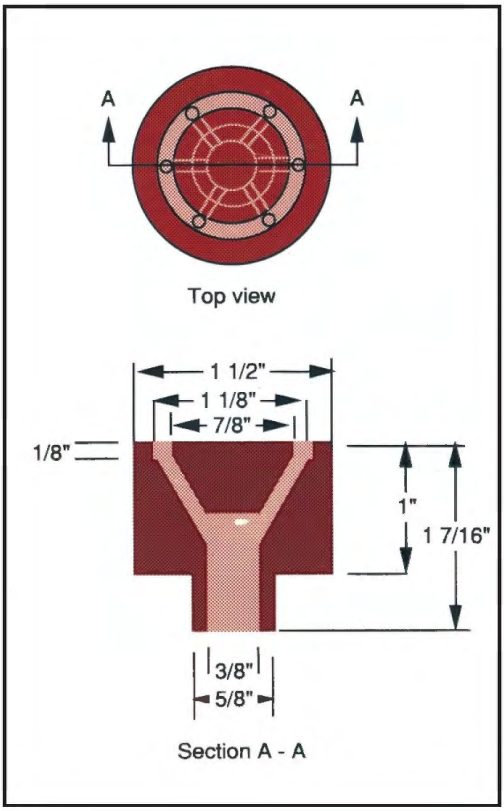


**Photo 19.** *To hold a disc with a hole in the center*

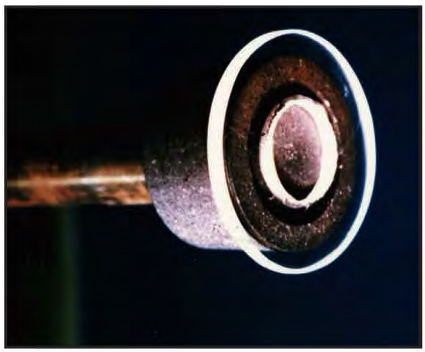

**Photo 20**

face than on the end of a tube (Photos 19, 20 & 21).

Making short domed glass pieces are easy but trying to hold them to fire polish the open ends was difficult and tedious. With the rotating vacuum swivel and the first small graphite holder, it became very easy. One after another is placed onto the graphite holder, fire polished and dropped into a pan of vermiculite. The next dome is quickly loaded onto the graphite holder. This can be done so fast that there is no need to turn the vacuum

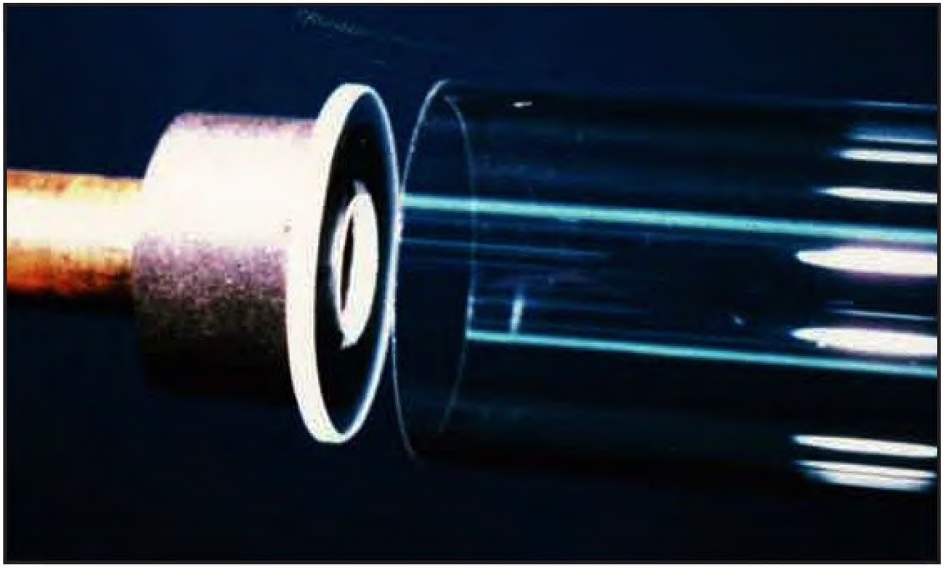

**Photo 21**

**Photo 22**

**Photo 23**

**Photo 25**

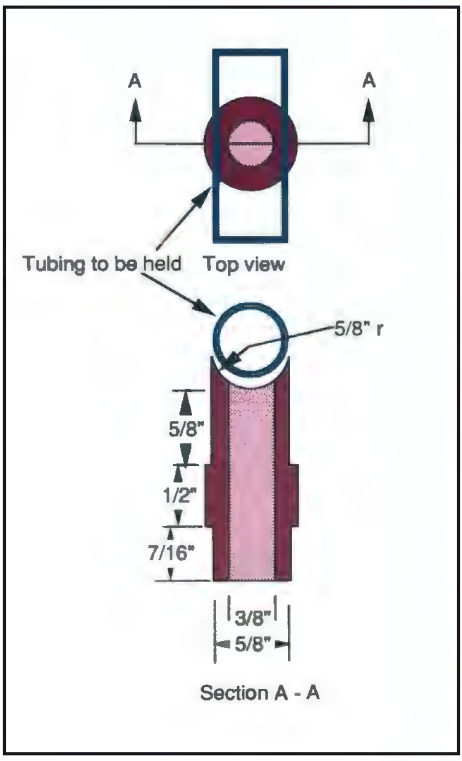


**Photo 24**

**Photo 26**

and release valves. Just pull one off and stick another one on. It also works on flat bottom dishes (Photos 22 & 23).

The fourth graphite holder is my favorite. I have many different sizes to accommodate many glass tubing diameters. It is used for making 90 degree, right angle splices. The graphite holder is machined in the normal style, however, the end that receives the glass is machined with a cradle to hold a glass tube on its sidewall. This machining is done with an end mill cutter that is exactly the same diameter as the glass tube that it will hold (Photos 24, 25 & 26).

Here are some photos of apparatus on which I have made right angle splices with this style graphite holder (Photos 27, 28 & 29).

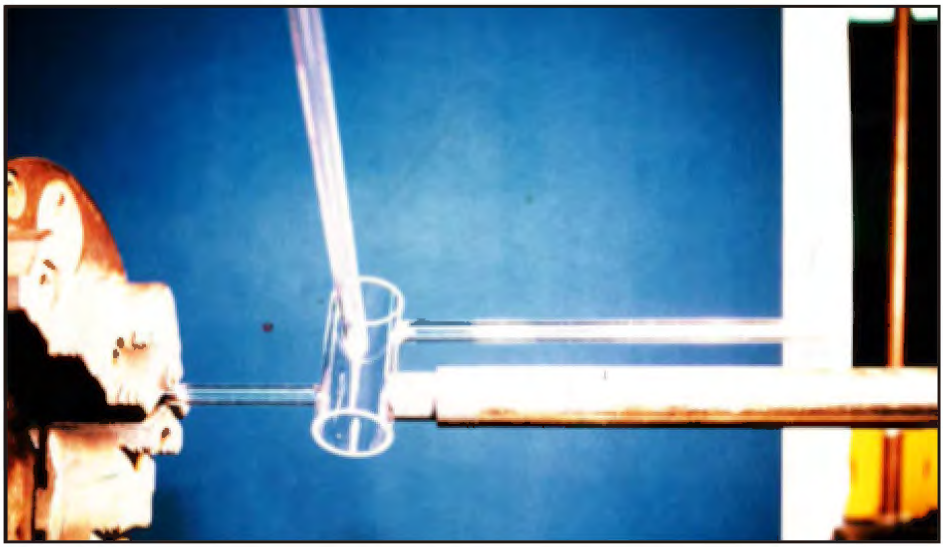

**Photo 27**

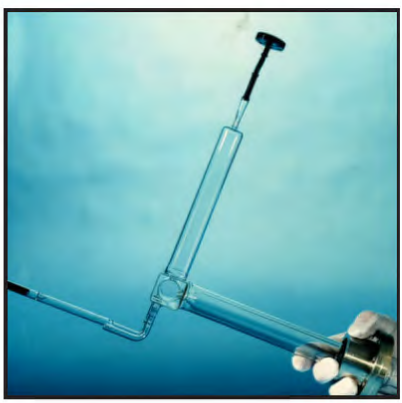

**Photo 28**

**Photo 29**

## MODIFIED MACHINIST SQUARE

Note in photo # 29, I am holding a small machinist square to measure the 90 degree of the attached tube. The machinist square is modified. The outside corner has been machined off which allows the square to be placed up against the tubes for better accuracy. If it

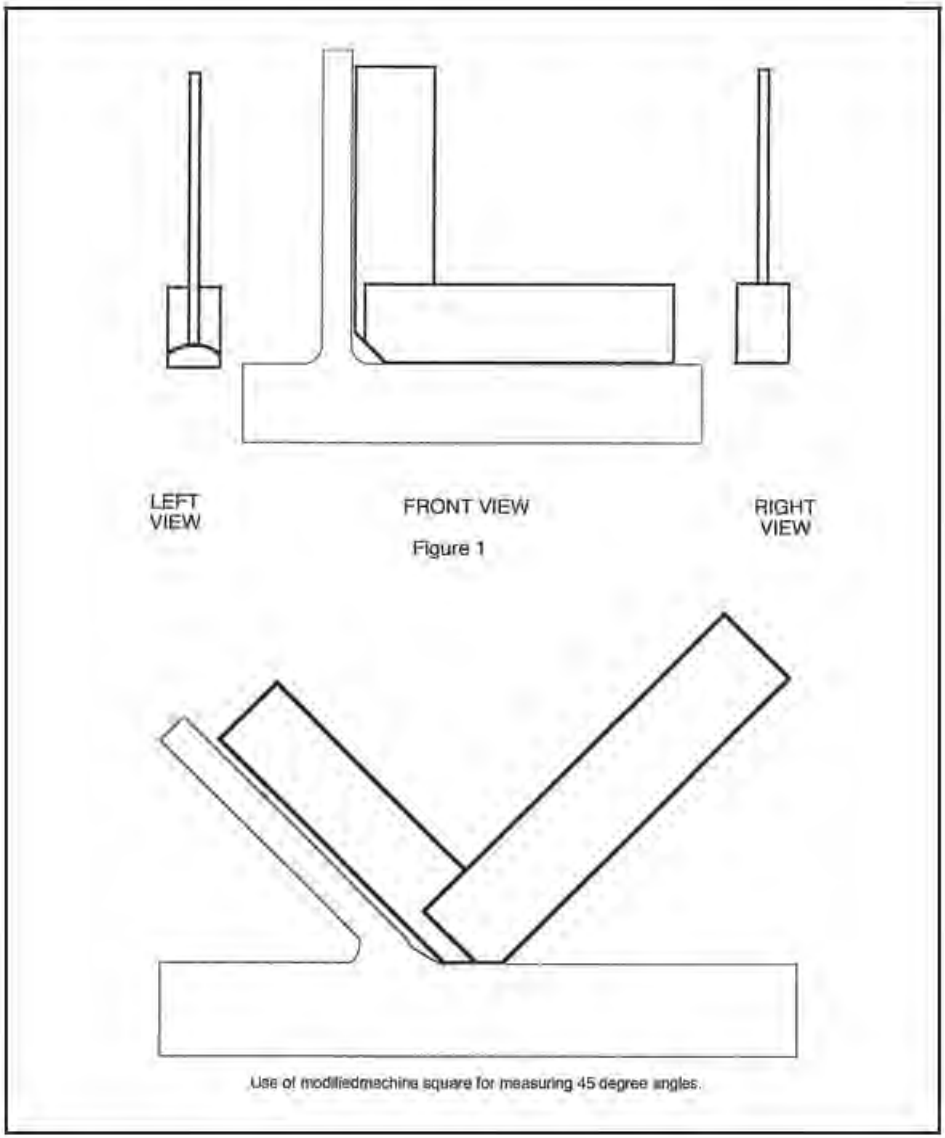


**Photo 30.** *Modified machinist square*

were not modified in this manner, the round contour of the larger tube would not allow the square to get in to touch the vertical tube. This modified machinist square also works great to check tubes that are sealed onto a manifold at 90 degrees (Photos 29 & 30).

## GRAPHITE ROLLER FOR ENLARGING GLASS TUBING

Square graphite blocks have also been used for decades for enlarging the outside diameter of glass tubing. This is done to achieve a diameter that is not a standard size, or many times, the technique is used to obtain a thinner wall thickness than normally available. By using a square block, the graphite gets hot and will become porous. The porous surface will produce lines or ridges in the surface of your tube. The graphite will also shrink in size which will produce a tube that increases in diameter as you go along the length.

I decided to make a graphite roller that spins with the friction of the glass tube being blown into it (Photo 31).

By having the graphite spin, there is more surface to absorb the heat. The graphite does not get oxidized, so your tube will stay a uniform diameter over the 3-4 feet you are blowing it up and it will not cause lines or ridges on the surface. When producing a long length, you gradually move the roller along the tube until the desired length is reached (Photos 32 & 33).

**Photo 31**

**Photo 32**

To achieve the new diameter, subtract the diameter of the starting tubing from the new larger diameter. This will give you the difference in the two diameters. Divide that number by 2. This will give you the radius of the difference which is the size you make the spacing between the original tube and the top of the graphite roller. I use a quality set of metal drills for the spacing. I find one that equals the spacing and adjust the height of the roller from one side to the other while the glass

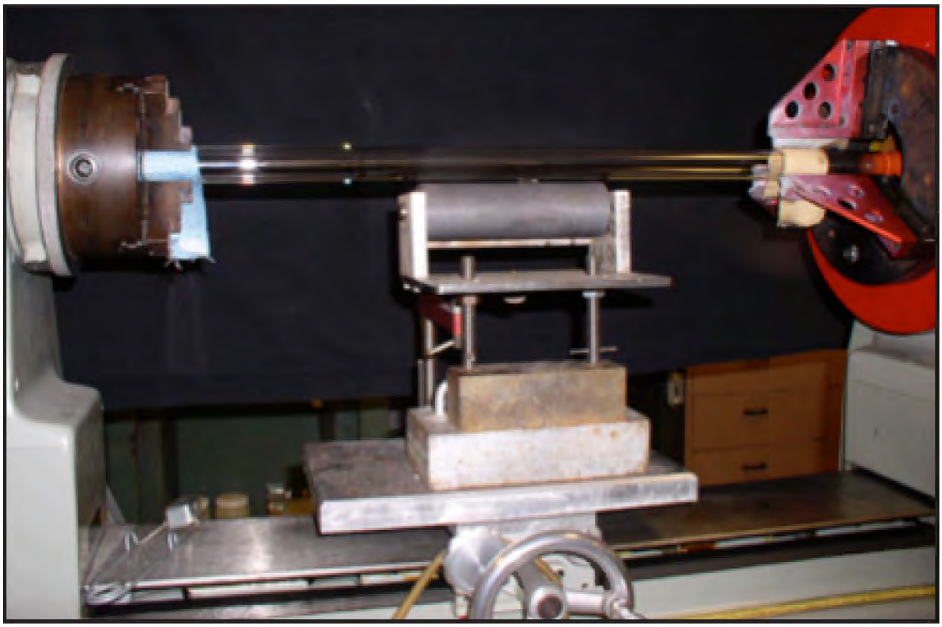

**Photo 33**

**Photo 34**

tube is turning. When you get the adjustment correct, the drill bit will slide out from under the glass tube (Photo 34).

Here are the drawings for the fixture that holds the graphite roller (Photos 35, 36 & 37).

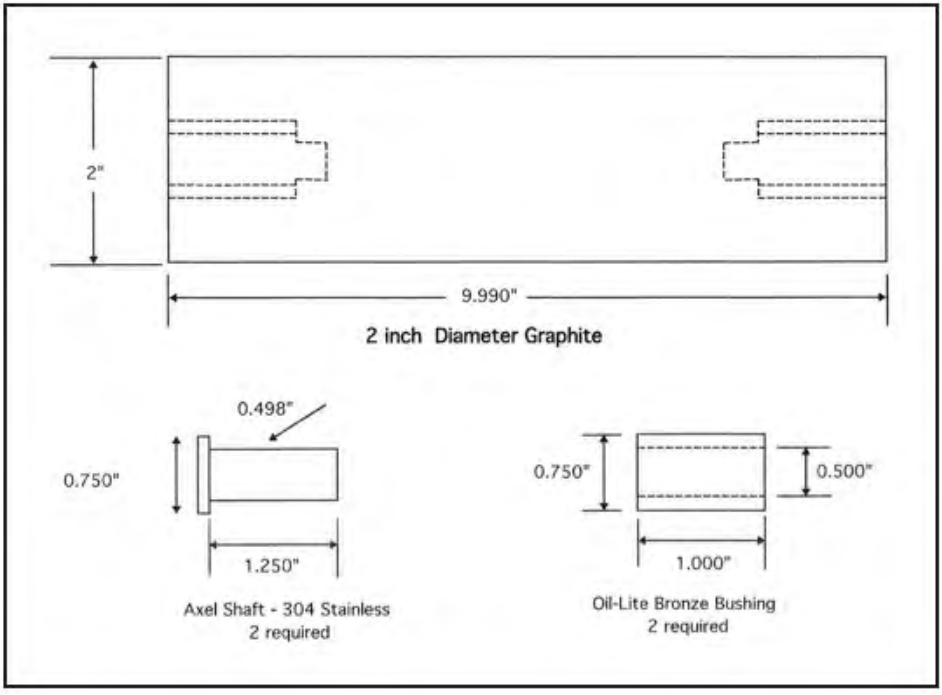


**Photo 35.** *Graphite tubing resizing roller assembly*

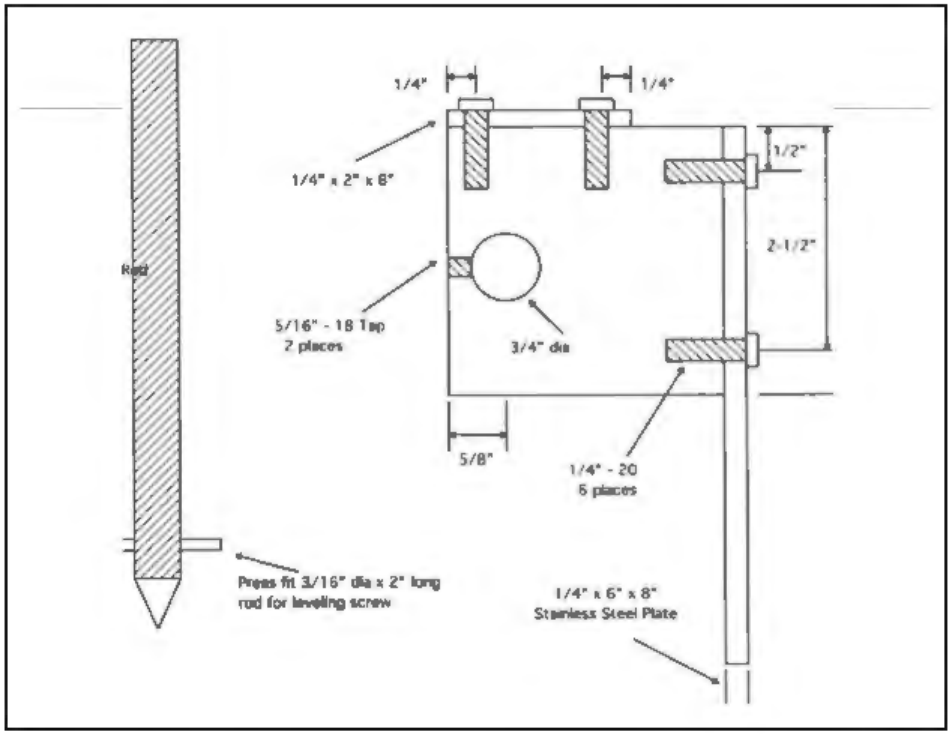


**Photo 36.** *Mounting plate assembly, side view*

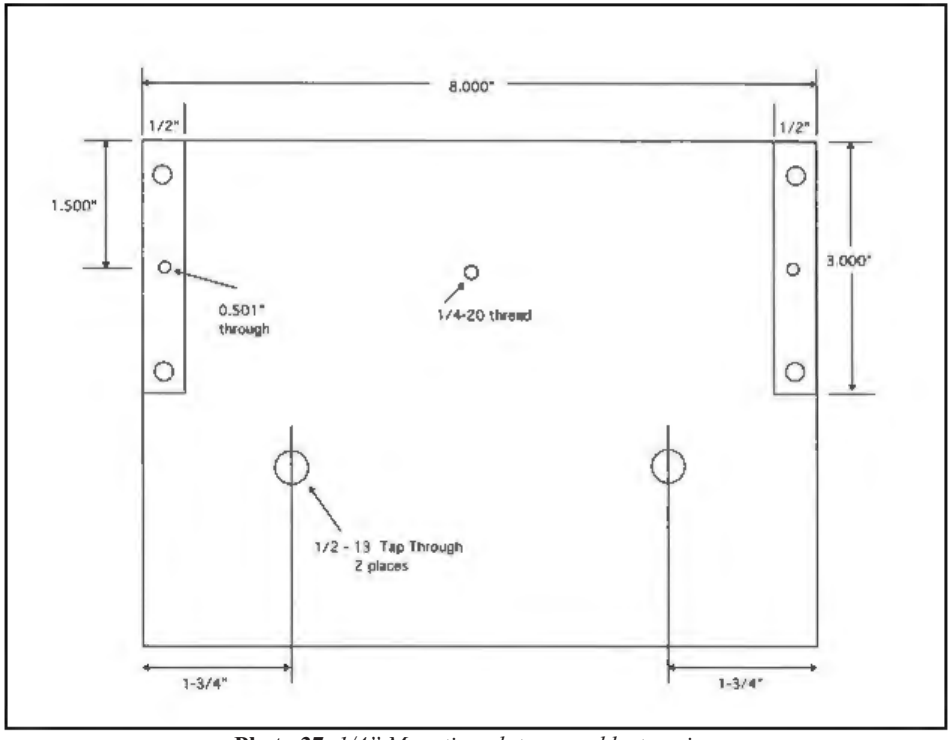


**Photo 37.** *1/4" Mounting plate assembly, top view*

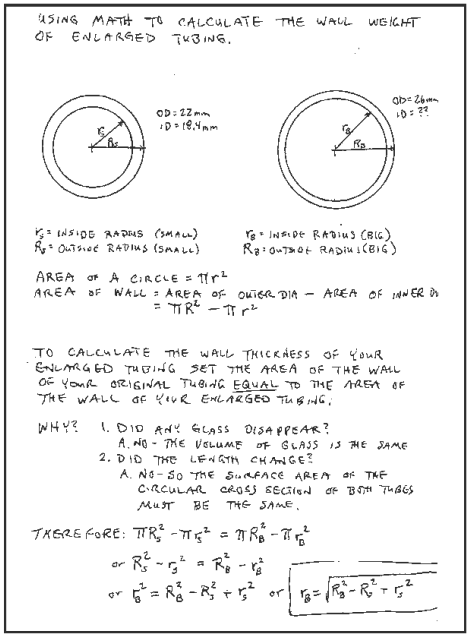


**Photo 38**

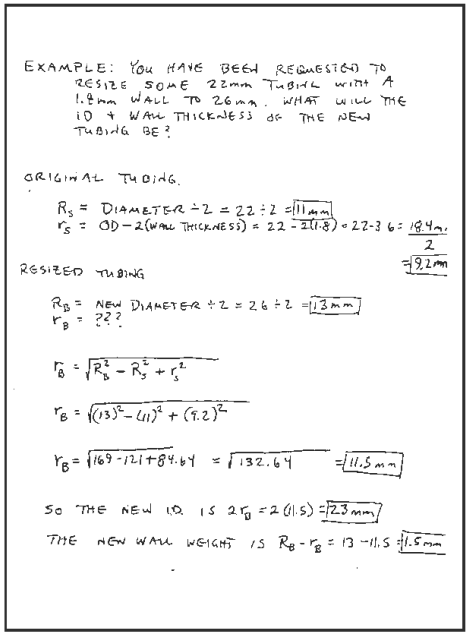


**Photo 39**

If you want to calculate how much space is needed to thin out the wall to a specific thickness, here are the notes to calculate this. I want to give credit for this tip to ASGS Past President, James Hodgson (Photos 38 & 39).

## ADJUSTABLE CUTTING FENCE FOR WET SAWS

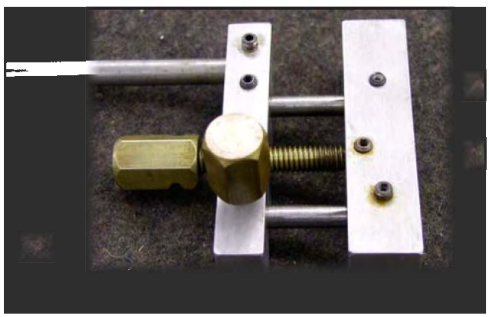

**Photo 40**

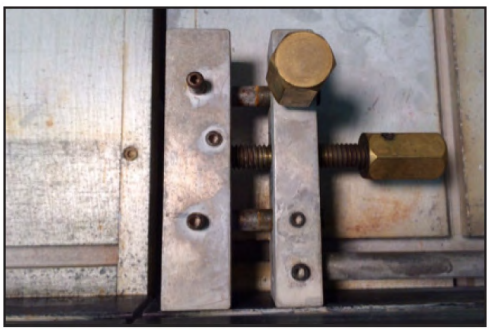

**Photo 41**

Many times I had to cut pieces of glass tubing to very exacting lengths and tolerances. With the standard cutting fence that typically comes with our wet saws, this can be a very tedious task. You set the fence, make a cut, measure the length and it is slightly too long. You loosen the fence, tap it with your knuckle, tighten it and make another cut. This time it is a couple of thousandths too short. I put an end to this misery by designing an adjustable vernier fence that will fit my wet saw (Photo 40).

You can then set the fence with a ruler or caliper and make a first cut. If it needs adjustment, simply loosen the locking bolt and turn the adjuster in or out to change the length.

To calibrate your adjustable cutting fence, put a mark on the top facet of your hex head to denote your starting point and cut

the end of a glass tube. Turn the adjuster thread until the hex head makes one full revolution. Measure your cut piece with a micrometer and divide by 6. This will give you the precise length that the cut changes with each facet the hex makes. This has not only helped me make more precision length cuts but also saved me a lot of time (Photo 41).

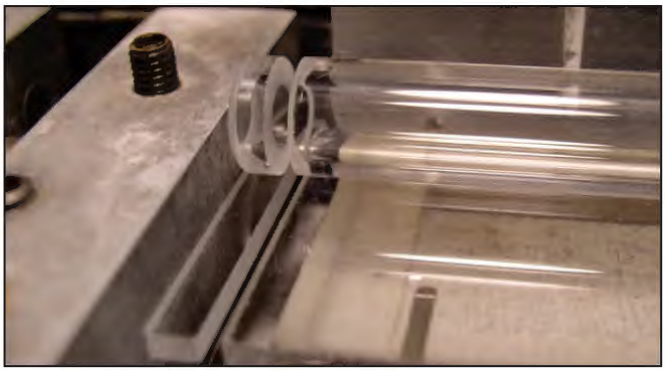

**Photo 42**

I like to use Lucite® blocks to rest my glass on for cutting. When cutting thin slices of glass, I lay a 1/8" thick plate of window glass between the two Lucite® blocks with the plate laying flat on the bottom block. I cut a slot at the desired length of the tube to be cut and then lay my glass tube on that glass plate. By doing this when you cut the narrow piece of glass, it will remain on the glass plate that is supporting it. Your cut piece will not slip and fall into the bottom of your saw (Photo 42).

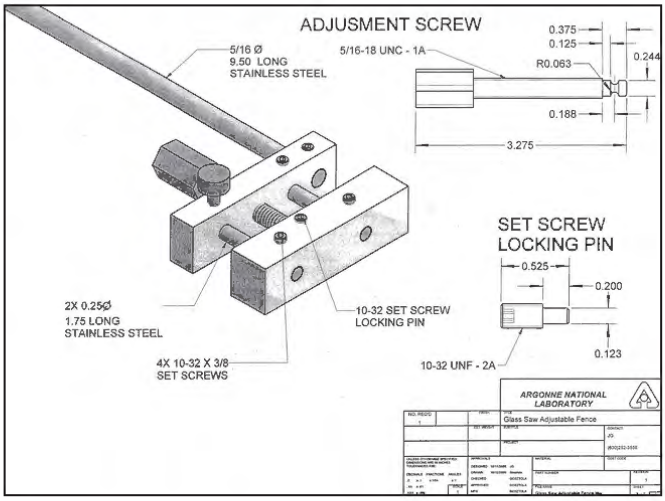


**Photo 43**

Here are the drawings for the adjustable wet saw fence (Photos 43 & 44).

Thank you for your interest in these tips and unique tools that I have shared with you. I would like to thank Ian Duncanson and James Hodgson for their contributions to this paper and my education.

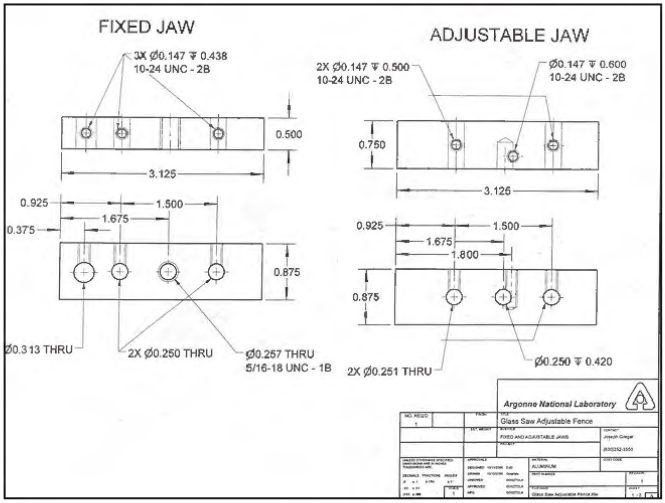


**Photo 44**

# Chemical Vapor Deposition Reactor for Diamond Deposition

by

**Kevin E. Bennet and Steven M. Anderson***

## ABSTRACT

*The production of diamond for creation of electrodes to measure electroactive compounds, specifically in the deep brain structures, has been recently solved by the design and fabrication of a low pressure chemical vapor deposition reactor. The measurement of chemical species present in living brain is valuable for developing an understanding of the operation of the normal brain and using that knowledge to restore normal function of the brain caused by trauma or other disease states. The design of the chemical vapor deposition (CVD) reactor was executed in borosilicate glass to provide the ability to quickly modify the reactor if required, allow visual inspection of the process and use emission spectra temperature measurement devices for control of the reaction system. We review the design and execution of the system, which has provided a production capability of these specialized electrodes for several years.*

## BACKGROUND

The use of diamond electrodes for electrochemical sensing in biological systems is a relatively recent occurrence, and was determined to be of importance due to the failure of other electrode systems. The value of the diamond electrode is excellent biocompatibility, high chemical/oxidation resistance, adsorption of neurochemicals of interest to the surface, physically hard, and experimentally having a long operational lifetime. By varying the feed gasses from the base feed of methane and hydrogen, dopants can be incorporated into the diamond crystal lattice.

Diamond production has been a major interest of many laboratories over the years with attempts to change or suppress the formation of graphitic carbon which forms hexagonal sheets to the tetrahedral crystal structure of diamond. It is commonly known that at very high pressures and temperatures, diamond can be formed. A metastable area in the carbon phase diagram (pressure/temperature stability graph) (Geophys Res. 85(B12) (1980) 6930) shows that metastable diamond can be formed at low temperatures, below approximately 1500 degrees C and at moderately low pressures (nominally 20 torr). This route to diamond was disclosed by W.G. Eversole in 1962; however the industrial use did not take off until the 1980s for the improvement of cutting tools.

Various laboratories were contacted concerning collaboration in the development of diamond electrodes; it was quickly determined, however, that the quality of material needed was not available. This started the internal development of the diamond reactor in the Division of Engineering of Mayo Clinic. A variety of substrates have been used within our experimental reactor including single crystal silicon and tungsten.

A horizontal reactor (Photo 1) was created in borosilicate, with cooling jacket, since the internal reaction temperature is substantially above the softening point of the glass. Water cooling is sufficient to keep the surface temperature low to reduce outgassing. The design incorporates glass KF flanges to enable electrical feedthroughs and the support of the substrates on which diamond is deposited.

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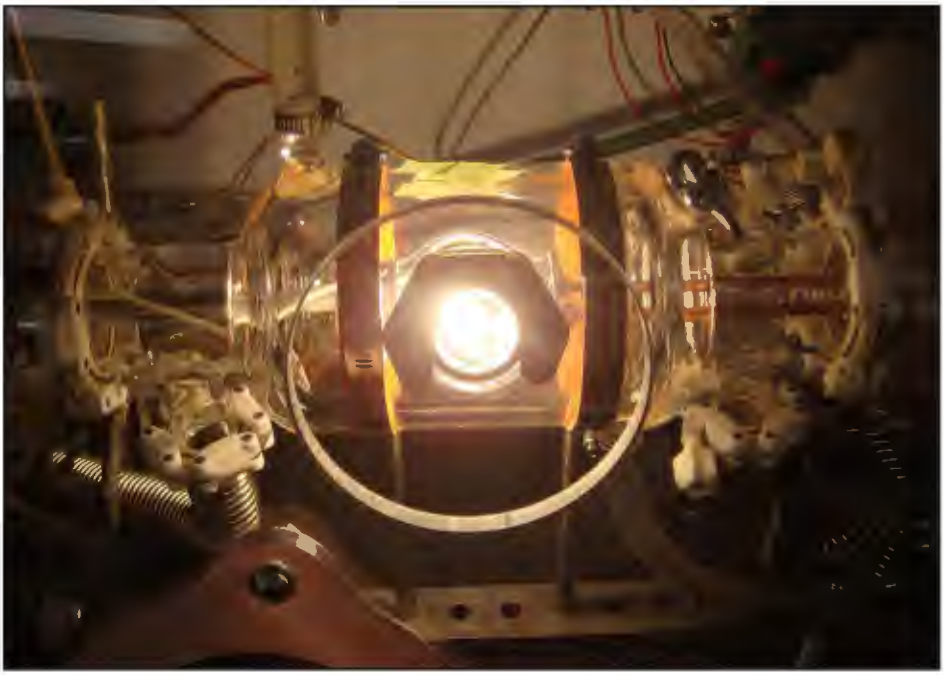

**Photo 1: The CVD diamond reactor showing water cooling jacket, mixed reactive gas introduction on the right, vacuum exhaust on the left. Right flange has the high current electrodes for powering the filament. Left flange has molybdenum post feedthrough allowing water cooling of system as well as rotation to provide for uniform coating of substrates.**

Photo 2 is a scanning electron micrograph of deposited diamond crystals showing the typical morphology of the crystals formed at high temperature and low pressure. The growth rate of the diamond crystals can reach 2 microns per hour in this reactor.

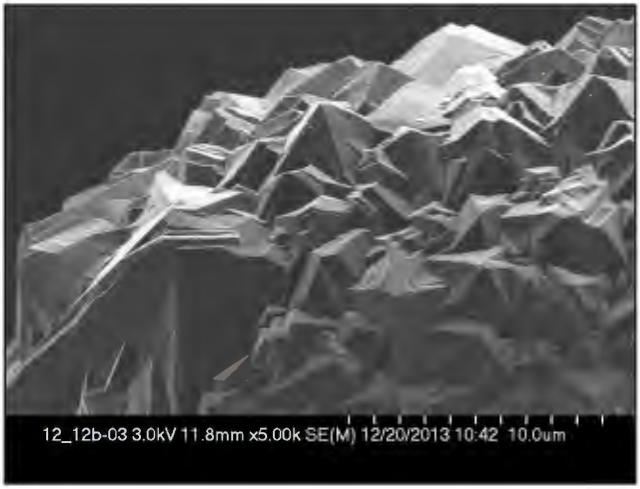


**Photo 2: Image of diamond crystals**

## METHODS

The jacketed reactor vessel is of conventional construction techniques for borosilicate laboratory devices. We chose a 100 mm o.d. tube for the inner chamber, and a 120 mm o.d. tube as the outer jacket. Our filament, substrate holders, gas inlet and exhaust ports are connected with KF series (KF-50 and KF-25) glass and stainless steel flanges. These were sealed with a combination of clamps, and Viton® O-rings were used to create a vacuum tight seal. However, the jacketed view port fabrication is unusual and deserves elaboration.

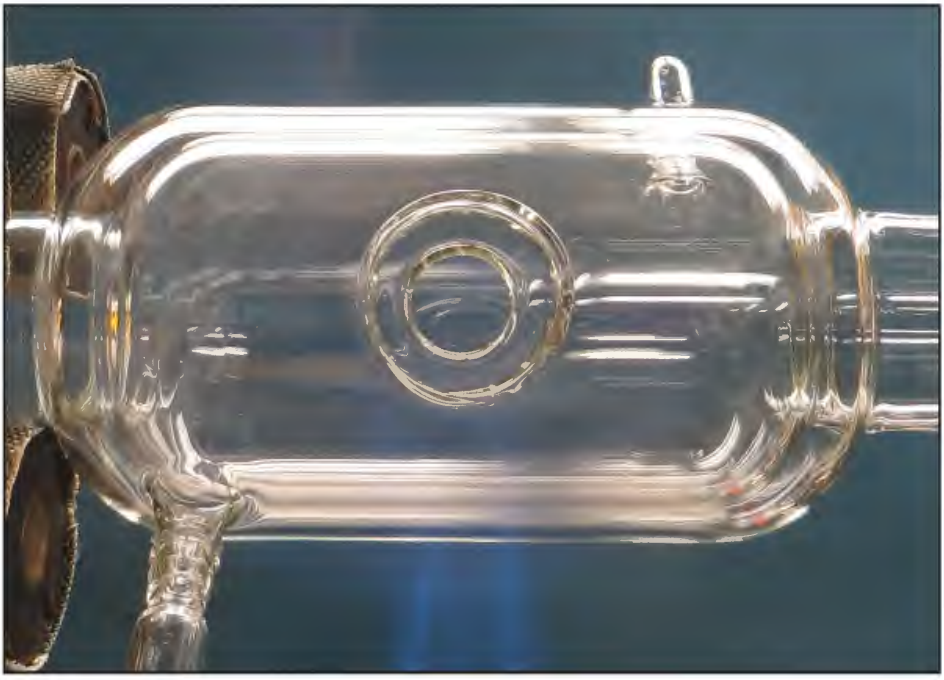

**Photo 3: A 45 mm opening has been prepared in the outer jacket and a 28 mm opening is ready on the inner chamber**

**Photo 4: The 40 mm outer jacket is held in place by a brace rod**

The water jacketed viewing port was made with a 25 mm o.d. tube jacketed by a 40 mm o.d. outer tube. The quartz window is mounted on a Viton® O-ring with a #25 O-ring joint. The window is held in place with a horseshoe clamp. As shown in Figure 3, after creating the reactor body with dual ring seals, a 45 mm opening has been prepared in the outer jacket and a 28 mm opening is produced in the inner chamber.

A 28 mm tube is sealed into the inner chamber of the appropriate length, and a 40 mm outer tube is prepared by pulling a point to serve as a handle and brace then sealed to a rod previously sealed to the hose barb. (Photo 4) A blow hose connection is made through the external chamber and internal chamber to allow working of the seal.

Photo 5 shows the sealing of the 40 mm outer jacket to the 28 mm internal tube while mounted in the lathe to allow positioning of the joint to create the ring seal. This positioning technique allowed for better access to the softened glass and resulted in a more uniform seal.

After flame cutting the excess 48 mm tube above the ring joint, an O-ring flange (joint) was attached and sealed in place. The O-ring flange allows the sealing of windows of various compositions to provide optical transparency to the frequencies of light of interest. (Photo 6)

**Photo 5: The 40 mm outer jacket is heated just above the 28 mm tube and, with a combination of sucking and blowing while rotating the lathe by hand, a ring seal is formed between the 40 mm and 28 mm tubes.**

**Photo 6: After removing the excess 48 mm tube, a 25 mm i.d. O-ring joint has been attached and sealed into place.**

## RESULTS

The exceptional collaboration between the glassblower, and engineering staff (chemical, mechanical, and electrical) as well as machinists and technologists, created a robust system, without the need for significant debugging or redesign. The combination of glass and metallic systems allows the continued expansion of capabilities and control systems to ensure optimal power input and gas composition at low pressure (20 torr total pressure). Diamond crystals of defined composition (specifically doping levels) are routinely grown at rates of up to 2 microns per hour.

## SUMMARY

The glass reactor system was designed and fabricated over a period of four weeks from the initiation of the project, and the system was on line producing acceptable diamond electrodes in an additional two weeks. The design has been effective and has been in production use since mid-year 2012.

# Design Mathematics for the Glass Shop
# Part 2
# The Oft-talked About, Much Feared Sequel

**by**
**Richard Ponton***

## ABSTRACT

*This is a follow-up to my 2012 paper. The volume and surface area formulas previously discussed will be reviewed. Then a discussion of ellipsoids and how to estimate values for them will expand on this material. Also covered will be how to precisely estimate the linear amount of glass needed to create a bead of a specific size, as well as the simple task of resizing tubing and the not so simple task of calculating the resulting wall thickness of the newly resized tubing.*

## INTRODUCTION

In 1983, while writing "A Brief History of Time," cosmologist Steven Hawking was warned by his editor that every mathematical equation he inserted in his book would cut sales in half. Hawking would go on to publish one of the most complex "armchair" books ever written, sell a "cagillion" copies, and manage to only have one equation: $e=mc^2$ in the entire text. I did not follow his editor's advice.

At the 2013 ASGS Symposium, I presented a paper covering some basic (and a few not so basic) geometry formulas and how they can be applied to the glass shop to help drive the design phase of a job. After seeing all of the glazed eyes when I was finished, a thought occurred to me: "these people want more!" What follows is a short recap of what was discussed previously, and I will then consider the one basic geometric shape useful to glassblowers that I did not cover in 2013. I had many, many requests for this information (well, one request). After that, I will venture out of the realm of basic geometric shapes and into some math formulas more directly pertinent to the glassblower in his or her shop.

As we begin to think about using math to find things like volume and surface area, it is important to keep in mind one very important thing: as glassblowers, we frequently have to deal with and bounce between fractional and metric dimensions. Often they appear on the same drawing. When calculating volumes or surface area, we must be cognizant of this fact. These formulas all work with either fractional or metric numbers, but of course, the math must be done exclusively in one or the other or else erroneous answers will follow. Before beginning all work, you must look at your drawing and convert your numbers to one unit or the other. I convert everything to metric. Conversion from fractional to millimeters is done with the following conversion formula:

| | |
|---|---|
| $v_e = \frac{v_a}{25.4}$ | • $V_e$= Value in Inches<br>• $V_a$= Value in Millimeters |

Remember: we must keep the units separate in order for the answer to equal.

In my previous paper, I covered the basic geometric shapes: cylinders, spheres, hemispheres, cones and cone frustums. Within those five shapes, the volume and surface area

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of both were discussed. For the benefit of anyone who slipped into a coma as a result of my last paper, following is the list of formulas I used in rapid fire succession:

| Shape | Volume | Surface Area (Lateral) |
|---|---|---|
| Cylinder | $v = \pi r^2 h$ | $a = 2\pi rh$ |
| Sphere | $v = \frac{4}{3}\pi r^3$ | $a = 4\pi r^2$ |
| Hemisphere | $v = \{\frac{4}{3}\pi r^3\}/2$ | $a = \frac{4\pi r^2}{2}$ |
| Cone | $v = \frac{\pi r^2 h}{3}$ | $a = \pi rs$ |
| Cone Frustrum | $v = \frac{\pi\left(R^2 + Rr + r^2\right)h}{3}$ | $a = \pi(r + R)s$ |
| | • r = radius (or small radius, where applicable)<br>• R = large radius (where applicable)<br>• v = volume<br>• h = height | • R = radius of large cylinder<br>• r = radius of small cylinder<br>• a = area<br>• h = height<br>• $a_e$ = area in inches square<br>• $a_o$ = area in millimeters square<br>To convert from $mm^2$ to $in^2$:<br>$a_e = a_o\,(0.00155)$ |

When trying to find volume or surface area of a coil, it can easily be achieved after you unwind the coil. Then it is just a real long tube. So get the coil into a warming fire. The trick is to soften it up just enough to bend it without the coil collapsing. Straighten out the coil, measure, and rewrap.

Or, you can use a modified version of the Pythagorean Theorem.

| | |
|---|---|
| $L = \sqrt{(\pi DN)^2 + (PN)^2}$ | • D = Outer diameter of coil<br>• N = Number of turns in coil<br>• P = Pitch of coil<br>• L = Length of straightened tube |

Now that that is all behind us, let us move on. While I covered many of the basic geometric shapes in 2013, there was one rather obscure shape I neglected to discuss. It is a shape used in one particular way in the glass shop, and it should be immediately familiar: the ellipsoid (Figure 1).

An ellipsoid is a multidimensional shape, rounded, but with multiple axes, think of an egg or a football. Where do we use these? It is the base shape for an Allihn condenser bulb. There are a lot of different types of ellipsoids: that is, fancy names for ellipsoids with three different axes, ones with two similar axes, one with a longer axis, one with

two same axes, one with a shorter axis. If you ever want to sound smart in front of your customers, just remember: the individual bulbs in an Allihn condenser are known as prolate spheroids.

To solve the volume of an ellipsoid, you use a pretty simple, and if you are a little mathematically inclined, familiar formula:

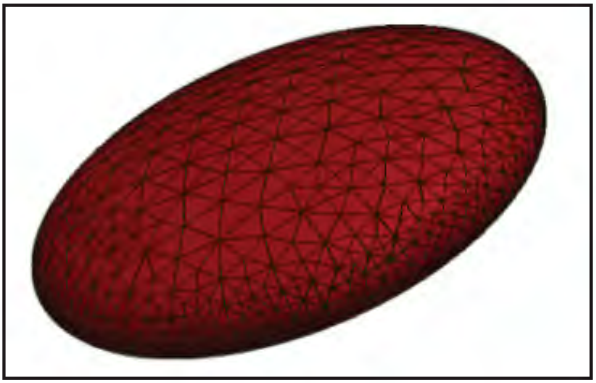


**Figure 1**

| | |
|---|---|
| $v = \frac{4}{3}\pi abc$ | • v = volume of ellipsoid<br>• a = radii 1<br>• b = radii 2<br>• c = radii 3 |

Why is this familiar? Well, when we were discussing the volume of a sphere, we used the formula: $v = {}^{4}/_{3}\,\pi r^3$ which could be written $v = {}^{4}/_{3}\,\pi rrr$ since a sphere has a radius that is the same in all directions. In fact, a sphere is a type of ellipsoid known technically as a degenerate ellipsoid.

An example of this: say we have a customer who consistently plugs up his Soxhlet extractor. He wants a condenser on said Soxhlet. The condenser will have five bulbs, be 30 mm in diameter and each bulb will be 50 mm long. Since he floods the condenser all the time, he wants to know the capacity of the condenser before distillate comes out the top. You set to work:

| | |
|---|---|
| $v = \frac{4}{3}\pi abc$<br>$= v = \frac{4}{3}\pi 15 * 25 * 15$<br>$= v = \frac{4}{3}\pi 5625$<br>$= v = 23561.9\,mm^2$<br><br>23561.9 $mm^3$=23.5 $cm^3$= 23.5 ml | • v = volume of ellipsoid<br>• a = radii 1<br>• b = radii 2<br>• c = radii 3 |
| $23.5 * 5 = 117.5$ | Total volume of bulbs is 117.5 ml |

Looking at ellipsoids, the next question becomes "how do we calculate the surface area"? Simply put, there is no simple, algebraic way to calculate that. To get an exact answer requires a royally awful calculus derivation. Although my recommendation is to not do it, presented below is the derivation used to find the surface area of an ellipsoid:[1]

[1] Stuart R. Keller, "Mathematics of Computation," *The Journal of the American Mathematics Society* 33:145 (January 1979).

The equation of an elliptical surface having semi axis lengths of a, b, and c may be written as

$$z = f(x,y) = \pm c(1 - \frac{x^2}{a^2} - \frac{y^2}{b^2})^{\frac{1}{2}} \text{ for } x^2/a^2 + y^2/b^2 \leq 1$$

The element of the surface area is given by

$$dS = \left[1 + f_x^2 + f_y^2\right]^{\frac{1}{2}} dxdy$$

The surface area may be written as

$$S = 4\int_0^a G9x)dx$$

Where

$$G(x) = \int_{-b(1-\frac{x^2}{a^2})^{1/2}}^{b(1-\frac{x^2}{a^2})^{1/2}} \frac{\left[1 - \frac{\left(1-\frac{c^2}{a^2}\right)x^2}{a^2} - \frac{\left(1-\frac{c^2}{b^2}\right)y^2}{b^2}\right]^{1/2}}{\left[1 - \frac{x^2}{a^2} - \frac{y^2}{b^2}\right]^{1/2}} dy$$

In order that the inner integral may be evaluated effectively, it is desirable that it be written in such a manner that a numerical integration rule of Gauss type be employed. Therefore, a change of variable integration is made via

$$t = \frac{y}{b\left(1 - \frac{x^2}{a^2}\right)^{1/2}}$$

Then G(x) may be written as

$$G(x) = \int_{-1}^{1} \frac{g(f,t)}{\sqrt{1-t^2}} dt$$

Where

$$g(x,t) = b\left\{\left[1 - \left(1 - \frac{c^2}{b^2}\right)t^2\right] - \left[\left(1 - \frac{c^2}{a^2}\right) - \left(1 - \frac{c^2}{b^2}\right)t^2\right]\frac{x^2}{a^2}\right\}^{\frac{1}{2}}$$

The formulation of G(x)

$$G(x) \approx \frac{\pi}{n}\sum_{j=1}^{n} g(x,t_j)$$

Therefore approximation by

$$S \approx 4\int_0^a \left\{\frac{\pi}{n}\sum_{j=1}^{n} g(x,t_j)\right\} dx$$

Since integration and summation may be interchanged:

$$S \approx \frac{\pi}{n}\sum_{j=1}^{n}\int_0^a g(x,t_1)dx$$

The integral thus can be written by

$$I = \int_0^a g(x,t_j)dx = b\int_0^a (\alpha + \beta x^2)^{\frac{1}{2}} dx$$

| | |
|---|---|
| Where | $$\alpha = 1 - \left(1 - \frac{c^2}{b^2}\right) t_j^2$$ |
| And | $$\beta = -\frac{\left[\left(1 - \frac{c^2}{a^2}\right) - \left(1 - \frac{c^2}{b^2}\right) t_j^2\right]}{a^2}$$ |
| If a≥b<c | $$\alpha > 1$$ |
| | $$\beta < 0$$ |
| And | $$I = \left(\frac{b}{2}\right)\left\{a(\alpha + \beta a^2)^{\frac{1}{2}} + \left[\frac{\alpha}{-\beta^{1/2}}\right] \sin^{-1}\left[a\left(\frac{-\beta}{\alpha}\right)^{1/2}\right]\right\}$$ |
| Therefore | $$S \approx \frac{2\pi ab}{n} \sum_{j=1}^{n} \left\{ \frac{c}{a} + \frac{1 - \left(1 - {}^{c^2}/_{b^2}\right) t_j^2}{\left[\left(1 - {}^{c^2}/_{a^2}\right) - \left(1 - {}^{c^2}/_{b^2}\right) t_j^2\right]^{\frac{1}{2}}} * \sin^{-1} \frac{\left[\left(1 - \frac{c^2}{a^2}\right) - \left(1 - \frac{c^2}{b^2}\right) t_j^2\right]^{\frac{1}{2}}}{\left[\frac{\left[\left(1 - \frac{c^2}{a^2}\right) - \left(1 - \frac{c^2}{a^2}\right) t_j^{2\frac{1}{2}}\right]}{\left[1 - \left(1 - \frac{c^2}{b^2}\right) t_j^2\right]^{\frac{1}{2}}}\right]} \right\}$$ |
| Since Gaussian rules dictate that prolate spheroids reduce as n→∞ it then reduces to | $$S = 2\pi b^2 + \frac{2\pi ab}{\left(1 - \frac{b^2}{a^2}\right)^{\frac{1}{2}} \sin^{-1}\left(1 - \frac{b^2}{a^2}\right)^{\frac{1}{2}}}$$ |

If you do not want to do that page and a half of mathematical calculations (and I stress, you do **not** want to do that) you can use a formula that, while not exactly accurate, forms a pretty close approximation:

| | |
|---|---|
| $s \approx 4\pi \left( \frac{(ab)^{1.6} + (ac)^{1.6} + (bc)^{1.6}}{3} \right)^{1.6}$ | • s = Surface area<br>• a = Axis 1<br>• b = Axis 2<br>• c = Axis 3 |

Is this only an approximate answer? Yes it is, but realistically, it is accurate to within 1.2%, which, given the changes in wall thickness, the tubing stubs between the bulbs, and the general inaccuracy of our work, is well within our margin of error.

Let us return to our example from above. We made the condenser, and then later, another student asks the important question: What is the surface area of the condenser that was made? We set to work:

| | |
|---|---|
| $s \approx 4\pi \frac{(ab)^{1.6} + (ac)^{1.6} + (bc)^{1.6}}{3}^{\frac{1}{1.6}}$<br>$s \approx 4\pi \frac{(15*15)^{1.6} + (15*25)^{1.6} + (15*15)^{1.6}}{3}$<br>$s \approx 3522.53$ | • s = Surface area<br>• a = Axis 1<br>• b = Axis 2<br>• c = Axis 3<br>Per Bulb |
| $3522.53 * 5 = 17612$ | 17612.6mm² |
| 17612.6*0.00155=27.3 | 27.3in² |

Remember earlier in the paper when I said that I converted everything into metric units all of the time? Since we use in² instead of mm² when talking about surface area, this is the one instance in our work where I convert my metric numbers to fractional numbers. With the multiplier of 0.00155, we can convert mm² into in² with the following formula:

| | |
|---|---|
| $a_e = a_o(0.00155)$ | • $a_e$= area in inches square<br>• $a_o$= area in millimeters square |

I would like to now turn away from basic volumes and surface area calculations. Let us see how to work math into our basic manufacturing processes. A note however: as much as I use math in my work and as much as I would like to delude myself about my mathematical acumen, everything from here on out is not my own work. Up until now, we have been looking at basic geometry. When we talk about basic math like a = $\pi r^2$, we are using what in math is called a calculus proof. That formula is the answer to the calculus problem.

So that means that, theoretically, I could simply look at any question I have in the glass shop, plot the glass on a Cartesian graph, write an integral, integrate, and generate a formula for you all to use. Theoretically, I am also capable of writing Emmersonian type poetry; after all, I know words. But I cannot. I am a master at co-opting someone else's work however. The good thing for all of us is that we have a Society like this one,

a Society that is full of people far smarter than we are. Some of those smart people even marry smarter people, and we get to use their genius as well. Such will be the case with everything I talk about from here on out. When I cannot figure out any math type stuff, I send an email to Georges Kopp. When (occasionally) he is equally stymied, he turns to his wife Dr. Julan Zhao who digs us out of holes we cannot and the ASGS benefits.

Sometimes in the course of our work, we find the need to create our own beaded or square flange on a piece of tubing. If it has to be a specific size, this can take a lot of time in trial and error attempts. Can we calculate the amount of glass we need to melt before we start? Of course we can.

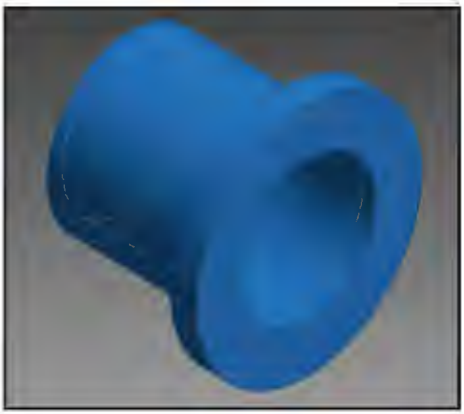


**Figure 2**

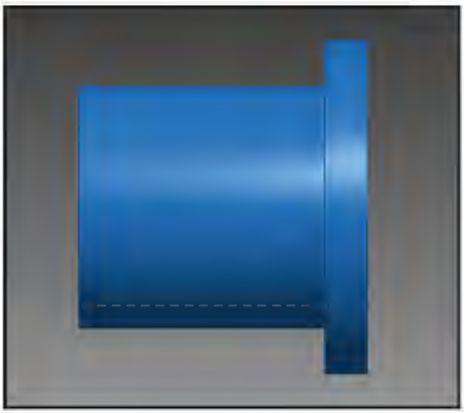


**Figure 3**

When looking at a square bead on a tube (see Figures 2 and 3), what we are trying to figure out is: first, what is the volume of glass in the final flange, second, what length of tubing will be needed to fill that volume. This can be determined in a single step if we use the following formula:

| | |
|---|---|
| $$x = t\frac{\left(\frac{f}{2}\right)^2 - \left(\frac{d}{2}\right)^2}{\left(\frac{D}{2}\right)^2 - \left(\frac{d}{2}\right)^2}$$ | • x = length of glass needed<br>• f = flange diameter<br>• t = flange thickness<br>• D = tubing outer diameter<br>• d = tubing inner diameter |

So, as an example, if we needed a 30 mm flat flange, 5 mm thick, made on 1”MW tubing (2.4 mm wall), how much glass must be gathered to make the flange right the first time?

| | |
|---|---|
| $$x = 5\frac{\left(\frac{30}{2}\right)^2 - \left(\frac{20.2}{2}\right)^2}{\left(\frac{25.4}{2}\right)^2 - \left(\frac{20.2}{2}\right)^2}$$<br>$$x = 5\frac{225 - 102.01}{161.29 - 102.01}$$<br>$$x = 5 * 2.07$$ | • x = length of glass needed<br>• f = flange diameter<br>• t = flange thickness<br>• D = tubing outer diameter<br>• d = tubing inner diameter |
| $$x = 10.37$$ | • Tubing softened should be 10.37 mm long |

For a beaded flange, it again is simply finding the volume of the bead, then finding the corresponding volume of tubing. Putting this in a single formula proved very challenging and thankfully Dr. Zhao could do so where neither I nor Georges could.

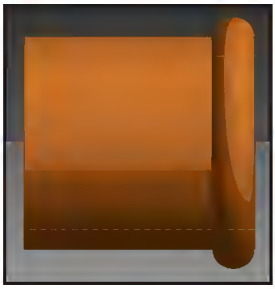


**Figure 4**

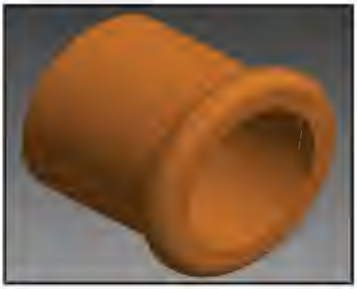


**Figure 5**

| | |
|---|---|
| $x = 4\pi b^2 \frac{\frac{d}{2} + 4\frac{\frac{b}{3}}{\pi}}{d^2 - (d - 2t)^2}$ | • x = length of glass needed<br>• b = bead radius<br>• d = tubing diameter<br>• t = tubing wall thickness |

The only weird number here is the bead radius: since this is not the bead diameter, we need to calculate the radius of the bead. Looking at the bead sideways (Figure 4), we see that the bead is a semicircle on top of the tubing. The bead radius is the radius of the circle of which the bead is a part, ignoring the tubing. It is found by the following:

| | |
|---|---|
| $b = \frac{B - d}{2}$ | • b = Bead radius<br>• B = total bead diameter<br>• d = Tubing diameter |

Quickly looking at an example of this, let us examine again a piece of 1" MW tubing. This time, let us put a bead with an overall diameter of 30 mm. How much tubing will we need? First, we need to determine the bead radius:

| | |
|---|---|
| $b = \frac{30 - 25.4}{2}$ | b = 2.3 |

Now, we simply plug in the numbers to find our answer:

| | |
|---|---|
| $x = 4\pi b^2 \frac{\frac{d}{2} + 4\frac{\frac{b}{3}}{\pi}}{d^2 - (d - 2t)^2}$<br>$x = 4\pi 2.3^2 \frac{\frac{25.4}{2} + 4\frac{\frac{2.3}{3}}{\pi}}{25.4^2 - (25.4 - 2 * 2.4)^2}$<br>$x = 66.48 \frac{13.677}{220.64}$<br>$x = 66.48 * 0.062$ | |
| $x = 4.12$ | Tubing required for bead is 4.12 mm length |

And now, I would like to show one last formula. This is the problem I was trying to solve back in 2012. I worked with Georges to try and find a solution, and after he (with his wife's help once again) sent me this information, I decided that I should share it with you at a symposium.

We all know how to resize tubing whether we need a small length of tubing we do not have or we need some oddly specific piece of glass that is not generally available. There have been many papers, posters, and workshop demonstrations in the past that have shown how to do this; however, the following question remains: we now have a length of tubing with a specific outer diameter, but what is the new inner diameter? As we stretch the tubing out, the new diameter comes out of the wall thereby making the wall thickness thinner.

How is this important to us? It can be vital. A change in wall thickness alters the inner dimension which will impact the tube's volume, surface area and pressure or, if it is too thin, vacuum abilities. Knowing the new tube's i.d. can also simplify your decision as to which tubing to start with. Do you start off with a piece of standard wall that is really close to your desired finish diameter or a medium wall tube that is a little smaller? Your answer will depend on what your finished product will need to be. Finding the finished tubing's wall thickness is found using the following formula:

| | |
|---|---|
| $$T = \frac{D - \sqrt{D^2 - d^2 + (d - 2t)^2}}{2}$$ | • D = Resized tubing diameter<br>• d = Original tubing diameter<br>• t = Original tubing thickness<br>• T = Resized tubing thickness |

I am going to give two examples at the same time, side by side, as if I were trying to decide between one starting tube or another. I need a piece of tubing with an outer diameter of 32.25 mm. Looking at my tubing in stock, I find I have 30 mm x 1.4 mm wall and 28 mm X 4 mm wall. Which shall I use?

| Using 30 mm tubing | Using 28 mm tubing |
|---|---|
| $$T = \frac{32.25 - \sqrt{32.25^2 - 30^2 + (30 - 2*1.4)^2}}{2}$$<br>$$T = \frac{32.25 - \sqrt{1040.0625 - 900 + 739.84}}{2}$$<br>$$T = \frac{32.25 - 29.663}{2}$$<br>$$T = 1.29\ mm$$ | $$T = \frac{32.25 - \sqrt{32.25^2 - 28^2 + (28 - 2*4)^2}}{2}$$<br>$$T = \frac{32.25 - \sqrt{1040.0625 - 784 + 400}}{2}$$<br>$$T = \frac{32.25 - 25.61}{2}$$<br>$$T = 3.32\ mm$$ |

So I can have a final inner dimension of either 1.29 mm or 3.32 mm. I can then look at the design of the piece made and determine which tubing thickness fits my needs better.

# Making a Cube Trap

**by**
**Tsuyoshi Nakamura***

## ABSTRACT

*How to make a complex, small cube trap including techniques of how to cut the glass, drill holes in borosilicate glass, fusion of glass plates and assembling of all parts.*

**Photo 1. Glass cell, which is mostly done by using pieces of flat borosilicate glass**

## SUPPLIES

3 mm borosilicate plate glass

Generic glass roller cutter

Water

Drill Press

Core Drill

Hand torch

Ribbon torch

Annealing oven

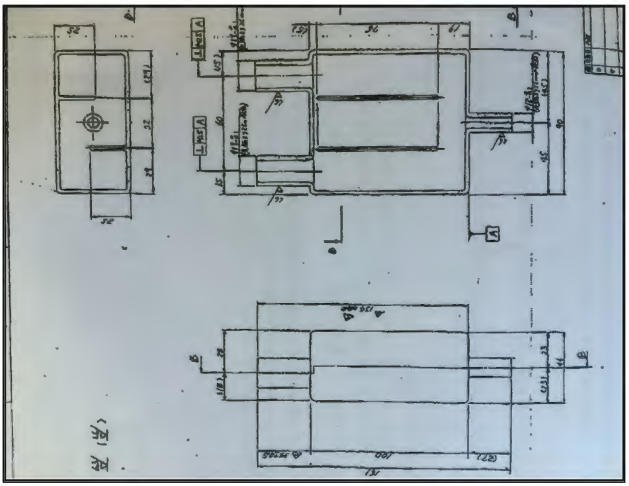


**Photo 2. Blueprint of glass cell**

* Nakamura Rika Inc., Tokyo, Japan. Email: tsun@t3.rim.or.jp.

## INTRODUCTION

There are various approaches for making any scientific glass apparatus. Usually the process for this cell is done using glass tubing. I have a different and simple approach to making a glass cell which is mostly done by using pieces of flat borosilicate glass (Photos 1 and 2). I am happy to share this with you. This is the simplified explanation: I start by cutting the flat plate; next, the flat plate is connected to the tube. The other side of the flat plate is connected to other flat plates. The box is now assembled. These steps will be explained in more detail throughout this paper.

## CUTTING THE GLASS PLATE

For this cell I am using a 3 mm borosilicate plate. First, you will cut the plate to the required size (*customer's request*, Photo 2). To cut the glass, you can use the generic roller cutter because this flat plate glass is thinner and can easily be cut, but care must be taken to avoid damaging the plate. The plates are placed on a flat table or cutting table: slide the glass cutter to make a scratch mark along the first side. In the scratch mark, add water (to weaken the glass) and bend the glass by force on the opposite side of the scratch mark; repeat for all sides. You can use this technique to cut thin glass tubing as was demonstrated in the 2012 ASGS Symposium in Corning, NY.

## CONNECTING THE FLAT PLATE TO GLASS TUBING

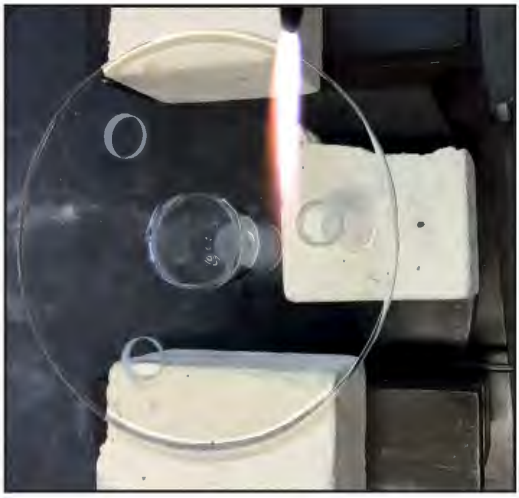
In the flat glass, drill a hole, using a diamond core drill in the drill press (Photo 3) of the same inside diameter as the connection glass tubing.

Place the glass tubing on top of the hole of the flat glass to make sure that it fits (Photo 4).


**Photo 3. Hole drilled using a diamond core drill in the drill press**

**Photo 4. Glass tubing on top of the hole of the flat glass**

**Photo 5. Pre-warming the glass plates**



**Photos 6 & 7 (above and below). This technique can be used to put joints on a large flask cover**

Separate and place them in the annealing oven at a temperature of approximately 585ºC for 15 minutes to warm them (Photo 5).

Put the glass tube back into the flat plate; start slowly heating (with your torch) the area where the hole and the tubing are in contact. Seal both sides; when both sides are sealed and there is no distortion, put the piece back into the oven. Repeat the same steps for all connections and holes.

Per example, this technique can be used to put joints on a large flask cover.

The same steps are followed (Photos 6 & 7).

You can also do T-Seals on a tube (Photo 8).

## CONNECTING PLATE TO PLATE

The technique explained is a great help in making this cell.

To connect a plate on to another plate, you must first make a support. I made a simple support using two graphite blocks, a brick and a graphite brick (Photo 9).

**Photo 8. T-seals on tubing can be made using this technique**

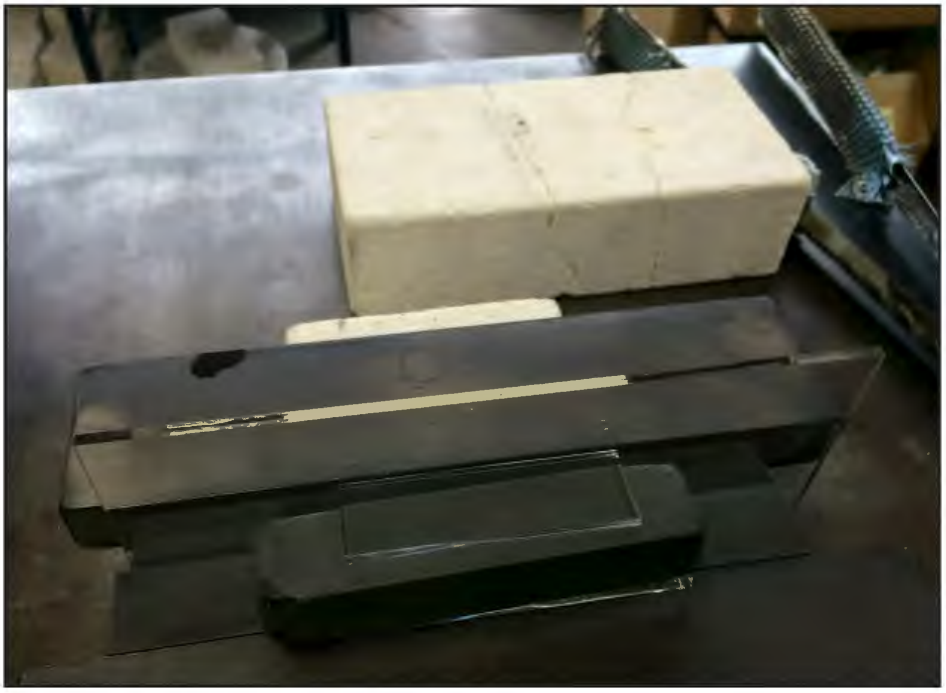


**Photo 9. Made a simple support using two graphite blocks, a brick and graphite brick**

**Photo 10. Glass plates kept warm on the graphite support**

Warm the plates in the oven and warm the support using your torch.

Take the warm plates out of the oven, place them on the graphite support (Photo 10). Tack the corners then seal the entire side (Photo 11). This needs to be done quickly to avoid cracking.

Continuously heat the support, flipping the plates as needed to seal the other side (Photos 11 & 12). The support helps to keep the sides and the bottom flat.

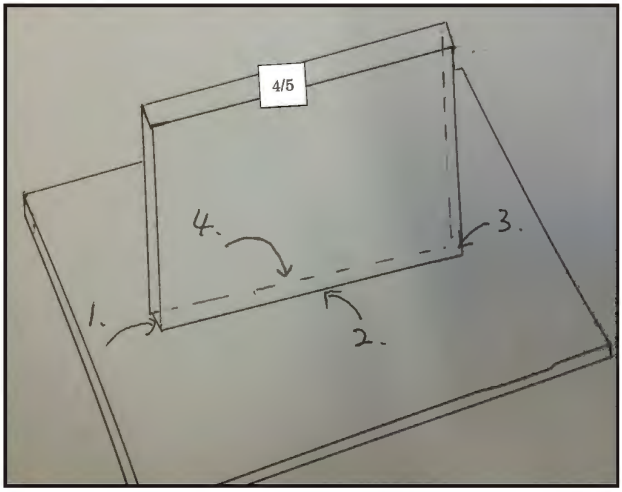



**Photo 11. Order of the tacking and sides to be sealed**

Put this back in the oven to anneal at approximately 585ºC.

This technique can also be used to put a baffle plate onto tubing (Photo 13).

**Photo 12. Corners are tacked then seal the entire side**

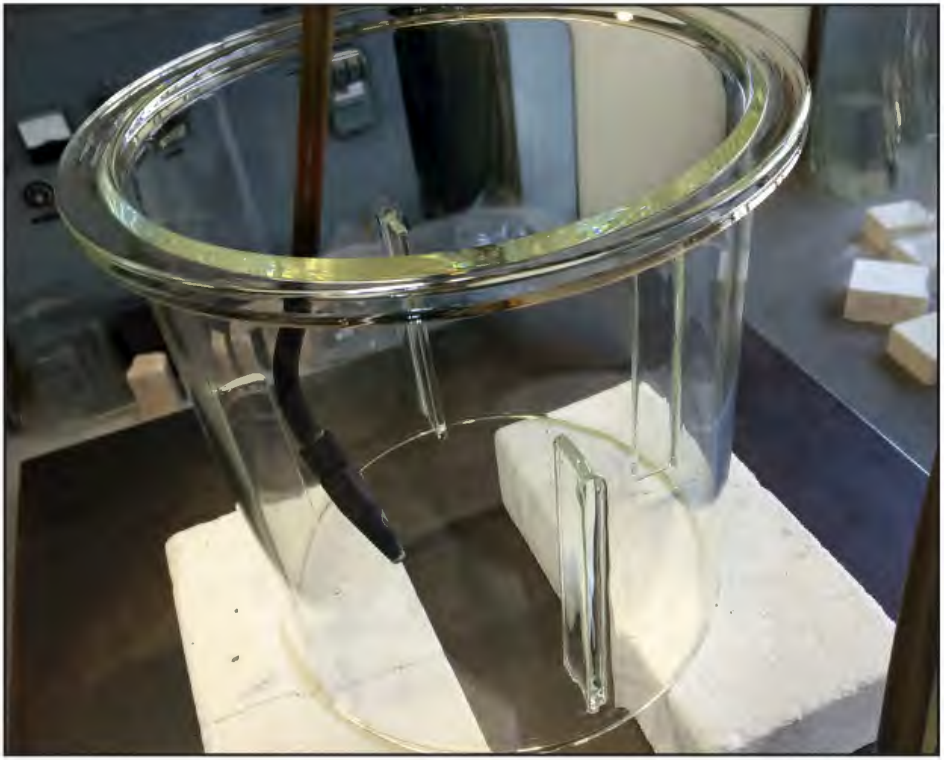


**Photo 13. This technique can also be used to put a baffle plate onto tubing**

## ASSEMBLY OF THE BOX

Gather all of the parts that were prepared until now. Modify your support as needed *(Photo 14)*. Make sure the parts are all warmed and the support is warmed. Overlap the ends and the edges of the plates to be assembled. You can use your ribbon burner to make clean seals *(Photo 15)*.

**Photo 14. Modify your support as needed**

**Photo 15. You can use your ribbon burner to make clean seals**

You can anneal each section in the oven between sides. If you are accustomed to this technique, you can use it to connect a round plate to a large diameter tube *(Photo 13)*. In the case of large diameter tubing, it is simple to attach a bottom plate.

## SUMMARY

I introduced a variety of flat glass techniques: cutting, connecting tubing, connecting plate, the assembly of the box. This has introduced you to another way of assembling flat plate glass to tubing or to other flat plates. A process that is thought to be difficult can be much easier with the techniques I have shared in this paper. Hopefully I have changed your point of view and given you more ideas.

# Glassware for Isotope Analysis
# Processing Samples for Mass Spectrometry

by
**Brian Markowicz***

## ABSTRACT

*The purpose of this paper is to explore types of glassware that I have been asked to manufacture and/or maintain for the purposes of preparing samples for isotopic analysis. This includes traditional vacuum lines used for the loading of samples and standards for combustion, as well as vacuum lines for the cleaning, separation, measurement and collection of sample for use in isotope mass spectrometry. I will also cover a lesser known sample preparatory line that is used to convert carbon dioxide into graphite powder that is needed for carbon dating by accelerator mass spectrometry.*

## INTRODUCTION

### Isotopes – What they can tell us

Each element has a set number of protons, this is known as the atomic number. This is what determines an element's place on the Periodic Table. However, the number of neutrons in an element can vary, and these versions of the same element are known as isotopes. These isotopes have a different mass number due to the additional neutrons, and radioisotopes occur because too many neutrons exist in the nucleus to maintain stability. These decay into stable isotopes in a specific and constant time frame known as a half-life.

**Photo 1.** *This is the stable isotope prep line used to load samples, separate $CO_2$ or deuterium with cold traps, measure, split gas and transfer into sample bottles. There are two lines on each side and four in total.*

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By looking at the ratio or abundance of isotopes, we are able to gather a wealth of information about a sample. It is possible to determine the age of a substance, the purity of a sample and the rough geological origin; oftentimes the diet of an animal is able to be determined through these methods.

## BACKGROUND

Oftentimes in analytical chemistry and especially in carbon dating, the chemist is forced to perform an analysis on a sample that is small and sometimes irreplaceable. The vacuum systems described in this paper have the advantage of being able to gather the maximum amount of information from the smallest sample in a safe and redundant way.

Isotope analysis is in high demand for authenticity testing of foods, flavors and beverages. Because petroleum products are older than 50,000 years, they are completely devoid of C14. The sample can be compared against a standard on an accelerator mass spectrometer that will reveal whether the product is all natural or has been adulterated with petroleum products.

**Photo 2a.** *This is the graphite C14 prep line. Once the $CO_2$ is split into separate bottles on the stable isotope line, one bottle is brought here for graphitization. The $CO_2$ is measured again and then the proper amount of hydrogen is introduced in the presence of iron catalyst, desiccant and heat. The reaction happens in ampoules in the bottom of the picture attached to the ultra-torr fittings. These ampoules are inserted into a tube furnace.*

**Photo 2b.** *A close-up of the ampoules containing 10 mg of iron filings. This is where the graphite for C14 analysis will form when hydrogen and $CO_2$ are added in presence of 600 degrees Celsius heat. Each "T" has a pressure transducer to monitor the reaction, as well as an ampoule of desiccant to capture water. They are equally spaced to fit into a tube furnace.*

## LOADING SAMPLES

The stable isotope line serves to load samples for combustion. This is done by dipping a capillary tube in the sample. This capillary is then loaded into a 6 mm ampoule which is

**Photo 3.** *A sample is mixed with cupric oxide. It is placed under vacuum in liquid nitrogen to prevent evaporation while sealing with a hand torch.*

**Photo 4a.** *This is the ampoule cracker that we use to open combustion samples. It is a 28/15 ball joint with a 3/8" tube that fits into a Cajon ultra-torr. This makes it easily replaceable.*

also loaded with cupric oxide. This ampoule is then evacuated of air while sitting in a dewar of liquid nitrogen. (Photo 3) The purpose of the liquid nitrogen is to keep volatile substances from boiling off under vacuum.

## SEALING SAMPLES

Once the sample is loaded with cupric oxide, placed under a vacuum and frozen (Photo 4a), it is sealed off with a National hand torch (Photo 4b). This is done twice to provide an A and a B sample to determine precision. These samples are then numbered and placed in a rack (Photo 4c) to be combusted in the kiln overnight. The samples are combusted at 575° C (Photos 5a & 5b).

## ISOLATING $CO_2$

The combusted ampoule is cracked open by scoring and placing into it a 28/15 ball and socket joint. The next step in the process is to separate the $CO_2$ from nitrogen and water; this is accomplished by using dual cold traps, one with dry ice and propanol, and the other

**Photo 4b.** *Once a capillary tube is used to pick up a small amount of liquid sample, it is loaded into a 6 mm tube that is also loaded with cupric oxide. This tube is put into a Cajon fitting and evacuated while in liquid nitrogen to prevent evaporation. The ampoule is then sealed with a hand torch, and set aside to combust in the oven.*

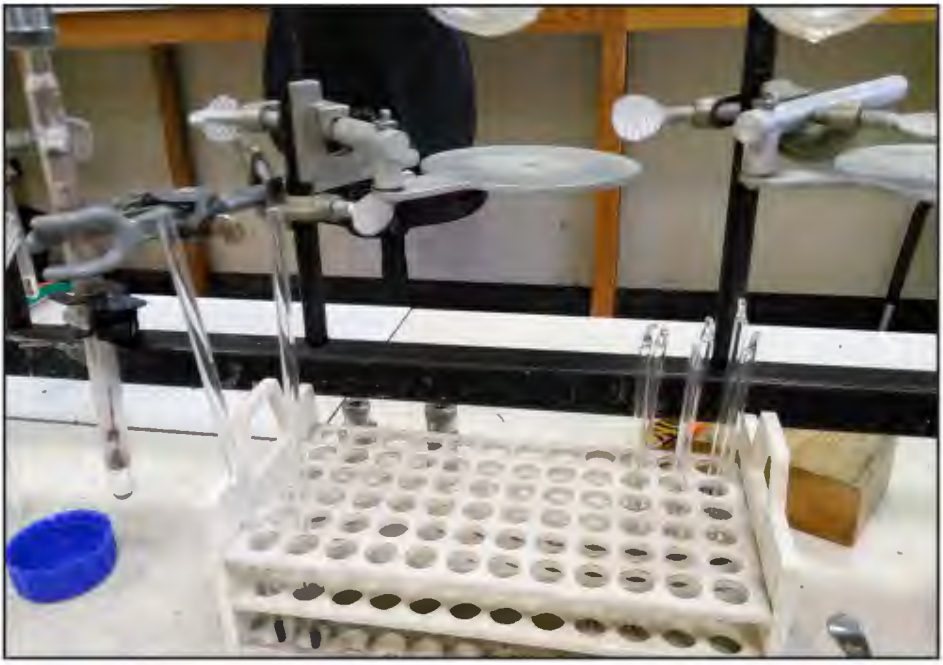

**Photo 4c.** *This is a rack that we use to keep samples in order, while they are being loaded and sealed.*

**Photo 5a.** *Labeled samples: once they have been combusted in the oven overnight and are ready for separation and bottling on the stable isotope line.*

**Photo 5b.** *This is a rack that we use to combust the samples in the kiln.*

with liquid nitrogen. The dry ice and propanol mix will capture the water that is left over from the reaction with cupric oxide (Photo 6).

One advantage of this line is that this water can be saved and reloaded into another 6 mm ampoule with zinc if analysis of deuterium/hydrogen is also desired (Photo 7).

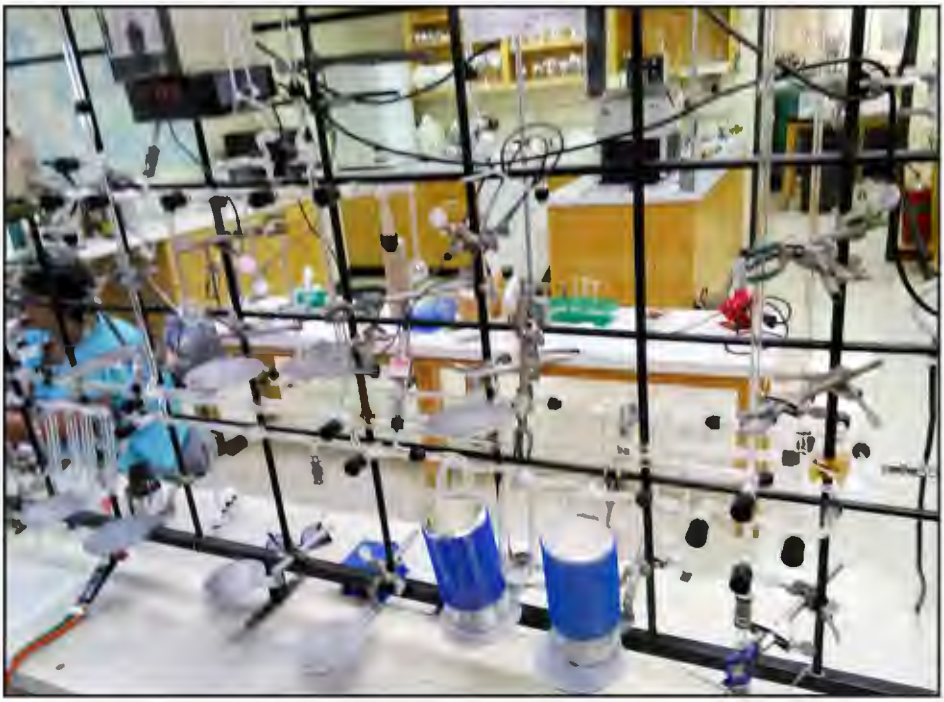

**Photo 6**

**Photo 7.** *Spare sets of 28/15 ball and socket ampoule crackers are kept ready in case one was to break. Easily replaceable due to 3/8" ultra-torr.*

## MEASURING AND SPLITTING

Once the water is trapped by the dry ice/propanol and the $CO_2$ is captured in the liquid nitrogen cold trap, the system is then opened to vacuum so that any remaining nitrogen and unwanted gasses are pumped away (Photo 8a). The vacuum system is closed and a pathway is opened by 0-4 hi vac valves to a section of two measuring bulbs, pirani gauge and sample bottles, also with 0-4 hi-vac valves. The liquid nitrogen dewar is removed from the loop trap (Photo 8b) and placed under the large measuring bulb. The $CO_2$ will quickly migrate to the bulb, where it is collected and closed off. By removing the liquid nitrogen, the gas will expand and the pirani gauge or manometer will allow you to calculate the moles of $CO_2$. By opening a pathway to the sample bottle and using the liquid nitrogen, the gas is transferred in the same way. While the Isotope Ratio Mass Spectrometer (IRMS) can measure

as little as 30 moles of $CO_2$, the graphite line requires 80-120 moles to create enough material for the target of the accelerator mass spectrometer (Diagram 1).

**Photo 8a.** *This is a close-up of where we measure and split samples. Only 80 moles is needed for the mass spectrometer, and the rest is saved for the accelerator mass spectrometer if needed. You can see two different sized bulbs in the middle where gas is cryogenically transferred as well as vacuum gauges to measure the volume of gas for calculation.*

**Photo 8b.** *A close-up of the splitting bulbs, where gas is measured and divided, separated by a 0-4 high vacuum valve. If necessary, some of the sample can be pumped away and split again if too large.*

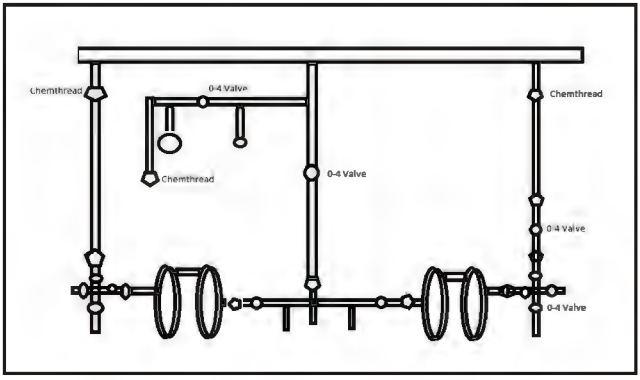


**Diagram 1.** *This drawing is too crude to use but it shows how the line has two sides to import samples, with two sets of liquid nitrogen and dry ice/propanol traps. It makes use of a shared section for measuring, splitting and bottling gases using Chem Thread #9 connectors.*

## $CO_2$ TO GRAPHITE

Once the $CO_2$ is separated, measured and transferred into a sample bottle, it is ready to run on an available IRMS. In order to be run on an accelerator mass spectrometer, further steps are required to convert the $CO_2$ into graphite that can be pressed into a target. The

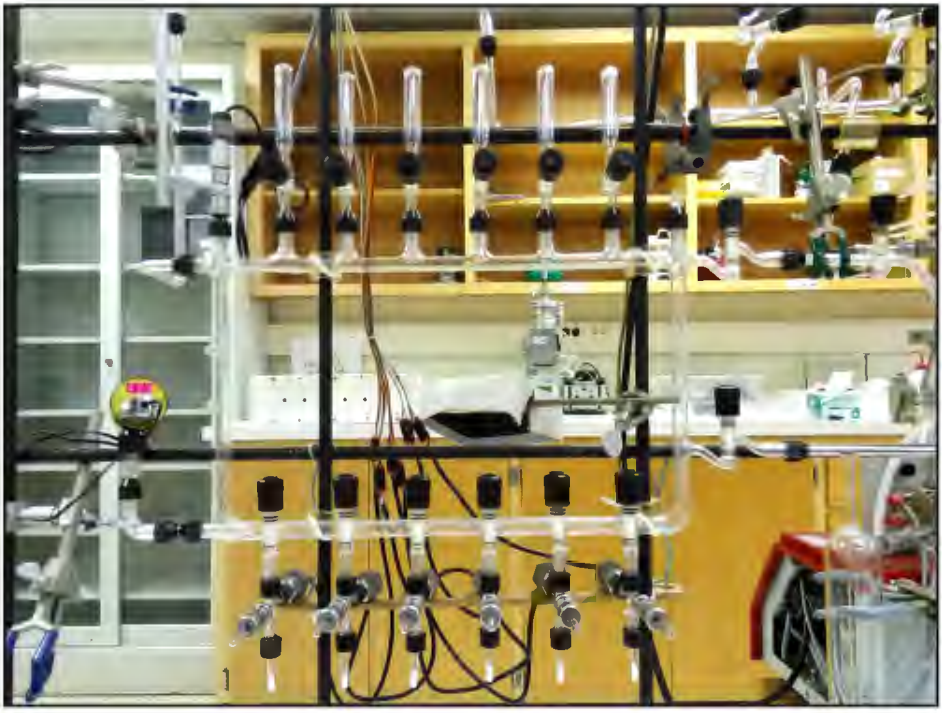

**Photo 9.** *This is the graphite line assembled and ready to use. The top six sample bottles have $CO_2$ from prep line. The bottom has the glass T's with pressure gauge, desiccant, and iron catalyst. The tube furnace is placed on the bottom and hydrogen is added. The last side goes to a pressure transducer to monitor the reduction in pressure, indicating when the reaction is finished.*

samples on this particular line are done in a rack of six, with two sides for a total of twelve samples at a time. The sample bottles are connected to the manifold with Chemglass #9 Chem Threads; the manifold is then evacuated (Photo 9).

While the manifold is being pumped down, the rest of the system is assembled for the reaction. For the graphite to form, the $CO_2$ is combined with hydrogen in the presence of a small amount of iron catalyst. These are individual reactors and allow for separate loading of iron catalyst and a desiccant to remove water. This is done by using a tee with two Chem Thread #7s (Photo 10a). The portion with the iron catalyst where the graphite will form must be baked in a tube furnace (Photo 11). Because this section will be exposed to a high tem-

**Photo 10a.** *This is a T from the graphite line, one side holds iron catalyst where the sample graphite will form, another holds desiccant; one goes into a 0-4 valve where the $CO_2$ and hydrogen will be added. The last side goes to a pressure transducer to monitor the reduction in pressure, indicating when the reaction is finished.*

**Photo 10b.** *Iron catalyst where the graphite made from $CO_2$ for the accelerator mass spectrometer will be formed.*

perature, ¼" Cajon ultra-torr fittings are a better choice for a vacuum tight connection (Photo 10b).

## CONCLUSION

Isotope analysis, whether for authenticity testing, or carbon dating is often done in a demanding schedule with samples that are very valuable. For this reason, a vacuum line is needed that is reliable, redundant, and modular. In the event that a portion of the vacuum line does break, it is often crucial that the line be repaired or replaced in a very short time frame. Through the use of O-ring joints such as Chem Threads and ultra-torr, a design can be made with parts that are easily replaced or removed for easy repair in the glassblowing shop. This reduces down time for expensive analytical equipment such as an accelerator mass spectrometer. While *in situ* repairs are still needed, an efficient modular design using O-ring joints will bring this need to an absolute minimum.

**Photo 11.** *Tube furnace for the graphite line: where the $CO_2$, hydrogen and iron catalyst react.*

## BIBLIOGRAPHY

Hill, Wallace G. “Vacuum Systems, Construction, Operation, Behavior.” *Fusion* XXVII.4 (November 1980): 39-41.

Vogel, J.S, Turtletaub, K.W., Finkel, R., Nelson, D.E. “Accelerator Mass Spectrometry Isotope Quantification at Attomole Sensitivity.” *Analytical Chemistry* 67(11) (1995): 353A-359A.

Mandoli, Harry. “Vacuum Technology” *Proceedings of the 10th Symposium on the Art of Scientific Glassblowing*. Ed. George Sites (San Francisco, CA: June 30 – July 2, 1965): 97-105.

Derby, James V. “Design Considerations for High Temperature Vacuum Systems Used in Gas Analysis.” *Proceedings of the 11th Symposium on the Art of Scientific Glassblowing*. Ed: George Sites (Boston, MA: June 8-10, 1966): 9-16.

Wise, David P. “A Large Modular Hi-Vacuum System for Air Sensitive Manipulation.” *Proceedings of the 47th Symposium on the Art of Scientific Glassblowing*. Ed. Marylin Brown (Point Clear, AL: May 28-June 2, 2002): 12-21.

## CREDITS

I would like to thank and credit the Center for Applied Isotope Studies at the University of Georgia for the opportunity to build, repair and use these types of vacuum lines. It has been a very rewarding experience and it has given me an understanding of the practical application of glassware that I often do not get to see in use. Specifically, I would like to thank Dr. Randy Culp, Ph.D., Associate Director and head of the Stable Isotope and Natural Product testing labs.

# My Experience at Salem Community College

**by**

**Elayne Ashley,[*] Jennifer Langill,[**] and Erin Austerberry[***]**

## ABSTRACT

*Every Scientific Glass Technology (SGT) student attending Salem Community College has their own story. Each student attends with different backgrounds and different goals for their future. However, the experience of being an SGT student at Salem is a common tie that creates a bond between us and joins us together despite our differences. In this three part paper, we will discuss those common experiences. Elayne Ashley will discuss the program in general and obstacles we had to overcome to ready ourselves to enter the scientific glass industry. Jennifer Langill will discuss the chemistry classes, which are probably the most important courses we take outside of the Glass Education Center. She will discuss how the Chemistry program is set up to prepare us for careers in scientific glass. And lastly, Erin Austerberry will jump into the details of one student's chemistry project.*

## PART I – ELAYNE ASHLEY

**Photo 1.** *Glass Education Center Flame Shop, Salem Community College*

The students face many challenges while attending Salem Community College. One of the largest hurdles is travel, work and housing. The Glass Education Center (GEC) is located about 20 miles away from the main campus of Salem Community College (SCC). There are also limited housing options for students as the school does not offer any housing arrangements. Many students will share a rented house in the surrounding neighborhood but are unprepared for the cost of living in southern NJ. Independent students typically live in areas farther away to compensate for finding employment and more cost effective housing options. Not only is the average cost of apartments and housing more expensive than most surrounding areas, but the opportunity for employment is limited as well. Most part-time employment in the area does not pay more than minimum wage, and local glass shops are over a forty-five minute drive from campus. On the occasion that a glass studio is willing to hire a student, they are typically not compensated any more than a new hire with no glass experience.

The GEC facilities are located twenty minutes from the main campus. The facilities feature four distinct studios set in a 10,000 square-foot open design building adjacent to the landfill to recover methane gas. You can read more about it on their website at www.salemcc.edu/

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**Photo 2.** *Dennis Briening teaching students*

**Photo 3.** *Bob Russell with Elayne Ashley and Erin Austerberry after a lathe maintenance demonstration*

**Photo 4. S***nyder Column by Corina Guerra*

glass/. Dennis Briening heads the Scientific Glass Technology program and is an invaluable resource to the program. Dennis teaches both first and second year classes, in addition to spearheading many committees, advocating for student resources, and organizing the International Flameworkers Conference that is held at the facilities every spring. Joe Barker volunteers his time during the day to assist students with project work and to petition for studio improvements. A recent success of professor and volunteer efforts was an installation of two extra rows of torch benches for students. New lighting was also installed to create a better working environment. As the program has nearly doubled and more in the past three years, classes have grown to include evenings and weekends to accommodate varying student schedules. The evening classes are taught by Bob Russell and Dan Walker, both currently scientific glassblowers lending their wonderfully skilled techniques to students. While the SGT classes have expanded into the evenings to accommodate working student schedules, the other program requirements are still only taught during the regular daytime hours at the main campus. This is another roadblock to working students: the limited time to take general education classes. Students who are working full-time will have extreme difficulty trying to attend the program-specific Chemistry for Glassblowers when it is only available during their working hours.

According to the February 1978 *Fusion*, the College was offering a degree plan for employed scientific glassblowers at a cost of $20 per credit hour with a $25 assessment fee per class. Today, the program is offered at $150 per credit hour, with fees and charges that

bring the tuition of an out-of-county student (most students attend from out-of-state) to a total of $1,477 for only the single SGT class during one semester. Students who take full-time coursework (approximately three to four classes) face a year-long tuition package of about $6000. Outside of these costs, students are also responsible for procuring their own tools. The school provides the student with glass, oxygen, gas and equipment but the access to these resources is limited. While the school is able to provide most of its supplies, many surrounding companies donate much of the glassware used by the students. The donations from the local companies are generous; however, the school is unable to accept larger donations from other companies farther away due to logistics and limitations in funding to transport materials. The limitation of supplies impacts the student's productivity and most students are only able to complete one or two repetitions per assignment. While studio amenities are comparable to similar institutions, basic resources accessible to students is limited. The water fountain in the lobby is the only nutritional resource provided to students at the Glass Center. The main campus provides a small cafeteria and ample vending machines but that is a 20 minute drive from the GEC. No such amenities are provided at the Glass Center where many students spend hours each day; while a cafeteria may be too much to ask, a vending machine with sports drinks and reasonably healthy snacks is not. The work students do at the studio is physically demanding and requires proper hydration. With the glass lab being so far from any other businesses, it is important for the students to have reasonable access to food and drinks.

Students at SCC have many opportunities to be involved in the greater glass community. The American Society of Scientific Glassblowers Delaware Valley Section hosts its fall meetings at the school and offers many opportunities to students. To encourage students to become involved, they offer a scholarship for a Student or a Junior member to attend the annual symposium. There is also a student-run Glass Club that offers opportunities for students to sell their glass work and art. The Glass Club has taken initiatives to write proposals for studio improvements and to host or sponsor philanthropic events. The International Flameworkers Conference is held at the school every year and allows students to volunteer and to assist visiting artists and scientific glassblowers. Amy Lemaire, a local artist and professor at the school, and Paul Stankard host an annual trip for the students to visit the Corning Museum in Corning, NY. Throughout the SGT program, various field trips are taken to the companies in the surrounding areas. Led by the instructors, students are taken to a nearby quartz fabrication shop, scientific glass shops, and even a few chemical companies. This is a great opportunity for students to see the apparatus they produce in action and to understand more about the process of fabrication and the application of the glassware as they become more familiar with it. Students enrolled in the SGT program are awarded a key opportunity that those learning elseware are not.

| First Semester | | Credits |
|---|---|---|
| ☐ CSC 115 | Computer Applications* | 3 |
| ☐ ENG 101 | English Composition I | 3 |
| ☐ SGT 113 | Introduction to Scientific Glass† | 6 |
| ☐ | Humanities Elective | 3 |
| | | *15* |
| **Second Semester** | | |
| ☐ ENG 122 | Business and Occupational Writing | 3 |
| ☐ SGT 114 | Basic Apparatus Fabrication‡ | 6 |
| ☐ SGT 115 | Technical Drawing and CAD for Glassblowers‡ | 3 |
| ☐ | Social Science Elective | 3 |
| | | *15* |
| **Third Semester** | | |
| ☐ BUS 102 | Introduction to Business | 3 |
| ☐ CHM 130 | Basic and Organic Chemistry I† | 3 |
| ☐ SGT 210 | Advanced Fabrication I† | 6 |
| ☐ | Open Elective | 3 |
| | | *15* |
| **Fourth Semester** | | |
| ☐ CHM 108 | Organic Chemistry for Glassblowers‡ | 4 |
| ☐ FNA 120 | Cold Glass Assemblage & Surface Treatment | 3 |
| ☐ SGT 211 | Advanced Fabrication II† | 6 |
| ☐ | Mathematics Elective+ | 3/4 |
| | | *16/17* |

**Photo 5.** *Scientific Glass Technology Recommended Curriculum*

"Introduction to Scientific Glass" is the first required course in the SGT program. This

is a great class for students who have not flameworked before and even for those who have worked with glass but not in the same capacity. The class begins with basic discussions on different types of glasses and benchworking methods. Borosilicate bends, points, olives, side seals and straight seals are the majority of the coursework.

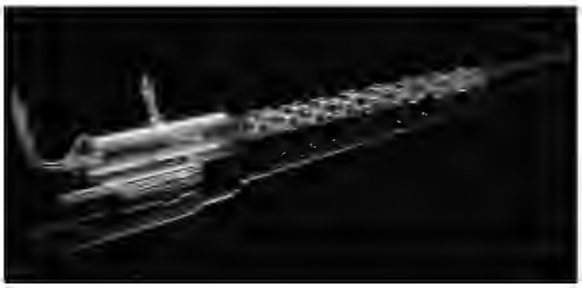

**Photo 6.** *Gas scrubber by Elayne Ashley*

The second half of the first year begins with "Basic Apparatus Fabrication" where students are challenged to create apparatus with more components. Ring seals, dewars, and Vigreux columns are added to the array, while fabrication becomes more complex. There is also an added emphasis on holders and technical skills in designing them. A basic CAD & Technical drawing class is included in the first year allowing students to have a better understanding of how to draft and to read prints. The class begins with hand-drawn prints, learning about scale and the use of tools, then transfers into computer application. After learning both methods, students are given the option to choose hand-drawing or computer rendering for their remaining projects during the second half of the class. The other required class during the first year is "Business and Occupational Writing." While this class would seem relevant, the course content needs to be reviewed.

"Advanced Fabrication I & II" are where the real tasks begin! Students are introduced to the lathe and allowed more freedom in choosing how they construct their projects. More projects are introduced that require complex holders and a detailed understanding of airflow. Typically students are also building apparatus for use in their concurrent chemistry class which allows them the opportunity to see their skills in action. During the second year, a keener eye is used for tolerances and harsher restrictions are set on projects. Students are also encouraged to reverse engineer prints and are given critical thinking tasks to prepare for the workplace. "Introduction to Business" is a step in the right direction for the program but lacks applicable content. The idea is for students to understand what might be required if they were to work independently and open their own shop after school, which some choose to do. While the idea behind including a business class is an excellent one, as an introduction class it mostly contains information on the basics of different types of businesses and their larger role in the global market. The class closes with writing a business plan but is otherwise irrelevant. A more successful class might be "Business of Entrepreneurs" or anything that would include applying the skills of marketing, economics, finance and accounting for

**Photo 7.** *Joe Barker assisting Elayne Ashley in a special topic project*

small businesses — something in a more "how-to" style than a basic overview more relevant to a high school survey class. "Cold Glass Assemblage" is a great class in the program. Students are taught the basic skills of cutting, grinding, polishing, gluing and cold assemblage and are given the freedom to choose an artistic or scientific approach to all projects. This is an excellent feature of the class as it allows the students to be very technical in their approach and to learn about the optics of polishing and the removal of blemishes, yet it allows many of them to flex their creative muscles in a different capacity. The final two classes are "Basic and Organic Chemistry" and "Organic Chemistry for Glassblowers." These will be discussed in detail in Part II.

## PART II – JENNIFER LANGILL

As a part of the Salem Community College Scientific Glass Technology program during the years of 2013-2015, I was required to take "Chemistry 130" and "Chemistry 108." These classes, "Basic Chemistry" and "Chemistry for Glassblowers," were an important piece of learning to become a scientific glassblower. Both classes were taught by Brenda Quinn. I would like to explore the class content, goals and objectives as they relate to the Scientific Glass Technology (SGT) Degree.

**Photo 7.** *Limonene Distillation apparatus by Elayne Ashley*

"Chemistry 130" is the prerequisite class and is titled "Introduction to Basic and Organic Chemistry." The course covers the basic principles of Inorganic and Organic Chemistry. The students study theory as well as solve mathematical problems involving atomic theory, conversions, measurements, density, specific heat, nomenclature, types of reactions, stoichiometry, gasses, and acids and bases. (Quinn, 2013) The students were taught by lecture, in-class work, homework that was mostly equation solving, and tests. The class did a couple of short labs, but the focus was more on theory. This class was a requirement for several majors including SGT, so the students were from several different majors.

"Chemistry 108" was the second class required and is titled "Organic Chemistry for Glassblowers." This class is only available to those students enrolled in the SGT major allowing the school to customize the curriculum to the major. The class continued the focus on nomenclature and introduced us to bond theory, properties and reactions of a variety of classes of Organic Compounds. (Quinn, 2014) This class included a lab component. In the lab portion of the class, we were exposed to organic laboratory techniques,

such as simple, vacuum, and fractional distillations, reflux reactions, extractions and chromatography. (Quinn, 2014) Our coursework was tailored to center around glassware. While learning about the laboratory techniques, we studied the glassware used in the techniques, how it was constructed and why it was constructed the way it was. Early on in the course, we entered the classroom to find almost all of the labware pulled out of the cupboards, and placed on the lab benches with numbers. We were tasked to identify each piece, explain how it is used, and list the considerations a glassblower needs to take during the construction. It was the professor's objective to get us to think both like chemists as well as glassblowers. It was that objective that caused Ms. Quinn to design the final project in collaboration with Dennis Briening.

The final project required that students find a lab partner or two, identify an experiment they would like to perform, design the glassware, make the glassware, perform the experiment in front of the class, explain the theory, chemistry and history behind the lab technique, and explain the glassware they created for the project. Each student was expected to participate in all aspects of the project and was expected to be able to explain the chemistry, the glassware, and to answer questions. There were a variety of experiments: simple distillations, fractional distillations, steam distillations, and oil extractions using a soxhlet apparatus. This project was great for the students because we were able to experience firsthand the role that the quality of our glass construction played on the success of the experiment. We learned that dimensions were important. Some experiments took too long to finish in one four-hour class because the glassware that was created was too large. The lessons in our glass fabrication class were reinforced. Some experiments failed when seals cracked or a tiny leak was discovered. These failures taught us all more than the successes did, they made us think critically about the construction of an apparatus and the environment in which the experiment was being performed.

These hands-on assignments, the experiments and the glassware identification project were strategically designed by Ms. Quinn. She realized that glassblowers are not your typical students: they are often more hands-on learners. She wanted to give them the ability to demonstrate their knowledge in a different way than on a test or in a research paper. These projects allowed those students to become excited about the subject, to teach the other students what they learned about chemistry and to show off the glassware they made. Ms. Quinn's ultimate goal was to give the students a "working knowledge of the language of chemistry" and "confidence in what they learned in both chemistry and glass fabrication classes." (B. Quinn, personal communication, March 19, 2015)

## PART III – ERIN AUSTERBERRY

### Extracting Clove Oil from Ground Cloves

### INTRODUCTION

For our final chemistry project, we were paired up and had to pick an organic chemistry reaction for which we made the apparatus and then carried it out. My partner, Anthony Casuccio and I chose the extraction of clove oil using steam distillation. Cloves are the dried flower buds of the clove tree, *Eugenia caryophyllata*, found in India and other locations in the Far East. Clove oil consists primarily of eugenol along with eugenol acetate, caryophyllene, and other minor compounds. Eugenol is the major compound, comprising 85-90%, while eugenol acetate comprises 9-10%. Eugenol is a turpine and responsible for the aromatic, flavor and antiseptic properties of the clove oil. The boiling

point of eugenol is 254 degrees C. It can be used as an antiseptic, mild local anesthetic and for flavoring perfume or food.

**HISTORY**

Distillation has been in use since the 1st century in Alexandria. In 1500, German alchemist Hieronymous Braunschweig pubished *The Art of Distillation* which was the first book dedicated to distilling. As alchemy evolved into chemistry, they began using vessels called 'retorts' and 'alembics.' Originally made of glass, these were eventually made of copper. Early distillation was done in batches, and redistilled to increase purity.

According to Dalton's law, the total vapor pressure of a solution is the sum of all the individual vapor pressures in the solution. As a mixture is heated, each individual component increases in vapor pressure, thus raising the total vapor pressure of the mixture. When this total pressure is the same as the pressure of the air surrounding the liquid, the liquid begins to vaporize or boil.

We use steam distillation when the mixture of steam and oil distills below the boiling point of water and below the boiling point of the oil because the mixture of vapor pressures allows it to boil at a lower temperature than the usual boiling point.

**SAFETY PRECAUTIONS**

A small vent to release excess steam and pressure and to avoid an explosion!

Eugenol is caustic! Use care when handling.

Grease joints to ensure airtight seals.

**MATERIALS**

- distillation apparatus
- 150 ml round bottom boiling flask
- straight condenser
- Klaussen adapter
- 100 ml receiving flask
- separatory funnel
- thermometer
- 5 g cloves in 40 ml water
- 5 ml ether
- 10 ml NaCl solution
- gloves

**PROCEDURE**

Add 5 g ground cloves to 40 ml water in your 150 ml flask. Attach to distillation unit and put on heating mantle. Apply heat slowly as mixture can foam. Distill until no oily layer is apparent. Transfer distillate to separatory funnel and add the NaCl solution. Rinse condenser and receiving flask with 5 mg ether and add this also to the separatory funnel. Swirl gently and vent the funnel, then shake vigorously with frequent venting. Allow layers to separate. Drain aqueous layer off the bottom, and transfer ether layer to a 50 ml

flask. Return the aqueous layer to the separatory funnel and extract two more times with 5 ml of ether. Rotary evaporation can then be used to remove the ether from the oil.

## TESTING FOR EUGENOL

Eugenol contains a carbon-carbon double bond and an aromatic hydroxyl group called a phenol. These functional groups provide the basis for simple chemical tests used to characterize the clove oil. A solution of bromine ($Br_2$) in dichloromethane decolorizes as bromine reacts with the double bond to form a colorless compound. A positive test is the disappearance of the red bromine color into a pale yellow color. You can also use a potassium permanganate ($KMnO_4$) solution that will oxidize a double bond at room temperature to form a 1,2-diol with the simultaneous reduction of $Mn^{+7}$ in $KMnO_4$ to $Mn^{+4}$ in manganese dioxide ($MnO_2$). A positive test is the disappearance of the purple $KMnO_4$ and the appearance of $MnO_2$ as a muddy brown precipitate.

The test was positive and the results successful!

## WORKS CITED

Quinn, B. (2013). *Introduction to Basic and Organic Chemistry* [Class Syllabus]. Department of Science, Salem Community College, Carneys Point, NJ.

Quinn, B. (2014). *Organic Chemistry for Glassblowers* [Class Syllabus]. Department of Science, Salem Community College, Carneys Point, NJ.

# 2015 Technical Posters

Steven M. Anderson, Dr. Mark Benscoter and Dr. Chris McLeod

**"Temperature Controlled Reservoir for In-vitro Heart Reanimation"**

Mayo Clinic
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Jacob Chambers, Aaron Kirchhoff and Richard Sheridan

**"Soxhlet Extractor Used to Fabricate Large Diameter Wafer Washer"**

National Institute of Standards and Technology
U.S. Department of Commerce
100 Bureau Dr.
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Doni Hatz

**"Jacketed Vessel: Rheology Chamber with Injection Ports"**

The Proctor & Gamble Company
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Mason, OH 45040
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Adam Kennedy and Michael Ronalter

**"Kipp's Apparatus"**

University of Texas at Austin
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Austin TX 78712-0165
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Christopher J. Miller, Tracy Drier, Jennifer Faust, Christine Hahn and Gilbert M. Nathanson

**"A Novel Method for Liquid Microjet Fabrication"**

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# 2015 Technical Posters (Continued)

Lori Neu

**"Recommended Personal Protective Equipment for Hydrofluoric Acid Cleaning and Etching"**

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# One-page Posters

Tracy Owen Drier

**"Construction of Thin, Small Diameter Frits"**

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Stephanie Hitchcock

**"Blowing Glass in -40°**

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Guelph, Ontario N1K 1A8
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Frank Meints

**"Quick Threads/Emergency Threads in Glass"**

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# 2015 Technical Demonstrations

Sabrina Bélanger – *Memorial University of Newfoundland*
**"Construction of a Glass Blow Hose Swivel"**

Christopher Bock – *Sea Cube Co.*
**"Ring Sealing a 3 mm Tube to a Flat Bottom"**

Tim Drier – *Dow Chemical*
**"The Use of a Torch Hip-slide"**

Tom Galbraith – *Lumi Scientific*
**"Fuming Silver and Gold"**

Hideaki Hashimoto – *Tokyo Seisakusiyo Co., Ltd.*
**"Construction of Jacketed Reactor without the Use of Internal Padding"**

Chris Miller – *University of Wisconsin – Madison*
**"Precision Nozzles Used for Beam Scattering Experiments Studying Chemistry at Glass/Liquid Surface Interface"**

Doug Navalinsky – *NavCour Glassware*
**"Glass Cutting at the Lathe"**

Erich Moraine – *Wild Rose Glass*
**"Jigs and Fixtures for Product Consistency"**

Kyle Myer – *Aldrich Chemical Company*
**"The Uses for a 2 Arm Lathe Chuck"**

Peter Schweifel – *Glasobjekte Schweifel*
**"There's No Business like Glass Business"**

Pat Smythe – *Precision Glassblowing of Colorado*
**"Construction of a Condenser with Tangential Side Arms Using a Single Blow Source Method"**

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# 2015 Symposium Attendees

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Jeff Babbitt
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Scott Bankroff
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