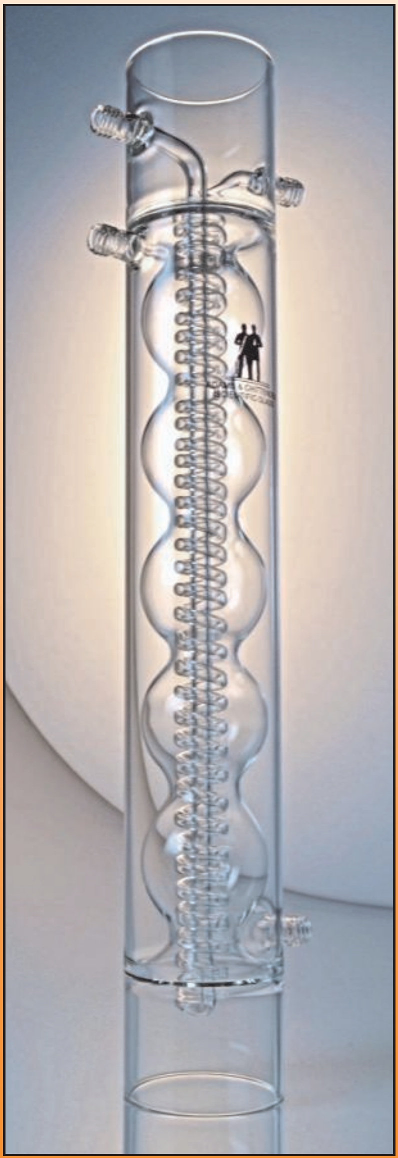
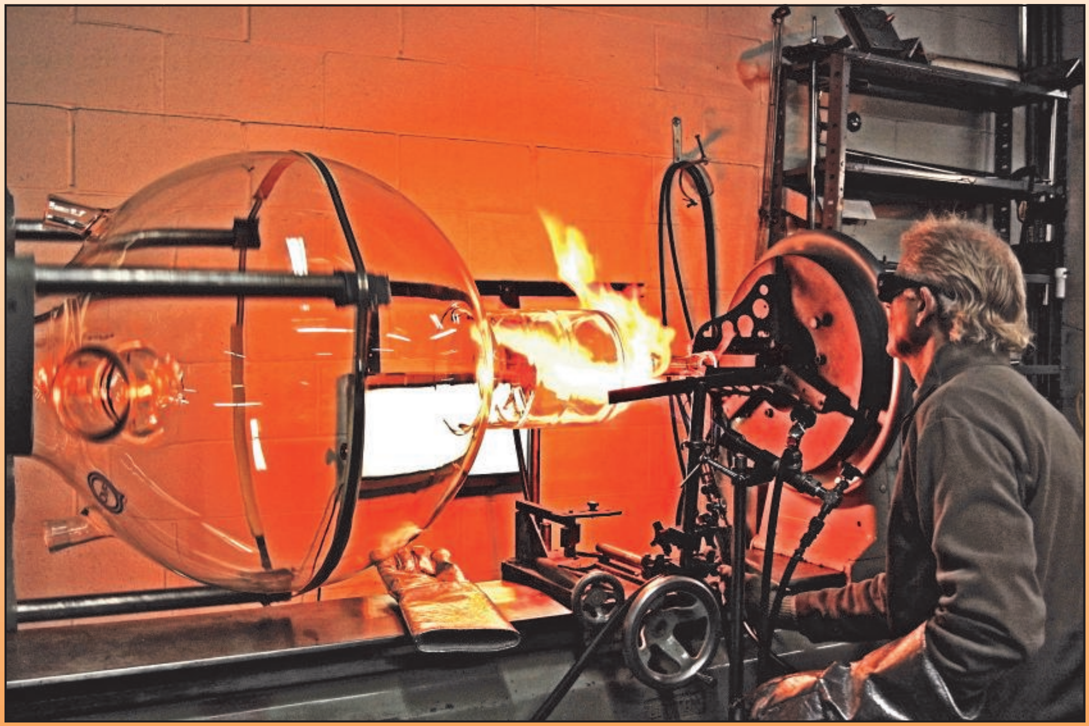
Volume 26, Number 4 Winter 2019

THE NEWSJOURNAL

EARLY AMERICAN PATTERN GLASS SOCIETY

..... to foster and encourage the collection, appreciation, study, preservation and documentation of early American pattern glassware; its makers, and its place in American life, past and present.





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The purpose of the Society is to foster and encourage the collection, appreciation, study, preservation and documentation of early American pattern glassware, its makers and its place in American life, past and present.

The Early American Pattern Glass Society is a non-profit, tax-exempt organization, with the designation of 501 (c)(3) status from the Internal Revenue Service. Dues and gifts to the Society are tax-deductible.

MAILING ADDRESS

Early American Pattern Glass Society, 3294 540th SW, Riverside Iowa 52327

WEBSITE: www.eapgs.org

FUTURE ANNUAL MEETINGS

April 30 - May 3, 2020, Carlisle Pennsylvania

NEWSJOURNAL PUBLICATION SCHEDULE

Spring: Content Deadline January 15, Mail February 15
Summer: Content Deadline April 15, Mail May 15
Fall: Content Deadline July 15, Mail August 15
Winter: Content Deadline October 15, Mail November 15

Send all material for publication, preferably in a "Word" document to: Carl Hearn at larchmoor3335@start.ca

The NewsJournal is printed and mailed by:
La Crosse Mail & Print Solutions Inc., La Crosse, Wisconsin.
The NewsJournal is mailed under a Second Class, "Not For Profit" permit number issued by the U.S. Post Office.

ISSN: 2157-3433

Cover Photo: George Crittenden modifying a large 200L QVF reactor. The two glassware images are described in the body of the feature article. All photos courtesy of Adams & Chittenden Scientific Class.

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“So Many Things Profitable for Man’s Use”

The Essential Role of Scientific and Laboratory Glassblowing

Editor’s Note: This article has been thirty months in the making. I first identified the potential for an article at the Ohio Glass Museum in Lancaster Ohio when I discovered a display about scientific and laboratory glass making. The museum provided me with several contacts all of which ended up at a dead end.

I wandered around with the idea of the article all of 2018 and then came across the website of Adams & Chittenden Scientific Glass. The photography was wonderful, the narrative straight forward and the presentation professional. I made email contact with George Chittenden and he quickly offered me the use of his photographs but as a small hands-on operation he did not have the time or interest in trying to write an article.

Adams & Chittenden Scientific Glass is located in Berkeley, California so for me living east of the Mississippi it was impossible to plan a trip to visit his operation and establish the outline for an article. An evening spent working at the kitchen table, with a detailed map of California in one hand and a copy of the Societies membership directory in the other hand, established the fact that several of our members lived in the Berkley area. In fact Mary Millman lived just some twenty miles away from Adams & Chittenden. Mary served as a Trustee in 2013/14 and I had several good conversations with her and I became aware of her attention to detail and I had made an assumption that she had some writing skills.

So now you have an understanding of how this article has come about: I remained in the background, Mary was the front person and author on behalf of the NewsJournal and George has become a willing participant in the interview, review of the details and source of all the photography.

Mary in her introduction has identified the common historical “thread of glass” that is behind both pressed glass and scientific laboratory glass. Some readers may find this article a little off-topic but I hope that with an open mind you can learn about another aspect of how glass has been part of American life both past and present.

Enjoy the read.

by Mary Millman

***“The list of scientific fields of enquiry that could not have existed without glass instrumentation are legion: histology, pathology, protozoology, bacteriology, and molecular biology to name but a few. Astronomy, the more general biological sciences, physics, mineralogy, engineering, paleontology, vulcanology and geology would have emerged much more slowly and in a very different form without the help of glass instruments. For example, without clear glass, the gas laws would not have been discovered so there would have been no steam engine, no internal combustion engine, no electricity, no light bulbs, no cameras and no television”.
(Macfarlane and Martin)***

Most Society members know a little something about the origins of the 19th century American pressed glass industry because, on a daily basis, we collect, use, analyze, admire, buy and sell its surviving products. Generally the American pressed glass industry, as we understand and study it, began around 1825 when Deming Jarves (1790-1869), who did **not** invent the glass pressing process, included a lever-operated glass pressing machine alongside his group of master glass blowers at the new Boston & Sandwich Glass Company factory at Sandwich, Massachusetts.

In so doing Jarves laid out the paradigm for the industrialization of American domestic glassware. Inherent in the vibrant expansion of American population, settlement and commerce that animated the first half of the 19th century was a surging demand for glass vessels, tableware, lighting and other items of material culture. To service this demand the lever-operated glass press surpassed the capacity of the gaffer’s blowpipe, but it did not surpass the gaffer. For most of the second half of the 19th century, the press required his expertise with soda lime and high lead content glass and his mastery of the ancient art of glass. Inevitably though industrialization achieved reliable mechanical production of perfect multiples. The gaffer’s individual creative input faded; by the first decades of the 20th century the **early** American pressed glass industry had come to an end.

Such is the enduring importance of glass to our civilization that, also by the early 20th century, an entirely new glass industry was taking shape, an industry that would not only call forth the ancient craft of the glass blower but, in addition, lead glass making and glass blowing to new, unforeseen heights. In April, 1918 *The*

New York Times called that industry "chemical laboratory glassware" and today, a century later, we know it as "scientific and laboratory glass". How it came to be an industry at all is bound up with the rapid development of chemical and medical science in late 19th century Europe. How it came to be an American industry is a tale of ingenuity, unexpected opportunity and hard fought, realized ambition. (*"A New Industry Created", The New York Times, April 21, 1918*)

The origin story here is as complex and meandering as the origins of early American pressed glass are simple and linear. Many people from different disciplines and points of view recently have written about the development of scientific and laboratory glass, most to identify the basic historical facts and some to explore its the deeper import.

From this latter group Alan Macfarlane and Gerry Martin wrote a short essay *("A World of Glass" for Science, 2004)*, in which they set forth some important and very big ideas about the role of glass in western civilization from the Middle Ages forward. They point out that the period 1200 to 1850 saw "a revolution in the acquisition of knowledge which affected two basic human capacities: the way in which we think and our sense of sight". Glass was the enabler for much of this development. Although glass beads, vessels, vases and containers, window panes, and mirrors had been in use in various Eurasian cultures for centuries, it was glass' ability to bend light - the lens - that literally shaped and drove the knowledge revolution.

"Glass helped to accelerate the amazing acquisition of knowledge about the natural and physical worlds by providing new scientific instruments: microscopes, telescopes, barometers, thermometers, vacuum flasks, retort flasks, and many others. ***Glass literally opened people's eyes and minds to new possibilities and turned Western civilization from an aural to a visual mode of interpreting experience."***

Using soda lime glass, the composition of which is basically unchanged since Roman times (Pliny the Elder described it!), Europeans made eyeglasses and optical lenses as early as the 13th century. Skilled glassblowers of succeeding centuries used it to create the elaborate spiraling forms for distillation and many of the glassware containers that are still today necessary for scientific research. By the mid-19th century though, when Europe had become the center of scientific research, it was apparent to many that scientific progress required improved tools. Research scientists needed to see better and more deeply in order to advance.

In 1870 the German physicist and optical scientist Ernst Karl Abbe, himself convinced that better optics would proceed only from better glass, famously implored European glass makers to create better types of glass instead of making better windows. In response, Friedrich Otto Schott, the son of a window glass maker and an educated chemical technologist, took up the challenge with determination. He "systematically produced glass with every conceivable oxide additive he could think of."

(*Chemistry World, "The Chemist's Best Friend" Tabitha Watson, 6 July 2018*)

Schott gave his recipes to Abbe who handed them on to the noted scientific instrument maker, Carl Zeiss for the manufacture of superior lenses. As an internationally leading technology enterprise, Zeiss is still in business today.

Glassblowers of Murano, 1886 by Charles Frederic Ulric, oil on panel. Permanent collection of the Metropolitan Museum of Art, New York, New York.

Schott, Abbe and Zeiss recognized that the best of Schott's recipes made **borosilicate** glass. Its relative purity - over 80% silicon dioxide - and its relatively greater portion of boron trioxide meant greater resistance to chemical attack, and to thermal and mechanical shock. For the research scientist, each of these qualities and all of them taken together marked an enormous advance over soda lime glass. Less obvious at the time, these qualities also benefited the glass blower by way of expanding the possibilities for constructing unique, bespoke scientific and laboratory apparatus of the type that could never be mechanically industrialized. From its beginning, borosilicate glass widened the range of the glassblower's ancient craft and secured his position as ultimate steward of the art of glass.

Borosilicate glass was commercialized rapidly. Schott branded his glass "Duran". Zeiss founded The Jena Glass Works in 1884 to manufacture "Jena Glass" chemical laboratory ware. Test tubes, beakers, Erlenmeyer flasks - these forms of conventional laboratory glassware were industrialized early on and served the goals of advancing science and enlarging commerce. At the same time borosilicate glass reached practical hands-on fields such as medicine (test tubes, pipettes, Petri dishes), and agriculture (graduated long neck flasks, Babcock bottles) where battling germs and measuring quality determined success. "Jena glass" had a virtual monopoly. European and American research laboratories and industrial and medical enterprises relied heavily on it into the 20th century.

Schott's research and recipes had been available to a wide community. Some American glass works were producing borosili-

ZEISS

SCHOTT
glass made of ideas

CORNING

PYREX®
A Corning Brand

Zeiss AG, founded in 1846, headquarters Oberkochen, Germany, Schott AG founded in 1884, headquarters Mainz, Germany, Corning Flint Glass Works established in 1868, Corning, New York and the Pyrex logo first introduced to the public in 1915.

cate glass as early as 1904. With a characteristically practical bent American research into borosilicate composition and qualities first proceeded with specific applications in mind. One humble product of Corning Glass Works offers a great example.

Established in 1868 at Corning in upstate New York, the Glass Works' location had been deliberately selected for ease of access to the extensive waterways of the Erie Canal and numerous railway networks. While enhanced resistance to thermal stress was a leading quality promised by Schott's borosilicate recipe, in practice the degree of resistance was not sufficient to prevent railroad signal lanterns from shattering in sleet or freezing rain. The work of Corning chemist, W. C. Taylor, produced a form of borosilicate with greater thermal stress resistance, called "fire glass" and later branded "Pyrex". In addition to the dazzling array of fine decorative cut glass that gave the whole town the nickname "Crystal City", Corning could now produce battery jars and signal lanterns that did not shatter in New York winters.

Another Corning scientist, physicist Jesse Littleton, pioneered the domestic uses of Pyrex that led directly to "see-through Pyrex glass cookware". For his acute commercial instinct, Mr. Littleton had his wife, Bessie, to thank. As the Corning Museum of Glass describes it, when he came to Corning in 1914

" . . . Littleton's job was to evaluate the properties of the new glass. One day his wife's ceramic casserole dish cracked. Bessie suggested that the heat resistant glass might be just right for cooking. Jesse went to the lab and sawed off a battery jar [in which his wife] successfully baked a cake. Bessie continued baking in battery jars and even made custards in lamp chimneys."

(*"Finding the Right Recipe: Borosilicate Glass", All About Glass, Corning Museum of Glass. https://www.emog.org/article/finding-right-recipe-borosilicate-glass)*

Corning and other glass works experimented with borosilicate glass but they did not produce scientific laboratory ware. American laboratories, universities, hospitals and industries were dependent on the transatlantic import trade in "Jena glass" and other European brands. On July 27, 1914 no one challenged this relationship but the next day, July 28, 1914, it became impossible. Archduke Franz Ferdinand was assassinated in Sarajevo alighting a braided fuse of mutual defense alliances that led to global war, the "Great War", World War I. Woodrow Wilson declared U.S. neutrality, but the trade lanes went dark partly because of the treacherous seas where Germany conducted unrestricted submarine warfare. Suddenly America was cut off from Europe.

The scale of the economic disruption was aggravated by the vigor of American production which was spared direct contact with the ravages of the war. Research continued, demand increased. By 1916 and heralded by the laboratory glass adaptations of Corning's Pyrex, Corning Glass Works and other American manufacturers launched or stepped up production of laboratory glass. Technological advances led to very efficient fully automatic production of not only lab glass but also window glass and pressed glass in general. By early 1918 *The New York Times* stated of "chemical glass" that "practically the whole of the available supply now in this country is of domestic manufacture, much of which is ware sold under branded names which were unknown a short time ago." In a little less than four years the American scientific and laboratory glass industry had bolted into existence.

It is sometimes said that the government insured the success of the industry by enacting tariffs to restrain the resurgence of the European brands. It is likely that Harding's temporary Emergency Tariff Act of May 27, 1921, though directed primarily at agricultural imports, had such effect. The succeeding permanent "Fordney-McCumber Tariff Act" (1922) burdened imported "Earthenware, and Glass" at 48.71.

(*"Smoot-Hawley Tariff", Anthony O'Brien EH.Net [Economic History Association])*

Hindsight permits but cannot prove a counter theory, that American research and industrial innovation was so energetic and the American borosilicate production was of such quality and availability that the European brands could not have regained dominance. The tariffs could also be seen as a reflection of collective confidence in the domestic industry.

For whatever reasons, the American scientific and laboratory glass industry flourished after WWI and flourishes now. For "glass people" it is satisfying to remember and to acknowledge that the highly skilled interaction between an individual glass blower and borosilicate glass always was and is today the heart of that industry.

"So many things profitable for man's use"

"Glass is one of the true fruits of the Art of fire . . . It is a thing profitable . . . not to say necessary to prepare medicine for man . . . indeed so many things profitable for man's use are made, that seem impossible to be made without the use of it; . . ."

(Art of Glass, Antonio Neri, Florentine Priest and Alchemist, 1611.)

After WW I the American scientific and laboratory glass industry drilled down on mechanization in order to provision the growing domestic medical and research markets with the basic forms of lab ware. [To view the ‘basic forms’, search for “Images for Inventing American Laboratory Glass”. For the most famous mass production device of the time, visit the Corning Museum of Glass website for the video, “The Ribbon Machine”. It produced light bulbs at the rate of 1,600 per minute in the 1920s.] Production and distribution are forward looking commercial functions. The underlying worlds of academic, industrial, and medical research retained their 19th century characteristics until the massive social upheavals of World War II ushered in new, more technical and diversified configurations for research and production.

Note: “Corning Inc. was once a light-bulb pioneer”, Larry Wilson, **Star Gazette**, Jan 29, 2016 *stargazette.com/story/money/2016/01/2q9/corning-inc-once-light-bulb-pioneer/79512336*. Another site for the video is: *the awesomer.com/glass.ribbon.machine/411752*

The opportunity to do bespoke work in the post WWI period existed if at all within a particularly insular institutional field. For the individual glass blower this meant that some form of personal apprenticeship was the only gateway; that even after a decade of hands-on, mentored achievement perhaps resulting in mastery, earnings would be modest; and that good positions were far and few between in various institutions such as the science departments of major research universities, medical schools and hospitals, as well as industrial or governmental research labs. More than one observer has noticed that for the pyromaniacs among us the pursuit of scientific glass blowing is as much an act of love as a professional calling.

The advent of the Great Depression rattled the scientific glass industry but it did not hinder its expansion. Probably because of the economies of proximity to raw materials, a handful of small glassworks began to gather in southern New Jersey where high grade silica sand is readily available. The area around Vineland (unincorporated until 1952) began to envision its destiny as the epicenter of the scientific and laboratory glass industry. A modern day pharmaceutical glass leader, Ace Glass, still a family owned business, was founded there in 1936, and owed its early growth, if not its survival, to US Defense Department contracts for glass electrical components during WW II. A little later in 1946 three hopeful local glassblowers with the war behind them founded Chemglass which today, employing well over 100 scientific glass blowers, is one of the world’s largest producers of scientific glassware.

In the 1950s when American domestic markets started to roar again, the industry faced a new era of innovative research, unexpected technical advances and highly diversified applications for borosilicate glass apparatus. All of this fell first on the shoulders of the individual scientific glass blower whose centuries-old reliance on the basic hand tools—lathes and torches—would soon be augmented by computer assisted furnaces, diamond grinding and lapping machines, lasers, and ultra-sonic mills. No longer necessarily needed in the shadows of university science departments, scientific glass blowers had to find their way in an evolving, commercialized environment. And so, recognizing a need, in 1952 Allen Alexander founded the American Scientific Glassblowing Society (ASGS) dedicated to the promulgation of scien-

5.5 liter fully jacketed filter featuring a 150 mm frit completely jacketed for in-line filtration.

tific glassblowing and to the “education of its members through the exchange of technique and knowledge in papers, meetings and workshops”. American scientific glassblowers, though spread out across the industry, acquired an advocate and a professional home. And shortly thereafter, in the Vineland, New Jersey area, the Salem County Technical Institute (now Salem Community College at Carneys Point, New Jersey) offered the first post-secondary training program for scientific glass blowers. Today, the Scientific Glass Technology program remains the only two-year degree program of its kind in North America. It teaches the skills and the hard science necessary to embark on a modern career in scientific and laboratory glass blowing.

Since the 1950s some counter trends have affected the scientific glass blowing industry with consequences for glass blowers. Universities and some laboratories, through outsourcing bespoke research apparatus and repairs, have continued the drawdown of in-house glass blowers. Additionally, other materials have challenged borosilicate glass. In the construction of distillation apparatus, for example, metal is now preferred over glass; in the field of medical apparatus polymers are preferable for so many applications that the market is now called Laboratory Glassware and Plasticware.***** Finally, scientific and laboratory glass itself has diversified. At least two new types of glass—aluminosilicate and

Glass Dephlegmator; a small portion of a commercial distillation setup for the limited production of gourmet spirits

quartz—surpass the qualities of borosilicate in very specific applications. Each of these requires a new skill set to work. So in the midst of booming markets observers see decline in the use of glass, in scientific glassblowing job opportunities, and decline in the numbers of glass blowers. And yet glass is now as essential to scientific and medical research as it was in the Middle Ages and only scientific glass blowers can materialize the apparatus essential to innovation. 3D printing cannot handle molten glass.

*Point of interest and reality check: The Laboratory Glassware and Plasticware Market reached a value of US$5.6 Billion in 2018 and is set to reach US$6.9 Billion by 2024. *PRNewswire, CISION, May 8, 2019. prnewswire.com*

Since 1993 Adams & Chittenden Scientific Glass, located on Eighth Street in the old manufacturing district of Berkeley, California, has carried out its purpose: "We manufacture laboratory glassware and glass tools for scientific and industrial uses of all sorts." Today George Chittenden likens A & C to ": . . . a university glass shop to the world. We do all kinds of custom glass work and send it to places all over the globe."

Thanks in part to the elevation of their profile through their beautiful and instructive website (George took all the pictures), their reputation for highest quality borosilicate glassware has gotten around.

Tom Adams with a degree in physics from UC Berkeley and 20 years of glass blowing behind him and George Chittenden with a degree in Art: Ceramics and Glass from San Jose State and about 15 years of experience including an apprenticeship behind him formed an old fashioned partnership in hopes of "making a go" of scientific and laboratory glass blowing. Though there were four or five other glass blowing shops in the area at the time, Tom and George knew that they were starting out "in the heart of one of the world's most vibrant centers for research and technology" where of course they had to "bootstrap" in the beginning, but they could count on real opportunities to do the most challenging and the most satisfying bespoke projects. Those opportunities did materialize and Adams & Chittenden met them head on as the website illustrates. From the smaller specialized wine and whiskey thieves to the larger 11' distillation components,* quality scientific glass blowing is the 26-year through line.

Along the way Tom and George created a thriving "boomer" business which they are now attempting to pass along to their employee glass blowers in a collective form. With deep assurance that scientific and laboratory glass blowers will 'always' be needed, that their innovative and creative function is essential to science and progress, Tom Adams and George Chittenden having given their full measure to the ancient Art of Glass, can step aside with well-founded confidence and respect for their successors. It would be good for the new entity to keep the old logo for its iconic message: two silhouetted figures joined in consultation, one holding a torch, the other an Erlenmeyer flask. Bespoke scientific and laboratory glass at its best.

Need a paragraph here to introduce the
oncept of the interview

Mary: Let's start with borosilicate glass, the primary medium for scientific and laboratory glass.

George: Borosilicate glass. "Borosilicate" is a reference to boron. Metallic oxides give glass its properties generally - color, hardness, workability, light transmission, and so forth. Boron gives a real thermal resilience, a low coefficient of expansion, so that we are able to heat it up locally, in one spot, and not break the whole piece of glass.

For example we are able to melt a hole in normal windowpane glass but the window will not survive because its composition is soda lime. The stresses that are produced between the hot part and the cold part will result in breakage pretty quickly. The addition of boron produces glass with very little thermal expansion. This is really a desirable property for being able to heat it up in just one spot.

Traditionally hot glass is blown out of a very hot tank of molten glass. The whole piece is kept hot while it is worked through to completion. The ability to heat up borosilicate glass locally from

Klien bottle variations; Windowed on the right, Holey in the certre and Disconnected on the left.

a cold state is a tremendous advance. It allows us to construct elaborate apparatus.

Mary: Are there any other types of glass that work for scientific or laboratory purposes?

George: There are other specialty glasses. One is aluminosilicate glass which is used when you want to contain gasses for a really long time. It is not quite as porous, if you will; it doesn't "leak" as much as borosilicate glass. Aluminosilicate acts differently, it works differently, and it requires an adjustment in technique to work it.

Another is "quartz glass" which is essentially very pure fused silica. This material can withstand extremes in temperature changes and not break, but still acts like glass and we can slam it with a hydrogen-oxygen flame—2000 degrees - and then dunk it in water and nothing will happen.

This kind of glass is used widely in the production of silicon wafers, such as quartz chambers and fixtures where literally nothing will contaminate the wafers upon which the chips are made. Even tiny amounts of foreign matter, metal from sputtering torches for example, will contaminate the chips. This is a whole industry unto itself.

Mary: Is it separate from scientific and laboratory glass?

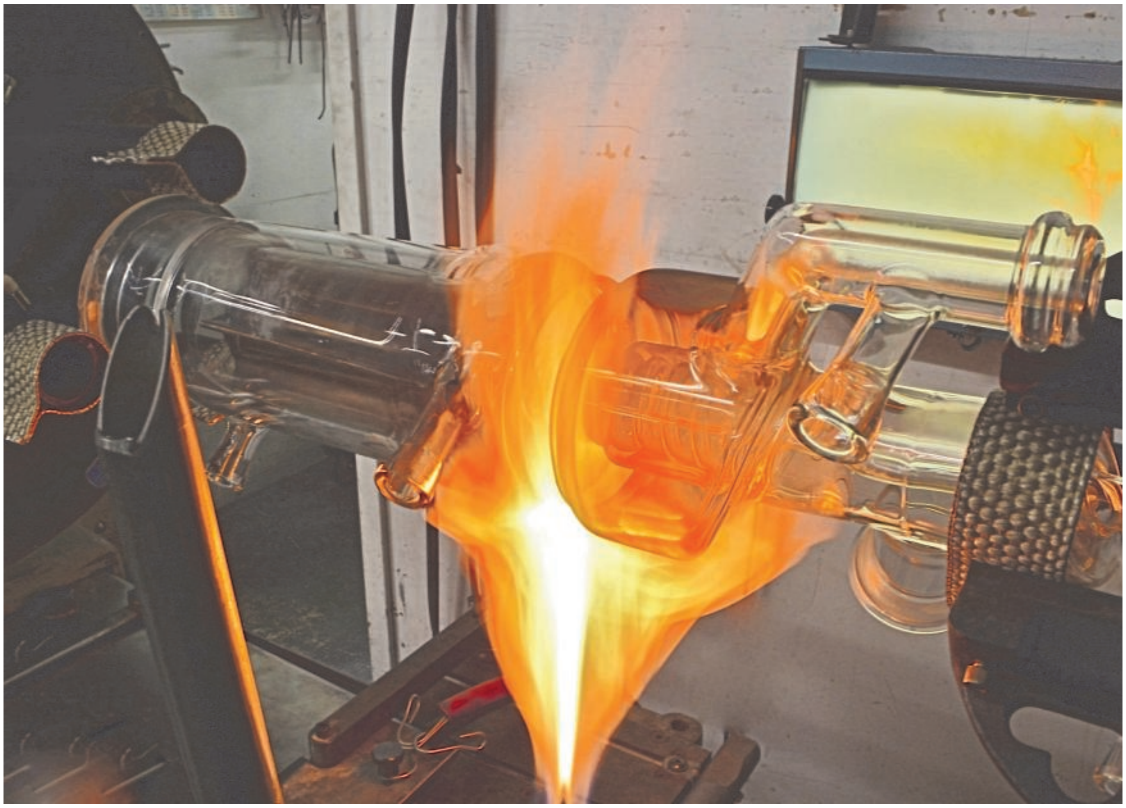
George: Well, I wouldn't call it separate; a specialization perhaps. There are many "quartz people" in our society, the American Scientific Glassblowers Society. We use quartz here at Adams Chittenden for some of our processes. We can work it, but our specialty is borosilicate glass.

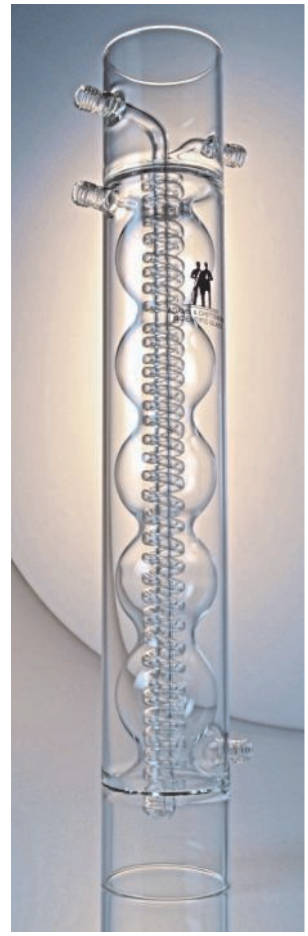
Mary: And so, the primacy of borosilicate glass, what accounts for that? Is it the best medium for essentially hand worked glass? Are you saying that it is friendliest to a glassblower, to a human?

George: That's part of it. Expense and the economics of working with any particular glass are also drivers. Borosilicate is relatively inexpensive. Quartz glass is a much more expensive material; it is more expensive to produce, and the environment to fabricate it in is much more intensive and expensive. Hypothetically, if you wanted to make something out of quartz, it could be thousands of dollars. In borosilicate, the same thing is going to be much less. Borosilicate has been a good choice for hand worked laboratory glassware, but it depends on the requirements of the application. Borosilicate cannot take the extremes in temperature that quartz ware can sustain, among other characteristics.

Mary: Would you say that the incredible distillation apparatus are the best examples of the virtues of borosilicate glass?

George: Those are great examples but may I show you a simple example? This is a Klein bottle, a useless item, not a tool. But for people who study topological surfaces, this is a model of four dimensional space. A Mobius strip is another such model, where you take a two dimensional surface, give it a half twist and join the ends to show three dimensional space.





Above: Repair to a wiped film evaporator. This construction of the glassware required special considerations. The "coldfinger" must remain centered and the jacketing necessitates keeping the piece HOT during certain repairs. Right: Borosilicate Chiller Condenser, a hybrid condenser column 3.5" in diameter and 24" tall. This column will be connected using stainless steal flanges

With a Klein bottle, you pick a spot on the surface and follow it around; it conceptually turns itself inside out. The math that describes this ends either in zero or infinity. So when mathematicians actually see a glass model of four dimensional space, they often love it. Actually I have one cut in half, which is also interesting. Its cross-section is the symbol of infinity which is what the math describes. It is a fairly simple shape but it has its own virtues—it models abstract thought.

Mary: I am very interested in the origin story of Adams and Chittenden. Tom has a degree in physics, you are an artist by education. It caught my attention that those two backgrounds created this business. In the western world going back quite a ways, glass has been called an art and a science. Both you and Tom worked at R & D Glass in Berkeley. What was that?

George: R & D Glass Company was started in the '60s by three glassblowers, the original owners. They did lots of great work. I think part of the story had to do with the University of California at Berkeley being nearby. At one time there were six glass blowers serving the various research needs of the science departments. That was true in most universities, certainly the ones around the Bay Area—Berkeley, Stanford, San Francisco, Hayward and Santa Cruz. Little by little the universities have not rehired in-house staff. When glassblowers retire, their positions are not filled. But historically there has always been a need to support research with glass tools.

Tom began glassblowing at R & D after college and became a good glass blower there. By the time I moved to the area, Tom was responsible for the design work at R & D. I don't think it is a stretch to see how his education in science, in combination with his chops as glass blower, helped him ask the right questions regarding the design of glass tools. He worked there for more than 20 years.

Mary: Was your trajectory different?

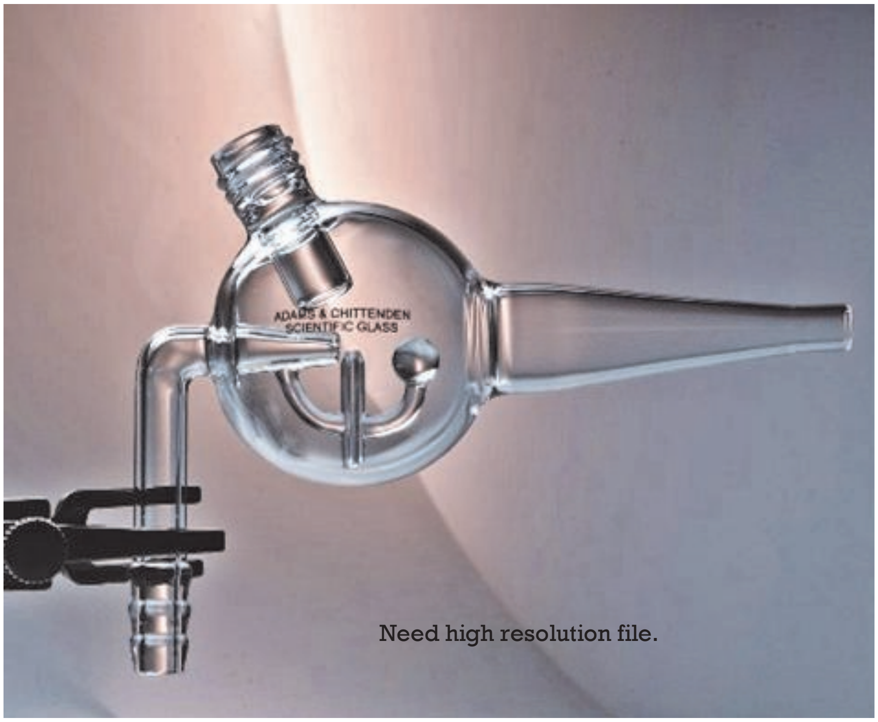
George: Yes. As a young kid I loved science and the natural world and wanted to be a scientist. I was one of those guys who got good grades in high school but got weeded out in college in the first year. I took a year off to evaluate my life. I started to take art classes for the first time and found that I loved them. I returned to school to pursue art.

Mary: To San Jose State in Ceramics and Glass? Now that is really the back door.

George: Looking backwards it could appear like a clever strategy for my trajectory, but it was complete serendipity. After finishing college I took a year abroad, and began contemplating the future. What was I going to do for a living? I was a glass blower. I thought I would check out scientific glass blowing which I didn't know anything about.

I got a phone book and I went around to 20 shops that were in the South Bay. I said, "I'm enthusiastic, I want to learn glass blowing." One place would say, "Well you have to do a single task for six months . . ." and I would say, "But I am really motivated, I learn fast." And they would say, "Well that's our program."

Then I found this masterful Dutch scientific glass blower who had trained as a young man in Holland. He was working by him-



Above: Atomizer. Right: Custom bend thief, for larger capacity sampling ~ 300 ml.

self and he needed help. Under this man I had an old school apprenticeship for a number of years. As I got better he would show me the next thing, and sometimes I would challenge him, "I think I can make that." He was skeptical, "No, you can't make that." And I would say, "I bet you a case of beer I can make that." And I made it. And he would "Welch" on me and not pay up! But I was happy to do it; I understood that I was getting great exposure and a good opportunity.

Mary: So when you got to R & D you were ready.

George: I went into the shop as a glass blower. Tom was in the front office doing virtually all the interface with clients and customers—helping people design their projects, understanding what they needed, working that all out. Then Tom would give us glass blowers the jobs.

This was the arrangement for years and then one day when I came back from a two week vacation, the owner pulled me aside and said he was selling the business. I said "What?! This is our livelihood. Why don't you sell it to us? He said that the wheels were already in motion, but he would introduce us to the new owner. I made the same pitch to him. "This is our livelihood, we are doing it for the long haul." He said, "Oh don't worry. We are not going to change anything."

Mary: I'll bet that didn't happen.

George: As it turned out, after working for him for three years, we could see that though he had an MBA, it did not qualify him to run a glass shop. People were leaving. Finally when the new owner refused to give Tom the raise he had asked for, Tom decided to leave too. Tom thought he would join his wife in letterpress printing and not continue with glass.

I was alarmed! From my perspective Tom was the only good thing still there. After he left, I went to him and said "Let's do something, let's try it. Maybe we can make a go of it." That was 1993 and we decided to try. We both borrowed money from our parents and bootstrapped our way up. It has really been an American kind of story.

Mary: It is a wonderful story.

George: Yes, and it continues to be. Today we are like a university glass shop to the world. We do all kinds of custom glass work and send it to places all over the globe. Researchers find us on the internet; this week we sent glass to Russia, to Germany—we are sending it all over the place.

We have a good reputation in the glass blowing world as well. Our colleagues generally think we are doing well, and we get young glass blowers coming to us hoping to work here.

Mary: So briefly what are your thoughts about the future of borosilicate glass, of glass blowers, and of Adams and Chittenden Glass Co.?

George: From my perspective there is always going to be a need for people who can understand and work scientific glass. And although there is a burgeoning industry in 3D printing which works well for a lot of material, it is going to be very difficult for that process to replace a glass blower because of glass' unique material set.

The specific combination of characteristics makes it a difficult problem for 3D printing. A lot of the problems involve redistributing hot glass and the feedback loop necessary to perform this redistribution while keeping everything hot. That is where the glass blower comes in. You know, people, humans are still much better than machines at taking in feedback and processing that.

Microbial fuel cell fitted with glass NW flanges for replaceable membranes.

Not to mention other aspects of our work, such as innovation and creative process.

Currently computers are primitive; they only do exactly what we tell them to do. But humans can interpret; we can read written words even when all the vowels have been removed. We can fill in the blanks. I don't see that our niche as scientific glass blowers will be changing significantly, at least not in the near future. Fundamentally there is always going to be a need for glass and the people who understand it on a working, material level.

And I think our new crew of glass blowers will do well. When Tom and I were their age, our national organization, the American Scientific Glassblowers Association, was about one thousand members strong. Now it is half those numbers but glass blowers are in big demand in universities and in private research facilities. I believe that glass blowers are going to be more valuable than we have been in the 25 years of Adams and Chittenden Scientific Glass.

Mary: What is the future of the enterprise, Adams and Chittenden Scientific Glass?

George: With the help of the organization, Project Equity, we are transitioning our partnership (Tom and I are old fashioned partners) to a co-op corporation. Project Equity has been really profound in shaping this up for us. They have helped us with legal assistance, with the financial arrangements; they have educated us all and will continue to counsel us as a collective.

Also our local city government has just approved city funding in support of worker co-ops. There is a growing awareness in the greater Bay Area about worker owned co-ops as a solution for the succession of small "boomer" businesses such as ours. It is so much better than simply closing the doors when the owners retire. And ideally, this progression can help address the rampant income inequality we see these days.

The employees are learning what is involved institutionally. Our crew right now is young. They are learning how we do the glass blowing and there is still plenty to learn. For instance, scale. Those bigger machines you saw in the shop require a physical experience and understanding of how to control large amount of hot glass. I am doing most of that now, and I'm using every opportunity to pass it on. And now they will have to learn the business side also.

Mary: So, given what a high level of experience and technique it would take to run a place like this, and the unique capacity of Tom and your own unique contribution, it must be scary to hand this over to a number of people.

George: Yeah! Of course it is. Thank you for observing that.

Mary: Can you even do that?

George: We are going to find out.