Proceedings

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Symposium
on the
Art of Scientific Glassblowing

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The American Scientific
Glassblowers Society

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THE
AMERICAN SCIENTIFIC GLASSBLOWERS SOCIETY
Madison, NC

The American Scientific Glassblowers Society
P.O. Box 778
Madison, NC 27025
Phone: (336) 427-2406
Fax: (336) 427-2496
natl-office@asgs-glass.org

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2006 - 2007

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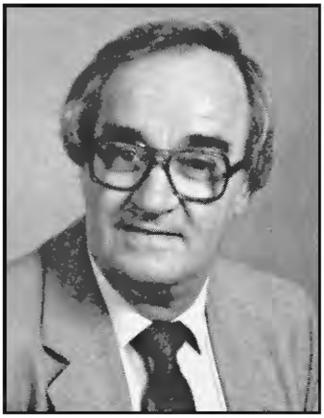
The ASGS Junior Program Turns Twenty

by
Joseph S. Gregar[a]

ABSTRACT

This paper is dedicated to the late Past-President David Chandler for having a dream and being able to see the Junior program become a reality. This paper is intended to document into the ASGS archives the history and the legacy of the Junior program.



David Chandler
June 23, 1934 – Sept. 6, 1993

There have been many "catch phrases" used to promote our annual symposia:

A Glass Act
We Could Make Glass
40 Years of Achievement
Glass Blowing "The Found Art"
Raise Your Glass to Fifty Years
"GLASSBLOWING" an Art and a Science

There were phrases that made us look into the future:

Glass – The Future
New Horizons in Glass
Building Toward the Future
Practical Glass: Past Present Future
Dimensions for Tomorrow's Technology
The Next Glass Generation / A Diverse New Beginning

Here are my two favorites that really describe the mission of the ASGS:
A Time to Share
Progress Through Education

It is my personal feeling that sharing our knowledge and education in scientific glassblowing are the two key factors that drive the Junior program.

There are three elements to the complete "Junior Program":

- **The Junior Member Workshop**
  This is a free two-day comprehensive hands-on workshop where 12 Junior members can participate in learning scientific glassblowing basics along with specially selected skill sets that are very challenging. They get up-close and personal attention from many of our skilled and accomplished member instructors.

- **The Memorial Award**
  Talented Junior members can be nominated for this prestigious award. After the candidates are reviewed, one nominee is selected through a voting process to receive a trip to the next symposium with most expenses paid.

[a] Argonne National Labs, 9700 S. Cass Ave, Chemical Sciences & Engineering Building, 200 N-101, Argonne, Illinois 60439. E-mail: jgregar@anl.gov.

- **The Memorial Scroll**
  This is a way to honor our many deceased members. Local Sections of the ASGS can include the names of members they have lost and the Board of Directors will approve their addition to the scroll. Here is a complete listing of the Memorial Award winners:

1987	Ian B. Duncanson	1994	Anastacio Bonilla	2001	Jeffrey Noyes
1888	None	1995	Michael D. Campbell	2002	Charles D. Christman
1989	Donald E. Woodyard	1996	Daniel Vogt	2003	Christopher Marshall
1990	Colin L. Chandler	1997	James R. Hodgson	2004	Kellie Wannett
1991	Laura S. Thacker	1998	Tracy Drier	2005	Philip Legge
1992	Steve M. Anderson	1999	Kenneth E. Owens	2006	Joseph Flunker
1993	Lisa Malchow	2000	Richard J. Ponton	2007	Kevin Moeller

THE MEMORIAL SCROLL

J. Allen Alexander
Robert Anderson
Bill Bate
Joseph W. Baum
Kenneth Bittner
David S. Blessing
Allan B. Brown
Michael Caselli
David Chandler
Wendell D. Clark
Ward A. Cornell
Harold E. Crampton
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Al Kalbin
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Russell Langley
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Horst Joachim Morgenfruh
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Roy W. Tiege
Matthew F. Tighe, III
William H. Tozer
Rudolf Volk
Robert J. Walsh
Karl H. Walther
Merrill Watson
Joseph West, Sr.
Edgar L. Wheeler
William A. Wilt, Sr.

JUNIOR MEMBER WORKSHOP HISTORY

The first Junior Workshop took place in 1987. It was held at the Massachusetts Institute of Technology as part of the American Scientific Glassblowers Society's 32nd Annual Symposium and Exhibition in Boston, MA.

The Junior Workshop was the brilliant idea of one of my closest friends and favorite glassblowers, Past-President David Chandler. Although David had the foresight and realized the need to help our Junior members along, sadly he was taken from us prematurely. David was President of the ASGS in 1987 and he had the dream to start a program for the Junior members as he felt our Society should help these members advance through their difficult years of learning scientific glassblowing. David recruited top glassblowers from our Society to teach the Juniors the most accepted basic techniques and the most modern methods. So from the very first year, David along with Symposium Chair, Richard Ryan, put together a great program. At that time, little did David know that his dream would be so successful; I remember him telling me that he hoped the program would continue for a few years. David was the first Junior Liaison Committee Chair, holding that position for the first few years of the program. When he asked me to take over the program in 1988, its second year, he communicated to me his dreams and vision. I later became the Committee Chair in about 1992. Now it is 2007 and we are celebrating the Junior Member Workshop program's twentieth anniversary. David would be very happy and I hope proud of the program's success. I'm very proud that David approached me for this task, and whenever anyone asks me how or when I started this program, I am very quick to give all the credit to David Chandler. It truly was his dream and he started the ball rolling; it was very easy for me to step in and continue his dream.

I would like to credit the instructors who participated in the first Junior Workshop in 1987; they did not know what to expect or how it would be accepted and at that time nobody knew if any Juniors would sign up for it. These instructors were David Chandler (University of Waterloo, initiator of the program), Larry Harmon (Carnegie Mellon University, organizer), Anne Hostetter (University of Guelph), Fred Kennedy (Texas Instruments), and Richard Ryan (Bomco Inc., 1987 Symposium Chair).

These individuals were significant in starting a program for the ASGS that would become one of the most valuable assets and successful programs in ASGS history. If any past, present or future Junior members are fortunate enough to meet any of these great individuals, please thank them for their participation, contribution and generosity.

David Chandler

Fred Kennedy

Anne Hostetter

Dick Ryan

Photos from the history-making, first Junior Member Workshop in 1987.

THE INSTRUCTORS

There have been 28 generous ASGS members and friends who have been instructors during the twenty years of this Workshop. I graciously thank each and every one of them for the continued success of the program. I would like to acknowledge them all so they can also be documented in the program's history.

Steve Anderson
Ron Bihler
Ted Bolan
Kathleen Carraro
David Chandler
Gary Coyne
Gary Dobos
Ian Duncanson
Daniel Edwards
Joseph Gregar
Michael Greico
Larry Harmon
James Hodgson
Anne Hostetter
Fred Kennedy
Owen Kingsbury
Jack Korfhage
Egon Kummer
Fridolin Kummer
Barry Lafler
Manfred Langer
Larry McCollum
Marvin Molodow
Mac Nudd
Thomas Orr
Kenneth Owens
Robert Ponton
Richard Ryan
Ottmar Safferling
Thomas Schul
Ben Seal
David Searle
Curt Sexton
Robert Singer
Janice Singhaus
Mike Souza
Robert Wallace

Junior Workshop Instructors History (*Alphabetically)*

Instructor	1987	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	TOTALS
Steve Anderson																					x	1
Ron Bihler																				x		1
Ted Bolan			x																			1
Kathleen Carraro								x														1
David Chandler	x		x			x																3
Gary Coyne				x	x	x			x					x						x		6
Gary Dobos												x										1
Ian Duncanson				x	x	x	x	x											x			6
Daniel Edwards									x		x		x		x	x	x	x	x	x		9
Joseph Gregar		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	19
Mike Greico						x					x					x						3
Larry Harmon	x																					1
James Hodgson																x				x		2
Anne Hostetter	x																					1
Fred Kennedy	x																					1
Owen Kingsbury							x		x													2
Jack Korfhage												x										1
Egon Kummer				x																		1
Fredolin Kummer			x	x		x	x	x														5
Barry Lafler				x	x			x		x	x	x			x			x	x			9
Manfred Langer						x																1
Larry McCollum																x						1
Marvin Molodow	x			x																		2
Mac Nudd		x																				1
Thomas Orr							x															1
Ken Owens																x						1
Robert Ponton		x						x		x	x			x	x		x				x	9
Richard Ryan	x					x																2
Ottmar Safferling				x		x	x	x	x	x	x											7
Thomas Schul						x				x												2
Ben Seal			x																			1
David Searle			x																			1
Curt Sexton													x									1
Robert Singer								x	x	x	x	x	x	x	x	x	x	x	x	x	x	14
Jan Singhass												x										1
Michael Souza											x											1
Robert Wallace						x																1

These are our over achievers and the backbone of the program's twenty-year history.

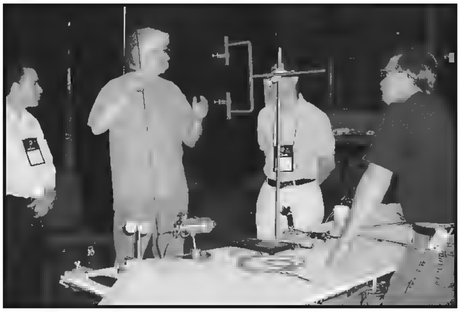
Robert Ponton, Joseph Gregar, Robert Singer, Daniel Edwards **Barry Lafler**

Daniel Edwards

Joseph Gregar

Robert Singer

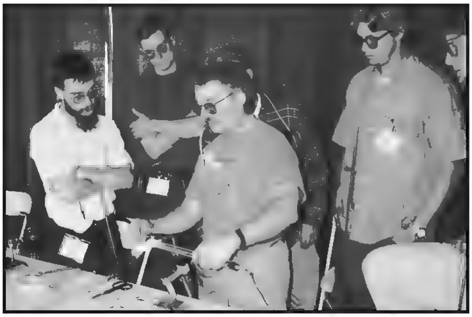

Robert Ponton




Barry Lafler

You can see the dedication of our instructors and the interest of the students from these photos.

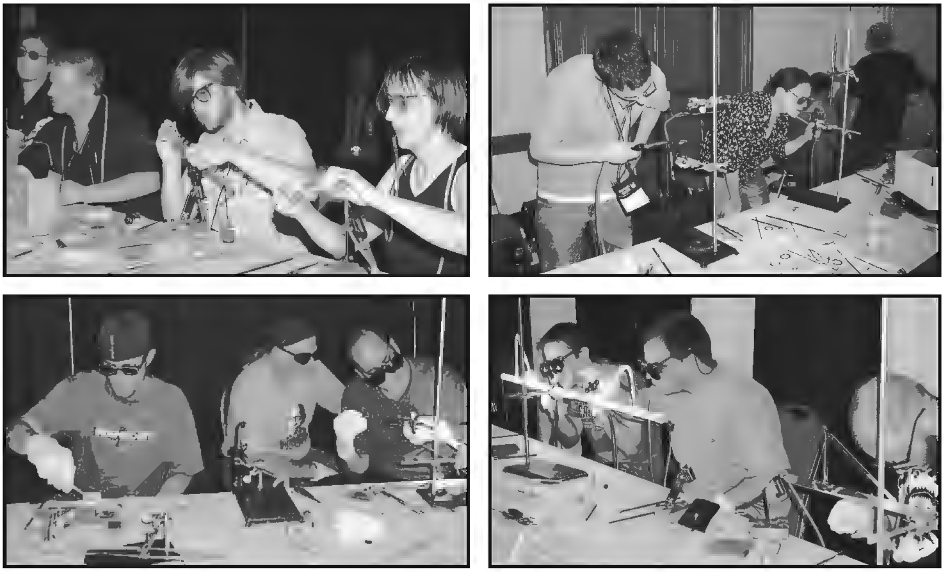
I always hear that it is hard to get people involved in contributive projects. I want it to be known that I never had to ask any one of these instructors more than once to participate. They were all very gracious and excited to help. Hopefully they all feel the same way I do: "this has been a very rewarding experience for me."

Group photos from past symposia

Group photos from past symposia

Junior members in action



Junior members in action

ASGS Junior Workshop Program

1987-2007

Here is a chronological listing of the topics and exercises that were taught over the course of the twenty years.

Boston, Massachusetts, 1987

The first Junior Member Workshop was held at the Massachusetts Institute of Technology as part of the ASGS 32nd Annual Symposium and Exhibition in Boston, MA. The program stated "Instruction and demonstration of techniques as requested by Junior Members attending." They demonstrated quartz work, optical cells, lathe and grinding techniques.

The instructors were: David Chandler, Larry Harmon, Anne Hostetter, Fred Kennedy, and Richard Ryan.

Atlantic City, New Jersey, 1988 – "Using Alternative Approaches in Glassblowing"

This Workshop was designed to instruct Junior members how to complete key glassblowing skills using three different techniques. Many times the beginning scientific glassblowing is in an industrial or production type of employment and is not allowed to be creative or imaginative. They may be taught only one way to complete a task and this Workshop showed them alternative approaches. Straight seals, "T" seals and ring seals were taught using the standard bench burner, hand torch and ring stand, and lathe techniques. This Workshop also taught Juniors how to construct simple adapters, internal drip tip adapters, cold traps and bubblers using the above techniques. If the junior skill levels were more advanced, small Dewars and sublimators were also taught. Bending techniques were also part of the program and 3" diameter ring seals were demonstrated on a glass lathe.

The instructors were Joe Gregar and Robert Ponton.

Milwaukee, Wisconsin, 1989

The first day was held in the hotel with silvering techniques with pre-mixed solutions, cutting of flat glass in both straight and free form odd shapes along with the longitudinal splitting of tubing for sample boats. There was also a panel discussion showing glassblowing tools and fixtures that can easily be made.

Day two was held in Robert Ponton's glass shop at the University of Wisconsin-Milwaukee. Lecture, questions, demonstrations and personal participation on selected topics included straight seals between different diameter tubes, how to seal and work with capillary tubing, ring seals, frit sealing, internal seals, Dewar seals, chromatography and the technique for blowing a flask inside another flask. The instructors were Ted Bolan, David Chandler, Joe Gregar, Fred Kummer, Ottmar Safferling, Ben Seal and David Searle.

Orlando, Florida, 1990 – "Vacuum Technology"

The Workshops began with a lecture on what is vacuum, quality of vacuum and leak detection techniques. Also discussed were the different types of vacuum gauges and equipment, their use and applications.

The second day was held at Scientific Glass of Florida (Mel Hart) where hands-on glassblowing was demonstrated. The instructors were: Ian Duncanson, Joseph Gregar, Fred Kummer, Egon Kummer and Ottmar Safferling.

Albany, New York, 1991

The Workshops started with the description and demonstration of several different types of glass shaping machinery: the belt sander, different types of cutting equipment and drilling holes in glass with tungsten wire. Glass lathe, different types of bench work, vacuum rack work and glass coils were taught. Specific topics were the construction of a short path distillation head, glass to tungsten seals, optical cuvettes, 'U' tube manometers and NMR tube cleaners. This was held at Advance Glass Technology in Bloomington, NY. The instructors were: Joe Gregar, Fred Kummer, Ottmar Safferling and Rob Wallace.

The second day, a lecture format "High Vacuum on Wheels" Workshop was held in the hotel. This covered the history and theory of vacuum technology with a computer drawing demonstration for vacuum systems. The second half of the lecture was how to determine what type of vacuum system to build, its cost, safety considerations, components and operation. The instructors were: Gary Coyne, Ian Duncanson, and Barry Lafler.

Dearborn, Michigan, 1992

This year offered the art of glass tooling, glass to metal seals, frit sealing, adhesives and sealants and flange forming. The second day taught the construction of multi-neck boiling flasks, coil winding, quartz to Pyrex graded seals and a "How To" demonstration for repair work. The instructors were: David Chandler, Ian Duncanson, Joe Gregar, Mike Greico, Fred Kummer, Richard Ryan, Tom Schul, Ottmar Safferling, and Robert Wallace.

San Diego, California, 1993

The mystery of sealing glass to ceramics, an introduction to beginning quartz work, quartz optical window sealing and tungsten to quartz seals. The second day we offered the construction of cold traps, condensers, how to attach a hose connection in only one attempt, cylindrical and spherical Dewars and some wet saw cutting techniques. The instructors were: Ian Duncanson, Joe Gregar. Owen Kingsbury, Fred Kummer, Thomas Orr and Ottmar Safferling.

Pittsburgh, Pennsylvania, 1994

This Workshop offered a beginning chemistry and safety lecture. Thin film coatings were discussed and demonstrated, coil winding, the assembly of coil condensers, Pyrex to quartz seals, silvering and a demonstration of how PH electrodes are manufactured. Also covered was quartz to tungsten seals, bending tubing, basic quartz working and how to seal fritted discs into tubing. The instructors were: Kathleen Carraro, Ph.D., Ian Duncanson, Joseph Gregar, Fred Kummer, Barry Lafler, Robert Ponton, Ottmar Safferling and Robert Singer.

Seattle, Washington, 1995

This Workshop taught glass to metal seals, cutting techniques, preparing tubes for the sealing-off operation under vacuum conditions, the construction of quartz Dewars and bending techniques. The second day taught vacuum forming of tubing on a graphite mandrel, re-sizing of tubing on a graphite block, the construction of small quartz boxes, hand blown micro-ware flasks, ring seals and use and applications of ultraviolet curing cements. The instructors were: Gary Coyne, Daniel Edwards, Joseph Gregar, Owen Kingsbury, Ottmar Safferling and Robert Singer.

New Orleans, Louisiana, 1996 – "Using Alternative Approaches in Scientific Glassblowing"

This Workshop was a repeat of the one offered in Atlantic City, NJ in 1988. It was designed to instruct Junior members how to complete key glassblowing skills using three different techniques. Many times, beginning scientific glassblowing is in an industrial or production type of employment and is not allowed to be creative or imaginative. They may be taught only one way to complete a task and this Workshop showed them alternative approaches. Straight seals, "T" seals and ring seals were taught using the standard bench burner, hand torch and ring stand, and lathe techniques. This Workshop also taught Juniors how to construct simple adapters, internal drip tip adapters, cold traps and bubblers using the above techniques. If the junior skill levels were more advanced, small Dewars and sublimators were also taught. Some quartz exercises were also added to the program. The instructors were; Joseph Gregar, Barry Lafler, Robert Ponton, Ottmar Safferling, Thomas Schul, and Robert Singer

Albuquerque, New Mexico, 1997

Featured was the construction of quartz plasma tubes, a demonstration on the working characteristics and techniques for successfully working aluminosilicate glass and helpful techniques and demonstration on the "Mystery of Repair Work." We demonstrated making square drawn tubing from round tubing and drilling holes in glass. A lecture was given on understanding and how to correctly read the typical measuring instruments commonly used in scientific glassblowing. We also tutored in-situ glassblowing techniques for building vacuum rack equipment and how to make the uncommon "blow out seal." The instructors were: Daniel Edwards, Joseph Gregar, Mike Greico, Barry Lafler, Robert Ponton, Ottmar Safferling, Robert Singer, and Mike Souza.

Minneapolis, Minnesota, 1998

This Workshop taught hands-on glass tooling of joints, stopcock barrels, small flasks and hose connections, the construction of multi-neck flasks with joints, screw threads and thermowells, the assembly of separatory funnels and Kuderna-Danish flasks by using special kits, and the use of screw thread connectors. We also showed a new graphite holder for making special screw thread adapters and the tricks to make splicing capillary tubing fun and easy. Also featured was a technique to cut ground joints on an angle in preparation to splice onto flasks, the construction of cold traps and simple vacuum manifolds, leak detection, cutting tubing using the hot wire cutting technique, and basic quartz glassblowing techniques. Also demonstrated were techniques necessary for sealing fritted discs into tubing, the construction and purpose of glass bellows in jacketed apparatus, and more basic quartz glassblowing exercises including how to make quartz bends. The instructors were: Gary Dobos, Joseph Gregar, Jack Korfhage, Barry Lafler, Ottmar Safferling, and Robert Singer and Janice Singhass.

Princeton, New Jersey, 1999
This Workshop featured basic quartz working techniques, how to select the correct size quartz filling rod and size or type of torch necessary for the work, how to add solid quartz rod handles or loops onto quartz tubing and how to make quartz bends, a technique for making small borosilicate flasks blown directly on standard taper joints, the construction of small vapor traps, "T" and "Y" adapter tubes, and a technique for repairing broken ground stirring rod shafts. We featured the construction of borosilicate break seals, sealing fritted discs into tubing and making gas dispersion tubes. More advanced quartz working techniques included making ring seals through the side of quartz tubing and the construction techniques for making a small quartz box. We also showed how to cut glass with a portable hand diamond saw. The instructors were: Daniel Edwards, Joseph Gregar, Curt Sexton and Robert Singer.

Lake Tahoe, Nevada, 2000
This Workshop featured basic glassblowing techniques for straight seals, side seals and bends in both borosilicate and quartz tubing, small cold traps, techniques for welding quartz plate, splicing square to round tubing and splicing capillary tubing, techniques for attaching quartz flanges onto CFQ tubing, ring seals for thermowells, and quartz to borosilicate graded seals. Also techniques for installing vapor arms on glassware, as found on pressure equalizing addition funnels. The instructors were: Gary Coyne, Joseph Gregar, Robert Ponton and Robert Singer.

Colorado Springs, Colorado, 2001
This Workshop featured basic borosilicate and quartz working techniques for those who need them including straight seals, side seals and bends. Students learned how to make the top end of a jacketed distillation head with the Dewar seal and the side ring seal through the body, the technique to attach quartz flanges onto quartz tubing, the importance of using a remote safety blowing apparatus for working on possibly contaminated systems, and how to make a remote blowing apparatus that students took home with them. More glassblowing fundamentals were taught to help improve skills: make glass coils and construct coil condensers, techniques to weld quartz plate together to construct tanks and boxes and to assemble separatory funnels by using special kits that were offered. The instructors were: Daniel Edwards, Joseph Gregar, Barry Lafler, Robert Ponton and Robert Singer.

Point Clear, Alabama, 2002
This Workshop featured basic borosilicate glass and quartz working techniques including straight seals, side seals and bends, how to construct an NMR tube cleaner, techniques for making glass bellows, optical quartz window sealing, re-size tubing, quartz boxes and glass tooling, sealing off tubes under vacuum, leak detection, vacuum forming tubing and quartz Dewar construction. Glassblowing fundamentals to help improve skills using both quartz and borosilicate glass. The instructors were: Daniel Edwards, Joseph Gregar, Michael Grieco, James Hodgson, Larry McCollum, Ken Owens and Robert Singer.

Cleveland, Ohio, 2003

The students learned how to make round bottoms on 70 mm diameter borosilicate tubing, how to add smaller tubes onto the rounded ends and fabricated small quartz boiling flasks. A glass cutting workshop included: dry score cutting and wet saw techniques on both flat glass and tubing, thermal shock cutting of tubing using flame techniques and the hot wire method, and techniques for slicing tubing lengthwise. For those who needed them, this Workshop also featured basic borosilicate glass and quartz working techniques, how to seal flat quartz plates into quartz tubes, construct cylindrical Dewars, silvering techniques, and how to weld quartz plates together for tanks and boxes. Glassblowing fundamentals to help improve skills using both quartz and borosilicate glass. The instructors were: Daniel Edwards, Joseph Gregar, Robert Ponton and Robert Singer.

Saratoga Springs, New York, 2004

The students learned how to do "In-situ" glassblowing or rack work for building vacuum rack equipment, sealing quartz frits into quartz tubing, how to make the slightly known "blow out seal," how to drill holes in glass and graphite holders for working with screw threads. For those who needed them, this Workshop also featured basic borosilicate glass and quartz working techniques. Construct quartz boats for holding semiconductor wafers using fixtures and quartz rod, blown micro flasks directly onto ground joints, sealing on hose connections and disc style gas dispersion tubes. Glassblowing fundamentals to help improve skills using both quartz and borosilicate glass. The instructors were: Daniel Edwards, Joseph Gregar, Barry Lafler and Robert Singer.

Bloomingdale, Illinois, 2005

This Workshop showed techniques for quartz Dewars, coil winding, coil condenser assembly, low form Dewars, a vacuum swivel holder and basic quartz working techniques. There was a Vacuum Technology section featuring vacuum leak detection and vacuum seal off techniques. Glassblowing fundamentals to help improve skills using both quartz and borosilicate glass. The instructors were: Ian Duncanson, Daniel Edwards, Joseph Gregar, Barry Lafler and Robert Singer.

Manhattan Beach, California, 2006

There was an opening lecture on Sodium Migration. Optical flat grinding, remote safety blowing apparatus, tungsten to glass seals and quartz flanges were taught. Also, vacuum forming tubing, optical window sealing, and basic quartz working. There was a short course on "Strain in Glass." Techniques and theory of polariscopes were taught. Juniors made their own polariscope to take home. Glassblowing fundamentals to help improve skills using both quartz and borosilicate glass. The instructors were: Ron Bihler Gary Coyne, Daniel Edwards, Joseph Gregar, James Hodgson, Robert Ponton and Robert Singer.

Portsmouth, Virginia, 2007

This year the Workshop program was cut down to only one day. For those who were interested we held a "Panel Discussion" for a few hours the evening preceeding the Workshop. In this evening format, our instructors brought in what we call "Tricks of the Trade" and interesting tools. There was also a "Questions and Answers" portion of the evening where the students could ask our panel any questions they had. Then, "Different Approaches to Scientific Glassblowing" emphasized how to use different techniques to accomplish a completed piece. Bench burner and ring stand/hand torch techniques were taught along with alternative methods and techniques for glassblowing basics such as straight seals, side seals and ring seals. Students were also taught the technique for welding quartz plates together. The instructors were: Steve Anderson, Joseph Gregar, Robert Ponton and Robert Singer.

There are many benefits of the Junior program; the main one is that many times we are able to give the Junior member something really special. This is truly a great "member benefit." After several workshop experiences, they understand the value of their membership and association with the Society and many Junior members have become contributing members of the ASGS.

Here is a small list of national contributions from past Junior members:
Sean Adams: National Director
Steve Anderson: National Director, Education, Awards Committee Chair
Michelle Archer: Technical Papers Coordinator
Waine Archer: ASGS Treasurer
Karen Carraro: National Director
Charles Christman: ASGS Secretary, National Director
Gary Coyne: ASGS President, ASGS Secretary, References & Abstracts Committee Chair
Patrick DeFlorio: National Director
Tim Drier: National Director
Tracy Drier: Questions and Answers Committee Chair
Ian Duncanson: ASGS President, ASGS Treasurer
Gary Gregston: Methods & Materials Committee Chair
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Robert Ponton: ASGS President, National Director, Symposium Chair, Auctioneer
Edwin Powell: ASGS President, National Director, Membership Committee
Hans Rohner: National Director, Outreach Committee Chair
Brian Schwandt: National Director
Robert Singer: ASGS President, National Director
Richard Smith: ASGS President, National Director

There are many more Junior members who have contributed to the National ASGS by being on the President's standing committees and symposium committees. Many Junior members have also served as officers and committee members within their Sections. Unfortunately these records were not available, but I would like to thank all Junior members who have contributed and shared their time and talents with the Society.

This program has rewarded me with twenty exciting years. I would like to thank the ASGS and David Chandler for allowing me to head this program and again I thank all the members who have helped me make the Junior Program one of the longest running successful programs of the American Scientific Glassblowers Society.

The Conglomeration Of Accumulated Assortments Of The Hodgepodge Collection Of Simplistic Ideas That Leaked Out Of My Aging Brain This Past Year

by

Robert J. Ponton[a]

ABSTRACT

This paper will lightly touch on a variety of topics to include two different Schlenk line designs that allow for easier and safer use by the end user, a simple short path condenser, modifications to a tile saw for glass shop use, and a device to grind windows and fritted discs.

The idea of a technical paper with more than a single idea was first presented in the ASGS program by Dave Daenzer some years ago. He presented a collection of ideas from the Great Lakes Section. In that spirit, I will present a number of small ideas collected into one presentation. None of these ideas are presented as the best or only way to approach these issues. They are simply things that work for the applications for which I have used them. If they work for you that is great. If they do not, maybe you can modify them to suit your particular needs. I would welcome any positive modifications or improvements to that which I present today and look forward to seeing those ideas presented here next year or in *Fusion*.

TILE SAW MODIFICATIONS

Like most glass shops, I have a standard 14 inch cut-off saw. While this accommodates most glass shop needs, the 4-inch depth of cut is sometimes rather limiting. Some of the higher end cut-off saws have the table attachment that can turn the saw into something akin to a table saw. Most glass shops do not have this attachment and we are stuck with only being able to make a 4-inch cut. (Photo 1)

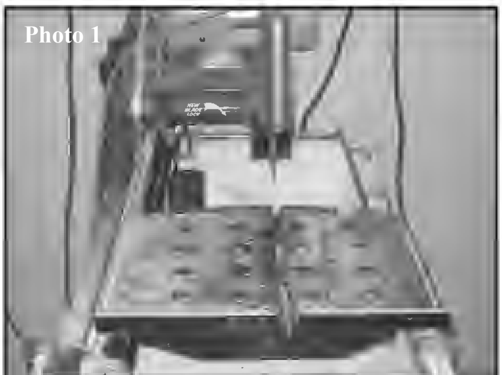


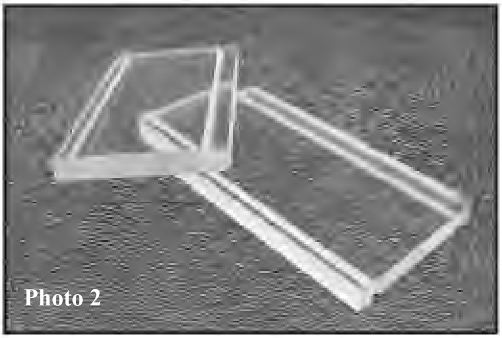
Photo 1

In addition to the standard cut-off saw, I also have a contractor's tile saw. This saw is a floor model provided by MK Diamond Products Company, model MK-101. At a cost of under $900.00 this saw may well fit many small shop budgets. The standard table provided with this saw is well designed for its intended purpose which is cutting floor tiles. Modifications need to be made to make this saw a better fit to the glass shop.

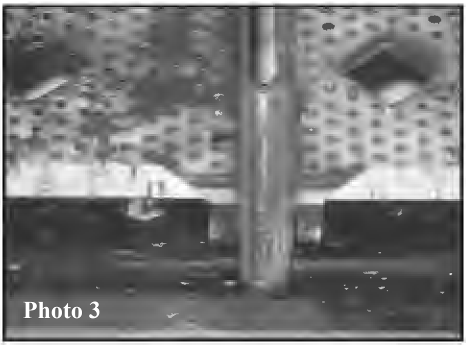
The first modification made was to replace the rough diamond blade with a silicon carbide blade. Given the projects for which I use the saw, the thinner carbide blade made for a better option. The fine diamond blades used on our standard cut-off saws are also a

[a] Institute of Polymer Science, University of Akron, Akron, Ohio 44325. E-mail: ponton@uakron.edu.

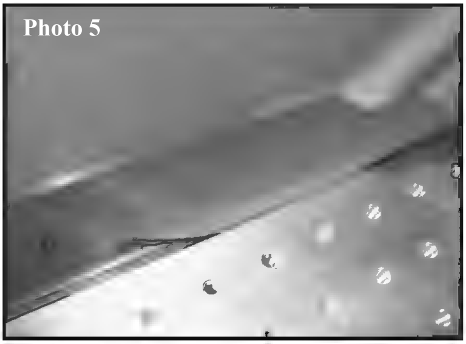
good fit for this saw. Find the blade that best fits your application. My reason for the silicon carbide blade has to do with narrowness of the blade and cost. For one of the projects I need a narrow kerf and the silicon carbide blade meets this requirement. (Photo 2)

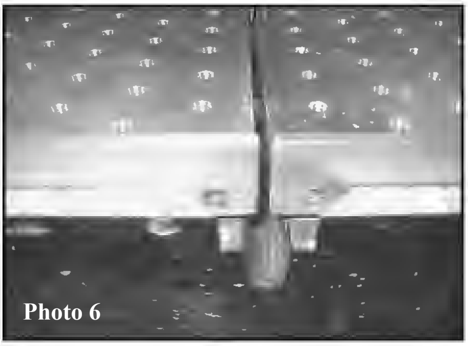


The second modification requires the assistance of a machine shop. I am fortunate to have a good machine shop available to me at the University of Akron. I had our machinist make a new table top for the saw. It is made of 3/8 inch thick aluminum plate sized to cover the existing table. By careful positioning, the space between the blade and the table can be brought to a minimum. This allows for close cuts of glass plate with full support of the material. The end point where the fence and the table top meet is also closely controlled to give full support of the work piece. (Photos 3 and 4)



The table top is further enhanced by a series of holes across the surface equally spaced and tapped to accommodate ¼ – 20 screws. With aluminum jigs, glass plate can be held firmly in almost any position. It is important to firmly secure all work on the table. (Photos 5, 6 and 7)





One of the projects I use this equipment for is to cut a grove in a ¼ inch thick glass plate. The depth of the groove must be constant across the length of the "window." To set the depth, I use a standard lab jack between the table and the body of the saw. (Photo 8) Once the depth is set, I remove the jack and proceed with the cut. A second common project is the manufacture of small glass boxes used as molds for polymer resin. (Photo 9)

The modifications made to this inexpensive tile saw have greatly enhanced the product capability of my shop. As with any new tool, I have found that once it makes its way into the shop, uses beyond what it was first purchased for become apparent.

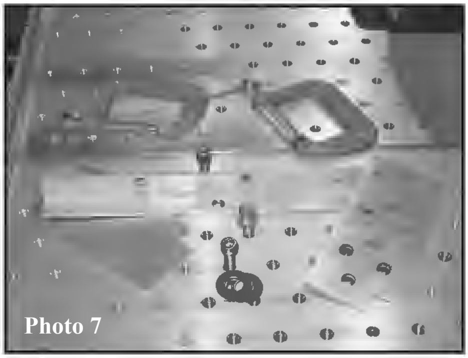


Photo 7

CAUTION
Given that the blade is mounted above the table and the silicon carbide blades are relatively aggressive, the saw has a tendency to pull the work into the blade. This can result in a violent and total destruction of the blade. With this in mind, I wear leather gloves and a face shield when using this saw. Keep a constant outward pressure on the table and feed the work very slowly. (Photos 8 and 9)


Photo 8


Photo 9

SCHLENK LINES

In recent years the Schlenk line has become a standard piece of equipment in many research laboratories. While the Schlenk line has become commonly used, there are many variations on the theme. I offer two more variations here. Most of the variations on Schlenk lines have to do with stopcock design and placement. My first offering does exactly that.

The first Schlenk lines with which I came in contact utilized glass double oblique vacuum stopcocks or glass double oblique pressure stopcocks. These stopcocks work exceedingly well and have the advantage of compactness. A single stopcock that will access both the gas and vacuum manifold make these ideal. The downside for these stopcocks in the eyes of the researcher seems to be the maintenance of the stopcock grease and possible contamination of the grease with their product. (Figure 1)

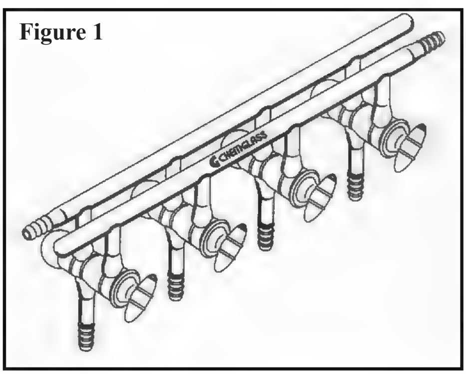


Figure 1

More and more, the researchers look to utilize Teflon high vacuum stopcocks to eliminate the issue of the grease. Given the design limitations of the Teflon high vacuum stopcock, two stopcocks are now needed to accomplish the same job of the glass double oblique stopcock. The May 1997 issue of *Fusion* features an article by Mike Souza from Princeton University that discusses the different approaches used in his design and the Wayda/Dye Line. I recommend you read this well-written article.

Commercially made Schlenk lines using 90 degree Teflon high vacuum stopcocks are most often used in the wrong configuration. That is to say the manifolds are set up with one stopcock facing the operator and the second facing 180 degrees away from the operator. This makes the operation of the Schlenk line both inconvenient and, more importantly, unsafe. These manifolds were originally designed with the stopcocks intended to be one over the other so both would be visible and accessible to the operator from the front. The example on the left shows the proper configuration for safe use and the example on the right shows the incorrect configuration. The latter is however the more commonly used configuration. (Figures 2 and 3)

Figure 2

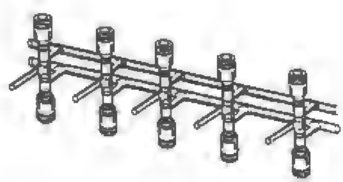
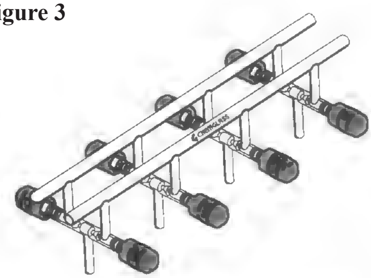


Figure 3



I believe the reason these are so often used incorrectly comes from the design of the glass double oblique design where the single stopcock hangs below the manifolds so the rubber hose that is usually attached to the stopcock hangs down. Researchers want the rubber hose to hang straight down. Given that the rubber or Tygon tubing is flexible, it will hang just fine off the taps coming out from the Schlenk line used in its proper configuration.

Photo 10

The Schlenk lines I have been making the past couple of years use the Teflon high vacuum stopcocks available from a number of vendors. I start by sealing two of them together in the lathe. Using a three inch ribbon burner on my hand torch, I make a U bend. In the center of the bend, I attach an 8 mm medium wall tube. This is the tube the researcher will use to connect their apparatus to. I next bend the sidearm tube 90 degrees to the barrel of one of the stopcocks and again at 90 degrees to bring the tube back in the upright position. This configuration allows for both stopcocks to face the researcher when using the line. It also

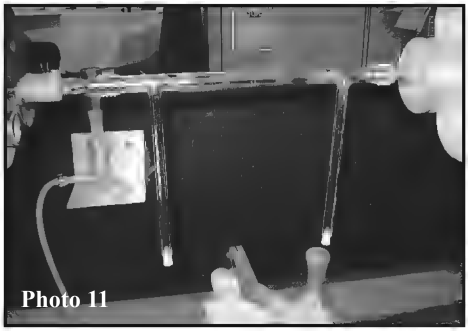


Photo 11

keeps the stopcocks relatively close together, which in turn shortens the length of the Schlenk line. (Photos 10 through 16)

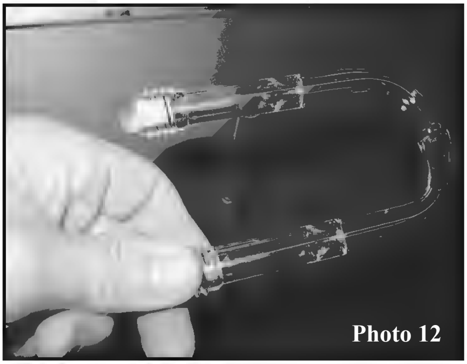


Photo 12


Photo 13


Photo 14


Photo 15

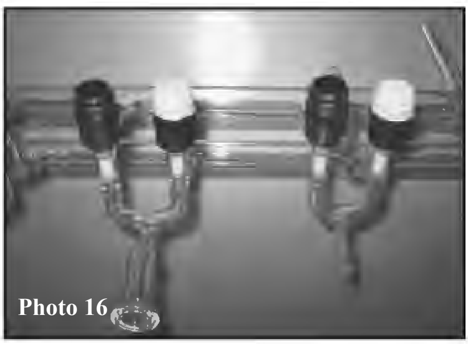


Photo 16

Figure 4

Safety Rules for Using a Schlenk Line

A Schlenk line is a dual line manifold connecting Vacuum and Gas to a common take off port. This line has different colored stopcocks to aid in the safe use.

GAS Stopcocks are painted with Yellow Caps

Vacuum Stopcocks are Black

Safe use of stopcocks:

1- All stopcocks should be opened using 2 hands. One to hold the barrel of the stopcock and the other opens or closes the valve using thumb and 2 fingers. DO NOT OVER TIGHTEN VALVES, THEY ARE MADE OF GLASS.
2- Open and close all stopcocks slowly. A quick rush of air or vacuum where not expected can cause serious problems. Open and Close slowly !!!!
3- Wear your safety goggles at all times.

To further help with ease of operation and safe use, I color code the gas side of the line by painting the caps of the stopcocks a different color than the vacuum side. I also provide a safety sheet indicating this safety modification with each Schlenk line. A copy of this sheet is provided here. (Figure 4)

The second design for a very

simple Schlenk line is most generally suited for the undergraduate laboratories. It really has only one glass manifold. It uses the glass double oblique stopcock attached to the vacuum manifold with a standard 24/40 joint. The second arm of the stopcock is hooked directly to the gas feed using flexible tubing. A back flow bubbler can be easily attached between the gas source and stopcock if deemed necessary. Beyond the simplicity of design and construction, this design offers the ease of quick repair when the student breaks the stopcock. A couple of spare stopcock assemblies in the drawer make replacement quick and easy. (Photos 17 and 18)

Photo 17

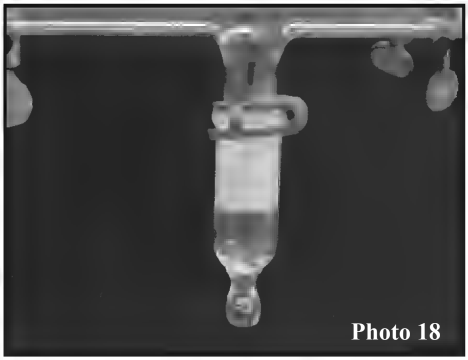


Photo 18

Both systems noted above have their particular limitations but serve the needs of the research or teaching labs in which they are used. The key for all of us is to endeavor to find out what the needs are of those requesting equipment from us. A good analogy is the organic chemist who asked me to make a high vacuum system for him like the one his buddy used. What he showed me was a 4 stopcock manifold attached directly to a mechanical pump that smelled like every known organic solvent combined. It was better than the manifold attached to the water aspirator but definitely not a high vacuum system. All he really needed was the water aspirator. We settled on a manifold with a trap between the manifold and the pump. Try and match the apparatus to the need. It is not always easy.

SHORT PATH CONDENSER

This simple approach to the standard short path condenser is offered in brief with the hope that it may offer an alternative to the common method of building the apparatus in two steps. A solid approach to making this piece is to build the main body and then anneal that before attaching the top. This alternative will show how to construct the condenser all from one end, allowing you to flame anneal at the end followed by oven annealing at the end of the day.

Start by attaching a 14/20 inner standard taper joint to a length of 22 mm standard wall tubing 19-20 cm long. (Photo 19) This will make up the main body of the condenser. Follow this by pushing up a "Maria" on a length of 12 mm standard wall tubing. Immediately past the "Maria," pull off the 12 mm and replace with a length of 6 mm standard wall tubing. Repeat this to the other side of the "Maria" however

Photo 19

replace with 8 mm standard wall tubing. Flame cut and slightly flair the 8 mm tubing approximately 4 cm from the “Maria.” Cut the 6 mm tubing approximately 8 cm from the “Maria” and set aside.

Fabricate whatever design top you are planning on using and set that aside as well. For the purposes of this paper and the demonstration later, I will use the most common top design. Set three hose connections aside with one having a short piece of 8 mm tubing sealed off to one side.

Photograph 20 shows the holders I use in the construction of this apparatus. They are simple and consist mainly of standard tubing and the glassblower’s friend, masking tape. I use these over and over again until one of them decides to commit suicide by leaping to the floor. Holder #1 is simply a short length of 10 mm medium wall inserted with masking tape on each end into a 14/20 outer standard taper joint. Holder #2 is a length of 16 mm standard wall tubing shoulder sealed to a 5 mm length of tubing cut to 1.5 cm. A blow-by hole is made in the shoulder and masking tape is wrapped in two places to fit easily inside on the 22 mm main body of the condenser. Holder # 3 is a 10/30 inner joint with a handle bent at 90 degrees to the joint. Lastly is a 14/20 cap. (Photo 20)


Photo 20

To construct the condenser, place the main body into the holder with the 10 mm centering tube in it. Slide the “Maria” with the 6 mm side down. The 6 mm tube should rest inside the 10 mm centering tube. Cork the open end of the 22 mm and shrink the 22 mm onto the “Maria.” Work this seal thoroughly and add the first hose connection with the 8 mm side tube. Follow this by adding the second hose connection immediately next to the “Maria.” Warm the whole piece and connect the two hose connections using the 8 mm attached to hose connection #1. This will allow you to blow on both sides of the “Maria” after making the top ring seal. Remove the holder from the main body of the condenser and make the ring seal between the 8 mm inner tube and the 22 mm outer body. Add the last hose connection, flame anneal a bit and follow by adding the top, the glass rod brace, and final flame annealing. Set the apparatus aside and anneal at the end of the day. (Photos 21 through 26)


Photo 21

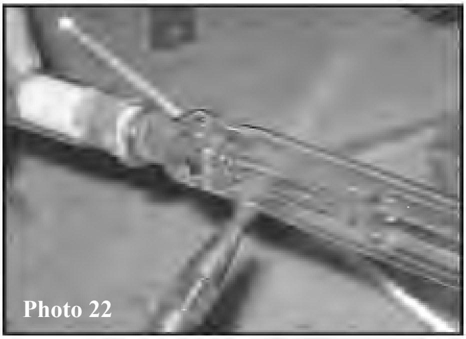


Photo 22

Photo 23

Photo 24

Photo 25

Photo 26

WINDOW & FRITTED DISC JIG

At times I have needed to re-size borosilicate and quartz windows for various applications. I usually carry a small number of sizes ranging from ½ inch to 4 inch borosilicate windows and a smaller selection of quartz windows. (Photo 27)

When a job would require a size I did not carry, I would re-size using one of the following tried and true methods of making a window. The first is to wax a larger window onto a length of tubing the same size as what is needed and carefully grind it down to size on the belt sander. The advantage to this method is that the wax will come off leaving no residue or marks on the window. The disadvantage for me is that on more than one occasion I would be a little too aggressive and the window would move or fly off the end of the tube. The second and more secure way to hold the window in place is to cement it on with a UV curing cement, and after grinding it, run it through the annealing oven to release the window. This works very well but it always leaves a very slight shadow where the cement held the window to the tube. For most applications, this does not seem to matter. I always worried that the end user would have issues with this shadow.

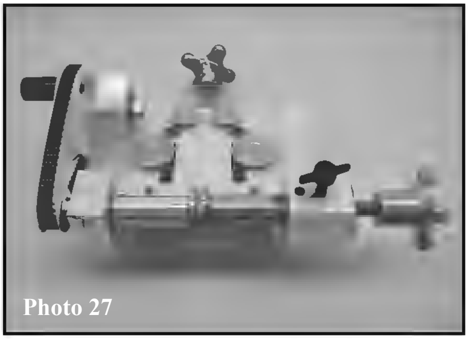


Photo 27

I asked our machinist if he could make a jig that would re-size the windows using no cement or wax to hold the glass. The device he made fits on my belt sander and, with removable discs of various sizes, I can make windows of any size. I rough cut glass or quartz plate to the approximate size, place them between the appropriate stainless steel discs and grind them. (Photos 28 and 29)

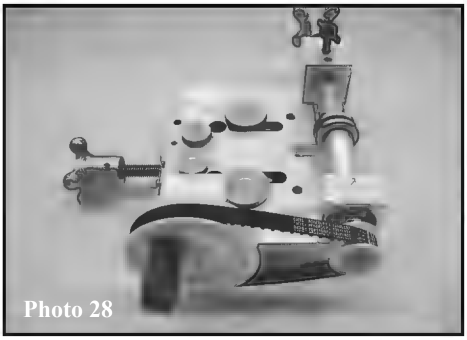


Photo 28

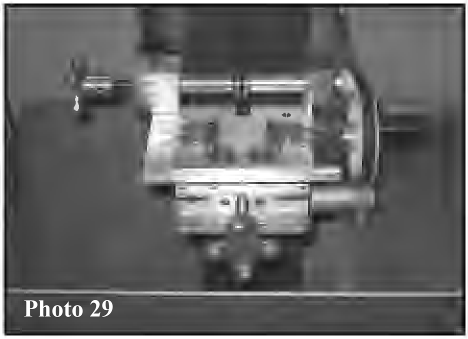


Photo 29

This device also works very well for grinding fritted discs to match the inside diameter of whatever size tubing you are using.

ACKNOWLEDGEMENTS

This paper would not have been possible without the support of the University of Akron, Institute of Polymer Science, the skills and design input of our machinist, Mr. Ed Laughlin, and my boss, Lynn Ponton, whose skill with the computer helped me assemble this document.

Chemglass granted permission to use drawings from their catalog; thanks David.

Photos by Stumpf Ganooter.

Continuing Studies Of Sodium Migration In Glass Caused By Flamework

by
Gary Coyne[a]

ABSTRACT

This paper focuses on the changes in solubility in borosilicate glass caused by heating the glass with a gas-oxygen flame for different amounts of time and at different temperatures. Also discussed are issues of sodium loss caused by this heating and the role of sodium as a fluxing (and solubility) agent in glass.

The properties of glass (viscosity, index of refraction, etc.) typically refer to the glass as shipped by the supplier. However, after having observed a decrease in the sodium content in glass due to flameworking in a previous paper,[1] we are left with a question as to what the characteristics are of glass after it has been flameworked. It is unlikely that we are adding anything to the glass composition (beyond inorganic dirt caused by inadequate cleaning of the glass), but if we are removing material, then we are changing the material ratios from the original glass composition.

INTRODUCTION

This paper focuses on the changes in solubility of borosilicate glass in relation to the time and temperature that the glass is heated (by a glassblowing torch).

The glass matrix is typically composed of three basic components:

- Formers: anything that can be melted into a glass, typically and often SiO_2
- Stabilizers: things that help prevent the glass from dissolving such as AlO_2, PbO, and $CaCO_3$
- Fluxes: things that help the glass melt at a lower temperature such as Soda Ash (Na_2CO_3), or Potash (K_2CO_3)

In borosilicate glass, these would be divided as following (by weight):

- Formers: SiO_2 (≈ 80.5%)
- Stabilizers: boric oxide (B_2O_3-12.9%), aluminum oxide (Al_2O_3-2.2%)
- Fluxes: sodium oxide (Na_2O-3.8%), potassium oxide (K_2O-0.4%), and calcium oxide (CaO-0.1%)

There is an interesting balance between the stabilizers and the fluxes in that if the ratio of fluxes to stabilizers is high, the glass is easier to melt but the glass is more soluble. On the other hand, if the stabilizers have a higher ratio to fluxes, the glass becomes easier to devitrify. Thus, the glass we receive is balanced for optimum use.

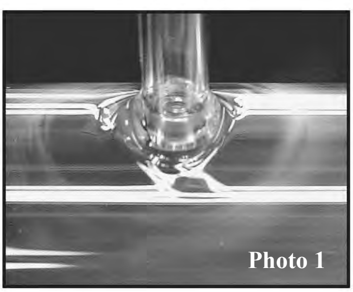


Photo 1

In the paper presented in 2001, sodium migration initiated by a gas-oxy flame on glass was verified. The "whitish" deposit seen by glassblowers (Photo 1) turned out to be Na_2O. Observant glassblowers

[a] Chemistry Glass Department, California State University, Los Angeles, Los Angeles, CA 90032. E-mail: gcoyne@calstatela.edu.

[1] Gary S. Coyne, "An Analysis of the Sodium Oxide Deposition on Borosilicate Glass Caused by Flame Working," *Proceedings of the 46th Symposium on the Art of Scientific Glassblowing* (Colorado Springs, CO 2001): 2-11.

have seen a void of sodium emissions immediately adjacent to a heated glass region and extra emissions a short distance away when flame annealing (Photo 2). The focus of that paper was both to verify what the content of the whitish deposit was and that placement of the torch's flame on the glass changed the concentration of sodium in the glass (see Table 1). Key points on Table 1 should be compared to the control sample on the left of unheated borosilicate glass. The second sample to the left shows the amount of Na_2O collected as a forced deposit (see the whitish deposit on Photo 1). The two samples on the far right display two opposite sides of the same sample of a flat borosilicate glass plate. The sample on the far right shows the quantity of Na_2O on the side directly hit by a torch while the second sample from the right shows the amount of Na_2O determined on the other side of the same sample. Sodium is both driven away from regions under the flame of a torch into other regions of the glass object as well as driven off the glass into the atmosphere.


Photo 2

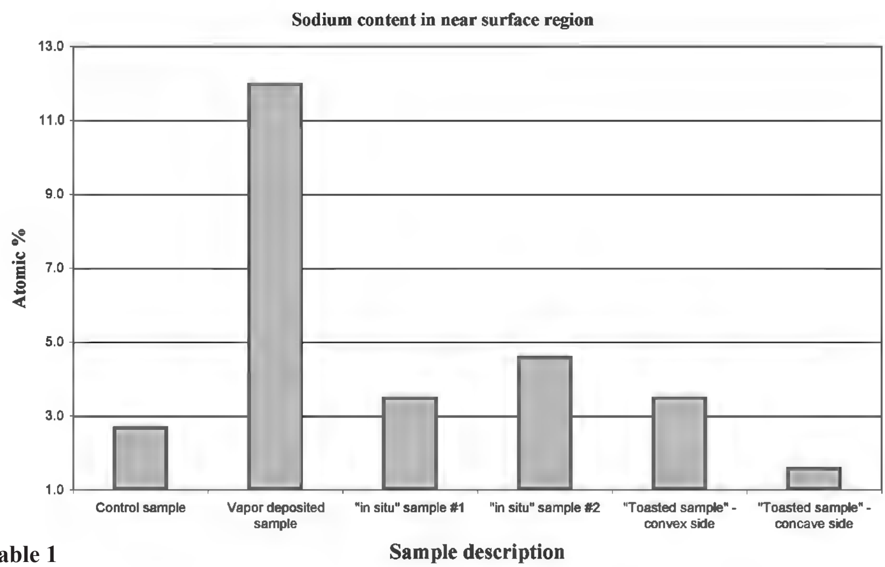


Table 1

The changes in how glass flows caused by overheating glass are well known to glassblowers as can be seen when you lightly heat glass to a "rosy" state and then pull the glass to a point. As seen in Photo 3, the pulled region is graceful and smooth. If the same glass is heated to an extremely high (white hot) temperature and pulled, the glass has "chunky" regions (Photo 4) that do not flow.

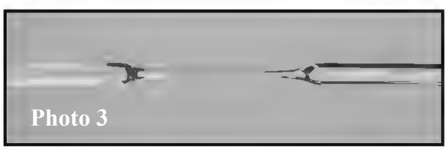


Photo 3

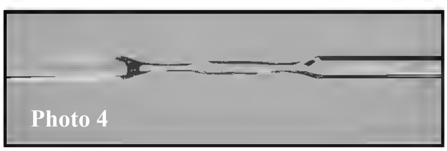


Photo 4

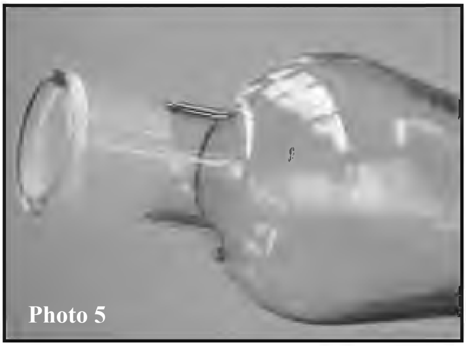


Photo 5


Photo 6


Photo 7

One example often encountered by glassblowers of this phenomenon is seen after doing a flame-cut where a small "burnt" section of glass does not flow into the rest of the glass as seen in Photo 5. The close-up, seen in Photo 6, also shows a full line of "changed glass." These regions will not completely anneal because the composition of the glass has changed as shown in Photo 7. It should be pointed out that there is no profound strain in the regions of the "burnt" glass, rather a continual region of strain at the seal similar to a union of two glasses with fairly similar, albeit somewhat different, coefficients of expansion. In other words, the general properties of this "new glass" is not substantially different, but its ability to flow into and with the original glass composition is limited.

This brings up the primary question of this paper: if one can use the dynamics of glass flow as an indicator of the changing composition of glass caused by flameworking, can there be other indicators that change as well?

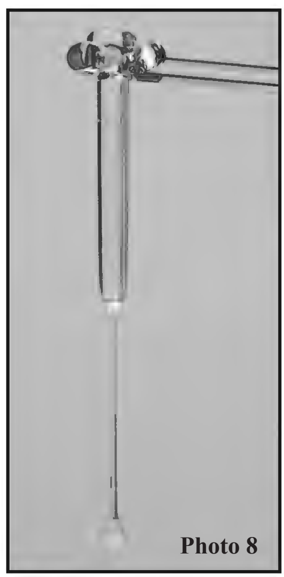


Photo 8

About fifteen years ago, I did an experiment with my glassblowing class where two glass rods (one borosilicate and one soft glass) were heated on one end to create a ball and suspended in a 5–10% solution of HF. Over the period of a week, the students recorded the diameter of the rods and the balls. Within a day or two, the soda-lime glass rod was gone (displaying the greater solubility of that glass) and by the end of the week, the borosilicate rod and ball had significantly decreased in size as seen in Photo 8. Unfortunately, since the class only had access to a cheap caliper, any measurements of different solubility rates were rather suspect.

While the solubility of glass in HF may seem not relevant as HF is not commonly used in or around most laboratories, the base bath is. Base baths are best used for the final removal of silicon grease from joints or stopcocks. While a base bath does remove silicon grease, as a glass stripper it also removes glass. Glassware that is left in a base bath for some time is often easy to spot as seen in Photo 9 where the surface is etched along regions of minor surface scratches.

Photo 9

If any dirt is on the glassware, the dirt is removed along with some layers of glass. Students see the removal of the dirt as a sign of easy cleaning and find the base bath a convenient tool as it provides an avoidance of elbow grease. Thus, students feel that "if 15 minutes is good, an hour is better, and a weekend is just right" for cleaning glassware. The use of HF in this experiment, as opposed to a base bath, was simply to speed the attack on the glass and thereby save time.

THE EXPERIMENT

After some analysis, it was decided to heat the glass to a rosy level for 10, 20, and 40 seconds and then to heat the glass to a white-hot amount for 10, 20, and 40 seconds. In addition, a sample of borosilicate glass that had not been heated and a piece of quartz (also unheated) were added to the test as controls. Lastly, a piece of devitrified glass was added to the test—this latter item was added mostly out of curiosity.

The dynamics of this test presented a bit of a quandary: how to heat glass by a torch to a pre-determined temperature and hold that for a defined period of time. After much analysis and examination of the equipment available, the answer was that this was not possible. While it cannot be determined what specific temperature glass is heated to, it was possible to bring the glass to a uniform temperature by simply observing the color of the glass. Thus, when this paper refers to a "rosy temperature," what is being referred to is the temperature to which glass is brought for simple operations. The "white hot" temperature is the temperature glass is brought to when one is heating the glass too much as it is likely to start a re-boil of the glass. In the end, it was fairly easy to maintain the temperature of the glass at a fairly even and consistent temperature level throughout. Needing to keep my eyes on the glass, I had a student time my activities: I told him when the glass was up to temperature and he told me when to stop.

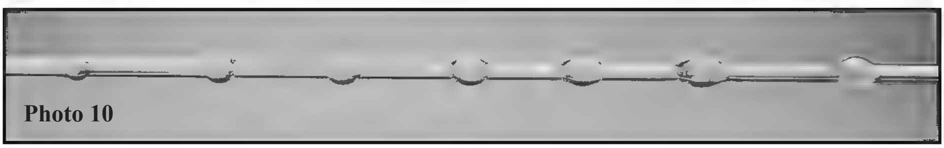


Photo 10

Once the samples were generated as seen in Figure 10, a cut was made off to one side of the middle of each sample on a diamond saw. Once one side was cut, the remaining piece was placed vertically within a previously cut glass tube. The cut glass tube (with the sample inside) was then filled with paraffin to stabilize and support the sample. Now, with the sample supported, an equal width-sized piece from all the samples was sawed off on the wet saw. In Photo 11 you can see a sample after it has been cut and a tube still filled with a sample and paraffin. The wax was burnt off in an annealing oven overnight. The next morning, each sample was dried in an oven at 250° C for 30 minutes, weighed, and measured in thickness and diameter.

Photo 11

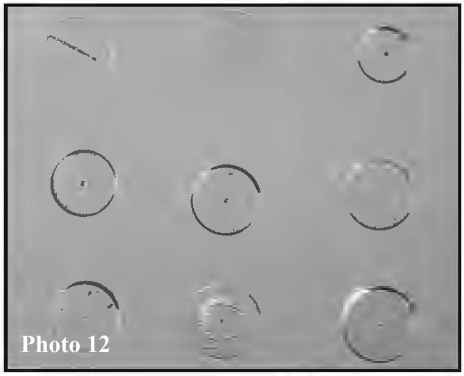


Photo 12

Each sample was then placed in a plastic beaker containing 60 ml of full strength (48-50%) HF acid for one hour. In addition to the glass sample, a Teflon-covered magnet bar was placed in the plastic beaker and the beaker was placed on a Magno-stirrer. The speed of the Magno-stirrer was set fast enough to force the glass disk to tumble around in the beaker exposing all parts of the glass but not so fast as to cause any splashing out of the beaker. The HF was used once for each sample and the remains were poured in a collection bottle. After a thorough rinsing, a final rinse in distilled water, and drying of the sample (for 30 minutes at 250° C), each sample was again weighed and measured. The individual sliced samples after their HF soaking can be seen in Photo 12.

THE RESULTS AND DISCUSSION

The results were very straightforward: the percent of glass lost is inversely related to the amount of time and/or the intensity of the flame on the glass. That is, the longer the flame was on the glass and/or the hotter the flame on the glass, the less soluble the glass was in the HF.

As seen in Table 2, the quartz standard, with no sodium content, lost about 8% of its weight, while the borosilicate standard lost about 34%.

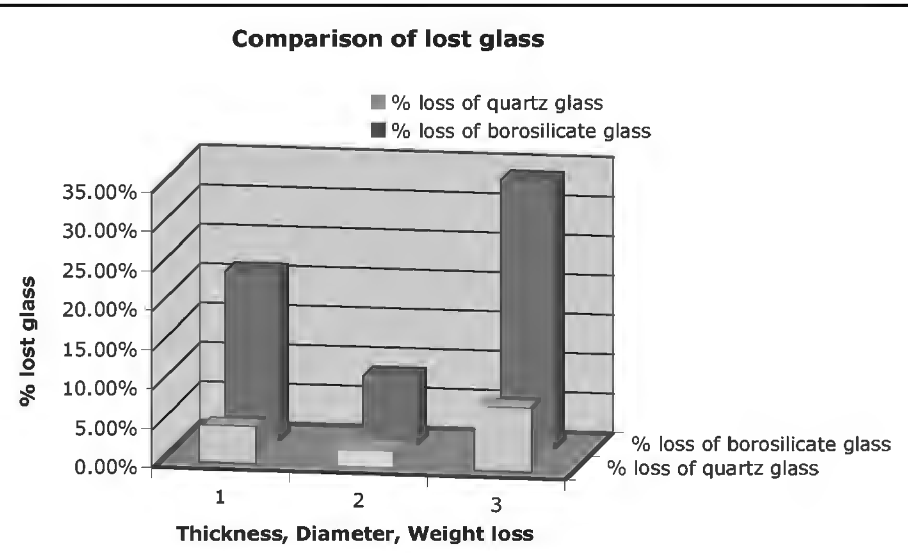


Table 2

If you look at either Table 2 or Table 3, you can see that it is easy to see that the diameter of the glass was less soluble than the thickness of the glass. This can probably be explained by the greater surface area presented by the rough surface of the glass' cut face. The circumference, being a very smooth (freshly fire-polished) surface, had universally less glass lost due to solubility.

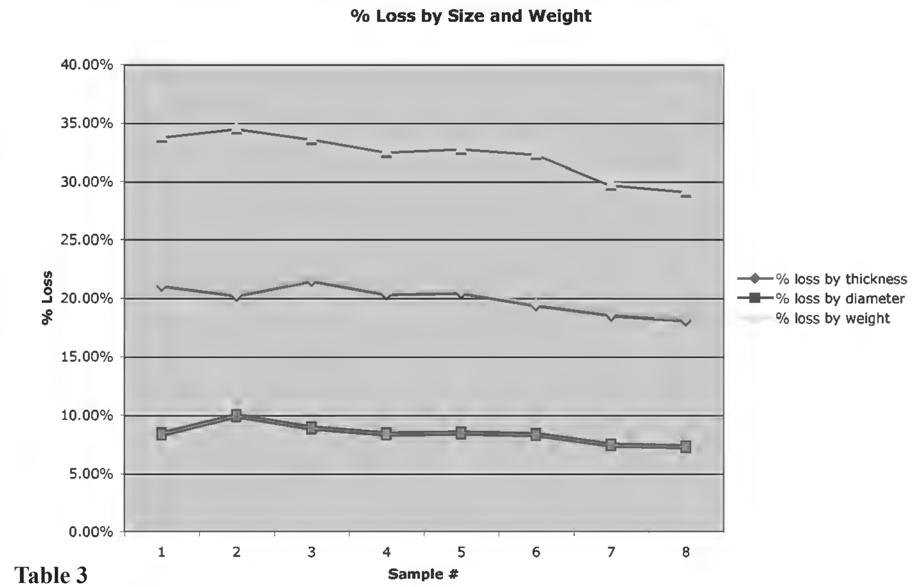


Table 3

Focusing on the weight lost as seen in Table 3 there is a curious increase in solubility of the 10-second rosy sample. However the 20-second rosy is a tad less soluble than the non-heated sample while the 40-second rosy sample is significantly less soluble than the non-heated sample. The 10-second white hot sample is slightly more soluble than the 40 second rosy heating while the 20- and 40-second white hot each are less soluble than the 10-second white hot sample respectively.

What this clearly shows is that the temperature and the time that glass is heated does affect the solubility of glass in a glass stripping environment.

Examining the surface of the cut glass does not offer an easy explanation. My original expectation was that since the flame is heating the surface of the glass and the inside of the glass is protected from the direct flame, the glass should be more soluble inside than outside and if the thickness was measured, it would show a concave surface.

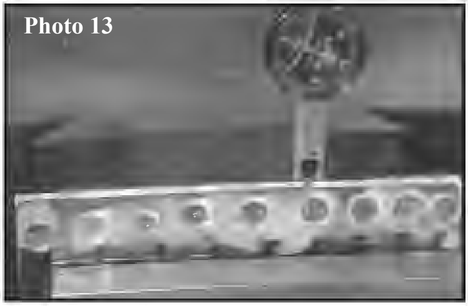


Photo 13

To test this, the glass disks were mounted on a flat glass plate using bees wax. The plate was placed in a milling machine so that a micrometer could be brushed across the surface as seen in Photo 13. Measurements were taken at each edge, the center, and two points across each side for a total of seven measurements across the surface. Two sets of measurements for each disk were made going both left-to-right and right-to-left. The measurements were consistent regardless of the direction of travel.

The results were far from what was expected as the Surface Contour graph shows in Table 4. The contours show no consistent surface and are far from the concave shape expected. The best explanation at this point in time is that the solubility of the glass was entirely random and non-uniform.

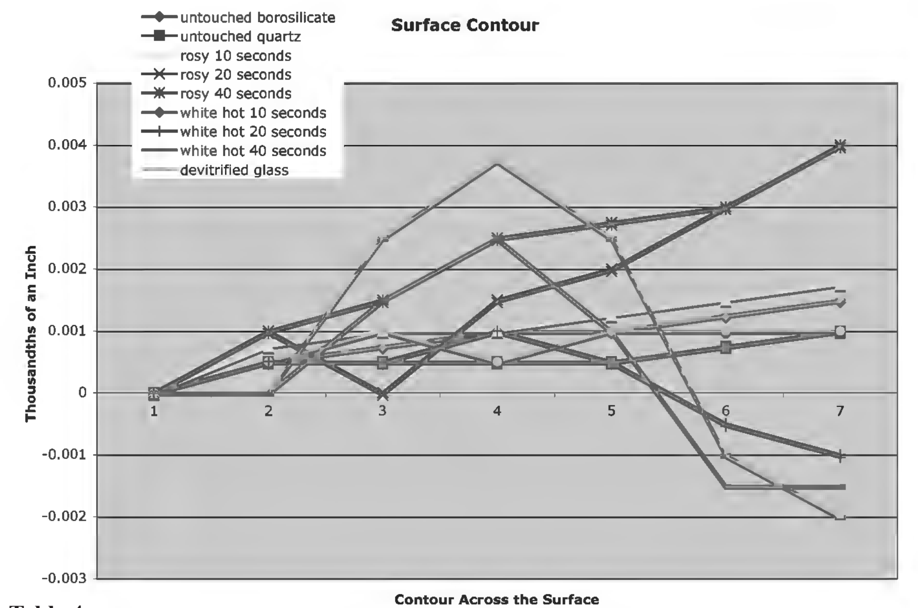


Table 4

CONCLUSION

It has been shown that the longer and/or hotter you heat glass with a torch the less soluble the glass becomes. While this may seem like a great selling point, it actually is not. The reality is that while heating glass does decrease solubility, glassblowers do not heat a broad section of glass uniformly—the tip of the flame does not heat all heated points the same amount nor for the same length of time. What this paper demonstrates is that when we heat glass, the glass we have heated will have decreased solubility. If we do not heat the glass uniformly, then the solubility will be non-uniform. The effects are not profound, but it does not take much to cause a leak in a stopcock or a joint.

On the other hand, these results can be useful when explaining to people that it is not wise to let a base bath do the glass cleaning—all that should be necessary is 15–20 minutes.

What this simple test has done is to open the door for more research. One data point for each test is not profound but does provide proof-of-concept. Currently plans are underway to do a five-fold increase in testing data.

Heat Transfer And Efficiency Of Glass Condensers

by

James R. Hodgson[a]

ABSTRACT

Heat transfer by conduction can be calculated using Fourier's Law. In the special case of borosilicate glass condensers, the mechanism of heat transfer can be simplified to provide an effective comparison of condenser efficiency.

INTRODUCTION

It is hard to be a scientific glassblower and not be aware of the many different kinds of condensers. There are the old reliables: West, Graham, Allihn, Friedrichs, and Hopkins. There are condensers with coils, balls, two jackets, and a cold finger. At recent symposia, papers have been presented on large coil condensers for rotary evaporation, tube condensers meant to duplicate large scale processes, and various designs intended to condense more efficiently. For a scientific glassblower, they share one thing in common... they are all usually made out of borosilicate glass. But there the similarities end.

HEAT TRANSFER BY CONDUCTION

Different condensers serve different purposes and certainly they do not look much alike except they often have an inlet and outlet for water used to cool the condenser. Another property that all condensers share is that heat is transferred by conduction. Conduction takes place when a temperature difference exists across a solid medium. When the hot vapors rise inside the condenser, energy is transferred across the glass wall to the cooling liquid or air on the other side. It seems obvious that all condensers cannot be equally efficient. The question in my mind has been how to determine that efficiency. I will assume that the most important part of the phenomenon is the transfer through the glass walls of the condenser.

CALCULATING HEAT TRANSFER

It would be possible to test every configuration of condenser, checking the temperature at various locations and monitoring the water inlet and outlet temperatures to see how much cooling was taking place. In a way, some of this experimental work has already been done for us and the result is Fourier's Law, used to express heat transfer by conduction.

FOURIER'S LAW

$q = k\,A\,dT / s$ where

- q = the heat transferred per unit time (in Watts)
- A = the heat transfer area (in meters squared)
- k = the thermal conductivity coefficient of the material (W/mK or W/m ºC)
- dT = the temperature difference across the material (K or ºC)
- s = the material thickness (in meters)

These terms all make physical sense. We can use this equation to know how much heat is transferred per unit time; the higher the number, the more efficient our condenser is.

A larger surface area will naturally conduct more heat.
A material with a high thermal conductivity will be more efficient.

[a] Department of Chemistry, Kansas State University, Manhattan, KS 66506. E-mail: hodgson@ksu.edu.

If the temperature difference is greater (like a dewar condenser filled with a dry ice/acetone mixture as opposed to a condenser utilizing chilled water), then the condenser will conduct heat away more rapidly.

The thickness of the material also makes a difference and the rate is inversely proportional to the thickness. You would not expect a condenser made of heavy wall tubing to work as efficiently as one made of standard wall tubing.

Thermal conductivity has been examined extensively and values of k are relatively easy to obtain from various tables. Here are a few values of k (W/mK) for some common materials:

Copper	401
Gold	350
Aluminum	250
Stainless Steel	16
Pyrex	1.0
Styrofoam	0.033

There are no real surprises in the list. As you would expect from your experience, the metals are some of the best conductors with glass a relatively low 1. It is a good thing that glass has many other useful properties because as a conductor it certainly does not rank near the top.

Using Fourier's Law to calculate the rate of heat transfer in a condenser is relatively simple. If you want to just compare efficiencies of borosilicate glass condensers the matter is even simpler. Because the thermal conductivity of borosilicate glass is constant, it can be eliminated from the equation for comparison of relative efficiencies. If the heat transfer surfaces were exposed to the same temperatures on either side, then the temperature difference can also be eliminated from the equation. This just leaves the surface area and the thickness of the glass wall. So for comparison purposes, just calculate the surface area of your condenser and divide by the wall weight. The higher number will be the more efficient condenser. However, it is still relatively easy to calculate the actual heat transfer in more complex cases (for instance, a reflux condenser would have two different temperature differences: the temperature difference between the vapor and the water in the coil and the temperature difference between the vapor and the air outside the condenser).

EXAMPLES

1. A coil condenser has been requested. Our glassblower likes to do good-looking work with a minimum of wasted effort. Since it is easy to coil heavier wall tubing without collapsing the wall, the glassblower decides to use special wall 8 mm tubing. How does this compare to standard wall 8 mm tubing?

A. We will assume that in each instance we use the same length of tubing to make our coil. We can easily determine the surface area of each and use the known thickness to calculate the relative efficiencies.

For the standard wall tubing:
Surface Area = length x circumference
Surface Area = length x Π x mean diameter
Surface Area = 120 cm x 3.14159 x 0.7 cm
Surface Area = 264 square centimeters
Thickness = 0.1 cm
Efficiency = Surface Area/Thickness = 264/0.1 = 2640

For special wall tubing:
Surface Area = 120 cm x 3.14159 x 0.65 cm
Surface Area = 245 square centimeters
Thickness = 0.15 cm
Efficiency = 245/0.15 = 1633

The condenser made with the standard wall coil is half again more efficient than the coil made from special wall tubing.

2. The glassblower has been asked to fabricate a standard Leibig condenser with an effective length of 50 cm. He has an abundance of 12 mm and 13 mm tubing to use for the inside wall. Which would be the most efficient?

A. Everyone is aware that the wall thickness of tubing jumps in discrete increments. In this case the 12 mm tubing has a wall thickness of 1mm and the 13 mm tubing has a wall thickness of 1.2 mm.

For the 12 mm tubing:
Surface Area = 100 cm x 3.14159 x 1.1 cm = 346 square centimeters
Thickness = 0.1 cm
Efficiency = 3455

For the 13 mm tubing:
Surface Area = 100 cm x 3.14159 x 1.18 cm = 370 square centimeters
Thickness = 0.12 cm
Efficiency = 3089

In this case the 12 mm tubing would make the more efficient condenser. Although the surface area of the 13 mm tubing is greater, the increased thickness makes it a less efficient condenser.

Using the basics presented above, it is possible to calculate the relative efficiency of almost any glass condenser. In the case of a "super" condenser which incorporates coils, cold fingers and jackets, it would be necessary to calculate the contribution made by each component and add them together for a total efficiency. Remember, the wall weight of each portion must be considered also.

CONCLUSION

In spite of a formula with a mathematician's name attached to it do not be misled. Any chemical engineering student could tell you that heat transfer is not nearly this simple. However, the low conductivity of glass essentially reduces the problem to the rate of transfer through the glass to the cooling medium. For our purposes, on laboratory scale glass condensers, this approximate method of calculating condenser efficiency gives us a starting point and forces us to think about how our glassware will be used.

REFERENCES

http://www.engineeringtoolbox.com/

ACKNOWLEDGEMENTS

I would like to express my appreciation to Kansas State University and the Department of Chemistry for their support of the scientific glassblowing facility and their continuing encouragement of my professional endeavors.

In Search Of Dark Matter: An Argon Separator For Deeply Mined CO_2

by

Michael J Souza[a]

ABSTRACT

The isotope ^{39}Argon has very low radiation background and promises to be a useful element to detect dark matter. It can be found beneath the Earth's crust in deeply mined CO_2 wells. The paper describes design considerations for a cryogenic trap that can process large volumes of this CO_2 into solids and allow ^{39}Ar to be trapped and separated as a liquid. It also describes use of insulation foam as a holding material for the construction of the trap.

INTRODUCTION

According to the "Standard Model" in physics, dark matter and dark energy accounts for nearly 96% of the known universe and the remaining 4% is all that has been directly observable by mankind. We know these forces exist because of inferred gravitational effects and the rotational speed of galaxies. Determining the nature of this missing matter is one of the most important problems in modern cosmology and particle physics.

What is the universe made of?

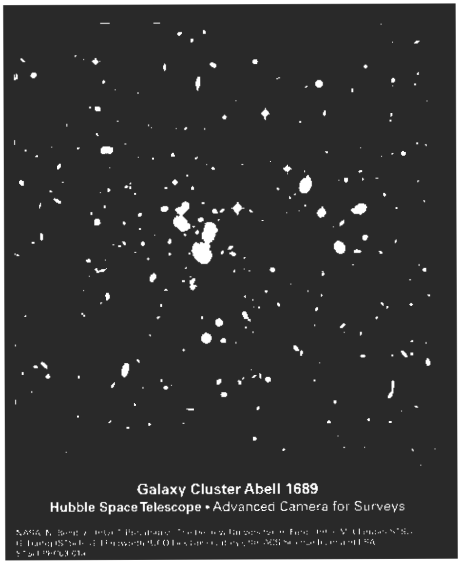
Chart provided by Princeton's Particle & Nuclear Astrophysics Dept.

We have not been able to observe much of the universe. The problem is that this particular type of matter does not emit or reflect enough electromagnetic radiation to be observed directly. However, gravitational effects on matter that is visible undeniably infer its presence in two observable phenomena. In 1933, Franz Zwicky at CalTech looked at the outer edges of galaxies and studied their orbital speed. He found that stars far from

[a] Department of Chemistry, Princeton University, Princeton, NJ, 08544. E-mail: mjsouza@princeton.edu.

the center of galaxies have much higher velocities than predicted by the conventional laws of physics.[1] *According to Newton's long-standing laws of motion, these stars were traveling 400 times faster than observable matter could possibly account for.*

Another important tool for future dark matter observations is gravitational lensing.[2] Lensing relies on the effects of general relativity to predict masses without relying on dynamics and so is a completely independent means of measuring the dark matter. Einstein long ago predicted that light bends as it is influenced by gravity. Optical images from Space Telescope Hubble were used to determine the location of the mass in the clusters. This was done by measuring the effect of gravitational lensing, where gravity from the Galaxy Clusters distorts light from background galaxies as predicted by Einstein's theory of general relativity.[3]



(Photo courtesy of NASA and the European Space Agency)

THE EXPERIMENT: LOOKING FOR WIMPS

In astrophysics, WIMPs, or weakly interacting massive particles, are hypothetical particles serving as one possible solution to the dark matter problem. These particles interact through the weak nuclear force and gravity, and possibly through other interactions no stronger than the weak force. Because they do not interact with electromagnetism they cannot be seen directly, and because they do not interact with the strong nuclear force they do not react strongly with atomic nuclei. Thus all of the conventional tools used until now have proven to be inadequate

Princeton's Particle and Nuclear Astrophysics Department is a member of an international group of scientists known as WARP (Wimp Argon Programme). Princeton and their collaborators believe a key to the dark matter puzzle is the interaction of Argon with sub-atomic particles known as WIMPs. Ultra-pure isotopic argon that has no radiation background is used as a scintillator for interaction of WIMPs that produce nuclear recoils in the gas-phase that give off photons detected by photo-multipliers.

Argon present in the atmosphere has a radiation background that acts like static to the sensitive detectors. Until now, obtaining isotopic rare forms of argon without gamma background has been expensive and time consuming. Recent discoveries (in the Southwest region of the United States, bordering Colorado and New Mexico) of CO_2 wells found deep below the Earth's crust show that there is a significant amount of pure argon that is present in this trapped CO_2.

[1] Fritz Zwicky, "On the Masses of Nebulae and of Clusters of Nebulae," *The Astrophysical Journal*, 86.3 (October 1937): 217.

[2] A. Lewis et al, "X-ray: NASA/CXC/UCI," Optical: Palo Alto Observatory. DSS.

[3] E. Hupp et al, "NASA Finds Direct Proof of Dark Matter," *NASA News*, Aug. 21, 2006, http://www.nasa.gov/home/hqnews/2006/aug/HQ_06297_CHANDRA_DARK_MATTER.htm.

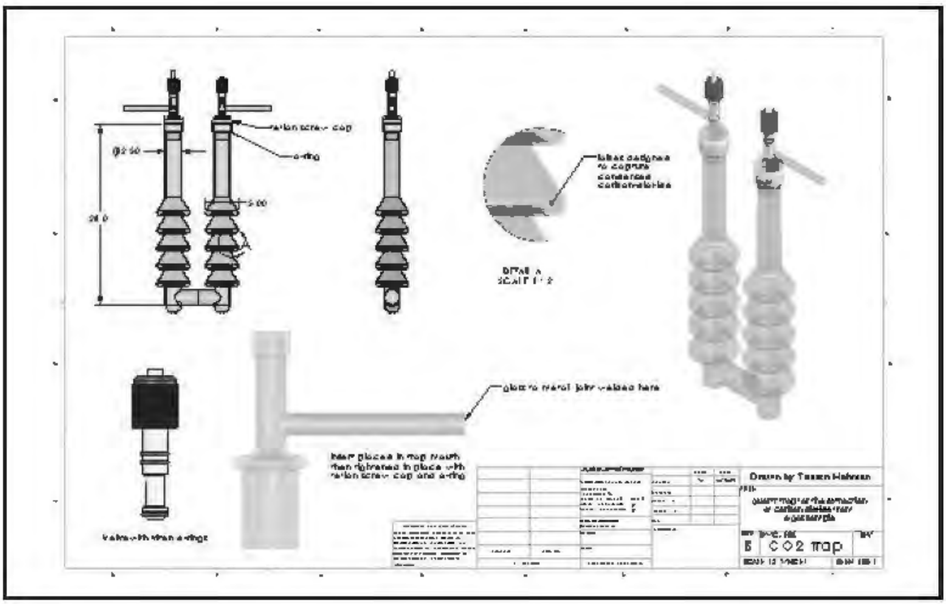
A systematic flow trap would be required for the task of separating the argon from the bulk CO_2. The separation would be done by use of a vacuum cryogenic process. In essence, the CO_2 is frozen as a solid at -78ºC using liquid nitrogen (-236ºC). The argon is frozen as a liquid at -233ºC and boiled out of the cryogenic trap by vacuum.

DESIGN CONSIDERATIONS

To yield even a few cc's of the argon requires that hundreds of liters of CO_2 be processed. To handle this kind of volume, the trap would have to be large capacity and maintain high throughput during the separation process. Additional traps and getters would also be needed to further separate and trap the argon.

In consultation with the investigators, an alembic design was chosen as the central trap for the CO_2. Its geometry provides surface area and turbulence for the flowing CO_2 to form as a solid without obstruction of the system. By assembling the alembics in series, one can also raise and lower the liquid nitrogen trap to diffuse the gas into the solid phase in stages so as to allow the precipitate to form evenly.

Alembic 1 *(photo by Ernst De Haas)*



Argon Separator Trap *(Supplied by Tristen Hohman)*

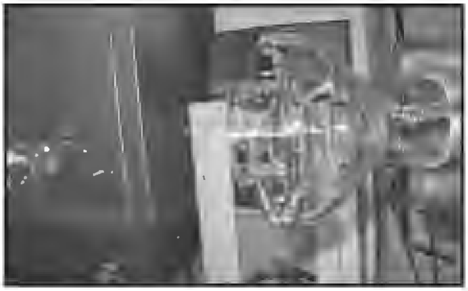
CONSTRUCTING THE ARGON TRAP

Assembling the alembics was made easier by using 2 liter round bottom flasks. The necks and bottoms were replaced with 64 mm standard wall tubes. The operation was done on the lathe by centrifugal force and without the need of blowing and the use of holders or plugs.

Step 1. The 2 liter flask has 64 mm tubing spun sealed to each end.

Step 2. The radius is softened by fire and recessed into the flask.

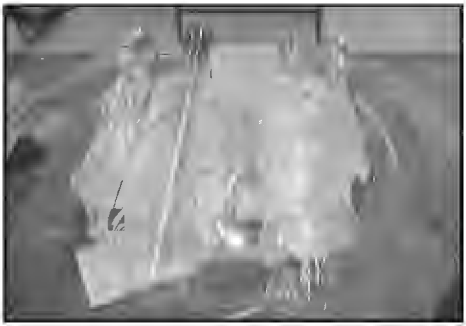
Step 3. A completed alembic is ready to be firecut.



Step 4. An alembic is now ready to be sealed to the next flask.

A total of ten flasks were used to produce two towers, consisting of five alembics on each tower. Two #50 Ace threaded joints were used as inlets at the top. These fittings would facilitate the use of two large (25 mm) ChemValves™. The valves would connect to the CO_2 source on one side and to the rest of the vacuum system on the opposing side.

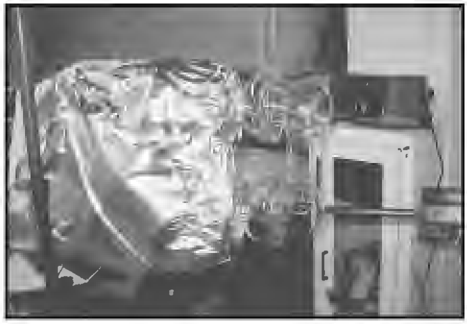
Connecting the alembic towers at the bottom into a "U" shaped trap required the use of unconventional methods for support. Heavy glass support rods would be problematic because of the temperature gradients imposed by immersing the trap into the liquid nitrogen. In addition, the alembic shapes did not offer sufficient surface structures for wood blocks and hose bands. *The answer to these problems came by using spray foam insulation.*



Set-up 1. A frame that mimicked the inner diameter of our liquid nitrogen dewar was constructed and lined with aluminum foil which does not adhere well to the foam.

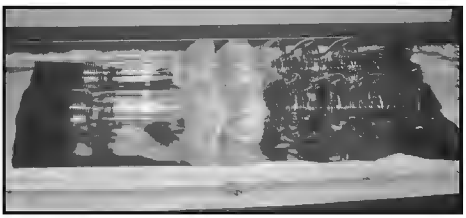
Set-up 2. The foam is applied to the jig and allowed to cure overnight.

Set-up 3. After the foam was cured, we noticed the foam's expansion caused the assembly to spread apart our jig and moved the specifications outside of our tolerance. Cutting the foam and trimming the center to correct the spacing to size easily remedied this problem.



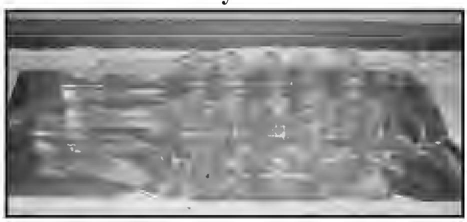
Set-up 4. The foam and duct tape is heavily insulated with aluminum foil and the trap is ready to be sealed.

Trimmed for Oven

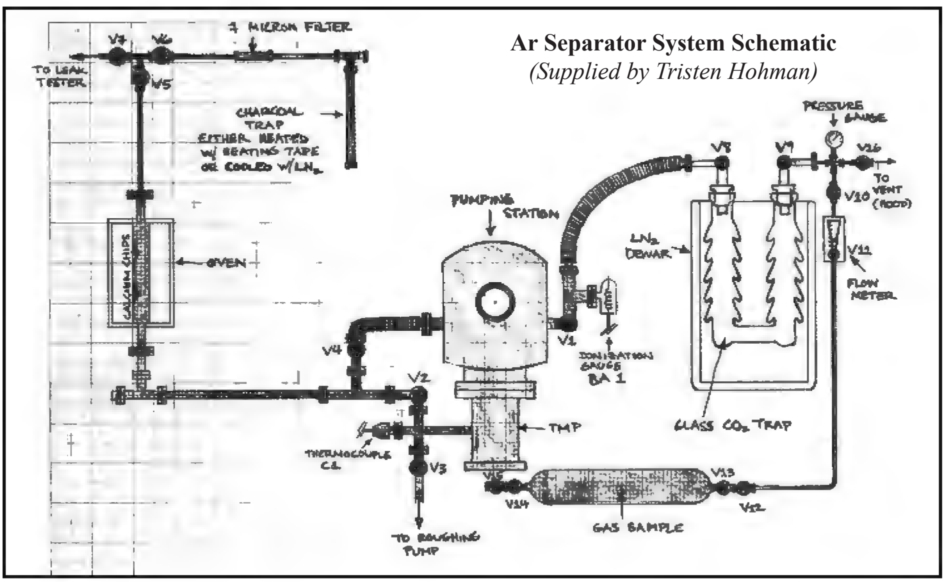


The wrapping and excess foam is removed and the trap is ready to be annealed. A sheet of foil is used to protect the oven bottom from trapping ash.

Annealed Assembly



After the annealing cycle, there is little trace of the foam and the glassware did not require further cleaning.



Ar Separator System Schematic
(Supplied by Tristen Hohman)

HOW THE SYSTEM WORKS

The gas sample of CO_2 from the New Mexico site is stored in high-pressure cylinders that are pressure regulated and connected to the trap inlet on the right. A stainless steel dewar is mounted on a riser jack and filled with liquid nitrogen. This allows the controlled accumulation of solid CO_2, from bottom to top. As the CO_2 forms to solid, the vacuum outlet is opened to the turbo-pump and an RGA (Residual Gas Analyzer) detects trace gases and the argon. Calcium is heated to 800ºC and is used as a primary getter to removed residual gases. Further filtering is done by use of a 3-micron filter and finally by an activated charcoal trap that adsorbs the argon.

In the final step, a compression seal connects a glass cell made entirely of Suprasil™.[4] Below the compression seal, the cell has a constriction and at the bottom of the cell, a break seal adapter is in place. The cell is evacuated and next the argon from the charcoal trap is cryo-pumped into the cell by liquid nitrogen and is flame sealed off the system. The accumulated cells are sent to Argonne National Lab for analysis and eventually collected for transfer to the WIMP scintillator.

CONCLUSION

The alembic design for the Argon separator allowed the group to be able to process hundreds of liters of CO_2 as a solid without obstruction. The use of ready-made flasks, as well as the spin sealing technique, greatly reduced labor costs and provided uniform fabrication for the glassware. The use of foam as supporting material proved to be resilient and adaptable. The application and removal of the foam was easily performed and greatly reduced the risk of glass fracture making what would have been a daunting task quite easy.

ACKNOWLEDGEMENTS

I would like to thank Professor Frank Calaprice & Professor Cristiano Galbiati at Princeton's Particle & Nuclear Astrophysics Dept. for their support and Ernst De Haas and Tristen Hohman for use of their graphics.

6 ft 6" tall Tristen Hohman (class of 2008) is pictured raising the riser jack for the dewar.

[4] Suprasil™ is a synthetic glass and because the glass does not use mined elements from the earth's surface, it uniquely provides a glass that has no radiation background.

It Works For Us

by

Wiliam C. Sexton[a]

ABSTRACT

Since the Glass Apparatus Lab at the Savannah River National Laboratory supports nuclear research, safety has always been very important; to date there has not been a lost time accident in the Glassblowing Lab. This paper will take you through the Glass Apparatus Lab sharing the little things that have worked for us over the years.

This presentation will take you through the Glass Apparatus Lab at the Savannah River National Laboratory. It is an old shop built in the early 1950's as part of the Savannah River Labs which was the support Laboratory for the Savannah River Site. Randy Searle was the first scientific glassblower for the Lab and was instrumental in the design and set-up of the Glassblowing Lab. The following slides will share with you some of the "little" things our shop has done over the years and "they work for us".

The Emergency Propane Shut-Off is located in the hallway next to the entrance to the Glass Lab. This valve shuts off all propane to the Lab. (Photo 1)

Work Area vs. Office Space: we use a yellow line on the floor to separate the work area from the office space. Eye protection is required in the work area. (Photo 2)

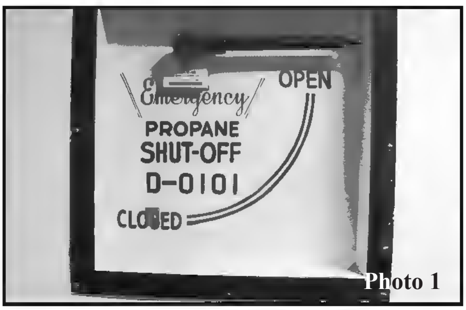


Photo 1

Photo 2

The Designated Office Space sign is to clearly separate one area from the other. (Photo 3)

A picture is worth a thousand words. All Glass Shops need a display cabinet. We have pieces in our cabinet dating back to the early 1950's. (Photo 4)

Photo 3

Photo 4

[a] Savannah River National Laboratory, 773-AVD0101, Savannah River Site, Aiken, SC 29808. E-mail: william.sexton@srnl.doe.gov

The gas lines into the lab are color coded and clearly labeled. All the lines have a shut-off valve. (Photo 5)

These are the lines that lead to one of our lathes. We have color coded quick connects and Grade "T" welding tubing. Note the elbows on the valves to eliminate having a bend in the tubing. (Photo 6)

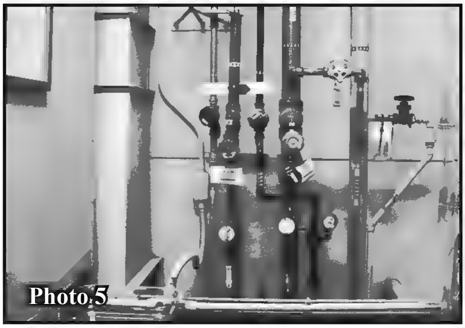


Photo 5

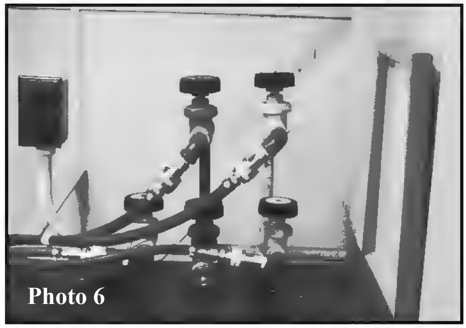


Photo 6

All of our hoses are attached with Oetiker Clamps. The tubing is Tygon Pressure Formulation B-44-4X I. B. This tubing is approved for propane, oxygen, and hydrogen with a pressure rating of 250 psi. (Photo 7)

For my Carlisle "CC" Burner, I use the screw connections with the Type "T" Welding Tubing. These screw fittings are available from Carlisle. (Photo 8)

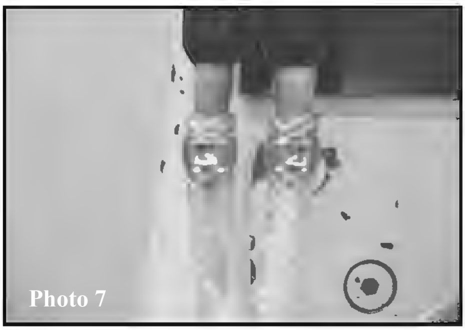


Photo 7

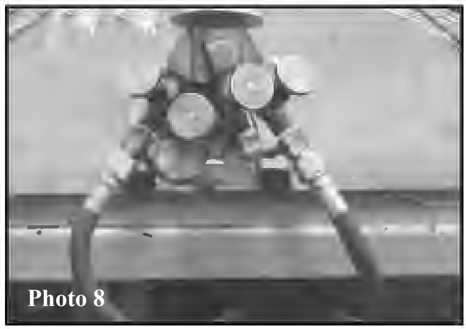


Photo 8

For our lathe burners, we had our machine shop fabricate longer gas leads and we use quick connects. We also use the Type "T" welding tubing in this application. (Photo 9)

This guard was added to prevent the hand torch tubing from becoming caught between the gas valves. (Photo 10)


Photo 9

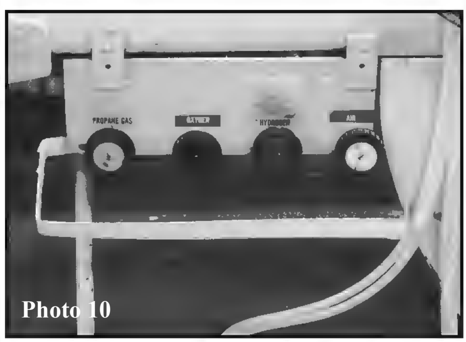


Photo 10

We have the chuck keys attached to the chuck. This is a Litton six jaw chuck. (Photo 11)

Here is a close-up of the chuck key. (Photo 12)


Photo 11


Photo 12

This is our leg extender for the gas foot peddle. It allows the user to stay further away from the lathe carriage. It is adjustable. (Photo 13)

Here we have remote switches for two of our ovens. They allow the ovens to be opened and closed from the lathe. (Photo 14)

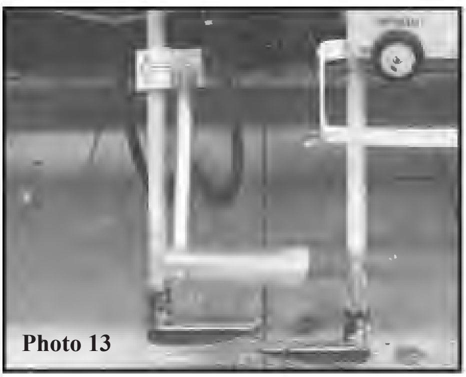


Photo 13

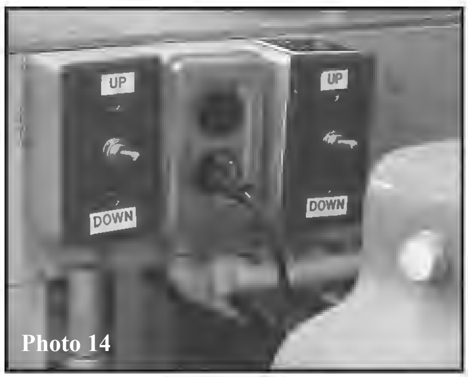


Photo 14

This shows the position of the ovens with respect to the lathes. (Photo 15)

All of our ovens have their own disconnect which is clearly labeled. (Photo 16)

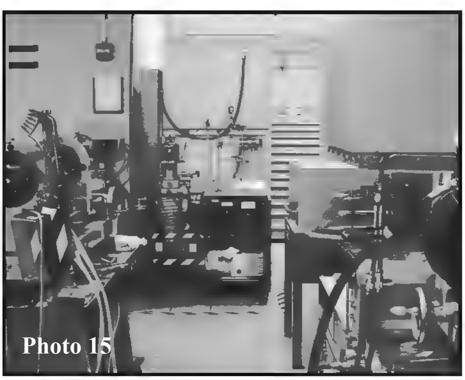


Photo 15

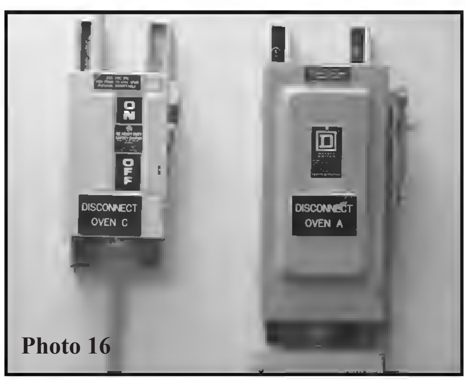


Photo 16

This is a safety latch which is engaged when the oven is fully open. (Photo 17)

This is our vacuum system. (Photo 18)


Photo 17

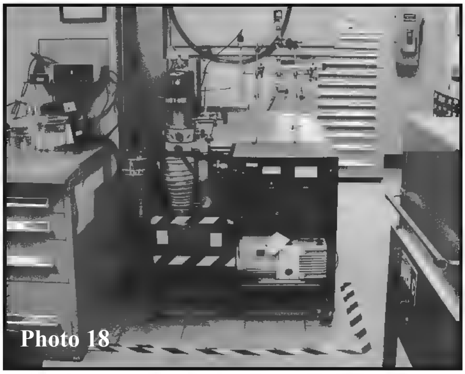


Photo 18

Velcro: this works great to keep up with your blow hose. (Photo 19)

Our Flammable Cabinet is located away from the open flame area. The cabinet is made of plywood. (Photo 20)


Photo 19

Photo 20

This is a Lexan Cover we had made to cover our flat grinder. It keeps the grinder clean and makes a convenient work space. (Photo 21)

We added a belt guard to our wet sander. We did not need the entire belt exposed. We also added some split tubing to cushion the upper metal framework. (Photo 22)

Photo 21


Photo 22

This is a sediment tank. It has three chambers where all the glass sediment settles out before the water is pumped to the drain. (Photo 23)

We added a Lexan adjustable blade guard to our band saw. (Photo 24)

Photo 23

Photo 24

A large stainless steel catch pan was fabricated to catch the dripping water from the band saw table. (Photo 25)

This is our coring set-up. The stainless tray has a drain hole in the back corner. We use both flexible and rigid tubing on our water feed line. (Photo 26)


Photo 25

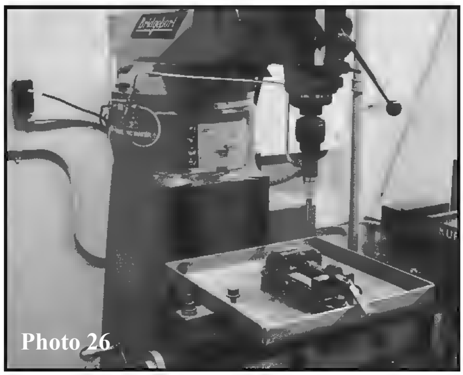


Photo 26

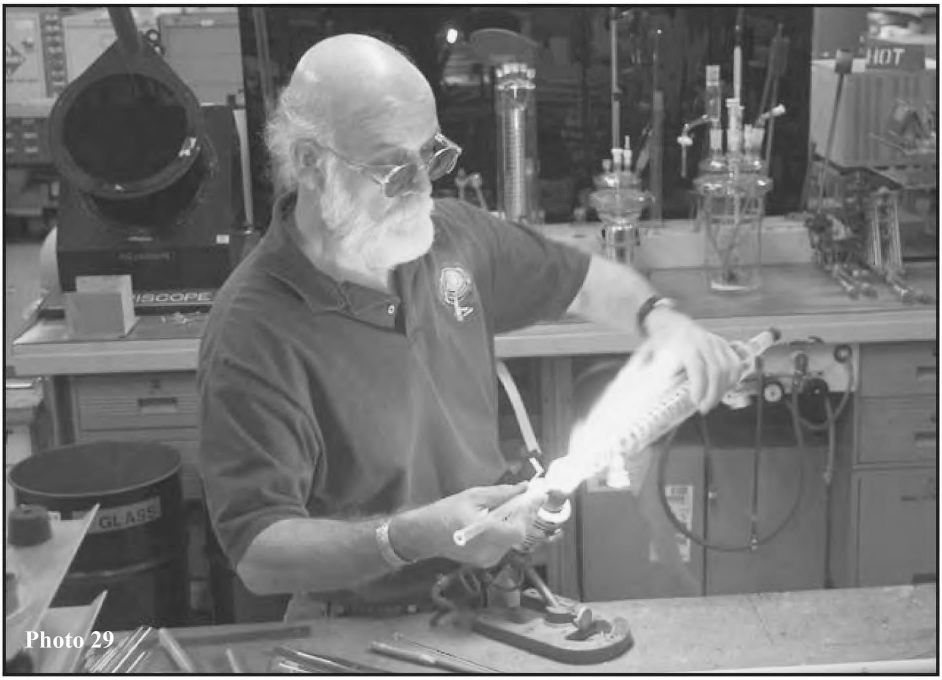
This is a magnetic safety switch. It the chuck key is removed, the machine cannot be turned on. (Photo 27)

A piece of equipment all glass shops should have is a spot welder. This unit is circa 1948. (Photo 28)

Photo 27


Photo 28

"The Man" at work. (Photo 29)



In conclusion I would like to state that the Glass Development Lab has never had a lost time accident. In fact, the Savannah River National Laboratory has the best safety record of all of the DOE National Labs.

A special thanks to Kim Balbag for her help in preparing my presentation.

Murano, Italy: Study With Cesare Toffolo

by

Doni Hatz[a]

ABSTRACT

Murano, Italy has a rich history in glassblowing that has shaped the development of techniques, traditional and new, throughout the world. Cesare Toffolo's flameworked glass reflects traditional Venetian design with classic grace of form while incorporating a contemporary style. This paper will give the scientific glassblower insight into some of Cesare's mastery of manipulating glass.

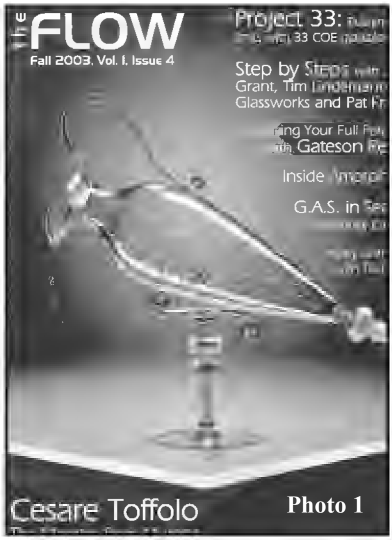


Photo 1

Going to Italy to experience Venetian glassblowing has always been one of my dreams. Finally after many years of blowing glass and after countless times people would ask me if I have ever been to Italy, I can say, "Yes, I have been to Murano to study glassblowing with one of the masters in flamework." I took a month off from my day job blowing scientific glass in October 2006 and resided in a small loft apartment on the island of Murano across the water from Venice.

I focused my study with Cesare Toffolo, a world-renowned master of flamework glass. His well-established career includes exhibiting and teaching workshops around the world. For some reason, I wanted to experience my class with Cesare in Italy where a rich history of glassblowing has existed for centuries. His work is shown on the cover of *The Flow*, Fall 2003, Vol. 1 Issue 4, where he was the featured artist (Photo 1).

Photo 2

Cesare grew up in a family of top glass artists. His Grandfather Giacomo Toffolo worked at the famed Venini Furnace becoming a master glassblower at an early age. Florino Toffolo, Cesare's father, also became a Master Glass Blower at Venini by age 17. Florino specialized in flamework and gained the acceptance of the most traditional people of Murano. He incorporated tools commonly used for "hot shop" (off-hand glassblowing) using jacks (smooth tipped forceps), diamond shears and shears (scissors) to name a few of the tools that spilled over onto the flamework bench. Cesare began an apprenticeship with his father at age 15. Unfortunately, his father passed away two years later but Cesare continued on, learning and mastering flamework. He has two sons, Emanual (24) and Elia (20) who also flamework glass (Photo 2).

[a] The Procter & Gamble Company, Mason Business Center, 8700 Mason Montgomery Road, Mason, OH 45040. E-mail: hatzdj@pg.com.

The Flow features some of Cesare's beautiful artwork: a large bottle and vase. To give some scale to these pieces, the bottle is approximately 6" o.d. x 16" high. The vase is approximately 4" o.d. x 16" with gold leaf applied to the surface of the design (Photos 3 & 4).

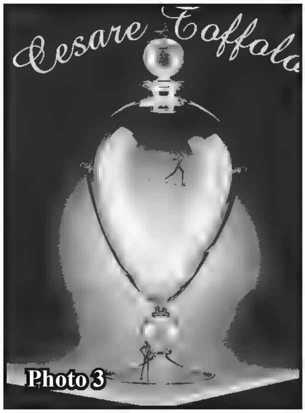


Photo 3

Photo 4

After a long overnight flight from Cincinnati and bus to Venice, I am in the middle of the Grand Canal. There are no more cars: only boats ferry you around this small chain of islands. This was my first opportunity to see the Grand Canal and I began snapping pictures of the rich architecture of the buildings and bridges (Photo 5). The beauty of Venice is evident in the old and contemporary homes that are embellished with flower boxes on the windowsills and balconies all over the islands (Photo 6).


Photo 5


Photo 6

Leaving the Grand Canal behind, I arrive in Murano only a short ten-minute boat ride across the water. It harbors more glass shops than ever seen in one place. Every step along the sidewalk, glass shops entice tourists fresh off the boats from Venice to buy their wares. In Photo 7, I am standing in front of the Toffolo Studio; it has a small narrow entrance to the gallery, quite typical for many shops in Murano and Venice. As I walk into the gallery, I notice that the walls are lined with shelves full of elegantly-placed glass vessels grouped by color. The display shelves are filled with Cesare's artwork and a section in the back includes work by his son, Emanuel, who specializes in bugs. In the back, a spiral staircase takes you to the second floor gallery full of larger, more expensive pieces from Cesare as well


Photo 7

Photo 8

Photo 9

as Lucio Bubacco, Pino Signoretti and other famous glassblowers from Murano (Photo 8). Further up the spiral staircase to the third floor, I reach the workshop studio. In the middle of the room, a large spacious table seats four students comfortably and at the head of the table there is a bench for Cesare to oversee our progress (Photo 9).

Part of the class fee includes an apartment that is a short quarter-mile walk from the studio. This white building has four apartments that are commonly rented to students from Cesare's and Lucio's classes (Photo 10). I was lucky to have the second floor loft apartment overlooking the water that included everything I would need, even a computer. Photo 11 captures the view of the sunrise which was so beautiful to wake up to everyday.

Photo 10

Photo 11

On Murano, everything arrives by boat including oxygen tanks for the countless glassblowing studios around the island (Photo 12). All the little things like styrofoam peanuts for packing material, cardboard boxes, glass rods, fruit and vegetables are delivered by little boats every day.

In the studio, Cesare started me off pulling points and blowing up bulbs out of 30 mm o.d. conturex tubing. This would identify twisting of the tubing while blowing up the tube.

Photo 12

His style is very similar to the training I received at Salem Community College from Joe Luisi. When I watched Cesare blow glass, I noticed small differences. He would elevate the tube while turning with a puff of air, bring it down in front of him horizontally, adjust the alignment of the points and bulb (while turning the tube), then lower the tube downward turning and blowing until the desired finished size of bulb was achieved. Each bulb was blown to a very thin wall weight where points and shoulders of the points had to be perfect to flare up the lip and have the top of the bowl come out perfectly. It made me think that he was like a scientific glassblower except with goblets, exact and precise with his glass carefully measuring the bowls to specific dimensions for repeatability. This is done so that, in the event of reorders of specific glasses, he could make exact copies.

The first week was spent blowing up bulbs and making goblet feet with a Herbert Arnold Zenit torch with a foot pedal kick off. After blowing up several goblet bowls, Cesare would check on my progress and grade the bowls. He split the exercises into half days: in the morning blow up bulbs and flare up the lip with straight walls, in the afternoon blow up bulbs and flare the lip outward.

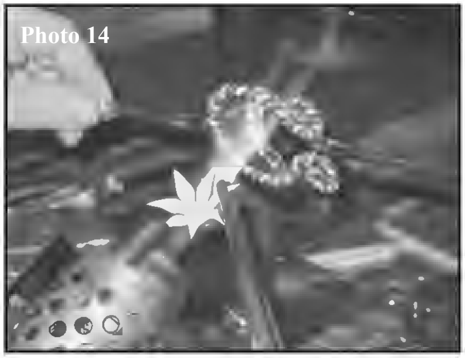
Each day I would practice new exercises with small changes in the techniques to make a different shape. Each piece required a different method of heat in the flame as well as tools for shaping the glass. Diamond shears were used to constrict a groove between the bulb and the point, then a squeeze with the shears scored the tube and the point popped off. Next I opened the hole flaring up the lip with jacks or sometimes by spinning the glass with centrifugal force to get the desired shape of the goblet bowl.

I was a student again, forcing myself to do things differently than I was trained or that I had maybe forgotten. I realized how overwhelming it was to remember all the little things to get it right, forcing myself not to fall into my own patterns. I felt like I was struggling and slow in picking up the perfection needed to whip things out in one shot. It was a re-training of my hands to stretch the boundaries of what is comfortable for me and to force myself to learn his methods. It was not until later in the week that I found out that for most students he would focus on one technique per day whereas he had me practice two techniques per day. I know that does not seem like much but every little bit maximized the techniques I could learn during my session. That is why he schedules four-week sessions at his studio. He explained that one week is never enough to teach the students and the short courses only skim the surface of these techniques. He wants to make sure his students understand and learn the techniques well before leaving his class.


Photo 13

The second week focused on individual parts for the stem of a goblet: filligrana canes, flowers, swans and more decorations. The "lira" is a harp-shaped piece made with a filligrana cane and "morise" is applied to the lira (Photo 13).

The morise is a 4 mm clear rod fused on the outside edge of the lira, reheated with a small pinpoint flame, pinching the clear glass along the perimeter with needle nose tweezers. A swan or flowers would be placed in the center of the lira before sealing to a goblet foot then adding the goblet bowl to complete the piece. Photo 14 shows one of two flowers that are to be placed in the Lira; another flower is placed on the other side on the cross bar to complete this section.



While I practiced, Cesare worked on pieces for his production line that would be placed in the gallery downstairs. One of my goals was to learn the encapsulation of gold leaf. This is commonly applied to soft glass but easy to burn up and vaporize in borosilicate glass. Cesare has mastered encasing gold leaf between two tubes without losing the gold. I captured a videotape of Cesare working with the gold leaf (unfortunately only still photos can be shown in this paper). The gold leaf comes in four-inch squares; one sheet is placed on the graphite plate below the torch. Two tubes are blown up thin to half the wall thickness of standard wall tubing; there is a point on one end and open on the other end. Another tube is blown up slightly smaller than the other and can fit inside the first tube blown up for this project. Each tube is kept warm by flashing them in the flame with a soft bushy fire. (Unfortunately it is too difficult to explain flame styles and differences in this paper.)

The inside tube is heated hot but not molten and is rolled onto the gold leaf. The outside tube is heated, the gold tube is placed inside it then blown up to wet the surface and the tubes become one piece (Photo 15). (This is so tricky since the tubes are hot and it is easy to touch the tubes together before getting the tube completely inside the other.)

The new gold tube is heated with a soft hot flame across the surface to ensure that the pieces are completely fused together. The flame cannot be too hot or else the gold dis-

Photo 16

solves into the glass. Slowly the outside tube is softened from one end to the other, slowly wetting the surface on the gold while squeezing out air bubbles between the two surfaces—yes, this is the second tricky part for success. Surface decorations are added to the gold leaf tube being careful to NOT overheat the glass as that will dissolve the gold (Photo 16).

Photo 17

The Optic (Star) Mold is shown in Photo 17 with 4 mm rods (or fibers) placed in each indent. A tube is prepared with a point and closed end. It is heated to soft but not molten temperature and plunged into the mold (Photo 18). A small puff of air into the tube is needed to make sure the rods are fused to surface. In a blink of an eye, the 4 mm rods are fused to the surface making a perfectly uniform striped patterned design (Photo 19). This is a huge timesaving technique as compared to individually striping each colored rod onto the surface of the tube.

Photo 18

Photo 19

In the following group of photos, Cesare is making a bottle out of several sections of glass: cobalt blue and clear tubing with small lines of black glass between the sections. (Many photos were omitted for publishing.) Photo 20 shows the lip wrap (a small stripe of color on the edge of the tube) of black around the blue tubing. Notice the use of shears to cut off the excess black glass that overlapped at the end of the lip wrap (Photo 21). The use of jacks help to flare up the tubing to achieve uniform thickness (Photo 22). Photos 23 to 34 show many simple and complicated techniques in one piece of glass. It comes to shape as he changes axis and seals the glass on the side, then he continues to add sections of glass. Each technique, of course, has a name, encalmo (splicing of individual tubes), lip wrap (of color), montage (several sections of glass and changed axis). These photos also show his use of the tools: flaring with jacks, necking with diamond shears, flaring with graphite jacks, as well as checking his measurement with the calipers.

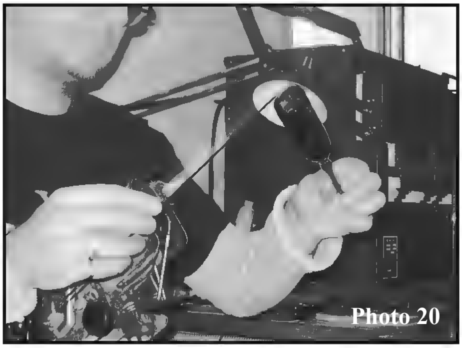


Photo 20


Photo 21


Photo 22


Photo 23


Photo 24


Photo 25


Photo 26


Photo 27


Photo 28


Photo 29


Photo 30


Photo 31


Photo 32

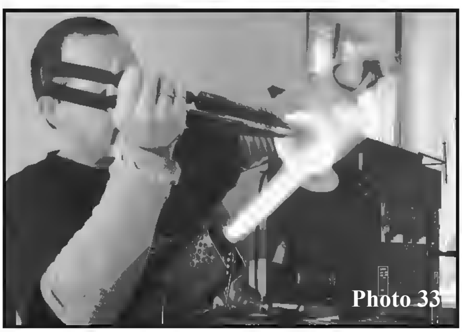


Photo 33

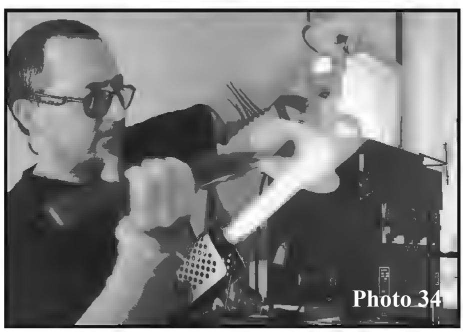


Photo 34

Unfortunately my session had to end. Photo 35 shows my last day of class hanging out with Cesare.

Vittorio Costantini is a most notable glass artist worth a quick trip to Venice. I have known Vittorio several years since he has demonstrated at several Glass Art Society conferences. I visited him at his studio several times during my stay; Photo 36 is of the day


Photo 35

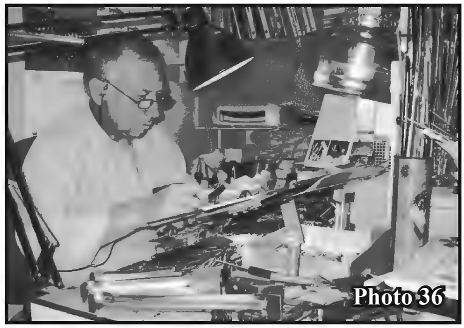


Photo 36

when I happened to catch him working on a tropical fish sculpture in his studio.


Photo 37

Many examples of extremely beautiful glass surrounded my every step in Murano and Venice. Everyday I passed this old brick church, not knowing that right behind the walls were beautiful chandeliers until my roommate Barb pulled me inside to look at them. Photo 37 shows just one of the many chandeliers hanging from the ceiling at the Church of St. Peter the Martyr on my walk to the studio.

ACKNOWLEGEMENTS

I would like to thank the following: Cesare for allowing me to photograph and videotape him working at the torch; *The Flow* for allowing me the use of photos from their article about Cesare and their support of advancing flamework to all through their publication; and lastly, Procter & Gamble for allowing me to take off a month and still have a job to come back to.

Safety Eyewear For Glass Workers

by
Michael DeMasi[a]

ABSTRACT

Glassblowing has been around since the beginning of time and this craft still remains strong today. It is important that glass workers practice safe work habits and also protect their eyes with safety eyewear.

LIABILITY DISCLAIMER

Phillips Safety employees are not optometrists and can only make suggestions concerning eye protection. There are many types of eye protection available and Phillips manufactures as many as possible. Phillips Safety Products does not accept any liability concerning eye damage arising from the use, misuse, or nonuse of any eyewear products we sell.

INTRODUCTION

Most glass workers are very knowledgeable about the history of glass since it is so important to their craft, so I have written some facts/trivia which might be of interest to this group.

GLASSBLOWING HISTORY/TRIVIA

Natural glass has existed since the beginnings of time and is formed when certain types of rocks melt as a result of high-temperature phenomena, such as volcanic eruptions, lightning strikes, or the impact of meteorites, and then cool and solidify rapidly.

- No one knows exactly when or where glass was first made.
- The first evidence of glass work was found in Egyptian stone beads coated with a glasslike glaze in 1200 BC.
- The first glass making "manual" dates back to about 650 BC. Instructions on how to make glass are contained in tablets from the library of the Assyrian king, Ashurbanipal.
- Glassblowing was started between 27 BC and 14 AD and was attributed to Syrian craftsmen.
- In the last century BC, ancient Romans began blowing glass inside moulds, greatly increasing the variety of shapes possible for hollow glass items.
- The long metal tube used in the blowing process has changed very little since then.
- The Egyptians were the first culture to establish a continuous stable glass industry.
- The basic components of glass are sand (silica), soda, and limestone.
- Art glass is a one-of-a-kind product. Each individual piece is handmade, distinct, and intrinsically unique.
- Glass is one of the most durable materials on the surface of the earth.
- The only material that has a harder surface than glass is a diamond.

Since eyes are the most important instrument to glass workers and to everyone, listed below is a history of eyewear. It is important to note that safety glasses are a relatively recent invention within the last 120 years and are a modified version of conventional eyewear.

[a] Phillips Safety Products, 123 Lincoln Blvd., Middlesex NJ, 08846. E-mail: mdemasi@phillips-safety.com.

EYEWEAR /LENS HISTORY

- In 4 BC-65 AD, a Roman statesman used a glass globe filled with water as a magnifying glass.
- The earliest known lenses were made from polished crystal, often quartz, and have been dated as early as 700 BC.
- Greeks filled glass spheres with water to make lenses.
- Glass lenses were not thought of until the 13th century. This was when Roger Bacon used part of glass spheres as magnifying glasses and recommended that they be used to help people read.
- Roger Bacon got his inspiration from Albacen who, in the 10th century, discovered that light reflects from objects and does not get released from them.
- Eyeglasses for distance vision appeared in the early 1400's.
- In the 1600's, the first eyeglass frame temples were made.
- In 1784, Ben Franklin invented bifocal lenses.
- Trifocal lenses were introduced by John Hawkins.
- On November 2, 1880, a patent was granted to Mr. P. Johnson for the invention of "Eye Protectors."

SAFETY EYEWEAR

- Safety glasses are a kind of eye protection against flying debris or against visible and near-visible light or radiation.
- The American National Standards Institute has established ANSI Z87.1 for safety glasses in the United States.
- Recent safety glasses have a more stylish design which encourages people to use them.

Many times workers do not wear safety glasses for the following reasons: Style is the #1 reason. Workers feel they look awkward or nerdy. When it comes to eye safety, this is no excuse. Here are some popular lame excuses why employees do not wear eye protection at work:

- They cannot see through the lens. It is dirty, foggy, or scratched.
- The safety glasses provided are uncomfortable.
- They get headaches from wearing safety glasses.
- They wear prescription glasses instead. (This may be acceptable with side shields).
- They have lost their safety glasses.
- It is not enforced. Managers themselves do not comply with safety.

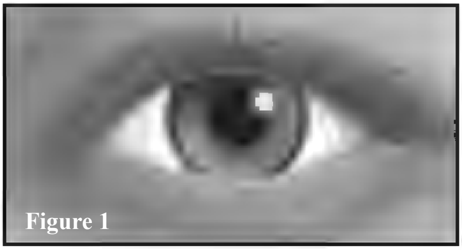


Figure 1

Types of Optical radiation and possible effects on the function of the eye

During all welding and cutting operations, a harmful optical radiation is emitted. The intensity of this radiation depends on the welding processes used and the melting temperatures. The correct selection and the appropriate use of the welding filter eliminate eye damage and reduce visual acuity.

Types of optical radiation and possible effects on the function of the eye			
Optical radiation during welding	to the eye	direct effects on the eye	indirect effects on the eye
Ultraviolet radiation	invisible	high radiant intensity glare	painful corneal inflammation of keratitis and conjunctivitis
Visible radiation (Light)	visible	heating of the aqueous humor and the lens lenticular opacity	permanent reduction of the visual acuity leading to cataract
Infrared radiation	invisible	burning of the retina	

Figure 2

Since it is so important that eyes are adequately protected when doing glasswork, welding, manufacturing work, etc., safety eye wear was introduced to the market. Seventy-five years ago, the Phillips family became a manufacturer of optical lenses for all applications from safety lenses for military use, glassblowers, welders, etc., as well as for the medical and industrial safety markets. Phillips Safety Products is one of the leading global manufacturers of occupational safety glasses.

Phillips offers the following types of glasswear:

- Didymium
- Ace
- Green Ace
- Neotherm (Cobalt Blue)
- Athermal (Green Shade)
- Athermal with Gold Coating

ROSE DIDYMIUM GLASS

Rose didymium is a high luminous transmittance filter specifically designed to absorb bright yellow sodium flare (589 nm) which occurs when heating glass. Didymium lenses protect the eyes from certain visible and UV light produced in the glassblowing process. They enable the glassblower to see the glass while it is being worked in the flame. This is the classic filter that has been used for many years in all types of hot glass applications, as well as kiln working.

The lens is dichroic (exhibits different colors under various light sources). Under incandescent light, the lens is a pronounced rose color, but changes to greenish blue under fluorescent light. The spectral analysis of this glass at 3.2 mm thick indicates that it has good protection against ultraviolet radiation up to 360 nm, has excellent filtration at the sodium line, and excellent overall visible transmission from 400 nm to 725 nm. The glass does not offer much protection in the near or mid-infrared ranges. In general, this lens is adequate for many glassworking applications where the amount of radiation generated is low.

Suggested uses: beginning lampwork using hot head torches and MAPP gas, or propane torches with soft glass. Periodically viewing small kilns, acetylene torch work on silver and gold jewelry, enameling of jewelry, and operation requiring occasional viewing of heat sources in excess of 1000 degrees, but not for use with high pressure torches on hard materials where very high temperatures are generated.

OPHTHALMIC DIDYMIUM FILTER AND OPTICAL CONTRAST ENHANCEMENT FILTER

CONTRAST ENHANCEMENT GLASS (ACE) (Phillips 202)

Schott Glass Technologies has developed a new contrast enhancement glass for spectacle lenses. The new material, called ACE, short for Amethyst Contrast Enhancer, utilizes rare earth oxides in the glass composition to achieve the unique color enhancing characteristics. Basically, the color enhancement concept works by selectively positioning transmission in the blue, green, and red spectral regions whereby one can improve the color discrimination between different color objects. These are the same colors used to produce a color television picture. They optimize the readability of such displays under high ambient light conditions.

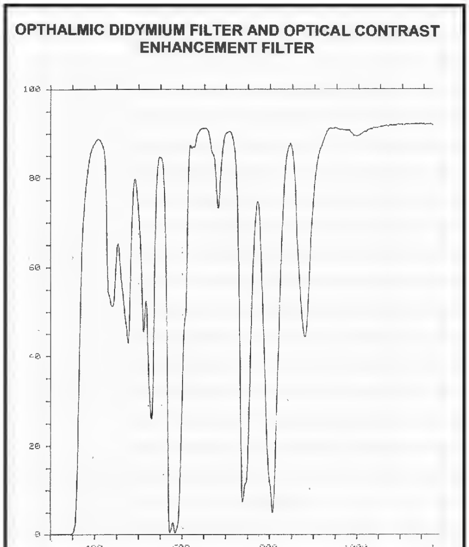
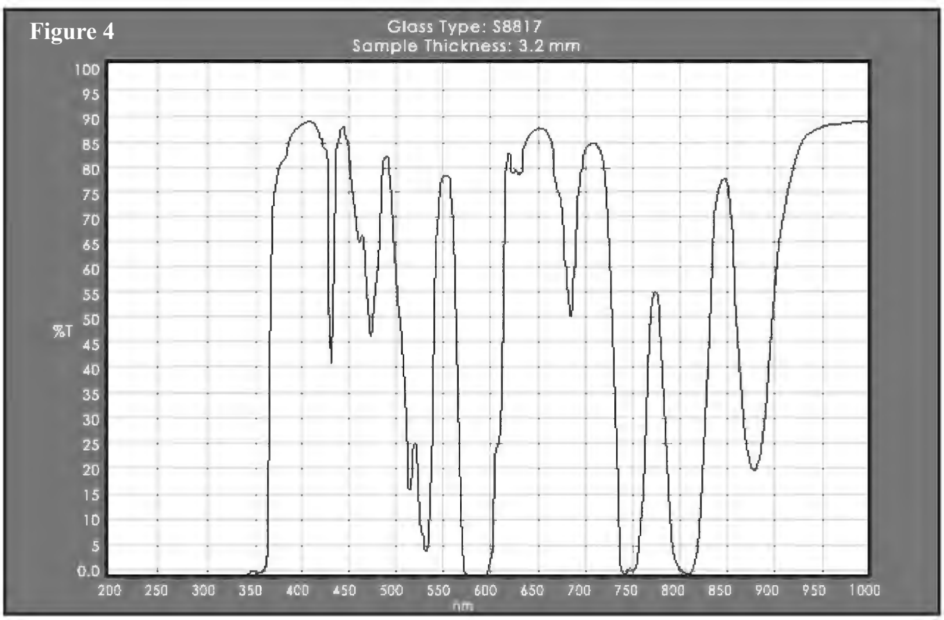


Figure 3

The Phillips 202 (ACE) is becoming a preferable choice of hot glass workers. It is very comfortable for viewing under high ambient light conditions such as when working with hot glass or glowing heat sources for a duration of time. Phillips 202 Glass utilizes rare earth oxides in its composition to provide the same filtration. This glass is very efficient in filtering sodium flare in addition to providing ultraviolet protection to 390 mm. Also, although it has a relatively low luminous transmission of 38%, it is not recommended for sun protection unless UV filtering coatings are applied.

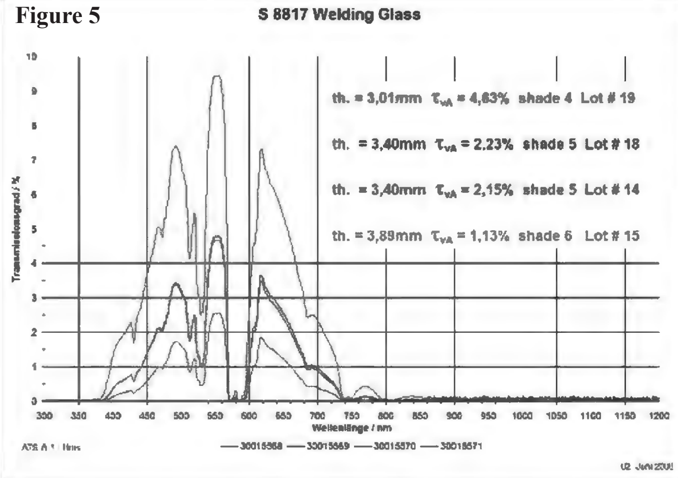
GLASS TYPE S8817 SAMPLE THICKNESS: 3.2MM

Figure 4



GREEN ACE IR (BOROSCOPES)

Figure 5



Boroscopes are designed to meet the need for the extra UV and IR protection needed when working on borosilicate glass. Phillips Boroscopes are specially formulated glass filter lenses that Phillips Safety Products exclusively owns. These lenses have been developed for the lampworking and glassblowing markets. This revolutionary product is greatly lighter than conventional laminated products and comes in a full coverage lens. This is a higher quality design because there are no areas without shading. Boroscopes should be worn when working on hard glass types where regular didymium or Phillips 202 (ACE) are not adequate due to the fact of insufficient filtration of ultra violet and infrared absorption. Boroscopes are available in a Phillips 3 or 5 depending on your personal use.

WELDING EYEWEAR (ATHERMAL)

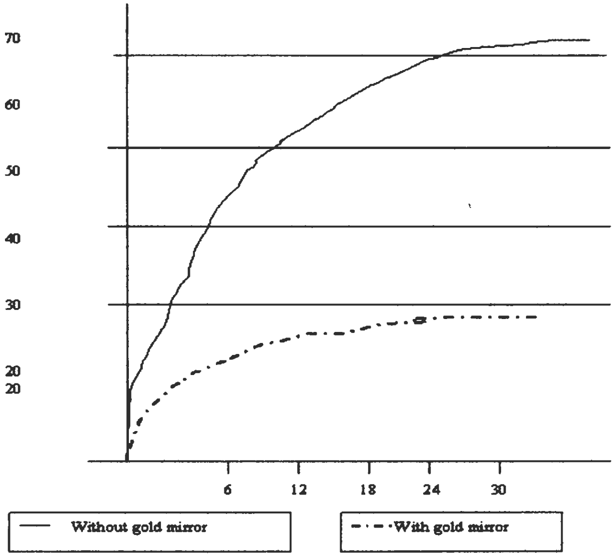
The welding lens is green in color. The spectral response of this glass shows excellent ultraviolet and infrared protection. The visible light transmission will depend on the chosen shade. The higher the number, the darker the glasses. The filter **DOES NOT** provide sodium flare protection. Lenses are available in plane (non-prescription), single vision, and laminated bifocals. Lenses can be purchased with Gold Coating to reflect the heat away from your face and eyes.

Figure 6

Type of filter	Standard dimensions	Shade no.	Used in
curved	Sizes to customer specifications Curvature 2.5 dpt	2-8	Protective spectacles
plane	50 mm0	8-14	Protective spectacles
	110X90mm	"	Welding helmets and
	110X85 mm	"	Hand shields
	110 X 80 mm	"	"
	110X 60 mm	"	"
	110 X 55 mm	"	"
	108 X 83 mm (4 1/4 X 3 1/4")	"	"
	108 X 51 mm (4 1/4 X 2")	"	"
	105 X 50 mm		
	98 X 75 mm	"	"
	Other sizes on customer request		
larger sizes to customer specifications		2-14	Welder's cabins

Figure 7

Heating of ATHERMAL shade 11A1 DIN, with and without gold mirror coating (measurement conditions: welding with 6 mm electrodes, current intensity 350 Amperes, working distance 40 cm).



ANSI CHART

Figure 8

ANSI CHART

ANSI Z87.1 Table 1 Transimittance Requirements for Clear Lenses and General Purpose Filters

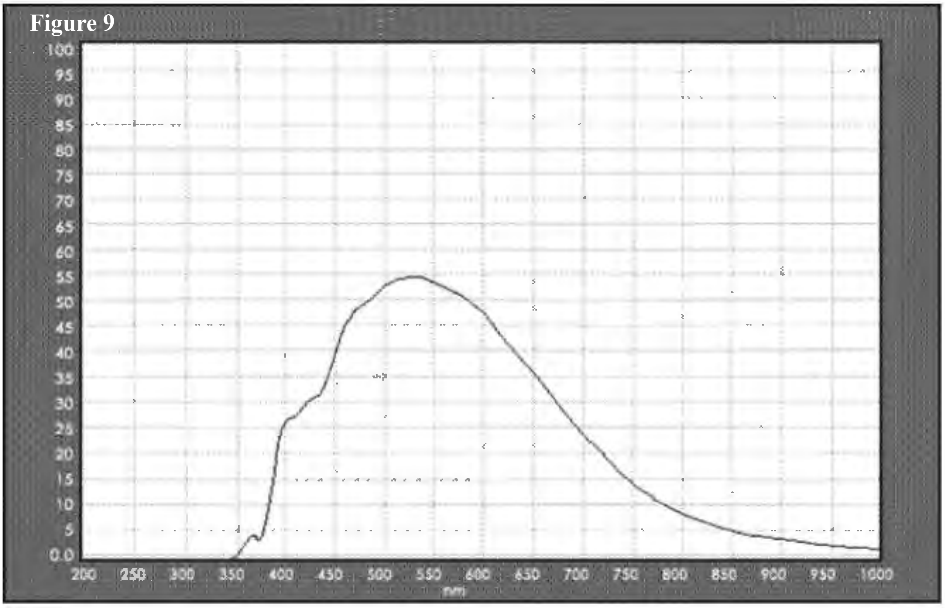
Shade Number	Luminous Transmittance			Maximum Effective Far UltraViolet Average Transmittance	Maximum InfraRed Average Transmittance
	Maximum	Nominal	Minimum		
Clear	100%	-	85%	-	-
1.5	67%	61.5%	55%	0.1%	25%
1.7	55%	50.1%	43%	0.1%	20%
2.0	43%	37.3%	29%	0.1%	15%
2.5	29%	22.8%	18.0%	0.1%	12%
3.0	18%	13.9%	8.50%	0.07%	9%
4	8.50%	5.18%	3.16%	0.04%	5%
5	3.16%	1.93%	1.18%	0.02%	2.5%
6	1.18%	0.72%	0.44%	0.01%	1.5%
7	0.44%	0.27%	0.164%	0.007%	1.3%
8	0.164%	0.100%	0.061%	0.004%	1.0%
9	0.061%	0.037%	0.023%	0.002%	0.8%
10	0.023%	0.0139%	0.0085%	0.001%	0.6%
11	0.0085%	0.0052%	0.0032%	0.0007%	0.5%
12	0.0032%	0.0019%	0.0012%	0.0004%	0.5%
13	0.0012%	0.00072%	0.00044%	0.0002%	0.4%
14	0.00044%	0.00027%	0.00016%	0.0001%	0.3%

LIGHT GREEN

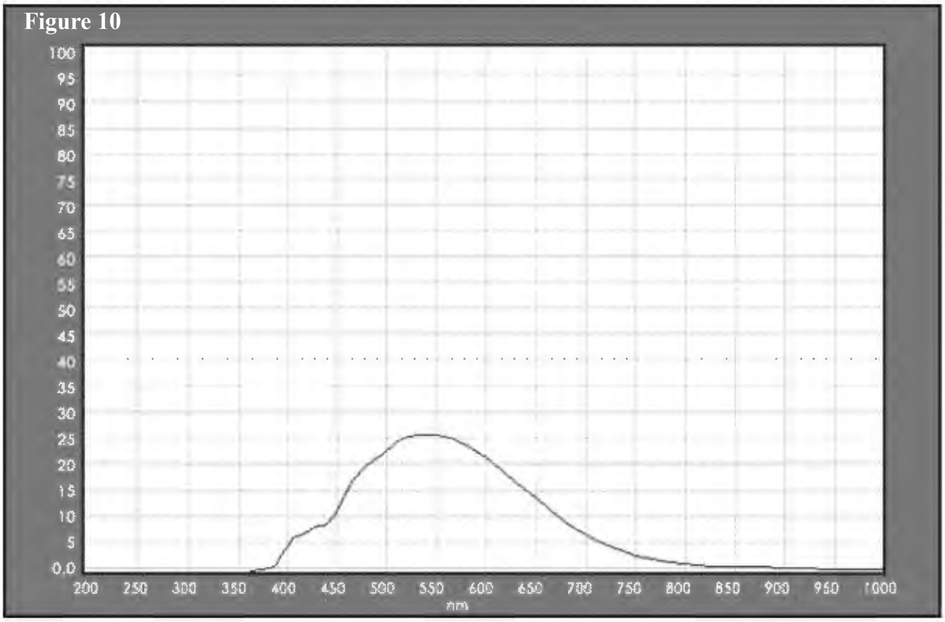
S8317 Green Welding, Shade 1.7
S8320 Green Welding, Shade 2.0
S8325 Green Welding, Shade 2.5
S8339 Green Welding, Shade 3.0
S8340 Green Welding, Shade 4.0

Light Green glass in nature. Excellent UV and IR Protection. Sometimes used in hot metal observation.

GLASS TYPE S8317 SAMPLE THICKNESS: 3.2 mm

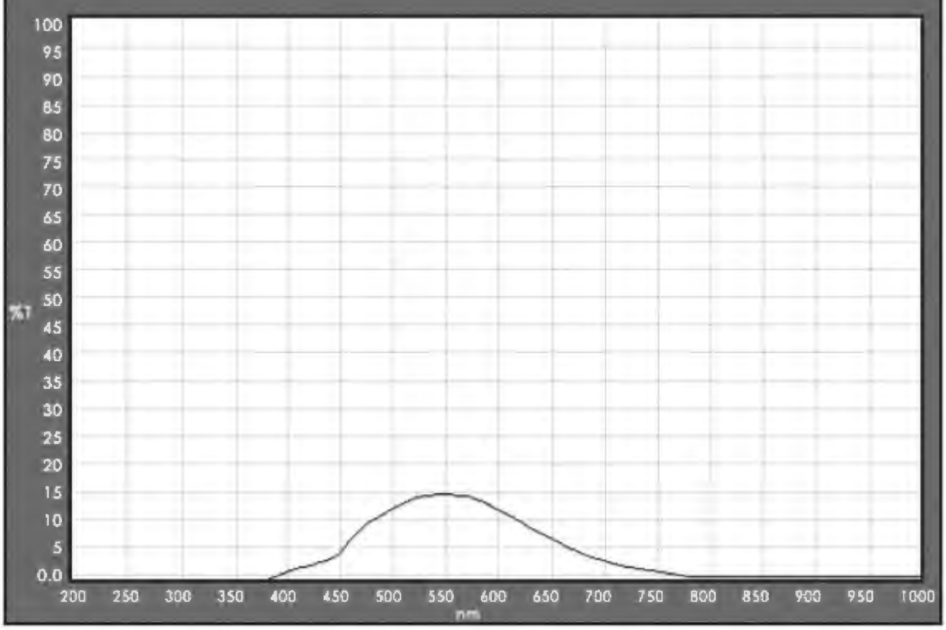


GLASS TYPE: S8325 SAMPLE THICKNESS: 3.2 mm



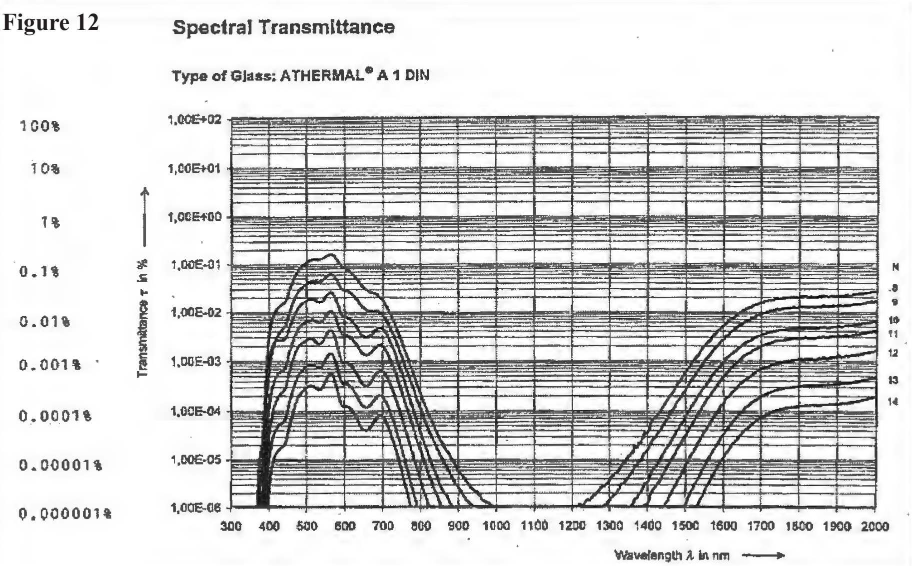
GLASS TYPE: S8330
SAMPLE THICKNESS: 3.2 mm

Figure 11



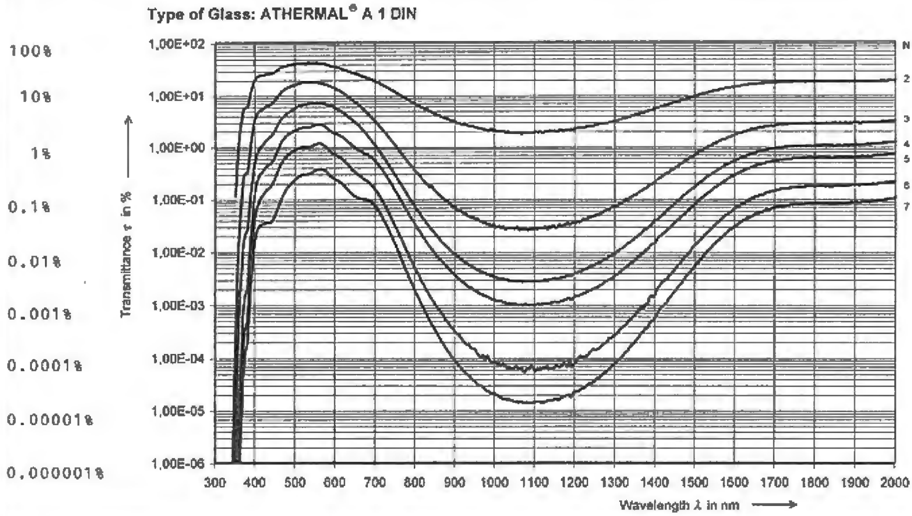
SPECTRAL TRANSMITTANCE
Type of Glass: ATHERMAL A 1 DIN

Figure 12



SPECTRAL TRANSMITTANCE

Figure 13



SPECIFICATION

Temperature Rise of ATHERMAL Welding Filters With and Without Heat Reflecting Mirror Coatings

During extreme heat exposure, the eyes must be given extra protection. High radiated energies can develop, especially during hot welding, inert gas welding, arc welding, or plasma welding of large work pieces. During these welding operations, the distance between the eyes and the protective filter is often very small. After 20 minutes of usage, the

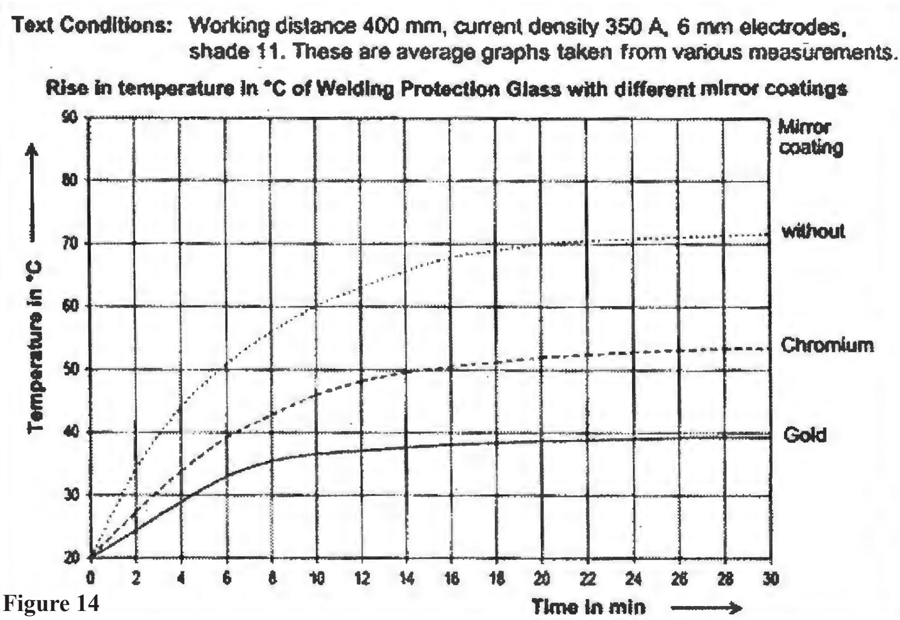


Figure 14

conventional uncoated protective filter may reach a temperature of approximately 70°C. These high temperatures are disagreeable and injurious to the eyes.

An extra safeguard against heat exposition of the protective filter is offered by heat reflecting coatings. The maximum protection is secured by gold mirror coating (Au). Under the prescribed test conditions, the gold mirror coating does only reach the body temperature after 20 minutes of exposure. Using the less expensive chrome mirror coating (Cr), the protective filter gets hotter, but temperatures of <55°C are still in the acceptable range.

Derived from the temperature rise of an optimum Cr mirror coating, the mean reflectivity in the near and mean IR range has to be at least 60%. Mirror coatings with a remarkably lower reflectance do not have any acceptable protective function within the eye protection.

SPECTRAL REFLECTANCE

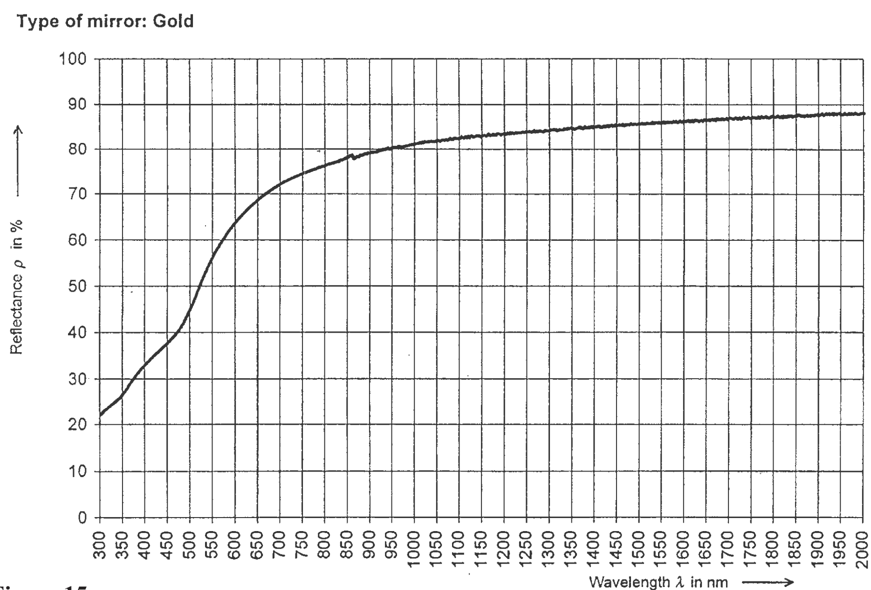


Figure 15

CONCLUSION

REMEMBER: your eyes are your most important instrument. Always wear eye protection to protect your eyes.

The Relationship Between Neon And Scientific Glassblowing

by

Douglas Navalinsky[a]

ABSTRACT

Discussion of types of glass used for neon and scientific glassblowing. Topics include types of fires used, bending and sealing techniques, and tools used for each medium. Also discussed are vacuum equipment and manifold designs as well as filling tubing with neon or argon gas.

1. Similarities
   a) Tubing in lengths of 4 feet or 1.5 meters
   b) Making straight seals and side seals on tubing
   c) bends of various angles including U-bends and offset bends
   d) neon electrodes have glass to metal seal

2. Differences
   a) neon tubing is lead glass or soda lime
   b) use gas and forced air to run torches instead of oxygen
   c) bending done on benchtop covered with fiberglass pattern paper
   d) three commonly used torches include: opposing torch heads with 1" wide flame; adjustable ribbon burner; small opposing head hand held torch for tipping off vacuum connection.

3. Electrode composition
   a) nickel wire sealed through glass to nickel shell with ceramic collar for centering in tube
   b) electrode length varies from 50 mm to 75 mm long on tubing from 8 mm to 18 mm in diameter

4. Neon tube processing
   a) neon unit connected to vacuum system by 5 mm diameter tube
   b) vacuum drawn down to approximately 2 torr
   c) elecricity applied to unit by means of a large adjustable transformer through the electrode leads. This heats the unit and electrode shell causing the glass and electrodes to outgas.
   d) unit heated to 250 degrees C. At this point the unit remains under vacuum while cooling off.
   e) at 50 degrees C the main vacuum is closed and unit is filled with neon or argon gas to a fill pressure between 8 and 18 torr depending on tube diameter.
   f) finally unit is sealed off with small hand torch.

5. Color in neon tubes
   a) gas type, neon = red/orange, argon = blue
   b) phosphor powder coating in tube
   c) colored tube
   d) combination of any of the above

6. An open discussion and questions

[a] NavCour Glassware, 605 Clague Parkway, Bay Village, OH 44140. E-mail: dn@navcour.com

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