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SEAL TESTING IN THE DEVELOPMENT OF A NEW, HARD MOLYBDENUM SEALING GLASS, CORNING CODE 1725

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Abstract

Using cylindrical bead seals to evaluate expansion mismatch of candidate glass compositions with respect to molybdenum, key data was established to assist in the development of a new, very hard molybdenum sealing glass, Corning Code 1725. A major application for this glass is for tungsten halogen lamp envelopes.

Mismatch data is established through the reduction of stress-retardation data taken by conventional techniques. Corrections to standard formulae recently established by Gulati and Hagy are applied and shown to enhance the analyses.

Through the use of a furnace, mismatch-temperature curves are established from room temperature to above the glass annealing point. This information was used to tailor the glass expansion to fit customer requirements.

1. Introduction

For a number of years, Corning Code 1720 aluminosilicate glass has proven to be a suitable envelope and molybdenum sealing mate for tungsten-halogen cycle lamps. As the data show later in this paper, glass-wire seals made with this combination result with axial compression in the glass, with the metal being higher in expansion from the setting point of the glass to room temperature.

In general, lamp manufacturers have preferred to have this mode of stress in seals, having experienced cracking when axial tension occurred. One condition that produces axial tension is the expansion mismatch reversal at high operational temperatures of lamps. Failures due to axial tension were, therefore, increased as more compact, higher power lamps were developed. In addition, these new lamps operate at such increased temperatures that viscous distortion can be a problem. Obviously, this problem calls for a harder glass which will be evaluated by annealing and strain points in this paper.

It will be demonstrated that cylindrical bead seals fabricated from molybdenum wire and candidate glasses are efficient, effective means to generate meaningful mismatch-temperature data. Expansion relationships are established and in combination with manufacturing constraints lead to the development of a new, hard sealing aluminosilicate glass, Corning Code 1725.

2. Experimental Method

2.1 Seal Fabrication

Seals were made by heating crushed glass, 1/32" to 1/8" in size, around molybdenum wire in a graphite mold which also served as a susceptor for inductance heating. The thermal schedule takes 20 minutes, 10 minutes heating to 1200° to 1350°C depending on the particular glass, holding at maximum temperature for five minutes, and cooling. The mold-glass assembly is housed in a VYCOR™ brand glass tube flushed with an argon -3% hydrogen gas mixture. The ground glass was washed thoroughly and dried to reduce reboil from fires.

Three sources of molybdenum wire were used: 0.060cm diameter source unknown, 0.062cm diameter from Climax, and 0.033cm diameter from General Electric. Seal testing indicated that the three lots were identical in expansion.

Seals were normally 0.4cm in diameter and 1 to 1.5cm in length.

2.2 Retardation - Temperature Measurement

Specimen seals were supported on a ceramic platform at the center of a Nichrome-wound tubular furnace equipped with 3/16" diameter sighting holes. The furnace tube is 14 ½" long with a 1" I.D. and 1/8" wall.

The junction of a type S thermocouple is within 1mm of the seal surface. Temperature is read directly on a Doric Trendicator 400A instrument.

A Friedel polarimeter was used to measure the optical retardation at the glass-metal interface as shown in Figure 1. Filtered white light was used which was characterized as having peak transmission at 522nm. The light path is normal to the seal axis.

A seal is heated slightly above the temperature at which the stress retardation goes to zero and remains zero on further heating - about 50°C above the annealing point of the glass. The seal is then cooled at 300°C per hour to a temperature 100°C below the strain point, after which cooling is accelerated and arbitrary. Optical retardations are taken at enough arbitrarily selected temperatures to describe the curve.

2.3 Data Reduction

Optical retardation data is used to calculate the total expansion differential (mismatch) at any temperature by use of the following expression

$$T = \frac{2.90(1-\gamma_g)F}{CKE_g\sqrt{B^2-A^2}}\left[\frac{E_gB^2}{E_mA^2} - \frac{E_g}{E_m} + 1\right]10^6 \quad (1)$$

where: δ_T = total mismatch, ppm.
E_m = elastic modulus of molybdenum, psi,
E_g = elastic modulus of glass, psi,
γ_g = Poisson's ratio of glass,
C = shape factor
K = stress-optical constant, nm/cm/psi,
B = diameter of glass bead, cm,
A = diameter of molybdenum wire, cm, and
F = Polarimeter compensation angle, degrees.

From the standpoint of usual bead-seal practices, these seals are non-ideal. They give high B/A ratios, 7.3 for the larger wire and 13.3 for the smaller wire. Recent work by Gulati and Hagy[1] evaluated the shape factor C as a function of B/A and E_m/E_g. Unfortunately this work did not evaluate C for high values of either ratio. For B/A = 7.3, C was extrapolated linearly to a value of 0.66 for $E_m/E_g = 3$. Actually $E_m/E_g = 4$ for these materials, but this does not seem to cause much error since the curves level off above $E_m/E_g = 3$. For the smaller wire with B/A = 13.3, a very low value of C was obtained by linear extrapolation resulting in ridiculously high mismatch values. For this reason the value of C was kept at 0.66 for the smaller wire analyses which brought the mismatch curves into convincing agreement with the heavier wire data. The smaller wire seal data lacks sensitivity in mismatch and, therefore, no data is presented in this paper.

2.4 Glasses Studied

Table 1 gives annealing point, strain point, 0.300 °C expansion, and two mismatch functions discussed later for seven glasses studied. Two versions of the General Electric 180 hard sealing glass are included for comparison.

The literature gives an $E_m = 48 \times 10^6$psi for molybdenum. For Code 1720 glass, $E_g = 12.3 \times 10^6$psi, whereas experimental glasses Z and Z′ yielded a value of 12.1×10^6psi, not significantly different. The stress-optical constant for glass Code 1720 is 0.191nm/cm/psi. A value of 0.188 nm/cm/psi was obtained for Z glass. Accordingly, E_g was assumed to be 12.2×10^6psi and K was assumed to be 0.190nm/cm/psi for all glasses except GE180. In order to make the expansion parameters fit, the product KE_g in Equation 1 had to be increased by 18%. No direct measurements of these properties were made to confirm this adjustment.

3. Experimental Results

When nominal values are substituted in Equation 1, one degree Friedel of analyzer rotation is equivalent to 45ppm in total mismatch. The standard deviation for determining the analyzer position is 0.33° or 15ppm. The scatter of points around the curve drawn is in keeping with this analysis.

The curve of most interest initially is that for Code 1720 glass vs. molybdenum, shown in Figure 2. This shows a room temperature mismatch of + 150ppm, but a crossover temperature below 200 °C. Hence, the need to increase the crossover temperature and annealing point are apparent for higher temperature applications. However, the room temperature mismatch is ideal.

Another starting point comparison was necessary. Some negative reaction to Corning Code 1776 had been encountered in the field. Figure 3 helps explain why this occurred. The mismatch is negative over the complete range, producing axial tension at all temperatures.

Composition studies produced glasses that had higher crossover temperatures and higher annealing points like experimental glasses Z and Z′ shown in Figure 4. In most respects these glasses seemed to be ideal but there was strong opinion that they were not hard enough, viscously.

The General Electric glasses shown in Figure 5 are characterized by very high crossover temperatures and high positive mismatch at room temperature.

As composition research moved towards higher annealing points, liquidus temperature and other manufacturing considerations forced moves towards lower thermal expansions. Accordingly, Code 1725 emerged as a very hard (annealing point = 804 °C), high crossover temperature (~600 °C), and relatively high room temperature positive mismatch as shown in Figure 6.

Since molybdenum is a constant reference, the difference in the total expansion mismatch between two fixed temperatures should be proportional to the thermal expansion coefficient of the glass over a fixed range. In Figure 7, the mismatch change from 25 °C to 500 °C (Δ_{RT}-Δ_{500}) is plotted as a function of the independently determined 0-300 °C average expansion of the test glass. This linear relationship, established with six of the glasses initially, agreed well with the final values for Code 1725 glass. This plot predicts a 0-300 °C expansion coefficient of 5.4ppm/°C for molybdenum, the point where Δ_{RT}-Δ_{500} = 0.

The expansion coefficient of molybdenum as a function of temperature was derived by algebraically adding the mismatch curve to the glass expansion curve. This was done for three of the glasses as shown in Figure 8. These values are in reasonably good agreement with the American Institute of Physics Handbook data, and even closer to unreported work by the author in 1953. The values from the Handbook are probably for ultra-pure molybdenum. In any event, the discrepancy is not large, and this is a credit to seal analyses. Part of the problem may be that the glass expansion curve was determined on cooling at a slower rate (100 °C/hour) than that used for the seals. Another source of small errors is that E_m, E_g, and K are assumed to be constant with temperature, whereas all three change by a few percent.

4. Conclusions and Discussion

Cylindrical bead seals provide an excellent basis for tailoring mismatch in sealing glass development. Recent modifications to the working mismatch formula by Gulati and Hagy improve mismatch determination accuracy as shown by the close agreement of derived molybdenum expansion data with the literature.

Corning Code 1725 glass developed through seal analyses is a very hard, high crossover molybdenum sealing glass. The relatively high room temperature positive mismatch is only of concern from the associated radial tension that results in the seal. Actual lamp manufacturing has shown that the seals have high integrity with this mismatch and will not fail if they are made with sufficiently high temperature and flow to avoid re-entrant geometries.

5. References

1. S.T. Gulati and H.E. Hagy, "Expansion Measurement Using Short Cylindrical Seal: Theory and Experiment" pp. 111-130 in Thermal Expansion 6, Edited by Ian D. Peggs, Plenum Press (1978).

Table 1

Study Glasses and Physical Properties

	CGW Code 1720	CGW Code 1776	Older GE 180	Newer GE 180	Z	Z'	CGW Code 1725
Ann. Pt., °C	712	749	798	785	794	778	804
St. Pt., °C	667	705	747	732	749	732	755
0–300 °α, ppm/°C	4.2	5.25	4.42	4.56	4.60	4.79	4.3
Δ_{RT}, ppm	+150	-330	+520	+460	+300	+210	+690
Δ_{500}, ppm	-360	-380	+ 30	+ 30	- 90	-130	+140

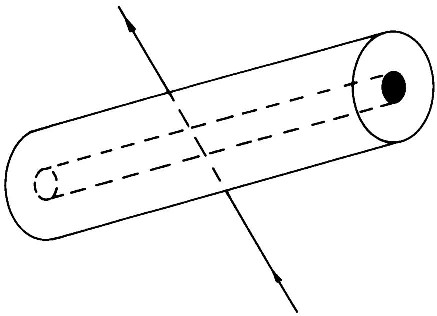

Figure 1. Glass-to-Metal Cylindrical Bead Seal Geometrical Configuration Showing Line-of-Sight for Optical Retardation Measurement.

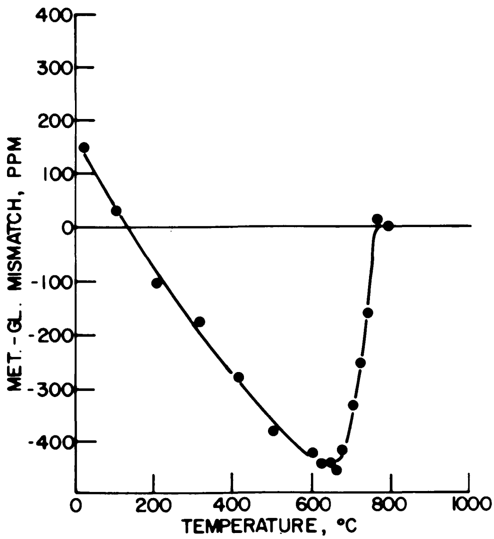

Figure 2. Thermal Expansion Mismatch-Temperature Relationship Between Corning Code 1720 Glass and Molybdenum.

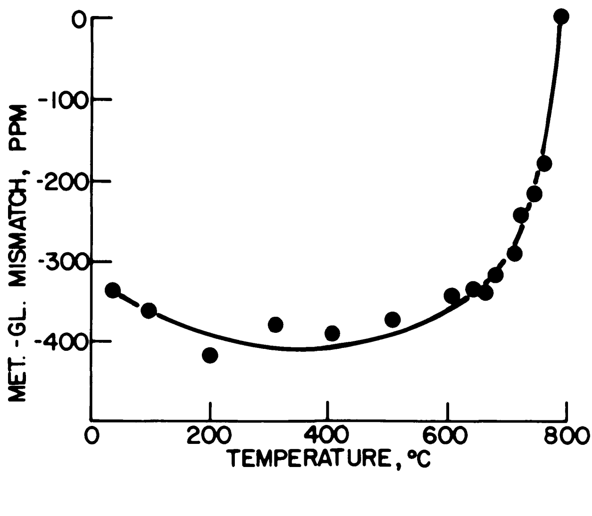

Figure 3. Thermal Expansion Mismatch-Temperature Relationship Between Corning Code 1776 Glass and Molybdenum.

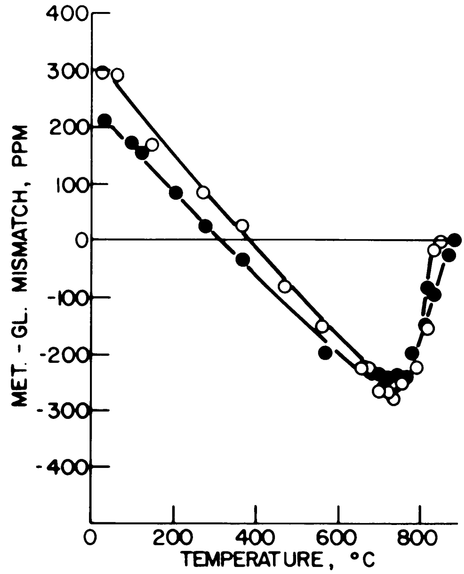

Figure 4. Thermal Expansion Mismatch-Temperature Relationship Between Corning Experimental Glasses Z (open circles), Z′ (dark circles) and Molybdenum.

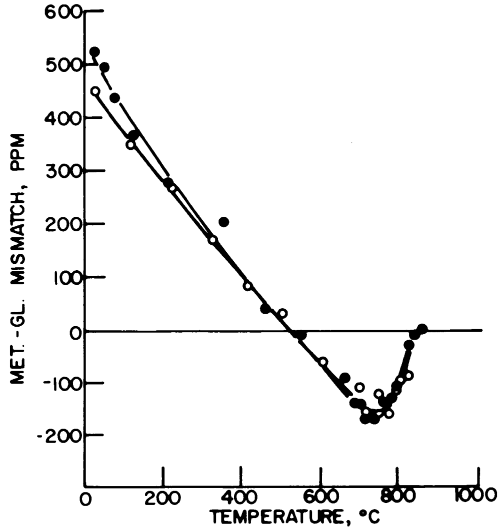

Figure 5. Thermal Expansion Mismatch-Temperature Relationship Between General Electric Glass 180 and Molybdenum; Older Modification (dark circles) and Newer Modification (open circles).

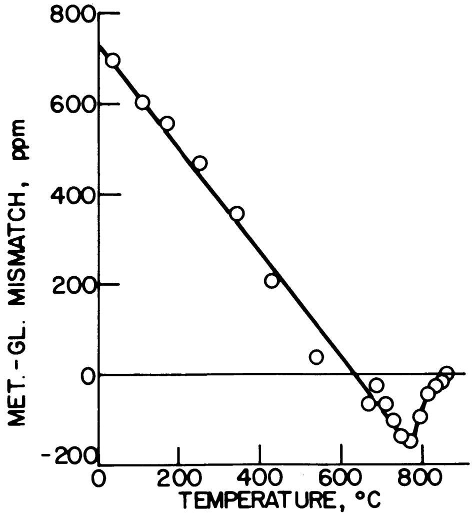

Figure 6. Thermal Expansion Mismatch-Temperature Relationship Between Corning Code 1725 Glass and Molybdenum.

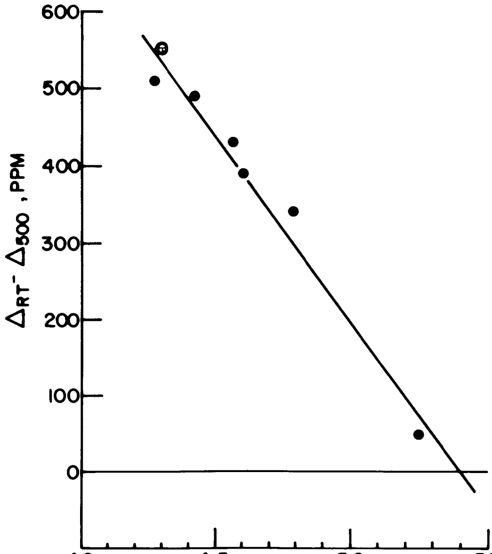

Figure 7. Thermal Expansion Mismatch Differential Between 25° and 500 °C as a Function of Glass Expansion Coefficient (0 to 300 °C) for the Seven Study Glasses; Corning Code 1725 Glass is Depicted by the Open Circle Data Point.

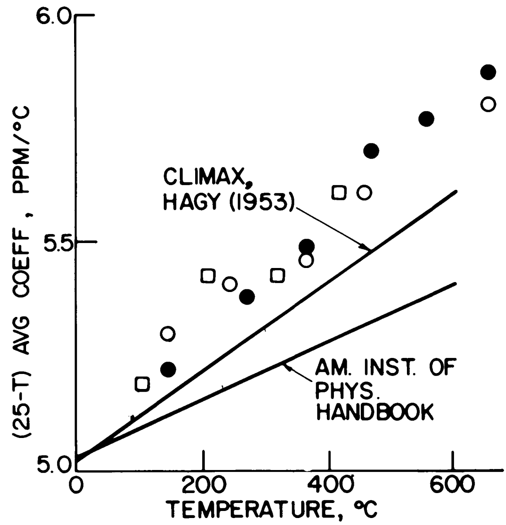

Figure 8. Derived Thermal Expansion Coefficient-Temperature Data for Molybdenum with a Comparison to Data from Two Other Sources; Data Derived from Three Study Glasses: Code 1720 Glass (squares), Experimental Glass Z (open circles), and Experimental Glass Z′ (dark circles).

MINIATURE GLASS COATED INDUCTION COILS

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Introduction

Induction coils or general purpose radio-frequency inductors are produced in a variety of shapes and sizes. Some coils may be insulated while others are not.

For the purpose of welding glass-to-metal or metal-to-metal, most coils could be rather large in diameter while they are also water-cooled in order to protect them against heat reflection from the treated material. In such cases the coil material will simply be copper pipe of different diameters.

Where induction coils need to be submersed in a liquid, the coil may have a layer of insulating material over it.

To keep the "noise levels" down, produced by the coil, we preferably use metals with low resistance such as: copper, silver, gold, platinum, tin, or a mixture of niobium and tin.

The induction coil described hereafter is of a microsize that's insulated with quartz glass. It was originally designed for nuclear magnetic resonance (N.M.R.) receiver coil purposes, but such coils are not specifically limited for that particular application. The question that I really want to answer is simply: "How do you fabricate a small quartz coil with a low resistance metal wire inside of it"?

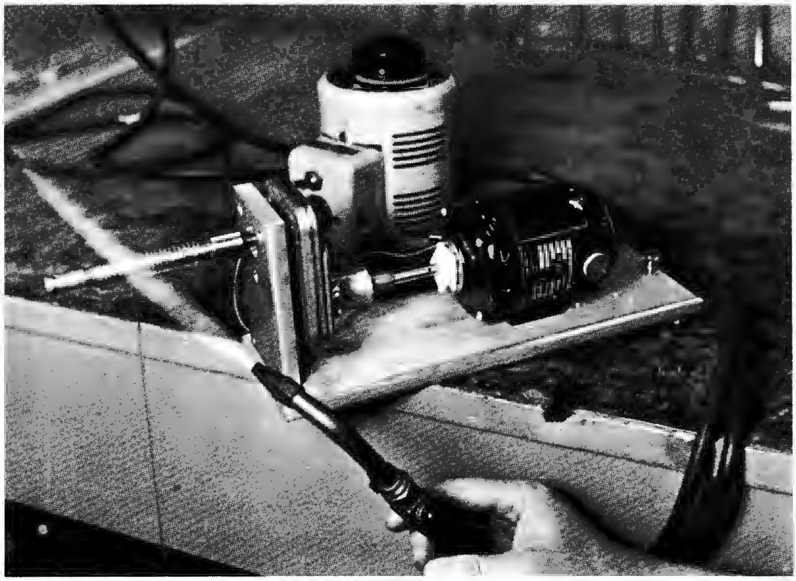
It's impossible to push a very thin, low resistance wire of any kind through a micro glass coil. Therefore, pure silver, in the form of small beads, is molten directly into the coil.

Due to its low resistance, silver is one of the preferred metals for induction. It has a melting point temperature of 960.8 °C and a thermal expansion coefficient of 19.6×10^{-6} (cm./cm. °C) while quartz glass has a thermal expansion coefficient of $.55 \times 10^{-6}$ (cm./cm. °C) and an average annealing temperature of 1150 °C. This means that the silver metal opposite the quartz glass are two ideal materials to be combined under these circumstances.

Preparation of Small Quartz Coils

The quartz tubing used for making the coil should preferably be of fairly heavy wall. For example, a 1.5 mm. O.D. with a .5 mm I.D. is a good ratio. Wrapping the coil should be done as evenly as possible because the inside diameter should be kept as constant as possible over the entire length of the coil. Constricted parts may hinder the proper function of the induction principles.

To accomplish this, the coil is wrapped around a stainless steel mandrel which is attached onto a speedreducer. By means of a variac the speed of a variable motor can be controlled in order to activate the speedreducer and make it turn at the required R.P.M.'s (Fig. I.)

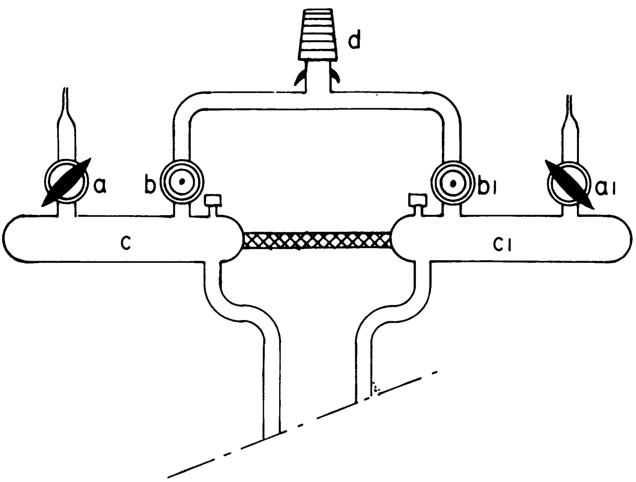


A large hand-operated bolt permits the bed of the coilmaking equipment to be set at an angle; this is to control the speed of the coil so that the windings can be spaced properly or prevent overlapping. A small weight hooked on the end of the quartz tubing will keep a slight tension on the glass while it's wrapped around the mandrel. The softening of the quartz is done by means of a handtorch using propane gas and oxygen. Once the coil is wrapped it can be removed from the mandrel; the coil ends can be reheated and brought into the desired position.

Outline of Silver Melting

Besides making the quartz glass coil itself, some additional non-standard equipment will be needed to perform this technique successfully. One of these items is a small secondary vacuum manifold consisting of two separate controllable sections that are interconnected to either the primary vacuum line and/or an argon cylinder (Fig. II). Each manifold section has two vacuum stopcocks and a socket for rubber stopper welded onto it.

secondary vacuum manifold



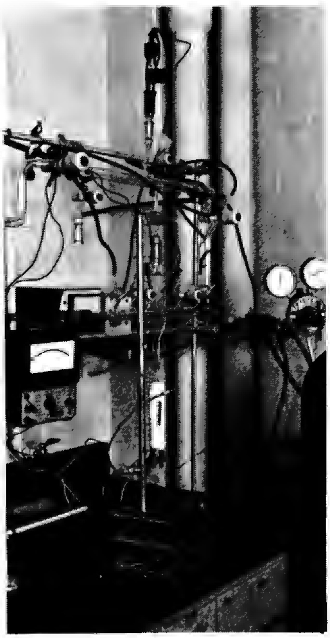
a-a1: constricted glass high vac. stopcocks
b-b1: teflon high vac. stopcocks
c-c1: manifold
d: vacuumline connection

Stopcock B and B1 are high vacuum, teflon plug valves that are both interconnected onto a standard tapered joint (or other type of connector) which is adapted to the primary vacuum system. Stopcock A and A1 are all glass high vacuum stopcocks. The top ends are drawn out into a fine capillary to make it easier to control the stream of argon gas. Again both stopcocks are interconnected by means of rubber tubing which is attached on the regulator outlet of the argon cylinder.

Another item needed is a small electrical furnace that consists of a medium wall quartz tube that's wrapped with Kantal A heating wire (Fig. III). A blank spot is left open in the furnace insulation to serve as a view window. The furnace is connected onto a variac for temperature selection while a thermocouple is inserted in the furnace, when in operation, to read the actual temperature inside the small quartz tube oven. The furnace insulation material is Sauereisen sealing cement.

Procedure

The quartz coil combined with the silver beads reservoir are welded onto the downlines of the manifold by means of two graded seals. The electric oven and thermocouple are brought in place while a thin nichrome wire is inserted through each of the rubber stoppers and into both downlines of the manifold. The nichrome wires may reach as far down as the bottom of the silver reservoir in both lines. Both wires are later connected onto a Volt-Ohm meter for control purposes (Fig. IV).



Step 1. Close A and A1; open B and B1 and evacuate the system.

Step 2. Close B and open A. The system will be filled with argon gas coming in at a very low pressure.

Step 3. Close A. All argon gas in manifold C, silver reservoir, coil and manifold C1 will be removed through stopcock B1.

Step 4. Repeat argon rinse one more time.

Step 5. Switch electrical furnace on and repeat the argon rinse when temperature inside the furnace is approximately 500 °C.

Step 6. Close A and A1. Open B and B1 and evacuate the system while heating.

Step 7. When the temperature in the furnace reaches 1000 °C, the silver granules have molten. Close B and open A. The argon gas will pressure the liquid silver slowly into the coil.

Step 8. When silver fills both leads and coil, open B and close A.

Step 9. Turn electrical furnace off gradually.

Between Step 7 and 8 the Volt-Ohm meter can be switched on, and if both ends of the nichrome wire make a contact with the molten silver we should be able to determine if the silverfilling of the coil is continuous. Should an interruption occur, the liquid silver then can be collected back into the reservoir and we can start again with Step 7.

WHAT EVERY GLASS BLOWER SHOULD KNOW ABOUT FIBER OPTICS

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Before mentioning various types of fibers and their applications, one should know how an individual fiber is constructed. Each fiber is made of two glasses with different indices of refraction for the core and the cladding to maximize the ability to transmit light. The softening points and coefficients of expansion of the two glasses must be carefully matched. The outer glass should have a slightly higher softening point and a slightly higher coefficient of expansion. The simplest fabrication procedure is to use tubing for the cladding (low index of refraction) and rod for the core (high index of refraction). The rod is inserted in the tubing and the combination is lowered into a vertical furnace and drawn down to the desired diameter. See figures I & II.

Individual fibers cannot transmit an image. However, by carefully aligning many fibers in a flexible bundle or a solid rod, an image may be transmitted. The resolution of these bundles depends upon the diameter of the fibers. The flexible bundle is extensively used in medical instruments where the device is inserted through natural openings in the human body and in a variety of inspections where access with other optical instruments is not possible, e.g., inspecting behind the fan blades in an aircraft engine, the welding on submarine structures, etc.

For maximum flexibility the bundles are loosely joined along their length except at their ends which are cemented together to retain alignment and then polished. Because cement has a tendency to deteriorate, it would be helpful to develop a fusion process which would eliminate the need for cement. One has to realize, however, the difficulty in this, due to the thin cladding on each fiber which must not be disturbed during fusion.

There is another type of fiber optics imaging structure, called a multifiber, which we assemble from 11,000 fibers bundled in hexagonal close packing, then heat in a vertical furnace, and draw down to form an approximately ½ mm diameter rod. Because this requires uniform heating of the bundle, it is extremely difficult to produce a perfect and stable multifiber structure, free of broken fibers which appear as black spots in the conveyed image. When totally fused and rigid, a high resolution can be attained in this type of fiber, which enables one to construct a very small probe suitable for use in a hypodermic needle. The individual fibers in a multifiber of this type are usually about 5 u in diameter, less than ⅒th of the size of an average human hair. See figures III & IV.

The absence of lenses at the end of any image-conveying bundle requires that the end of the fiber bundle be placed in contact with the specimen being viewed, limiting the field of view to the small area of the imaging bundle.

An effort to develop a small lens system to match the fiber-bundles was successful, and we now have lens systems as small as ½ mm in diameter, with a 90° field of view and a depth of field from 3mm to infinity. We have brought an 0.8 mm diameter lens system to demonstrate it to you. This system consists of nine elements including three lenses. See figure V.

Another type of fiber which in the last few years has become a household word is the communication fiber, developed by Corning Glass Works, a glass so pure that it can transmit light long distances with minimum loss. A single fiber of this type, 0.1 mm diameter, can now be made to carry up to 672 one-way conversations simultaneously. This means that eight fibers, a bundle no thicker than a pencil lead, could do the job now being done by a 3-in telephone copper cable. These fibers are immune to leaking cross talk and static because of their glass construction. Splicing of the ends of two fibers together is done by joining the ends in such a way as to minimize transmission loss through the splice. These techniques have been discussed in other papers.

Optical fibers are also used to provide illumination in a variety of instruments today. Fabrication of these fiber bundles is considerably simpler than fabricating imaging bundles because alignment or coherence is not necessary. In many applications, a single large fiber rod can be used and heat bended to fit into a particular configuration. This must be done with a low flame and in a gentle curve in order to minimize transmission loss.

Fiber optics has been developed to a very sophisticated level. There exist applications of fiber optics in the fields of communications, medicine, inspection, spectrophotometery, robotics, and lasers. Despite this sophistication, there are still many fundamental problems to be solved and applications to be discovered by the innovative glassblower.

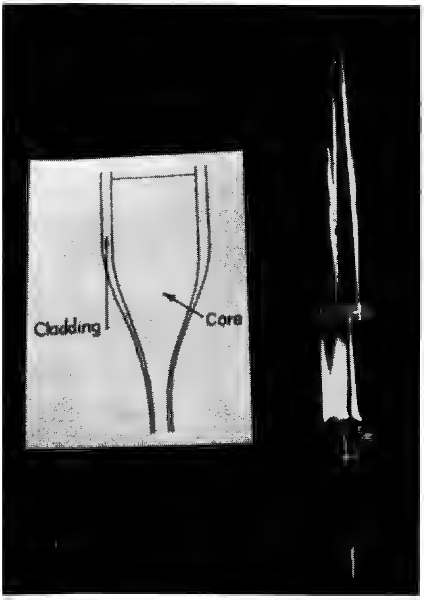

Fig. I Boule assembly for drawing single fibers.

Fig II. Furnace and drawing mechanism for pulling fibers.

Fig. III Multiple fiber coherent Boule assembly consisting of 11,000 fibers, each .4mm/dia. drawn down to form approx. .5mm/dia. rod.

Fig. IV Portion of cross section of rod drawn from a multifiber Boule.

Fig. V Fiber optic hypodermic probe (used to view tooth root canals) consisting of viewing fibers with lens system and illumination all in needle .036" diameter.

MAKING A POLARISCOPE

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Introduction

It is well known that when a stressed piece of glassware is placed between two polarizing plates, with the polarizing planes set at 90° to each other, a light source at one end will show those stresses in the form of light and dark bands when observed through the opposite plate. If a very thin crystalline sheet, is interposed at the observer end, the light and dark bands are seen with a varying color tint which is considered to give superior sensitivity. A sheet this thin is commonly called a quarter wave plate.

Since commercial polariscopes cost as much as 400 to 500 dollars it seemed appropriate to describe a polariscope which can be made for less than one tenth of that. The Glassblower's test for thermally induced strains in glassware does not require a quantitative analysis of the strain, so to him a polariscope is merely a "go-no go" gauge.

Method of Construction

This polariscope uses a linear polaroid sheet mounted in a suitable housing with a light bulb for illumination, a pair of polaroid sun glasses for the observer with a thin sheet of split mica fastened to the lense. Polarizing material can be purchased either directly from the Polaroid Corp., or much more economically from Edmund Scientific Co. The Polaroid Corp. now sells a polarizing sheet with a quarter wave plate built in. This material is known as circular polarizer. But since a 19" × 50" sheet of this material sells for $65.00 each, (enough to make 237 polariscopes) we used the split mica method to provide the quarter wave plate. More on that later.

To make the light source it is convenient to use an empty metal 5 gallon solvent or oil can. The bottoms and tops of these cans are usually recessed about ⅜ inch deep so if the top is removed leaving about ⅜ inch of the bottom intact you now have a recessed ledge on which to rest the polarizing plate.

Cut the polaroid sheet with scissors to the diameter of the prepared ledge. About 10 inches. Also cut two pieces of window glass the same diameter, one of which should be ground on the surface to serve as a diffuser. Plastic diffuser material could be used instead of the ground glass if preferred. Sandwich the polarizing material between the glass plates and tape them together around the edge. They are ready to be placed in the recess of the can.

The other end of the can remains intact except that a porcelain socket is mounted at the bottom to accept an ordinary 100 watt bulb. The new type circular flourescent tubes might be superior to the incandescent bulb. It is advisable to paint the inside of the housing with aluminum paint and also place a sheet of aluminum foil along the bottom before mounting the socket, to provide a reflecting surface. A length of ½ inch "thin wall" conduit is attached to the lamp housing and brought down and out far enough to allow viewing space, then up in front of the polaroid screen. After adding a short section of "wiremold" at 90° to the pipe we have a support for the analyzing spectacles and for a toggle switch to operate the light. Simply wire the switch in series with the bulb and bring a cord out of the side of the can using a rubber or porcelain grommet in the housing.

The spectacles are "Polaroid" sun glasses and are mounted by the ear-pieces to the "wiremold". If wire ear-pieces are available, cut off the curved portion and solder them to short sections of 3/16 inch brass rod which have been threaded. The ear-pieces are bent so that the threaded end can be fed through drilled holes in the "wiremold" with nuts on either side, having the lenses facing the light source. If plastic ear-pieces are used, they can be cut off short, drilled and screwed to a flat brass strip which is in turn screwed to the "wiremold". If "wiremold" is unavailable a "handy" box will suffice.

The instrument is now complete except for the quarter wave plate to provide the color tint to the observed strain area. John Strong, in "Procedures in Experimental Physics", states that a sheet of mica 0.036 millimeters thick will act as a quarter wave plate suitable for the wave lengths of which we are concerned.

The starting sheet is trimmed to about 3 inches square with sharp tin snips so as to have clean edges. The exact size is immaterial. One corner of the starting sheet is frayed out by rubbing it, and a clean needle is introduced to divide the sheet approximately in half. A drop of water is introduced into the cavity so produced. The mica is then split all around the edges by working the needle along, point first at an angle of about 30°, so that the first cleavage starts inside the boundary of the sheet. This avoids terraced cleavage. After the needle has gone around the circumference, a second drop of water is introduced and the plates are drawn apart. The water so facilitates cleavage that the sheets may be separated as easily as the pages of a book. This process is repeated until the thickness is as thin as desired. Each time the sheet is divided so as to give two sheets of approximately the same thickness.

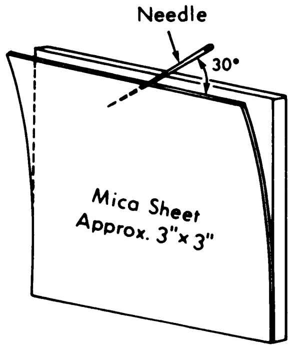
The large plates in the light source are now rotated to the point of maximum transmission of light when observed through the analyzer spectacles. After placing a specimen of stressed glassware in the observation zone, place the split plate in front of the spectacle lens and rotate until the desirable tint appears. If the proper thickness has not been achieved it can be split again. A good way to approximate the thickness is to weigh the sheet with a good balance. The proper thickness is in the range of 8 mg. per $cm.^2$. When satisfied with the color tint, the plates may be cut into circles of the proper size by tracing around a metal template with a needle, and then fastened to the lens with a drop or two of "Canada Balsam" or any other favorite adhesive.

The whole assembly can be mounted on the wall with a "U" shaped bracket fastened to the center of the light housing. Or mounted on a tri-pod base which will provide portability. This shop has two such polariscopes which have been in use for over 20 years.

References

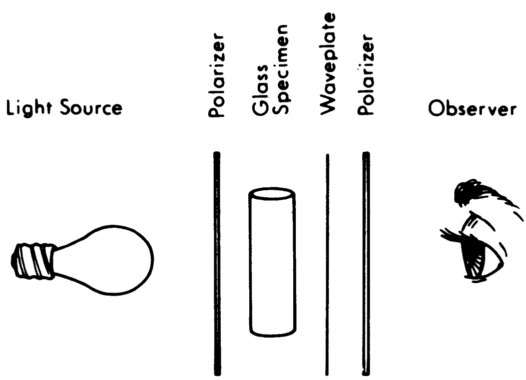
1. Procedures in Experimental Physics, John Strong, Prentice Hall Inc. (1944)
2. Strong J. Rev. Sci Instruments, G, 243 (1935)
3. Scientific Glassblowing, E.L. Wheeler, Interscience Pub. Inc. New York (1958)

Mica and Canada Balsam



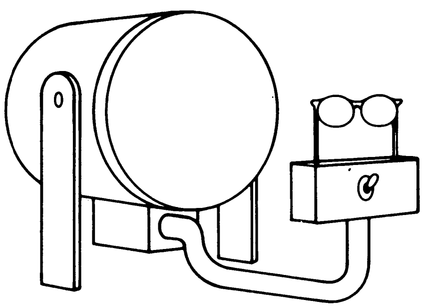
Carolina Biological Supply
Burlington, No. Carolina 27215

Sargent - Welch Co.
7300 Linder
P.O. 1026
Skokie, Illinois 60077



BASIC POLARSCOPE

Polarizing Materials



Polaroid Corp.
Polarizer Division
1 Upland Rd.
Norwood, Mass. 02062
617-769-6800

Edmund Scientific Co.
300 Edscorp Bldg.
Barrington, N.J. 08007

GRINDING AND POLISHING OF GLASS

Francis J. Gutberlet
Eastman Kodak Company
Rochester, New York

Introduction

Man's fascination to form useful objects out of glass type materials by grinding and polishing started hundreds of years ago. Archaeologists have found crudely formed lenses dating back to 3000 B.C. that are thought to have been used to start ceremonial fires. Amazing even more was the dual discovery, dated around 1000 B.C., of a clay tablet and a natural quartz lens roughly shaped on a pottery wheel. The lens was needed to read the small markings pressed into the tablet.

Sir Isaac Newton, "The Father of Modern Optics", started in the 16th Century to record scientific experimentations into the grinding and polishing of glasses. He introduced the use of pitch as a polishing material, a mechanical oscillating motion that is still used in modern surfacing equipment, plus he proposed a theory as to what occurs as glass materials are ground and polished. Since his time a multitude of grinding and polishing theories have appeared, making glass grinding and polishing a complex picture with minimum mutual agreement.

Basics of Grinding and Polishing Glass

The simplest analogy to explain what happens in grinding and polishing of glass, is to think of a master cabinet maker, as he strives to produce a mirror finish on a rare piece of wood. He uses a series of sandpapers, starting with a coarse grain to shape the surface, followed by a series of medium and finer grain sandpapers to gradually change the wood's surface shape and texture into the smooth, mirror finish desired. Each size sandpaper abrades away the wood surface as individual sawdust particles of a particular size. The cabinet-maker must constantly check to see that each sandpapering step removes the rough texture and remnant scratches left on the wood's surface from the previous sanding step.

Similarly, the grinding and polishing of optical glass is a series of surfacing operations, starting with a rough grinding or shaping operation, followed by a series of progressive finer grinding operations, and then finalized by a series of polishing operations. The quality and uniformity of the desired finished optical surface determine the number and types of surfacing operations required. Each operation is planned and controlled to remove enough stock from the glass's surface, to eliminate the coarse surface from the previous surfacing operation, leaving a new finer textured surface on the glass.

This chart (Chart 'A' in addendum) shows a cross-section of a piece of glass, depicting a simple three stage surfacing operation with the normal amounts of glass removal planned for each operation. It should be noted that as an abrasive grain travels across the glass surface it not only abrades away the glass as small particles, but it also causes sub-surface defects in the form of fine cracks or fissures down into the glass. Basically the size of the abrasive grain determines the magnitude of the sub-surface defect. The stock removal at each operation should be great enough to remove the sub-surface damage caused in the previous surfacing operation. A planned and controlled stock removal schedule ensures surface integrity with increased glass strength. My own experience has shown this to be true, first, in that eliminating sub-surface damage prevented cracks from opening in bifocal fusion operations, and secondly, the increased durability of controlled ground and polish surfaces to with-stand ultra-sonic cleaning action.

A recent published example of successful controlled stock removal programing is the surfacing of the fused silica Space Shuttle Orbitor windows. This surfacing program was designed to remove a thickness of stock at each step equivalent to about three times the abrasive grain size of the previous step, thereby definitely erasing the sub-surface damage of the previous step. The eight surfacing steps in this controlled grinding and polishing schedule, significantly increased the strength of the fused silica glass windows, as can be attested to by the three successful flights of the same Orbitor Shuttle.

Abrasive and Tooling Review

Now that you are aware of the increasing importance of programed stock removal to producing stronger and more durable glass optics, you can appreciate the growing needs for grinding and polishing materials and tooling that are uniform and reliable in structure, with good performance over a reasonable tool life. Let's compare some of the materials and tooling that were available to the optician up to twenty years ago, against currently available commercial products. Hopefully some of the recently developed commercial products can be a help to you in your work.

I. Grinding Abrasives

DIAMOND
CORUNDUM
EMERY
FLINT
GARNET

These materials are all found in natural resources, processed, and sized into various grain sizes. They have a long history of use as grinding abrasives for glass and other materials. Their performance and life are very much influenced by the quality and purity of the raw material.

To override the unstable characteristics of natural materials, man has begun manufacturing artificial materials, with controlled physical properties, such as crystal structure, size, and shape of the abrasive grains. Some of these are:

SYNTHETIC DIAMOND
BORON NITRIDE
BORON CARBIDE
SILICON CARBIDE
ALUMINUM OXIDE

These abrasives are extremely tough, durable, resistant to wear, and capable of penetrating almost any surface. Their grinding characteristics are consistent from lot to lot, because of uniformity in manufactured quality and purity. They are available in a wide range of grain sizes, as powders, or liquid suspensions, and even in pressurized spray cans.

Work continues on the development of new synthetic materials. One interesting abrasive material introduced recently is a synthetic diamond fabricated in a long needle shape, then plated with metal.

These diamond particles are subjected to a strong magnetic field as they are formed into a resinoid bonded tool. The needle shaped particles are aligned by the magnetic field so that the ends are perpendicular to the tool's work surface and held firmly in place by the resinoid bond. The crystaline structure of each needle shaped particle is such that the end's cutting edge wears in the abrading operation until it is blunt, then it breaks away, exposing a new sharp cutting edge. Renewal of the cutting edge occurs repeatedly over the entire length of each exposed particle. Total tooling life is extended by this action, along with excellent free-cutting performance. This type of tooling is now used to grind very hard materials, but in time this shaped grain orientation principle might be adapted to surfacing softer materials.

II. Grinding Tools

WOOD
STONE
METALS
CERAMICS

The opticians of the past were limited in their loose abrasive grinding operations by having only a few natural materials suited for tools. These tools varied in life and performance, again depending on the material's origin. Man has recognized this problem and has begun fabricating grinding tools with a variety of abrasive grains incorporated into the tool. The goal is to produce a grinding tool with long life expectancy, free-cutting and acceptable surfacing performances. Let's review three types of these fixed abrasive tools:

SINTERED DIAMOND
PLATED DIAMOND
DIAMOND SHEET

Sintered diamond tooling is formed by mixing the powdered diamond abrasives with metal powders or resins, then pressing and solidifying the materials together into a tool shape desired. These shapes can be cup wheels, periphery wheels, pellets, core drills, laps, etc. The tool's performance characteristics can be tailored to a specific grinding operation by adjusting the bond, the diamond particle size, the diamond concentration, and the diamond type - natural vs. synthetic.

Single layer plated diamond tools are now being produced with new plating methods and materials, that: create firm bonding between the diamond particles and the tool body, distribute the diamond particles evenly across the tool's surface, and produce a very aggressive cutting surface on the tool. Complex, accurate tooling shapes can now be formed out of metals, then plated with a single layer of diamond abrasives. Tolerances of tenths of thousands can be held both on the tool body and the plated surface. These shaped tools are used to grind the reverse shape onto a work piece.

Diamond sheet material is a unique "do-it-yourself" type of diamond tooling that came on market, 2 or 3 years ago. It is basically a thin sheet material that is impregnated with diamond throughout its entire thickness. It can be cut with a scissors or paper cutter, then formed into a tool by bending or pressing it onto a tool body and adhering it with soft solder or epoxies. Tooling applications are only limited by your imagination. It's been used to fabricate core drills, plano grinders, cup wheels, and saw blades. It is supplied in a variety of sheet thicknesses and abrasive grain sizes.

III. **Polishing Abrasives**

PUMICE
TALC
IRON OXIDE
CERIUM OXIDE

These are a few of the polishing abrasives used in the past to polish glasses. Cerium oxide compounds referred to here were processed from mineral ores that contained radio-active materials. Strict environmental and pollution regulations in the past 10 years shutdown most of the domestic manufacturers, who used this radio-active type ore. For a few years, the supply of cerium oxide compounds became very scarce, price increased dramatically, with more and more dependence on foreign sources.

Now U.S.A. manufacturers have developed new Cerium Polishing Compounds from a domestic non-radioactive ore. These polishing compounds are equal and in many ways give even better performances than the old type cerium oxide compounds. The manufacturers are learning how to control particle shape, size, hardness, and purity. Polishing compounds are being fabricated for specific polishing operations and materials. A wide selection of these new cerium polishing compounds are available from a variety of commercial sources.

IV. Polishing Tools

A review of polishing tools used in the past shows that all the materials are dependent on nature's resources.

PITCH
WOOD
LEATHER
FELT
METALS

These polishing tool materials have given way to synthetic materials formulated with stable chemical and physical properties not found in nature, but desired in polishing operations. Let's review a few:

POLYURATHANE
POROMERIC MATERIALS
SYNTHETIC WAXES
PLASTIC-METAL

Polyurathane is a micro-cellular rigid foam material supplied with or without a polishing agent within its structure. The random sized and distribution of the bubbles throughout the material enhances the slurry flow and cooling between the innerface of the work and tool, producing high stock removal rates.

Poromeric materials are blends of polyurathanes and polyester micro-fibers simulating nature's felt and cloth type materials. Their unique pore structure, hardness, density, and other physical parameters combine to produce faster stock removal with increased surface quality and yields.

Synthetic waxes are combinations of resins, artificial fillers, and hardening agents developed specifically for high-speed polishing glasses.

Plastic-metal polishing materials have been on the market for a few years, but only in the last 2 or 3 years have they gained much success in both grinding and polishing operations.

Conclusion

It's impossible to list all the commercial sources of these new materials, and ethically it would not be right to single out specific manufacturers. However, I would like to point out some techniques that will help you find sources for these products.

TECHNICAL MEETING
TRADE MAGAZINES
VENDOR CONTRACTS

Attending technical meetings, such as this conference, is an opportunity to hear of new products from the talks, contacts with attending vendors, and conversations with colleagues.

Reading or glancing through trade magazines regularly keeps you informed of the introduction of new products. Use of reader's information postcards is a big help in getting more data on specific items.

A form letter survey, requesting current literature from the manufacturers of grinding and polishing products listed in the "Thomas Register" and "The Optical Purchasing Directory" can bring you a wide range of product data. Don't overlook the small manufacturers, they sometimes are the most capable in producing the specialized material or product you want.

Build good working relationships with a few vendor's sales engineers. Those who periodically show up, know their products, and show genuine interest and desire to help you with your problems.

We must constantly be on the lookout for newly developed materials and tooling that might be incorporated into our work. Your imagination and American ingenuity is needed now to remain competitive in business.

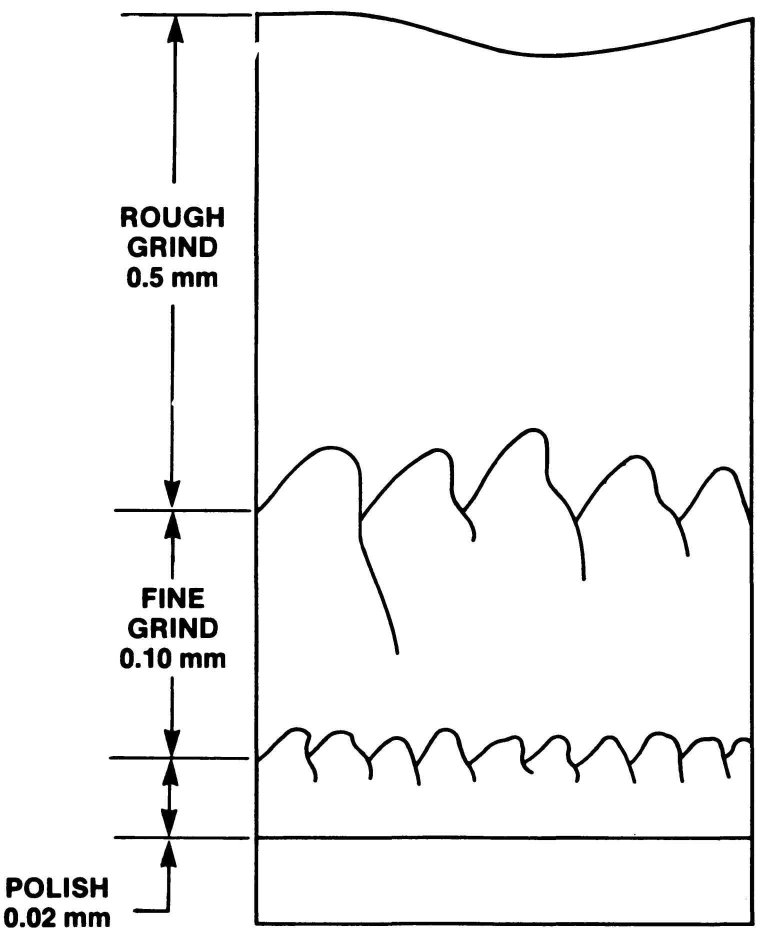


CHART 'A'

GLASS IN BIOTECHNOLOGY

Gerald A. Levine
Corning Glass Works
Corning, N.Y.

Glass is one of the oldest and newest technologies. It has been used through recorded history of man in thousands of ways. Even today, it continues as a unique technical material, whether in usage as the covering for the space shuttle, to open a new method of optical communications, to concentrate highly corrosive fluids or to recover energy from low temperature dryers. These are not surprises to you laboratory experts who everyday work with the industrial and medical research community making the apparatus which opens the door to these new technologies. I have been invited to talk on "new" biotechnology, and why this is interesting for Corning Glass Works.

My apologies to those of you very well versed in biotechnology, but bear with me as I bring your associates up to speed in what is the core of this new field.

It is axiomatic that different species cannot be mated and reproduce. You can't cross a dog with a cat, man with a mouse, etc. Impossibilities are now occurring, as we read every day that human proteins are being produced in microbial species, and obscure fungal proteins in bacteria.

Two questions immediately emerge, how can this be done, and, so what. *First the how.* The door was opened by Watson and Crick almost 30 years ago explaining how the genetic code operates in the "Double Helix". This DNA string (deoxyribonucleic acids) acts as a sequence encoding within every cell the complete genetic code of each living organism. Importantly, this DNA is composed of exactly the same chemicals for all species. Whether man, mouse, bacterial, fungi or plant, the DNA strands are linked by sequences of thymine, adenine, cytosine and guamine. One could think of the DNA as a signature. Each section along this sequence has a specific instruction to produce a particular protein such as insulin or lactase. And I repeat, the DNA sequence of all living cells uses the same four nucleic acids. During the past years biochemists have mapped the sequences in several cells and have learned how to snip out a sequence from one cell, insert it into another cell and have it do the job it previously did (called expression). This is the exciting new technology often referred to as recombinant DNA.

So what? Several examples will follow. People suffering from diabetes require injections of insulin. Where does this come from? Up to now it is purified pork or cow insulin, which is an analog that works in a human. It is now possible to snip the DNA sequence for human insulin, transfer into a microbe and ferment the microbe to produce human insulin with a process quite similar to wine production.

Another example is to make growth hormone. Experiments are underway stimulating growth of pigs and cows. This, once again, doesn't come from blood serum of pigs and cows, but by harvesting metabolites produced by microbes which have been recombined to produce this hormone. Can you visualize cows milking at two times their current rate, or 3,000 pound pigs?

Marion Billington, my secretary, came into my office and told me a suspicious polyp was observed during a routine check up. She needed time off to go into surgery. The next day, she was operated on and one family member called me with the results. The polyp was cancerous, had metastasized and, the surgeon could do nothing. Marion is dead 10 years now, long before the word *Interferon* reached Time, Newsweek, or the Corning Leader. A human protein found in cells exhibiting anti-viral behavior, which could possibly attack cancers.

Interferon samples could be harvested in milligrams by collecting and purifying human blood samples, in pound quantities by tissue culturing selected human cells, and in ton quantities by the genetic engineering a microorganism. Implicit is the reduction of production times of years to minutes. The excitement of the new technology — the opportunity for a cancer control agent, the hope for the future spurs our interest and prayers.

Interferon Production

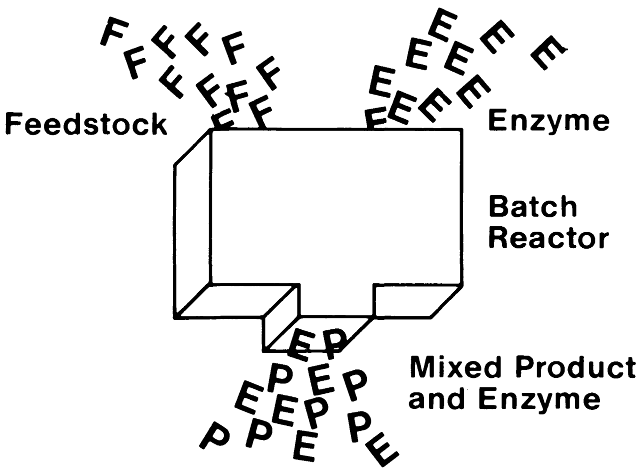
- Fractionation of Blood
  Doubling volume means double population - 20 Years
- Tissue Culturing of Human Cells
  Doubling Cells - 1-2 Days
- Fermenting a Genetically Engineered Bacteria
  Doubling Cells - 20-60 Minutes

Other proteins of great importance are enzymes. Enzymes are biological catalysts, each doing one specific function, at body temperature, modest ph and pressure. Thousands have been identified, hundreds can be purchased, but those which have annual sales exceeding $10MM are limited to about ten. I have so far explained the new science and its exciting possibilities. Why is it of interest to glass people?

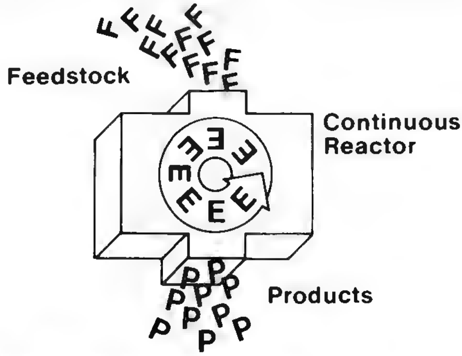
ENZYMES SALES > $10MM/Year

	Growth Rate
α-Amylase	Very High
Glucoamylase	Very High
Glucose Isomerase	Very High
Invertase	Low
Pectinase	Low
Protease, Bacterial	Med.
Protease, Pancreatic	Low
Protease, Plant	Low
Rennet, Animal	Low
Rennet, Microbial	High

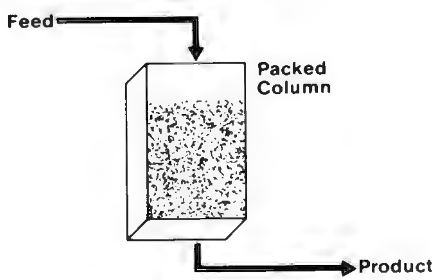
I will now discuss the role for immobilization of enzymes on inorganic carriers. The normal way to use an enzyme is to mix it with the feedstock, wait for completion of the reaction and then discharge the enzyme and product. This is batch processing. Immobilization means the fixing of the enzyme in a form which allows the enzyme to be active while it is held in place. This fixation allows the process to be a continuous flow process where the enzyme is repeatedly used until the activity drops to unacceptable levels. Depending upon the enzyme, half lives could be measured in weeks, months, or years. There are many researchers in enzyme immobilization, and there are many approaches. Corning's approach is to use a highly purified enzyme attached to an inorganic carrier. The immobilized enzyme is placed into



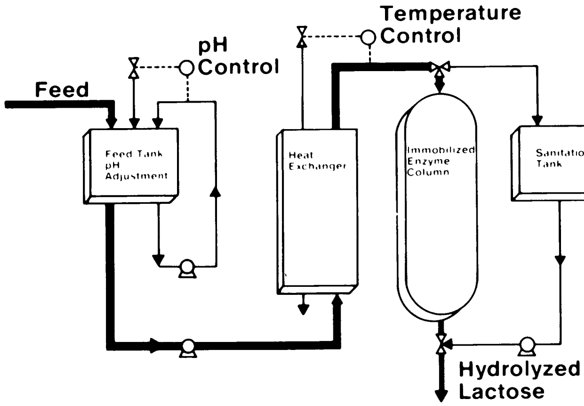
a packed column, and then into production. Feed conditioning is required. The right acidity, the right temperature and the right cleaning procedure.



Corning Support Material for Immobilization Technology



Immobilized Enzymes Process



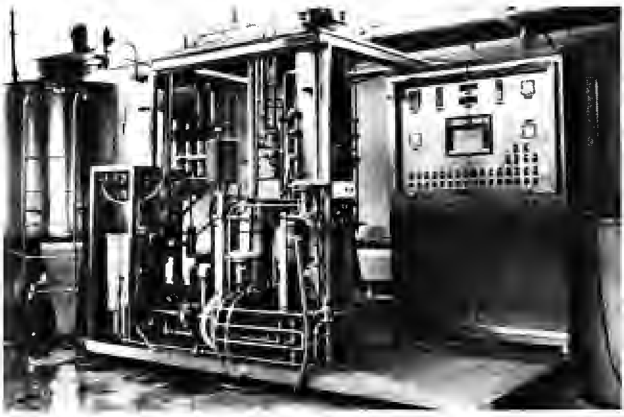
Whey Hydrolysis

Corning is currently operating semi-industrial dairy plants for lactose hydrolysis in England, France, USA and New Zealand. Commercial scale dairy plants are imminent. The enzyme used is β-galactosidase which is immobilized onto a silica carrier with chemical coupling. The process has been petitioned for GRAS approval. Its use is to convert the waste product of cheese production (whey) into a valuable product. Whey has protein of better quality than the average present in whole milk, it has salts, minerals, vitamins, hormones and lactose. Lactose is a sugar molecule made up of equal portions of glucose and galactose. The lactose is "mother's milk," and is used for infant formulas, for feeding newborn animals and a variety of other purposes. But it has limitations. It is not sweet, it is not readily digestible by many humans, animals or microorganisms. It precipitates when concentrated. Corning has been systematically exploring the enzyme processing of lactose into its monosaccharides.

We have demonstrated that the immobilized enzyme process works under all extremes of whey. With the protein present or absent and with the salts present or absent. Products can be made from this which contains the excellent protein of the whey, and where the lactose has been made sweet, soluble and digestible by lactose intolerant people, animals and microorganisms. Having done this, Corning expects to begin marketing products from this technology through a joint venture with the Kroger Co. named NutriSearch in North

America, and a joint venture in United Kingdom with the Milk Marketing Board, called Specialist Dairy Ingredients.

Corning Whole-Whey Hydrolysis Installation in the U.S.A.



Corning Commercial Lactose Hydrolysis Plant

Our commercial expectation is that this immobilized enzyme technology will enable the sale of whey based products in the $50-100 million/year range.

But my commentary has been about one specific enzyme — the lactose one. Each of you know there are thousands of enzymes. To put together the right research and engineering skills, Corning and Genentech have formed a joint venture called Genencor which will use the skills of DNA recombination and immobilization to strike into other production processes using glass and biochemistry. We consider this new science to be very exciting. Corning is positioning itself to be an important factor in this field, with capabilities at the recombinant DNA level, to produce enzyme, enzyme systems, and make unique end products with these processes.

Additionally, those familiar with Corning Brand Tissue Products know of our commitment in this market. We have acquired the KC Biological Company who are specialists in media, and have a significant R&D program for this field.

Our expectation is that these new approaches will grow a business approaching $500 million dollars of annual sales in 10 years. . . coupling new science and inorganic technology.

THE EVOLUTION OF A ROTARY HIGH VACUUM SEAL.

by Anthony J. Hawkins

Abstract

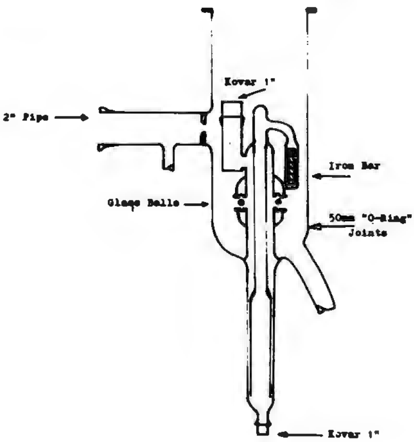
High Vacuum apparatus using "Pyrex" type glass tubing often undergoes design transformations as technical problems are encountered. The author discusses a series of design changes for a Rotary Seal Crack-Propagation Measurement Apparatus.

Introduction

The apparatus discussed here are two separate and distinct designs. The first one is basically all glass, the second one glass and metal. The purpose of the investigation for which these reaction vessels were made is as follows:

1) Have a chamber within which, under Ultra-High Vacuum in the range of 1×10^{-9} torr or better, glass surfaces could be cleave-fractured prior to the deposition of a thin film of Gold (Au) metal.
2) Have the capability for the introduction of contaminating gas into the chamber under controlled conditions.

As is usual in these circumstances, a group discussion was held to determine the practical feasibility of initial designs and requirements. From this, it was decided to construct the all glass rotary seal shown in Picture #1 as a trial run, from which the operator would be able to determine optimum rotation speeds, angles of rotation and applied mechanical pressure parameters.



Although this first chamber design was soon discarded, it has, at least to the author's knowledge, a unique feature.

This is the use of two #50 "O-Ring" joints (Pyrex) together with glass balls in place of the rubber "O-Ring" to form a ball-race type bearing surface which allowed one of the joints to be axially rotated about its center by means of a bar of Iron, glass enclosed, attached to the center joint and activated in turn by a magnetic source outside the system. This is shown more clearly in schematic form in Picture #2 above. The glass balls (1) formed a close ring using as many as could be fitted into the space available. Rotation was found to be quite smooth and "wear and tear" did not present a problem in the short time the apparatus was used. No lubricant was used although there was no particular reason to avoid its use.

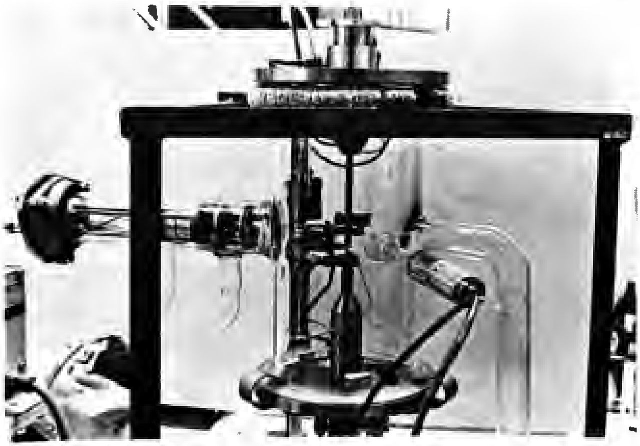
Space will not allow a detailed discussion of the construction method which is self evident for the most part. A much more detailed explanation is contained in the Doctoral Thesis listed in the acknowledgements at the end of this article.

As stated previously, the above design was discarded in favor of a glass/metal vessel which gave a much superior rotary movement without the "jiggling" of the glass ball-race.

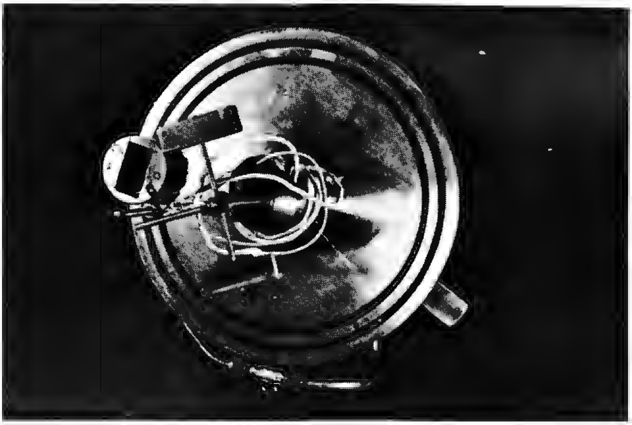
The reason for constructing an improved version can be briefly stated as follows:

1) A support-mount was needed to hold the wedge and heat-source *firmly* in order to satisfactorily cleave the glass sample. Because a Quartz lamp capable of high temperature was to be used, any danger of heat induced strain required the mount to be kept rotated as far away as possible from the 2" pipe sidearm.
2) When the sample cleaved-surface was broken and exposed, the sample holder had to be rotated to a fixed distance from the Gold metal evaporation source in the pipe sidearm.

The new design is shown in Picture #3 below.



As can be seen, the end flanges were sealed with a Stainless Steel plate ½" thick. Both plates have double "O-Rings" in position to contact the glass flange, as shown in Picture #4 below.



The space between the "O-Rings" was evacuated to a pressure of 1×10^{-3} torr or better. Thus the leakage past the outer seal was pumped away and the innermost "O-Ring" seal only needed to seal against a very small pressure differential. The Rotary Shafts through the end plates, (Picture #3 above), employed a similar type of seal.

The evaporator heater coil and metal source were contained inside the 2" diameter Pipeline sidearm and the beam of evaporated metal was defined in ultimate area by a slotted Aluminum disc, sealed to the glass wall of the sidearm by an "O-Ring", with a magnetically operated shutter orifice acting to open or close the slot in the disc as required. This can be seen sealing the sidearm at the point where the sidearm joins the vertical body of the larger glass chamber.

"Bakeout" of the whole apparatus was by means of strip-heaters mounted on insulation board and the degree of Vacuum in the chamber was continuously monitored by a Bayard-Alpert type Ionisation Gauge. This was separated from the vacuum system used to evacuate the sidearm since the evaporation of the gold raised vapour pressure to unacceptable levels in the sidearm relative to the main chamber. A bakeout temperature of 200 °C was used so as not to cause damage to any of the components within the system. All components were carefully selected to have characteristics such as very low vapour pressures and chemical stability suitable for High and Ultra-high Vacuum with the associated "Bakeout" temperature.

All electrical leads were introduced into the chamber through the 1" Kovar tube seals shown at the bottom of Picture #1 and the Pin seals on the top and bottom of the steel plates in Picture #3 respectively.

Experimental Method

Simply stated, a crack was started in a small square or rectangle of single strength window glass, about an inch long, the crack to extend about $\frac{3}{16}$" into the glass body. Mounted on a holder, the sample, now under vacuum, was rotated under a wedge angled such as to increase pressure at point of contact on the sample the further the sample travelled.

Exposed to the heat of a Quartz lamp(2), the wedge slowly expanded, exerting additional pressure on the crack over which it was located. By this means, total control was maintained over the amount of "crack creep" length at any given point. Finally the sample severed into two halves, one of which was allowed to drop away, leaving a pristine surface exposed to such pressure, gas mix etc. as was introduced into the chamber. Gold metal was then evaporated onto the pristine surface after the sample and holder had been rotated to a point directly in front of the sidearm enclosing the evaporation unit. After aging for five hours, the sample was removed and placed in a container for immediate Gold film surface evaluation under the Electron Microscope.

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References

1) Glass, Ceramic or Steel Balls can be obtained from:
   a) Jaygo Inc., 197 Seventh Ave., Hawthorne, N.J. (07506)
   b) Hartford-Universal Co., Rocky Hill, Conn. (06067)
   c) Consulting the "Thomas Register" of Suppliers.

2) The Quartz lamp used was a 600 watt, 120 volt high intensity projection type with a fused quartz envelope. Normal voltage for crack propagation was 8 volts, this allowing maximum Infra-Red radiation. A Powerstat transformer allowed voltage variation.

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Acknowledgments

The Author wishes to thank Drs. David R. Rossington and John C. Pulver for permission to reproduce Photographs 3 and 4 and short portions of explanatory text from the Doctoral Theses of John C. Pulver entitled "Coalescence of Thin Films of Gold Condensed on Glass" - Alfred University 1973.

SCIENTIFIC GLASSBLOWING CERTIFICATION AND DEGREE PROGRAMS AT SALEM COMMUNITY COLLEGE

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The scientific glassblowing curriculum at Salem Community College is designed to develop each student to his/her fullest potential in the shortest time so that he/she will be an informed, competent and responsible citizen capable of assuming a productive place in our society.

To achieve these goals the College provides: the opportunity for students to prepare themselves to enter employment with a strong background in lab methods and practices; intensive instruction in manipulative skills with daily demonstrations and lectures for mastery of the basic essentials in fabricating glassware; and a practical method of training students to read, interpret and design blueprints and sketches of sophisticated glassware.

Students from all over the country enrolled in our program have a high success rate of being properly trained to accept employment. Continued training with a minimum of instruction, in a variety of scientific glass settings, has helped us to achieve our goals.

In 1959 while on loan from Ace Glass Inc., I became the first Scientific Glassblowing instructor, at a Vocational Technical School in the United States. With the help of a selected advisory committee from the Vineland, N.J. Glass Industry, we set up facilities and prepared a program to train potential glassblowing trainees. We graduated nine students in 1960 and I'm pleased to learn that eight of the nine students who completed the one year course have gone on to distinguish themselves as fine scientific glassblowers. After one year I returned to Industry.

In 1979 I was asked to return to what was now the Salem Community College. The transformation from a Vocational-Technical School to a two year college had taken place in 1972. I accepted the position to occupy the Chair in Glass Technology. Joe Barker, our Society's executive director of education and advisory board chairman of Scientific Glassblowing at Salem Community College, was responsible for my return from Ace Glass Inc., where I had worked and instructed for forty years. Actually the decision to return wasn't as difficult as it appeared. I had thoroughly enjoyed the year I instructed and was eager to accept the challenge of upgrading the glass program which I was told had deteriorated.

Today after three years of hard work, a capable advisory board and plenty of material help from industry we have a fine, solid one-year certification course and a two-year associate degree to offer. Because the demand for Scientific Glassblowers has been so great all our students have been hired after one year (some after only one semester) and only a few have stayed on to receive an associate's degree in glassblowing.

Our glassblowing students come from all parts of the country: California, Washington State, Illinois, Georgia, New York, Michigan and Pennsylvania, to name a few. Some have applied from as far as Africa, and Venezuela.

Each year employer representatives from research labs and industrial glass plants call or visit the college to hire our glass trainees. We set up interviews for students and management and upon graduation they usually are hired. We maintain a close relationship with all our glass students and check on their progress.

The college campus is located in suburban and rural settings, just minutes from the Delaware Memorial Bridge, exit 1, of the New Jersey turnpike and the southern end of Interstate Route 295. Three college buildings are located on twenty acres in Carney's Point, New Jersey. The center building, Golfview, where the glass laboratory is located, is flanked by two new twin buildings built by the students enrolled in construction courses.

The glass shop consists of one large room with 22 fully equipped benches, one small lathe, one medium sized lathe and other necessary equipment to simulate a modern glass shop such as: annealing oven, wet saw, dry saw, a wash tub, polariscope, et cetera. The room is very well lighted and has a good ventilation system.

Curriculum

Below are the six courses and a description of each class offered in the 1st and 2nd semester for students seeking a certificate in Scientific Glass Technology. On the following pages are the course descriptions and requirements for student trainees working for an associate degree in Scientific Glass Technology.

SCIENTIFIC GLASS TECHNOLOGY
(certificate)

		Lecture	Lab	Credits
Fall Semester				
SGT 103	Lab Methods/Practices	2	6	4
SGT 104	Scientific Glass Techniques	2	6	4
SGT 105	Basic Apparatus	2	6	4
		6	18	12
Spring Semester				
SGT 201	Blueprint Reading/Design	2	6	4
SGT 202	Advanced Fabricaton	2	6	4
SGT 203	Lathe/Specialties	2	6	4
		6	18	12

Course Descriptions

SGT 103 Lab Methods and Practices (2:6:4)

An introductory study of setting up a glass laboratory, for the purpose of learning the operations of plant equipment and safety. To simulate the requirements of a modern glass plant, or research lab. Formal and informal lectures on equipment use will be given.

SGT 104 Scientific Glass Techniques (2:6:4)

A study of the fundamental skills and techniques of glassblowing as applied to the fabrication of glass apparatus. Emphasis is placed on the manipulative skills and dexterity, study and use of basic tools, materials and equipment. An introductory course is correct interpretation of simple blueprint reading and drafting skills as applied to Scientific Glassblowing.

SGT 105 Basic Apparatus (2:6:4)

An introductory study of the fundamental principles and practices of

Scientific Glassblowing as applied to the fabrication of laboratory research glass apparatus. Emphasis on basic skills.

SGT 201 Blueprint Reading and Design (2:6:4)

Use and principle of Vernier Calipers, metric and English measurements, drafting and shop applications as symbol representation of glass parts. Lecture, visual aids and design to be taught each day.

Prerequisites: SGT 103, SGT 104, SGT 105

SGT 202 Advanced Fabrication (2:6:4)

A course designed to strengthen the understanding of sophisticated scientific glassware and to refine the skills necessary for fabrication and repair. More emphasis will be placed on precision and speed. Demonstration, lecture and safety will enhance the course.

SGT 203 Lathe Specialties (2:6:4)

A course designed to introduce the operation of a glass lathe for use in fundamental glassblowing. Emphasis on lathe familiarization and technique.

SCIENTIFIC GLASS TECHNOLOGY
(AAS Degree)

		Lecture	Lab	Credits
FIRST YEAR				
Fall Semester				
SGT 103	Lab Methods/Practices	2	6	4
SGT 104	Scientific Glass Techniques	2	6	4
SGT 105	Basic Apparatus	2	6	4
ENG 101	English I	3	0	3
	Math Elective	3	0	3
				18
Spring Semester				
SGT 201	Blueprint Reading/Design	2	6	4
SGT 202	Advanced Fabrication	2	6	4

SGT 203	Lathe/Specialties	2	6	4
ENG 102	English II	3	0	3
	Math Elective	3	0	3
				18

SECOND YEAR

Fall Semester

CHM 101	College Chemistry I	3	3	4
	Physical Science Elective	3	3	4
	Humanities Elective	3	0	3
SGT 264	Glass Projects Seminar I	2	6	4
				15

Spring Semester

CHM 102	College Chemistry II	3	3	4
	Physical Science Elective	3	3	4
	Social Science Elective	3	0	3
SGT 265	Glass Projects Seminar II	2	6	4
				15

SGT 264 Glass Projects Seminar I (2:6:4)

This is a 2nd year, 1st semester course designed to bring to focus all courses learned in the first year. Special projects will be assigned to test the students creativeness, ability to plan ahead, mechanical aptitude, and general all around knowledge. Precision and speed will be stressed more. To introduce the student to special techniques and applications not covered in the first year.

SGT 265 Glass Projects Seminar II (2:6:4)

This is a 2nd year, 2nd semester course designed to maintain and refine all the skills and techniques learned in the first three semesters. Emphasis is on beauty, precision and speed. Fabrication of more functional apparatus according to specifications of blueprint drawings from research and industrial scientific glass facilities.

Course Activities

Instructor demonstration and advanced techniques with individual help on chosen projects. Special mechanical assignments for maintenance of old equipment and installation of new.

Application for Admission

To complete the application for admission, the following steps must be adhered to:

1. Complete admission form and submit it with a $15 application fee (checks made payable to Salem Community College).
2. Request your high school to send an official transcript to the Office of Admissions. Applicants possessing a High School Equivalency Diploma should send a copy to the Office of Admissions.
3. Complete the N.J. Basic Skills Test (required by Dept. of Higher Education). This test is given on assigned dates through our Testing Center. Call 299-2100 for an appointment.
4. Transfer students: A copy of your college transcript must be forwarded to the Office of Admissions.
5. Applicants are strongly encouraged to visit the campus at their earliest convenience. The Admissions Staff will be happy to have you as our guest.
6. Everyone planning to apply for financial aid of any kind (State Guaranteed Loans, Federal Programs, College Grants or Work Study Grants) MUST SUBMIT THE FINANCIAL AID FORM (FAF) which may be obtained from High School Guidance Counselors or the Admissions Office at SCC.

Fees

Salem Community College is a publicly supported institution: the tuition paid by the student represents less than one-fourth of the total cost of his/her attendance. The remainder is made up by support from the county, the state of New Jersey and auxiliary resources.

Student tuition is charged by the credit. Maximum tuition charges for full-time study are: county resident -- $600.00; out-of-county or out-of-state resident -- $700.00. Completion of the registration form enrolls the student in course(s) and is the student's commitment to payment of tuition/fees and to class attendance.

Tuition Per Credit:	
County Resident	$25.00
Out-of-County	30.00
Out-of-State	30.00
Registration/Services Fees:	
Semester/Session registration for full and part-time students	15.00
Per credit academic and student services	1.75
Administrative Fees:	
Application-one time for all students	15.00
Transcript - after first copy	1.00
Bad check	5.00
Graduation Fee	25.00
Instructional/Materials Fees:	
Lab - per weekly contract hour	4.00
Clinical - per weekly contract hour	4.00
Lab/clinical makeup - per day	15.00
Co op. internship, practicum - per weekly contract hour	4.00
Computer course fee	30.00
Photography course fee	30.00
Ornamental glass course fee	30.00
Credit by exam/advance placement	15.00

Late registration charge: All students are expected to comply with the schedule of registration as published in the college calendar. Late registration will be permitted during the first 10 days of classes for those who failed to register during the regular registration period; a $10 non-refundable late fee will be charged.

Schedule change fee -- Drop-Add: All schedule changes must be initiated on an official "drop-add" form. A non-refundable fee of $5 is charged each time a change is made.

Senior Citizens (age 58 and over) are accepted on a space available basis for each class. They are not required to pay application, registration or tuition fees. They must pay all other required fees.

PLEASE ALLOW 4 WEEKS AFTER CLASSES BEGIN FOR PRO-

CESSING REFUNDS: To withdraw from any course a student must complete a Withdrawal Form and have it approved by the Records Office. Course drops or withdrawals not processed through the Records Office may result in the grade of "F" appearing on the student's record. This applies whether the student attended one class meeting or no class meetings. No refund will be awarded after the fourth week of scheduled class.

Tools Student Needs
Scientific Glass Department

Didymium Glasses	
Didymium Clip-Ons	
Swivels ¼ inch	
Mouth Pieces (TIPS)	
Metal Rulers 15 inch	
Calipers Vernier 5 inch	
Carbon Reamers 3⁄16 & ¼ inch	
Red China Pencils	
Abrasive Marking Pencils (Hard Carbon)	
Tweezers 10 inch	
Picks	
Knives (Tungsten Carbide)	
Sparker (Lighter)	
Carbon Paddles 3 x 4 inch	
Tubing ⅛ inch dia.	
Scientific Glass Blowing Book (1&2) and/or (3&4)	
Blueprint Reading For Glass Technology	

College Provides

Glass Blowing Bench (needle valve, oxygen gauge)
Carlisle C C Burner

Hand Torch and Holder

Rollers (support)

Roller (straighten)

Chair

Cullet Bucket

Glass Rack

Rubber Tubing (for burners)

Corks

Glass Tubing & Rod

1st Semester

You will be graded on the following:

103-01 - Lab Methods and Practices

1. Knowledge of equipment and its uses
2. Cleanliness of bench and equipment
3. Conservation of energy and glass
4. Lateness - absenteeism
5. Attitude

104-01 - Scientific Glass Techniques

1. Glass rotation and handling (Free Hand and with use of swivel)
2. Blue print reading (correct interpretation)
3. Use of bench burner
4. Use of hand torch
5. Up-to-date note book

105-01 - Basic Apparatus

1. Finished Product
   A. Quality
   B. Precise measurements
   C. Cleanliness of glass
   D. Time involved
2. Lecture testing (written exams)

Please ask for interpretation if there is anything you do not understand.

Returning Semester

You will be graded on the following:

201-01 - Blue Print Reading and Design

1. Up-to-date note book
2. Personal blue print drawings
3. Terms and knowledge
4. Lateness - absenteeism
5. Attitude

202-01 - Advanced Fabrication

1. Finished Product
   A. Quality
   B. Precise measurements
   C. Cleanliness of Glass
   D. Time involved
2. Lecture testing (written exams)

203-01 - Lathe/Specialties

1. Project Evaluation

Please ask for an interpretation if there is anything you do not understand.

Basics (1 year)

The following basics will be covered in the 1st and 2nd semester. Each semester covers a 16 week period beginning September 1st through May 15th.

1. Pull point
2. Round bottom
3. Flat bottom
4. Constriction
5. Bead
6. Flare
7. Foot
8. Lugs

9. Hooks
10. Buttons
11. Taper
12. Bending (angles)
13. U bends
14. Indenting
15. Pick holes
16. Push up ring (maria)
17. Hose connection
18. Straight seal (same size)
19. Sealing (2 different sizes)
20. Capillary seal
21. Blow bulb
    a. squat
    b. elongated
    c. round
    d. tapered
22. Side seals
    a. angle seal
23. Joining side seals
24. Ring seal
25. Side ring seal
26. Condenser seals
    a. Hopkins type
27. Blind seal
28. Rod supports
29. Wrap coils
30. Inner bore seal (plug)
31. Stop cock
    a. prepare stems
    b. seal
32. Lathe (basics)

Glass Shop Safety Rules

1. Keep bench and cutting tables and equipment clean
2. Check fuel pressures
3. Make sure burner is properly secured to bench top
4. Do not use *plastic* butane lighters
5. Keep glass knife sharp
6. Maintain concentration on project at hand
7. Exercise care slipping hose onto glass tube
8. Keep hair trim, clothes out of danger
9. Fire polish tube ends
10. Don't put paper or other waste in cullet bucket
11. Keep bench top free of glass threads and broken glass
12. Don't overfill cullet bucket
13. Put hot glass on glass rack, not table
14. Use asbestos gloves when removing items from lehr
15. Receive *instruction* before handling acids
16. In case of fire use asbestos blanket
    Extinguisher located in rear of the glass department.
    (check location)
17. Keep fans operating as long as there are students working with *fire*.

18. Safety glasses should be used at cutting wheels
19. No horseplay allowed
20. Only students allowed in the glass department except upon instructor's permission.

Lab Methods/Practices
Course Outline

I. Setting up glassblowing bench
   A. Materials
      1. wood
      2. metal
      3. transite
   B. Dimensions
   C. Equipment
      1. Blast burner
      2. Hand Torch
      3. Rollers
         a. support
         b. straightening
      4. Bunsen burner
      5. Glass rack
      6. Cullet bucket
      7. Hand tools (necessary)
      8. Accessories
         a. glasses
            1. Didymium
         b. scoring knife (file)
            1. sharpening technique
               a. tungsten carbide
         c. tweezers
         d. reamers
            1. carbon
            2. brass (wax)
         e. carbon paddle
         f. calipers (Vernier)
         g. swivel
         h. pick
         i. abrasive pencil
         j. china pencil

k. chair

9. needle valves
10. oxygen pressure gauge
11. foot control (optional)

II. Outside Supply Source
   A. Natural gas meter (propane)
      1. pipe sizes
      2. pressure regulator
   B. Oxygen Containers
      1. liquid oxygen (G.P. 4500 cubic feet)
      2. high pressure oxygen (22 hundred pd 70 degrees)
      3. hydrogen

III. Glass characteristics
   A. Kind
      1. Borosilicate
         a. Pyrex
         b. Kimax
      2. N.C.
      3. Soft
      4. Lead
      5. Uranium
      6. Nonex
      7. Vycor
      8. Quartz
   B. Type
      1. Standard wall
      2. Medium wall
      3. Heavy wall
      4. Rod
      5. Capillary
   C. Physical Properties
      1. Behavior
      2. Softening point
      3. Annealing range
      4. Detecting strain
      5. Bloom and Devitrification

IV. Plant Equipment (Operation Maintenance)

A. Annealing Oven (Lehr)
    1. Temperature settings
    2. Glass placement
B. Polariscope
    1. Recognizing strain patterns
C. Wet Saw (Glass Cutting)
    1. Materials
        a. carborundum wheels
        b. diamond wheels
        c. wood cutting supports
D. Dry saw
    1. cutting material (steel)
    2. cutting operation

V. Lecture
    A. History Orientation
    B. Explanation of Scientific Glassblower versus German style glassblower
    C. Energy of industry, research labs
        1. production
        2. technology
        3. necessary background
    D. Importance of absenteeism, lateness and attitude
    E. Relationship of management versus workers

VI. Review safety methods of outlines 1, 2, 3, 4, & 5

Scientific Glass Techniques
Course Outline

I. Glass Rotation and handling
    A. Glass manipulation
    B. Free hand rotation
        1. balance
        2. rotation
        3. blowing pressure
        4. parallel evenness
    C. Swivel (holder)
        1. construction

a. connectors
b. advantages, disadvantages
c. maintenance

II. Blue Prints
   A. Drawings
   B. Interpretation
   C. Terms
   D. Metric System
   E. Vernier Calipers
   F. Drafting terms and techniques

III. Blast Burner
   A. Carlisle CC Burner
      1. valve settings
      2. rubber tubing
         a. sizes
         b. clamps
         c. directions (bench valves)
   B. Hand Torch
      1. Universal
      2. National
         a. tip changes
         b. valve setting
         c. rubber tubing size
      3. Application

IV. Preoperational Techniques
   A. Making swivel holder
   B. Rubber tubing adaptors
   C. Cork adapters
      1. cork boring
      2. hot tungsten
   D. Wet saw grinding
      1. carbon reamers
      2. tungsten pick
      3. files
   E. Sharpening scoring knife
      1. carbon stone
      2. flat wheel

F. Cleanliness (glass)
    1. wash tub
    2. brush
G. Removing frozen stopper plugs

V. Notebook
    A. Résumé
    B. Instructional material
    C. Personal sketches, blueprints
    D. Other (glass related information)
    E. Safety rules
    F. Test results

VI. Field Trip Observation
    A. Lathe
    B. Tooling
    C. Precision Bore
    D. Grounding
    E. Graduating (etching)
    F. Artistic

VII. Safety
    A. Blast burner
    B. Hand torch
    C. Glass handling
    D. Blowing hot ends
    E. Cork insertion

Basic Apparatus
Course Outline
(1st semester)

I. Basics
    A. Pull points
    B. Constructing
    C. Round bottom
    D. Flat bottoms
    E. Beading
    F. Flaring

1. foot

G. Rod to rod seals
1. ball
2. hooks
3. nobs
4. buttons
5. rod to tubing

H. Tapering
1. short
2. long

I. Bending
1. Angles
2. U bends

J. Sealing tubes
1. straight seals
2. different sizes

K. Blowing Bulbs
1. Maria hose connecting
2. Elongated
3. Round
4. Squat
5. Tapered

L. Indenting
1. use of pick
2. sucked in
3. push in (reamer)

M. Holes
1. blowing
2. picking

N. Side sealing
1. straight
2. angles

Tubing sizes
5-25mm
rod sizes
2mm-7mm

Designs
Functional and Non Functional

Test tubes (modified)		Gas Wash Bottle
Tissue grinders	Connecting Tubes	Vigreaux column
Adaptors	Offset	Morton flash
Check valves		
Drying tubes		
	Pipette (modified)	T tubes
	Nitrometer	U tubes
Stirring shafts		V tubes
Plugs		Moisture test receiver
Impinger	Flasks (modified)	Reaction Vessel
	Gas leveling bulb	Claisen (modified)
	Distilling flask	
Centrifuge tubes	Erlenmeyer	
Viscosimeter		

Blueprint Reading/Design
Course Outline

I. Blueprint interpretation
   A. Daily drawings, sketches on black board
   B. Lecture testing

II. Blueprint drawings
   A. Metric system
   B. Vernier Calipers
   C. Protractors
   D. Terms and Knowledge
   E. Sketching and drawing

III. Lateness, Absenteeism and attitude
   A. Industry requirements

IV. Notebook
   A. Résumé
   B. Scientific Glass Techniques
   C. Test Results
   D. Blueprint drawings
      1. front view
      2. top view
   E. Creative designs
   F. Artistic patterns

V. Safety
   A. Rules

Advanced Fabrication
Course Outline

I. Ringseals
   A. Single tube (maria)
   B. Side
   C. Condenser
      1. tube Liebig With holder
      2. bulb Allihn Without holder

3. coil West
Graham

D. Flare (1 side)
E. Hopkins type (2 sides)

II. Pre-sealing preparations
A. Cork boring
B. All type holders
C. Rubber joiners
D. Corrugated paper
E. Wax (flaring tool)
F. Tissue paper (cork leaks)
G. Swivel (neck brace)
H. Use of V carbon
I. Hot cut machine
J. Tape (asbestos or substitute)
K. Mandrel (coil wrapping)
1. tubing
2. rod

Lathe/Specialties
Course Outline

I. Lathe Operation
A. Familiarization
1. chucks (jaws)
2. direction and speed control
3. tail stock movement
4. spindle bore
5. fires
a. burner carrier
b. Bunsen burner
6. swivel hookup
7. kick off
a. solenoid

II. Tools
A. Carbon paddle
B. Carbon reamers
C. Rod/glass peeling

D. Tweezers
E. Swivel

III. Basic Glassblowing (Lathe)
A. Straight seals
B. sealing (various sizes)
C. Constriction
D. Bulb blowing
1. various shapes
E. Side sealing
F. Glass tube cutting
1. lathe technique
G. Round bottom
H. Flat bottom

IV. Safety

Glass Projects Seminar I
Course Outline

I. Orientation
A. Course Objectives
B. Special Apparatus Design
C. Reports and drawings to be submitted

II. Written Tests
A. Identifying
B. General knowledge and applied word terminology
C. Blueprint drawing and design
D. Field trip observation

III. Fabrication (Glass)
A. Improvement
1. quality
2. cleanliness
3. precisions
4. speed

IV. Volumetric
   A. Pipette
   B. Burette
   C. Cylinder (graduated)
   D. Bulb blowing

V. Lathe
   A. Large tubing

VI. Instruction (student)
   A. Lathe
   B. Bench

VII. Glass to Metal Demonstration

VIII. Quartz
   A. Characteristics
   B. Working tools

IX. Required reports on field trips

Glass Projects Seminar II
Course Outline

I. Orientation
   A. Course objectives
   B. Special apparatus design
   C. Reports and drawings to be submitted

II. Written Tests
   A. Identifying
   B. General knowledge and applied word terminology
   C. Blueprint drawing and design
   D. Field trip observation

III. Fabrication (Glass)
   A. Improvement
      1. quality
      2. cleanliness
      3. precisions
      4. speed

IV. Volumetric
    A. Pipette
    B. Burette
    C. Cylinder (graduated)
    D. Bulb blowing

V. Lathe
    A. Large tubing

VI. Instruction (student)
    A. Lathe
    B. Bench

VII. Glass to Metal Demonstration

VIII. Quartz
    A. Characteristics
    B. Working tools

IX. Required reports on field trips

Course Requirements and Means of Evaluation:

I. Attendance: In order for a student to obtain maximum understanding from the course, 100% attendance is expected. Not only will attendance be reflected in student grading but will appear in a special profile on each student.

II. Assignments:
    A. The student is responsible for all assignments.
    B. Most assignments will be graded in conjunction with the finished product and observation of methods and practices employed in the lab.
    C. Assignments partially completed will receive partial credit.
    D. Lecture testing will be included in this course.

III. Grading *Scientific Glass Interpretation*

A - 90 to 100 . . . . Superior
B - 80 to 89 . . . . Good-Very Good
C - 70 to 79 . . . . Mediocre
D - 60 to 69 . . . . Poor
F - Below 60 . . . . Failing
I - Incomplete

Grading System and Requirements

Each student is offered 30 hours of lab training. It is the responsibility of each student to arrange to complete 4 hours each day 8:00 a.m. to 12:00 noon (regular hours) plus a minimum of 5 extra hours a week. Available practice time: 12:00 until 2:00 Monday thru Friday.

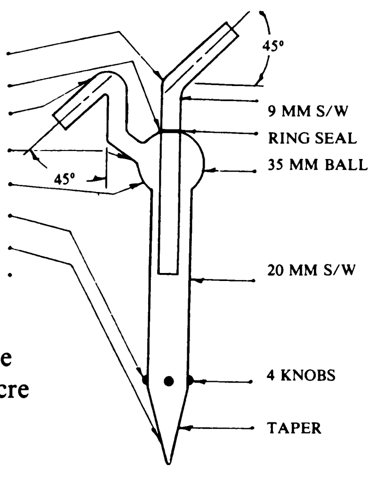
Lecture and demonstrations will be included in our regular hours each day. Assignments will be given out each week to students for maintenance of the glassblowing department.

For example: Floor cleaning
Wet saw
Dry saw Clean and maintain
Lathe

A blueprint drawing of the glass apparatus must accompany each assignment. There will be one break each day from 9:45 a.m. till 10:00 a.m. No one is permitted to leave the department without permission by the instructor. Each piece of apparatus will be graded to scale 100 points.

Example:

BEND	5
RINGSEAL	30
BEND	10
SIDE SEAL	15
BALL	10
NOBS	10
TAPER	10
MEASUREMENT PRECISION BASED ON THE DEGREE OF DIFFICULTY	5
	100



A's and B's are acceptable
C's are considered mediocre
D's are poor
Below is failing

Exams to cover *three weeks*. To account for 70% of your grade.

Actual Work --	70%
Lecture Testing --	10%
Other --	20%
	100%

Course Objectives: (Student)

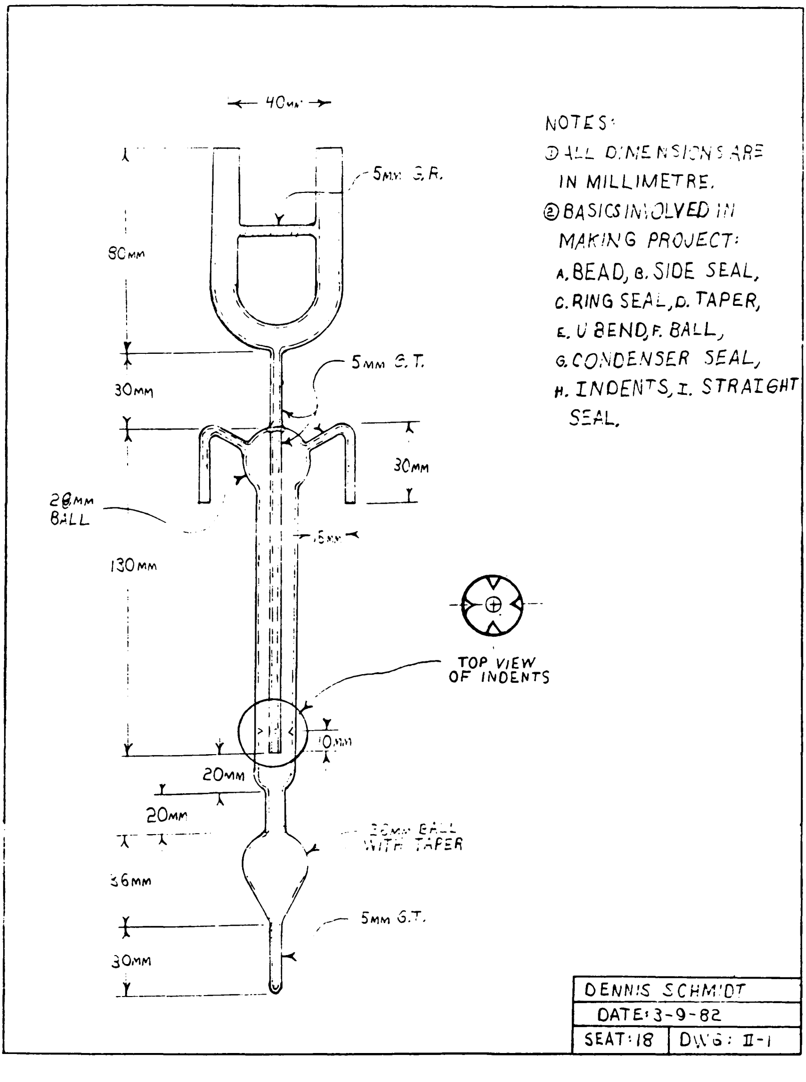
Upon completion of courses Lab Methods/Practices, Scientific Glass Techniques and Basic Apparatus in the first semester and Blueprint Reading and Design, Advanced Fabrication and Lathe/ Specialties in the second semester the student should:

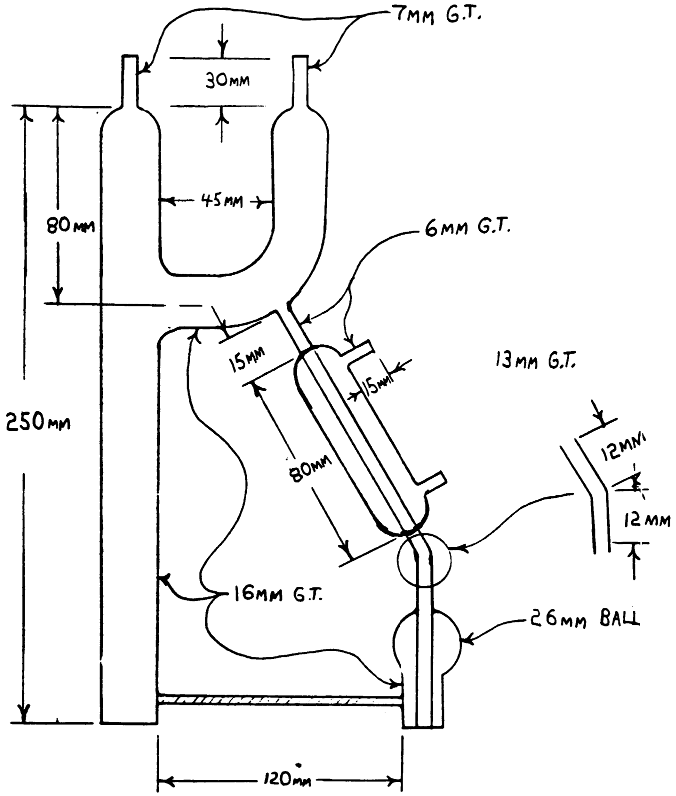
1. Be able to set up a scientific glassblowing bench and be acquainted with sources of energy necessary in melting and shaping glass tubing rod.
2. Be able to operate and maintain plant equipment with responsibility of each:
   a. be able to use the wet saw for cutting straight and angles in glass.
   b. have mastered the technique of snapping glass on the dry saw.
   c. be able to detect strains using a polariscope.
   d. be able to operate an annealing oven to remove strain from glass
   e. be able to set up a ribbon burner for making large U bends
   f. have learned preparational techniques of sharpening scoring knives, cork boring, using rubber joiners, corrugated paper, wax and V carbons.
3. Be able to identify the technical names of all materials, equipment, hand tools and know the uses of each.
4. Be prepared to enter employment with a good background in lab methods and practices.
5. Be aware of all safety practices.
6. Have a knowledge of free hand rotation and the use of a swivel in glass manipulation.
7. Be able to construct a swivel holder and to use same.

8. Be able to interpret blueprint drawings of fabricated glass apparatus.
9. Know how to sketch and draw blueprints of fabricated glassware.
10. Have a notebook containing instructional information, personal blueprint drawings and sketches and diagrams of glassblowing procedures for various projects.
11. Have a knowledge of setting degrees of fire necessary for melting and shaping glass of various densities properly.
12. Be able to read and interpret a Vernier Caliper.
13. Be able to fabricate simple to complex apparatus interpreted from blueprint drawings.
14. Be aware of the importance of cleanliness of materials, quality, precision, alignment and time involved using a minimum of material.
15. Have the knowledge and manipulative skills to fabricate modified test tubes, various distillings apparatus, modified flasks, condensers, Vigreaux columns, Dewars, Extraction Chambers and many other specific name jobs.
    a. simple to very complicated glassware according to individual talent.
16. Know the basic component parts of the lathe, basic operations of sealing straight and various size tubing together, constrictions, round and flat bottoms, beading, flaring, bulb blowing, tapering and cracking off.
17. Have seen demonstrations in glass-to-metal sealing, quartz, soft glass, etc., grinding precision bore processing, graduating, tooling, vacuum system explanation.
18. Be prepared to enter employment fully aware of management's expectations and requirements, able to communicate intelligently and prepared with the necessary basics to accept a minimum of instruction for fabrication of scientific glassware.

Acknowledgement

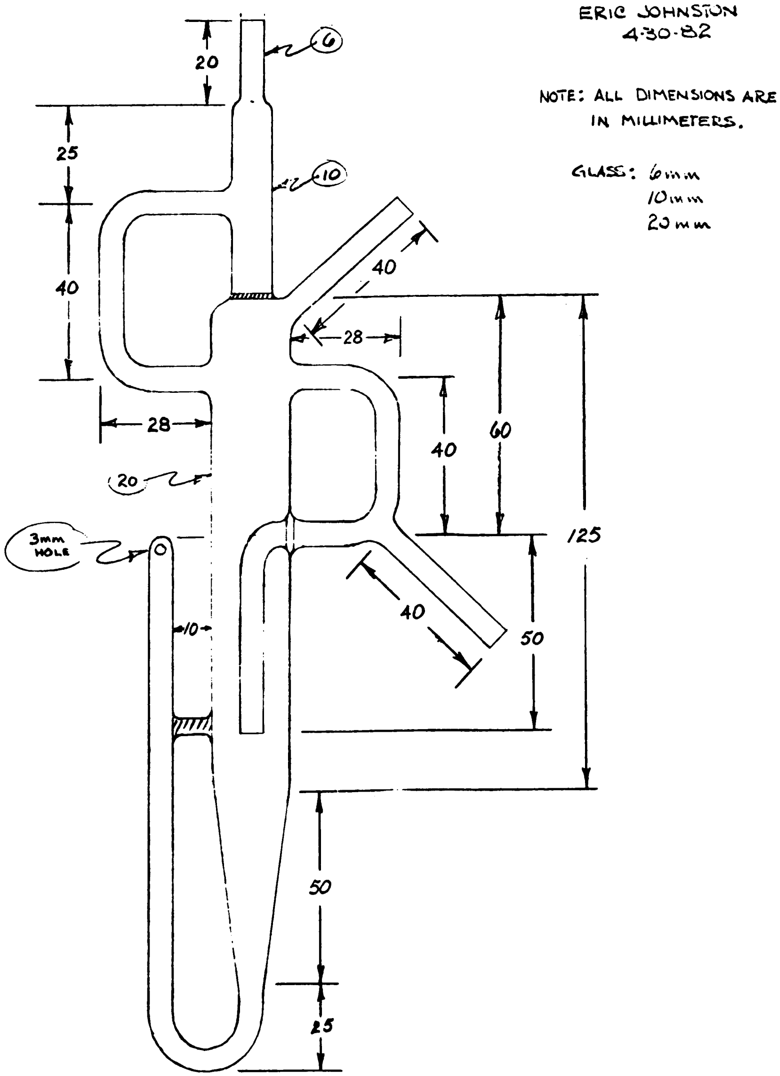
I would like to thank Mr. Bardo and the Rochester Symposium Committee for asking me to present a paper on Scientific Glassblowing at Salem Community College and also Acting President Guy Altieri for giving me permission to share our glass program syllabus.

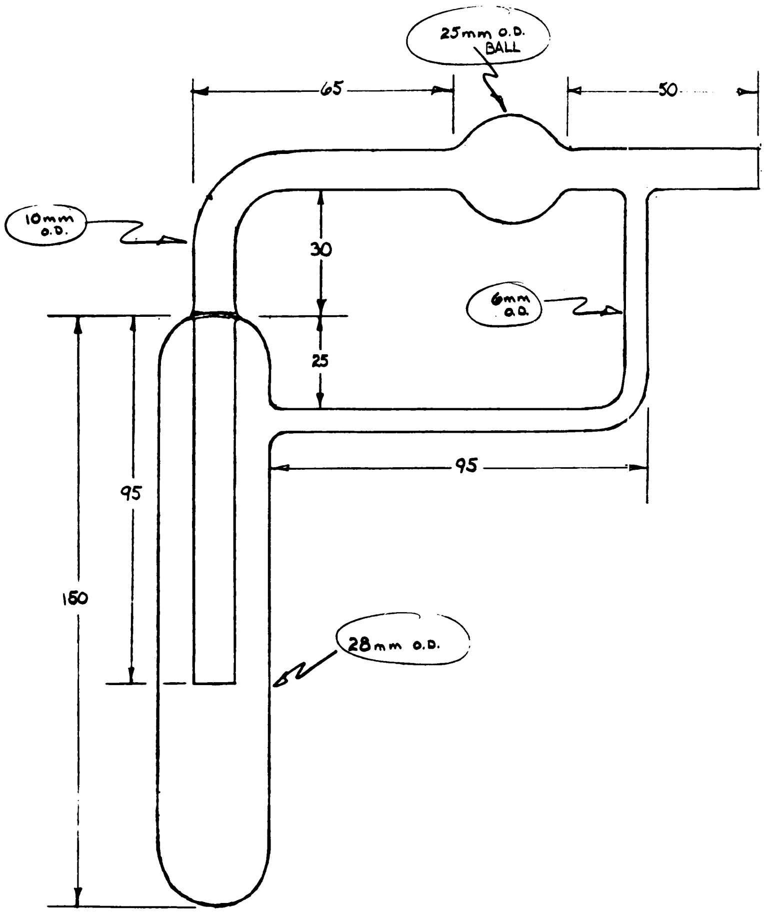




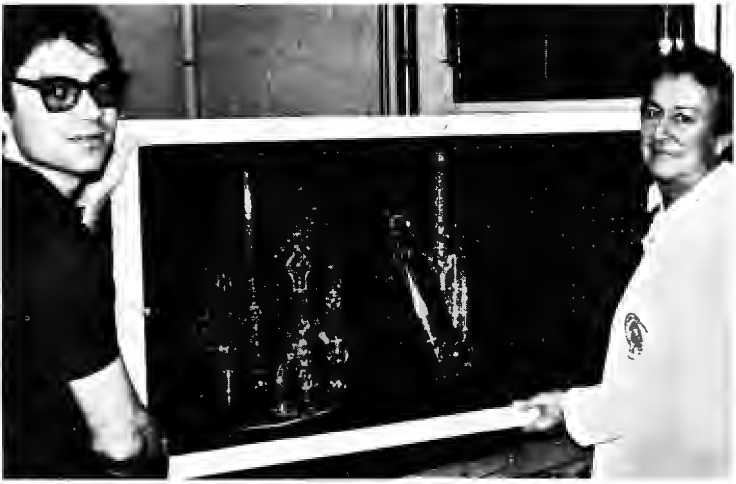
NOTES:
① ALL DIMENSIONS ARE IN MILLIMETRE.
② BASICS INVOLVED IN MAKING PROJECT:
Ⓐ BENDING Ⓑ BALL Ⓒ STRAIGHT SEAL
Ⓓ SIDE SEAL Ⓔ CONDENSER SEAL
Ⓕ RING SEAL Ⓖ ROD SUPPORTS

DWG: II-9


ERIC JOHNSTON
4-30-82
NOTE: ALL DIMENSIONS ARE
IN MILLIMETERS.
GLASS: 6mm
10mm
20mm
20
6
25
10
40
40
28
60
40
28
20
125
3mm
HOLE
10
40
50
50
25



25mm O.D. BALL
65
50
10mm O.D.
30
6mm O.D.
25
95
95
150
28mm O.D.



Some creative pieces by students

Cutting on a wet saw

Lehring appraratus

Using the lathe

Checking strain with a polariscope

Demonstration

A VACUUM HOLDER FOR SEALING TILTED FACEPLATES

Siegfried Greiner
Zenith Radio Corporation
1000 Milwaukee Ave.
Glenview, Illinois 60025

Introduction

In 1981 Zenith Radio introduced a 45'' diagonal rear secreen projection television. In this paper I will review the development of Zenith's projection television.

Also I will tell you in detail about a holder we designed for sealing glass faceplates to the Cathode ray tubes used in projection television sets.

Description of The Set and Its Operation

When not in use, the projection television looks like a fine piece of furniture and should fit well in any living room. When the set is turned on, the top opens up and the viewing screen rises into position.

The picture producing portion of the projection system consists of one red, one green and one blue cathode ray tube, each mounted near the bottom rear of the set.

The optical light path in this rear projection system uses two folds to project the image onto a viewing screen. This way the cabinet depth is held to a minimum.

Manufacture of Straight Bulbs

When we decided to build a projection television set that would use three tubes and three lenses, we knew that the tube would have to have the following characteristics:

1. It had to be made from non-browning glass, for the tubes would be operated at over 30 KV.
2. Faceplate thickness had to be about .400'' thick and 6 inches in diameter.
3. A deflection angle of 72°.
4. The glass had to retard X-rays.

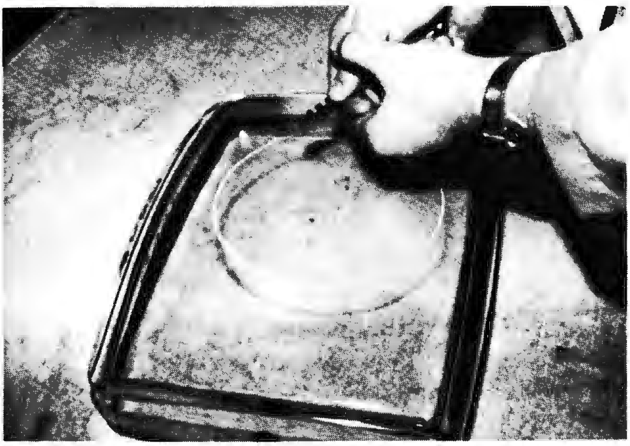
We decided on a round rather than rectangular bulb for ease of manufacture and for mechanical strength.

Several glass manufacturers were called to see if they had "off the shelf" bulbs of this type. We soon found that glass companies who had the right type of glass did not make small bulbs. Manufacturers of small bulbs did not have the right kind of glass.

The decision was made, therefore, to build about 30 bulbs in our glass shop. This would give us a chance to evaluate their performance and make changes if necessary, without the expense and delay of tooling changes that occur once the glass is being mass produced.

Fabrication of Bulbs

Discs of about 6.5 inches in diameter were cut from 13" color cathode ray tube panels. This was done by marking a circle on the glass with a pen and then using a glass cutter with a carbide wheel to score the glass along the circle. The panel is then turned over and tapped with the ball end of the glass cutter until a crack is visible along the scribed line.



The disc is removed by scoring four radial lines from the circle to the edge of the panel and cracking the excess glass by tapping along the lines.

The glass plate was then placed into an oven. The temperature was raised to 700°C until the plate sagged flat. After the glass was cool, it was ground and polished, and the edges were ground and beveled.

The funnel portion of the bulb was cut from a 19" color cathode ray tube funnel. The cut was made at a diameter of about 7.5" diameter. This was done by holding the glass to be cut, in a lathe, and scribing the area where the cut was to be made while the lathe was rotating. A tungsten carbide tipped tool is used for this.

A very small, gas-oxygen flame was held about ½" from the scratch to create enough tensil stress to crack the glass along the scribed line.

The glass faceplate was held in a lathe with the use of a vacuum chuck. The funnel portion was held in a machine chuck in the tailstock of the lathe.

Both parts were preheated slowly using a gas-air mixture in a radiant burner. When the glass temperature approached 350°C, a gas-oxygen crossfire was used to heat the sealing edges to the melting point. The parts were brought together and a good seal was made by slowly blowing through the neck of the funnel while shaping with a graphite paddle.

The funnel was then heated to the softening point and molded to the desired 72° contour. This was done by placing a graphite mold on the neck of the funnel and blowing by mouth into the bulb through a blow hose. A metal anode button was sealed into the side of the funnel. This was done by blowing a hole through the glass, then placing a preglassed metal alloy button into the hole and fusing it using a hand torch. The bulb was then partially annealed while rotating in the lathe, and finally, annealed in a preheated oven at about 450°C.

Reason For Tilted Faceplates

Soon after some of these bulbs were converted into working cathode ray tubes, it was determined that the outside tubes -- the blue and the red color -- should be made with tilted faceplates. Tilting the faceplates results in a picture on the faceplate of the tube which is trapezoidal rather than rectangular.

This trapezoidal distortion is made such that it is exactly equal, but opposite to the trapezoidal distortion which occurs when the red and blue pictures are registered (converged) with the green picture on the viewing screen. The result is a rectangular, color, picture, achieved without complicated, expensive, trapezoidal and convergence correction electronic circuits.

Tilted Faceplate Holder Design

We investigated several methods for sealing a funnel to a faceplate at a tilt. We considered grinding the funnel seal area to the proper angle and then frit sealing the faceplate to the angularly ground funnel. We considered using a vacuum holder with the angle cut in the carbon and then flame sealing the faceplate by having the torch follow the sealing area. However, none of these ideas appeared to be the ideal method. We felt the best approach would be to design a vacuum holder for the faceplate which could be tilted while the faceplate was held in place.

We designed the holder so that the degree of tilt could be changed with only a minimum of modification.

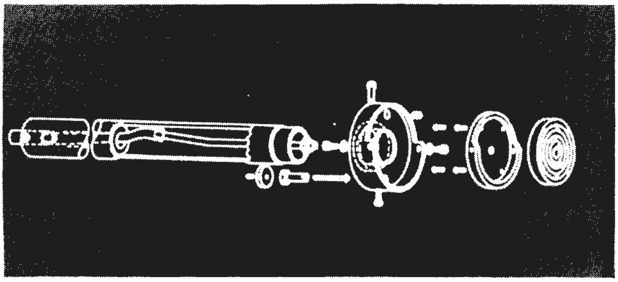


FIGURE 3 is an exploded view diagram of the tiltable vacuum holder we designed. The holder is constructed of an outer, fixed shell, and an inner, moveable member. The outer part is made of a 2" diameter stainless steel tubing that can be held in a machine chuck. A dish is mounted to the end of the tubing. In the dish are two pivot holes 180° apart. A knurled knob is attached to a ¼" shaft and a steel spring located 90° from the pivot holes.

New Holder

The inner part of the vacuum holder has a graphite plate with several rings, mounted to a ⅜" stainless steel plate. In this plate are 2 tapped ¼ × 20, screw holes. A ⅜" steel tube is threaded to the center of the plate. At the end of this tubing is a 12" long, ½" diameter rubber hose that leads to another steel shaft.

To assemble the holder, the inner member is inserted into the outer one. The pivot holes are aligned with the tapped screw holes and shoulder screws are inserted. These screws act as the pivot when the inner part is being tilted.

A set screw at the end of the 2" shaft is tightened to hold the steel tubing at the end of the hose, this is where the vacuum connection is made.

The holder is now ready to be placed into a lathe. An adjusting screw, in which the ¼" shaft is located can now be turned to insure that the carbon runs absolutely true.

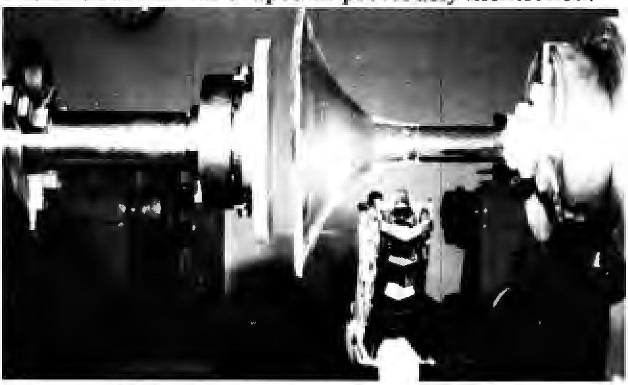
The length of the ¼" shaft from the springpin to the rounded end determines the tilt of the faceplate.

This is the only part of the holder that has to be replaced when an angular change of the faceplate is desired.

Manufacture of Tilted Bulbs

Holder Function

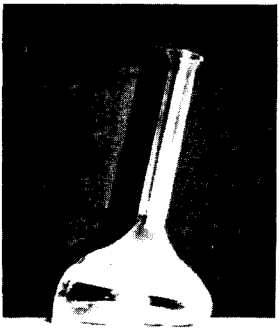
The glass was set up in the lathe as before, the plate now held perpendicular on the vacuum chuck. After preheating, the glass faceplate was fused to the funnel, and allowed to cool below the softening point. The funnel was shaped as previously mentioned.



With the crossfire, about an inch of glass was heated until it became soft. At this point the lathe was stopped, the shaft on the vacuum chuck was pushed to its predetermined stop and locked into position by twisting it 90°. The lathe was started again and the light distortion in the glass was smoothed out by heating it again with the crossfire blowing and alternately paddling.

Every tilted faceplate bulb produced had precisely the angle set by the holder. The angular tilt of the faceplate for our projection television application turned out to be 4.74°.

During the development for different approaches of projection television, bulbs were made with faceplate tilt angles of 10° using the same holder and technique.



Conclusion

I hope this presentation has given you some insight into what goes into a large screen projection television.

The holder design that was discussed, while designed for a specific purpose, could be adapted to help you with some of the requirements that you may have at your place of business.

I would like to thank Al Blacker, Manager Elect. Optics Dev. for his help, and encouragement to present this paper.

PROFESSIONALISM

William A. Gilhooley
Manager-Glass Equipment Shop
General Electric Research Shop
Development Center
Schenectady, New York

In May of 1976, then President Earl Nagle of the ASGS received a letter from the United States Labor Department stating that a new classification of Scientific Glassblower had been developed and would be printed in the Dictionary of Occupational Titles. This classification placed Scientific Glassblowers in a professional category. It gave the Scientific Glassblower the ability to achieve a status never before attainable. This classification was obtained through the extraordinary efforts of the then officers of this Society. It was no gift, requiring many hours of work preparing documents, making personal visits and telephone calls, and finally an evaluation by a Labor Department representative visiting three glassblowing shops in the New York area. This new classification should not be taken lightly. Those who hope to attain this classification also assume a great responsibility. A responsibility to your employer and yourself.

What is a profession? Webster defines it as a calling requiring specialized knowledge and often long and intensive academic preparation. A professional is characterized as conforming to the technical or ethical standards of a profession, which brings us to *professionalism*. Webster defines it as the conduct, aims or qualities that characterize or mark a profession or a professional person. This is professionalism.

Historically, many have equated professionalism with specific occupations and educational backgrounds. Doctors, lawyers, scientists and educators are frequently referred to as "professionals." Yet the term is not commonly applied to gardeners, plumbers, machinists or secretaries. John Gardner, former Secretary of Health, Education and Welfare, offers his views on such labeling in the following quotation:

"The society that scorns excellence in plumbing because it is a humble activity and tolerates shoddiness in philosophy, because philosophy is an exalted activity, will have neither good plumbing nor good philosophy. Neither its pipes nor its theories will hold water."

You are probably asking yourself what has this to do with me. It has everything to do with you and me. We are professionals and we had better act as professionals. I have heard about glassblowers or others looking for jobs and when the position is filled with what looks like a lesser qualified person, other contenders for the job can't understand why the employer made the choices they did. I don't know how every employer makes such choices, but I have been in a position to make such selections after interviewing candidates for various jobs. I look for skills certainly, but I am equally concerned with the person's overall attitude. What is the person's attitude toward supervision, his peers, the people being served. *Attitude.* Remember the definition of professionalism. The *conduct*, the quality of the person. If a person possesses a good attitude, good qualities and conducts himself/herself accordingly, what he/she lacks in skill or knowledge, can be learned because the person possesses the right *attitude.*

What is our responsibility to ourselves and to our employees. We are obligated to make certain that our conduct commands respect from those with whom we come in contact. How often have we been turned off by the approach used by some people we are working with. If they demean you, you only hear a fraction of what they say. So we should be alert and not guilty of the same conduct. That is our responsibility to ourselves, our emloyer and those with whom we work. We should always give our loyalty and the best we have to our profession. We should gladly articulate advice to help our associates from making mistakes in their daily work. A colleague of mine has a plaque hanging in his office which is a quote by Elbert Hubbard. It reads as follows.

"REMEMBER THIS"

"IF YOU WORK FOR A MAN, in Heaven's name, WORK for him. If he pays you wages which supply you bread and butter, work for him; speak well of him; stand by him and stand by the institution he represents. If put to a pinch, an ounce of loyalty is worth a pound of cleverness. If you must vilify, condemn and eternally disparage - resign your position, and when you are outside, damn to your heart's content, but as long as you are part of the institution, do not condemn it. If you do that, you are loosening the tendrils that are holding you to the institution, and the first high wind that comes along, you will be uprooted and blown away, and probably will never know the reason why."

As stated earlier, the ASGS presently enjoys having a Scientific Glassblower rating under a Professional classification in the D.O.T. This does not come with a lifetime guarantee; that is, if we do not live up to the expectations of a professional, someone, namely industry, the Government or an industrial consulting firm could challenge our right to such a title. If we have not improved our educational foundation, if we have not increased our practical skills, and if we lack the attitude of a Professional classification.

As those before you worked to improve the glassblowing profession, it is your challenge to make certain we maintain what we have and also to further improve our station in life. You younger members should be looking to get degrees. In most localities, there are mechanisms whereby work experience is recognized as credits toward a degree. It is your future, and you should take the initiative to grasp every opportunity presented to you. That is your responsibility to yourself and your profession.

I would like to go a step further and ask what is our responsibility to our Society. In the past, before the founding of the American Scientific Glassblowers Society, glassblowers were regarded as individualistic, hard to get along with, and prima donnas. We sincerely hope that this perception of glassblowers has changed to an image of cooperative ladies and gentlemen who know their profession, share their knowledge, do their very best, and in general are true professionals. I can vouch for GE CRD Glassblowers and those with whom I have been associated with in our Society.

This is what I believe we owe our Society - a good reputation throughout the scientific community. That is what the founders of our Society were striving for. The men that I have associated with for years in this Society were constantly concerned with our image. Now, it's time for your generation to carry on and further enhance the ideals of our Society.

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