

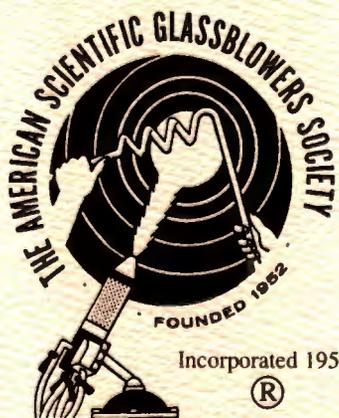
PROCEEDINGS

THE FORTY-FIRST
SYMPOSIUM

ON THE

**ART OF SCIENTIFIC
GLASSBLOWING**

1996



THE
AMERICAN SCIENTIFIC GLASSBLOWERS SOCIETY

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New Orleans, Louisiana

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The Forty-first
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on the
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St. Paul, MN

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Papers

Bernard Gitton's Incredible Water Clock

by

David Wedsworth

Eli Lilly, Indianapolis, IN 46285

Dr. Bernard Gitton is a French mathematician and physicist. As a young man he earned two doctorates in nuclear physics and later worked at the National Center for Scientific Research, the Curie Laboratory and another Lab in Orsay, France. In the laboratory he discovered that many functional things were also very beautiful and it became his interest to combine art and science to show that physics was not all daunting and boring. Since 1979, he has successfully pursued this dream.

In an interview, Dr. Gitton refers to a French saying, "le temps s'écoule" or "time flows." It is a common expression but one that reflects one of man's most ancient means of time measurement, the flow of water. A Clepsydra is a device that marks time by measuring the flow of water through a small orifice. Invented in ancient Egypt, the water clock was considered a major breakthrough because, unlike the sundial, it could function day or night and rain or shine. Clepsydras were greatly improved upon and remained popular through the seventeenth century but, even with better designs, water clocks were not very accurate due to physical variances such as temperature and barometric pressure. With the invention of the pendulum in the eighteenth century, a far more accurate system, interest in clepsydras faded. For aesthetic reasons, Mr. Gitton decided that combining the flow of water with the pendulum would create a fascinating time device, and he has certainly succeeded.

Gitton's clocks range in size from six feet to forty-six feet tall and there are fifty or so located around the world. There are eleven of the large clepsydras located globally with one each in France, Japan and The United States, and two each in Brazil, Indonesia, Portugal and Germany.

It takes three men six to eight months to fabricate, assemble, test and install one of the large clocks. The many components of the clock fit together through a variety of gaskets and compression fittings. Nothing is actually fused together upon installation. The capacity is 200 liters or 53 gallons and consists of 50% de-ionized water and 50% methyl alcohol. The alcohol is added to prohibit algae growth and the mixture can be colored to suit the desire of the client. At the Indianapolis Children's Museum the clock contains blue liquid.

Standing 13 meters or 46 1/2 feet tall, the clock consists of many blown glass globes, hollow discs, two holding tanks and a pendulum. There are twelve globes on the left, each with a corresponding number representing one hour. On the right are thirty hollow discs each representing two minutes and numbered in ten-minute increments. You can tell the time of day by the number of hour globes and minute discs which are filled.

The design of Gitton's clepsydra is ingenious and the hydrodynamics are as follows: the liquid in the large tank at the top flows through two circuits which are separate yet interact. To set the clock in motion, water pours into a scoop-shaped container ("C" as

shown in blueprint) that, when filled, causes the pendulum to move. At this first stage of flow, the water is the “motor” which oscillates the pendulum. This movement is a timing device that regulates intervals of water and triggers the events to follow. The only moving part on the clock is the top of the pendulum which pivots on a pair of needle bearings. The clock is entirely gravity-driven with the exception of an electric pump used to fill the upper holding tank.

Responding to the pendulum oscillations are a series of five siphons which receive intervals of water from the scoop as it fills and dumps. The siphons divide the pendulum oscillations so that the fifth one (S5) will cycle at two-minute intervals. At the end of this interval, the fifth siphon drains into the lower tank and a reduction in pressure occurs which activates the second circuit. The resulting vacuum triggers a waiting bulb (F2) whose volume siphons into a two-minute disc.

When the thirtieth disc is filled, the pressure of the entire minutes column pushes over another siphon (S.M.) and once again a vacuum is created. This suction, occurring at a sixty-minute interval, triggers a second bulb (D) whose volume siphons into the next hour globe. Simply put, the clock follows the principle of numeration or the counting of controlled intervals.

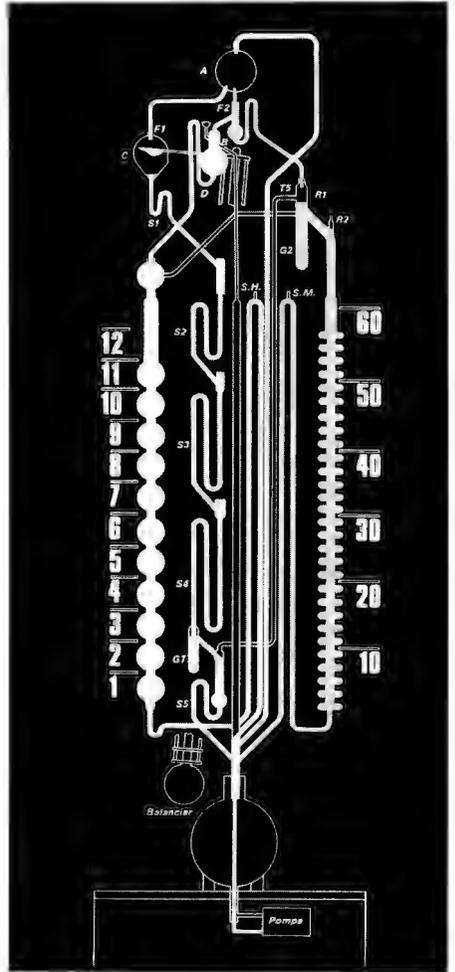
Without question the most popular time to observe the clock is at the stroke of mid-day. At the end of the noon hour, the minute column siphons once again, but this time, the pressure of the entire hour-column pushes over yet another siphon (S.H.) and the entire sequence begins again at 1:00 thus completing the twelve-hour cycle.

As a technical achievement alone, Gitton’s clepsydra is phenomenal. As an artistic statement, it is pure poetry in motion. Combining the serene quality of fluid motion with the mystical wonder of time flow, it invokes feelings that enchant both the young and old alike.

I would like to thank the Children’s Museum of Indianapolis for their cooperation and a special thanks to Mr. Bernard Gitton for his permission and for his incredible Time Flow clock.



Bernard Gitton's water clock.



Blue print for water clock.

The Corning Connection

by

Sally Prash

The Corning Museum of Glass

Corning, New York 14830

The Corning Museum of Glass in Corning NY has recently opened a new educational facility to teach many different aspects of glassmaking including scientific glassblowing. Corning has named the new department The Studio. With more than 5,000 square feet of space and a wide range of courses year round, The Studio offers participants at all levels of expertise an opportunity for hands-on learning about glass. The Studio was designed to provide a creative environment for learning, experimentation and collaboration. As part of The Corning Museum of Glass, The Studio offers access to the world's greatest glass collection and library on glass.

Corning is located in the southwestern section of the Finger Lakes Region of New York state. The Corning area is known for wine industry, museums, summer theaters, fall foliage, nature centers and the large state forests. Of course the main attraction is The Corning Museum of Glass.

Dedicated to the history, art and science of glass, The Corning Museum first opened its doors on May 19th, 1951. Unfortunately, in 1972 a devastating flood generated by Tropical Storm Agnes submerged the collections under nearly 5 1/2 feet of water. Five hundred glass objects were broken and half of the library was covered with water. On May 28th, 1980 a new building was opened. Its unusual shape relates closely to glass making and to the Museum's collection. The galleries within the irregular outline were designed to reflect the amount of glassmaking activity during different periods through the centuries. The library is the core of the Museum. Around it stretches a time tunnel illustrating three thousand five hundred years of glassmaking history.

The Rakow library located in the center of the museum is the foremost library in the world on the art and history of glass and early glassmaking. The book and periodical collection of approximately 70,000 volumes includes publications in 41 languages, ranging in date from a 12th century manuscript to the latest biographies of 20th century glass artists. The glass researcher will find, either in the original or copied on microfilm, an extensive collection of glass factory correspondence, trade catalogs, directories, patents, auction catalogs, posters and designs by artists like Tiffany and Lalique. Currently the library receives almost 850 magazine titles, including *Fusion*. The library also has an extensive audio-visual collection including slides, films, videos and tapes.

You may also see exquisite crystal objects being created by master crafts people in the Steuben Factory. From the start of the blown glass to copper wheel engraving to the final polishing touch, Corning lets you view all aspects of the Steuben process.

What better place for a glass school; Corning has it all. This is the first summer The Studio will be in operation. Classes concentrating on glassblowing and flameworking

are being offered. In the fall we will add other glassworking courses to our program, such as pate de verre, mold making, casting, engraving, scientific glassblowing and enameling. Working with Salem Community College and colleges in the area of Corning, we plan on giving a two-year program for beginners in the field of scientific glassblowing. Also, each semester we will give a four-day workshop in a specific field of scientific glassblowing for people already working in the field of scientific glass. You may receive credit for classes taken at The Studio. Hopefully this will turn into a certification program for scientific glassblowers to gain recognition for their skill.

The opening of The Studio took place over the Memorial Day weekend. Lino Tagliapietra, Paul Stankard and myself demonstrated different aspects of glass. The Studio is set up so small tours can move about freely from one area to the next but still be separated enough so as not to disturb the classes. Let's go on a tour to see each room of The Studio.



The hot shop is the largest room, providing the glass worker with all the latest equipment. A large viewing area with bleachers gives tours time to watch each demo.



A cold shop provides the glass worker with lapping wheels, belt sanders and polishers.



The sandblasting room is just off of the cold shop.



The technicians' shop is for upkeep and repair of The Studio.



And of course the best is the lampworking shop located next to the engraving and the mold shop.

Here in Corning's new studio, students can learn glassworking skills, then spend time examining the collection, researching glass history, perhaps studying an object made by the instructor of the course or by some glassworker from the distant past who once struggled to master the very same skills. We are seeking suggestions and/or help in instruction. If interested, please contact:

The Studio of The Corning Museum of Glass
One Museum Way
Corning, NY 14830-2253 USA
Phone: (607) 974-6467
Fax: (607) 974-6370

Design and Fabrication of a Quartz Furnace Insert for the Measurement of Electrical Conductivity of Magnetic Materials

by

Christian Bousset and Dr. J.F. DiTusa
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 Baton Rouge, LA 70803

Abstract: This paper will use the design and fabrication of a quartz furnace insert along with a few other projects to illustrate one of the main roles of scientific glassblowers employed by research institutions. This role is the translation of ideas conceived by scientists into functioning and aesthetically pleasing apparatus using ingenuity, astuteness, and knowledge of glass, in addition to the manual skill of a fabricator.

In December 1994, Dr. DiTusa from the Physics Department at LSU came to the glassblowing shop with an idea about making a quartz tube insert for the measurement of electrical conductivity of magnetic materials. He reminded me that in order to have a complete description of the interplay between the magnetic and electrical properties

of a material, high temperature conductivity must be taken into consideration. However, at temperatures much above room temperature many materials will become either oxidized or reduced in an environment open to air. Thus it is difficult to measure the intrinsic conductivity of a material without a change in its chemical composition.

A gas was chosen based on the chemistry of the sample so that the sample stoichiometry (the quantities of chemical elements involved in a chemical reaction) remained constant during measurement. The experiment was to run from 30° to 1000°C. Next, Dr. DiTusa showed me his sketch (fig. A1). Essentially, he needed a quartz tube of 1" o.d. and 18" long with an inlet and outlet for the gas and a tube that would slide inside. This 1" o.d. tubing should not leak.

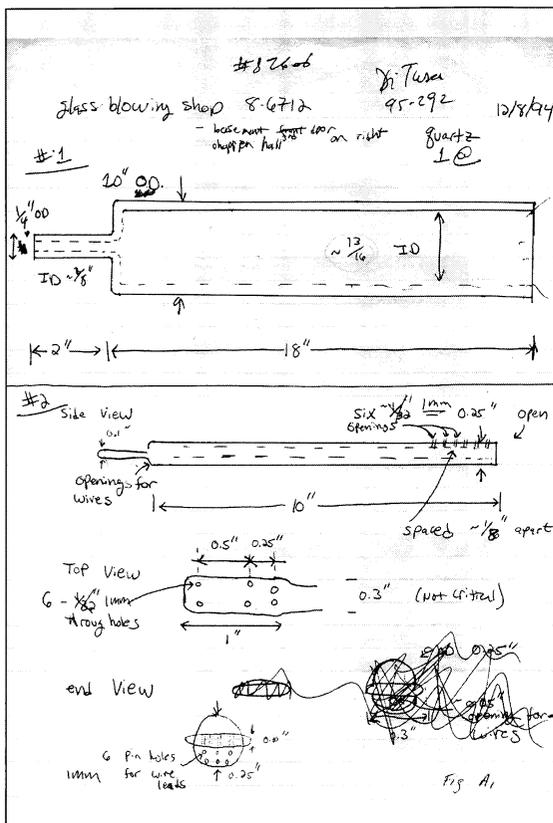


Figure A1

At the end of the inner tube he needed a sample holder with holes of 1mm diameter or less through which to run electrical wiring. The sample holder would have to be located in the middle of the furnace tubes. Six leads were needed, two for a thermocouple and four at the same location.

On his sketch, Dr. DiTusa did not show how to insulate the wires. The fact that the gas should not leak outside the furnace and yet the platinum leads had to go through the quartz wall, was reminiscent of other projects where we had to work with merely a few hints and were asked to transform a sketchy concept into a functional product.

To insulate the wire, I thought that using small tubes (1.5mm i.d. quartz tubing) arranged around the inner circumference of the tube and fused at both ends might suffice (see photos A2 and A3 and figure A2). Making the sample holder was the next problem. Our drilling facilities could not make such a small hole, and our microsandblaster was out of operation at the time. To make the holder, I decided to use six capillary tubes (with an inner diameter of less than 1mm) cut into lengths of 2mm. They were later fused to the central piece at the required distances 12mm and 6mm apart. The sample holder attached later to the rest of the inner tubes (see figure A3 and photos A5, A6, and A7). The platinum leads were made gas-tight in each orifice on the outside of the furnace insert with a high temperature epoxy cement or with sodium silicate.



Photo A2



Photo A3

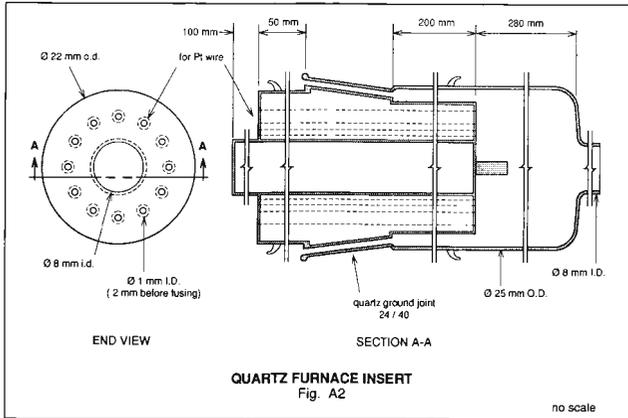


Figure A2

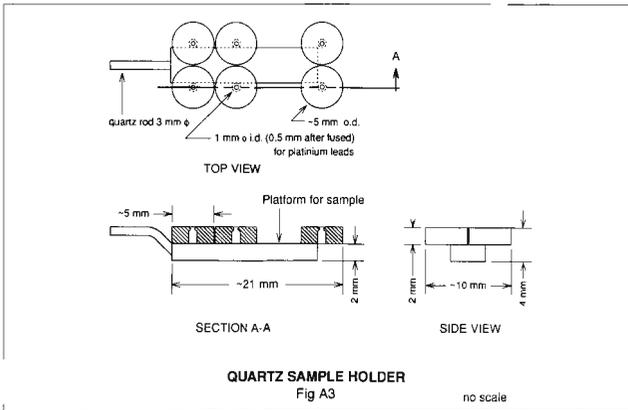


Figure A3

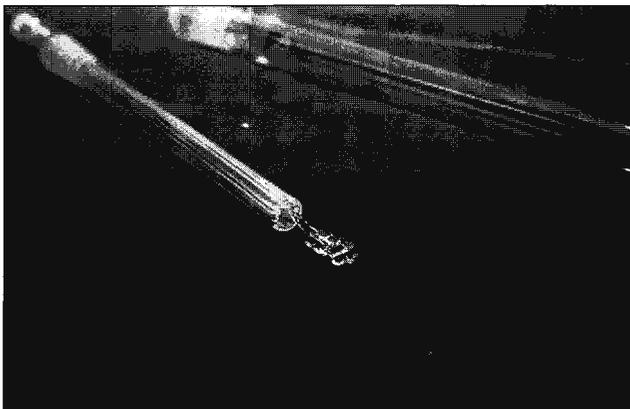


Photo A5



Photo A6



Photo A7

As examples of the exploration carried out in this apparatus, we have included two figures showing the resistivity of two insulating systems at high temperature. The first example, shown in figure A8, is $Y_{2-x}Ca_xBaNiO_5$, a one dimensional Heisenberg antiferromagnet kept in an oxygen atmosphere in order to keep the oxygen content of the sample constant over the temperature range from room temperature (300K) to 1000K. The second example, shown in figure A9, is FeSi, a Kondo insulating material, in an argon atmosphere in order to keep this material from oxidizing over the temperature range 200K (data taken in a cryostat) to 600K. These measurements up to 1000 K have been compared to the prediction of recent theories of the interaction of the spin and charge degrees of freedom in correlated systems.

Now I would like to describe other prototypes done in the same fashion and worthy of mention from earlier in my career. In 1988, Dr. Paul Russo from the Chemistry Department at LSU wanted me to fabricate an acetone percolator device for the ultra cleaning of quartz cuvettes used in spectroscopy (see sketch, figure B1). After discussing this apparatus with him, I came up with a few ideas and improvements of my own, which made the unit more efficient even though they made it more complex. Importantly, for a proud craftsman, it became more challenging and rewarding in the sense of accomplishment, (see drawing, figure B2, and also photos B3 and B4).

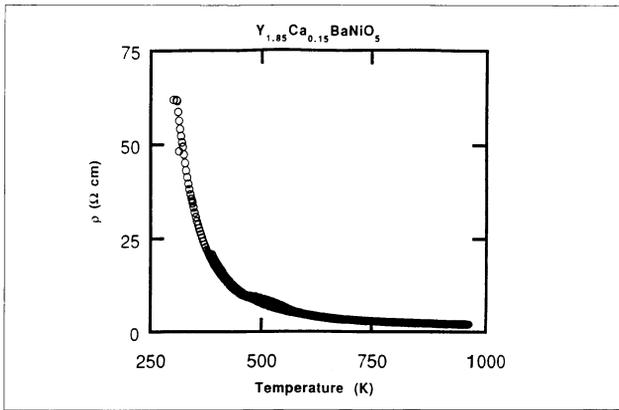


Figure A8

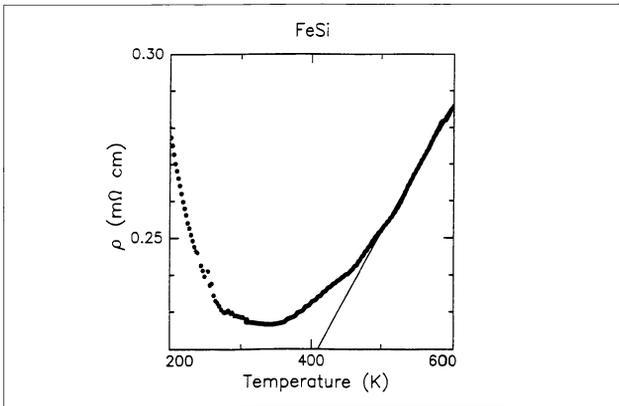


Figure A9

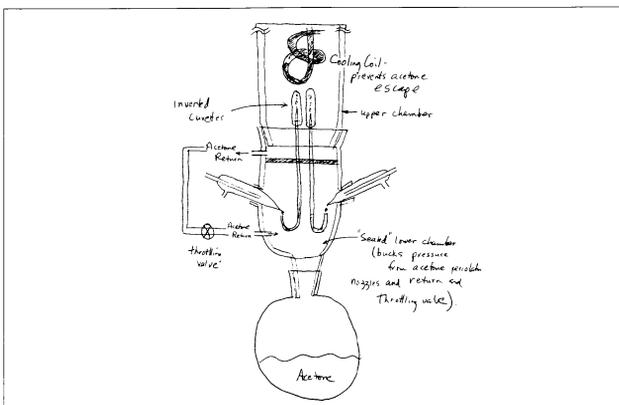


Figure B1

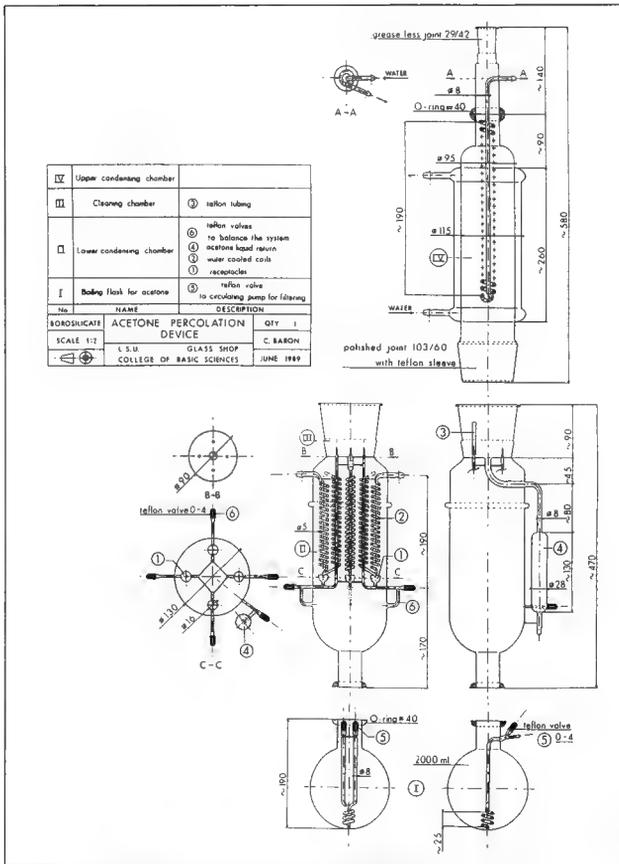


Figure B2



Photo B3



Photo B4

When I was at the State University of New York at Stony Brook in Rudy Schlott's glass shop in the early 1970's, Dr. Arnold Wishnia, a biophysical chemist, was doing experiments to study the active sites of proteins with a glass cell that had to be immersed in a bath kept at a certain temperature. Each time a sample had to be taken out of the cell, it had to be removed from the bath, which unfortunately altered the temperature (see drawing, figure C1). After watching the experiment a few times, it struck me that we could enclose the whole cell in a thermostatted jacket. Because of the way it would have to be built, I had to change the mechanism to move the radioactive gas in the cell. By using a propeller activated with an outside motor, the results were successful. I made several similar cells with different configurations (see drawings, figures C2 and C3, and also photos C1 and C2).

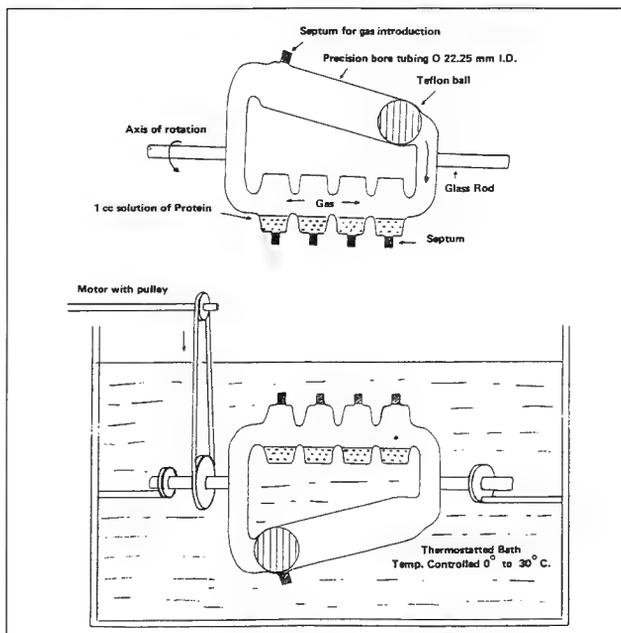


Figure C1

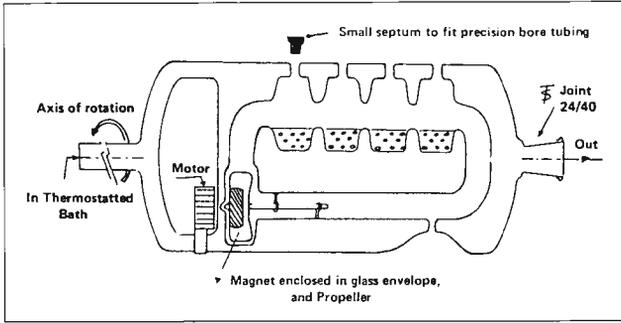


Figure C2

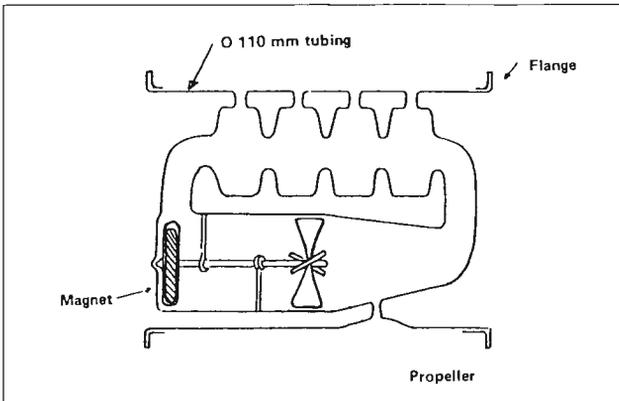


Figure C3



Photo C1



Photo C2

During the same period, T.H. Cheng, a graduate student of Dr. N. Hirota, a spectroscopist, wanted us to build a large liquid helium/liquid nitrogen dewar to study crystals at very low temperature, 4.2 to 1.1 degrees Kelvin; but again we observed that when you have two dewars within each other and you pour liquid nitrogen in the cavity between, you have a generator of bubbles at the tail interfering with the light path where you want to observe the crystal (see drawing, figure D1). We therefore decided to create a tunnel of sorts for the light to go through the N_2 (see drawing, figure D2). In order to do that, we had to build a one-body, four-walled dewar. Creating such a liquid helium/liquid nitrogen dewar presented quite a challenging project (drawing, figure D3), although we later learned that this design had been previously used (see photos D4 and D5).

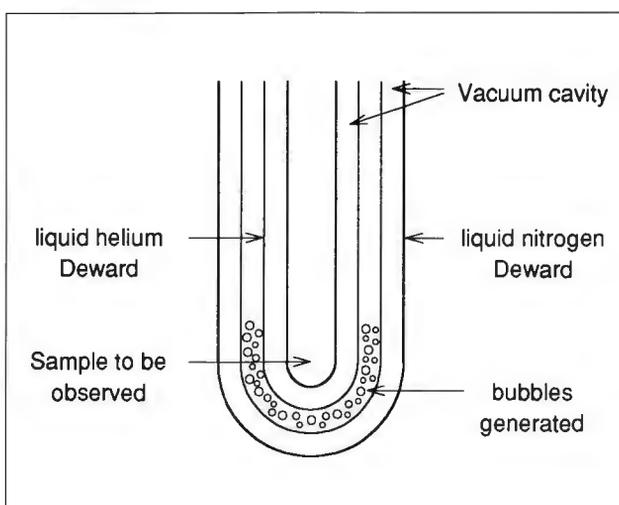


Figure D1

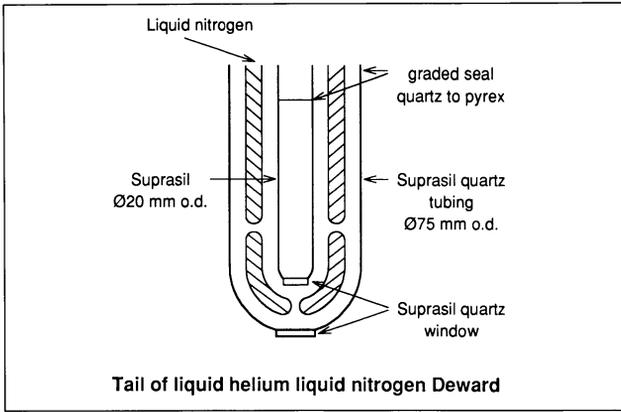


Figure D2

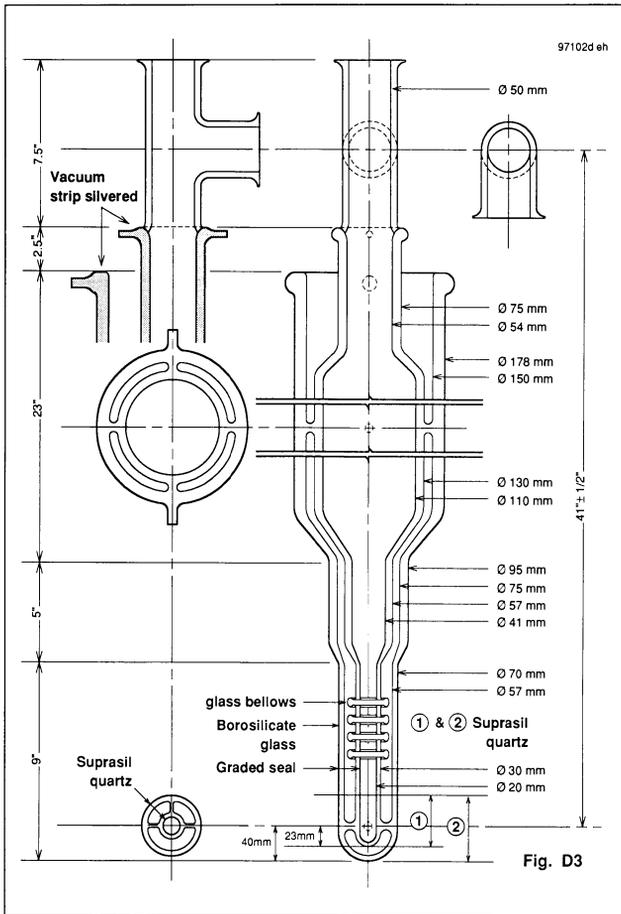


Figure D3



Photo D4

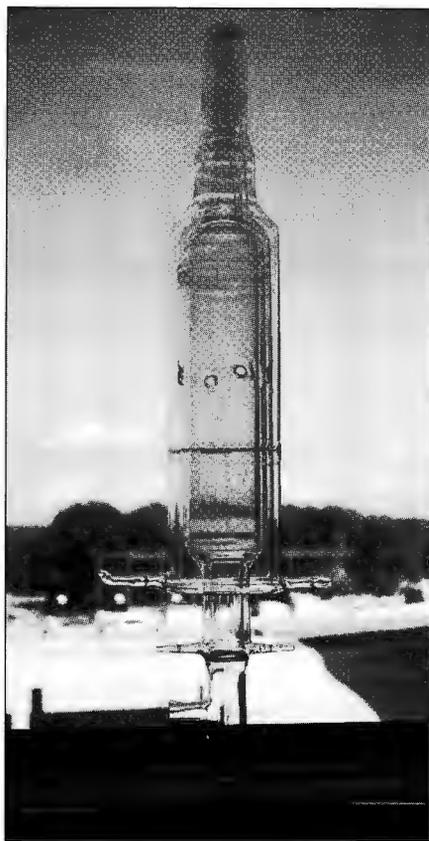


Photo D5

Perhaps one of my most challenging single glassblowing task was to seal sixteen tubes going through a 178mm diameter tubing, arranged eccentrically within specific angles with a tolerance of 1° and in the same plane since the finished apparatus was to be used with a laser to study a crystal (see drawing, fig. E1). It is obvious, when looking at the configuration, that all the seals had to be done at one time, and the entire area had to be kept warm in the process. It took me several hours to make all the final seals with Siegfried Stolp helping me keep it alive (see photos E2 and E3).

To conclude, there is always a challenge to the basic work of the craftsman that we perform every day. We can sometimes take our work to another level; our value is not only in the fabrication, but in ingenuity and new design. It is this astuteness that makes us unique among the support staff of a scientific research group. This summer I nurtured a splendid flower called the passion flower (see photo F1). Looking at the beauty and complexity of this flower reminded me that nature is a far greater engineer than any human. Some great glassblower could probably reproduce this flower out of glass, but it would not close at night and open in the morning!

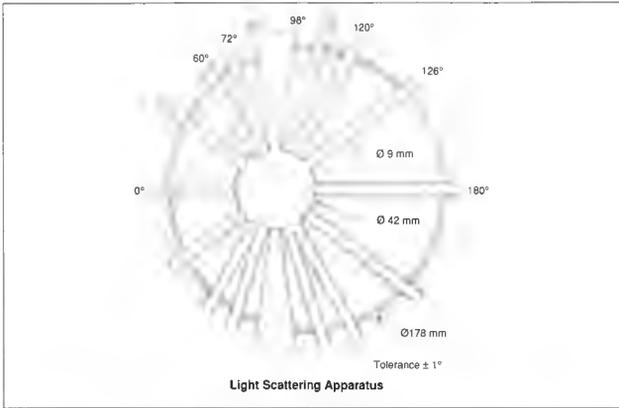


Figure E1

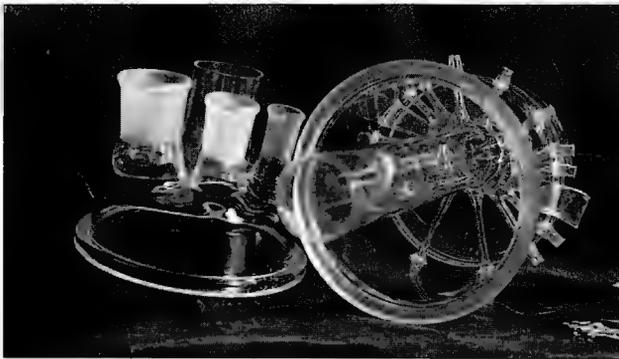


Photo E2



Photo E3



Photo F1

Acknowledgments. I would like to thank Dean Peter Rabideau and Dr. H. Silverman of the College of Basic Sciences who made it possible for me to present this paper and to manage the technical paper session at the ASGS Symposium in New Orleans. I would also like to thank the faculty and staff for their inspiration, Linda DiAntoni who helped me with corresponding and typing, Enrique Hurtado who helped me with the computer-assisted drawings, Vincent Guerrini who did more than his share of glassblowing at LSU while I was busy preparing for the Symposium, my wife and two sons for also helping me with typing and revisions, and all my friends past and present who have touched my life as a scientific glassblower.

Detection of NO₂ by Open Path FTIR During The Glassblowing Process

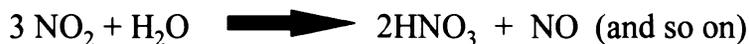
by Eugene Billiot, Stefan Thibodeaux, Christian Boussett,
Vincent Guerrini and Isiah M. Warner*
Department of Chemistry, Louisiana State University
Baton Rouge, LA 70803

Abstract

Open Path Fourier Transform Infrared Spectroscopy (OPFTIR) is used to measure the concentration of NO₂ to which workers in the glass shop at Louisiana State University are exposed. The NO₂ is monitored under various conditions while glassblowers are working with various high temperature flames.

Introduction

It is well established that some potentially hazardous gases are produced during the glassblowing process. The most insidious and toxic of these gases is nitrogen dioxide (NO₂). Nitrogen dioxide is produced from nitrogen (N₂) in the atmosphere combining with oxygen (O₂) to form nitrogen monoxide (NO). For this reaction to occur, a certain amount of energy must be added to the system (43,200 calories/mole). During the glassblowing process, high temperature flames are sometimes used, especially when working with quartz. These high temperature flames supply the necessary energy for nitrogen and oxygen to combine to form NO. The NO then reacts spontaneously with the oxygen in the air to form NO₂. Nitrogen dioxide, which is a reddish brown gas, can then combine with the moisture in the air to form nitric acid (HNO₃) and NO. The NO can then react with oxygen to form more NO₂. The above reactions are expressed in chemical equation form as:



Several chronic and acute health effects have been linked to exposure to NO₂. Some of these are listed below.

Acute (short term exposure) Health Effects:

- Exposure to 1.6 ppm for 3 minutes causes an increase in airway resistance in chronic bronchitis
- Exposure to 50-110 ppm causes inflammation of the lungs for a period of 6-8 weeks after which time the subject usually recovers
- Exposure to 150-200 ppm causes bronchiolitis fibrosa obliterans, a condition fatal within 3-5 weeks after exposure

* Author to whom correspondence should be addressed.

- Death generally results within 2-10 days after exposure to 500 ppm or more

Chronic (long term exposure) Health Effects:

- Development of emphysema
- Damage to lung tissue
- Enlargement of spleen
- Nonspecific immunological changes
- Behavioral or central nervous system changes
- NO₂ is also believed to play an important role in pulmonary and/or systemic carcinogenesis

The United States Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) have set certain limits of safe exposure of NO₂ for the work place and for the general population. The Occupational Safety and Health Administration, which regulates the workplace environment, set a limit of 5 ppm for a 15 minute average and 3 ppm for an 8 hour average. The EPA, which regulates the general population exposure, has declared the following reactions to exposure: **Alert** at 0.6 ppm one hour average or 0.15 ppm for a 24 hour average; **Warning** at 1.2 ppm 1 hour average and 0.3 ppm for a 24 hour average; **Emergency action** at 1.6 ppm 1 hour average or 0.4 ppm for a 24 hour average; **Significant harm to health** at 2 ppm 1 hour average or 0.5 ppm for a 24 hour average.

In this manuscript, we report the use of Open Path Fourier Transform Infrared Spectroscopy to monitor various concentrations of NO₂ in a glassblowing laboratory. The concentrations of NO₂ are measured under conditions which simulate actual glassblowing conditions.

Experimental Section

A single-beam spectrum was recorded using a Midac Open Path FTIR Spectrometer (Irvine, CA) model # A2490. This system consisted of a 10 meter multi-pass White cell with a HgCdTe detector operated at 77 degrees K. The spectroscopic software was GRAMS/386 from Galactic Industries (Salem, NH). A digitized library of infrared absorption spectra of gases were purchased from Infrared Analysis Inc. (Anaheim, CA). The instrumental setup is shown in photos 1a-1d.



Photo 1A. View of instrument and researchers operating the equipment



Photo 1B. Front view of instrument

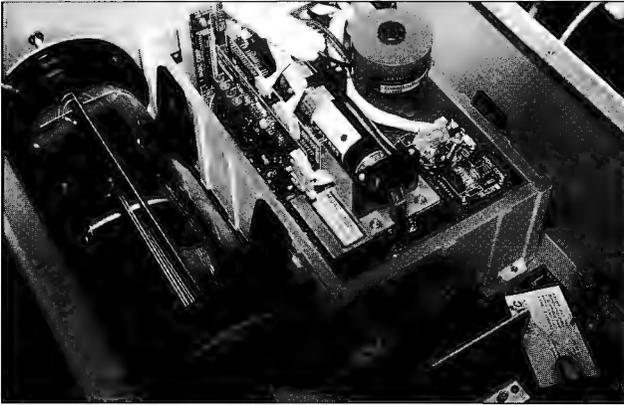


Photo 1C. View of inside of instrument (electronics and HgCdTe detector to the left, 10 meter White Cell to the right)

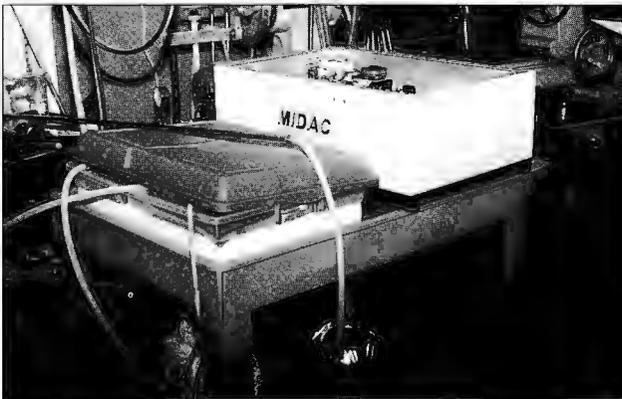


Photo 1D. View of instrument in the background and cryogenic trap in the foreground

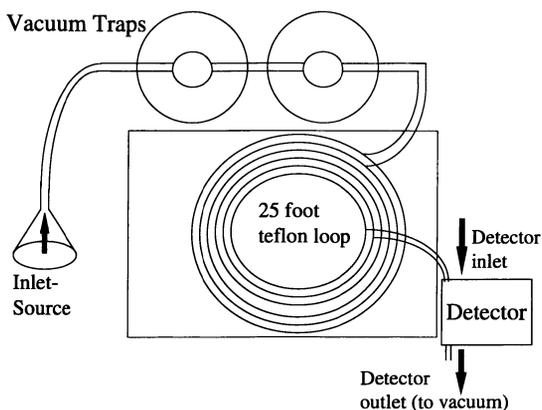


Figure 1. Instrumental configuration of sample collection system.

In order to eliminate interference from moisture, the air was dried prior to analysis by passing the air through a cryogenic trap, see Figure 1. The cryogenic trap consisted of two vacuum traps in series followed by about 25 feet of teflon tubing all of which was immersed in a bath of acetone/dry ice. The air sample was introduced into the system by applying a vacuum on the outlet side of the White cell with the inlet side of the White cell connected to the outlet end of the cryogenic trap. The air sample was collected using a stainless steel funnel attached to the teflon tubing which was connected to the inlet end of the first vacuum trap.

Before each run, prior to igniting torches, a background spectrum was collected. The background spectrum consisted of 25 scans at a resolution of 0.5 cm^{-1} . During the run, sample spectra were collected every minute using the same parameters as the background spectrum. The sample spectrum were then ratioed against the background spectra to yield the absorbance spectra. Next, the absorbance spectrum was subtracted from the library spectra to obtain the concentration of NO_2 , in ppm-meters. The subtracted result was then divided by the path length of the white cell, which was 10 meters to yield the concentration of NO_2 in ppm.

The experiments were divided into two parts. In the first part, measurements were taken while heating a large diameter quartz tube on a lathe. The setup of the lathe and the instrument is shown in photos 2 and 3. The measurements were taken next to the lathe operator, as close to his head as possible so as to be representative of the true exposure to the worker. Two different fuels were used for glassblowing in this part of the study, natural gas and hydrogen. In both cases, oxygen was added to the system to yield a cleaner hotter flame. The torch used on the lathe was a Litton 14-fire 7-jet swivel burner, a closeup of which is shown in photo 4. In the second part of the study, measurements were taken at different areas around a work bench while two glassblowers were performing routine work at a table 7 feet wide with an 18 1/2 inch high partition in the center of the table between the two workers. Photos 5 and 6 show the setup used in this part of the experiment. The torch used in this part of the study was a Carlisle (CC) burner model # 10A001.

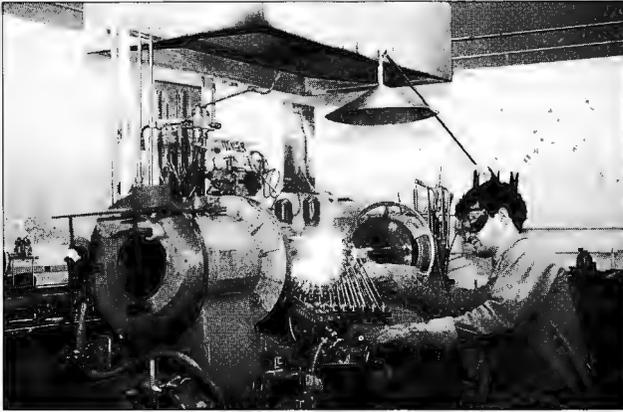


Photo 2. Side view of lathe

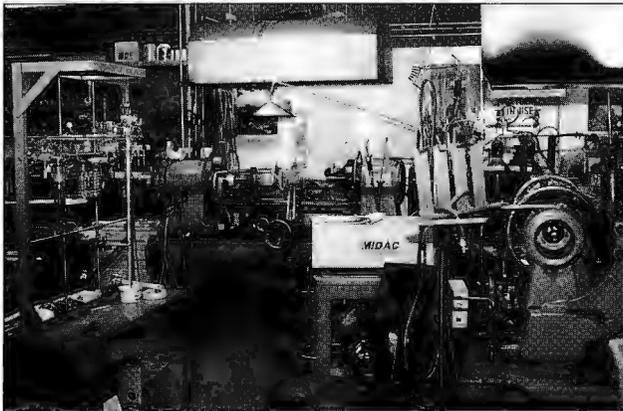


Photo 3. Front view of lathe



Photo 4. Closeup view of burner



Photo 5. View of bench with partition shown in the background

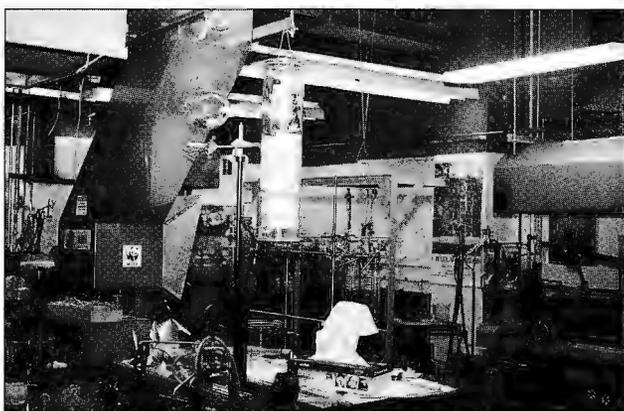


Photo 6. Expanded view of shop with bench shown to the left and lathe on the right

Results and Discussion

The data presented here are the result of some preliminary studies. More experiments are planned to verify the accuracy of the method used. In the first part of this study, with the work done on the lathe, several experiments were performed.

Experiments with a natural gas flame:

In the first experiment, a natural gas flame was used and measurements were taken over a fifty minute period, Figure 2. Within this fifty minute period, the flame was turned off three times and reignited twice. At eight minutes the temperature of the flame started decreasing because the oxygen in the tank began to deplete. At 18 minutes the flame was reignited with a new tank of oxygen. The flame was again turned off at 32 minutes and reignited at 33 minutes. Finally, the flame was turned off at 40 minutes and at 42 minutes, a stainless steel tube attached to the end of the teflon tubing, was inserted into the quartz bottle to measure the concentration of NO_2 inside the quartz bottle. As can be seen from Figure 2, whenever the flame was lit, the concentration of NO_2 was significantly above

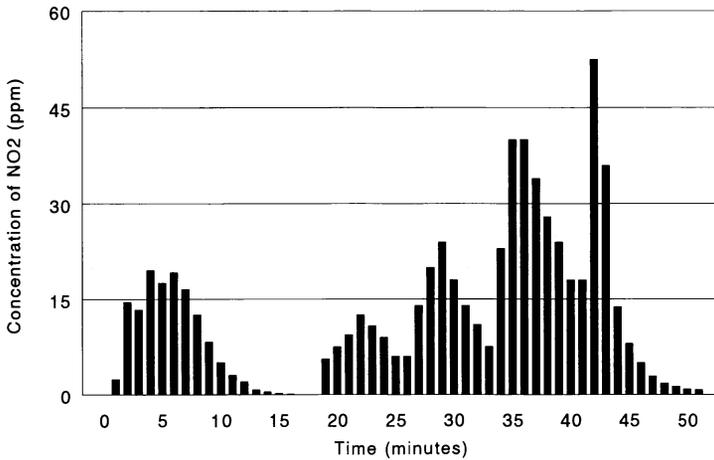


Figure 2. Measurement of NO₂ versus time using a natural gas flame.

EPA or OSHA limits if the time of exposure exceeded 15 minutes in the case of OSHA or one hour in the case of EPA. At times, the concentration of NO₂ was as high as 40 ppm, which is dangerously close to the 50-100 ppm concentration which can cause inflammation of the lungs for a 6-8 week period.

In the next experiment, three 15 minute runs were made: two with the hood off and one with the hood on. These runs were also done with a natural gas flame. As can be seen from Figure 3, the hood that was used seemed to be ineffective for work on the lathe. The concentration of NO₂ that the worker was exposed to was the same with the hood turned off or on. It is obvious from this data that the hood system by the lathe was inadequate for the work being done. The hood, which was about two to three feet from the worker's head, probably could not pull enough draft to compensate for the turbulence created by the large flame surrounding the bottom third of the quartz bottle.

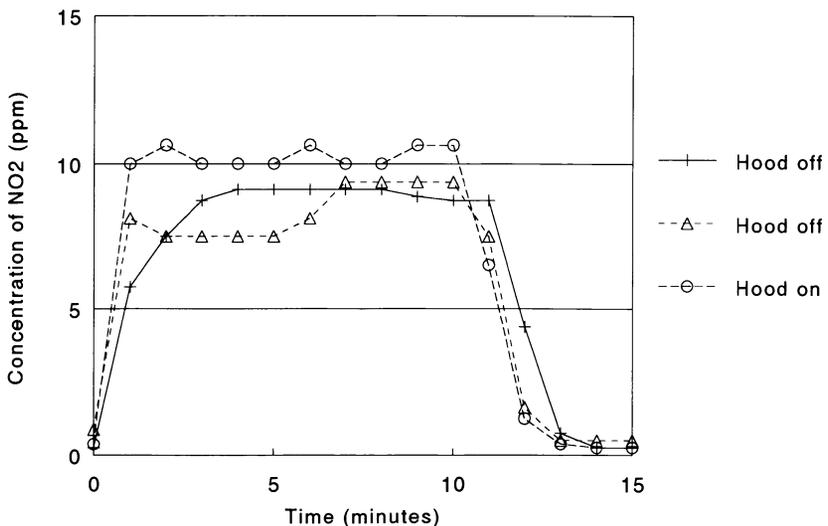


Figure 3. Comparison of NO₂ measured with hood on and with hood off.

Experiments with a hydrogen flame:

Two sets of experiments were performed with a hydrogen flame. In the first experiment, a low temperature hydrogen flame was used and measurements taken over a fifty minute period (Figure 4). At twenty minutes, the flame was turned off. The concentration of NO_2 slowly decreased over the next fifteen minutes. In the next experiment, with the hydrogen flame, a higher temperature flame was used. Measurements for this experiment were taken over a thirty minute period (Figure 5). At ten minutes the hydrogen tank began to deplete and at 16 minutes the flame was extinguished. For this experiment, the concentrations of NO_2 reached nearly 100 ppm. This is a potentially very dangerous concentration. As stated earlier, concentrations of 150-200 ppm can cause bronchiolitis fibrosa obliterans, a condition fatal within 3-5 weeks.

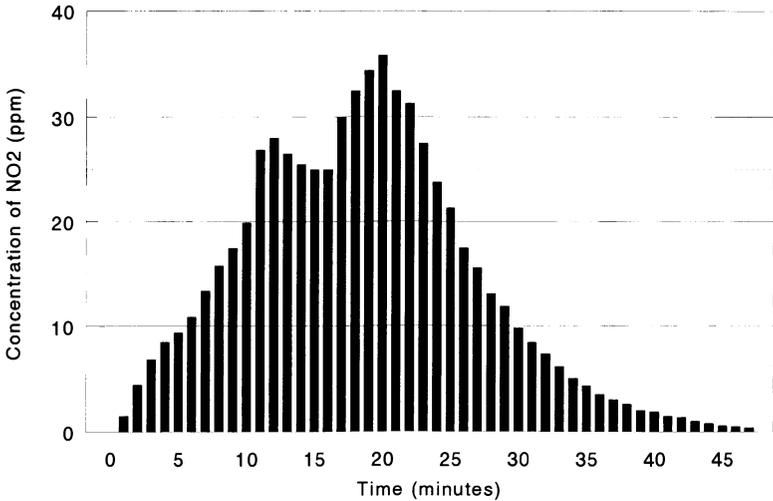


Figure 4. Measurement of NO_2 versus time using a low temperature helium flame.

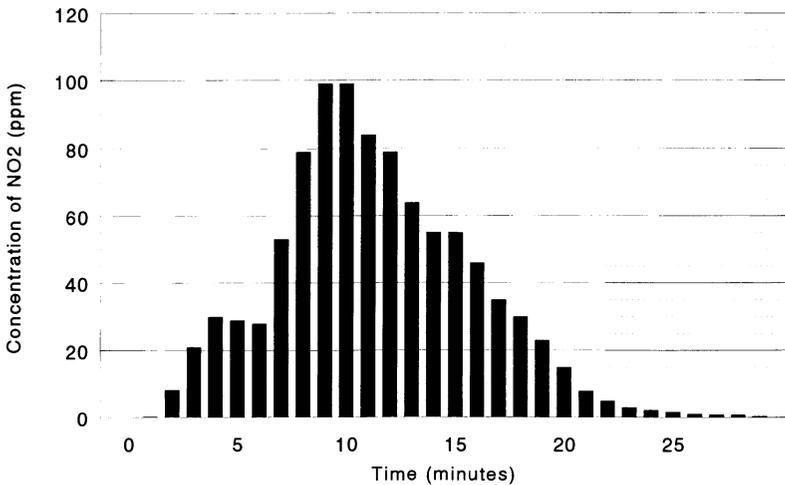


Figure 5. Measurement of NO_2 versus time using a high temperature helium flame.

Measurements at the work bench:

In the second part of the study, measurements were taken at several locations on a work bench while two workers performed routine work. The protocol was as described in the experimental section. This experiment consisted of 15 minute measurements at three separate locations on the work bench. Two of the sets of measurements were taken next to the two workers, which were on opposite ends of the table, and one was taken at the center of the table between the two workers. There was no measurable level of NO_2 next to the two workers. At the center of the table, concentrations of almost 10 ppm were detected, (Figure 6). At nine minutes, the flame was turned off and the concentration of NO_2 rapidly fell to undetectable levels.

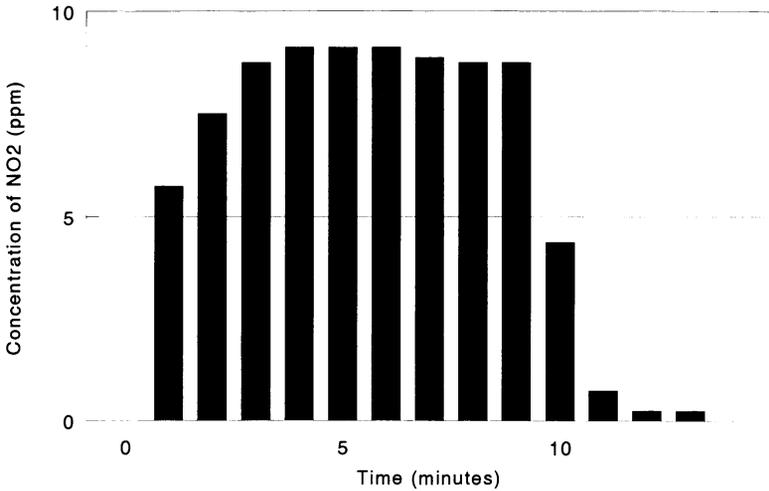


Figure 6. Measurement of NO_2 at center of work table.

Conclusions

The results of these preliminary studies indicate that a potentially very serious situation exists when working on a lathe with high temperature flames. The results showed that the ventilation system used in the glassblowing shop under study was inadequate to protect the workers from harmful concentrations of NO_2 . Subsequent examination of the hood system throughout our building showed that many of our systems were not functioning properly. Corrective measures to eliminate this problem are underway.

Our studies also show, as would be expected, that as the temperature of the flame increased so does the concentration of NO_2 . Finally, the results also indicated that, under the conditions studied, the work bench area was adequately ventilated so that the workers were not exposed to any measurable amount of NO_2 .

Etching or Frosting of Glass

by

Don Lillie

Lillie Glassblowers

Smyrna, GA 30082

There are several definitions in reference to abrading the surface of glass mechanically. Sandblasting, to me, is the process of blowing sand under pressure to violently remove unwanted material. Frosting implies a more delicate process to create a light surface texture. Etching is a more artistic term referring to surface removal either single or multiple level designation. Whatever term you use, it refers to the abrading of the surface of the glass to render it opaque, translucent or decorative.

In order to accomplish a professional etching result, you must have the proper equipment, either basic or complex. The first requirement is an air compressor: a simple single-stage or a heavy-duty double-stage. It should have an adequate capacity to supply proper PSI and volume relative to your requirements. Our system has a 120 PSI tank pressure, 80 PSI line pressure, a 7 CFM flow rate and two moisture traps to ensure “dry” operation. The tank has a drain valve which is emptied every two weeks, especially in hot humid conditions.

The Service cabinet is simply a box with remote access to contain the piece while it is exposed to the etching process. Our cabinet is a professional model by RJL of Chicago with an inverted pyramid reservoir for reusing the abrasive and a siphon-style gun. An internal light source and comfortable, flexible glove inserts allow desirable results, especially with a foot pedal to control the abrasive stream. The gun contains a replaceable nozzle which regulates the stream size and direction of the abrasive. It can be metal, ceramic or boron carbide depending on your budget. Nozzle orifices regulate the time of the etching process.

There are many choices for the abrasive medium. You could use sand with a Knopps hardness scale at 820, or glass beads at 530, but the two most used are alumina which is 2100 on the scale or silicon carbide at 2480. Alumina gives a whiter finish but is softer and has a static problem. Silicon carbide is the most durable, cleans easily and is readily available in a choice of grit sizes. We use 150 C grit silicon carbide supplied in 50# cans. Of course to the wealthy, one could use diamond dust which tops the hardness scale at 7000 but would be astronomically expensive. When the etching time starts to increase, it signifies that the powder has been physically depleted of its etching ability and needs to be replaced.

The most important aspect of etching is an adequate and efficient exhaust system. At operating pressure, the powder becomes a dust capable of penetrating and diffusing everywhere. Our unit contains a vacuum system which passes the exhaust from the cabinet through a water bath and an air filter cartridge before it exits outside. Figure 1 shows the exhaust chamber where the dust exits the cabinet on the right and is water-purged and air-filtered before venting outside the building. Inside the cabinet, all surfaces to be etched and any openings in hollow items must be masked off and closed. We use only 3M masking tape because it produces a sharp borderline and removes easily.



Figure 1.

There are certain applications to using a blast cabinet in the scientific shop. A surface area company once told me that the true surface area inside a blown flask is 2.1 times the linear calculated area. Etching the surface would increase it even more! It could also apply to condensing surfaces, flat receivers or any collecting area. Or, one can reduce an oversize tube to the precise O.D. of a fitting - especially helpful in metric or English metal connectors. Etching a stem increases the friction between the ferrule and the glass. If a finished surface is desired, then a soaking in HF and subsequent polish will achieve the desired result.

We were required to apply 5/8" diameter spots to some quartz tubes we fabricated. After unsatisfactory results with white ceramic decals, we resorted to etching them with our blasting process. Circles were punched out of 2" masking tape with a 5/8" sharpened brass tube and applied accordingly. Figure 2 shows a fire polished stem on the left, an abraded 1/2" dia section in the center and a 5/8" circle on a quartz tube on the right. Your ingenuity can lead to numerous clever and unique scientific applications.

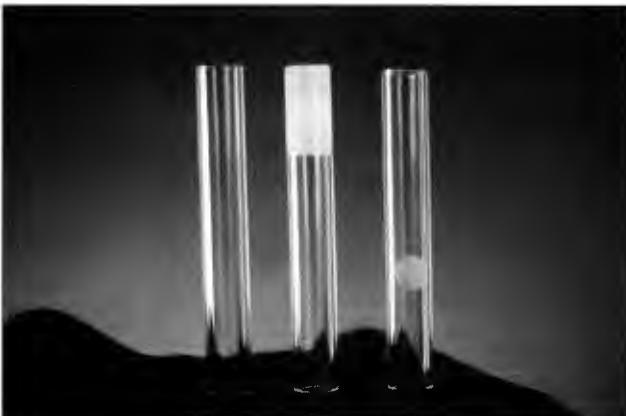


Figure 2.

Finally, the most current application is the artistic field. An object can become more varied and focused if certain outlines are detailed. We have applied our knowledge of etching to highlight and beautify some of our creations. Figures 3 and 4 display this concept.

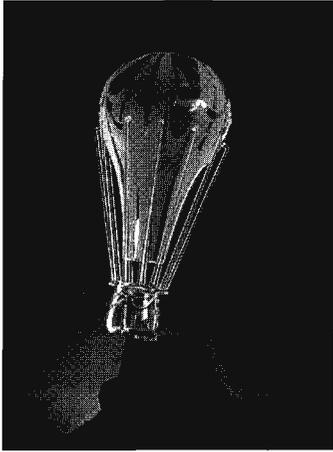


Figure 3.

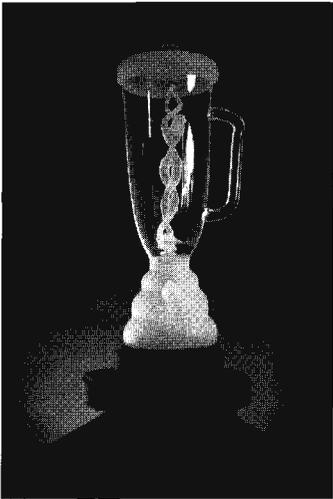


Figure 4.

So this is etching, frosting or sandblasting, whatever definition you want to use; but its application is only restricted by the limits of your ingenuity, imagination and perspective.

The Fabrication and Installation of a Hydrogen Cell Used on the Satellite SOHO

by Christian Bernard

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The SOHO satellite (Solar and Heliospheric Observatory) carries 12 scientific experiments and is a cooperative effort of NASA and ASE, the European Space Agency. The mission was planned to last two years with a possible extension to six years. One of the important unanswered questions in solar physics and a main objective of SWAN is to understand the fast solar wind acceleration process.

The Solar Wind Anisotropies (SWAN) experiment gathers data on the flows of solar wind, the expansion of the solar corona by about 100,000 km into the interstellar medium. This experiment is a French-Finnish collaboration. The French group is from the Aeronomy lab of the CNRS, specializing in the study of the atmosphere above 5-6 km. This lab has 120 employees including 50 researchers and is located 15 km south of Paris (see picture 1). There are two Finnish groups, one from the Center of Technical Research of Finland and the other from the University of Turku. The principal investigator is Dr. Jean Loup Bertaux of the Aeronomy lab of the CNRS. The experiment consists of an electronic controller and two independent sensors for detecting Lyman alpha radiation (121.6 nm), one on each side of the satellite. Each sensor contains a hydrogen cell. This presentation will explain how the cell was fabricated in the glass shop of the Aeronomy department. The glass shop is shown in pictures 2-4. The SOHO satellite itself is shown in picture 5 as it appears in space and in picture 6 as it appears before launch. Picture 7 shows the SWAN sensor with the cell in place.



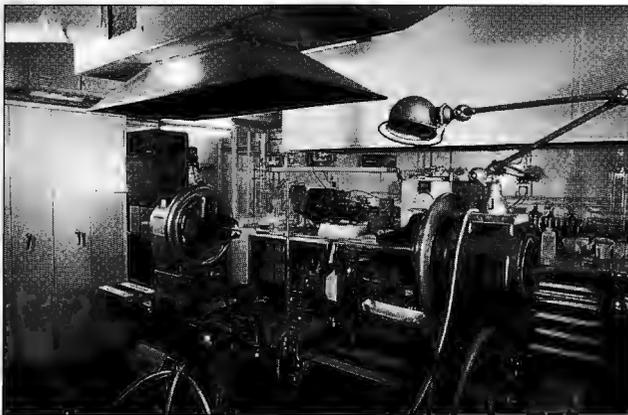
Picture 1.



Picture 2.



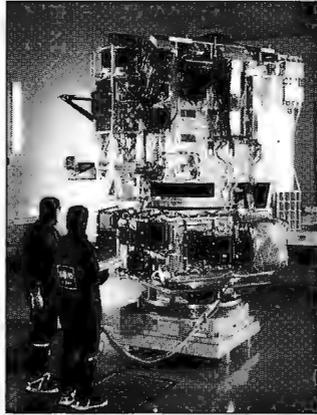
Picture 3.



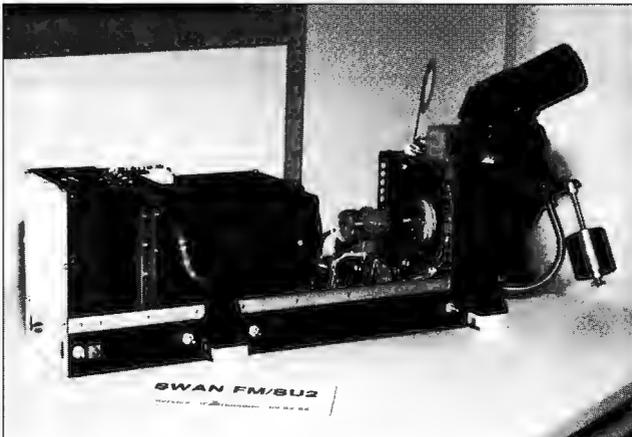
Picture 4.



Picture 5.

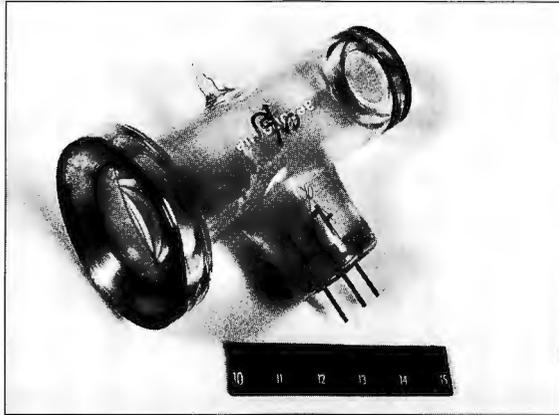


Picture 6.



Picture 7.

The hydrogen cell is made of S747.01 Corning glass with 2 magnesium fluoride windows. It is filled with low pressure hydrogen (1.2 mb) and has two tungsten filaments. The cell is shown in picture 8.



Picture 8.

A schematic of the sensor is shown in figure 9. The light enters the sensor through a kind of periscope which can be positioned. The light goes through the cell and is measured by the detector. The operating principle is as follows: when one of the filaments is heated, it causes a hydrogen molecule to decompose into two hydrogen atoms, which absorbs Lyman alpha radiation and keeps it from reaching the detector. In the off position, the radiation is not absorbed and goes through the cell normally. The difference is recorded.

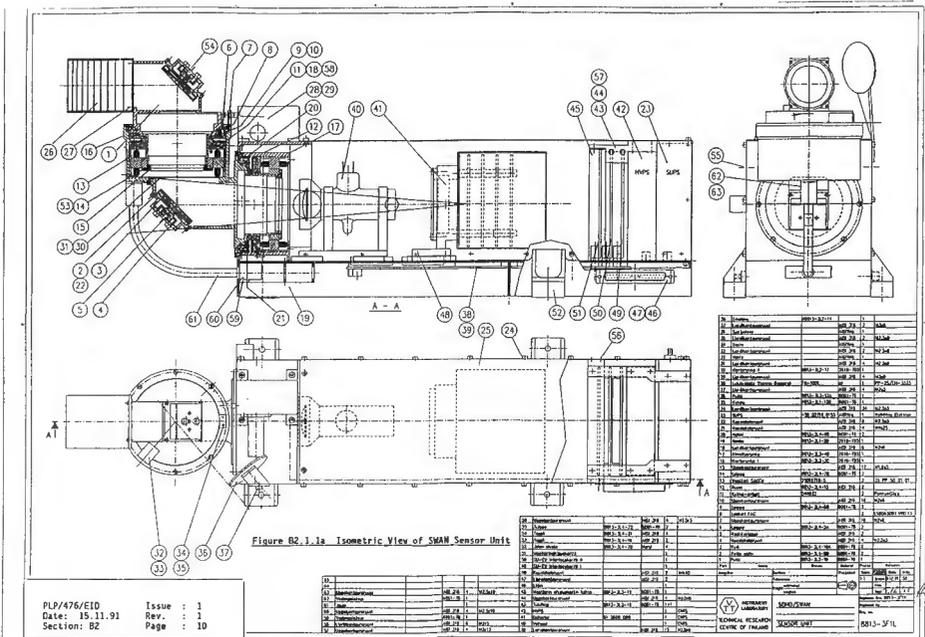


Figure 9.

Figure 10 shows the schematic used to construct the cell. The glassware fabrication diagram is shown in figure 11. Fabrication began with several lengths of 28mm diameter tubing having a tolerance of 0.2mm as required by the mechanical engineer.

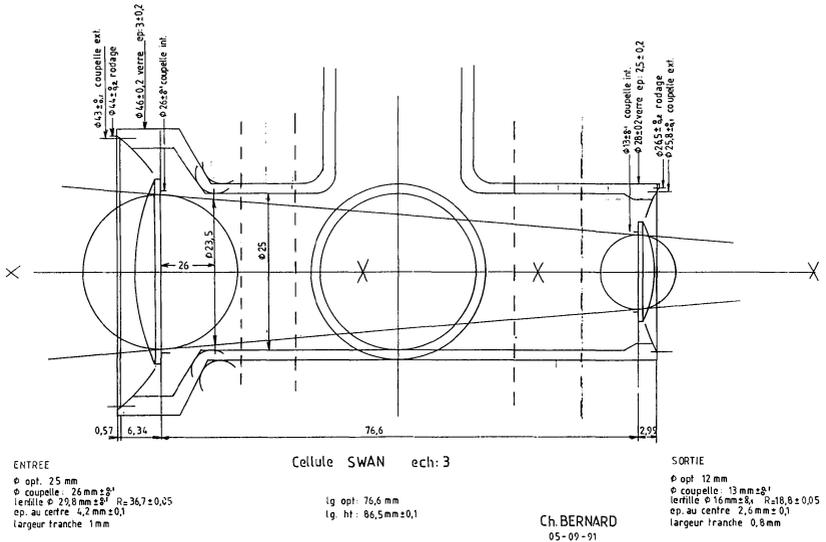


Figure 10.

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE
 SERVICE D'AERONOMIE

BP N° 3
 91321 Verrières le Buisson Cedex
 France
 Tél: (1) 84 47 42 45
 Telex: 402 400

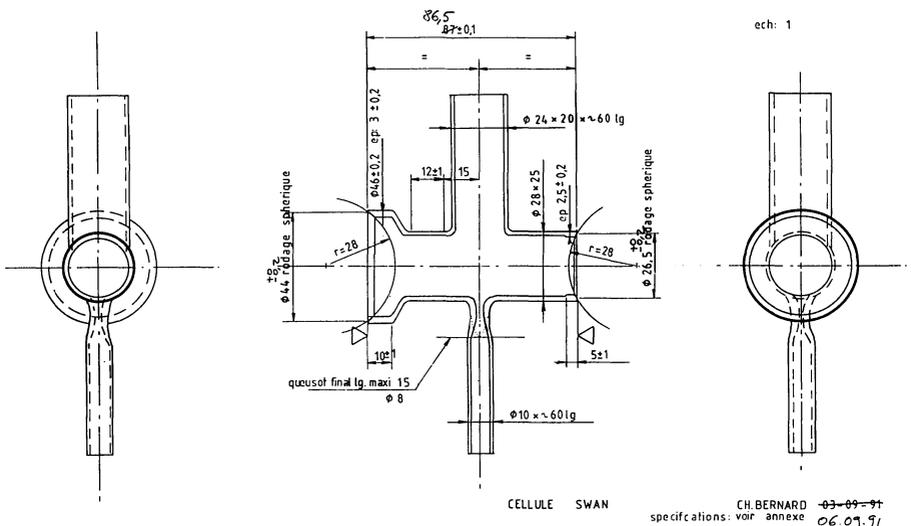


Figure 11.

The tungsten filament is a ribbon 0.02mm thick and 0.1 mm wide. It is electrically point-sealed to kovar with a nickel intermediary in a reducing atmosphere of 90% nitrogen and 10% hydrogen. The bottom of the filament is shown in figure 12. This is then sealed to the cell in reducing atmosphere. A small metal envelope covers the seal when it is reheated for one minute with a flame having a measured temperature of 600 degrees C and

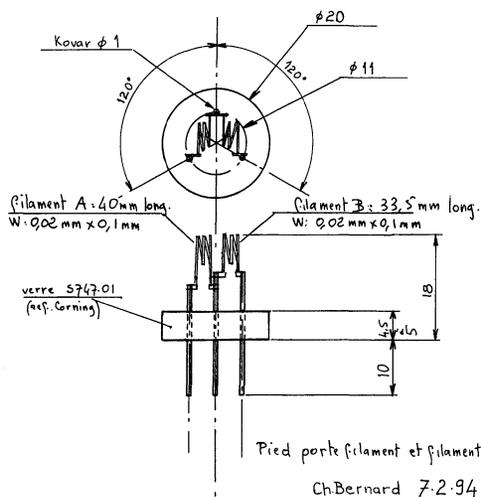


Figure 12.

allowed to cool naturally. The stress in the glass can be seen by viewing it through a polariscope. It is located outside the body of the cell and is not dangerous. The next step is to coat the magnesium fluoride windows with silver chloride and heat to 500 degrees C using high frequency electric current (figure 13). The two windows are coated one at a time. This is the work of Mme Bernard, who is here today. The cell is leak tested with helium and must meet a specification of 2×10^{-11} atm/cc/s.

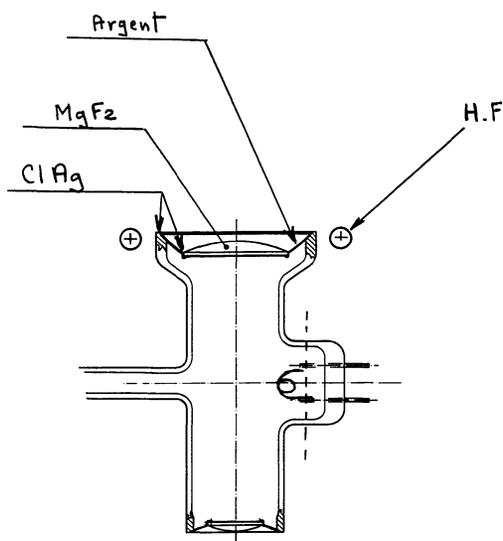
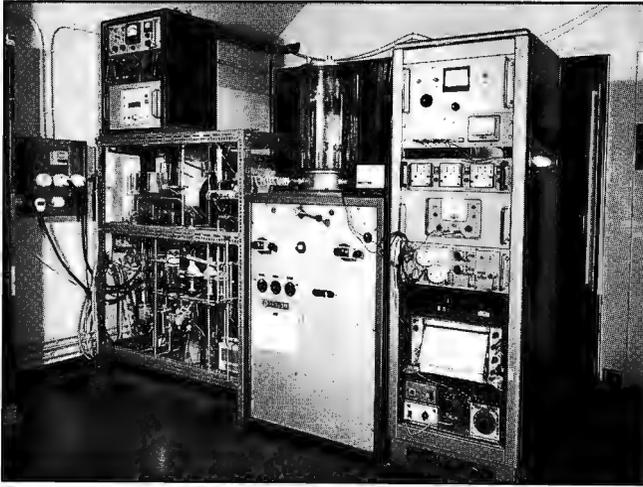


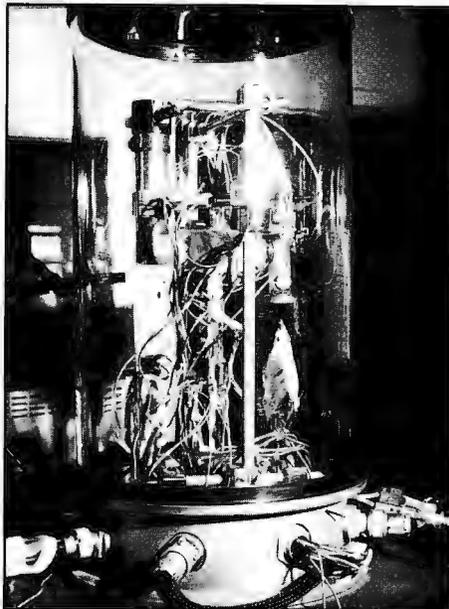
Figure 13.

The cell is in the center of a vacuum chamber connected by tubing crossing the wall to the glass pumping system (see pictures 14 and 15). The secondary pump is a three-stage oil diffusion pump in glass with 2 liquid nitrogen traps in series on the high vacuum side. Baking out is done with heating tape wrapped around the glass. The cell is heated under vacuum inside and out at 180 degrees C for 20 hours. Then the cell is cycled between vacuum and hydrogen to condition the filaments. The operation of the filaments is 45 seconds on, then 45 seconds off. Feeding current to the filaments is computer-controlled, and power, as well as intensity and temperature of the filaments, are recorded.

The cell is then sealed off.

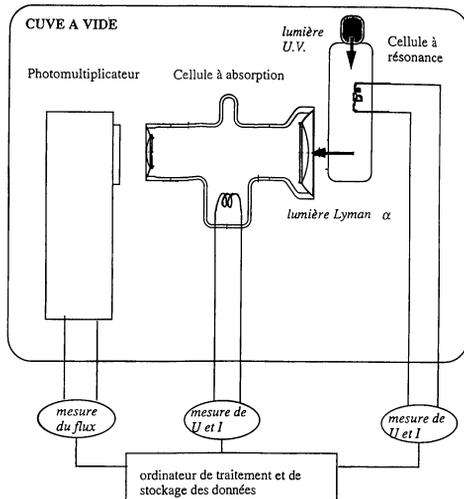


Picture 14.



Picture 15.

Figure 16 shows the cell in the vacuum chamber with the detector and the light source. The absorption measurements are made under about 10^{-7} mbar vacuum. The cell is lighted by UV light, the intensity is measured by the detector. All the data is sent to the computer and stored.



banc de test pour les cellules à hydrogène.

Figure 16.

Figure 17 shows a data sheet showing temperature, resistance, intensity, power, and reduction factor. The reduction factor is the relation between the measured light with the filament on and with the filament off. An example of curves of reduction factors as a function of temperature can be seen in figure 18, and in figure 19 is an example of curves of intensity as a function of power.

| SW16AB Epo-2 17:4427/04/96 | | | | | | | | | |
|----------------------------|--------|--------------------|----------|----------|-------------------------------|---------------------|------------|----------|--------|
| Cellule Absorption | | SWAN 15 (Oursoude) | | 18/01/95 | | Cellule à résonance | | CIS H 31 | |
| N°Ficheur C31-B15.0 | | sp Op 1 | R alcool | 0.8928 | Flamme B Section = 0.0270.1mm | | (-50.5mm) | | |
| Fabrication GOODFELLOW | | | | | | | | | |
| V (volts) | T (°C) | R (ohms) | I (amps) | Puiss W | FdR + | FdR - | Fact Réduc | | |
| 1 | 0.504 | 489.0 | 1.845 | 0.273 | 0.326 | | | | 1.0084 |
| 2 | 0.732 | 626.0 | 2.365 | 0.294 | 0.217 | | | | 1.0215 |
| 3 | 0.993 | 771.4 | 3.258 | 0.305 | 0.303 | | | | 1.0002 |
| 4 | 1.241 | 894.4 | 3.962 | 0.318 | 0.395 | | | | 0.8955 |
| 5 | 1.488 | 999.1 | 4.458 | 0.334 | 0.497 | | | | 0.7558 |
| 6 | 1.739 | 1091 | 4.958 | 0.351 | 0.610 | | | | 0.6868 |
| 7 | 1.990 | 1172 | 5.398 | 0.369 | 0.734 | | | | 0.7357 |
| 8 | 2.241 | 1243 | 5.792 | 0.387 | 0.867 | | | | 0.4914 |
| 9 | 2.486 | 1308 | 6.142 | 0.405 | 1.006 | | | | 0.2777 |
| 10 | 2.742 | 1368 | 6.476 | 0.423 | 1.161 | | | | 0.1481 |
| 11 | 2.987 | 1419 | 6.770 | 0.441 | 1.318 | | | | 0.0934 |
| 12 | 3.237 | 1467 | 7.048 | 0.459 | 1.487 | | | | 0.0592 |
| 13 | 3.488 | 1511 | 7.288 | 0.478 | 1.667 | | | | 0.0395 |
| 14 | 3.744 | 1553 | 7.534 | 0.497 | 1.861 | | | | 0.0254 |
| 15 | 3.989 | 1589 | 7.741 | 0.515 | 2.058 | | | | 0.0252 |
| 16 | 4.234 | 1622 | 7.901 | 0.534 | 2.260 | | | | 0.0252 |
| 17 | 4.489 | 1653 | 8.114 | 0.553 | 2.484 | | | | 0.0211 |
| 18 | 4.741 | 1682 | 8.281 | 0.573 | 2.714 | | | | 0.0216 |
| 19 | 4.986 | 1709 | 8.434 | 0.593 | 2.946 | | | | 0.0165 |
| Fabrication GOODFELLOW | | | | | | | | | |
| Cellule Absorption | | SWAN 15 (Oursoude) | | 18/01/95 | | Cellule à résonance | | CIS H 31 | |
| N°Ficheur C31-B15.0 | | sp Op 2 | R alcool | 1.2319 | Flamme A Section = 0.0270.1mm | | L40.2mm | | |
| Fabrication GOODFELLOW | | | | | | | | | |
| V (volts) | T (°C) | R (ohms) | I (amps) | Puiss W | FdR + | FdR - | Fact Réduc | | |
| 1 | 0.504 | 498.8 | 1.977 | 0.256 | 0.129 | | | | 1.0098 |
| 2 | 0.732 | 542.4 | 2.574 | 0.284 | 0.209 | | | | 1.0032 |
| 3 | 0.991 | 664.2 | 3.319 | 0.299 | 0.290 | | | | 1.0181 |
| 4 | 1.244 | 781.8 | 4.070 | 0.306 | 0.380 | | | | 1.0065 |
| 5 | 1.495 | 885.1 | 4.738 | 0.316 | 0.472 | | | | 1.0122 |
| 6 | 1.744 | 974.2 | 5.323 | 0.328 | 0.571 | | | | 0.9787 |
| 7 | 1.992 | 1050 | 5.845 | 0.341 | 0.676 | | | | 0.9506 |
| 8 | 2.240 | 1120 | 6.304 | 0.355 | 0.798 | | | | 0.8132 |
| 9 | 2.487 | 1185 | 6.728 | 0.370 | 0.929 | | | | 0.6199 |
| 10 | 2.740 | 1242 | 7.112 | 0.385 | 1.056 | | | | 0.3937 |
| 11 | 2.993 | 1295 | 7.473 | 0.401 | 1.199 | | | | 0.2142 |
| 12 | 3.240 | 1342 | 7.799 | 0.416 | 1.348 | | | | 0.1209 |
| 13 | 3.488 | 1387 | 8.102 | 0.431 | 1.502 | | | | 0.0781 |
| 14 | 3.744 | 1428 | 8.389 | 0.446 | 1.671 | | | | 0.0474 |
| 15 | 3.994 | 1468 | 8.655 | 0.461 | 1.843 | | | | 0.0291 |
| 16 | 4.241 | 1501 | 8.897 | 0.477 | 2.021 | | | | 0.0251 |
| 17 | 4.488 | 1533 | 9.124 | 0.492 | 2.208 | | | | 0.0287 |
| 18 | 4.741 | 1564 | 9.342 | 0.508 | 2.402 | | | | 0.0402 |
| 19 | 4.993 | 1593 | 9.545 | 0.523 | 2.612 | | | | 0.0280 |
| 20 | 5.241 | 1619 | 9.732 | 0.539 | 2.822 | | | | 0.016 |
| 21 | 5.488 | 1644 | 9.909 | 0.554 | 3.038 | | | | 0.014 |
| V (volts) | T (°C) | R (ohms) | I (amps) | Puiss W | FdR + | FdR - | Fact Réduc | | |

Figure 17.

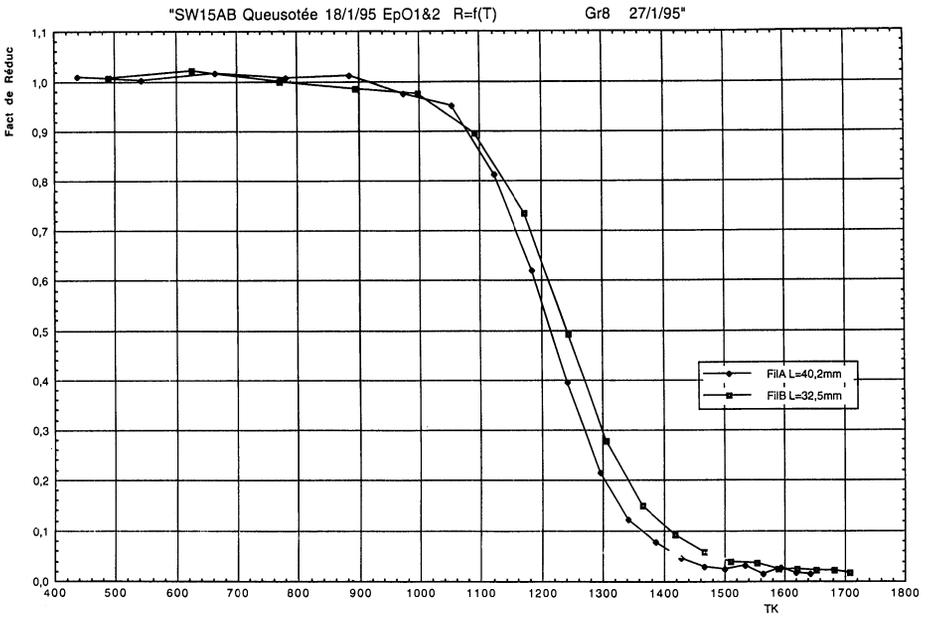


Figure 18.

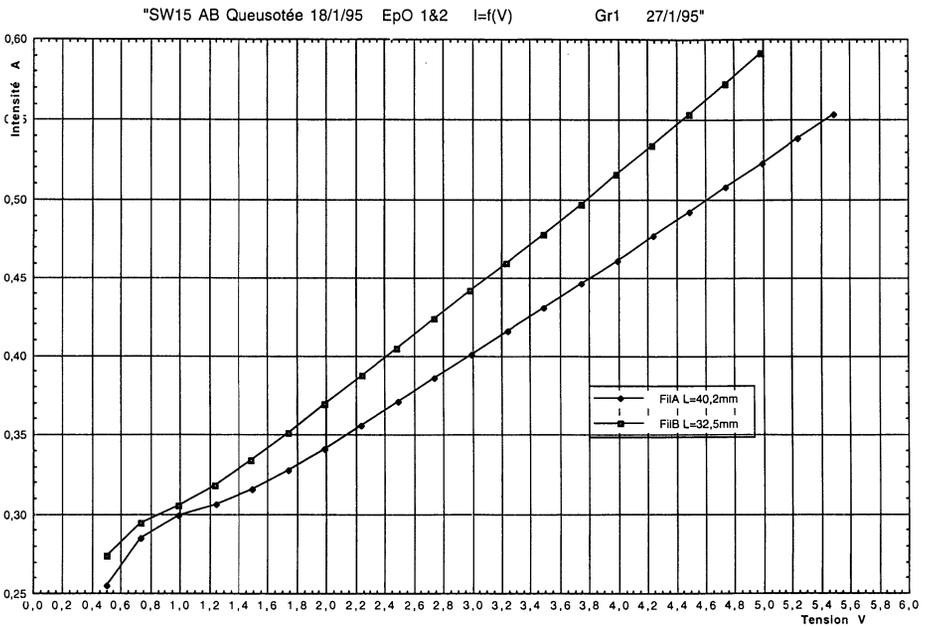


Figure 19.

An example of characteristics of a filament (5 sec on, then 5 sec off at 0.3 V increments) is shown in figure 20, while figure 21 shows an aging example, this one being 21 hours of use. The measurement and presentation of this data were done by Mme Bernard. These

CARACT. Cellule SWA15:
 R_froid= 1.204 Ohm
 à 293.8 °K
 T_on= 5 s, T_off= 5 s
 Mesure effectuée le 19 Jan 1995 à 10:55:02 par CHB
 CELL SUIS FILA QUEUSOTEE
 N° V (volts) T (°K) R (ohms) I (Amps)

| N° | V (volts) | T (°K) | R (ohms) | I (Amps) |
|----|-----------|--------|----------|----------|
| 1 | .3004 | 336.2 | 1.4206 | .21146 |
| 2 | .5983 | 419.2 | 1.8682 | .32163 |
| 3 | .9046 | 529.2 | 2.4769 | .36539 |
| 4 | 1.2201 | 725.2 | 3.6762 | .33189 |
| 5 | 1.5621 | 869 | 4.5954 | .32687 |
| 6 | 1.7979 | 993.3 | 5.4849 | .33264 |
| 7 | 2.0952 | 1090 | 6.8382 | .34699 |
| 8 | 2.3953 | 1168 | 6.5549 | .36542 |
| 9 | 2.6950 | 1240 | 7.0594 | .38236 |
| 10 | 2.9912 | 1366 | 7.4866 | .39954 |
| 11 | 3.2917 | 1367 | 7.9859 | .41636 |
| 12 | 3.5922 | 1422 | 8.2791 | .43389 |
| 13 | 3.8937 | 1472 | 8.6239 | .4515 |
| 14 | 4.1999 | 1518 | 8.9474 | .4694 |
| 15 | 4.5083 | 1560 | 9.2412 | .48698 |
| 16 | 4.791 | 1597 | 9.4999 | .50432 |
| 17 | 5.1031 | 1635 | 9.762 | .52275 |

SWA15-0351-CAR

CHARACTERISTIQUE Cellule SWB15, R_froid= .9983 Ohm à 294.5 °K, T_on= 5 s, T_off= 5 s
 Mesure effectuée le 19 Jan 1995 à 11:11:03 par CHB
 CELL SUIS FILB QUEUSOTEE
 SWB15-0345-CAR

| N° | V | T | R | I |
|-------|--------------|--------------|-----------------|----------------|
| N° 1 | U = .2992 V | T = 358.8 °K | R = 1.2644 Ohms | I = .23664 Amp |
| N° 2 | U = .5992 V | T = 479.2 °K | R = 1.7983 Ohms | I = .33321 Amp |
| N° 3 | U = .8995 V | T = 593.9 °K | R = 2.3713 Ohms | I = .37891 Amp |
| N° 4 | U = 1.2067 V | T = 758.9 °K | R = 3.191 Ohms | I = .37816 Amp |
| N° 5 | U = 1.4982 V | T = 935.9 °K | R = 4.1248 Ohms | I = .36322 Amp |
| N° 6 | U = 1.7951 V | T = 1077 °K | R = 4.8862 Ohms | I = .36738 Amp |
| N° 7 | U = 2.0925 V | T = 1187 °K | R = 5.482 Ohms | I = .38172 Amp |
| N° 8 | U = 2.3926 V | T = 1277 °K | R = 5.9822 Ohms | I = .39995 Amp |
| N° 9 | U = 2.691 V | T = 1352 °K | R = 6.3986 Ohms | I = .42056 Amp |
| N° 10 | U = 2.9995 V | T = 1419 °K | R = 6.7768 Ohms | I = .44261 Amp |
| N° 11 | U = 3.3018 V | T = 1479 °K | R = 7.1129 Ohms | I = .4642 Amp |
| N° 12 | U = 3.5999 V | T = 1530 °K | R = 7.4081 Ohms | I = .48594 Amp |
| N° 13 | U = 3.8977 V | T = 1578 °K | R = 7.6785 Ohms | I = .50761 Amp |
| N° 14 | U = 4.2008 V | T = 1622 °K | R = 7.9346 Ohms | I = .52943 Amp |
| N° 15 | U = 4.4983 V | T = 1661 °K | R = 8.1615 Ohms | I = .55116 Amp |

Figure 20.

measurements permit one to select the cells that have the best properties before putting them in service. Cells #10 and 15 are on board SOHO and functioning to the great satisfaction of the scientists.

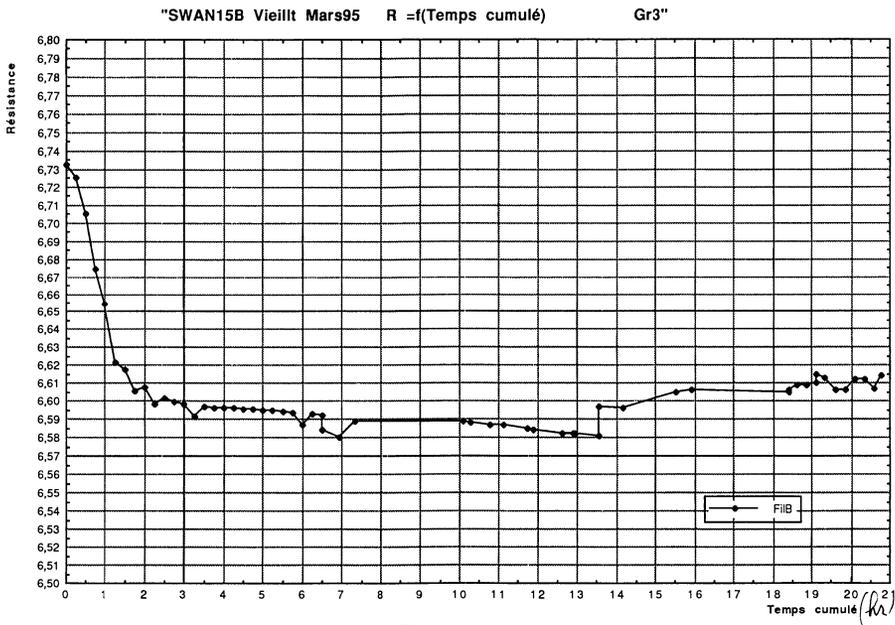


Figure 21.

Figure 22 and picture 23 shows how the cell is mounted on a support and held by two stainless steel bands with a 1mm thick viton spacer.

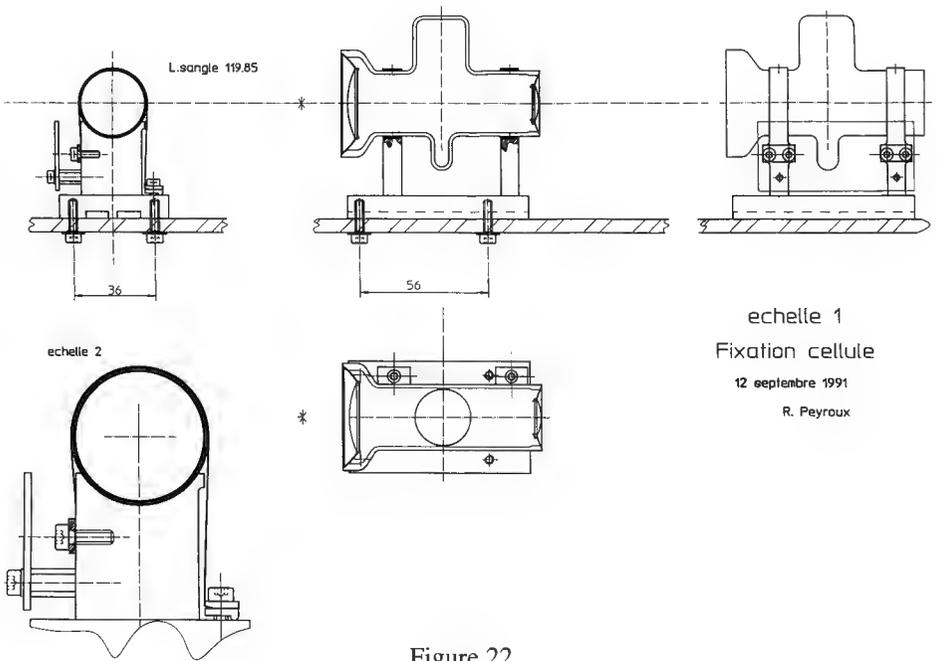
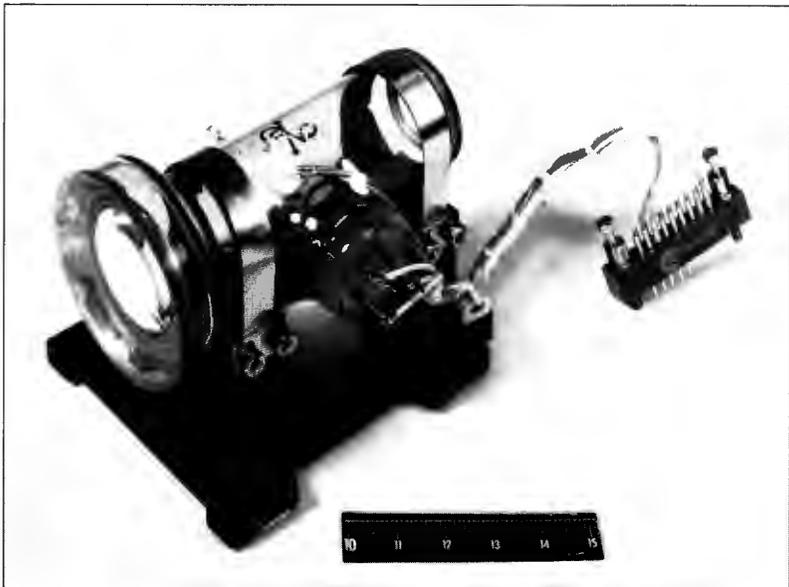
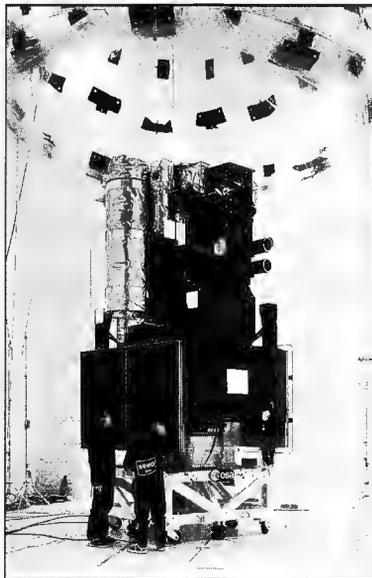


Figure 22.



Picture 23.

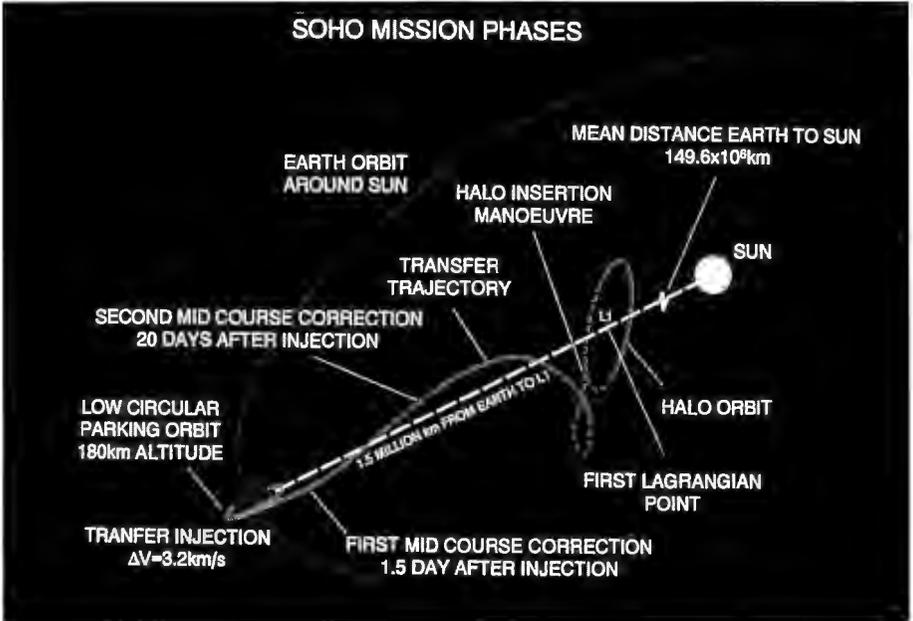
Picture 24 shows the SOHO ESA #7 and picture 25 shows its lift off of December 2, 1995 at Kennedy Space Center, Florida, with an Atlas IIAS rocket. The path of SOHO is shown in picture 26. The orbit is centered around a point in space, with the face always toward the sun.



Picture 24.



Picture 25.



Picture 26.

A map of the sky observed by Cells #10 and 15 can be seen in figure 27.

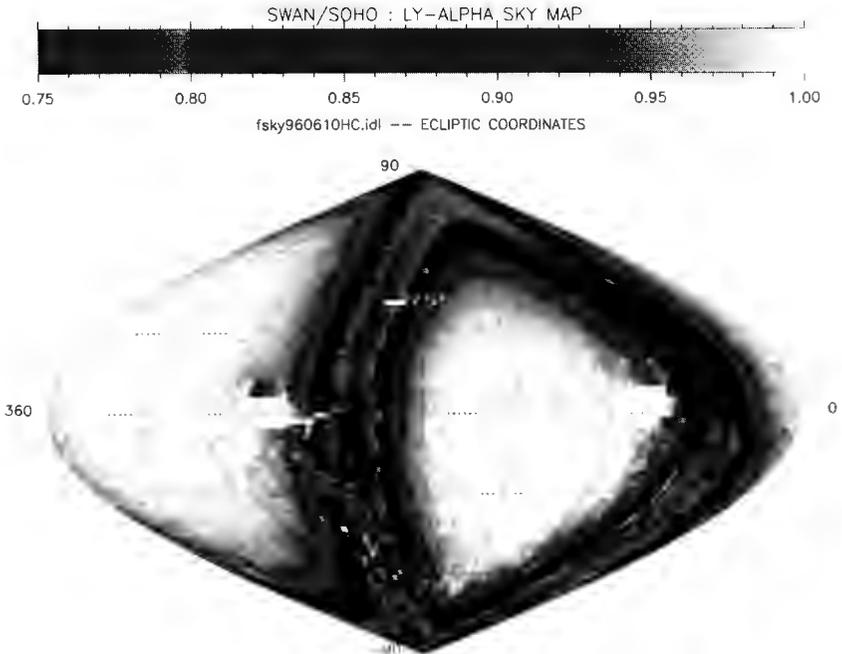


Figure 27.

From the Cathedral of Chartres to Silicon Valley

by

Mary Ann Caffery

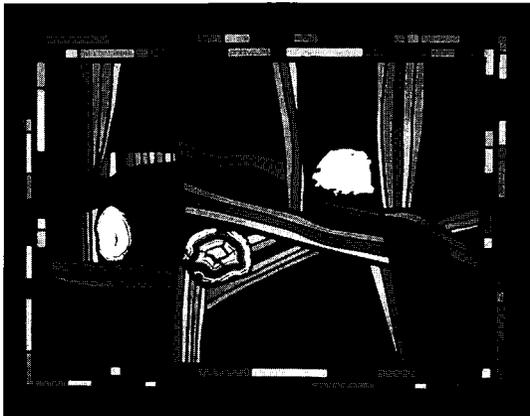
Glass Artist

Caffery Studio

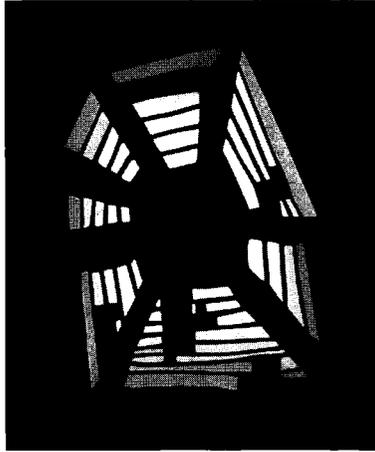
Baton Rouge, Louisiana 70806

When I received my B.S. in chemistry in 1972 I had no idea that I would eventually end up with a Master of Fine Arts degree in stained glass. As a chemistry major I was always fascinated with spatial relationships, orbitals and probabilities, entropy and thermodynamics. I loved physical chemistry laboratory because of the fabulous apparati we worked with when setting up experiments. P-chem lab was like conducting experiments in a sculpture museum. I have always loved stained glass, and it was this love of glass that led me into the field of art. My science background though has influenced the way that I approach doing art and in some cases even the subject matter. In science I sought knowledge—answers and solutions to physical questions and problems. In art I seek answers to philosophical questions involving truth, beauty, and life. Many of my questions have no concrete answers. Art involves communicating my ideas to people, but it also is a constant search inside myself for my soul.

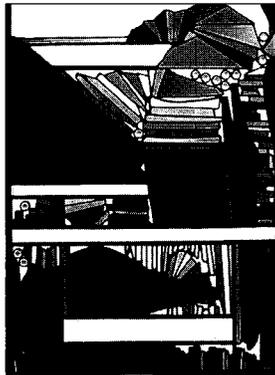
Some of my earliest stained glass work involved spatial relationships, such as Babylon, in which I used black glass with spectral intensity bands of colored glass and agate slices. (picture #1) In Beyond the Blue Horizon I took a piece of dark blue plexiglass and cut out openings into which I inserted gradations from yellow to red glass. (picture #2) In this piece the warm colors want to advance as the blue recedes, but the blue reads as being on the forward plane. In Gumball I used commercial clear ribbed glass to establish planes and stacked slivers of glass between the planes to create spatiality. (picture #3)



Picture 1. Babylon.

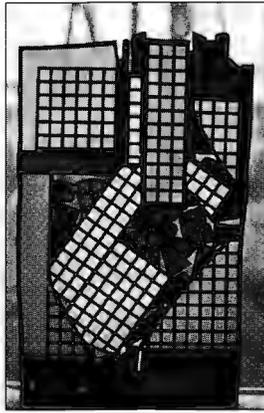


Picture 2. Beyond the Blue Horizon.

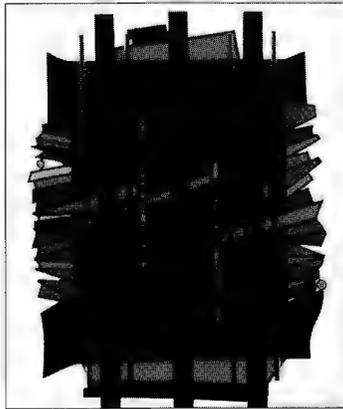


Picture 3. Gumball.

At some point I began to want to burst out of the straight edges of the window frame and began making irregularly shaped stained glass designs. Joachim's Trash is a window in which I used scraps of glass on which a grid had been silkscreened. I found the glass in a trash bin at a studio where I was studying in Germany and collaged it together by laying it out on a light table to do the design. (picture #4) I also began to introduce other objects into my work, such as in Walls, where I overlaid extruded aluminum bars onto the window, or in Temple, where I used agate slices. (pictures #5 & #6) I began to use mirror in windows to further explore the spatial illusions possible, such as in Reclining Nude. (picture #7) In my Jazz Train to Heaven series I used perforated aluminum overlaid and underlaid on lenses and rondels and achieved some interesting optical effects. (pictures #8, 9, 10) I found that some of the stained glass available is so heavily textured that looking at objects behind the window can produce some fascinating optical effects. (picture #11)



Picture 4. Joachim's Trash.



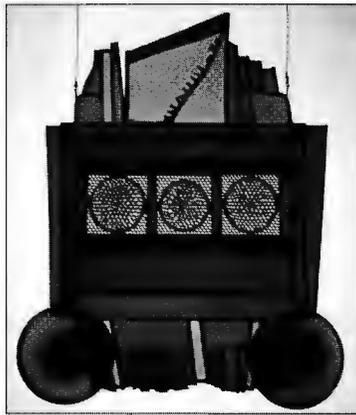
Picture 5. Walls.



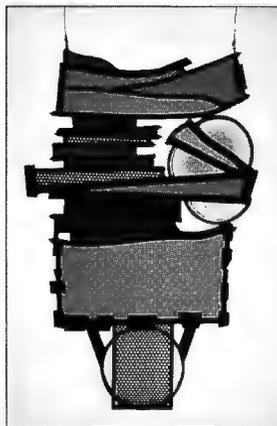
Picture 6. Temple.



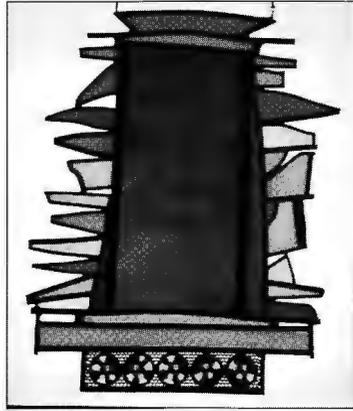
Picture 7. Reclining Nude.



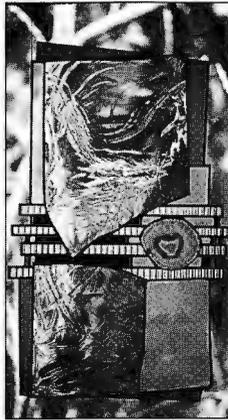
Picture 8. Jazz Train to Heaven.



Picture 9. Jazz Train to Heaven.

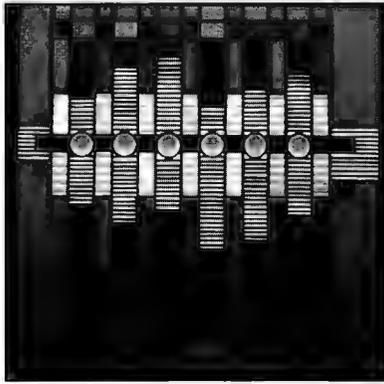


Picture 10. Jazz Train to Heaven.



Picture 11. Agate Diptych.

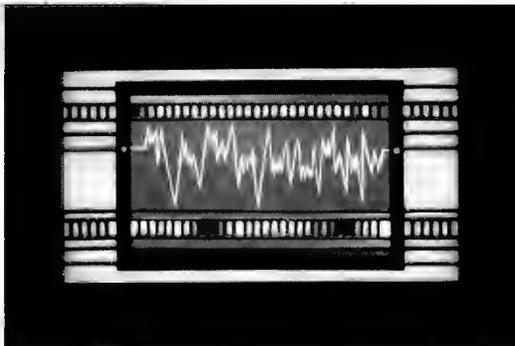
I also became extremely interested in electronics visually, such as printed circuit boards and circuit diagrams. I began translating my concepts of a circuit into stained glass, such as in Six Blue Muggels and Circuit, in which I leaned glass rods into the window. (pictures #12 & #13) I also took a number of electronics classes so that I could know how the insides of chips and components worked. At about the same time I was taking electronics classes I was walking through the library and saw a children's book lying on a table. It was titled Electricity for Boys, so I looked all through the library for a version of the book that was for girls. However none was found. I decided to make a piece of art called Electricity for Girls in honor of the non-existent book. (picture #14) This is the first piece of my art that involved light-emitting diodes. Electricity for Girls has two randomly blinking L.E.D.'s embedded in the lead of the stained glass window at each end of the electrical bolt. Also a first for me was that I designed a light box for this window to fit into so that it hung on the wall and had a self-contained light source. I did two more small lightbox pieces in this series before tackling Midnight on the Bayou, a rather large lightbox piece with over twenty-five red L.E.D.'s embedded in the lead channel within the stained glass. (picture #15) I had to attach all fifty wires to the back of the lead in the window so that they wouldn't show. I built circuits to control the blinking of the L.E.D.'s so that they had a slow, random blink pattern.



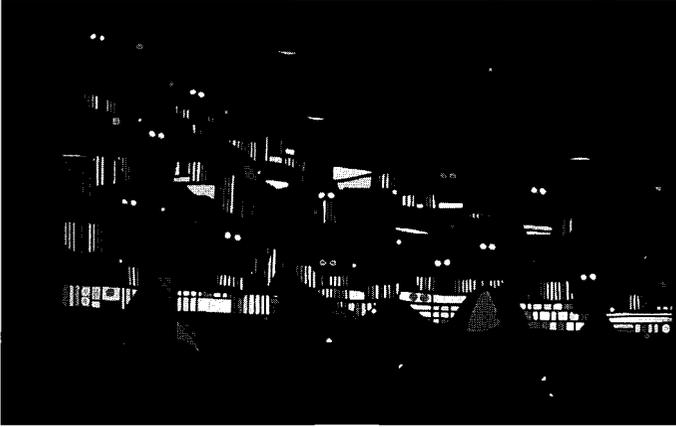
Picture 12. Six Blue Muggels.



Picture 13. Circuit.



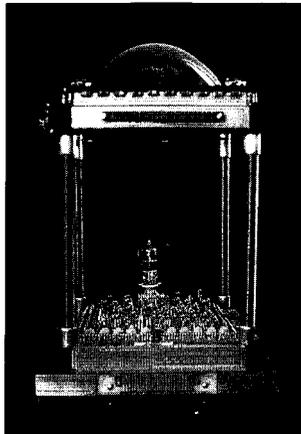
Picture 14. Electricity for Girls.



Picture 15. Midnight on the Bayou.

I was so involved with L.E.D.'s that I presented myself with the premise that if I were an L.E.D., what would I hold sacred in my life? What would my temple be like and who would be my saints? Sounds crazy but my mind starts to wander when I'm doing tedious soldering work. I wrote a series of seven short stories about different L.E.D. "tribes," and came to the conclusion that the vacuum tube would win hands down as the thing worshipped by an L.E.D. With that in mind I set about to build these L.E.D. temples, using glass, because silicon is a basic element in electronics, and all sorts of electronic components that looked interesting had some sort of meaning to an L.E.D. Resistors and capacitors were named as the saints and protectors of L.E.D.'s.

L.E.D. Temple was made from a vacuum-formed plexiglass bubble covering double ribbed clear glass which looked down on the floor of the temple. On the floor were over one hundred lighted red L.E.D.'s worshipping their vacuum tube on the altar. Copper-clad boards and wire-wrapped columns comprised the temple, which I based on the canopied structure that covered the burial place in St. Peter's Basilica in Rome. (pictures #16, #17, #18, #19) Sanctuary followed, using black on white flashed glass on which I etched electronic symbols. I used black glass rods for the roof and numeric displays



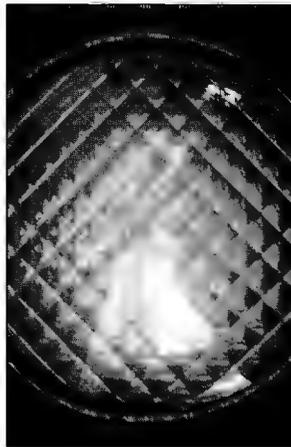
Picture 16. L.E.D. Temple.



Picture 17. Detail, L.E.D. Temple.

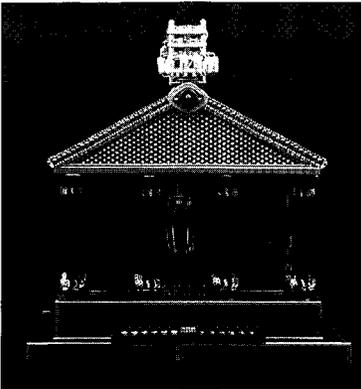


Picture 18. Detail, L.E.D. Temple.

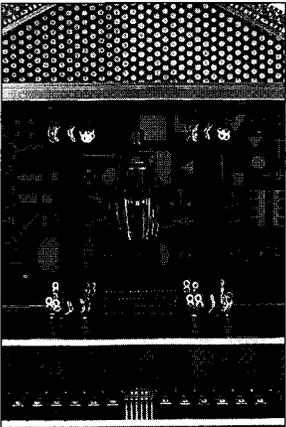


Picture 19. Detail, L.E.D. Temple.

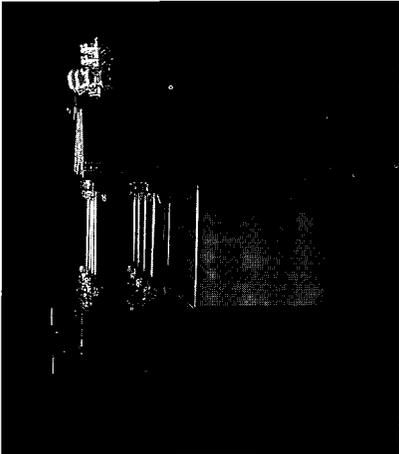
around the roof's edge. (pictures #20, #21, #22) I found a rather unusual blue vacuum tube and built the temple Blue Madonna around it. (pictures #23 and #24) The grid on



Picture 20. Sanctuary.



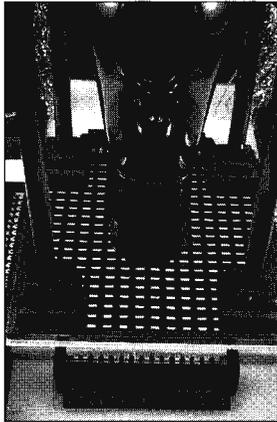
Picture 21. Detail, Sanctuary.



Picture 22. Detail, Sanctuary.

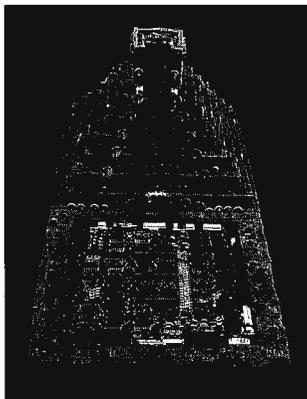


Picture 23. Blue Madonna.

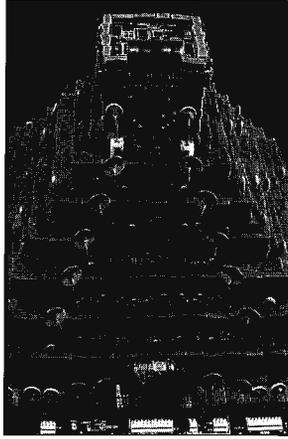


Picture 24. Detail, Blue Madonna.

the floor covered hot pink plexiglass, and a light source was located under the gridded glass. Sacrificial Rites is a temple based on step pyramids in the Yucatan, with printed circuit boards in the front court and resistors covering the steps up to the ceremonial room filled with L.E.D.'s and a vacuum tube. (pictures #25 and #26) Microlith is based on the



Picture 25. Sacrificial Rites.



Picture 26. Detail, Sacrificial Rites.

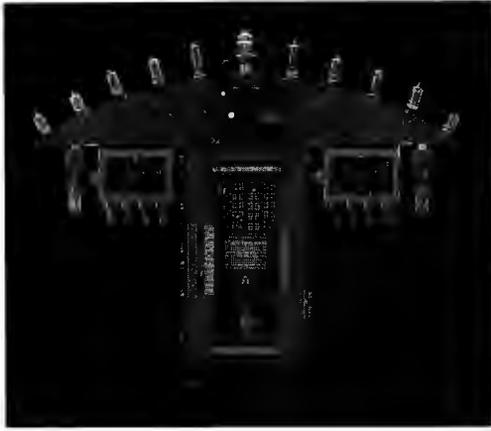
Stonehenge-type structures with a rather large vacuum tube in the center surrounded by a circle of glowing red L.E.D.'s (picture #27) This temple is built from a slab of deep blue glass from which I chiseled the vertical and horizontal pieces. I left the glass chips



Picture 27. Microlith.

lying on the floor of the temple, and the entire piece lies on a light source so that the glass glows blue. Electric Memorabilia for Humans hangs on a wall, and I used Italian glass mosaic tiles in the center with vacuum tubes across the top. The central piece can be removed and worn as a necklace. (picture #28) I was commissioned by someone who saw my temples to make a necklace that lighted. After much experimentation I came up with L.E.D. Necklace which is made of plastic laminate, electronic parts, and ten L.E.D.'s (pictures #29 and #30) I did not want the L.E.D.'s to blink so I had to incorporate a large battery pack at the back of the necklace, and I added an on/off switch so people wouldn't be disturbed in theatres when someone was wearing the necklace.

My most recent projects have been a series of stained glass windows based on electronics and Mayan symbolism found on temples in the Yucatan. Sacbe Circuit, Labna Online, and Uxmal Interface use white, red and blue glass predominantly, mixed with a



Picture 28. Electric Memorabilia for Humans.

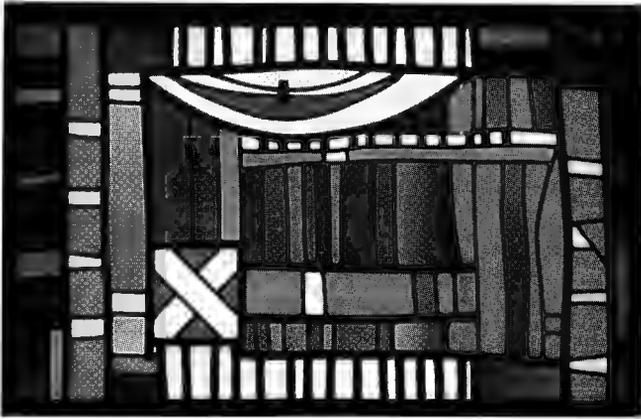


Picture 29. L.E.D. Necklace.

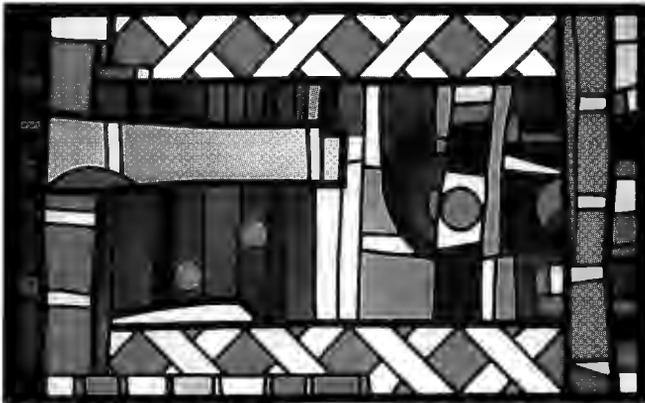


Picture 30. Detail, L.E.D. Necklace.

scattering of yellows and greens. (pictures #31, #32, #33) Windmills of My Mind is my latest sculpture using the remnants of an old weather balloon as the structure threaded



Picture 31. Sache Circuit.



Picture 32. Labna Online.



Picture 33. Uxmal Interface.

with glass rods and prisms. (picture #34) I used dichroic glass for color, and added a few objects to the inside of the piece.

My life as an artist has been filled with challenges and enjoyment, and I have been lucky to have studied with some of the greatest stained glass artists of our day. When I look at the work of scientific glassblowers I am in awe because much of what I see you doing could stand in museums side by side with some of the best sculpture of our day.



Picture 34. Windmills of My Mind.

Un des Meilleurs Ouvriers de France*

by

Yves Borrel, M.O.F.

Centre de Recherche, Ecole Polytechnique
Palaiseau, 91128 France

presented by Yves Borrel

translated by Christian Bousert

Louisiana State University

College of Basic Sciences

Baton Rouge, Louisiana 70803

Introduction The official title “Meilleur Ouvrier de France,” accorded by the French government, is recognized as representing great competence in one’s profession or craft. According to public opinion polls the prestige of this award surpasses all others including diplomas from great schools such as L’Ecole Polytechnique, founded in 1794, L’Ecole Nationale d’Administration, where France’s politicians are trained, and the French Conservatory of Music. Thirty-eight per cent of the public rank it high as compared with nineteen percent who recognize the Polytechnique’s diploma as an honor of distinction.

This title is much envied, and one of the most difficult to obtain. It requires a perfect mastery of one’s craft, extensive knowledge of technique, perseverance of hundreds of hours even 1000-1500 are sometimes necessary to achieve success with the final verdict by one’s peers.

History Lucien Klotz (1876-1946), a remarkable man, journalist, and art critic is where the history of the M.O.F. begins. M.O.F. stands for “Meilleurs Ouvriers de France” or “Best Craftsmen of France.” It is Klotz who promoted the idea of the M.O.F.

Recognizing the need to award achievement in the Field of Craftsmanship, Lucien Klotz in 1913 came up with the idea for a great “National Labor Exhibition” where workers wishing to be recognized for their various fields could be judged by a jury of their fellow craftsmen and by the public at large. He ran press campaigns, published articles, and solicited the help of celebrities, philanthropic sponsors and famous craftsmen of his time.

Workers, craftsmen, and artisans were invited to compete at the exhibition organized by their various guilds. In Paris in 1924 the first 144 M.O.F. titles were awarded. Mr. Albert Lebrun, who would later become president of France, stated at the time, “One should find it natural that each year, painters, sculptors, engravers, architects, musicians, all assemble at competitions and exhibitions to legitimize their talent and gain notoriety. Why then should we also not find it natural to bring together the main branches of national production to shed light on and reward the highest professional qualities, manual aptitude, technical expertise, creative imagination and thus as stated in Article One of the rules of the Exhibition develop among workers, craftsmen, and artisans and

*One of the Best Craftsmen of France.

apprentices a certain emulation of the trade, a spirit of progress, an attachment to the field which can only lead to the improvement of industry itself.”

Currently a permanent national committee established in Paris manages the organization of the competitions held every three years. After preparing the tests, it is up to each of the 200 specialty fields to establish the themes for each test, compose the juries, record the results and publish them upon approval by the National Ministry of Education. But how does one become a “Best Craftsman of France?” The National Labor Competition permits candidates to create a masterpiece on a specific theme to prove their talent. Therein they must show their dexterity, highly developed technical expertise, their know-how, creativity, good taste, as well as use of modern techniques alongside traditional methods. Afterwards they are judged by their peers in a two-tiered procedure. First there is the regional competition where the best creations are selected. Those chosen go on to the National Exhibition where the best of the nation receive prizes.

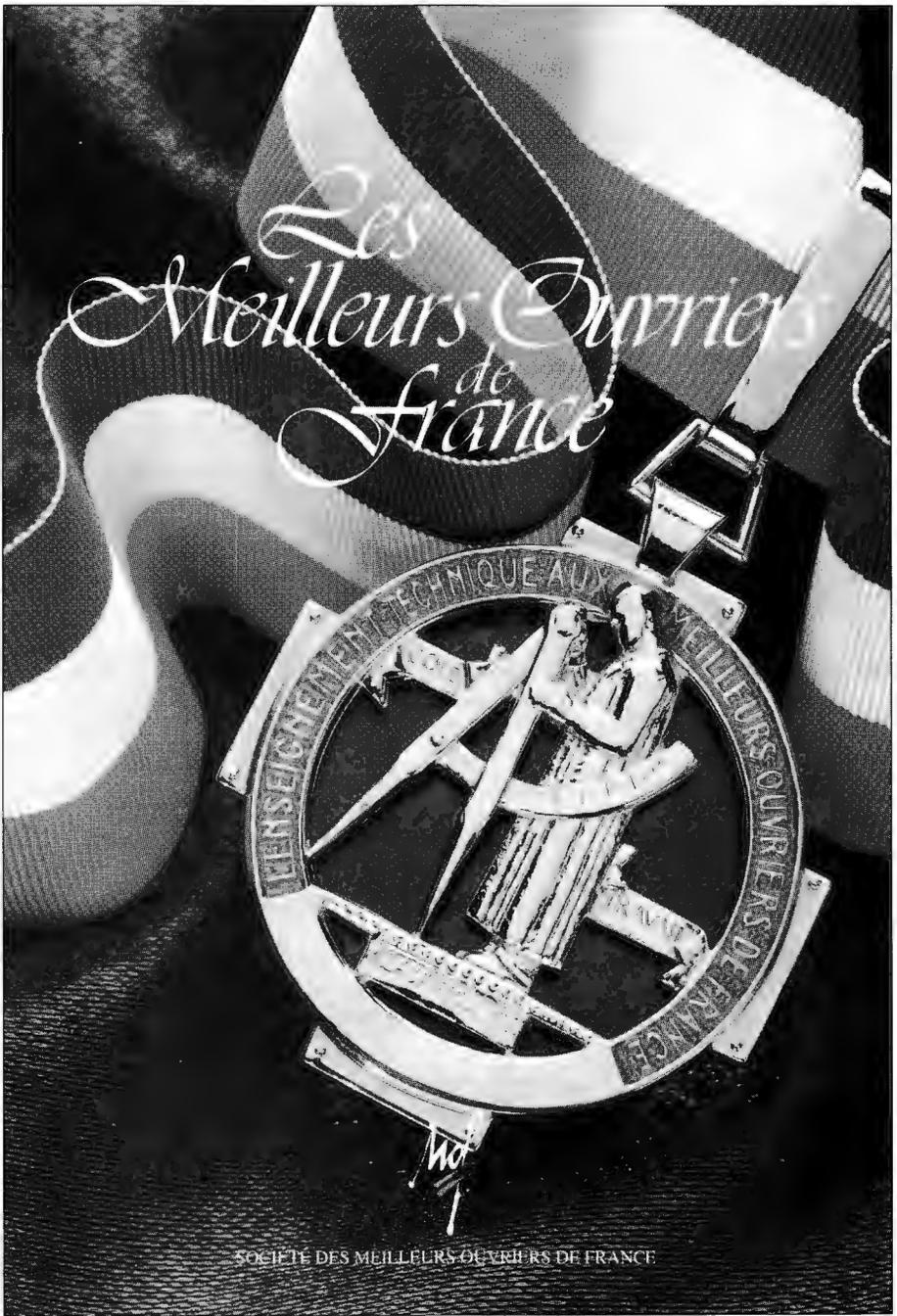
There can be several winners in a single category, just as there might be none at all in some years. The title of M.O.F. is awarded according to grades given for detail, sturdiness of composition, and creativity as evident in the techniques employed. An illustrated technical portfolio is also required and is of use for future instruction in that field. The winners receive the title “One of the Best Craftsmen in France.” The President of France hands out the certificates at a dignified ceremony at the Sorbonne, later that day. They are received at the Elysée Palace, the official residence of the French president.

They also receive the official insignia of the “Best Craftsmen of France” which consists of a bronze and enamel medallion engraved in 1932 by Lagriffoul. Its bearer must then continue his trade still perfecting it, thus proving his worthiness for the title by avoiding routine techniques and incorporating new ones. Sometimes he becomes an instructor, transferring his skill to those who one day will follow in his footsteps.

Each candidate can only compete in one category in a given year. They must be at least 25 years old, and a French citizen. Foreigners may register on the condition that they have worked in France for at least five years. Entry as a team is not only permitted but encouraged on the condition that each member can be judged individually.

The 200 fields are classed in 16 groups:

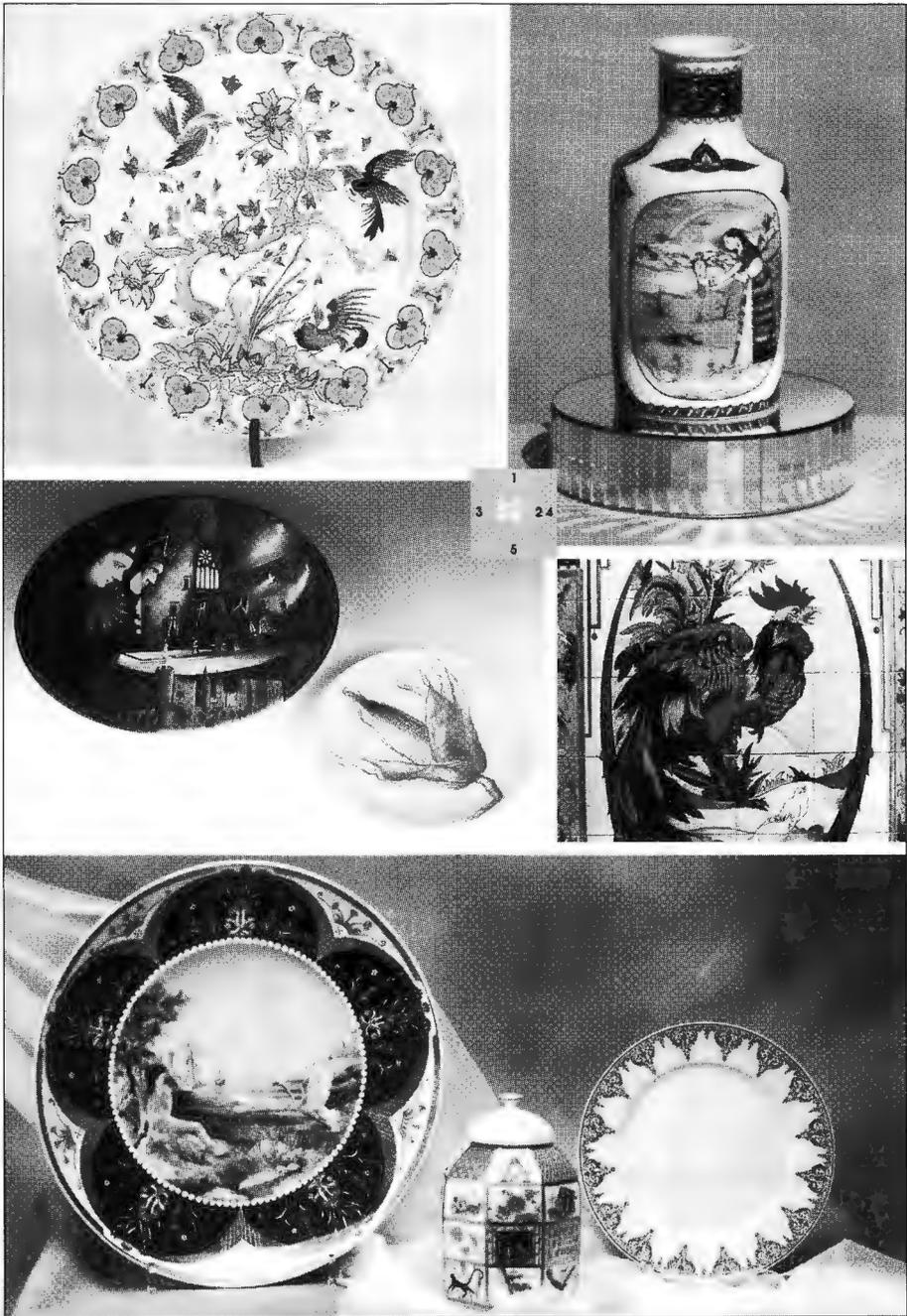
- Food
- Building Construction
- Garment industry
- Hairstyling & Cosmetology
- Textile industry
- Furniture (Photograph #1)
- Metallic structure
- Miscellaneous Industries
- Precision work
- Leather goods
- Graphic Arts



Print - M.O.F. Medallion.

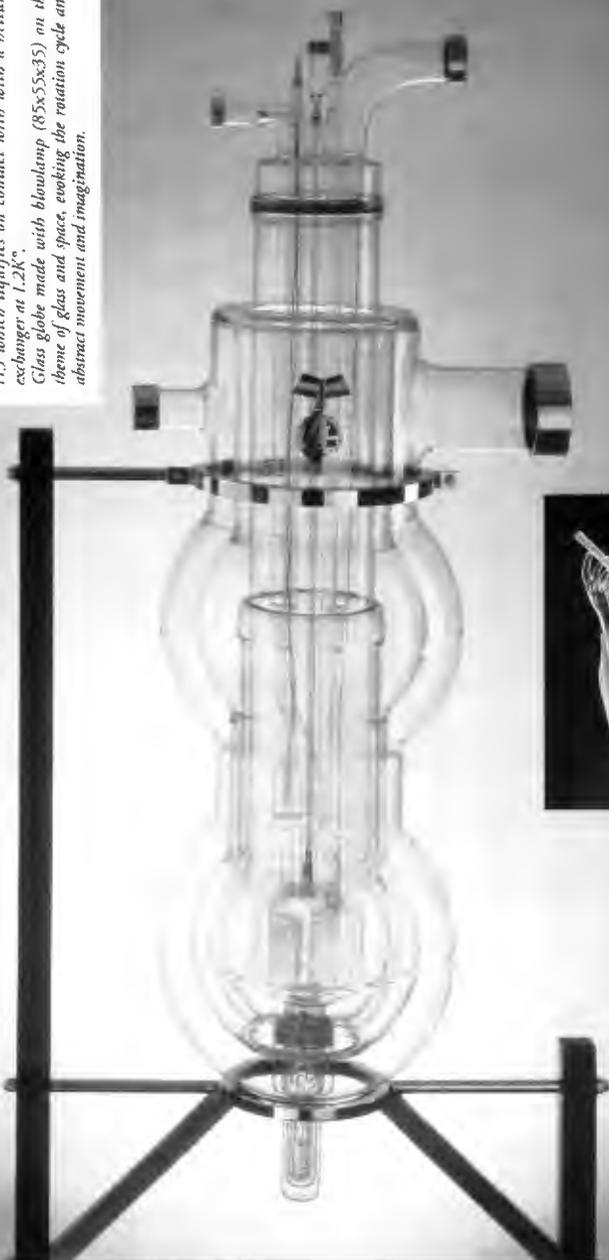


Photograph 1. Examples of Cabinetmaking & Marquetry.



Photograph 2. Examples of Art Enameling & Porcelain Decoration.

1 - Cryostat for magnetic measurements at low temperatures (-269/-271) contains helium and liquid nitrogen separated by vacuums, which the insulation of H3 which liquifies on contact with with a helium exchanger at 1.2K°.
Glass globe made with blowlamp (85x55x35) on the theme of glass and space, evoking the rotation cycle and abstract movement and imagination.



Photograph 3. Example of Scientific Glassware; a Cryostat.

- Artistic work in metal
- Floral Arts

Group XIII concerns the fields of glass and ceramics including:

- Porcelain (Photograph #2)
- Stained glass art
- Enamel work
- Santons (Christmas figurines)
- Hot blown glass (cane-blown)
- Cold shaped glass
- Engraving

As well as our glass specialties (see photograph #3) including:

- Scientific glassware in borosilicate from a required plan or diagram and, a separate category, scientific glassware of pure silica
- Glassware called “industrial” created from a required plan or diagram.
- Artistic glassware in solid or hollow glass on a specified theme.
- “Neon sign” on a specified theme.

The international spread of the M.O.F. has gone far beyond France’s borders. In Saudi Arabia for example the “black stone of Islam” in Mecca, the famous “Quaaba,” is protected by a cut crystal dome 1.4 meter high and 1 meter in diameter requiring 2 tons of glass, the work of one single M.O.F. artisan who took up the challenge which others had given up on. Another M.O.F. winner is responsible for decorating the leather for offices and private helicopters of the rich Emirates.

The sumptuous Basilica of Yamoussoukro in the Ivory Coast benefited from a competition between M.O.F. winners to design the stained glass windows and ornate engravings on precious metals, such as for sacred objects. An M.O.F. team even supplied that town’s National Institute for Sciences and Technology with their scientific materials.

In Japan where flower arranging is a high art, an M.O.F. florist/decorator was recognized and accorded three hours of television coverage. Now he gives lessons to the Japanese in flower arranging! Another M.O.F. winner in mosaics was chosen to decorate the giant swimming pools in Australia, and is known as the best tile-maker of that continent.

In culinary matters, the international cuisine and pastry competitions were conceived and organized by M.O.F. master chefs. M.O.F. winners also intervene to safeguard world architectural treasures. M.O.F. professionals restored the clock on the Cathedral of Beauvais as well as the Statue of Liberty in New York. Embroidered and velvet tapestries of France’s great castles are preserved by M.O.F. teams and the carpets of the Elysée Palace are maintained by an M.O.F. woman. An expert M.O.F. bookbinder heads the restoration lab of the French National Library.

The Lumière Brothers monument was made by an M.O.F. winner to honor their achievement in creating cinema. Another designed the model of the Barcelona Opera, the Bastille Opera, and the Ariane Rocket. For the Albertville Winter Olympic games, M.O.F. hairdressers arranged the hair of five hundred participants in the opening and closing ceremonies, three thousand journalists were fed around the clock by M.O.F.

teams, a 15-ton ice sculpture of the flame and rings was made by a M.O.F. pastry chef, and the five hundred bouquets given to the champions were arranged by a M.O.F. florist.

For the record books, the largest glass in the world with a volume of 220 liters was blown by M.O.F. master glassmakers. This same team was asked to commemorate the 100th anniversary of the discovery of radio by Branly by creating the symbol of the Paris-Moscow radio link in glass, a sculpture which was presented to Gorbachev on November 16, 1990. For work on the other extreme of the size scale, another M.O.F. winner undertook to reconstitute the skeleton of a tiny bird only 25mm in length with over 100 bones. These are but a few examples of the originality and prestige of M.O.F. know-how.

Yet if after seventy years such a unique competition is still supported by the French government, it owes this to the dynamism of the M.O.F. Society of winners who dedicate themselves to its continued support.

Since 1929, this rich society of 2500 members has applied the message of their first president, Georges Castellain, who stated, "We must make of our association one big family and consider ourselves brothers, born of the same father, Work, and the same mother, "France." We must help each other, protect each other, support each other in all life's circumstances."

Also, the M.O.F. will be happy to maintain a relationship with your great association, the American Scientific Glassblowers Society, and keep with you the ties of friendship that are likely to develop reciprocally. I therefore thank, on behalf of this associate and the "Best Craftsmen of France," our friend Christian Bousset for soliciting such an exchange with you in the course of this Symposium.

Great success to you all and a pledge of friendship from the "Meilleurs Ouvriers de France," the "Best Craftsmen of France."

Construction of the 1991 MOF Competition Design for Scientific Glassblowers.

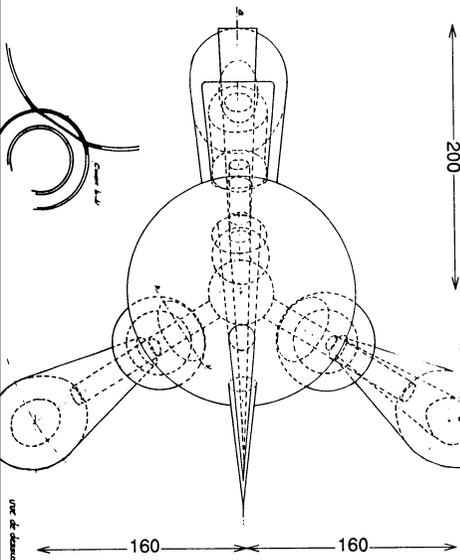
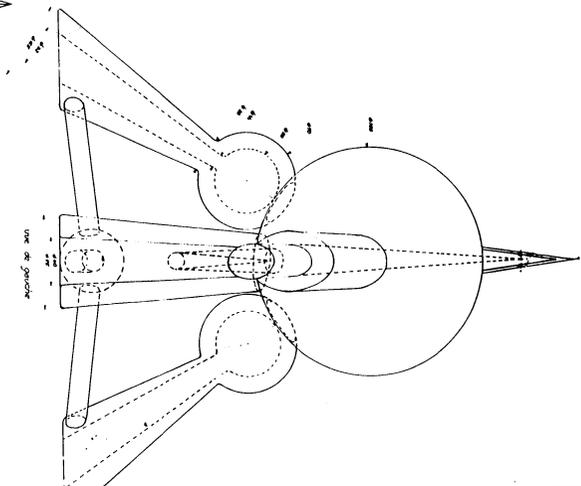
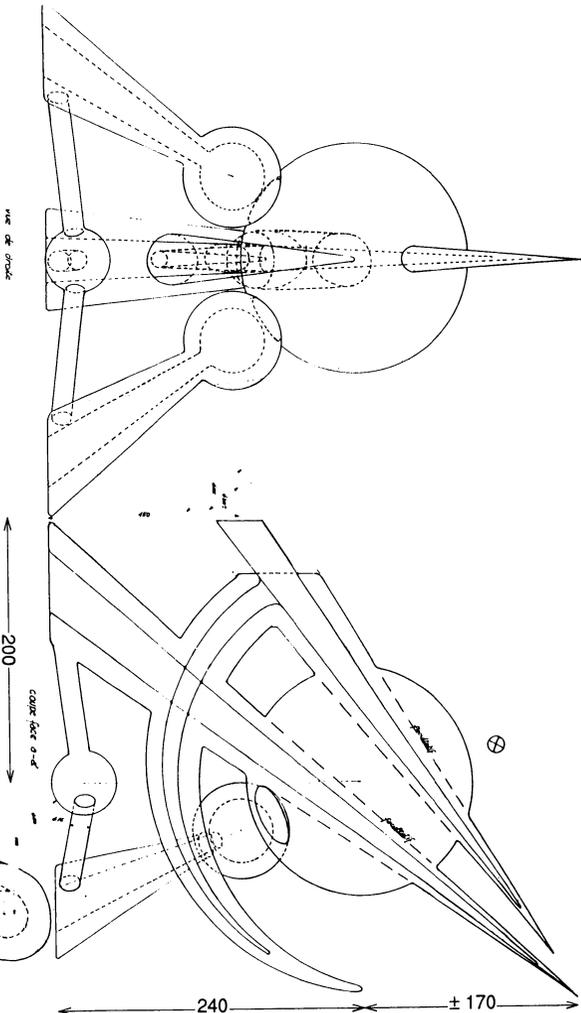
This work while using traditional techniques of glassblowing is also a glass structure where aesthetics come into play. This then must be taken into account in order to obtain a homogeneous totality on an "artistic" level as well as on a professional one.

The main technical difficulties involve attaching the feet to the large center bulb and the inner cones, all the while respecting the dimensions and the spatial arrangement.

Aesthetic difficulties include the clarity of the glass, the rigorous and strict alignment of the points, and the overall symmetry of the work.

We also notice that two forms interpenetrate each other, the curve and the cone; I therefore worked them differently to accentuate this contrast. The curves are blown, and are thus clear, in order to reinforce the gentle flow of this line. In stark opposition, the cones are shaped at the lathe to obtain more uniformity in the lines and more aggressiveness in the points.

The realization of two of these structures as well as all the preparations took me about four hundred hours of work. The original piece is now displayed at the Musée National



Le motif se rapporte au fait des monuments aux Français morts pendant la guerre et se rapporte à l'œuvre de sculpture de la même époque. Les dimensions des proportions les plus essentielles.

Le motif proposé peut être considéré comme symbolique. Le motif se rapporte à la sculpture et au monument aux Français morts pendant la guerre et se rapporte à l'œuvre de sculpture de la même époque. Les dimensions des proportions les plus essentielles.

" Les Peintres Ouvriers de France " 18^{ème} CONCOURS 1988 — 1989

des Meilleurs Ouvriers de France in Bourges, and the other can be seen at the Symposium in New Orleans (see drawing of the Masterpiece).

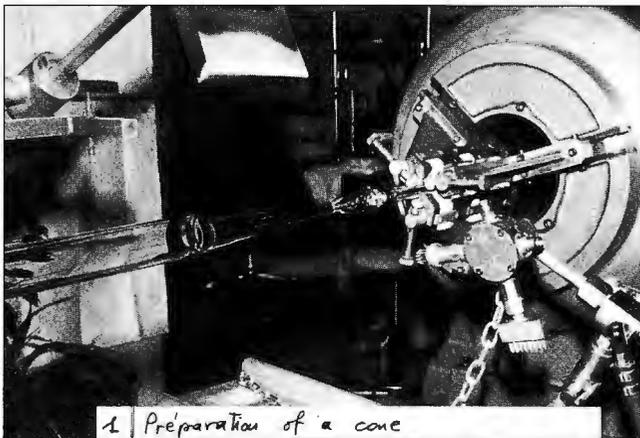
This structure was created in the following three stages:

1. The first step entails:
 - a. Making the two ball-feet
 - b. Shaping the rear foot and blowing the 180mm center bulb
 - c. The connection of the three feet on the center bulb
2. The second stage entails:
 - a. Fabricating the various “preparations” (curves & cones)
 - b. Assembling these items (“preparations”) into the structure
3. The third stage entails:
 - a. Creating the cross and affixing it to the center of the base of the three feet

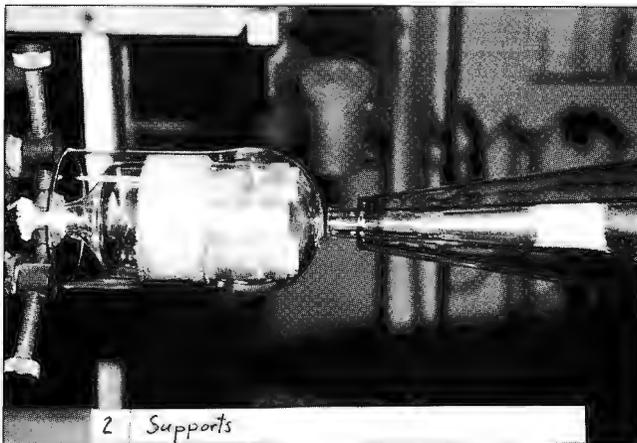
First Stage

I/a) Fabricating the ball-feet

- 1) The cones made up of these feet are shaped at the lathe using the articulated arm of the mobile carriage (Pictures 1-4)
- 2) The Picture 2 shows the system used for the creation of the central section on the foot's interior. The two cones making up the ball-foot are maintained one in the other by a tool squeezed in the right chuck.
- 3) The two balls making up this same foot are supported in the same way as the cones by a tool squeezed in the left chuck. The inner ball or bulb is positioned at the orifice designed for it through the outer bulb (Picture 3) and fused to the inner cone. This ensemble (bulb and cone) on the interior is pushed back to the interior of the outer bulb thus permitting the latter to be fused to the outer cone.
- 4) The holding tools are then replaced by a brace off-center, holding the two centered pieces one in the other. The inner and outer cones of the two feet are thus fused at their base, the eccentric one determining the precise angle of the base of the feet (Picture 4). The final length of the ball-foot is obtained by stations along the brace



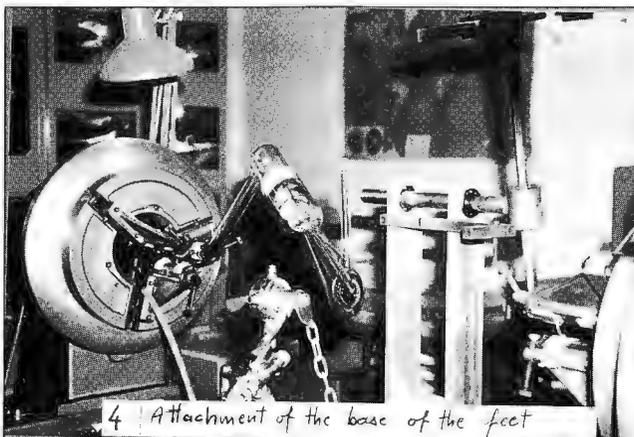
Picture 1.



Picture 2.



Picture 3.



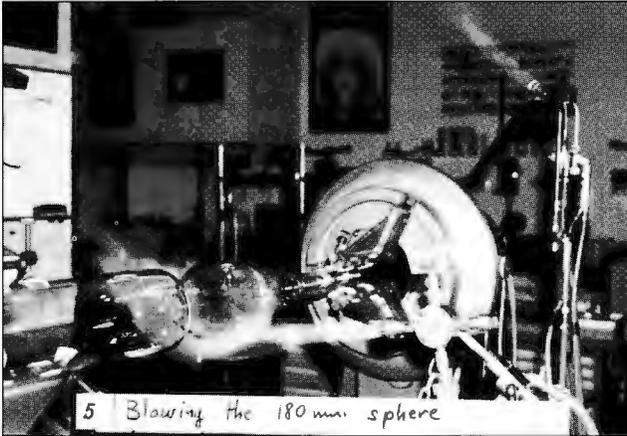
Picture 4.

and by lowering the graphite of the articulated arm of the lathe. The outer bulb remains to be closed up.

I/b) Shaping the rear foot and blowing the 180mm bulb.

The rear foot is shaped at the lathe. A brace will permit me to form the base of the foot as was done previously for the ball-feet.

- 1) The bulb of 180mm is blown from a tube of 130mm (Picture 5). On this bulb of 180mm, once completed, remains a tube of 20mm. This tube will permit me during



Picture 5.

the different following stages to hold in place by means of mechanical pliers the bulb of 180. This tube will disappear later when fusing the upper rear cone.

I/c) Connecting the three feet on the center bulb.

This action requires the utmost attention, for it will determine the symmetry of all of the actions to follow. This symmetry is obtained by a strict positioning at 120 degrees of the feet to be fused, but also by the base's orientation to them as well. Connecting the first foot determines the final base of the structure. The base of this foot defines, by its orientation, where the other feet are to be connected.

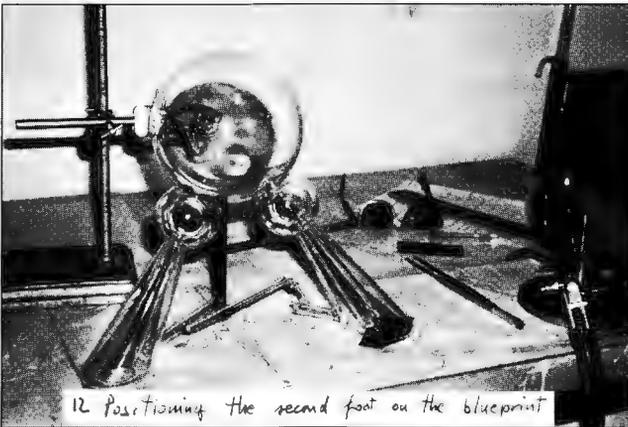
- 1) There is a blueprint on which the piece should rest if it is correctly constructed. The next operation consists of positioning one of the "ball-feet" and the sphere of 180mm (held from the rear) on this diagram.
- 2) The bulb of 75mm of the foot to be connected is separated from its upper part following the section b,b' of the design. This part (cup) will later be reconstituted during the process of sealing the foot by sucking on the bulb of 180mm. The exact position of the sphere of 180mm is defined by a stem of determined length placed under it and its projection on the diagram using a T-square (Picture 6).
- 3) These two elements, sphere & ball-foot, thus perfectly positioned, are made into a rigid structure using a bridging rod.



Picture 6.

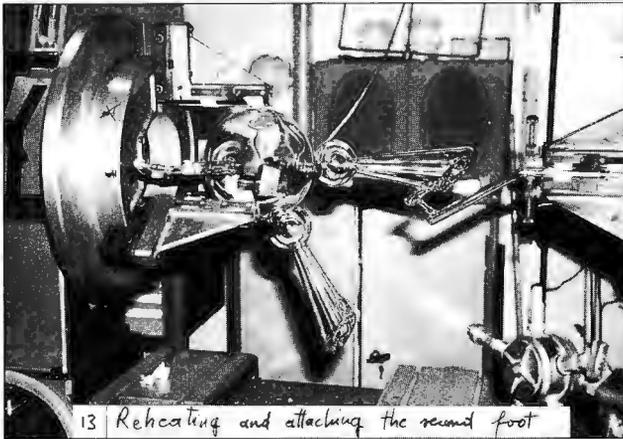


Picture 7.



Picture 8.

- 4) This ensemble is installed on the lathe (Picture 7). The foot is connected to the right chuck by attaching a bridge off-center. Then one can do away with the bridging rod and be certain of the right position of the two elements to be fused.



Picture 9.



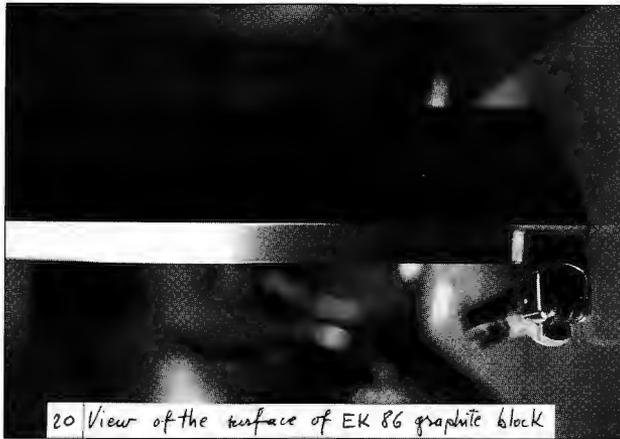
Picture 10.

- 5) Connecting the ball-feet onto the sphere of 180 is achieved by sticking without pulling (like a cold seal) in order to conserve the maximum angle of fusion between the two spheres of the section b,b'. (Pictures 8-10)

Second Stage

II/a) Fabricating the various "preparations" (cones & curves) to be attached inside and out of the first ensemble.

- 1) Making the inner cones is delicate because of their great length and necessitates for their shaping a graphite of excellent quality. I have therefore sought out information about suppliers of non-porous graphite and hold two brands in esteem.
- 2) The quality ELLOR 12-10 and 9 from Carbone-Lorraine in Gennevilliers and the quality EK86 and EK88 of LGD in Vitry-sur-Seine. These two varieties of graphite, a bit different in their gravulometry (Pictures 11-12), stand up to the flame and are easily polished.



Picture 11.



Picture 12.

- 3) The cones are made at the lathe after pulling a cone of diameter slightly smaller to that of the cone to be formed. A graphite is maintained above this cone at the desired angle and diameter with the help of the articulated arm of the lathe. Rotating on the lathe, the cone is then heated punctually from right to left and shaped little by little on the upper graphite by blowing.
- 4) The crescent cones are then fabricated at the bench. They are pulled and formed in a single operation. A photocopy of the blueprint displayed vertically must be used here as a model (Pictures 13 and 14).

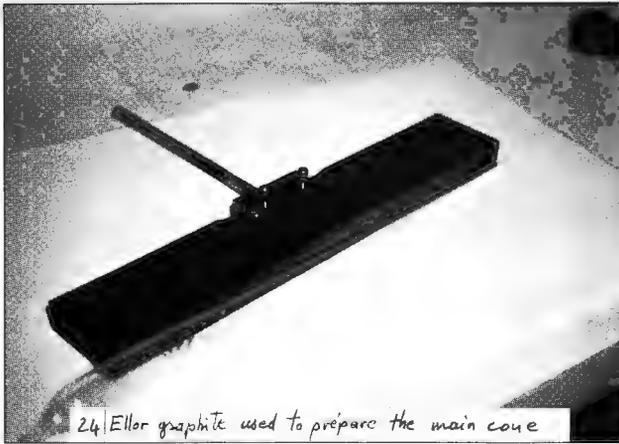
II/b Assembling the “preparations” onto and in the first ensemble.

The following photos (Pictures 15 to 30) show the chronological order of the work. They are all achieved with various hand torches (Picture 15). The structure is supported by a 3-finger chuck situated outside the lathe (Picture 18) in order to work facing the piece and to ensure maximum freedom around it.

Third Stage

III/a Fabricating the cross and sealing it to the center of the base of the three feet.

With the cross once in place at the base of the feet, the work is complete. It will go once



Picture 13.



Picture 14.

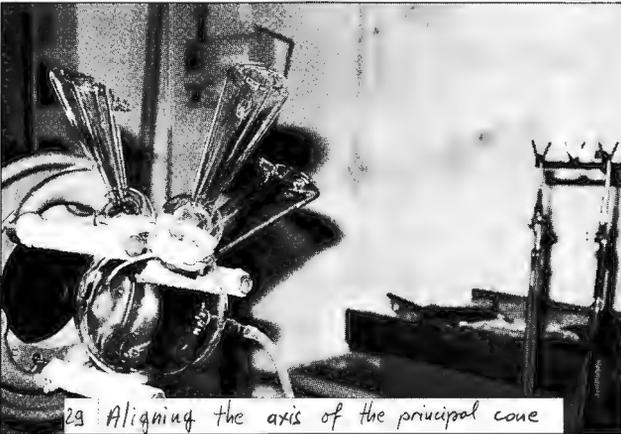


Picture 15.



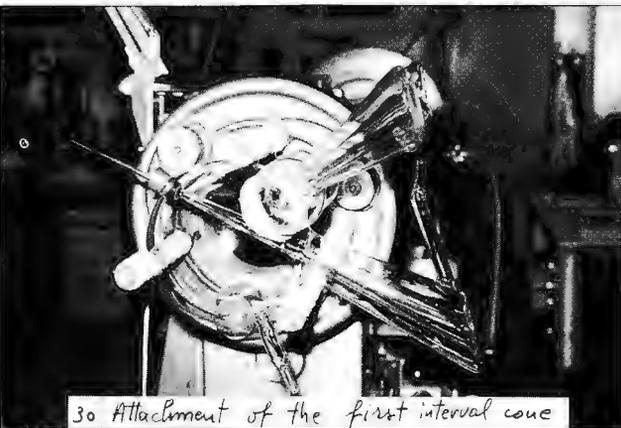
28 Piercing the base of the main cone

Picture 16.



29 Aligning the axis of the principal cone

Picture 17.



30 Attachment of the first interval cone

Picture 18.



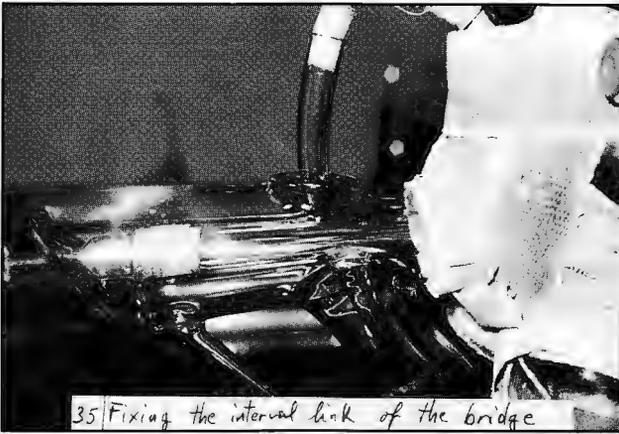
Picture 19.



Picture 20.



Picture 21.



Picture 22.



Picture 23.



Picture 24.



38 Removal of the 20mm Supporting stem

Picture 25.



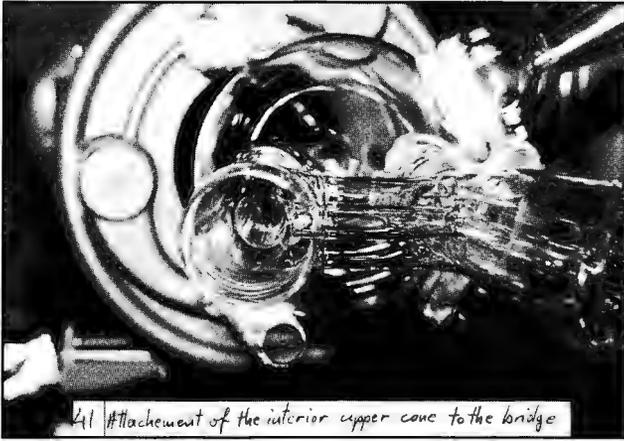
39 Attachment of the near upper cone

Picture 26.



40 Support for the interior upper cone

Picture 27.



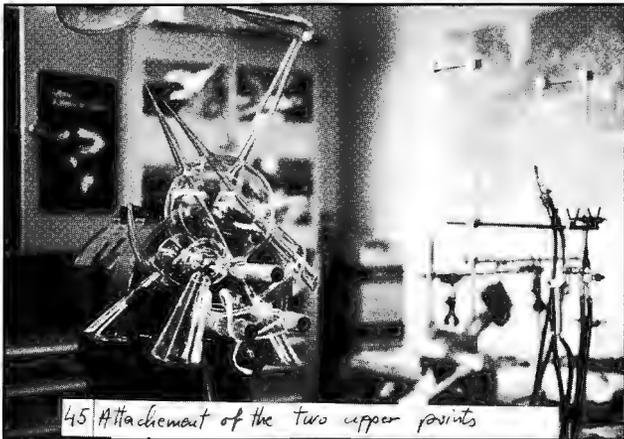
41 Attachment of the interior upper cone to the bridge

Picture 28.



43 Closing the upper cone

Picture 29.



45 Attachment of the two upper parts

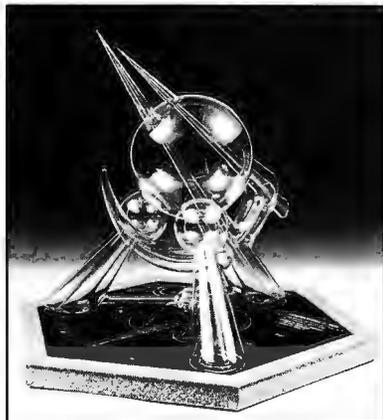
Picture 30.



Picture 31.



Picture 32.



Picture 33.

more into the annealing oven at 535°C and will be sealed under argon gas atmosphere to avoid any trace of internal condensation (Pictures 31 and 32).

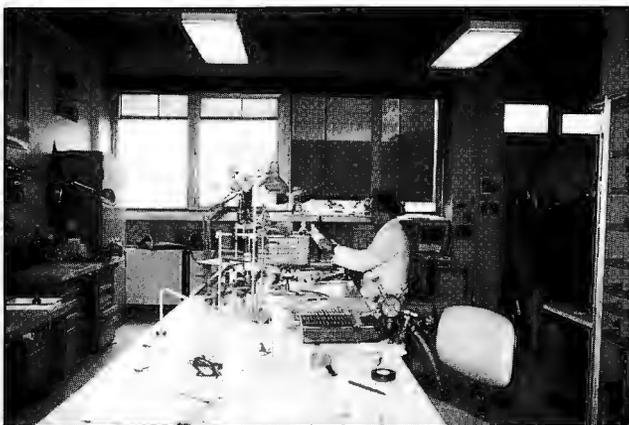
Picture 33 shows the completed Masterpiece.

About the Author. Yves Borrel has been employed at the Ecole Polytechnique since 1978 (see Pictures 34 and 35). He graduated from the Lycée Technique Dorian in Paris, France, as a scientific glassblower in 1970. In between he worked for Quickfit doing industrial glassware and at the C.E.A. (the French equivalent of the Atomic Energy Commission) in Saclay, France.

Acknowledgments. The translator wishes to acknowledge two members of the MOF's jury, Mr. H. Luneau, former headmaster at the Lycée Technique Dorian, and Mr. Pierre Pignat, a two-time MOF, for their immense expertise and their almost one hundred years of combined experience and dedication to the art and teaching of scientific glassblowing.



Picture 34.



Picture 35.

The Unintended Melting of Borosilicate Glass in a Microwave

by

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Los Angeles, California 90032

Introduction

To properly weigh a sample powder for analytical chemistry, it must be dried to remove all water, otherwise, the researcher will obtain an inaccurate reading. For years, the standard tool for this drying process was done in a conventional electric heating oven—a process that could easily take 1–2 hours (See Picture #1). In 1979, Dr. Hendrik Keyzer^{1,2} found that by placing the sample in a conventional microwave oven, this drying time could be cut down to 5–15 minutes (See Picture #2). Independent discovery of this process was later published in 1993³. Samples were placed in beakers, with three glass hooks on the edge of the beaker supporting a watch glass (See Picture 3). The watch glass is used to prevent unwanted materials from falling into the weighing bottles and the hooks allow moisture out. In the last several years, however, there have been occasional incidents where weighing bottles and glass hooks, all of borosilicate glass, have melted during the drying process. Picture #4 shows the result of a hook that melted onto the glass



Picture 1. Conventional Oven



Picture 2. Microwave Oven



Picture 3. Hook with Watch Bottle.



Picture 4. Oven Plate.

turntable plate of a microwave oven. This paper will attempt to describe the microwave heating process and provide the reasons for the *unintended* melting of glass.

Background

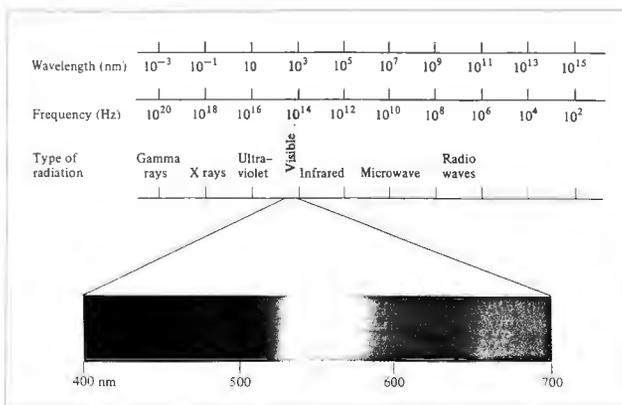


Figure 1. Electromagnetic Spectrum

The microwave region of the electromagnetic spectrum consists of a broad range of waves from about one centimeter to one meter in length. They lie between the infrared and radio wave range of the electromagnetic spectrum (see Figure 1⁴).

When an electromagnetic wave encounters a substance, the substance is considered transparent or opaque, depending on whether the wave passes through, or is blocked by the material. If the material is transparent, very little energy is absorbed by the material. If it is opaque, more energy is absorbed and a greater amount of energy is generated.

When microwave energy encounters opaque material, its molecules begin to twist, turn, and rotate many times per second as the molecules try to align themselves with the wave's frequency. This twisting, turning, and rotation causes heat from friction to be generated, thus heating the material and, by conduction, anything around the material. This creates the "internal" cooking that is substantially different from conventional cooking which is heating from the "outside in."

By heating liquids or foods by microwaves, the cooking process is much faster than conventional external heating. However, internal cooking does not allow food to brown or crisp. Thus, the texture and appearance we expect from standard cooking does not occur with microwave cooking.

Microwave ovens were first created in 1942 by the Raytheon Co. of Waltham Mass.. The story (probably apocryphal) is that P.L. Spencer discovered that microwaves used in signal transmission were melting the chocolate bar in his pocket. The first "Radarange" (\approx 1950) cost about \$3000⁵, were about the size of a refrigerator, and were used to heat and cook foods in hospitals. The first "table top" microwave ovens were developed by Amana Inc., in 1967, and with a power of about 700 watts, they cost about \$500–\$600⁶.

The microwaves for a microwave oven are generated by an electron tube, called a magnetron, that emits a frequency at about 2450 Hz, with a wave length of approximately 1–2 cm. In older or inexpensive microwave ovens, the microwaves are aimed at a fan that reflects the waves into the oven region (see Figure 2). This was done in an attempt to

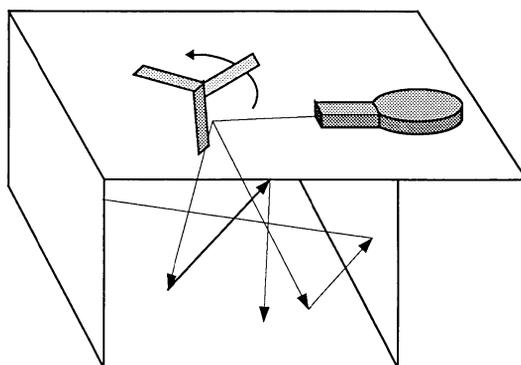


Figure 2.

provide a wide disbursement of waves and to try to eliminate “hot spots” within the oven chamber. Current and/or better quality ovens rely on a more precise opening of the magnetron casing, better aiming the waves throughout the oven chamber. If properly *aimed*, the beam will not only have no significant “hot spots,” but will be aimed away from the oven door.

As mentioned, when microwaves pass through a material, the material is considered transparent if a limited amount of heat is generated. Perfect transparency means that no energy is passed to the material. The level of absorbcency is determined by its $\tan \zeta$ (delta). The greater the $\tan \zeta$, the more energy is passed to the material. The smaller the $\tan \zeta$, the less energy is passed to the material ⁷. What we normally consider as being transparent, for example glass, does have some opacity toward microwaves. Contamination can increase the opacity.

When Dr. Kaiser first developed the microwave heating process, microwave ovens had one temperature, and the user could only vary the heating time. One older oven in our laboratory is of this type and is listed at 600 watts. Newer ovens can (sort of) vary the temperature and vary the heating time. In addition, these ovens are more powerful (our newer ovens are 1100 watts). It is assumed that the lab never had any melting problems in the beginning of this process because the ovens did not have the energy to melt the glass in the first place.

When the heat dial on a contemporary microwave is turned from high to medium, the microwave intensity is not cut in half. Rather, the magnetron cycles on and off, functioning half the time. The idea is that the magnetron heats up an area of food, and, while the magnetron is in the off-cycle, conduction heats up other parts of the food. (The technology to cut the intensity by half is available, but this level of technology would make it cost prohibitive.)

The physical state of the material being heated is important because, for example, ice (solid water) does not heat nearly as fast as does liquid water. Thus, when a frozen chicken is placed within a microwave, the spot that melts first provides liquid water. The liquid water is heated at a greater pace within the microwave oven, which can eventually cause a burn spot on an otherwise frozen chicken.

Common transparent materials generally include porcelain, china, and glass, but these are not all equally transparent. If you place a dry porcelain and borosilicate cup next to each other in a microwave oven and let it run for several minutes, the borosilicate glass will more than likely be too hot to touch while the porcelain cup will only be warm. However, there is quite a difference between too hot to touch and temperatures required for melting.

Experimental

In our laboratory, one of the more dramatic melting incidents was a weighing bottle containing calcium carbonate (CaCO_3) (See Picture #5). We speculated that the CaCO_3 was drying out in the microwave, and, once the water had evaporated, the CaCO_3 could superheat. Then in turn, the superheated CaCO_3 caused the glass to melt. The main problem with this theory was that the results were extremely inconsistent.



Picture 5. Weighing Bottle.



Picture 6. Melted Hooks.



Picture 7. Hook Testing.

Table 1
Results of Sodium Bicarbonate Soak

| | firepolished | shelf | crazed |
|----------------|---------------------|--------------|---------------|
| 3mm rod | 0/9 | 0/9 | 0/9 |
| 5mm rod | 0/9 | 1/9 | 0/9 |

To properly analyze whether the surface of the glass had any significance, we decided against using weighing bottles for experimentation due to costs. It was decided to use glass rods in the form of hooks. This was not an unreasonable test as there had been several situations where glass rods had also melted (See Picture 6).

To test what significance contamination held in the melting process, a 5% sodium bicarbonate solution (NaHCO_3) was prepared and the glass hooks were placed within for a fifteen-minute soak. There are obvious differences between a glass container partially filled with a substance and a glass rod with a material coated on its surface. However, at this point, it was believed that this was a surface phenomenon compounded by foreign material, and that if we could pin down what was taking place, the details could be dealt with later.

Three types of rods were developed for testing: 1) those that were 'off the shelf' and had normal surface wear and tear; 2) those where the surface had been firepolished along the entire rod leaving an unblemished surface; and finally 3) those that had some intentional crazing and surface checks. In addition, two different thickness of rods were used: a 5mm rod was used because this is the size rod used to make the glass hooks; and a 3mm rod was used because it is closer to the thickness of the weighing bottle. All rods were soaked in the sodium bicarbonate (NaHCO_3) solution. The NaHCO_3 was used because it is similar to CaCO_3 , and yet easier to work with, due to its greater solubility. Picture #7 shows the hooks set up for testing. The results are shown in Table 1.

Although there was one successful melt, the results were too inconsistent to be considered a solid lead for success. The melt was somewhat spectacular as it melted into the side of the beaker that supported the hook (See Picture #8).

The results did not provide any credibility to our initial theory and strongly led us to consider other causes. It was at that point that the manufacturing process of the hooks was reviewed.

The hooks are made by taking approximately two and one half inch pieces of 5mm glass



Picture 8. Fused Beaker.



Picture 9. Hook Construction.

rod, supporting them by one end with tweezers, firepolishing both ends, and heating the middle from above and below with a torch flame till the glass sags over to the desired angle (See Picture #9). The still-soft glass is then tossed onto a bench to sag itself flat before hardening. Occasionally, the tweezers are plunged into a beaker of water for cooling.

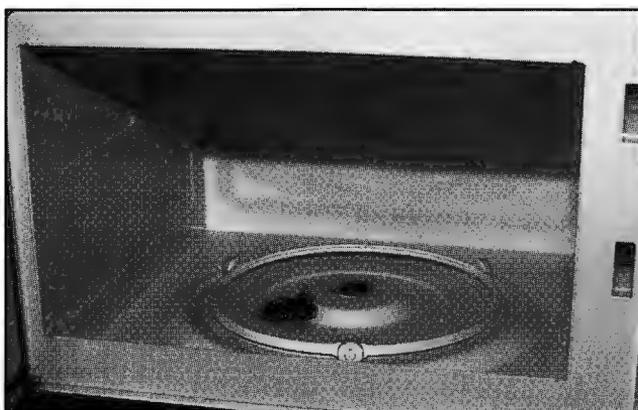
Reflection on the manufacturing process raised the concern that a flame sweeping past the tweezers might deposit some metal debris onto the glass surface. A new hook was prepared and preheated tweezers were touched on a spot of hot glass leaving a deposit of metal. This sample along with one hook prepared as "off the shelf" and a second prepared as firepolished were placed in the microwave oven and cooked for approximately fifteen minutes. The hook with the metal deposit melted at the site of the metal deposit (See Picture #10). What was curious about the result was that no glass thread remained on the (now separated) glass hook, and yet, the remains of a thread were stuck on the wall of the beaker. So at one point, the thread did exist. However, the "cooking" of the glass continued till the thread had been collected on the end of the separated pieces.



Picture 10. Successful Test Melt.



Picture 11. Good Oven Disk.



Picture 12. Bad Oven Disk.

Unfortunately, continued operation of the microwave oven for extended periods during these tests managed to melt the plastic cap on the central spindle. This cap is responsible for turning the glass plate carousel. Picture #11 shows what this plastic cap should look like. Picture #12 shows what happened to the cap after all this testing. Further experimentation has been delayed till repairs can be made.

Even if the deposit of metal on the hooks was the cause of their melting, there still was the issue of why the weighing bottles melted. It is believed that there might be two causes for this to happen.

One theory is the bottles may have been placed on a counter and picked up a fragment of metal contamination. Or, some metal contamination may have fallen into the beaker prior to placing the weighing bottle within. Since this is a student laboratory, such contamination is easily conceivable. Alternatively, as was done with the hooks, one must consider how weighing bottles are made. They are manufactured within an iron mold with a carbon deposit on the surface. It is possible that metal or carbon contamination might be deposited on the surface during the manufacturing process. Normally, this would never affect any laboratory operation, but the placement of such contamination in the microwave oven brings new factors to consider.

Conclusion

The resolution of this problem is potentially simple. The manufacturing process of the hooks can be changed to prevent metal deposition. The only option to prevent metal or carbon deposits on weighing bottles, however, is limited to visual inspection; it may or may not be possible to see this contamination.

One easy part of the process to control is the temperature of the microwave oven. Although the actual temperature cannot be adjusted, one can cycle the magnetron on and off, thus allowing the sample to dry out in the same time span as the older "cooler" ovens and with less chance for the glass to melt.

¹ Keyzer, Hendrik, "Teaching with the Commercial Microwave Oven," *J. College Science Teaching*, 9 (2) pp.91-92 (1979)

² Keyzer, Hendrik, "Some Uses for the Commercial Microwave Oven in Chemistry," *Chemistry in Australia*, 45 (2) pp. 44, 1978

³ Thompson, R.Q. and Ghadiali, M, "Microwave Drying of Precipitates for Gravimetric Analysis," *J. of Chem. Ed.* 70 (2) pp 170-71, 1993

⁴ Chang, Raymond, *Chemistry*, 4th Ed., pp 266 1991 McGraw-Hill Inc.

⁵ Microsoft "Encarta," 1995

⁶ Amana Corp., personal conversation.

⁷ Ku, Chen C. and Liepins, Raimond, "Electrical Properties of Polymers," *Chemical Principles*, pp. 61-63, 1987, Carl Hanser Verlag.

Posters

Construction of a Six-Sided Laser Optical Cell

by

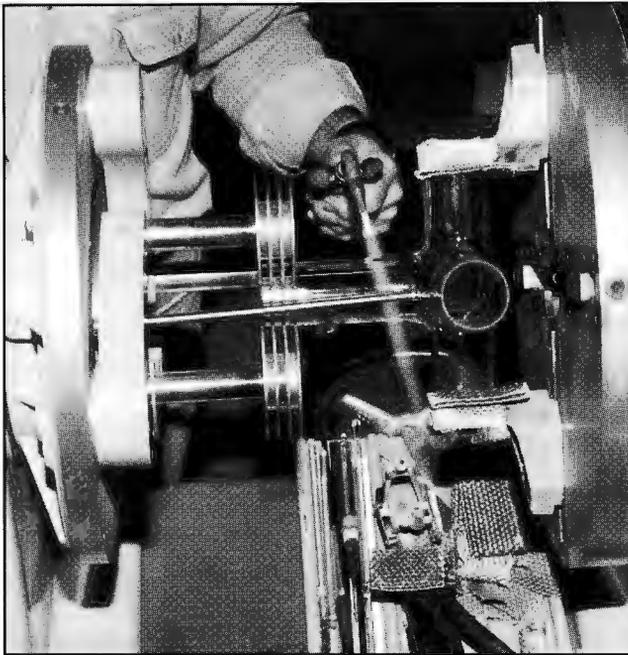
Richard G. Logsdon and Waine Archer

MST-7, Glass Shop

Los Alamos National Laboratory

Los Alamos, New Mexico 87544

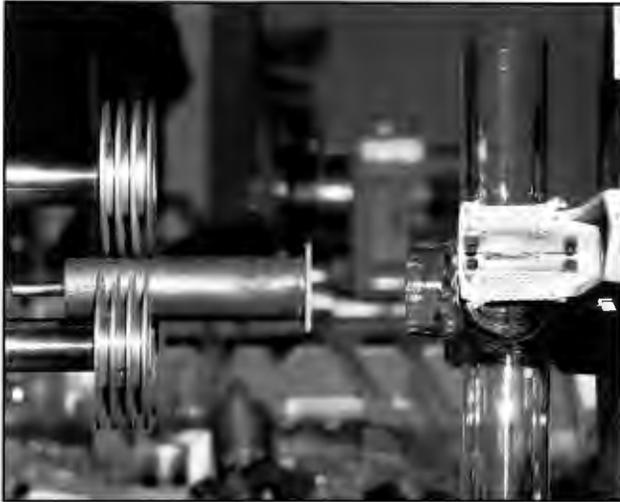
Physicists concerned with the study of man-made radioactive ions approached the glass shop to assist in the design and fabrication of a cell that could trap radioactive atoms in a high vacuum atmosphere. The design also had to allow for the focus of six laser beams simultaneously and for a port to load the atoms into the cell. The project was especially interesting because the researchers and the glass shop had to work in close association with one another.



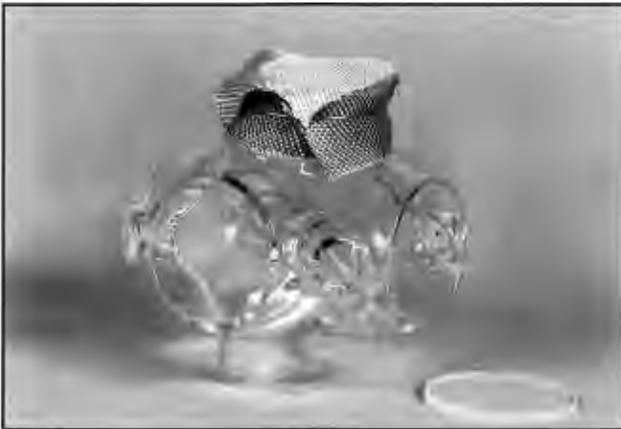
Picture 1.

The intersection of the six tubes is the first step of the assembly. 51 mm tubing is sealed on the lathe using an independent two jaw chuck to hold the awkward six-sided glass cell. A hole is picked in the side of the tube and flared to 51 mm. The seal is made using a hand torch and a long-handled carbon rod. The carbon rod is inserted through the tailstock to the inside of the pyrex tube to ream the seal from the inside, eliminating the need for air pressure. Each arm is cut to length on a diamond saw prior to window sealing.

The window is held by a carbon vacuum chuck and is preheated using a gas/air annealing fire. A hand torch with an OX-5 tip is used to pre-seal the window to the tube using a hydrogen/oxygen flame. The carbon chuck is immediately removed to prevent cracking. The lathe is then turned off and the seal is completed using a micro-torch fueled with hydrogen and oxygen while hand turning the lathe chuck.

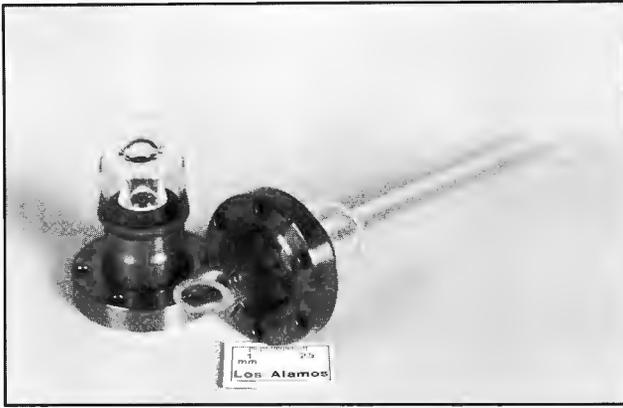


Picture 2.



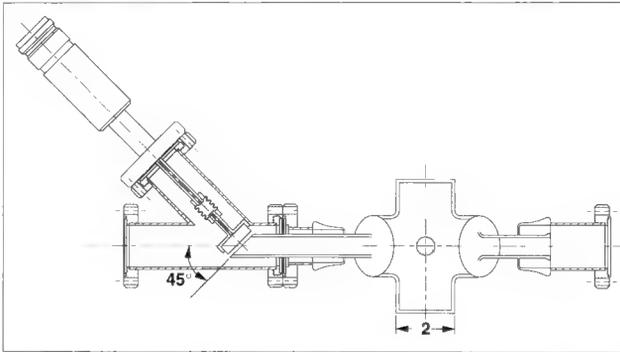
Picture 3.

After each window is sealed, the cell is oven annealed. The finished windows are wrapped with high temperature glass tape to protect them from direct fire when sealing subsequent windows to the cell. The conflat fittings required great precision with respect to the orientation of the flat internal window seal and the Brewster angle to the conflat. (top of page 96)

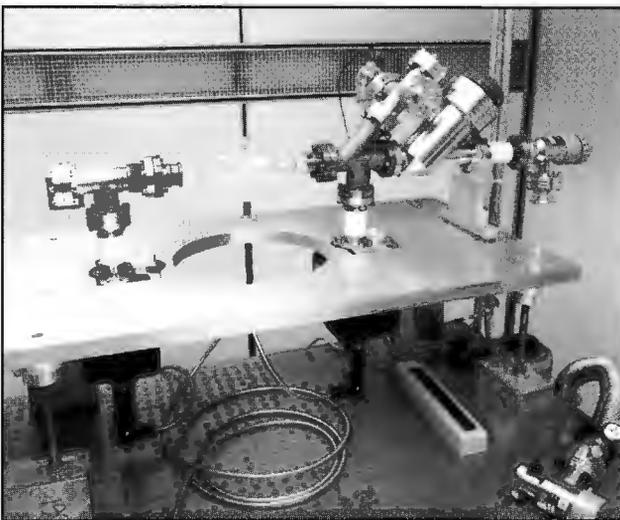


Picture 4.

The drawing and photo below show how the completed cell is attached to the vacuum system.



Drawing 1.

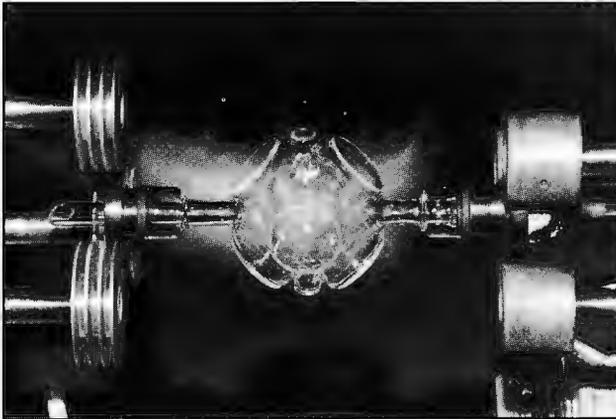


Picture 5.

The MST-7 machine shop at Los Alamos National Laboratories fabricated precision graphite fixtures to hold the conflat and glass parts in place while the ring seals were made.

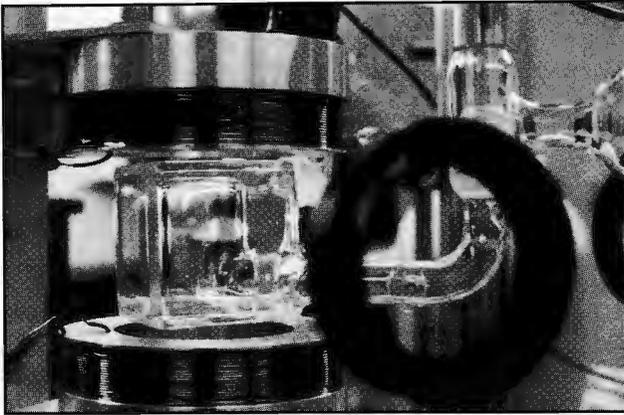


Picture 6.



Picture 7.

The conflat/window assemblies are the last parts sealed to the cell. The entire cell is flame annealed throughout the sealing process and then placed in a pre-heated oven. The completed optical laser trap required a variety of useful glassblowing techniques that could be used in other applications. The picture and text below show the laser trap in operation and the physicist's brief explanation of its use.



Picture 8.

Laser Beam Trapping of Radioactive Atoms

Ralf Guckert, Vern Sandberg, Dale Tupa, Dave Viera

At Los Alamos National Laboratory, light pressure is used to slow atoms in a gas and hold them at the intersection of six laser beams. The trapped atoms are levitated by the lasers, pinned in the middle of the glass vacuum cell.

There are several reasons why laser traps are a useful tool for studying radioactive atoms:

1. We want to study man-made radioactive atoms, which are difficult and expensive to make. Traps cool atoms down so they move very slowly. The atoms are moving so slowly that they have one millionth the speed of room temperature atoms. This means we can recycle atoms in a trap, testing and retesting them a million times, whereas room temperature atoms could escape after just one measurement.
2. Radioactive atoms disintegrate with time. With an atom trap, we can do experiments with radioactive atoms within 10 seconds of making them. There are many isotopes with lifetimes of a few minutes or hours that would disintegrate before they could be studied. By using an atom trap, we can study many isotopes that could not be studied before.
3. You can detect a single atom in a trap. An atom is held in a trap for such a long time, that it emits enough light during this time for us to see even a single atom. We can set up a trap to look for exotic radioactive atoms that are by-products of nuclear weapon production. This application may be important for nuclear treaty verification.

Acknowledgments: John Flower and Gary Warren-Photography and Jacob Bartos-MST-7 Machine Shop.

A Demonstration on Scientific Glassblowing

by

Michael J. Souza

Princeton University

Princeton, New Jersey 08544

Introduction

Many of the things a Scientific Glassblower does are applied to science and research, whether we make vacuum and semi-conductor apparatus for industry or we make glassware for electronic, chemical, environmental, and medical researchers. Explaining this to the public or, in my case, to high school students can be dry and boring. We tend to overlook that it is the medium we work that is the core of excitement for the public and us. Glass is a common fascination to people of all ages. A scientific glassblower can use glass to explain not only what he or she does, but also to explain a



lot about the world and science around us! This poster is designed to illustrate how glass can be used as a canvas to paint various pictures to educate the public about what we scientific glassblowers do and the importance of glass in today's world.

Preparation

- After you know who your audience is, *take some time to scout your location*. Find out where it will take place and what kind of elements you'll have to deal with. For instance, things such as gas supply, lighting, and how close your audience will be are all factors in giving the right presentation.
- Bring more than you need*. Among some of the extras to take along (besides the obvious torches, tools etc.) are various kinds of glass, some completed glassworks such as condensers and coils, press tools, a polariscope and several copies of *Fusion*.
- Design your demonstrations so they're short and have a point*. Don't spend too much time just glassblowing. Explain what you are doing as you do it.
- Draw everyday comparisons to explain things*. Compare glass to metal for instance; "Glass is an insulator. If I heat up an iron nail would I be able to hold it with my bare hands? Does glass conduct electricity?"
- Involve your audience*. Quiz them. Pass along interesting items, even get volunteers to assist you.
- Finally, be flexible! *Plan more demonstrations than you need*. As you talk you get a sense as to what demonstration would be more dramatic or prove a point to the audience.



Topics & Demonstrations - Part 1

•Topic: *Glass is a Supercool Liquid.*

Basic glassblowing techniques such as a round bottom, flaring glass, side seals, and cutting molten glass with scissors, all illustrate glass in its liquid state.

•Topic: *Glass cools so quickly that it cannot form a visible atomic structure.*

This is why glass is transparent and is a poor conductor of heat. Ask a member in the audience to help you pull a point. (Heat up plenty of glass and give them ample room to hold the end of the tube they're going to pull. When the glass is ready, give them one end of the tube and ask them to walk away from you very quickly but carefully. Demonstrate how thin the glass was pulled, how quickly it cooled, yet is still hollow. State how one lb. of glass can pull a fiber that can circle the Earth! Also note that 12 inches away from their hand that glass was over 1000C!

•Topic: *How does glass get colors?* Bring along some North Star frit (striking glass is best) and make a color bulb. If it's a striking glass, it will cool quickly and not have color until it's warmed up slowly again. This illustrates topic two as well. Also, use gold to give iridescence to the glass. This demonstrates how metal oxides give glass color.



Topics & Demonstrations - Part 2

•Topic: *Glass needs both a defect and an applied force to break.* Have a volunteer score and cut a 10 mm tube. Explain tensile pressure versus compression pressure. Score and thermally crack a larger tube.

•Topic: *How glass is tempered?* Demonstrate how a polariscope works by applying force to a glass rod. Next show some of your previous pieces of glass that you just worked under the scope. Explain thermal expansion and contraction. Then show safety glasses under the scope. Finally, demonstrate a Rupert drop or a Bologna bottle.

•Topic: *What does a Scientific Glassblower do?* (Save the best topic for last)! Detail some of the industries that require your expertise. The newer copies of *Fusion* have wonderful photos on their covers. Explain how you get involved in this profession and what your own job entails. Finally, have a Q&A session.



Conclusion

A good scientific lecture can change our perspective in a profound way on how we look at things. It specifically details what things are and why they are. But more than that, it sets us on a search to learn more.

A scientific glassblower has a distinct advantage in presenting a presentation. We have a unique ability. We're able to define our field in so many versatile ways and we work with what is truly a remarkable material simply known as Glass.

Afterward

Some of the "Topics" I've described give very little detail. I leave that up to you to discover if you haven't already. Local libraries, encyclopedias, and the Internet are all good resources. Most of the "Demonstrations" can be found in a paper done by an old friend no longer with us, James Morris, in the Proc. 24th Symp. ASGS pp 25-32.

This Poster is dedicated to Jim Morris

Jacketed Beaker with a Drain

by Doni Hatz

Proctor and Gamble Co.

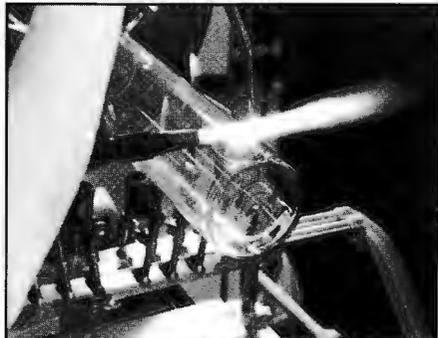
Loveland, Ohio 45140

A jacketed beaker with a drain is used as a constant temperature bath. The drain, a teflon stopcock, allows you to empty the contents without disturbing the sample or product inside the beaker. A micro slide rack, that is placed inside the beaker, is made to support 10 slides vertically. A magnetic stir circulates the inner contents of aqueous solution.

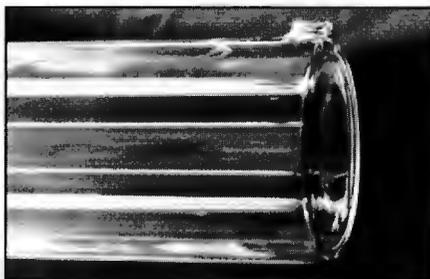
The inside piece is a 90mm OD tube and the outside is 110mm OD tubing for the jacket. Hose connections are sealed to the top and bottom of the outside jacket with a 2mm bore Teflon stopcock for the drain. The stopcock is prepared by thickening the end, then bending the other side arm (for the drain spout).

Prepare the inside 90mm OD tubing by heating the glass and pulling it down to a flat bottom; a cradle burner works very well, in this case a 6 head 7 jet burner is used.

A small seal is made near the bottom (this is the drain), keeping in mind that the fluid inside should be able to drain out completely. The seal is made by heating an 8mm rod, gathering it slightly (about 10mm), at the same time, heating the tubing area where the seal will be made.



The hot rod is attached and drawn up slowly blowing (late) into the tubing to create a short section of tubing.



Blow out a short seal, in this case 5mm height, and ream it out allowing a slight bead to form on the lip of the tubing. This is the distance that is between the inside and outside tubes. Flame anneal the tube.

Once cool, score and crack off the tubing to the desired length. In this case a 4 1/4 inch inside depth is needed and I add 1/2 inch to flare up to 110mm OD.

The usual way to measure is to subtract the OD of the inside tube (90mm) from the ID of the outside tube (104mm), then divide that by 2; this equals the gap but is usually not enough glass, so I always add 5mm to the 7mm gap.

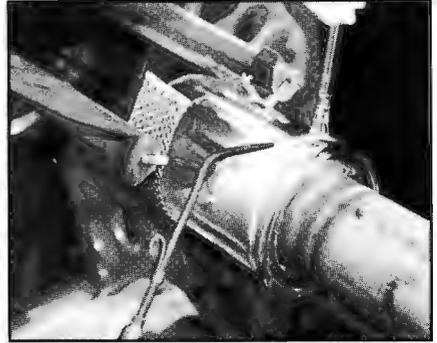
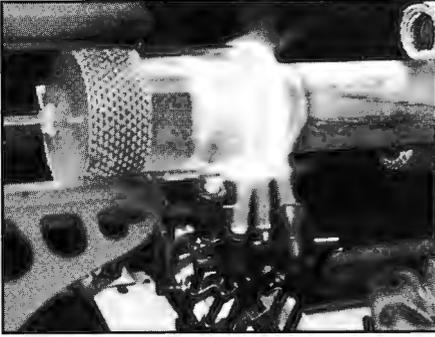


This is the glass to be flared up to the outside tube and sometimes larger tubing needs more glass.

$$\begin{aligned} 110 \text{ OD} &= 104\text{mm ID} \\ 90 \text{ OD} &= \underline{90\text{mm OD}} \\ &14 \text{ mm gap} \\ \text{divide by } 2 &= 7 \text{ mm on each side of inside tube} \\ \text{Add } 5 \text{ mm} &= 12 \text{ mm extra to cut} \end{aligned}$$

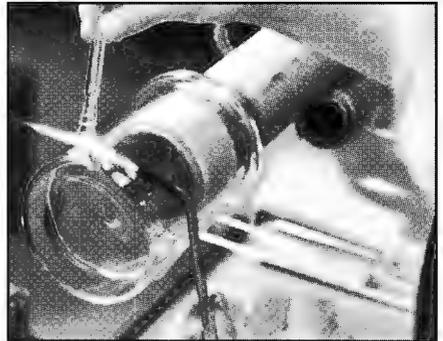
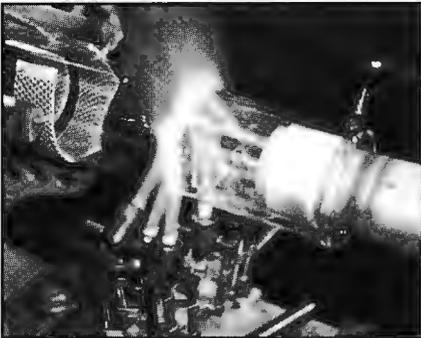
Prepare the 110mm OD tubing with a clean and straight end and chuck into the lathe. If the end is not straight this will cause problems in the dewar seal. The 90mm OD inside tube is supported on a stainless steel pipe or heavy wall tube. The support is wrapped tightly with two inch width high temperature cloth holding the 90mm tube tightly to prevent slipping (because this will be the support of the whole piece when the bottom part is being worked). Attach a Y connector to the blow hose but plug one side. This connector is needed after the dewar seal where the second blow hose will be connected to control the air pressure inside the jacketed beaker.

Seal the inside 90mm tube (with the flare) to the 110mm tubing using the cradle burner. Heating both tubes, attach and seal by reeling in the tail stock of the lathe and guiding the flare with a graphite rod or paddle. Flow the seal together; be aware of not blowing too hard and constricting down the inside tube as this will make it difficult to remove the support. In this case a lid will be made for the top so it is paddled slightly to ensure flatness.

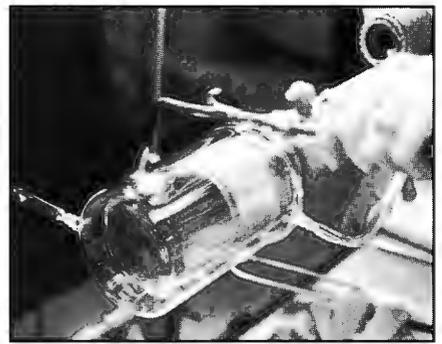
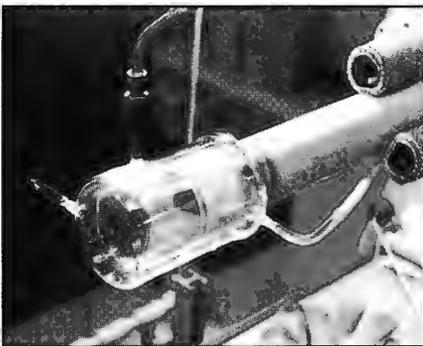


Prepare and seal on the top hose connection and bend the holder of the hose connection away from the beaker. Flame anneal, and let cool enough to attach #2 blow hose of the Y connector.

Heat and begin pulling down the 110mm tubing to a flat bottom. Prepare and seal on the bottom hose connection. Flame anneal



Heat the area where the drain is and seal. In this case I use two torches: a jet 7 (Jencons of Hemel Hempstead) for the initial heat of a larger area of glass; then a small torch tip to concentrate on the seal.



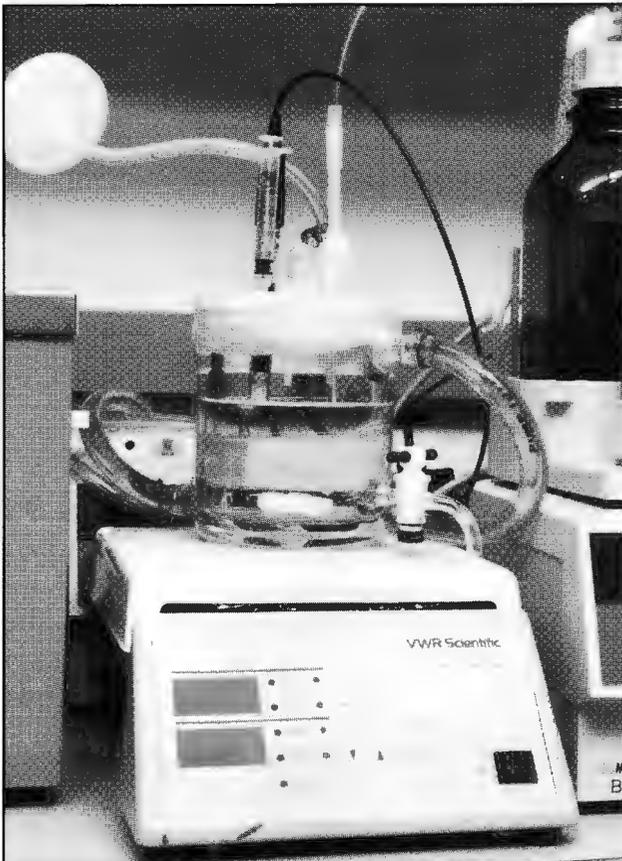
Flow the bead of the inside tube to the outside jacket where there is not a cleavage. (A cleavage can cause cracking in annealing or when repaired later). Blow out the hole by pinching the blow hose controlling the air pressure to the outside jacket (to prevent the outside jacket from blowing up). Ream out the seal area to the same size as the stopcock. Flame anneal while preheating the stopcock.



Heat the stopcock and beaker and seal together. Flame anneal.

Here is the completed beaker in the laboratory with the micro slide holder and magnetic stir in operation.

Acknowledgments go to Mike Burchfield, Eileen Fletcher and Alice Ruble



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“Cutting Flat Glass Discs & Sealing Them on to Tubing”

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“Fabricating a Quartz Flange by Lamination”

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Nancy Opsahl
Manon Ouellet
Ken Owens
Michael Palme
Angie Parillo
Edward V. Parillo
Charles Parkin
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Mary Partlow
C.S. Patel
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Antoinette Pesce
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Lynnette M. Ponton
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Jim Rayburn
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Douglas K.Reichardt
Arzinia Richardson
Bill Roach
Joe Roberts
Amo Roensch
Hans Rohner
Gary Ruiz
Glenn Rush
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| Rudy Schlott | Daryl W. Terry |
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| Billy Jack Sells | Carleta Underwood |
| Carleen Sexton | Dom Underwood |
| Curt Sexton | Michael Vandenhoff |
| Will Sexton | Daniel Vogt |
| William H. Shoup | Steve Volpe |
| Robert Singer | Robert Wallace |
| Jan Singhass | Steve Ware |
| David Smart | Andy Wargo |
| Katie Smart | Pat Wargo |
| Lorraine Smith | Dr. Isaiah Warner |
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| William A. Smith | Peter Weir |
| Bill Smutny | Lanah Wheeler |
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| Marie Snodgrass | Mark Wicker |
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| Tove Sorensen | Sieglinde Widmann |
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| Mary Spaan | William J. Wilt |
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