British Society of
Scientific Glassblowers Journal
VOL. 16
APRIL 1978
No. 2

Scientific Glassblower

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British Society of Scientific Glassblowers

Founded 1960

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time and date and place of arrival,
address whilst in the United Kingdom,
length of stay.

British Society of Scientific Glassblowers

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VOL. 16 APRIL 1978, No. 2

Editor R. E. Garrard
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Journal of the B.S.S.G. School of Chemistry
University of Bristol

CONTENTS

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THE PRODUCTION OF COMMERCIAL NICKEL ALLOYS FOR USE IN THE GLASS AND ELECTRONICS INDUSTRIES

by
K.D. BARR

INTRODUCTION

For many years, production developments in the manufacture of alloys of nickel (particularly containing controlled additions of iron, cobalt, chromium) were associated with developments in the field of glass technology. This was largely due to progress made in the vacuum tube technology of the electronics industry, where the necessity to produce a vacuum-tight seal around a metallic conductor brought about a marriage between controlled expansion nickel alloys and glass which has stood the test of time.

Nickel and nickel alloys have played such an important role in the electronics industry because they have the mechanical and physical properties needed for components operating under vacuum, often at high temperatures; they are also easily outgassed. "Pure" nickel grades can be readily produced with very low levels of impurities such as volatile metals, oxygen and other contaminants. Applications for these grades of nickel have traditionally, in vacuum tube technology, been in thermionic valves and tubes as support wires, grids, anodes and cathodes where special ion emission characteristics are required. A brief summary of the main commercial grades available are shown in Table 1.

The most important nickel alloys used specifically for the glass-to-metal seals in vacuum tubes are those containing additions of iron and cobalt or chromium, comprising a range of controlled expansion alloys from which compositions can be tailored to match the expansion curves of most commercial glasses. These alloys are available under a variety of Trade Names, but at Wiggins the Trade Mark "NILO" is used. The compositions of Wiggins alloys in this group are listed in Table 2.

The discovery, development and adoption of nickel-iron controlled expansion alloys as standard materials for glass-to-metal sealing has been well documented elsewhere, but basically they satisfy the eight general requirements for suitable metals as listed by Partridge.[1]

1) Its melting points must be higher than the working temperature of the glass.
2) Commercial quantities of it, of specified thermal expansion coefficient, should be available, metallurgically clean (i.e. free from non-metallic inclusions).
3) It must be sufficiently ductile to enable it to be formed into wire or strip without cracks, seams, laps or other mechanical defects.
4) The curves of thermal expansion of both metal and glass should in the case of matched seals, follow one another closely over the same specified range of temperature.

5) No allotropic transformations, accompanied by marked changes in thermal expansion rate, should occur in the metal over the range of temperature to which it may be subjected, either in making the seal or during its subsequent use.
6) Any layer of oxide formed during the process of making the glass-to-metal seal, should adhere firmly to both metal and glass.
7) High electrical and thermal conductivity are advantageous.
8) Ease of joining to other metals by welding or soldering.

[1]J.H. Partridge: "Glass to Metal" Seals. 1949.

Whilst nowadays some traditional applications for nickel alloys such as the thermionic "entertainment" valve—always a large user—are on the decline, others in semiconductors and integrated circuitry are on the increase. In some cases, the knowledge gained through vacuum tube technology has been directly useful in applying glass-sealing techniques to such applications as the hermetically sealed glass and ceramic encapsulated integrated circuit packages.

It is not, however, the purpose of this paper to give a detailed list of properties and applications of the nickel-iron alloys nor discuss at great length the technicalities of producing a sound glass-to-metal seal, all of which are adequately covered elsewhere and probably more familiar to the audience than to the author. It is proposed to give a brief insight into manufacturing methods used in the production of these materials and to later elaborate these notes with a short film about techniques.

PRODUCTION OF COMMERCIAL CONTROLLED EXPANSION ALLOYS

Melting and Casting

The first stage in production of commercial controlled expansion alloys is the melting and casting operation. These alloys derive their special properties largely through close control of compositions. Not only are the proportions of the alloying elements rigidly controlled, but steps have to be taken to rigorously exclude impurities. Raw materials are therefore carefully specified and are analysed before release to the melting department.

All melting of controlled expansion alloys at Wiggin is carried out in electric furnaces to avoid introducing contamination from combustion products. The furnace bodies have special basic linings to minimise contamination of the melt and carry-over of metal from melt to melt. The majority of nickel-iron alloys are melted in two 5,000kg direct-arc furnaces, while nickel-iron-chromium alloys may be melted in one of three coreless induction furnaces, two of 1,600kg capacity, one of 800kg capacity.

In the furnaces so far described, slag-forming materials are included with the original charge, and form a layer on top of the molten metal, excluding atmospheric contamination. The metal is poured into pre-heated ladles, and cast by one of three techniques: simple top casting with a tundish; uphill casting; or Durville casting. In

uphill casting, the metal runs from a central feeder into the bottom of several moulds, rising simultaneously in each. An exothermic material is floated on top of the molten metal to maintain the casting temperature and minimise oxidation and contamination. For alloys requiring a greater degree of soundness, the Durville casting technique is used. The molten metal is teemed into the receiving half of the Durville unit at a temperature consistent with the chemistry of the melt. It is held there until it falls to the optimum casting temperature, and the unit is then inverted carefully so that the molten metal flows into the casting section, leaving behind all the dross and inclusions that result from the teeming operation.

For the more demanding applications, where standards of composition control, cleanness and homogeneity required cannot be met by conventional melting and casting techniques, the manufacture has to resort to further refining.

Vacuum refining was a major step forward in the production of close-composition alloys. By holding molten metal at a pressure below 0.2 mm Hg, the level of impurities is reduced, since many gas and metal contaminants are readily evolved. Wiggins operate two 3 tonne double-bodied units capable of melting down a charge in one crucible while the other is holding a molten bath of metal under vacuum. A separate power supply is provided for induction stirring of the metal to assist removal of volatile impurities.

Even further improvements in cleanness and freedom from oxide inclusions can be made by excluding air from the melting process altogether and melting and casting under vacuum. A twin bodied, 1,600 kg vacuum induction furnace is in operation and has been used for critical application work. Modernisation schemes in hand include plans to increase capacity in vacuum melting, probably by the addition of two further units.

A further successful method of metal refining is the use of controlled solidification of the ingot. In electro-flux refining, the alloy to be refined is cast into an electrode, which is fed into a water-cooled mould in the bottom of which is a specially formulated slag with high electrical resistance. A voltage between the electrode and the mould baseplate causes current to flow through the slag, which becomes so hot that it melts metal from the end of the electrode. As metal collects in the bottom of the mould and solidifies from the bottom up, forming a solid homogeneous ingot. The molten slag rises on top of the metal, but also leaves a thin skin around the solidifying ingot, thereby improving surface quality and assisting removal from the mould. The latest Wiggin electro-flux refining furnace, was, when installed, the largest in Western Europe. It has two separate stations, each one being equipped for both single phase refining, using one electrode, or three-phase operation with three electrodes. In the latter mode, three electrodes feed into one mould to make one ingot up to 15 tonnes in weight, or three separate ingots each up to 5 tonnes. Recent trials in melting controlled expansion alloys by this method have produced very promising results.

Extrusion

After the melting and casting operation, cast ingots are machined and trimmed for the first break-down stage in the production of material in a suitable form for the end customer.

This, in the case of controlled expansion alloys, is the extrusion process. This is a very flexible method of breaking down cast ingots into almost any shape, suitable for further processing into rod, strip, sheet or tube. For the extrusion of nickel-alloys it has been found necessary to use glass as a lubricant for the metal flowing through the extrusion cylinder and die. Wiggin operate two extrusion presses; a 5,000 tonne Loewy accumulator-operated press, and a 3,500 tonne direct pumped press designed for automatic control. The shape to which ingots are extruded depends on the finished product required: hollow shell for tube, flat bar for strip, square bar and round bar for further processing to rod and wire.

At this stage also, the next operation obviously also varies depending on the final product.

Hot Rolling

Intermediate processing of extruded billets into sheet, strip or rod forms is most easily accomplished by hot rolling, since large reductions in thickness may be achieved with reasonable power whilst maintaining satisfactory metallurgical structures.

a) Strip — the starting stock for hot strip rolling is extruded bar 5-6 metres long and 4½ cms thick. These are rolled in one pass to about 3 or 4 mm thick on Sandzimir Planetary Mill. The action of this mill closely resembles a forging operation and is achieved by twenty small-diameter work rolls that rotate around each back-up roll like needle bearings around a shaft.

b) Rod — Rod-rolling is performed on a Morgardshammer continuous rolling mill of ten stands, the speed of each being variable over a wide range to cater for the varying hot-working characteristics of the alloys.
The ten stands consist of two heavy cogging mills, four intermediate and four finishing mills. The cogging mills reduce extruded billet to 5 cm square bars to round rod between 1.3 and 3.3 cm diameter. The finishing mills roll this to wire rod at 7.6 mm or 5.0 mm diameter for cold drawing to wire elsewhere in the works. Frequently all ten mills are employed simultaneously in reducing extruded bar to wire rod in one operation.

c) Sheet — On occasions, controlled expansion alloys are required in sheet form and in this event reduction of billets up to 90 kg by weight is carried out on two Davy United 2-high mills. Larger billets, up to 270 kg, can be rolled on a 3-high Lauth Mill before being finished on the Davy United mills. Rolling temperature are around 1020-1080° C for the nickel-iron alloys.

Cold Rolling

Cold Rolling is a finishing operation, capable of producing sheet and strip to close tolerances on thickness, and of imparting a good surface appearance to the metal. It can also be used to develop the required strength, hardness and grain size in the finished product.

Nickel alloys tend to work-harden quickly and one of the main problems in cold rolling is the relatively high power needed to deform them adequately, to avoid the need for frequent interstage annealing.

a) **Strip**—several 2-high and 4-high mills are used to break down the hot-rolled planetary mill strip to a thinner, uniform gauge suitable for finishing. This part-finished strip is then passed to one of five types of mill for finishing. Three of these are small specialist mills for producing strip with special finishes, special temper or of very thin gauge. The other two mills in fact produce the majority of NILO alloy strip and are:
   (i) A Robertson CMP mill—which is a 4-high reversing mill with driven back-up rolls and front and back tension. It is very versatile and can economically roll a wide variety of strip sizes in quick succession.
   (ii) A Fröhling mill. This 4-high mill is a high output unit and rolls strip at 300 metres/min with rolling loads up to 250 tonnes. Accurate gauge is achieved by very sensitive automatic control equipment, and the mill imparts a high quality surface finish to the strip.

b) **Sheet**— In the event of sheet being required, a 4-high Davy reversing mill, a 2-high Sendzmir, or one of several smaller mills can be employed to cold-roll to thicknesses in the range 0.3-4.0 mm.

Wire Drawing

A large proportion of sales of NILO alloys are delivered in the form of wire. Sizes of wire produced range from 8.0 mm down to 0.1 mm diameter.

Drawing machines range from single die, heavy duty machines, capable of breaking down wire rod for subsequent drawing, to multi-die machines with up to eleven dies for drawing down to finished sizes. High reductions can be given to most of the NILO alloys and drawing speeds of up to 300 metres/second may be realised.

Dies are normally of tungsten carbide for larger sizes, or diamond for sizes under 0.9 mm diameter. Lubricants used are drawing soap, lime or proprietary oils.

Interstage annealing plays a large part in the production of wire in the NILO alloy series, and a variety of controlled atmosphere furnaces, including electrically heated strand furnaces using a cracked ammonia atmosphere, operate in the range 700° C to 1100° C to produce clean, bright wire with the required properties.

Cold Drawn Tube and Solid Section

In certain instances, tube and solid section can be produced in the NILO alloys by cold drawing. The tubes or rods are pulled through a succession of dies of decreasing diameters. For tubes, a mandrel is located at the centre of the die to prevent inward collapse of the tube wall and to maintain the correct wall thickness. As in wire drawing, the metal has to be annealed from time to time as it work hardens.

Extruded tube "shells" are first passed through a Robertson tube reducer which effects a heavy reduction in the tube size in what amounts to a cold forging operation. The die is mounted on a saddle that reciprocates at between 90 and 220 strokes per minute. The tube is pulled over a tapered mandrel, while the reciprocating die block squeezes the metal down to the smaller diameter. The tube is turned through 60° for each stroke of the die block.

As the tubes or sections grow longer, they are sawn into shorter lengths for further work. Degreasing and pickling cycles are used to remove cutting dust, drawing lubricants or oxides from annealing operations, before further drawing operations are carried out on conventional draw benches.

These then are the major manufacturing processes which are involved in the production of a commercial nickel alloy. There are of course many subsidiary processes and operations without which the major processes could not continue. Also, of course, rigorous materials testing, quality control and inspection procedures, have to be applied to ensure that the product delivered to the customer meets his order requirements in every respect.

Acknowledgements

The author wishes to thank Messrs. Henry Wiggin & Co, Ltd, and Inco Europe Ltd, for permission to publish this paper.

*NILO and WIGGIN are Trade Marks.

THIS PAPER WAS PRESENTED AT THE 1976 SYMPOSIUM AT THE TARA HOTEL, LONDON. WE ARE INDEBTED TO THE AUTHOR.

TABLE 1
Commercial Grades of Nickel

Nickel 200— General purpose grade, used for support wires in lamps, bulbs and valves.

Nickel 205— Low carbon grade used for anodes in radio valves, cathode ray and television tubes. Easily outgassed.

Nickel 212— Contains a manganese addition for increased strength.

Nickel 222— A magnesium activated cathode nickel.

Nickel 270— A high purity grade made by powder metallurgy.

TABLE 2
Controlled Expansion Alloys of the "NILO" Series
For Glass-to-Metal Sealing Applications

NILO alloy 42 — 42% Nickel, Balance Iron. For "Dumet" manufascture and "Housekeeper" type seals.

NILO alloy 475 — 47% Nickel, 5% Chromium, Balance Iron.

NILO alloy 48 — 48% Nickel, Balance Iron. Compatible with soft lead and soda lime glasses.

NILO alloy 51 — 51% Nickel, Balance Iron. For soft glass envelopes.

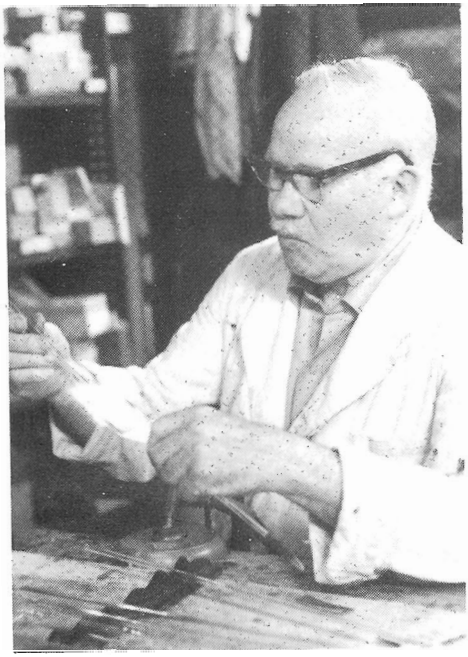
NILO alloy K — 29% Nickel, 17% Cobalt, Balance Iron. For Borosilicate type glasses.

"WELL I'LL BE BLOWED" or "STILL BLOWING STRONG"

Reginald William Conway, born 1st February 1897, father of six children, two girls and four boys. Three of his sons entered the glassblowing profession but only one, Vivian, remains in it and he has been glassblowing for thirty-three years, being awarded his Master's Certificate of the BSSG in 1976.

Reg joined the army in 1916, after a period was posted to Porton Experimental Station, Salisbury Plain, doing research in chemical warfare. From there he was posted to France and was demobbed in 1919.

He took a course at the Northern Polytechnic, London then moved to Manchester and started glassblowing professionally in 1921 for the Cotton Research Association. While in Manchester he also worked for ICI Dye Stuffs Division and Metropolitan Vickers Ltd.



He moved to Middlesex in 1929 where he worked for the Medical Research Council, Hampstead, his next move was to (the Gramophone Co.) HMV Research Laboratories, Hayes. In 1930-31 he moved on to Rugby where he worked in the BTH Research Laboratories.

1938 saw him back in London working for the British Drug Houses Ltd. In 1951 he started his own small business which he is still running. He has been glassblowing for fifty-six years and is eighty years old. One could call in on him any day of the week, including weekends, and find him sitting at his bench glassblowing.

He joined the Society of Glass Technology about 1931 and was made an honorary member about 1955. He joined the BSSG in 1963-64.

NEWS

FROM

SOUTHERN SECTION

Your committee was elected as follows:

Chairman	Mr. D. NEWALL
Secretary	Mr. J.R. MARLOW
Treasurer	Mr. W. BRENCH
B.O.E.	Mr. R.J.W. HARVEY, Mr. T. MAPLES
Member of Council	Mr. F. LUADAKA
Bulletin	Mr. L.F. PATRICK
Auditor	Mr. F. BRANFIELD

Our thanks to Charles Bradley who has been Secretary for a number of years. He has now handed over to John Marlow to whom we wish success. Thanks also to Ron Newman who was News Bulletin editor and into whose shoes I have stepped. I hope I can be as efficient.

There was a discussion concerning venues for future meetings and lectures; the point being raised as to how to interest more members to attend and participate.

A series of not too serious chats is to be given by Ron Harvey, entitled Historical and General Glass, Decoration and Art in Glass, and Electronic and Commercial Glass (not necessarily in that order). The lectures will be held at E.M.I. Industrial Electronics, Bury Street, Ruislip, opposite the Old Barn, starting at 7.30 p.m. and adjourning to the George public house not later than 9.00 p.m. Why not bring the wife and make this a social gathering and meet old friends and make new ones? The dates for these gatherings are: Monday 13th February, Monday 13th March and Monday 17th April. Hope to see you there.

The meeting closed at 9.30 p.m. Our thanks to Fred Luadaka for his hospitality, and to C.E.R.L. for the use of their facilities.

L.F. Patrick

EAST ANGLIA

A meeting was held on Friday the 9th September 1977 at the Playhouse, Harlow, Essex. The lecture was entitled "Glass Working Through the Ages", by Mr. Macer of Nazing Glass Works. The meeting was poorly attended due to difficulties in booking arrangements. However the meeting was found very interesting by those who attended.

J. E. Stark

NORTH WEST SECTION

The North West Section 77/78 programme has not commenced but the Section was well represented at the Annual Symposium. The members of the Section being mainly from the ICI and Liverpool University glass/shops. The Symposium Committee deserve a vote of thanks for their efforts in organising a well run Symposium.

I would also like to suggest a vote of thanks to the staff at Bristol Polytech particularly the catering staff for their help and co-operation.

Lastly why do some members never attend a Symposium? From the North West we never see anybody from Manchester University, Salford University or Lancaster University. Do these members ever ask their Supervisors to pay expenses etc? It's a question we will be asking at local level.

H.G. Chappell
Hon. Sec.

STICHTING GLASTECHNIEK (HOLLAND)
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5613 CL EINDHOVEN (HOLLAND)

Eindhoven, 1977-11-16

ABSTRACTS "GLASTECHNISCHE MEDEDELINGEN", No. 2, May 1977

— MIKRON, De Stichting Glastechniek en de Sektie Glastechniek (Sektie van de Vereniging MIKRON)
New society MIKRON: The Glasstechnical Foundation and the Section Glasstechnique of the new society.
A review is given of recent developments in organization, possibilities of combination of efforts in the general field of laboratory techniques, innovation

and product development in industry.
Sections of MIKRON are: — Precision mechanical products;
— Instrument construction;
— Glasstechniques.
Planned new sections are among others: Electronics, Microscopy, Vaccumtechnique.
3 pages, 1 figure, Ir. W. Luiten, Eindhoven.

— Report on proceedings 1976 Stichting Glastechniek, 3 pages.

— Koud water helpt brandwonden genezen (translated from "Fusion", August 1975): Cold water helps healing of burns, 2½ page.

— Wat gebeurt er bij slijpen van glas en keramiek? (What happens when grinding glass and ceramics?), A. Broese van Groenau, Eindhoven, 16½ pages, 17 figs.

— Vacuum technique, C.J. van Klink, Leiden, No. 11, 6 pages, 4 figures, (Continuation).

— Information:
— Pre-glowed incandescent lamp does not explode;
— Detection of mercury vapour;
— Smooth breaking surfaces for optical fibres;
— Machinable glass ceramics;
— Silicate science, Vol. VII: Glass science, W. Eitel, New York, Academic Press 1976: discussion.
— High power level tunable laser.

ABSTRACTS "GLASTECHNISCHE MEDEDELINGEN", No. 3, July 1977

— Measuring techniques in optics, J.G. de Bruin, Eindhoven, 7 p., 17 fig.
This treatise comprises the following items: Introduction, Interference, measuring instruments based on interference (test glasses, Arnulf-spherometer, optical ring spherometer, interferoscope etc.), measurement of angles, refraction and measurement, refractometer.

— Ultrasonic machining, D.C. Kennedy and R.J. Grieve (translation from The Production Engineer, Vol. 54, no. 9/September 1975), 10p., 7 fig.
A research review is given of ultrasonic machining with which process parameters are being evaluated. It is shown that some conclusion reached with previous research concerning specific circumstances, do not hold in a general way.

— Application of silicone film in glass technique, based on a BAYER-publication, 2 p. ('Baysilon' Olemulsionen, 1972).
Special attention is drawn to the application of silicone film on glass surfaces etc.

— Vacuum technique, C.J. van Klink, Leiden final part), 2½ p., 5 fig. (Continuation)

— Presentation of monthly 'MIKRONIEK' to readers of 'Glastechnische Mededelingen', 1 p.
A short bulletin giving information about the new society 'MIKRON, nederlandse vereniging van technici' (Dutch society of technicians) and its periodical 'MIKRONIEK'. The latter being distributed by way of introduction to G.T.M. readers.

— Information:
— Book: Stained glass — painting with light, Ed. Spectrum, Utrecht (Holland), 208 pages, illustrated, price HFL 125, (140 pictures).
Deals with an elaborate historical subject as an ancient form of art.

P.J. van der Burgh

GLASS/CERAMIC SEALS

We were faced with the problem of Silica furnace tubes being atteched by a corrosive gas, SO_2 at a temperature of 1800° C for treating specimens for 100 hours. It was found that these tubes would not withstand this treatment for the required length of time and so alternative materials were sought.

I do not claim that the technique described is new, but I found that on demonstration at various times, that many glassblowers were unaware of this possibility.

Using Aluminised Porcelain 525 (Thermal Syndicate or Morgan) or Mullite it is possible to join Q&Q joints as required, to the ceramic. Firstly the ceramic tube ends are feathered on a diamond edging wheel, then a section of W.1 glass is joined to these ends before joining the Pyrex joints. The ceramic tube is heated by a gas and air flame in the lathe to a cherry red, before bringing the W.1 into contact. The glass is then tooled down with a gas/oxygen flame to make a seal and the end of the ceramic is glassed as in glass/metal sealing. The W.1 is then blown out for the Q&Q joint required, to be joined.

Careful and slow annealing is necessary with a gas/air flame until a gas only flame forms a layer of soot at the joint. It was found these tubes were vacuum tight and a considerable saving in cost was made, as the tests were enabled to run for the required time and could be re-used almost indefinitely.

F.J. Luadaka

"ANDY" DOES THE B.S.S.G. PROUD

May 6th, 1977 will always be a date to remember in the life of Andrew Thompson, a Scientific Glassblower of Corning Limited and a well known member of our Society.

This was the day he presented President Carter with a piece of artistic glassware which he had constructed to commemorate the Presidential visit. This portrayed the famous legend of "George and the Dragon". President Carter's and Prime Minister Callaghan's tour included the ancestral home of the Washington family and a visit to the factories of Corning Limited of Sunderland.

At the end of the visit to Corning, Andy Thompson was introduced to the President and Mr. Callaghan and the presentation took place. "Andy" regularly enters the Society's competitions which are held each year to determine the most promising Scientific Glassblowers and Artistic Glassware Specialists. He has been particularly successful in these competitions having won the Flack Trophy for artistic work on three successive occasions and his entries for Scientific Glassblowing have gained him major honours on two occasions.

Corning Limited rewarded Andy recently by giving him a trip to their New York Headquarters so that he could demonstrate his skills to his American associates.

Tremendous interest was created among the Glass Craftsmen in the world famous Stueben Plant of Corning and local television covered his demonstrations.

President Carter was apparently delighted with Andy's gift and in a letter to Andy said he intended to put it on show in the White House after which he would present it to the American nation.

EIGHTEENTH

Symposium 1978

at Durham University

Thursday, Friday and Saturday
21st, 22nd, 23rd September 1978

Enquiries to: M. Oliver
50 Durham Road
East Herrington
Sunderland

LIBRARY NEWS

No. 6

ADDITIONS TO THE LIBRARY

BOOKS
Hazards in the Chemical Laboratory — G.D. Muir
Optics — W.T. Welford
The Glassmakers — T.C. Barker

JOURNALS
Vereinigung Deutscher Glasbläser Nachrichten No 4 Dec. 1977

BOOKLETS
Care and Handling of Glass Volumetric Apparatus — Courtesy of KIMBLE U.S.A.

CONTENTS OF: THE ART OF GLASSBLOWING

No. 8—1963 Let's Expand our Horizons — W.H. Haak
The Impact of an Advancing Science on the Glassmaker — G.B. Hares
Fitted Glass Filters — D.E. Ramm
Glass Lathe Chucks and Alignment of Glass Lathes — H.W. Nieman
A Device for Fabricating Coils of Glass Capillary Tubing — J.A. Perry
New Types of Glass Electrodes — J. Lees
The Use of Alumino-Silicate Glass in Microwave Devices — E.M. Doyle

Sealing to Silica and Similar Glasses — R.H. Dalton
Special Selection and Handling Techniques to be Observed in Fabrication of Optical High Purity Quartz Glasses — F.W. Wright
Characteristics of Fused Quartz and Techniques for Handling this Material and Some Recently Developed Varieties — R.J. Somer
High Temperature Phase Changes in Glass — O.H. Grauer
Glass Technology and Novel Information Presentation Devices — W.F. Niklas

Radiation Effects on Glass — P.S. Rudolph
Field Emission Microscopy — L.D. Smhmidt
Glass and Cryogenics — R.J. Szara
Optical Cryostats — Fisher-Haak-Johnson-Ramdas
Use of New Fluorocarbon Materials in the Design of Glass High Vacuum Valves and Joints — Abstract only — G. Urry
Glass Technology in the Computer Industry — J.H. Glaser
Unique Glass-Metal Seals Which are Thermally Cyclicol and Vacuum Tight — Dolenga-Gifford
Oxygen Outgassing Caused by Electron Bombardment ofGlass — J.L. Lineweaver

No. 9—1964 Strength and Weakness of Brittle Materials — C.J. Phillips
Ultra High Vacuum Technology — R.W. Roberts
Some Recent Contributions to Fused Quartz Technology — V.C. DeMaria

Quartz-Silica-Lucalox — R.J. Sommer
Sealing Glass to Ceramic Furnace Tubes — W.A. Gilhooley
Low Temperature Glass Seals — M. Liebson
Flame Spray Process and Spraying Techniques — F.J. Dittrich
The Elimination of Expansion Bellows and Spirals by use of Compression Strain — H.A. Kamphausen
Review of the Solder Glass Situation — K.G. Lusher
Sealing of Glass to Single Crystal and Polycrystalline Materials — F.W. Martin
Glass Technology Applied to Infra-red Detector Housing — S.R. Snyder
Infra-red Fibre Optical Materials — L.O. Upton
Moveable Componants in High Vacuum Systems — J.L.A. French
Quality Control Techniques in Apparatus Production — J.V. Armstrong
Practical Glass Cleaning — R.M. Tichane
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Manufacture of a Glass Thermometer — F.M. Weiss
The "Special Glass' Trend — F.L. Bishop
Designing with Glass and T.F.E. Plastic — J.F. McLay

BOOK REVIEWS

All the books reviewed here are available from the Library.

FURNACE OPERATIONS **R.D. Reed**
GULF PUBLISHING CO. 1976 **£12.00**

This book provides practical and useful information in the following areas. Flaring and Disposal, Efficiency and Fuel Conservation, Heat Transfer, Chimneys draft and flow of furnace gasses, Burners fuels and firing, Flow of fluids fuels and fuel systems, research and theory. The book also includes useful information on preventing air pollution and reducing furnace noise.

A glossary of terms is furnished to ease comprehension as well as an appendix of tables, containing basic information necessary in the process industries.

REDGRAVE'S HEALTH AND SAFETY IN FACTORIES **Judge I. Fyffe/E.A. Machin**
BUTTERWORTHS 1976 **£15.00**

A century ago the state of the law relating to factory safety was reviewed by a Royal Commission whose report foreshadowed the Factory and Workshop Act 1878, the first comprehensive essay in this field. In 1878 there also appeared the first edition of this book, the eponymous work of Alexander Redgrave, which in its successive editions has reflected the development of this branch of the law. Now it falls to this edition to include the far reaching provisions of the Health and Safety at Work etc., Act 1974, which was enacted following the Report of the Robens Committee "Safety and Health at Work (1972)" and the expressed purpose of which is to provide the framework within which there may in due course take place the progressive repeal of existing statutory provisions relating to industrial safety—among them the Factories Act 1961—thumb indexed for easy reference.

SULPHIDES (THE ART OF CAMEO INCRUSTATION) **P. Jokelson**
NELSON & SONS 1968 **£2.10**

This book provides an extensive history and biography for people who are interested not only in the beauty of sulphides, but in the history of the people they represent Some of the finest museum pieces and examples from private collections are represented by over 150 illustrations, many in colour.

QUARTERLY QUOTE

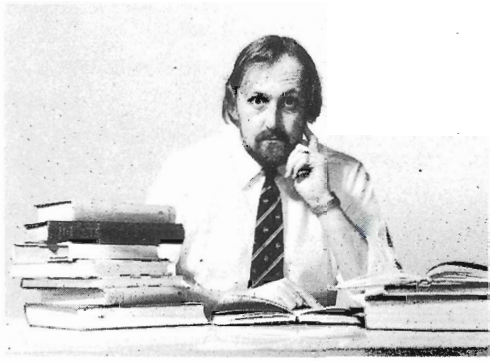
It is not wide reading but useful reading that tends to excellence.
ARISTIPPUS

HIGH VACUUM PUMPING EQUIPMENT **B.D. Power**
CHAPMAN & HALL 1966 **£5.00**

This book surveys the whole field of H.V. pumping equipment in detail. It provides information necessary in the proper choice of equipment, the correct design of systems, and the understanding of operation. There are discussions on the working principles, design, behaviour characteristics and operating procedure, for all important H.V. pumping devices used in reaching and maintaining pressures below 1 torr. Chapters are devoted to: oil sealed rotary pumps, oil and mercury diffusion pumps, vapour booster and ejector pumps, steam ejectors, mechanical booster on Roots pumps, molecular drag and turbo molecular pumps. Pumping arrangements depending upon: condensation and freezing, desicants or sorbents, ionisation and gettering are also considered. The book is fully illustrated with diagrams and tables.

REVIEWS FOR NEXT ISSUE

The Glassmakers	T.C. BARKER
Modern Physical Electronics	L. SOLYMAR
Making Stained Glass	R.G. METCALF
Optics	W.T. WELFORD



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ABSTRACTS

EDITED BY
P. HALLIWELL

Apparatus for the Measurement of Feedback Coefficient in Solid Biopolymers.
D.D. Ely, N.C. Lockhart, C.N. Richardson. *Journal of Physics E. Sci. Instrum.* 10, 12, 1220. December 1977.
Design and evaluation of an improved app. for the sensitive detection of small thermelectric effects in insulatry samples.

J.P.B.S.

Lampworking with Glass.
Keller Family. *Fusion.* 24, 1, 9. February 1977.
Lampworking was the earliest method known to the ancients working with glass, and for the first thousand or more years of the history of glass was the only viable means of any hand production. The article is the result of studies and experiments conducted by the Springfield School of Glass, U.S.A. for the purpose of establishing the history of Lampworking.

P.H.

Glass Optics.
J.D. Bain. *Fusion.* 24, 1, 23. February 1977.
A practical paper dealing with Shaping, Grinding, Polishing and Figuring.

P.H.

Technical Questions and Answers.
Fusion. 24, 1, 53. February 1977.
Questions answered include: How to put a spiral groove in a 54mm O.D. Tube. What type of material to use for moulds when press moulding small items.

P.H.

75 Years of Education and Examining in Leyden.
B. Kret. *Fusion.* 24, 2, 9. May 1977.
A brief history of the famous school in Holland.

P.H.

Technical Questions and Answers.
Fusion. 24, 2, 21. May 1977.
Questions answered include: How a sapphire window may be sealed to Kovar. What can be used as a sealing glass for non-magnetic metals.

P.H.

Glass Apparatus for Improved Gas Solubility Studies.
Dr. D. Krause Jr., G. Good. *Fusion.* 24, 3, 7. August 1977.
This apparatus and related equipment claims to be accurate to 0.01% depending upon the gas, much better than others have given. Diagrams and Photographs.

P.H.

An Inexpensive Medium Scale Preparative Electrophoresis Unit.
J.H. Harnson, J.A. Snyder, W.C. Harris. *Journal of Chem. Education.* 54, 8, 487. August 1977.
This paper presents a low cost temperature controlled unit which is easy to build and operate, and provides high resolution for small to medium scale experiments. Construction details, diagram.

P.H.

Technical Questions and Answers.
Fusion. 24, 3, 55. August 1977.
Questions answered include: A method of making quartz to borosilicate graded seals. What is the best material to make a mandrel for coiling 9mm OD quartz tube into a 3" circle with only the use of a cannon burner.

P.H.

Inexpensive Laboratory Flood Control and Alann Device.
A. Carlson, C.M. Criss. *Journal of Chem. Ed.* 54, 9, 573. September 1977.
A circuit diagram, sketch and instructions show the essence of such a system that has been successfully used. Other items such as heating mantles may be controlled.

P.H.

A Simple Glass Connector for Teflon Tubing.
J.I. Peterson, W.R. Dehn. *Journal of Chem. Ed.* 54, 9, 547. September 1977.
These glass connections, made by reamering the bore of heavy wall capillary tube, so the Teflon tube can be just pushed into the tapered section, can be used to interconnect lengths of Teflon tube of the same size, or different sizes by joining two sizes of glass together, and has found to be reliable in chromatography and other pressurized liquid systems.

P.H.

A Versatile Pen Holder for Chart Recorders.
H.J. Nieschlag. *Journal of Chemical Education.* 54, 9, 542. September 1977.
The pen holder described in this note can be installed on most recorders. It allows use of an inexpensive, pocket, nylon-tipped pen and requires only a small hole for mounting on the pen carrier. Diagram.

P.H.

Cell Cleaning Device for Small Optical Cells.
Fusion. 24, 4, 30. November 1977.
The note describes with the aid of sketch details on how to construct such a device.

P.H.

Permeation of Water at Low Pressure in Cellulose Acetate Membranes.
C. Fernandez-Pineda, J.I. Mengual. *Journal of Colloid and Interface Science.* 61, 1, 95. August 1977.
Line drawing of cell using glass cylinders and glass metal joints.

F.G.P.

The Influence of Contact Pressure and Saponification on the sliding Behaviour of Seavic Acid Monolayers.
R.J. Briscoe, D.C.B. Evans, D. Tabor. *Journal of Colloid and Interface Science.* 61, 1, 9. August 1977.
Unusual use to which two prisms are put to enable measurements to be made of a frictional force.

F.G.P.

A Simple Conductivity Bridge for Student Use.
G.M. Muha. *Journal of Chem. Education.* 54, 11, 677. November 1977.
This note describes a simple self contained unit suitable for student use for conductmetric titrations. Although it operates on the principle of the comparison method, it incorporates several improved features and is constructed using modern integrated circuits. Circuit diagram.

P.H.

Efficient Recovery of Sodium from Sodium Wastes
E. Chamot. *Journal of Chem. Education.* 54, 11, 665. November 1977.
A note describing how sodium may be recovered by using a modified Newmans technique.

P.H.

The Ox-Hydrogen Blowpipe.
J.D. Steele. *Journal of Chem. Education.* 54, 11, 657. November 1977.
A note cited from the 18th century book "A Fourteen Week Course in Chemistry". Illustration.

P.H.

Auxiliary Compartment for Coulometric Titrations
G.A. East, E. Bishop. *Journal of Analytical Chemistry.* 49, 12, 1885. October 1977.
The paper decribes with the aid of sketches an extremely simple and versatile auxiliary double compartment which is of low cost and resistance, readily assembled, utilizes stock materials, and has a small volume of intermediate electrolite/electrolytic contact area ratio.

P.H.

Solvent-Free Spitless Injection Method for Open Tubular Columns.
Leeuw, Maters, Meent, Boon. *Journal of Analytical Chem.* 49, 12, 1881. October 1977.
The introduction of samples into capilliary gas chromotographic columns is a matter of great delicacy. In practice this is often realised by using splitting devices. This report describes a spitless injection technique based on a very rapid and reproducible evaporation of a very small amount of solvent free sample. Detailed, Constructional and Operational Instructions. Diagrams.

P.H.

Metal Rod and Wire Electrode Holders.
G.A. East, E. Bishop. *Journal of Analytical Chem.* 49, 12, 1880. October 1977.
The paper describes novel electrode holders made of Teflon and silicone rubber that fulfil the requirements of experiments in constant current stripping coulometry. Diagrams.

P.H.

Precision Titrations Mini-Calorimeter
D. Ensor, L. Kullberg, G. Choppin. *Journal of Analytical Chemistry.* 49, 12, 1879. October 1977.
Paper describes the design and test of a reaction calorimeter operating with solution sample volumes in the range of 3-5mL.

P.H.

Non-membrane Amperometric Sensor for Dissolved Oxygen in Flow-through Systems.
Wolff, Mottola. *Journal of Analytical Chemistry.* 49, 13, 2118. November 1977.
The paper reports on the design and performance of an electrolytic (amperometric) non-membrane, three-electrode system with fast response to changes in dissolved oxygen concentration and specially suitable for use with solutions flowing in narrow tubing at constant rate. Diagrams, Constructional details.

P.H.

The Testing and Assessment of Materials Liable to Dust Explosion, or Fire.
J.H. Burgayne. *Journal of Chemistry and Industry.* 4, 81. February 1978.
In principle any combustible solid in a sufficiently finely divided condition may give rise to dust explosion hazard. Law now requires the recognition of industrial dusts liable to explode on ignition, and it imposes certain precautionary conditions on their handling in places of employment.

P.H.

Compendium of Low Temperature Physical Properties of Machinable Glass Ceramic Code 9658
N.W. Lawless. *Fusion.* 24, 4, 9. November 1977.
Because of its unique formability, the machinable glass ceramic Code 9658 is increasingly being used in various cryogenic applications. The feasibility of many of these applications depends on knowledge of the low temperature physical properties.

P.H.

Sealed Metal—Freezing Point Cell for Thermometer Calibration.
Henry E. Gostman. *Rev. Sci. Instrum.* 48, 10, 1351. October 1977.
Cell for realising the pure metal freezing points which are defining or reference temperatures of the International Practical Temperature Scale must be kept from degradation. Described is the design and construction of a sealed cell in which the danger of contamination is virtually eliminated.

J.P.B.S.

Superleaktight Teflon Gasket for use at low temperatures.
R. Gylling, M. Manninen, M. Veuro, W. Zimmermann Jr. *Rev. Sci. Instrum.* 48, 11, 1498. November 1977.
A commercial expanded Teflon gasket material, (Gore-Tex) in the form of 1mm diameter. Cord has been found useful in making 4He supertight seals.

J.P.B.S.

B.S.S.G.
ANNUAL COMPETITIONS

Thermal Award
A.D. Wood Cup
Corning Cup

All Student Entry

Flack Trophy
Open Competition
for
Artistic Glassworking

Competition Secretary:
R.G. Eustance
42A Boroughbridge Road,
Knaresborough,
Yorkshire

OPEN LETTER—TO ALL MEMBERS OF B.S.S.G.

If this article falls short of the usual literary standard it is because I am more at home with a torch in my hand than a pen. There is much, I feel, that is wrong within the society to a point where I wonder is it worth being a member any longer (after 12 years).

Something is missing, familiar faces fade away before one has put names to them.

On the surface the society progresses and looking back over 52 journals it is a credit to its members.

This is not the case.

Credit is due to a handful of individuals who have shaped the society "IN THEIR OWN IMAGE".

I must state at this point that I am judging the body mainly on the activities of my own section, SOUTHERN, though I am sure it is typical of most of the other sections.

Who do I blame for the situation?

Myself and the scores of people like me who have accepted what has been handed to them and said nothing.

In a word....APATHY.

Time and again my section committee have asked for advice, comments, criticism and every time I have had ideas and yet remained silent. I wonder how many members have done exactly that.

If this society is worth subscribing to it is worth becoming involved in.

In any association there are those who wish to lead and those who are content to follow, but the leaders must know — or the followers must indicate in which way they want to go.

Over the years I have seen many members in office. Look to your back issues and you will see the same names year after year after year. In the same office or another office or even taking on more than one task. Then they disappear.

Some I would like to think are replaced by people with the same enthusiasm, many I fear give up out of sheer disillusion.

I could go on, but would I also be wasting my time and anyway what is the point of this letter.

Well, I feel better for a start, why should I "DROP OUT" now my committee will get all my comments....or criticism.

Why don't you try it, you could feel better too.

W. Young
Southern Section

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Applicants should have at least 4 relevant 'O' Levels and be between 16 and 18 years of age.

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