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OF THE

BRITISH SOCIETY OF SCIENTIFIC GLASSBLOWERS

Vol. 7 MARCH 1969 No. 1

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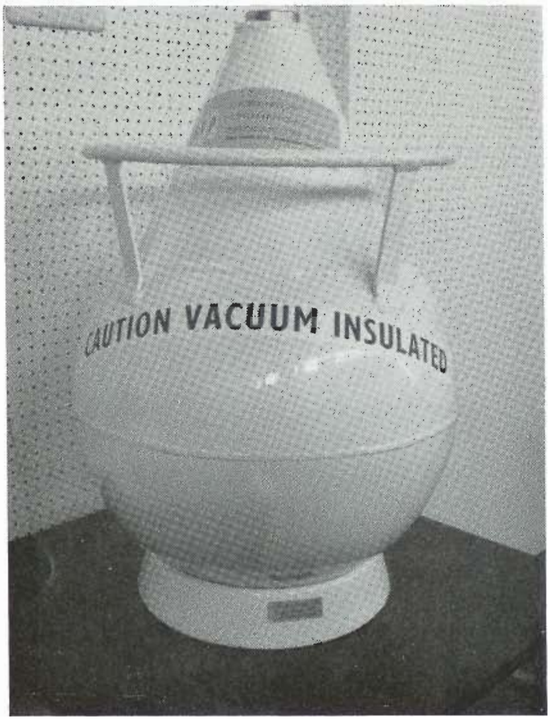

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9th Annual Symposium

18th, 19th, 20th September 1969

at the Royal Hotel and the Pavilion, Clacton-on-Sea, Essex

PROGRAMME

Thursday 18th September.

'Civic Reception' 8 p.m.

Friday 19th September.

10.00 a.m.	'Glassblowing Techniques'	Lecture and Discussion E. G. Evans
11.30 a.m.	'Training Scientific Glassblowers'	A. Behrens (Not yet confirmed)
12.15 p.m.	'Laboratory Optical Working'	R. Watkins
	LUNCH	
2.30 p.m.	'Q.V.F. Glass Pipeline'	Main aspect – Re-working pipeline apparatus James A. Jobling & Co. Ltd.
	Tea and Trade Exhibition.	
Evening	'SYMPOSIUM BANQUET, DANCE AND CABARET'	

Saturday 20th September

10.00 a.m.	'ANNUAL GENERAL MEETING'	
11.45 a.m.	'Technical Films'	A selection of British and American Films
	LUNCH	
2.30 p.m.	'Photographing Scientific Glassware'	Mr. Frank Joel (Smith & Nephew Research)
	Close	

The trade exhibition will be open during all breaks for refreshment and following tea each afternoon.

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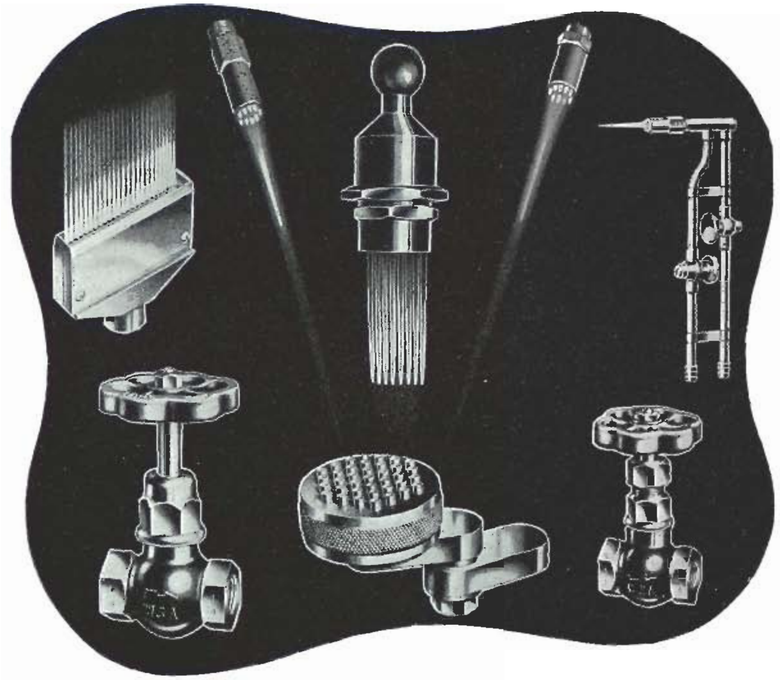

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VACUUM MEASUREMENT

by **J. C. SNAITH,** ***Physical Chemistry Dept., University of Bristol***

Lecture given at the Society Symposium 1968

1. Introduction

Pressure is measured by monitoring some property of the gas which is pressure dependent. Measurements in vacuo are required over a very considerable range, from atmospheric pressure to ultra high vacuum which is a billion times smaller. It is therefore not surprising that gas at one end of this range behaves in a way quite unrelated from that at the other. Consequently the gauge to be used for any particular system is decided more by the pressure at which it is to work than by considerations of size, accuracy and price. Similarly each type of manometer will work over a particular range of pressure which cannot be extended without considerable difficulty, expense, and loss of accuracy.

1.1 Gas Behaviour at Reduced Pressure

There is a range of pressures at which gas ceases to be like the fluid in which we live, a sort of light slightly viscous "liquid", and it then behaves as a collection of individual particles, the atoms or molecules. This change occurs when the particles no longer collide with each other very frequently, that is when the gas is sufficiently rarefied for the molecules to cross from one wall of their container to the other with only a very slim chance of meeting one of their fellows on the way. The change is described mathematically in terms of the mean free path, λ, which is the distance that the average particle will travel without a collision with another gas particle and is given by

$$\lambda = 8.59 \frac{\eta}{P} \left[\frac{T}{M}\right]^{1/2} \text{cm}$$

where η=viscosity (poise), P=pressure (torr), T=temperature, M=molecular weight.

The size of these parameters is similar for every gas, so that the transition of behaviour occurs over the same pressure range for each gas.

The change from bulk to individual behaviour occurs when λ is the same order as the size of the container, e.g. the pressure gauge at say 4 cm diameter, which corresponds to a pressure of about 10^{-3} torr (see Fig. 1). Particular properties noticeable to the vacuum engineer under the different conditions of vacuum are listed in Table 1.

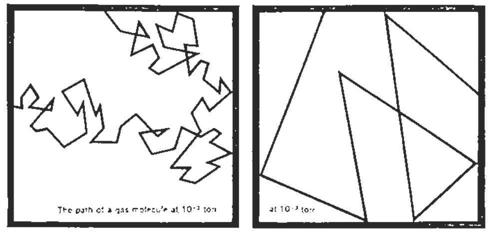

Fig. 1
Molecular paths

2. Gauge Operation

The devices used by gauges for the "bulk" region and those for the "individual" region are conveniently described as mechanical gauges and electrical gauges respectively. A third group which operate in the transition region make use of the dramatic loss in thermal conductivity between the two main groups. Table 2 lists the commonly used gauges, their operating ranges and method of operation.

For detailed information about the individual gauges and matters of vacuum technique there are many volumes on the subject. The books by Leck (1964) and Dushman (1962) have both been of considerable value in the author's laboratory.

2.1 Mechanical Gauges

Mechanical gauges use the force exerted by the gas to determine its pressure. This direct use of the definition of pressure as force per unit area means that every gas has the same action upon the gauges i.e. a reading of 10 torr means exactly the same whether it is air or xenon being measured. At the highest pressures we are considering, forces which are exerted by the gas are easy to measure, being of the order of several ounces per square inch.

At a thousandth of atmospheric pressure when there is not enough force available to support a

TABLE 1
Properties of Vaccua

760 – 1 torr	10^{-5} torr and below
Bulk properties	**Individual properties**
Viscous	No Viscosity
Exerts force	No force exerted
Has thermal conductivity (but not pressure dependent)	No thermal conductivity
A change made to one molecule is rapidly shared among the others.	Any molecule may be labelled (e.g. ionised) and counted.

column of mercury even 1 mm high, straight forward techniques are not then applicable and the increasing complexity necessary makes mechanical gauges for lower pressures unsuitable for general use.

Mechanical gauges are in general

(1) simple
(2) independent of type of gas
(3) absolute (no need to calibrate)

2.2 Electrical Gauges

There are numerous gauges which exploit the electronic properties of a gas molecule either by promoting outer electrons to an excited state, when they give off a coloured glow characteristic of the gas which is detected visually as the electrons jump back into their standard state. Excitation of the atoms is carried out by a high voltage, high frequency discharge through the gas produced by for example a tesla coil. A less crude method is to remove an electron from the molecule altogether. The resulting electron deficient particle (positive ion) is then attracted electrostatically to a conveniently placed electrode and "counted" as an aggregate ion current. Alternatively the ions are directed into a mass filter which separates the ions from the different gases into groups with the same charge per unit weight which are then counted individually, giving a mass spectrum of the gases present. These mass spectrometers are by far the most useful and informative instruments in vacuum technique and very few ultra high vacuum systems are considered complete without one.

Ionisation of the gas molecules is accomplished in one of two ways:

1. Collision with an electron produced by
   (*a*) hot filament
   (*b*) field emission (several kilovolts required)
2. Collision with an α particle from a radioactive source within the gauge.

At low pressures collisions are infrequent as shown above, and to give an acceptable ionising efficiency the electrons are caused to travel exaggerated distances by using wire cages for anodes which the electrons miss easily, or external magnetic fields which cause them to travel in tight spirals. In this way the path of an electron can be extended to several metres in a tiny gauge head.

Ionisation gauges therefore operate by removal of a constant proportion of gas in the gauge head as ions, which constitutes a pump.

Furthermore, when an electron is accelerated by a high voltage and strikes the anode, x-rays are produced which cause extra ion currents when they fall on the ion collector electrode. This constant ion current limits the lowest pressure which can be measured by a particular gauge geometry and operating potentials.

Some gases are more difficult to ionise than others depending on the ionisation potential and area of cross section so that for a similar constant ionising source, an electron current for example, the number of collisions and the proportion of them which produce an ion for collection varies from gas to gas. The gauge must therefore be calibrated for each gas. Conveniently a constant

TABLE 2
Summary of Gauges.

Pressure Range	MECHANICAL	THERMAL	ELECTRICAL
Atmos.-1mm	U-TUBE DIAPHRAGM VISCOSITY	THERMISTOR	DISCHARGE TUBE
1mm-10^{-4}	McLEOD	PIRANI THERMOCOUPLE THERMISTOR	TRIODE ION SCHULZ PHELPS
10^{-3}-10^{-7}	McLEOD KNUDSEN		PENNING TRIODE. BAYARD-ALPERT
10^{-6}-10^{-12}			READHEAD B.A. HOUSTON MASS SPECTROMETERS

factor separates the pressure of nitrogen (the usual standard) from the pressure of any other gas which would produce the same ion current throughout the pressure range. A table of these factors is given in Leck, p. 82.

An ion gauge makes a handy leak detector, for if a gas with a widely different gauge factor from that already in the system is introduced through the leak a noticeable response can be seen on the pressure meter indicating the whereabouts of the leak.

Electrical gauges

1. Cover huge range
2. Measure very low pressures
3. Require only a simple conversion factor for different gases
4. Pump quite fast
5. Cause considerable disturbance to the molecules

2.3 Thermal Gauges

The thermal gauges rely on the change in thermal conductivity of gases with pressure. Above 1 torr and below 10^{-4} torr there is little change in the gas conductivity, but between these limits it changes from its high pressure value to virtually zero.

The principle of operation of all these gauges is to maintain an object, usually metal, in the gas at a constant temperature and to measure the power required or some simple variation on this theme. As the conductivity falls with pressure the heat lost by the sensing element to the walls of the gauge decreases and less power is required to maintain it at a given temperature. The precise manner in which the conductivity varies with pressure is different for each gas so that a simple conversion factor is not adequate and a separate calibration curve is required throughout the pressure range.

The temperature used in these gauges is low (around 100°C), the voltages required very small, and no gas is removed from the system when the gauge is operating. The sensing element can be chosen as some inert material or glass encapsulated. Thermal gauges are the most inert of all, exciting little or no influence on the system to which they are attached.

Thermal gauges

1. can be made very accurate
2. are inert
3. work only over a small range
4. require full calibration for each gas

3. Measurement Technique

3.1 Using Mechanical Gauges

The simplest instruments use some work fluid such as a low vapour pressure oil or mercury. Mercury is volatile, S.V.P. $\sim 10^{-3}$ torr, so this liquid makes its presence felt throughout the vacuum system. Oil manometers need careful outgassing by heating and pumping to avoid bubbles forming at inconvenient times and random local changes in density. The oil will frequently dissolve large quantities of gas from the system at low pressure.

A McLeod gauge is probably the only example of a widely used type gauge which is operating outside the convenient pressure range for its type in this case "mechanical". A brief consideration of its problems will illustrate the point.

The readings of pressure given for gases which are below their boiling point at atmospheric pressure are inaccurate owing to liquefaction or condensation on the capillary walls. Thus the presence of condensible vapours must be excluded before the readings can become meaningful as the vapour pressure of the work fluid is frequently above the pressures to be "measured".

These problems can be overcome by cold trapping, but then the constant stream of mercury vapour from the gauge to the trap works like a diffusion pump evacuating the McLeod gauge and causing errors of up to 10%.

The gauge is also inconvenient as it is not continuous reading having to be run up and down for each determination so that rapid pressure fluctuations are missed altogether. There must be some telling advantages to account for their popularity for general use as opposed to use as a calibrating instrument.

3.2 Using Electrical Gauges

Electrical gauges produce excited atoms and ions which can be troublesome when the gas is used in some chemical study. Even the hot filament of an ion gauge say Tungsten at 2,000°C, can cause dissociation of hydrogen. At low pressures (10^{-6} and below) these gauges cannot be relied upon to give true pressure indications and 10% accuracy or even reproducibility is all that can be expected.

There are several reasons for innaccuracy which can be eliminated.

1. Gas streaming along a tube at low pressure with individual molecular behaviour may never find its way into a side arm containing a gauge so the pressure (now only meaningful in terms of No. of molecules per cc) is recorded too low and if in line with the stream, too high (Holland and Priestland, 1966).
2. Ion gauges pump very fast and cold cathode gauges (Penning, Redhead) pump at least ten times faster than hot cathode ion gauges. When a Bayard-Alpert ion gauge is operating at 100μ A emission (few control units will operate on less than this) it will produce an ion current of 10^{-13} amp which corresponds roughly to 10^6 ions collected per second. At 10^{-10} torr there are only 10^6 molecules per cc so that in a 100 cc gauge head 1% of the gas is removed every second. Most other types of ion gauge will pump faster than this. When pressure is to be known with any reliability other than in the gauge head, a tube of large conductance must connect the gauge head to the

section of the apparatus in question, or alternatively a "nude" or envelope free gauge can be mounted inside the vessel.

3. The sensitive amplifiers used to measure such minute currents respond to electrical disturbances in the vicinity. A tesla coil operated several yards away will register upon the pressure scale. Furthermore traces of evaporated metal or other contaminants inside and outside the gauge envelope between the terminals cause the insulation of the collector to become leaky, as for instance after outgassing the gauge at too high a pressure. Earthing all the other electrodes and applying a tesla discharge to the collector is usually effective in breaking down the leak path, but the gauge should be replaced as soon as is convenient. The normal plastic or rubber insulation on the 150v line to the grid of a hot cathode gauge is not proof against noticeable leakage to the ion collector lead, so these two should not be allowed to come into contact at all beyond the point where the collector's screening braid has been stripped away.

3.3 Thermal Transpiration

When two vessels containing gas at low pressure at different temperatures are connected by a tube or orifice, depending on the temperature difference a pressure difference will be set between them. At low pressures, i.e. when the mean free path of the gas is considerably more than the diameter of the connection between the vessels, say below 10^{-5} torr, this pressure difference, expressed as the thermal transpiration ratio, R, becomes

$$R = \frac{P_{hot}}{P_{cold}} = \left[\frac{T_{hot}}{T_{cold}}\right]^{1/2} \qquad \text{Knudsen 1910}$$

i.e. for liquid nitrogen as the cold and room temperature the hot baths respectively, pressures measured with a gauge at room temperature are nearly twice as large as that in the cold section of the apparatus. For high pressures, above 1 torr, the ratio becomes unity. The value of R throughout the pressure range has been the subject of much experiment and the following empirical equation has been suggested by Liang

$$R = \frac{\alpha(\phi_g X)^2 + \beta(\phi_g X) + R_m}{\alpha(\phi_g X)^2 + \beta(\phi_g X) + 1}$$

where α and β are experimental constants
φ_g is a constant peculiar to the gas in use
R_m is limiting value for low pressures
$X = P_2 \times$ diameter of tube at the temperature gradient in mm.
(Liang 1953)
R_m is usually accepted as the Knudsen value of

$$R = \left[\frac{T_1}{T_2}\right]^{1/2} = \frac{P_1}{P_2}$$

α and β were given by Liang as 2.52 and 3.74 for $T_2 = 295°K$, $T_1 = 77.5°K$, but more recent experiment using modern techniques indicate that $\alpha = 2.13$, $\beta = 2.35$ are more acceptable (Edmonds and Hobson 1965).
$\varphi_g = 1$ for Helium and for other gases φ_g can be calculated from the equation $0.27 \log \varphi = \log r - 0.41$, where r=collision diameter which gives, for xenon, for example, $\varphi_{Xe} = 6.87$, whereas the author has computed that $\varphi_{Xe} = 10.1$ gives a better fit to published data for xenon (Podgurski and Davis 1961) using the new α and β, see Fig. 2.

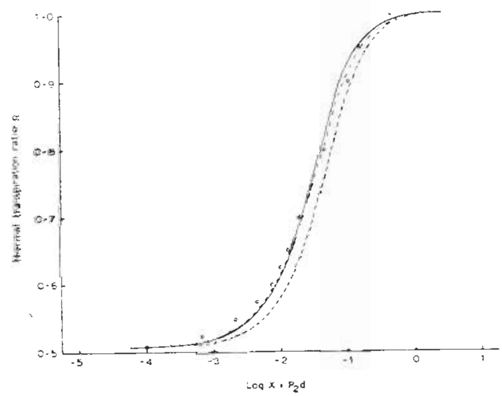

Fig. 2
Thermal Transpiration for Xenon
$T_1 = 77°K$ $T_2 = 299°K$

o Podgurski and Davis smoothed experimental points.
– – – – Liang Equation, Edmonds and Hobson values for α and β
–.–.–. Liang Equation, original values
——— Liang Equation, Edmonds and Hobson values for α, β authors' value for φ_{Xe}

It is clear therefore that while Liang's equation can be made to describe the variation of thermal transpiration ratio R very accurately, the constants must be chosen with care in the light of reliable experiment with the gas to be used, and in a system as similar as possible to that on which the correction is to be applied, particularly with regard to diameter of tubing and temperatures at the thermal gradient. A useful list of such measurements is given in the paper by Edmonds and Hobson.

Another equation has been used which is probably sufficiently accurate for most purposes (Ebert and Albrand 1963 also Hobson 1965).

$$R = \frac{P_1}{P_2} = \left[\frac{T_1}{T_2}\right]^{1/2(1+d/\lambda)}$$

where d = diameter of tube
λ = mean free path

Vacuum measurement is certainly a difficult occupation and the arrival of a perfect gauge will still not leave us problem free.

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THERMAL SYNDICATE AWARD

Extract from letter of 17th May 1968, to Mr. E. G. Evans.
Reported to and accepted by Council 28th July 1968.

(1) We will provide some form of trophy – probably a cup – which can be competed for annually among any student or apprentice member of your Society, by which we mean someone with less than five years experience as a scientific glassblower. The trophy will be awarded for the best submitted piece of apparatus fabricated primarily in vitreous silica but which may obviously include graded seals to other glass, etc. You may if you wish additionally stipulate that the trophy is not necessarily awarded in any year if only articles of insufficient merit are submitted.

(2) That we will provide annually a small replica of the above trophy, or perhaps a medal, if the trophy is in a form where a replica would be unsuitable, which the recipient may keep.

(3) That in addition to the above award your Council may choose a student for whom we would pay the expenses to spend up to a week in our own Works and where such a student could attend our Apprentice School and perhaps also some time in the Research Department.

We would expect that you would choose such a student on the basis that he had not previously had any appreciable experience in the working of vitreous silica but that his future career was likely to involve such work. We would expect also that such a student was not connected with any firm commercially interested in the sale of vitreous silica products. We do not, of course, wish to exclude students working for commercial firms who use vitreous silica in the manufacture of other products.

Entry pieces for the award must be in the hands of a member of the Board of Examiners by the end of July. The successful candidate will be notified and arrangements will be made to receive the award at the Annual Symposium.

Those members interested in the Studentship should notify their Section Secretary and Mr. N. H. Collins, 8 Holden Terrace, Waterloo, LIVERPOOL 22.

A. D. WOOD AND JOBLING CUPS

The attention of all **Student Members** is again drawn to the annual competitions. The two cups will be presented at the Symposium to the entrants whose work is judged by the Board of Examiners to be the most outstanding examples of craftsmanship. In addition certificates will be awarded to all entrants whose submitted work is considered to be of sufficient merit.

Entry pieces must be in the hands of a member of the Board of Examiners by the end of July. It is hoped the two successful entrants will attend the Symposium to personally receive the cup; with this in mind they will be notified of their success by the beginning of September. The Society will ensure the winners will not be seriously out of pocket by attending the Symposium.

A. D. Wood Cup To be held by the successful candidate for one year with a replica to be the entrant's personal property. Entrants for this award must be Student Members of the B.S.S.G. with glassblowing experience not exceeding three years.

Jobling Cup To be held by the successful candidate for one year with a replica to be the entrant's personal property. Entrants for this award must be Student Members of the B.S.S.G. with glassblowing experience not exceeding five years.

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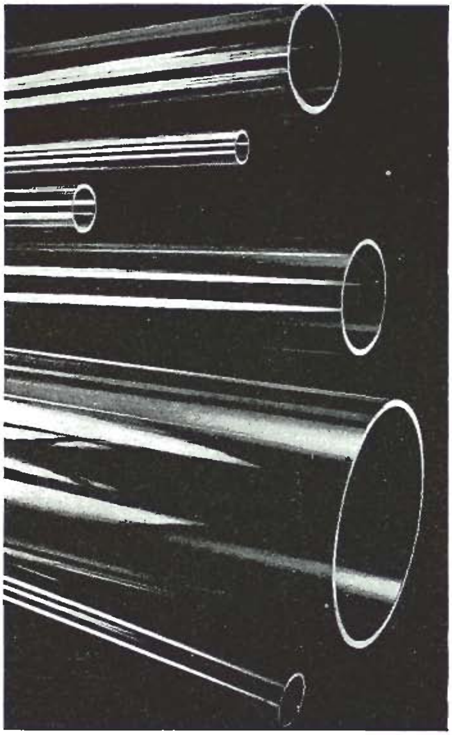

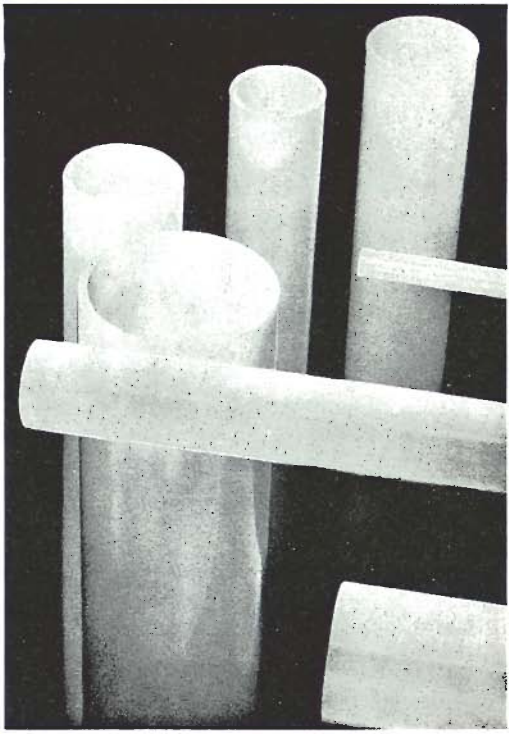

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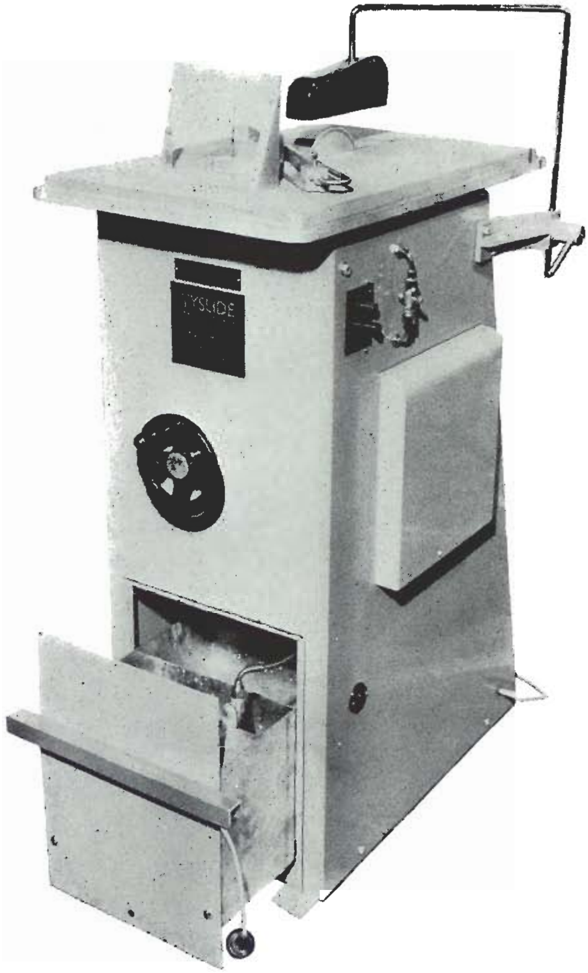

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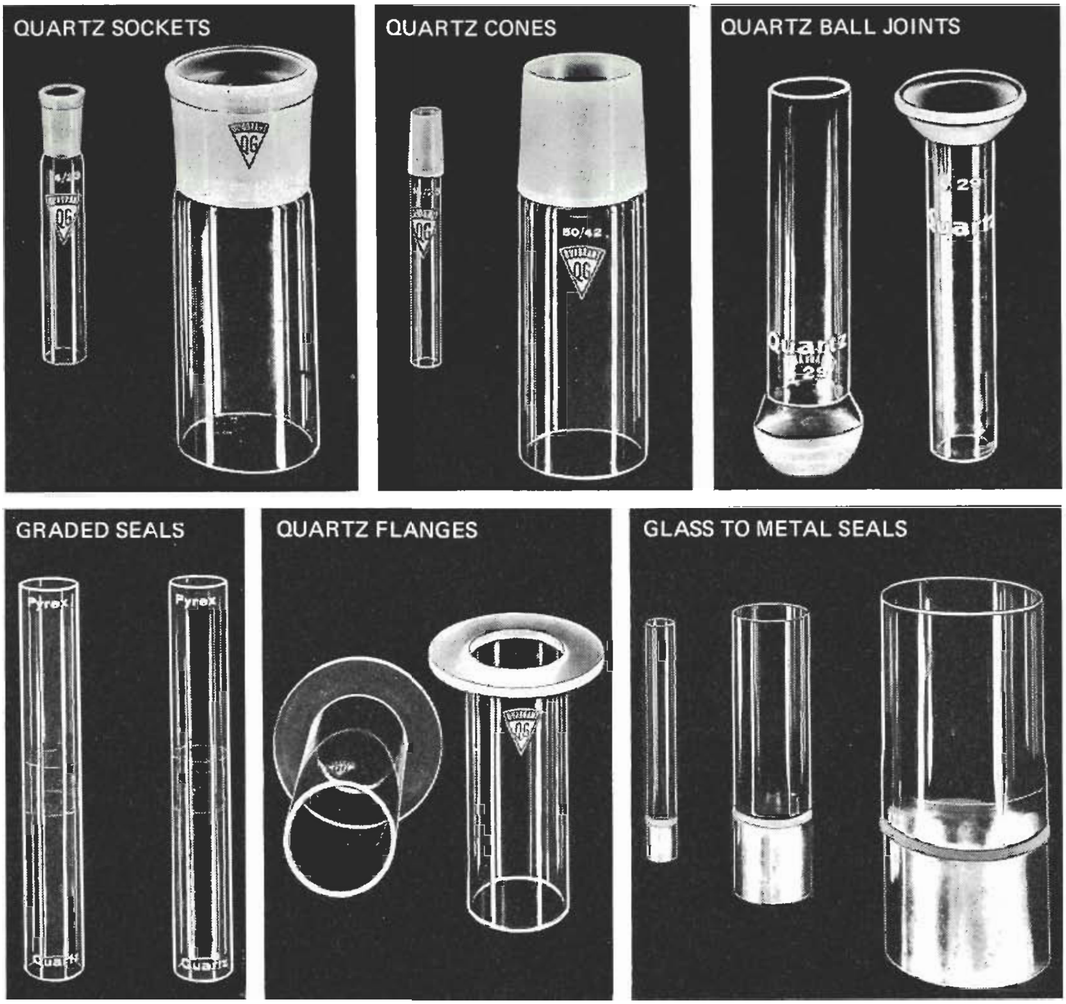

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ABSTRACTS

Compiled by S. D. Fussey, A.W.R.E.

GLASS APPARATUS

(548) **A Novel Stopcock for Gas Mixing of Solutions.**
F. R. Longo, P. H. Daum and T. Cachaza, *Jour. Chem. Educ.*, 45, 8, 541, Aug. 1968.
Four-way stopcock with gas entry through handle enabling mixing to take place in thermostat bath without removal. F.G.P.

(549) **An Apparatus for Large Scale Sublimation.**
R. I. Walter, *Jour. Chem. Educ.*, 45, 8, 539, Aug. 1968.
Cold finger, separate from rest of system, flange sealed with supported 'O' ring, capable of 5 grm. of sublimate per hour. F.G.P.

(550) **A Wing-Top Water Spreader.**
D. F. Montecalvo & D. F. Jacques, *Jour. Chem. Educ.*, 45, 7, 479, July 1968.
Apparatus for spraying water on to condensating flask of rotary evaporator using a fishtail jet. F.G.P.

(551) **An Easily Constructed Hour Cuvet.**
W. T. Roubal, *Jour. Chem. Educ.*, 45, 6, 439, June 1968.
A monitor for flowing streams in spectrophotometers. Description of use and manufacture in silica or pyrex. F.G.P.

(552) **A Mercury Dispenser.**
Iver W. Duedall, *Jour. Chem. Educ.*, 45, 6, 393, June 1968.
Simple tube using glass bead as a ball valve to both weigh and dispense mercury when calibrating small volume apparatus. F.G.P.

(553) **A Simple Dilatometer for Liquids.**
R. E. Wagner & E. F. Meyer, *Jour. Chem. Educ.*, 45, 5, 349, May 1968.
'U' Tube with capillary limb 20 ml. volume, actuated by Teflon needle valve. Accurate to plus or minus 0.002g/ml. F.G.P.

(554) **Oxidation of Ferrous Hydroxide Colloid.**
Katsuya Inouye, *Jour. Coll. Inter. Sci.*, 27, 2, 175, June 1968.
Schematic drawing of glass components for measuring gas effusion and gas permeability. F.P.G.

(555) **Determination of Trace Sulphur in Hydrocarbons by Pyrolysis and Hydrogenation.**
L. L. Farley & R. A. Winkler, *Jour. Anal. Chem.*, 40, 6, 962, 1968.
Description of a rapid, accurate method for the determination of sulphur in the fractional parts per million range by means of pyrolysis and hydrogenation. The spectrophotometric finish covers the range 0.2 to 5.0 ppm with an accuracy of plus or minus 10% of the amount present. Sketches and refs. B.R.W.

(556) **A Glass Trap for Absorbing the Fumes from Perchloric Acid Digestions.**
G. Benneyl, *Lab. Pract.*, 17, 3, 361, Mar. 1968.
Based on the design of Ekman 1949. Using a water pump, the fumes are drawn through a water trap and then through a porosity 3 glass sinter. Perchloric acid distilled from Kjeldahl flask at a rate of 1ml/min. gives at least 99% of the acid recovered in the trap. B.R.W.

(557) **Simple Apparatus for Measuring the Rate of Evolution of a Gas from a Reaction at Constant Temperature.**
R. T. Jacobson, *Lab. Pract.*, 17, 9, 1010, Sept. 1968.
Apparatus for measuring the rate of evolution of nitrogen. Sketch. B.R.W.

(558) **A Gas Mixing and Sampling Flask.**
R. P. De Grazio, *Jour. Gas Chrom.*, 6, 468, Sept. 1968.
Using a 500 cc. flask with two gas inlet ports, one of which is the syringe unit, the gases are mixed with a stainless steel propeller with an external magnetic rotary unit. In use over five days, five samples gave no difference peaks. Drawing, graph. D.A.H.

(559) **Turbidimetric Titrations of Polymers.**
W. Beattie and H. C. Jung, *Jour. Coll. & Inter. Sci.*, 27, 3, 585, July 1968.
An all glass, thermostatted and stirred light scattering cell. Diagram. F.G.P.

(560) **General Purpose Gas Sampling Tube.**
Earl Nagle and F. J. Norton, *Rev. Sci. Instr.*, 39, 9, Sept. 1968.
A gas sampling tube useful for mass spectrometric and other types of gas analysis. Dimensioned sketch. S.D.F.

(561) **All-Glass Recording Membrane Manometer.**
V. Chytry and Dhim, *Jour. Sci. Instr.* 1, series 2, 964–965, Sept. 1968.
An all-glass manometer having a pressure range 10 to 760 torr and precision of plus or minus 1%. An induction detector connected to a glass membrance by means of a long glass rod, enables deflection of the membrane to be converted to an electrical signal. Full description of construction and operation. Sketch. D.A.H.

GLASS TECHNIQUES

(562) **Large Molybdenum - to - Glass Seal.**
W. Elsholz, *Fusion*, 15, 3, 11–12, Aug. 1968.
Forcible cooling with compressed air enabled the author to make $\frac{3}{16}$" diameter molybdenum to 7052 glass seals used in the construction of hydrogen thyratrons. S.D.F.

GLASS TECHNIQUES

(563) **Thermo-shock Cutting of Glass Tubing.**
J. B. Chevallier, SIRA Rev., 9, 4, 121-122, Aug. 1968.
Development of equipment and parameters for cracking off smaller diameter glass tubing. S.D.F.

(564) **A Simple Technique for sealing Molybdenum to Alumina or Platinum to Alumina by means of a Glass-ceramic Seal.**
P. S. Rogers, J. Butler and B. C. H. Steele, *Jour. Sci. Instr.*, 2, series 2, 102, Jan. 1969.
From a given formula a glass melt is made and then crushed to pass a 150 mesh sieve. A further melt is given with CaF_2 at 1400°C, crushed and sieved again to pass 400 mesh. A paste is made with water and applied to the components. Three temperature gradients are used for the sealing. Mean co-efficient of expansion, $10{\cdot}1 \times 10^{-6}$ over temp. range 20-700°C. D.A.H.

MATERIALS

(565) **Diamond in the Laboratory.**
P. Mansdan, *Lab. Equip. Digest*, 6, 9, 65, Sept. 1968.
Description of various standard industrial diamond tools which are used in the laboratory and some which have been devised specifically for research. Some diamond applications in the manufacture of laboratory equipment are outlined. B.R.W.

GLASS

(566) **Glass-Making at SIRA**
J. Dracass, *SIRA Rev.*, 9, 4, 123–125, Aug. 1968.
A brief review of some of the accomplishments and available glass-making facilities at SIRA. S.D.F.

MISCELLANEOUS TECHNIQUES

(567) **Method of Stretching Polypropylene for Use as Soft X-Ray Detector Windows.**
A. J. Caruso & H. H. Kim, *Rev. Sci. Instru.*, 39, 7, 1059–1060, July 1968.
Preparation and evaluation of propylene as a soft X-ray detector window material. Film of approx. 26 micron thickness is reduced to 1 micron by stretching in a simple vacuum apparatus. Interference colours give guide to thickness. S.D.F.

(568) **A Technique for the Production of Transparent, Electrically-Conducting Tin Oxide Films on Glass Substrates.**
R. G. Livesey, E. Lyford & H. Moore, *Jour. Sci. Instru.*, 1, series 2, 947, Sept, 1968.
2" dia. pyrex tubes and 2" x 2" pyrex slides were coated by this process. Oxygen at the rate of 3 L per min. is blown over heated stannous chloride crystals, the resulting vapour being carried to the heated substrates via a tube. Films so formed had electrical resistance of 100-500 ohms per square cm. with optical transmission in the region of 85%. D.A.H.

(569) **AgCl Seal; A Simplifying Improvement.**
B. Caras, *Rev. Sci. Instr.*, 39, 10, 1441-1442, Oct. 1968.
A roughened surface produced by local grinding of the glass in the seal area permits preferential spreading of molten silver chloride. S.D.F.

(570) **A Method of Cleaning Glass Substrates.**
P. G. Hunt, *SIRA Rev.* 9, 4, 131, Aug. 1968.
A six-step method of cleaning glass substrates particularly related to the production of thin films. S.D.F.

(571) **A Controlled Temperature Cold Trap.**
A. F. Hyde and R. A. Redford, *Jour. Sci. Instr.*, 1, Series 2, 871, Aug. 1968.
Description of construction and operation of a glass trap

capable of being held indefinitely at any temperature between —196 and 0°C. A two-section glass tube is assembled with five thermo-couples and heater over insulating windings. The completed tube may be cooled by placing in a copper block immersed in liquid nitrogen or by sealing into a tube which is then filled with hydrogen and then immersed in liquid nitrogen. The trap may be used for separating gases, e.g. carbon dioxide and water vapour. Drawing. D.A.H.

(572) **48,000 Lamps a Day.**
A. Scott, *Engin.*, 207, 5360, 106-108, Jan. 1969.
The latest Badelex machine, with three attendants, can produce 2,000 general lighting service tungsten filament lamps an hour. The machine has nine sections integrated into one plant, performing all processes from stem making through to performance checking. S.D.F.

VACUUM

(573) **A particularly simple and inexpensive High vacuum lead-through.**
J. B. McKinnon, *Jour. Sci. Instru.*, 1, series 2, 969, Sept. 1968.
A cheap, solderless seal using marketed components of several sizes. A silver-plated, barbed spill is pushed into, and expands a PTFE bush inserted into a hole in the vacuum component. Five such seals, used with currents of 20 amps continuous and 50 amps intermittent, gave a leak rate of 7μ torr per sec. [1] D.A.H.

(574) **Obtaining high-temperature, vacuum-tight joints when glueing parts with vacuum cement.**
N. A. Mescheryakov, L. A. Kabanova & B. I. Boiko, *Instru. and Exper. Techs.*, 4, 919-920, July/Aug. 1967.
Details of making and using a vacuum cement for joining unlike materials. S.D.F.

(575) **Compact version of the ball and socket ultra-high vacuum valve.**
M. P. Hill & A. H. Moore, *Jour. Sci. Instru.*, 1, series 2, 953, Sept. 1968.
A robust design for larger sized ball valves. A winding-up system, incorporating a locking device, is used to raise the ball. A groove in the ball unit may be used as a calibrated leak. Drawing. D.A.H.

(576) **High vacuum micromanipulator.**
C. P. Dolan, *Rev. Sci. Instru.*, 39, 7, July 1968.
Mostly standard components are used to make this multi-directional manipulator. Mounting in a glass cross gives full view of the movement of apparatus attached to the operating end. Photograph and schematic drawing. S.D.F.

(577) **High Vacuum Feedthrough for Rotational and Trans lational Motion.**
C. S. Parmenter and M. W. Schuyler, *Rev. Sci. Instr.*, 39, 4, 611, April 1968.
A simple device using part of the body of a greaseless stopcock sealed through a chamber wall with epoxy resin. Sketch- S.D.F

MISCELLANEOUS

(578) **Servicing Electronic Laboratory Equipment**
L. W. Price, *Lab. Pract.*, 17, 9, 1006, Sept. 1968.
How to trace faults in, and care for a number of electro-chemical instruments is described. These include *p*H meters, titration equipment and oxygen and CO_2 electrodes. B.R.W.

(579) **Fabrication of Springs for a Variety of Uses.**
W. S. Gilman, *Jour. Chem. Educ.*, 45, 6, 385, June 1968.
Describes method of forming wires springs using machine screws as mandrels. F.G.P.

(580) **A Differential Expansion Holder for Kovar Parts.**
G. S. Sidhu & Davinder Singh, *Jour. Sci. Instru.*, 1, series 2, 883, Aug. 1968.
The use of a brass ring to hold kovar parts ensures a tight fit when glass-to-metal seal is made. Detailed drawing. D.A.H

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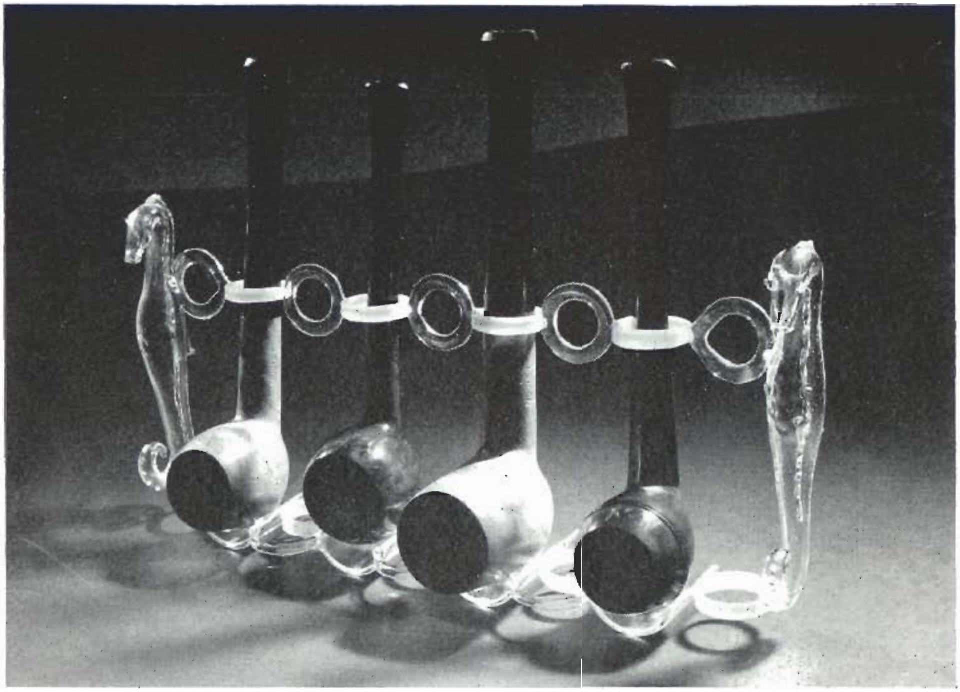

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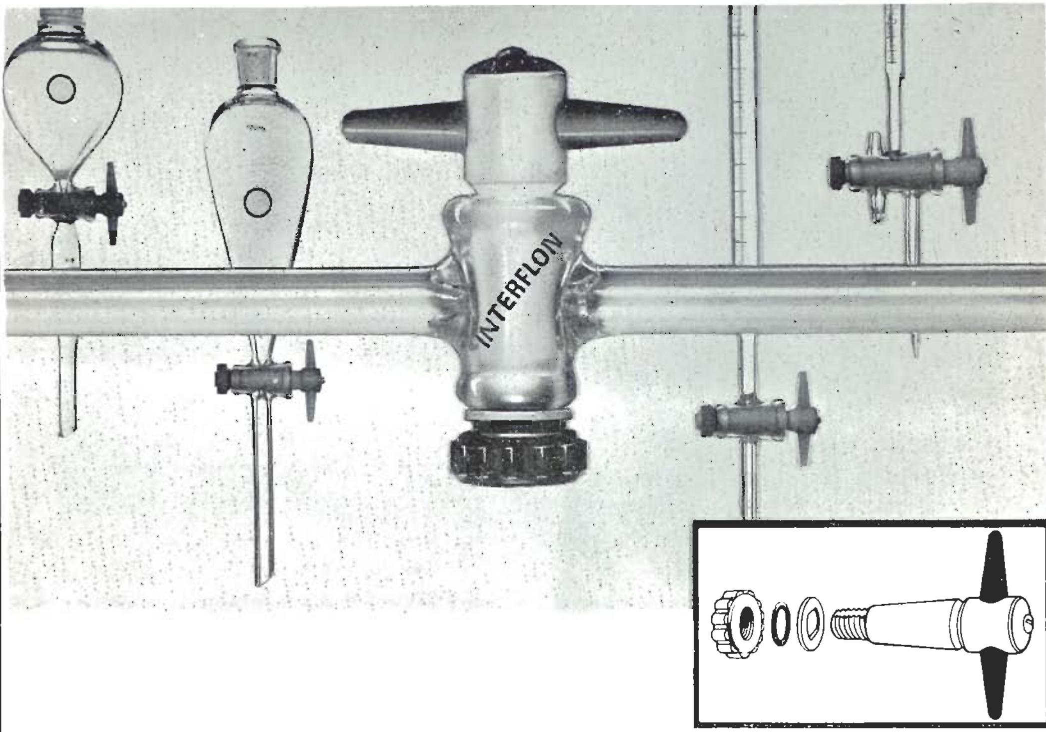

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TEMPERATURE MEASUREMENT

By Dr. J. L. HALES Chemical Standards Division, National Physical Laboratory
Lecture given at 1968 Symposium

There is a universal interest in the measurement of temperature. Whether inside or outside the laboratory, people are concerned to measure temperature or to relate it to other variables. The range of applications is legion including such diverse subjects as the stars, volcanoes, the earth's atmosphere, the human body, industrial furnaces and greenhouses.

Temperature cannot be measured directly in the sense that length can be measured. It is necessary to use a "transducer" which produces a corresponding scale reading or electrical quantity. Thus in a mercury thermometer a change in temperature produces a change in the volume of mercury, which is measured as the change in setting of mercury level in a capillary tube adjacent to a linear scale.

It is necessary to define the temperature scale. The traditional Centigrade (now Celsius) scale used the "ice" and "steam" points at 0° and 100°C respectively. The basic Thermodynamic Scale has only one fixed point, the triple-point of water at 273.1600K (0.0100°C). A sealed glass triple-point cell, containing only purified water, is used to define this temperature to within $\pm$ 0.0001°C. The Thermodynamic Scale is defined by a constant-volume gas thermometer, which relies on Boyle's law to achieve a close correlation between pressure and temperature. Pressure is measured to a high accuracy and corrections are applied to allow for slight deviations of the gas from Boyle's law. The thermometer is filled with hydrogen or helium, or at higher temperatures with nitrogen, the measurements being transferred to a secondary standard, a platinum resistance thermometer, or above 630°C a platinum/platinum-rhodium thermocouple. Alternatively, the secondary standard can be calibrated at certain additional fixed temperatures defined as the Practical Scale of temperature. They are:

Oxygen B.P. (–189.97°C), Water B.P. (100.000°C), zinc F.P. (419.505°C), Silver F.P. (960.8°C) and Gold F.P. (1063°C), where F.P. and B.P. signify freezing- and boiling-point.

The secondary standard thermometer is used to calibrate less accurate thermometers by comparison in a suitable stirred liquid bath at a steady or controlled temperature.

The choice of measuring device is governed by a number of factors. The *temperature range* required may exclude certain probes. Thus liquid-filled thermometers may freeze, or boil, while at elevated temperatures the probe material or its sheath may exhibit softening, melting, devitrification, corrosion or oxidation. Operation over a wide temperature range sometimes offers the choice of using either a single probe, or else several probes of higher sensitivity, each covering a narrower temperature range. The *stability* of a probe is important in certain applications where high *accuracy* is desired. The *sensitivity* of a probe is not the same thing as its accuracy, it only limits the attainable accuracy. Thus the temperature calibration may be in error, or extreme changes in temperature may cause strain, resulting in a change in calibration. The probe may still be accurate for the measurement of differences of temperature, but its absolute accuracy will suffer. *Robustness* is an important factor in industrial applications. Finally the *speed of response* to temperature change must be considered. This is governed both by the mass of material in the probe, i.e. by its heat capacity, and by the amount of insulation between the probe and its surroundings, i.e. by its thermal conductivity. It should be noted in passing that most temperature-measuring instruments can, in principle, be adapted for temperature control.

The various types of available equipment may now be considered. An expansion bulb of steel, containing liquid (usually mercury) or gas, can be attached by a length of steel capillary tube to a suitably calibrated Bourdon gauge and this robust instrument is sufficiently accurate for most industrial purposes. Another robust type of construction is associated with the differential expansion of a bimetal strip, often in the form of a spiral for increased sensitivity. The free end of the strip either gives a pointer indication, or else operates electrical contacts for control purposes. Mention should also be made of two other types of temperature indicator; temperature-sensitive paints which show a reversible change of colour at specified temperatures, and pyrometric cones of ceramic material (Seger Cones) which soften and then bend as furnace temperature rises.

The well-known liquid-in-glass thermometers are stable and fairly accurate, although easily fractured and rather slow to respond to temperature change. If the liquid in the stem is at a different temperature from that in the bulb, a correction must be applied. For use at lower temperatures, since mercury freezes near –39°C other liquids are used. Alcohol can be used down to –80°C and pentane down to –200°C. Mercury temperatures may be used up to 500°C but at this level the glass bulb tends to undergo dimensional changes, causing a drift in the calibration, and this can only be avoided by substituting fused silica for glass. Variations on the bulb thermometer theme include the sensitive Beckmann thermometer with adjustable range, used in differential measurements where the slow response can be tolerated; maximum and minimum thermometers, and control thermometers with fixed or adjustable electrical contacts, capable of giving $\pm 0.01°C$ control.

The remaining devices require electrical or electronic ancillary equipment, which increases their convenience as they can be used for remote indication, or for automatic recording on a chart. Resistance thermometers rely on measurement of the change of resistance with temperature. They consist of a winding of copper, nickel or platinum wire, forming a stable element which can be made compact and robust. Elements can be embedded in glass, but careful annealing is then necessary to reduce the effect of strain, and for really stable operation a different strain-free type of mounting is essential. The low sensitivity of these elements demands some sort of resistance or inductance bridge and an amplifier. The typical resistance of a platinum element would be 25 ohms at 0°C, 29.5 ohms at 45°C and 39 ohms at 140°C, which figures may be compared with those below for the thermistor. The other class of resistance element is the thermistor, consisting of a small bead of semi-conducting material which has a steep negative temperature/resistance coefficient. This highly sensitive probe has a fast response, but only behaves in a reasonably stable fashion below 150°C, and even then shows unpredictable drifts or jumps in the calibration. Typical resistance of a thermistor element would be 4000 ohms at 0°C, 1000 ohms at 45°C, and 100 ohms at 140°C, but a wide selection of resistance ranges is available.

The well-known thermocouple relies on the production of a voltage at the junction of two dissimilar metals (Seebeck effect). If a hot and cold junction are joined together, the resulting voltage will be approximately proportional to the temperature difference between the junctions. The thermocouple lacks sensitivity, but is capable of high stability in operation and can be made sufficiently compact to fit inside a hypodermic needle. For some applications improved sensitivity can be obtained by placing several hot and cold junctions in series. Thermocouple output voltage is usually measured either with a microammeter, or better with a potentiometer which draws no current from the couple.

For higher temperatures, where materials glow from red-heat up to blue-heat, an alternative to the thermocouple is the radiation pyrometer which measures the brightness and relates it to temperature. In the disappearing filament pyrometer, the heated object is compared visually with the filament of a standard lamp whose wattage, which is accurately related to temperature, can be varied. The other type of pyrometer measures the radiation level of the hot object more directly, using the electrical output from a thermopile or a photocell. The photoconductive lead sulphide cell is particularly sensitive and has the fast response time of one microsecond. This cell enables measurement of temperature by radiation to be made down to as low as 100°C.

The above list of devices is not exhaustive, and various new devices are making their appearance, but the main types of instrument for laboratory and industrial measurement have been covered.

COUNCIL MEETING 1st March 1969

This meeting replaced the one scheduled for 15th February when the weather conditions would have prevented the attendance of many representatives.

The official minutes are not yet available but the following points will be of interest.

Thermal Sydicate Award

The Secretary read a letter from Mr. D. Browell suggesting that full details of this award for competition pieces in fused silica should be published, and that in the judging, experts in this class of work be consulted as those normally concerned with borosilicate glassworking are not likely to be fully conversant with the standards which can be expected using various types of fused silica, e.g. electrically and flame fused.

It was agreed to meet Mr. Browell's wishes in both respects and the Board of Examiners is being asked to co-opt expert advisers for judging fused silica work.

Advertising the Society

An advertisement is to appear in *Laboratory Practice* to coincide with reports of the Labex 1969 Exhibition.

Society Finances

Mr. L. Benge, the Society Treasurer, again gave an up-to-date statement of accounts which included the balance sheet for 1968 which showed a healthy surplus of income over expenditure. Section expenditure for 1968 was presented in the form of a histogram on a per member basis. This makes an interesting study but it is emphasised that its purpose is only for general information.

An effort was also made to prepare a budget of Section expenditure for 1969 and various grants were agreed on to be available as required. It is important that Section treasurers should cooperate with Mr. Benge by sending in statements of Section accounts at the correct times.

With regard to Journal expenditure in 1969, it was agreed to allocate £400 to be available to Mr. Glover as needed.

It is the policy of the Treasurer to keep a large proportion of the Society's assets in an interest bearing deposit account from which it is calculated the income to the Society will be significant.

Journal

The Journal Treasurer, Mr. C. H. Glover, gave his figures for 1968 and reported that though a substantial sum was still due from advertisers his working balance was nil.

The Editor's report was mainly concerned with a proposal to alter the size and Editorial page and no objections being forthcoming, it was agreed to make preperations for the change.

Council meeting Travelling Expenses

It was agreed that these should be paid directly by the Society Treasurer, thus reducing the grants needed by Sections and that actual out-of-pocket expenses by the cheapest reasonable route can be claimed. There should be no exception in the case of one representative from the Scottish Section.

Honorariums

Though past commitments will be honoured it was decided to discontinue the practice as they in no way represent the value of the service to the Society by a long list of active officials. These should, however, submit claims for all expense incurred on behalf of the Society including telephone calls, postages and other small items.

President

This subject was discussed at length and it was agreed to invite members to submit names of persons to be used in compiling a list for consideration at a future meeting.

Vice-Chairman

Held in abeyance as was also the question of obtaining a Royal Charter.

1969 Symposium See Page 1.

Rule Books

Mr. J. Price of the Thames Valley Section volunteered to search past minutes of Council and A.G.Ms for rule changes and to pass these on to the Journal Editor for printing.

This Council meeting, in contrast to many preceding ones, was outstanding for the spirit of co-operation shown by Section representatives and the agenda which had been circulated well in advance by Mr. Stockton was dealt with smoothly and completed with time to spare for informal discussion which may result in further developments within the Society.

3rd March 1969 J. H. Burrow

SECTION ACTIVITIES

Thames Valley Section

In January Mr. C. H. Glover of Heathway Machinery Co., gave a lecture to the section on "Glassworking Machinery" which began with a brief history of bed shapes used on glassworking machines throughout the world and was followed by a description of the differences in head and tailstock bearings when used on very large bore machines. Next came a full description, with blackboard sketches, of automatic machines for joining neck tubes to colour television bulbs; automatic lathes for enlarging or reducing the diameter of silica tubes; machines for joining side arms to pierced stopcock barrels and a machine for diamond grinding the edges of television tube faceplates prior to frit sealing.

Mr. Glover's clear descriptions enabled members to engage in and enjoy a lively discussion of quite complicated engineering principles and we thank him for this talk.

The February talk was on "Technical Report Writing" by M. Deere, Reading University.

This lecture was not meant to tell us exactly which words to use in report writing, but to put over a communication system in a practical sense.

Ideas – consisting of information, sense, intention, feeling and tone – must be coded, i.e. put into scientific, medical, legal or other terms, or graphic images and then transmitted by speech or writing. This is a communication system and like most systems there is "noise", so importance must be attached to words, style and punctuations, which influence accuracy and pace, i.e. the output of significant ideas in one sentence.

This lecture, though with a rather boring title, was delivered with such skill and interest that the speaker's enthusiasm soon spread to the members. It is hoped that Mr. Deere can be persuaded to develop his theme still further at a future talk.

Following the A.G.M. held in March, the meeting was handed over to Hans Baumbach who described and demonstrated a number of bench and hand burners suitable for use with natural gas. Most members were able to try these burners and decide on their merits or otherwise. Hans also showed a number of other aids to glassblowing, all of which were widely discussed, praised and criticised.

Once again, a most interesting evening.

It is no longer possible to gather at the Clarendon Laboratory, Oxford, and as a number of Thames Valley members are located on or near the south coast, agreement was reached that Southampton should be our alternative meeting place, possible at C.E.G.B. Marchwood Laboratories. S.D.F.

Western Section

In December last an informal Christmas Dinner Party at Ashton Court Country Club was attended by 26 members and friends. After an excellent meal the remainder of the evening was spent in touring and using the Club's facilities including swimming pool and casino.

The Section A.G.M. held in January at the Chemistry Department, University of Bristol, was not well supported – only the committee and four other members being present. Most of the time was occupied with reports from the Chairman, Secretary, Treasurer and Council representative, and discussions arising from them. Following this it was found that while Mr. D. A. Jones agreed to continue as Section Treasurer no replacement could be found for Mr. D. Perkins the retiring secretary.

It was decided to continue the election of Section officers at the technical meeting in February but again the support was insufficient to proceed.

However, at the February meeting Mr. M. Locke, a student member gave a paper on the construction of small mercury discharge lamps. Mr. Locke has spent considerable time developing his own methods for making these lamps from fused silica with molybdenum strip electrodes, filling to the correct pressure with inert gas. His efforts have been successful and his mercury vapour discharge lamps are used in the department with good results and a long life. One lamp mounted in a holder was run as a demonstration to those present. Mr. Locke is to be congratulated on his talk which deserved a larger audience.

Southern Section

An excellent talk given to the section in December by Mr. W. Young on fused silica is reported in *News Bulletin* No. 12 together with the Istex glassworking demonstrations given by members of the Society.

On February 19th Mr. J. Jones of Signs and Components Ltd. gave a talk on Neon Signs, a full account of which will be given when available.

At the section A.G.M. in January the 1968 officers and committee were re-elected. The attendance was small considering the numerical strength of the Section and Mr. Maple in *News Bulletin* No. 13 makes a strong appeal for greater interest and members to come forward and voice opinions on Society matters. T.J.M.

Midland Section

In a report to Council the Section Chairman, Mr. L. C. Haynes, mentioned difficulties of members in getting time off to attend meetings and although some interesting visits had been arranged the response was poor and one was cancelled. A meeting will be held at Stone, Staffs, at which it is hoped to investigate future action for the benefit of the Section. The present officers agreed to continue pending the outcome of this meeting. S.G.Y.

North Eastern Section

The Section held its A.G.M. at the Mitre Hotel, Knaresborough on the 9th January and officers for 1969 were elected.

North Western Section

A meeting was held on the 6th December 1968 with eight members present. A list of lectures and visits for 1969 was drawn up including the following:—

Visit to I.C.I. Salt mine at Winsford.
Evening visit to Tetley Walkers.
Visit to Chance Bros. and Brierly Glass.
Visit to Wood Bros. at Barnsley.
Lecture on Graded Seals.
A one-day Symposium on Natural Gas at Warrington on 7th May to be held jointly with the North Eastern and Scottish Sections.

East Anglian Section

Officers for 1969 were elected at the A.G.M. on 14th January. There were also reports of progress in arranging the 9th Annual Symposium at Clacton-on-Sea on the 19th and 20th September.

I.S.T.E.X. 69

On Tuesday, 17th December, 1968, three members of the Thames Valley Section, Messrs. J. S. McDonald, R. Mason and R. Brown, and five Southern Section members, Messrs. E. White, R. W. Conway, H. G. C. Prior, H. Holmes and T. J. Maple, spent the day at Paddington Technical College demonstrating various aspects of scientific glassblowing to a never ending stream of visitors.

Mr. L. Barnes has a very fine teaching shop there and was our very friendly and helpful host for the day. Two of his students were also demonstrating beside the B.S.S.G. members.

This was a most successful day, enjoyed by demonstrators and visitors alike.

NEW MEMBERS

SOUTHERN SECTION
I. Senior, 30 Chelmer Drive, HUTTON, Essex. F
M. Pavdy (Miss), 23 Tenby House, Bourne Avenue, HAYES, Middx. S
C. Cullingford, 13, Hyde Close, HARPENDEN, Herts. S
E. Musanje, 24 Waterden Road, GUILDFORD, Surrey. S
A. Mavor, 77 Tanner Street, BARKING, London. A
F. Watson, 66 Garth Close, MORDEN, Surrey. F

EAST ANGLIA
A. Whybrow, 124 Lower Meadow, HARLOW, Essex. F
S. Fairbrother, 24 Jesus Lane, CAMBRIDGE. S
D. Ginn, 25 Rustat Road, CAMBRIDGE S
R. Smith, 102 Little Walden Road, SAFFRON WALDEN, Essex. S
P. Hotchkiss, 8 Buttersweet Rise, SAWBRIDGEWORTH, Herts. A
A. Walker, Fornells Church Road, GREAT HALLINGBURY, Essex. A

NORTH WESTERN
I. Parry, 25 Croftfield, MAGHULL, Lancs. F
B. Ward, The Haven, Common Lane, Lach Dennis NORTHWICH. F
W. Hickson, AEI–GEC Barton Dock Road, URMSTON, Lancs. S

NORTH EASTERN
C. Gasgoigne, 4 Meadow Road, KNARESBOROUGH, Yorks. S
D. Morgan, 49 Coniston Road, BARNSLEY, Yorks. F

OVERSEAS
G. Higginbotham, Chemistry Dept., Chiang Mai University, THAILAND. A
I. Deadman, 2 ave Felix Marchal, Schaerbeer, BRUXELLES, 3, BELGIUM. F
B. Arjuna Singh, Madurai University, Tamilnada, INDIA. F
A. Seer, 5377 Blue Haven Drive, East Lansing, MICHIGAN, 48823, U.S.A. F

BOARD OF EXAMINERS REPORT

SCIENTIFIC GLASSBLOWING STAGE ONE COURSE

The syllabus for the "Scientific Glassblowing Stage 1 Course" has been designed to progress from the Elementary syllabus using what has already been taught plus the techniques of additional glassblowing operations required in making up specific pieces of apparatus. The particular pieces of apparatus have been chosen with the intention of including a variety of common operations, yet to confine the standard to the reasonable scope of the syllabus.

At present the syllabus is being taught at Isleworth Polytechnic and Bristol Technical College. It is intended to be of use to the professional glassblower wishing to widen the field of his experience as well as to the student glassblower. The Board of Examiners can arrange for a B.S.S.G. examiner to be present at the examination of this syllabus. The Board will provide the examination drawings and mark sheets. Certificates will be available to successful candidates. A charge of three guineas per examination is made for this service.

Syllabus
Theory

Properties of glasses in general use: working temperatures; co-efficients of expansion; annealing; thermal resistance; correlation of these factors.

Cutting glass tubing: use of cutting knife; angle of cut; description of cut.

Blow-pipes: pre-mix and nozzle mix types. Adjustments to blow-pipes.

Gas supplies: safety precautions; non-return valves; oxygen and compressed air supplies.

Value of materials and equipment.

Manipulation – Material: borosilicate glass

1. Revision of "Introduction to Elementary Scientific Glassblowing" Syllabus.
2. *a*) Taper drawing.
   b) Reaming – receiver jet.
   c) Insertion seals.
   Apparatus – Filter Pump.
3. *a*) Diaphram seal.
   b) Syphon.
   c) Re-entrant join.
   d) Reaming – approx. 40mm. tubing.
   Apparatus – Soxhlet Extractor.
4. *a*) Capillary to tube join.
   b) Capillary to bulb join.
   c) Insertion seal.
   d) Re-entrant join.
   Apparatus – McLeod Gauge.

Examination on the above syllabus will cover an elementary standard of theory in addition to manipulation. Certificates will be awarded to successful candidates.

Printed syllabuses are available from the Secretary.

N. H. Collins

EXAMINERS

The following additions and one resignation bring up to date the list of examiners published in the Journal Vol.5, No.1, page 12.

Thames Valley Section
Resigned: D. G. Saxton.
Elected: J. W. Price,
9 Woodlands Close,
Dibden Purlieu,
Southampton.

East Anglian Section
Elected: A. E. Leutenegger,
3 Lantree Crescent,
Trumpington,
Cambridge.

Southern Section
Elected: B. Wigzell,
182 Wimbledon Park Road,
London, S.W.18.

EDITORIAL NOTES

In view of the decision at the March Council Meeting to increase the dimensions of the Journal we feel an explanation is needed for continuing Vol. 7 at the old size. It was found that the change will involve larger blocks for advertisements and the alteration of other permanent settings and although the cost for these is non recurring it was decided that more time for financial preparation is needed. We have therefore postponed the change until 1970

Various items including the remaining 1968 Symposium papers have been held over and will appear in the June issue. Nevertheless we shall welcome more material especially papers on technical subjects and Section meetings. We thank those who have prepared those already received. J.H.B.

1969 ANNUAL SUBSCRIPTIONS

These are now overdue and to avoid your name being withdrawn from the Journal circulation list payment to Mr. L. Benge should be made **immediately.**

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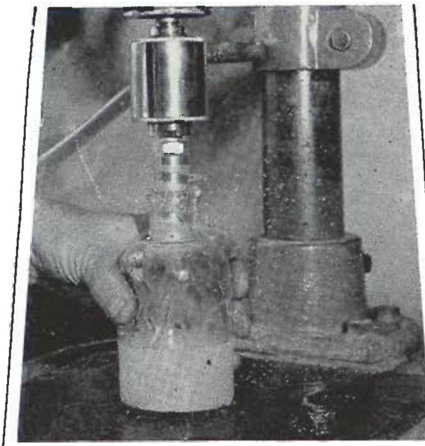

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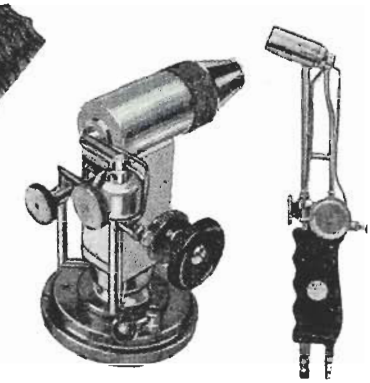

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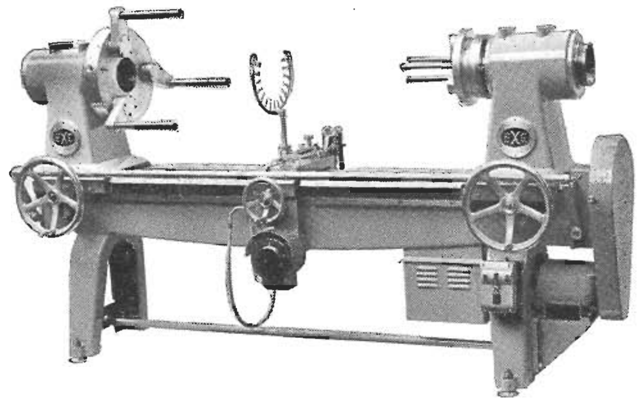

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