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British Society of Scientific Glassblowers

Founded 1960

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EDITORIAL

THE appeals in our last issue for more material for publication have, we are pleased to record, been answered in a very decisive way—there being more than enough technical contributions to fill this issue. To those who have responded so quickly many thanks, and to those who are in the process of doing so, do not relax as we can never have too much material.

But again reports of Society and Section activities are very scanty which is perhaps not so surprising during the summer months and we are hoping this will be remedied later on. But should this not happen and the present in-flow of technical material continue it will perhaps indicate that the true function of this Journal is not as many of us visualised, and the need for a medium to record technical information relating to our craft is greater than we imagined. The small voice heard in the background in the early days (of promoting the Journal) will have been proved right.

Not that we expect a continual supply of original ideas, as most of our techniques have their origins in well tried processes of bygone days; in fact it would be a useful exercise to trace the evolution of some of them.

But this should be no deterrent as except for that which appears in the few competent books on glassworking, there is a mass of technical information which although practised, has never been recorded and any individual author of a book is likely to be restricted in his presentation unless he can spend a long time in assessing all aspects and uses of a particular technique. Always it must be remembered that we cannot publish unless we are fed with suitable material and the wider the range of subjects covered the greater will be the interest shown, which is bound to be for the ultimate good of the Society.

J. H. BURROW

OBITUARY

R. L. Breadner

IT is with deep regret that we record the sudden death of Mr. R. L. Breadner at the age of 62.

For many years a leading figure in glass engineering he received his initial training while an assistant at Eton College, and in 1920 he joined the G.E.C. Research Laboratories, now the Hirst Research Centre, at Hammersmith. He transferred to Wembley with the Laboratories in 1923.

During his 45 years with the G.E.C. he built up a highly efficient glass working department and made many original contributions in the glass engineering field. He will be remembered with gratitude by the many scientific glassblowers he trained and who are now dispersed throughout the world.

His death is a great loss to scientific glassblowing and glass engineering, and we extend our sincere sympathy to his widow and son.

J.B.P.

Contributions for the December issue must be submitted by 16th October

The Journal is published quarterly by the B.S.S.G. and is available free to members and at 5s. per copy (or 17s. 6d. per annum) to non-members. Editorial communications should be addressed to the Editor, c/o H. H. Wills Physics Laboratory, Royal Fort, Clifton, Bristol 8, and enquiries for advertising space to Mr. I. C. P. Smith, 65 Woodberry Way, Chingford, London, E.4. Printed in Great Britain by E. G. Ellis & Sons, Willow Street, London, E.4.

Lecture given to the Western Section, June 1965

RECENT DEVELOPMENTS IN ULTRAHIGH VACUUM

by DEREK F. KLEMPERER, Ph.D.

Department of Physical Chemistry, University of Bristol

The Vacuum of Space

WHEN Russian space man Leonov emerged from his space ship for ten minutes in March, his altitude was 300 miles and he was stepping into a vacuum of about 7.10^{-10} torr. The feat of a space walk was performed again in June by American space man White. Looking beyond these technological accomplishments and the incredible bravery of the men, one cannot help noticing how we are living in a thin atmospheric skin which surrounds and clings to the earth. Figure 1 shows the variation of pressure with height ; at the first arrow (10 miles) the pressure is already down to one-tenth of the sea level value and at the second arrow we enter near space with 10^{-3} torr pressure.

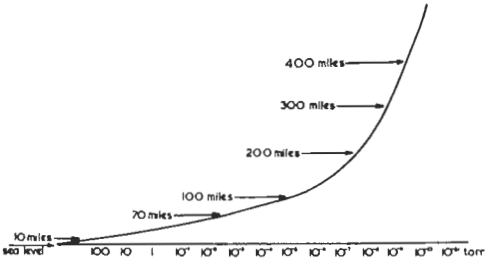


FIGURE 1
Variation of pressure with height above sea level

This is the sort of vacuum one gets with a good rotary oil pump down on earth—it is our laboratory forevacuum, as used for crude work and to back diffusion pumps which pull a high vacuum, i.e., pressures in the 10^{-6} torr range. Such pressures exist at 100 miles height and they can be simulated in systems containing greased stopcocks, rubber O-rings and un-outgassed mercury. Above 100 miles the pressure falls rapidly to the realms of ultrahigh vacuum, that is, vacua lying beyond the hitherto conventional laboratory vacua. At 1,000 miles height, the pressure is 10^{-14} torr and as we move out beyond satellite environments and into interplanetry space, so the pressure levels out to 10^{-16} torr. This is lower than anything achieved on earth. The record stands at 7.10^{-15} torr, being obtained by Hobson[1] in Canada last year.

Hobson used a system made of aluminosilicate glass because this glass is much less porous than "Pyrex" towards the 5 parts per million of atmospheric helium. The system was ion pumped to 8.10^{-13} torr and then immersed in liquid helium. Theoretically this should give 10^{-35} torr, corresponding to one or no molecule in an apparatus of usual laboratory dimensions and probably lying somewhere between the pressure in interstellar space (10^{-30} torr) and intergalactic space.

Vacuum in Terrestrial Systems

Despite the abundance of ultrahigh vacuum, no further away than Bristol is from Newcastle, UHV is neither easy to produce nor has it been available for long. Currently the world's largest space chamber is nearing completion at the Manned Spacecraft Center, near Houston, Texas. Pictures of this chamber appear on page 135 of the National Geographic Magazine for January 1965* and on page 48 of Time Magazine for 27th August 1965. It is a stainless steel silo with double walls standing 120 feet high. The circular access door is 40 feet in diameter and the chamber will comfortably hold an entire Apollo mooncraft.

At the other end of the size scale are the small glass ultrahigh vacuum systems used in laboratories to study the physics and chemistry of surfaces. The simplest UHV systems are, of course, ordinary radio valves which are carefully processed to attain low base pressures. But for the experimental scientist radio valves lack all versatility : whereas he needs to prepare specimens, handle gases, pump gases and measure pressures in his system, the radio valve is useless beyond the one specialised function for which it was produced. The simplest versatile system, therefore, rapidly acquires many of the unique items of UHV hardware which have been developing during the last fifteen years.

* The National Geographical Society, U.S.A., does not permit the release of its illustrations

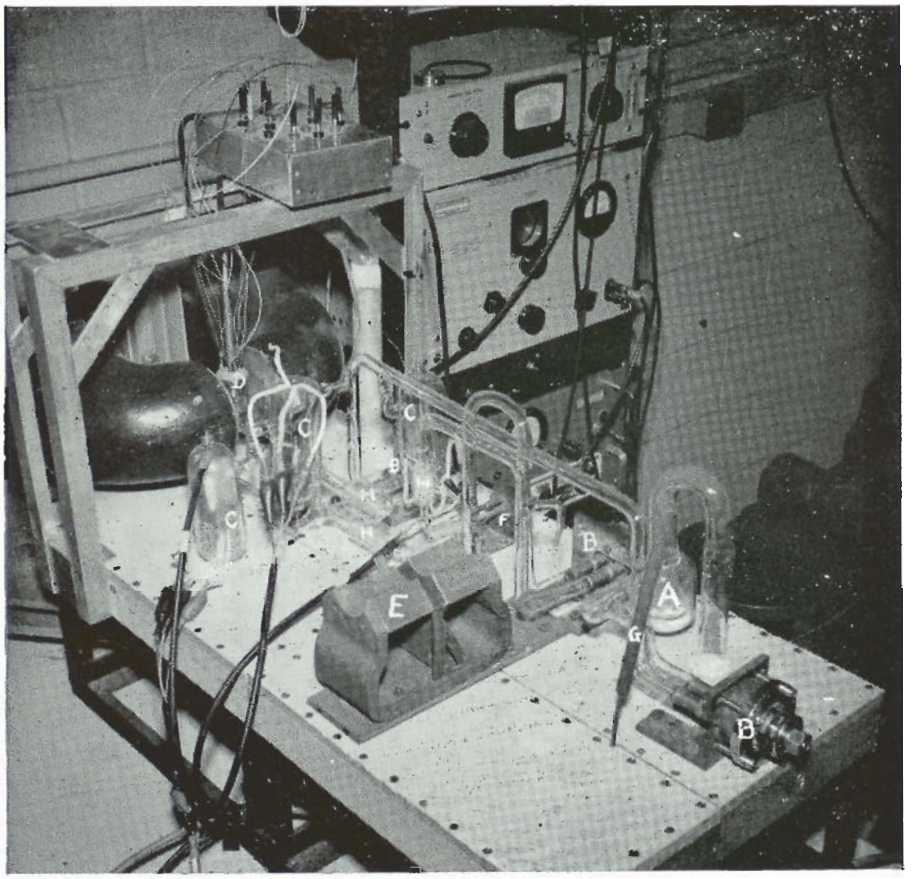


FIGURE 2

Typical small ultrahigh vacuum system—photographed by the author in Professor Alpert's laboratory, University of Illinois, 1962 (by permission)

Figure 2 shows a small system in which all the basic operations can be performed. Its components have been developed largely by Professor D. Alpert, whose name has been associated for longer than any other with UHV techniques. Conventional rotary oil and oil diffusion pumps are situated out of sight below the asbestos table top. The main pumping lead comes up at the right, through the table, and passes through a zeolite trap A to the first of the UHV taps B. After pumping out to 10^{-6} torr, this tap is shut and the ionisation gauges C are run to lower the pressure: the ionisation gauge, which will be described in a later section, is not only a pressure gauge but also a pump. Sitting between the pole pieces of the large permanent magnet is an omegatron D which is used to measure partial pressures of residual gases. The magnet E in the foreground has been used with a sector field mass spectrometer (not shown) for the same purpose. F is a special UHV tap which can be used as a controlled and reproducible gas leak. There are two gas flasks below the table.

Before there is any hope of producing UHV in a system of this type, two fundamental rules must be obeyed: only materials of negligible vapour pressure may be employed, and the whole system must either be pumped at a tremendous rate or outgassed by baking. By the first rule, we are forbidden to use rubber, oil, grease or mercury in the UHV section. Even brass (which contains zinc) and cadmium-containing solders are excluded. The seriousness of having a material of high vapour pressure present is easily illustrated by putting a shred of paper into an otherwise perfect system. One cannot pump below 10^{-5} torr or so while it is there.

Baking out

To obey the second rule, the entire system is best built inside an oven. It is then raised to 400°C or more for several hours with pumping. Except for the baseboard, which is permanently in position, the oven may be removed when not required. A convenient method is to assemble the oven as individual walls and a lid. Alternatively, a hood-like structure can be manipulated by hand or crane, depending on size. Figure 3 shows a large oven of the author's construction in Indiana University. Actually the picture shows two ovens in place on the frame, one on each side of a common dividing wall. Such twin ovens, which we have also found useful in Bristol, enable the traps and UHV ion pumps to be baked out separately and then used while the rest of the system is still hot. The ovens are over-powered so that bake-out temperatures are reached within two hours of switching the power on. The bulb G in Figure 2 is a mercury-in-steel thermometer bulb used to control the oven temperature.

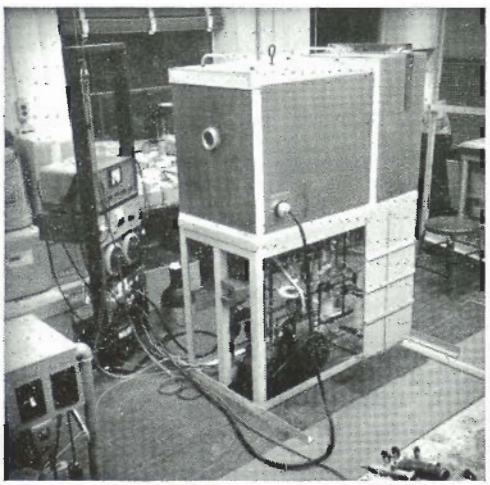


FIGURE 3

Twin ovens for baking out a UHV system

On baking out a system which has been exposed to air for any length of time, a lot of gas is thermally desorbed and pumped away. Without baking, this gas oozes out endlessly and constitutes a huge "virtual leak." If we neglect the gas driven out from any depth and consider only the surface monolayer, then complete desorption in a one litre sphere would already give 8.10^{-3} torr. One should realise that all the materials we handle in everyday life are heavily contaminated. Even a metal surface with the brightest mirror finish is loaded with sorbed gas and foreign, largely volatile matter.

The necessity to bake out places severe limitations on materials and techniques. It also introduces a hazard, because breakage at 400°C and consequent air in-rush inevitably causes ruinous corrosion to the inside of metallic components. Our laboratory is supplied with a nitrogen hose for these emergencies. Since breakage is the result of warping and differential expansion, a more effective measure is to insert flexible bellows between components. Such glass bellows are labelled H in Figure 2 and Figure 4 illustrates how we have chosen to tackle the problem here.

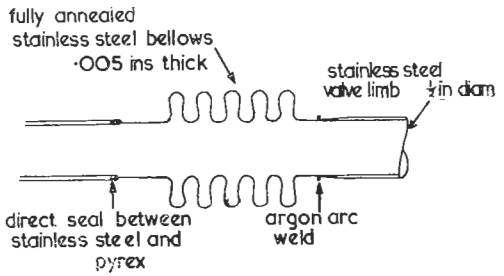


FIGURE 4

Flexible coupling between components of a UHV system

Since even the best elastomers like Viton A are ruled out for a bakeable UHV system, taps must be of all-metal construction and hydrogen brazed or argon arc welded together. Figure 5 shows a one-inch valve which we have designed and built at Bristol. The valve is closed by forcing a soft pad of pure silver on to a circular stainless

steel knife edge. When some 14 ft-lbs. of torque are applied to the differential screw, a sensitive mass spectrometer fails to detect any helium getting past the seal. Apart from the silver pad and two shear-gaskets of copper which seal the body up, the valve is made entirely of stainless steel.

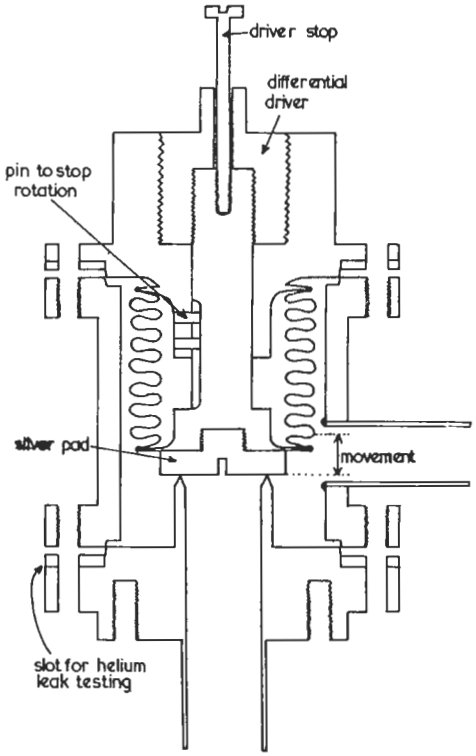


FIGURE 5

1in. valve constructed at Bristol. All parts except the silver pad are machined from stainless steel. The body is assembled using two copper gaskets and the whole valve is baked out at 400°C to free the interior of sorbed gases

Magnetically operated ball-and-socket valves are often recommended for UHV use. They are certainly cheaper and less vulnerable to corrosion but they always leak, they do not tolerate much pressure differential and they cannot be used to bleed gas. All-metal valves of acceptable standards have recently become available in this country. Manufacturers' catalogues list them up to 13-inch port size and weighing 550 lbs. Hydraulic operation is obviously necessary at this stage. A point which is not generally recognised is that many valves which are mass-produced for use at high pressures or with corrosive liquids are, with a little modification, suitable for UHV use.

Objectives

In the smaller laboratory systems, space simulation is not of especial interest. Rather one seeks to examine surfaces under really clean conditions. This involves producing a clean surface and then retaining it for the experimental duration. The vacuum is the means to this end and it is of interest, therefore, to see how quickly a clean surface becomes contaminated.

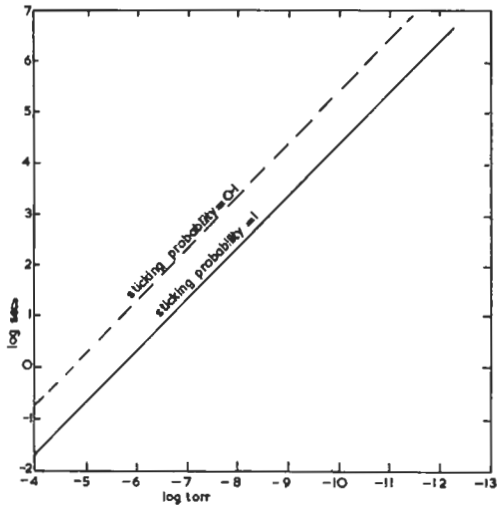


FIGURE 6

Times to form a monolayer of adsorbed gas on a clean surface

The time taken for a monolayer of gas molecules to form on the surface has been plotted against pressure in Figure 6. These times are derived from the frequency with which molecules hit the surface. It is also necessary to assume that all molecules stick and that the surface is smooth. Under these circumstances, the unbroken plot shows that a surface is altered after about one second at 10^{-6} torr, a few hours at 10^{-10} torr and only after a good day at 10^{-11} torr. Actually no surface is reactive enough to retain all

molecules that collide with it. Recent measurements suggest that the sticking probability for oxygen on metals, for instance, is even lower than 0.1. The broken plot in Figure 6 may thus be nearer the truth. Although it concedes a ten-fold increase in the contamination time, we must clearly produce UHV for any investigation of surface phenomena to be really fundamental. Air is the great contaminent. To make, say, a chemisorption run against a background pressure is like doing solution chemistry at the bottom of the river. A logical ideal would be to conduct our experiments above the atmosphere.

This driving interest in lower vacua has brought major advances in the measurement of low pressures during the last few years. By comparison less advance has been made with pumps, whilst many other system components and materials currently in use are already to be found in textbooks.[2] The remainder of this review is, therefore, devoted to ultralow pressure gauges. They all depend on ionisation of the residual gas, collection of the ions and measurement of the ion current. We shall look at the original UHV gauge first and then see how it is developing and being extended.

The Bayard-Alpert Gauge[3]

The modern Bayard-Alpert gauge (Figure 7(a) and (b)) is a triode valve which may be glassed into the system. Prior to the advent of sputter-ion pumps in 1958, the gauge was not only used to measure pressures but was also the standard pump. It is still the cheapest device and tends to

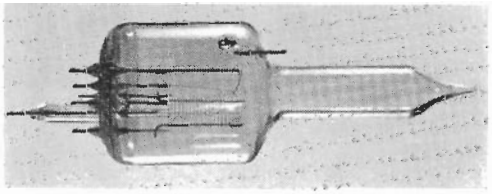


FIGURE 7(a)

The Mullard ionisation gauge IOG-12. A Bayard-Alpert type which is used with control unit WPS-3 over the pressure range 10^{-3} to 10^{-11} torr

be used in a UHV laboratory in the same expendable way in which we use electric light globes at home. The pumping effect is due to disappearance of gas ions from the gas phase ; they get stuck to the collector and the envelope. The envelope may be earthed to counter charge accumulations, using the electrical contact shown in Figure 7(a).

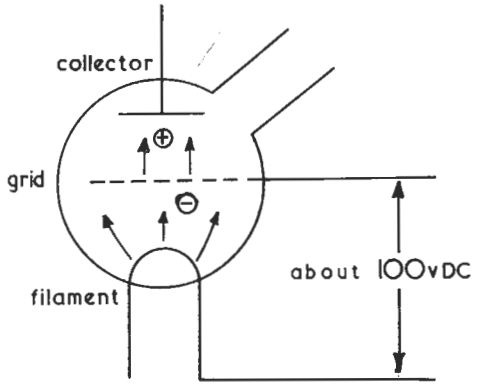


FIGURE 7(b)

How the ionisation gauge works. An electron current flows between the filament and the grid. It ionises gas molecules. These ions, whose number depends on pressure, are attracted to the collector and measured

To cover different pressure ranges, the electron current may be varied between, say, 1, 5 and 20 mA. It is preferable, however, to run at very low electron currents such as 1, 5 and 20 μA. Although this calls for a very sensitive electrometer to measure the ion currents, one does thereby reduce the gas pumping effect, the dissociation of gas molecules at the heated filament and the spontaneous variations in sensitivity which plague ionisation gauges. A fourth effect is also reduced ; it is the so-called X-ray effect, which determines the lowest pressure the gauge will measure.

The X-ray effect was discovered about 15 years ago when people who worked with ionisation gauges began to realise that pressures below 10^{-8} torr were simply not registered on the type of gauge then in use. Even though the vacuum conditions seemed to improve under careful processing, a permanent residual collector current was present regardless of pressure. This current is actually not an ion current arriving at the collector but an electron current leaving the

collector. It is photoemission stimulated by soft X-ray illumination which, in turn, has been generated at the grid:

total current = ion current (pressure sensitive) + photo current (permanent)

A thousand-fold reduction of X-ray photo current was accomplished in the Bayard-Alpert gauge by replacing the large-area collectors of radio-type triodes with a fine wire and inverting the geometry. Referring to Figure 7(a), the collector is the straight wire inside the grid spiral and a hair-pin filament is strung up outside the grid.

The permanent residual photo currents of the radio-triode and the Bayard-Alpert types of gauge are revealed by collector current characteristics (Figure 8). The upper plots in each case are typical curves for gas ionisation, being determined by the efficiency of electron impact. As the electron accelerating voltage on the grid is raised, so the collector current levels off to saturation.

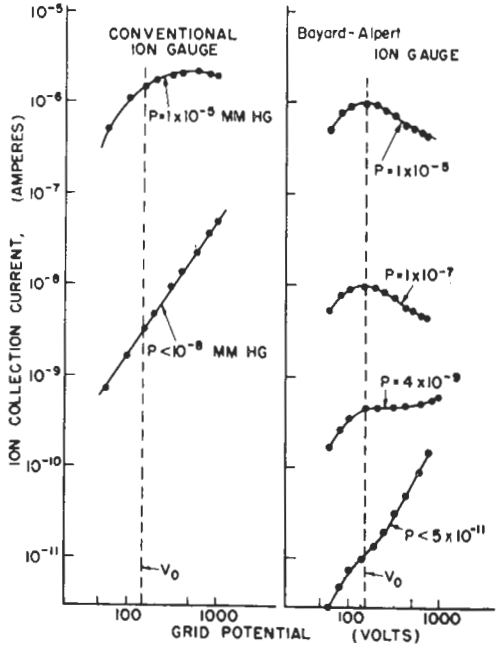


FIGURE 8

Collector current characteristics show up the X-ray effect. At left, a conventional radio-triode; at right, the Bayard-Alpert gauge.[3] Pressures for each curve are shown. V_0 is the potential at which the grid is normally run

But as the grid voltage is raised, so the X-ray effect continues to rise. This latter effect is eclipsed at high pressures, but is clearly visible in the curves at lower pressures. They reveal X-ray currents equivalent to 10^{-8} torr (old fashioned gauge) and 5.10^{-11} torr (Bayard-Alpert gauge).

Penetrating the X-ray Barrier

We can now discuss how the X-ray effect has been avoided and see how pressures below 5.10^{-11} torr have come to be measured recently employing several different methods. The gauges to be discussed are summarised in Table I (page 34), where the first entry is the Bayard-Alpert gauge described in the preceding section. The second column lists the lowest pressure p_X to which each gauge goes, being the X-ray current residue which is always there. The third column shows the lowest pressure p_{min} which can sensibly be measured as a result. p_{min} is 1.10^{-10} torr, for instance, when the X-ray current of a Bayard-Alpert gauge has been determined.

To lower the X-ray current residue, we can, as already stated, reduce the electron current emitted by the filament. We can also reduce the physical size of the collector. A reduction in diameter from the usual .005in. wire (125μ) shown in Figure 7(a) to 4μ gives an order lower in the residual current.

Many investigators have sought to measure lower base pressures still by using extra electrodes. In the case of a modulated gauge the extra electrode is a second collector wire which is used to measure the X-ray current. If this wire is at grid potential, it takes no ion current i, but when it is tied to the collector it takes a proportion α of the ion current away from the collector:

$$\text{Normal collector current} = i + i_R$$
$$\text{Modulated collector current} = (1-\alpha)i + i_R$$

The residual current i_R induced by X-irradiation is the same in each case and α is independent of pressure. At high pressures the residual current i_R may be neglected:

$$\text{Normal collector current} = I$$
$$\text{Modulated collector current} = (1-\alpha)I$$

These four equations enable us to evaluate the four unknowns. In a refinement of the method, modulation of the residual current is introduced:

$$\text{Normal collector current} = i + i_R$$
$$\text{Modulated collector current} = (1-\alpha)i + (1-\epsilon)i_R$$

	Gauge	P_x (Torr)	P_{min} (Torr)	Reference
1	Bayard-Alpert	3×10^{-11}	3×10^{-10} (P_x not measured) 1×10^{-10} (P_x measured)	D. Alpert, 1953, J. Appl. Phys. **24**, 860
2	Fine collector (4 microns) Bayard-Alpert	1.5×10^{-12} (Est)	$<2 \times 10^{-11}$	A. Van Oostrom, 1961, Trans. AVS Vac. Symp. **8**, 443
3	Modulated Bayard-Alpert	3×10^{-11} 3×10^{-11}	3×10^{-11} (ϵ assumed zero) 3×10^{-13} (ϵ measured)	P. A. Redhead, 1960, Rev. Sci. Instr. **31**, 343 J. P. Hobson, 1960, J. Vac. Sci. Tech. **1**, 1
4	Suppressor	$<2 \times 10^{-12}$	$<2 \times 10^{-11}$	W. C. Schuemann, 1963, Rev. Sci. Instr. **34**, 700
5	Modulated suppressor	$\sim 10^{-14}$	$<2 \times 10^{-12}$ (Est 10^{-13})	P. A. Redhead and J. P. Hobson, 1964, Conference on Fundamental Problems of Low Pressure Measurement, Teddington, England, September 1964
6	Orbitron	10^{-12} (Est)	$<5 \times 10^{-11}$	W. G. Mourad, T. Pauly and R. G. Herb, 1964, Rev. Sci. Instr. **35**, 661
7	Klopfer		$<10^{-11}$	A. Klopfer, 1961, Trans. AVS Vac. Symp. **8**, 439
8	Mass spectrometer (90° sector)	~0 (Est)	$<10^{-15}$ (Est 5×10^{-17})	W. D. Davis, 1962, Trans. AVS Vac. Symp. **9**, 363
9	Hot-cathode magnetron		$<10^{-11}$ (Est 4×10^{-14}) without multiplier (Est 3×10^{-17}) with multiplier	J. M. Lafferty, 1962, Trans. AVS Vac. Symp. **9**, 438 J. M. Lafferty, 1963, Rev. Sci. Inst. **34**, 467

TABLE 1

Low-pressure limits of hot-filament ionisation gauges. p_X = pressure at which ion current equals X-ray photo current. p_{min} = pressure at which estimated error is 10%. Est. = estimated but not measured directly. Values are given for normal operating conditions (from Hobson, J. P., and Redhead, P. A., 1965, J. Vac. Sci. Tech., 2, 93)

As indicated in Table 1, ϵ is not zero and can actually be measured.

In the fourth entry, a suppressor electrode has been developed to suppress photoemission. It is in the form of a ring maintained at +300 volts and suppresses emission quite well. An additional grounded shield, however, is required. When modulation is combined with suppression (fifth entry) the gauge will measure very low pressures but the instrument has become complicated and it is difficult to use.

Orbitron and Klopfer Gauge

A major advance is made when we make the X-ray current negligibly small compared with the ion current. This has been done by forcing the ionising electrons into extremely long paths and by locating the ion collector remotely from the main source of X-rays. When the electron paths are long, the ionising efficiency is high and the electron current can be drastically reduced without loss of sensitivity. This trick of increasing electron paths is as old as the Penning gauge, 1937, but it has lately reached such a degree of sophistication that it is employed in a large number of pumps and gauges. In the orbitron (Figure 9(a) and (b) which was introduced last year, the electrostatic field of a simple electrode system produces the comet-like orbits shown. No magnet is necessary. The ionising efficiency is so high that 4 μA of electron current will ionise as many gas molecules as a 8 mA current in a Bayard-Alpert gauge. The X-ray current is extremely small.

ABSTRACTS

CELLS
See (170).

CHROMATOGRAPHY
(166) Drying Manifold for Spot Tests and Chromatograms on paper.
Wong, F. F., and Carson, J. F., *Chemist-Analyst*, Vol. 52, No. 1, 1965, 20
Glass tube of about 2 inches in diameter with several ports, closed at one end, hot air from hair dryer blown in open end. Tube is lagged with asbestos paper. J.A.F.

(167) Devices for Maintaining a Constant Head and a Constant Flow Rate in Chromatographic Columns.
Conway, W. D., *Lab. Pract.*, Vol. 14, No. 8, 1965, 952-3.
Several devices are shown based on the "chicken feeder" principle. D.W.S.
See also (171).

CRYOSTATS
(168) Glass Dewar Flasks for Optical and Other Studies at Low Temperatures.
Schoein, L. J., and Broida, H. P., *Rev. Sci. Instrum.*, Vol. 33, No. 4, 1962, 470-3.
A Dewar flask is described having a metal shield cooled with liquid nitrogen. Stores helium with low loss rate. Adaptable for low temperature experiments and is relatively low priced to construct. Modifications of the flask have vapour-cooled radiation shields which replace liquid nitrogen cooled shields. S.G.Y.

EVAPORATORS
See (198).

EXTRACTORS
(169) Small Volume Liquid Liquid Extractor.
Spikner, J. E., Ward, V. F., and Towne, J. C., *Chemist-Analyst*, Vol. 52, No. 2, 1963, 50.
Useful for the extraction of small volumes of aqueous solutions with an organic solvent lighter than water. Made from standard ground glass joints and a heavy wall test tube. J.A.F.

FREEZING POINT
(170) A Freezing Point Cell for Volatile Solutions.
Glew, D. N., and Rath, N. S., *J. Sci. Instrum.*, Vol. 42, No. 8, 1965, 665-7.
This cell eliminates the dead space above the solution. D.W.S.

GAS HANDLING
(171) Gas Handling Apparatus for Gas Chromatography.
Vango, S. P., *Chemist-Analyst*, Vol. 52, No. 2, 1963, 53.
Unit of glass, with stopcocks and levelling bulb can be used for transferring gas in sampling bulb to syringe to be used for gas chromatography. J.A.F.

(172) Technique for Filling Hypodermic Syringes from Gas Cylinders.
Lodge, J. P., Pate, J. B., and Huitt, H. A., *Chemist-Analyst*, Vol. 52, No. 2, 1963, 53.
Uses a simple glass trap and vaccine bottle top to fill syringes from gas cylinders. J.A.F.

GLASS—CHEMISTRY
(173) Sealing Glasses (Part I)
Oldfield, L. F., *J. Brit. Soc. of Sci. Glassblowers*, Vol. 2, No 1, 1965, 3-8.
The author reviews the requirements the manufacturer must meet as (a) provision of a glass with correct properties to give low stress seal ; (b) glass must be of quality good enough for application ; (c) the glassware must conform to dimension tolerances; all these must be met at a reasonable cost. The article then examines ways of meeting these and discusses properties and ways and means. D.W.S.

(174) Some Unusual Glasses.
Adams, R. V., *Brit. Soc. of Sci. Glassblowers*, Vol. 1, No. 4, 1964, 46-53.
This paper deals with the development and properties of Iron-Sealing Glasses, Solder Glasses, Commercial Glasses from B_2O_3, Al_2O_3 and P_2O_5, Calcium Aluminate Glass, Tellurite Glasses and Vanadate Glasses. D.W.S.

GLASS—PHYSICS
(175) Termal Expansions of Borosilicate Glass in the Transformation range. Part I. Anomalous Behaviour of Tungsten and Molybdenum Sealing Glasses.
Oldfield, L. F., *Glass Technology*, Vol. 5, No. 4, 1964, 150-6.
It is shown that the routine control of borosilicate glass by means of expansion coefficient for low temperature range is unreliable. Discusses the anomally of sealing glasses of the same nominal composition and identical standard expansion coefficients may have quite different expansivities in their annealing ranges which can give undesirable stresses in glass-to- metal seals. S.G.Y.
See also (173), (174).

GLASSWORKING—MACHINES
(176) Plumbing for the Glassworking Lathe.
Litton, C. V., *Fusion*, Vol. 11, No. 4, 1964, 9-10.
Short article on the needs. D.W.S.

(177) Device for Feeding an Abrasive to a Lapping Machine.
(1) Boettcher, S. A. (2) Keefe, J. V.
Speedlap Corporation.
(1) *U.S. Patent* 3, 110, 991, 16th April, 1962.
(2) *U.S. Patent* 3, 110, 992, 7th February, 1963.
(1) Describes a special supply tube which conveys abrasive mixture from a rotating container on to the grinding laps, etc.
(2) The rotating container is reversed during changeover of work pieces to continually agitate the abrasive. S.G.Y.

(178) Swiss Patent 373, 528, 14th October, 1960.
Faciendа, A.
Table with rocking arrangement for automatic cutting of glass plates. Nine claims, seven illustrations. S.G.Y.

GLASSWORKING—METHODS
(179) Forming Contours on a Glass Lathe.
Bedford, J., *Fusion*, Vol. 12, No. 1, 1965, 8-10.
This gives a short account of the technique of centrifuging glass tube to a former constructed of Carbon or Monel metal. D.W.S.

(180) Colour Decoration and Printing on Glass Containers.
Hackett, J. W., and Holsher, H. H., *The Glass Industry*, Vol. 45, No. 8, 1964, 421.
Various techniques are discussed as applied for imaging and developing printing and forms on materials such as plastics, papers and metals. Suggestions are offered as to how these techniques may be adapted to transfer these forms onto glass. Electostatic printing on glass containers by Owen-Illenois is discussed in some detail. S.G.Y.

NON-RETURN VALVES
(181) A non-return Float Valve for Vacuum Pumps.
Smith, I. C. P., *J. Brit. Soc. of Sci. Glassblowers*, Vol. 1, No. 4, 1964, 53.
Details of construction are given. D.W.S.

(182) Float Check Valve for use with Water Aspirator.
Swift, L. J., *Chemist-Analyst*, Vol. 52, No. 1, 1963, 23.
Float valve using two modified glass ball and socket joints, stops water floding into apparatus if water pressure decreases. J.A.F

PUMPS—CIRCULATING

(183) **A Simple Laboratory Centrifugal Glass Circulating Pump and Gas Saturator for Liquids.**
Petriconi, G. L., Montefinale, A. C., and Papée, H. M., *J. Sci. Instrum.*, Vol. 42, No. 8, 1965, 662-3.
This pump uses a P.T.F.E. covered magnet rotated by a magnetic stirrer and seems to be a variation of other earlier types. D.W.S.

SAFETY

(184) **Silvering Solutions.**
J. Brit. Soc. of Sci. Glassblowers, Vol. 1, No. 4, 1964, 45.
Emphasises the need for getting rid of unwanted mixed ammoniacal silver nitrate solution as soon as possible. Two hours is considered the safe limit for keeping. D.W.S.

(185) **Hydrogen.**
Christie, H., *Fusion*, Vol. 11, No. 4, 1964, 21-2.
Lists safety hints when using and storing hydrogen. D.W.S.

(186) **Compressed Gases.**
Christie, H., *Fusion*, Vol. 12, No. 1, 1965, 24-7.
Gives many safety tips and hints on the use and mis-use of compressed gases. D.W.S.
See also (182), (189).

SEALS—GLASS TO CERAMIC

See (173).

SEALS—GRADED GLASS

See (173).

SEALS—GLASS TO METAL

(187) **Oxide-free Glass—Metal Seals and the Production.**
Karkera, B. A., and Raut, U. P., *Fusion*, Vol. 11, No. 4, 1964, 11-2.
Discusses the technique used. The tungsten rods are heated to bright red by passing an electric current. Oxidation is avoided by the atmosphere of burning hydrogen. A bead is formed by "wiping on" Corning 7740 or Kodial glass. D.W.S.

(188) **Technique for Sealing Tungsten to Quartz.**
Grant, E. E., and Tozer, W. H., *Fusion*, Vol. 12, No. 1, 1965, 11-2.
Short article on forming the seal using Corning 7230 glass or G.E.C. graded sealing cane No. 1, as the intermediate sealant. D.W.S.
See also (173), (174).

STILLS—WATER

(189) **Protective Cut-off for a Gas-operated Water Still.**
Ven Horst, H., *Chemist-Analyst*, Vol. 52, No. 1, 1963, 21.
Inexpensive valve assembly which stops the gas flow if water supply fails. Uses solenoid gas valve and float plus a micro-switch. J.A.F.

STIRRERS

(190) **Improved Seals for Stirrers.**
Ocón, J., Paz-Andrade, M. I., *Chemist-Analyst*, Vol. 52, No. 2, 1963, 51.
Suggests using P.T.F.E. balls instead of glass in conventional ball and socket stirrer. Ball to be turned from P.T.F.E. stock. (Abstractors' note. P.T.F.E. balls may be obtained commercially in the U.K.). J.A.F.

(191) **Immersible Magnetic Stirring Unit.**
Posey, C. D., Epperson, H. L., and Heric, E. L., *Chemist-Analyst*, Vol. 52, No 1, 1963, 22.
Magnetic stirring unit is sealed in cut down 4L beaker using simple glassblowing techniques. Gives two other references. J.A.F.

(192) **Technique for Agitation of Solution by Electrolytically Generated Gases.**
Franklin, T. C., and Barrett, J., *Chemist-Analyst*, Vol. 52, No. 1, 1963, 21.
Electrolytically generated hydrogen or oxygen is used to agitate a few mls. of solution. J.A.F.

STOPCOCKS

(193) **Stopcock Extractor**
Blackston, R. A., *J. Brit. Soc. of Sci. Glassblowers*, Vol. 2, No 1, 1965, 9.
A press is illustrated and described which removes stopcock keys without breaking. D.W.S.

(194) **Stopcock—Turning Device.**
Kesner, L., and Griffin, G. E., *Chemist-Analyst*, Vol. 52, No. 1, 1963, 30.
Will turn a glass stopcock on through 90° or 120° angle at a pre-determined time. Uses standard clamps and a clockwork alarm clock. J.A.F.

THERMOMETERS

(195) **Miniature Low-inertia Platinum Resistance Thermometer.**
Zaitsev, A. M., *Instrument and Experimental Techniques, U.S.S.R.*, No 1, pp. 250, Translation Pub., September, 1964.
Describes in detail a sealed resistance thermometer, dimensions 30 x 2 x 1 mm. Reproducibility not worse than 0.002°C after nine months in range —183 to 630°C. D.A.H.

THIN FILMS

(196) **Strip Silvering of Dewars.**
Hartley, E., *J. Brit. Soc. of Sci. Glassblowers*, Vol. 2, No 1, 1965, 10.
Suggests that a Dewar should be pre-treated with a solution of Stannous Chloride, Hydrochloric Acid in distilled water, then washed, rinsed with silver nitrate and finally with distilled water before using the Brashear process solutions (which are cooled to between 10 and 15°C). Gives a better result. D.W.S.

(197) **Refined Silvering Process**
Tozer, W. H., *Fusion*, Vol. 11, No. 4, 1964, 23-4.
Gives details of a three solution mix and method of use. D.W.S.

TRAPS

(198) **Trap for Rotating Evaporators.**
Beroza, M., *Chemist-Analyst*, Vol. 52, No. 1, 1963, 22.
Simple splashead type trap to be incorporated in the evaporator prevents impurities being returned to the solution. J.A.F.

VACUUM APPARATUS

(199) **Carbon Assimilation at Low-carbon Dioxide Levels (apparatus and technique).**
Orchard, B., and Heath, O. V. S., *J. Experimental Bot.*, Vol. 15, No. 44, 1964, 314-30.
Three experiments were made on leaves, semi-closed circuit, closed circuit and open circuit. The apparatus consists of an associated system of taps. R.C.P.

(200) **Enhancement of Photo-emission from Calcium Antimonide by Oxygen.**
Bloomer, R. N., and Cox, B. M., *Brit. J. App. Phys.*, Vol. 16, No. 5, 1965, 605-11.
A drawing of the apparatus used in this project is given along with the use. D.W.S.

(201) **Device for De-gassing Liquids and Solutions.**
Samigullin, F. M., and Agishev, A. Sh., *Instrument and Experimental Techniques, U.S.S.R.*, No. 1, pp. 244, Translation Pub., September, 1964.
Schematic diagram of glass apparatus for eliminating the paromagnetic oxygen dissolved in liquids, claimed as indispensable for invesigations on nmr method. D.A.H.

MISCELLANEOUS

(202) **Graphic Symbols for Glass Systems.**
McKenna, F. E., *J. Chem. Documentation*, Vol. 3, No. 1, 1963, 24-8.
Symbols representing various glass apparatus components are proposed for types of tubing, seals, joints, manometers, gauges, and pumps, also many designs of stopcocks. The symbols are demonstrated as simplifying an elaborate apparatus and are compatible to symbols used in metal systems. S.G.Y.

In an electrode arrangement devised by Klopfer the collector is completely shielded and, as shown in Figure 10, has been put inside a box. A magnetic field which is parallel to the electron beam is required to constrict the beam to a pencil. Electrons which move out of the pencil are bent back into it and none strike the inside of the box. A bonus on the design is the high degree of electrical screening around the collector. This means that the ion currents have low noise levels.

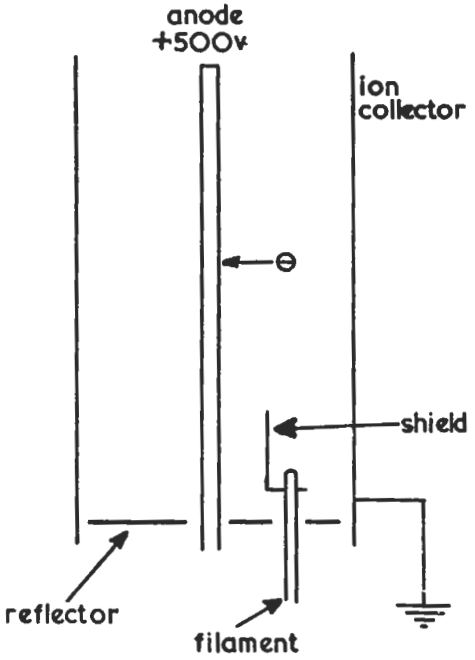
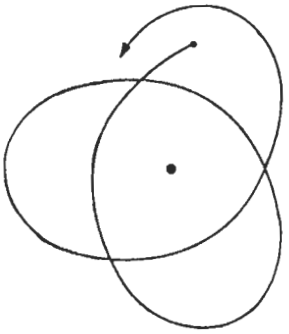


FIGURE 9(a)

Arrangement of electrodes in an orbitron gauge. The electrons are injected into the electrostatic field between two concentric cylinders



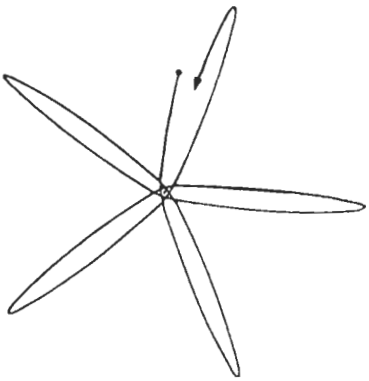


FIGURE 9(b)

Electrons pursue these long comet-like orbits about the anode. The tighter orbit has a lower angular momentum

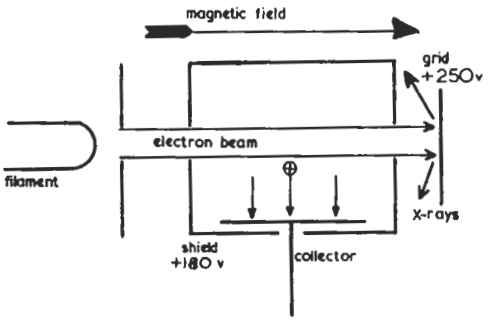


FIGURE 10

Simplified arrangement of electrodes in Klopfer's ionisation gauge

Mass Spectrometers

The ion collector in a mass spectrometer is completely screened from the sources of light and X-rays. p_X (Table 1) is therefore assessed at zero and extremely low pressures can be measured. The outstanding advantage of mass spectrometer pressure gauges, nevertheless, is that they measure partial pressures of the different gases present. As a result, the last few years have spawned a whole range of these instruments especially designed for use in UHV systems. A representative selection is shown in Table 2. With the exception of time-of-flight instruments, a magnetic field, an electric field, or a combination of both is used to split up the ions by mass. The ion optics involved has become steadily more complicated and further useful systems of analysis may well await discovery—there is currently much work in many countries devoted to partial pressure gauges.

In evaluating mass spectrometers one should not only inquire what minimum partial pressure is detectable but also the background against which this detection can be made. The cycloidal mass spectrometer and the omegatron, for instance, have comparable detection limits but the CMS 80 can tolerate a background pressure which is 10^3 times greater. The Farvitron does not show up constituents of less than 3% concentration. It does, however, display the whole spectrum continuously. Quadrupole mass spectrometers are capable of outstanding performance. Good resolution can be maintained to high mass numbers, but the geometry of these spectrometers is critical.

Magnetrons

The last entry in Table 1, the hot-cathode magnetron, is essentially an ionisation gauge with a magnet around it. Although the hot-cathode magnetron has been developed intensively in the last few years by Lafferty, we describe the simpler parent gauge due to Houston.[4] The electrode structure (Figure 11) is such that electrons are trapped by the crossed electric and magnetic fields. A special case of trochoidal trajectory results[5] which is bent back on itself by the end electrodes in the manner drawn. Electrons travel as much as 10^8 cm before reaching the anode. The ions formed travel directly to the collector because they are so much heavier that the magnetic field hardly affects them. The gauge is 10^3 times more sensitive than the Bayard-Alpert gauge for an electron emission 10^4 times smaller. In common with all devices employing efficient ionisation, however, the gauge pumps rapidly.

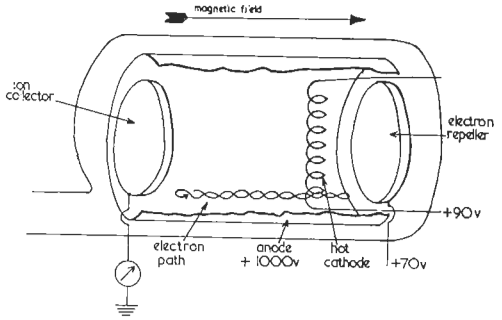


FIGURE 11

Houston's hot-cathode magnetron. The X-ray photoelectric emission is estimated as equivalent to 10^{-15} torr

All the ionisation gauges we have described so far employ hot cathodes. Hot cathodes interfere seriously with many experiments. The dissociation of diatomic gases has been mentioned and it leads to reaction between gas atoms and any available surface, including glass. Certain reactions may be catalysed by hot filaments and foreign ions are sometimes emitted. Accordingly it would be useful to have a cold-cathode magnetron (Penning gauge) suitable for modern UHV systems. Such a gauge has been developed by Redhead[6] and is commercially available abroad. We are collecting experience with the gauge in Bristol. Figure 12 shows the electrode structure. 6kV are applied between the anode and cathode to stimulate cold emission of electrons and to provide a strong electric field. Guard ring cathodes ensure that the field is uniform and prevent emission from the edges of the cathode. The electrons cannot escape from the discharge and perform oscillations which are not dissimilar to those in the Houston gauge. There is no grid so there is little X-ray effect. Some X-rays are produced when electrons strike the anode but this effect decreases with pressure.

Type of Mass Spectrometer	*Example*	*Cost (without pumps)*	*Mass range*	*Highest mass to be individually resolved*	*Lowest partial pressure detectable torr*	*Partial pressure sensitivity* P_{min}/P_{total}	*Magnet*	*Envelope*
		£						
Conventional 180° deflection magnetic deflection (steady H)	MS 10 by Associated Electrical Industries Ltd., Manchester, England	1,285	2-200	40	5.10^{-11}	200 ppm		Metal
90° deflection	22 PT 110 by General Electric Co., New York, U.S.A.	2,570	2-200	50	10^{-14}	10 ppm		Metal or glass
Cycloidal ... ... (crossed steady H and E)	CMS 80 by Balzers Aktiengesellschaft für Hochvakuumtechnik und Dünne Schichten, Principality of Liechtenstein	10,620	2-500	160	2.10^{-12}	0.1 ppm	Yes	Metal
Omegatron ... ... (crossed steady H and r.f. E)	D 16401 by Edwards High Vacuum Ltd., Crawley, Sussex, England	2,210	1-150	40	10^{-11}	100 ppm		Glass
Linear r.f. ... ... (r.f. E only)	Topatron by E. Leybold's Nachfolger, Cologne, Germany	1,360	2-100	10	5.10^{-9}	1,000 ppm		Metal or glass
Electrostatic ... ... (steady E well and superimposed r.f E.)	Farvitron by E. Leybold's Nachfolger, Cologne, Germany	2,370	2-250	none	10^{-8}	30,000 ppm		Glass
Quadrupole ... ... (crossed steady E and r.f. E)	Monopole by General Electric Co., New York, U.S.A.	4,070	1-300	250	10^{-14}	10 ppm	No	Metal
Time of flight ... ... (field-free drift region)	1111 by The Bendix Corporation, Cincinnati, Ohio, U.S.A.	7,360	0-500	100	10^{-11}	10 ppm		Metal

TABLE 2

Small bakeable mass spectrometers for partial pressure measurements in UHV systems. The methods used to analyse ions have been included in the first column. H = magnetic field, E = electrostatic field, r.f. = radio frequency

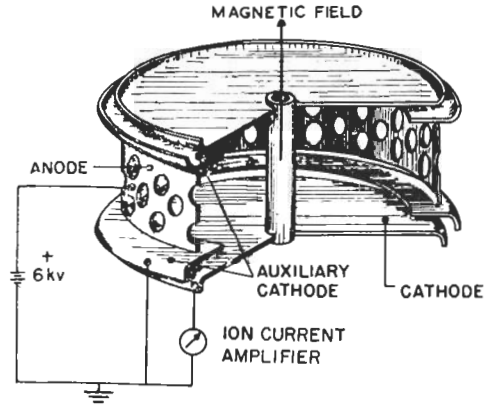


FIGURE 12

Redhead's cold-cathode magnetron — cutaway diagram of the electrodes. The perforations improve gas flow. Sensitivity is 45 times greater than a standard Bayard-Alpert gauge

Although the Redhead gauge is known to give readings to 10^{-11} torr, certain aspects of its operation are imperfectly understood. Its reluctance to strike at low pressures (one may wait 10 minutes) and spontaneous extinction of the discharge are troublesome. For this reason a triggered discharge gauge incorporating a tungsten filament has lately become available.

Cold-cathode magnetrons also exhibit variations in their sensitivity with respect to time and pressure. The problems of these gauges are embodied in a current advertisement which is reproduced by permission as Figure 13. Unfortunately this interesting advertisement does not tell us how the true vacuum line was measured. Indeed, it will probably take a little longer before entirely reliable measurements become possible at the extremely low pressures which can now be produced.

I am grateful to Mr. Keith Llewellin for help with the figures.

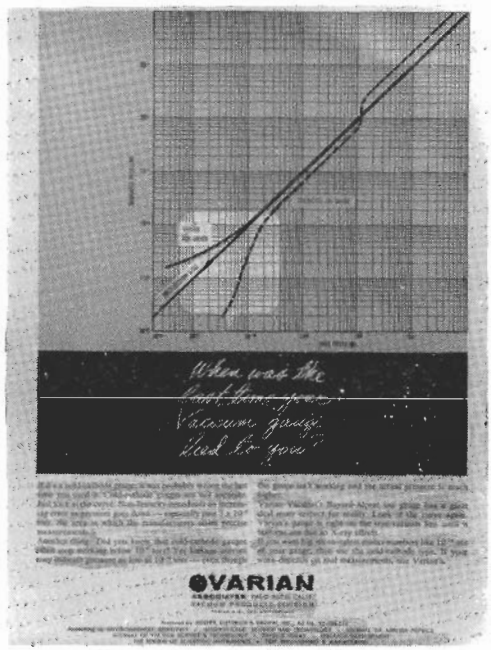


FIGURE 13

References

(1) Hobson, J. P., 1964, J. Vac. Sci. Tech., *1*, 1.

(2) Ultrahochvakuum, Trendelenburg, E. A. (Braun, Karlsruhe 1963); Ultrahigh Vacuum and its Applications, Roberts, R. W., and Vanderslice, T. A. (Prentice-Hall, London 1964).

(3) Bayard, R. T., and Alpert, D., 1950, Rev. Sci. Inst., *21*, 571.

(4) Houston, J. M., 1956, Bul. Am. Phys. Soc., *1*, 301.

(5) Electron Physics, Klemperer, O. (Butterworths, London 1959).

(6) Redhead, P. A., 1959, Can. J. Phys., *37*, 1260.

SECTION ACTIVITIES

North-Western Section

On Friday, 30th June, 1965, at the Pilkington Research Laboratories, Latham, Ormskirk, Lancs. the North-Western Section held a very successful combination of lectures, film shows and demonstrations.

The first lecture was given by Sister P. A. Grounds of Pilkington Brothers, on the general hazards in the glass industry. A film and slides were shown to illustrate types of accidents which can happen and sound professional advice was given on the treatment of casualties together with recommendations on safety spectacles and filters. This lecture appears in full on page 40. Mr. J. W. Kiggins, also of Pilkington Brothers, followed with a short introductory talk on high and low temperature brazing and soldering which was illustrated by a film and demonstrations.

The next section meeting will be at the White Hart Hotel, Warrington, where we intend to discuss education.

A works visit to Messrs. James Jobling & Co. Ltd., Sunderland, will take place early in September.

P. A. ATKINSON
Hon. Secretary
North-Western Section

Southern Section

The last lecture in the 1964-1965 programme of the Southern Section was given by Mr. S. Yorke, of Quickfit & Quartz Ltd., at a meeting held at Queen Elizabeth College, London, on Wednesday, 12th May, 1965. Mr. York described in great detail the techniques of " High Frequency Electrical Heating of Glass." Members were very interested in the lecture and at the end Mr. Yorke faced an audience intent on a long discussion.

Dagenham Cables Sports Club held a Gala Day on Saturday, 26th June, 1965 ; Messrs. Branfield, Gunn, Smith, Wingate, Wogzell and White attended to demonstrate glassblowing. Glassblowing in a tent is a novel experience, especially with a works fireman standing by fearing the worst. However, a good time was had by all, and Dagenham Cables Sports Club were kind enough to donate £10 10s. to the Society.

The 1965-1966 programme of the Southern Section is almost complete, members will be receiving a programme card in the near future.

E. WHITE

Western Section

The lecturer at the meeting held on Monday, 31st June, 1965, at the Royal Fort, Bristol University, was Dr. D. Klemperer of the Department of Chemistry, the subject being " Recent Developments in Ultrahigh Vacuum." During the course of the lecture Dr. Klemperer introduced two films and a number of slides. The lecturer is now engaged in U.H.V. research and has carried out work in the U.S.A. and Australia. A full report of the lecture is published in this Journal.

On 28th June, a party from the section paid a visit to Gooch and Housego Ltd. of Ilminster, Somerset. This company specialise in the precision cutting and grinding of glass and ceramics to very fine limits. They are also a very large producer of quartz crystal oscillators. During the visit we saw many interesting operations, the most impressive being in the hand polishing shop where these highly skilled craftsmen were producing optical flats and prisms. They were, we discovered, working to 1/10 fringe accuracy.

The meeting on Monday, 19th July, at the Royal Fort, Bristol University, had as guest lecturer Mr. G. Williams of Pilkington Brothers. He was assisted by Mr. Milner. The title of the lecture was " Sheet Glass Manufacture." To supplement the lecture two films were shown. The lecturer and the films dealt with the various forms of sheet glass, window glass, plate glass, float glass, figured glass and wired glass. Mr. Milner treated us to some amazing demonstrations with toughened glass.

D. W. SMITH

Midland Section

The Midland Section Committee held a meeting on Tuesday, 17th August, for the primary purpose of completing the arrangements for the Annual Colloquium to be held on 24th September.

It was confirmed by Mr. Haynes that the Hawarth Building, Chemistry Department of Birmingham University had been booked and also that car parking space would be available. The programme for the day was as laid out.

The meeting then went on to draw up a list of events for the Midland Section. This will be published when confirmed.

R. S. HANLEY

HAZARDS IN THE GLASS INDUSTRY

Lecture given to the North-Western Section by

SISTER P. A. GROUNDS *of Pilkington Brothers*

I WOULD like to talk to you on a subject which I hope will be of interest to you all, the hazards of the glass industry and their possible elimination. In particular, I would like to concentrate on the hazards which have been and still are peculiar to the glassblower.

During the latter half of the 19th century, glass making had a bad reputation for ill health, apart from accidents. Due to the exhaustion of blowing, and the presence in the air of minute irritant particles of silica, silicosis and other lung diseases were much in evidence. Many of the men suffered from poor sight; optical ailments, for example glassblowers' cataract; consumption; stomach disorders; dermatitis; skin infections; and bad legs. Generally, the standard of health in those days was low, which will have contributed to the poor health of the glassblower, in fact, in 1880, the average age at which glassblowing ceased was 32-34 years! To quote an old-timer recalling his youth in the glass industry: " . . . It looked easy, but you must remember that the blow-pipe weighed 25 lbs. and you had 60-70 lbs. of molten metal on the end of it, and it required a good deal of skill as well as physical strength to blow a cylinder 5 ft. long and of an even thickness and diameter throughout."

A newspaper cutting of the 80's announcing the discovery of a mechanical method of blowing commented: " Many attempts have been made to get rid of this painful process in the operation of glassblowing; but to this day in every bottle-house in England may be seen pale-faced men with their cheeks hanging in limp folds, the result of years of glassblowing by the mouth. Cases have been known in which mens' cheeks have been worn so thin that they have actually cracked. It is a common sight in the bottle-house to see blowers at work with their thin cheeks puffed out on either side like the fingers of a glove."

However, although the general health of the glassblower is no longer a great problem, we must not overlook the possibility of accidents occurring whilst handling or working glass. Great care must be exercised and every advantage should be taken when the use of protective clothing, and in particular safety spectacles, are available for use.

When working glass, safety spectacles are worn to protect the eyes against foreign bodies.

If reduction of luminous intensity is required or protection against radiant energy, the appropriate tinted glass as described in the list on page 42.

At this point a slide was shown of a man holding a pair of safety spectacles which had been spattered with molten metal, these spectacles saved the man's sight.

The second slide showed a pair of safety spectacles which had been hit by flying glass.

A film then followed showing accidents occurring in an American glass works and recommended methods of eye protection.

Now I would like to say a few words about first-aid treatment. As we have just seen a film on eye injuries, I think that would be an appropriate subject to start with.

Splinters or flakes of flying glass may enter the eye causing great discomfort. Glass is difficult to see in the eye and attempts should not be made to remove it if the glass is at all adherent to the eye as any interference may result in further injury. Any trace of blood, however slight, may indicate that glass has penetrated the eye, which is an extremely serious condition. A penetrating wound is caused by flying glass and the immediate history of the injury is of great medical importance in the subsequent treatment of the eye. Incidents predisposing this type of injury are, e.g. glass breaking and bouncing into the eye from a hard surface; or following the explosion of laboratory glassware, also the breaking of toughened glass.

The patient must be prevented from rubbing his eye as this will certainly aggravate the condition. He should be firmly reassured, a calm manner will allay some of his fear. If there is evidence of a possible serious injury, the casualty must be laid down in a safe place, out of the range of any further injury. When a first-aid box is at hand, an eye pad should be applied to the eye and secured round the head. When a first-aid kit is not available, it may be necessary to improvise an eye pad; a clean handkerchief or other such clean linen may be used for this purpose. Medical aid should be sought immediately. A slide was then shown of a loose foreign

body being removed quite easily from the eye with the corner of a clean handkerchief.

As many wounds of varying degree occur whilst handling glass, I would like to mention the treatment of wounds and the possible accompanying haemorrhage.

If anyone is unfortunate enough to cut themselves whilst handling glass, the extent of the injury should be assessed quickly and calmly, panic is infectious and will only add to the distress already being experienced by the casualty. Small wounds with little blood loss should be cleansed where possible with soap and water or a mild antiseptic cream and a dressing applied. Application of strong chemicals, e.g. iodine, is not recommended. If there is a possibility of glass being present in a wound, attempts to remove it are strongly ill-advised as further damage to blood vessels or nerves may be caused. Small pieces of glass may be forced further into the wound. Also any blood clots which have formed will be disturbed and may instigate fresh bleeding. In the case of a large piece of glass being embedded in a wound, a dressing should be built up around the offending glass to prevent direct pressure being applied on to the glass when the dressing is secured. In the event of haemorrhage from a wound it is useful for the attendant or first-aider to be able to assess the nature of the blood flow and act accordingly.

Blood from an artery is bright red in colour, if the injured artery is near the skin the blood is seen to spurt out in jets corresponding with the pulsations of the heart. Blood from a vein is dark red and flows in a brisk continuous stream. Arterial and Venous haemorrhage combined usually gushes out from the depth of the wound. Slight haemorrhage comes usually from injured capillaries and may flow in a continuous stream or merely ooze from all parts of the wound.

When an injury does occur the haemorrhage must be controlled as quickly as possible. Place the casualty in a suitable position, bearing in mind that blood escapes with less force when the patient sits, and still less when the patient lies down. This will also lessen the extent of shock, as the vital organs, for example the brain, will not be quite as deficient of blood and the oxygen it carries. Except in the case of a fractured limb, elevate the bleeding part to slow down the blood flow. Expose the wound, removing as little clothing as possible. Pressure is now applied, and maintained, either directly or indirectly, depending on the type and situation of the wound. Then a dressing pad and bandage is applied. When the wound is near a joint, for example the knee, immobilise the joint using splints if necessary.

Direct pressure control is applied with the thumbs or fingers over a pad, if available, to the part of the wound from which the blood is coming. When a foreign body or projecting broken bone is in the wound press alongside it and not over it. If the bleeding point is not readily visible, grasp the whole wound and squeeze it tightly. This will nearly always control the bleeding and allow time for a dressing to be prepared. Apply a suitable sized dressing and pad over the wound, press them well down and bandage them firmly into position. Deep wounds may need further pads on top of the first, thus pressing the dressing into the depth of the wound. Always be sure that the pad projects well above the level of the skin in order to provide adequate pressure on the torn edges of the blood vessels and also ensuring that the dressing is not lost inside the wound. The bandage should not be applied more tightly than is sufficient to stop bleeding. If blood still soaks through apply a further pad on top with a fresh bandage but do not remove the original pad and bandage. Direct pressure is successful in 99 per cent of cases. Severe haemorrhage can always be controlled by direct pressure at first until expert help arrives. If bleeding cannot be controlled by the application of direct pressure or when it is impossible to apply direct pressure successfully, apply indirect pressure to the appropriate pressure point. A pressure point is one where an artery can be pressed against the underlying bone to prevent the flow of blood beyond that point. There are four main pressure points which are: the carotid pressure point; the sub-clavian pressure point; the brachial pressure point; and the femoral pressure point.

If it is ever necessary to apply indirect pressure then obviously a serious injury must have been suffered, so I hope you will have already sent for medical aid. Very occasionally it is necessary to use a constrictive bandage. If this occasion should arise, and I sincerely hope not, it must be remembered that a constrictive bandage can cause a great deal of harm.

The recommended type of bandage is a rubber one, approximately 2½in. wide and about 4ft. in length. Use of a constrictive bandage is rather limited, it will control any limb bleeding, except in the forearm and lower leg where it cannot constrict blood vessels lying between two bones.

When it is applied it must be remembered that 15 minutes is the maximum for this bandage to be left in position, then it must be cautiously loosened. If bleeding should recommence then it should be re-tightened. Constrictive bandages may be improvised here by belts, ties, braces or slings, depending on what you happen to have handy at the time.

If the patient should have to get to hospital with the constrictive bandage on, a label must be attached to the patient stating the exact time at which the bandage was applied.

Small glass cuts or puncture wounds in the hands and fingers are common injuries, which sometimes damage a digital nerve or tendon.

A slide was then shown of one such innocent looking cut on the thumb, followed by a second slide showing the same thumb again, this time after digital nerve repair.

Laboratory technicians (and nurses fitting up drips) seem to be a little more vulnerable to this type of wound, often caused by the hand slipping when pressing a glass tube into a cork.

Then followed a slide which illustrated a classical text-book example of a tendon injury. The tendon was damaged in the middle third of the forearm, as it is an extensor tendon involved, the finger it controls has dropped and the patient is unable to lift it. Another example of a cut tendon was illustrated, this time on the back of the index finger. The white part visible in the centre of the wound was the severed edge of the tendon.

Burns

Finally, I would like to mention what I believe to be a common hazard amongst glassblowers, namely burns.

As a burn is caused by something hot, it is usually sterile, the aim of treatment is to keep it that way.

Superficial burns heal well with a sterile dressing applied to cover them.

Deeper burns heal with contracture, this is disabling on the flexor aspect of the fingers. It is often difficult at first to decide how deeply the burn has penetrated. If in any doubt, expert

LIST OF SAFETY SPECTACLE LENSES AND FILTERS

Type or Name	*Description*	*Notes and Recommendations*
Crookes B.2 ...	Laminated or non-laminated. Smoke-grey glass. Permanent filter	Reduction of glare and protection from heat radiations. When laminated, protects from flying particles also. Having a neutral tint, colour values remain the same and are not distorted. Absorption of ultra-violet and infra-red is good. This is particularly useful for long periods of work under extremely bright light and where glare is present
Protex and Protal	Green glass. Permanent filter. The protection and visual densities are obtained by pigmenting the entire body of the glass during manufacture	Reduction of the intensity of the visible radiation reaching the eyes of the operative enabling him to work in comfort. Absorption of invisible but harmful ultra-violet and infra-red radiations. Prolonged exposure to infra-red radiation is strongly suspected of being a contributory cause of cataract. Strong ultra-violet radiation causes acute pain, sometimes with serious side effects
Didymium ...	Glass. Permanent filter ...	Reduction of glare when fusing vitreous silica or other hard glass. Particularly recommended for glassblowing
Shadowlite ...	Laminated glass. Lightish brown inter-layer	Provides general relief from glare. Special new " Shadowlite " interlayer cannot fade. Light transmission 12 per cent. " Triplex " laminated glass ensures protection from risk of flying particles

medical advice must be sought. Blisters should not be burst or any burnt clothing removed which is involved in the wound. Strong chemicals, e.g. tannic acide, and flavine, etc., must not be used on the burn. It is sufficient to apply a dry sterile dressing until medical attention is sought. This treatment also applies to scalds.

The first of the two slides that followed depicted a small burn on the arm ; followed by a scald showing some blistering.

Chemical burns should be well washed in running water for 10 minutes before a dry dressing is applied.

Chemical burns of the eye must be continuously irrigated for 20 minutes and expert help sought. It would be impracticable to have all the antidotes available for the various chemicals in use. Therefore, water, saline or a buffered phosphate solution, which neutralises both acids and alkalis is used and has proved most effective.

The last slide showed the correct method of eye irrigation.

Conclusion

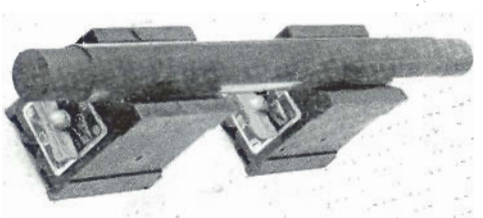
As you will appreciate first-aid is quite an extensive subject and we have only scratched the surface, but I do hope that what I have mentioned will be of some help to you people who are handling and working glass.

WORKSHOP NOTES

CUTTING CHROMATOGRAPHY TROUGHS

MANY engineering machines are adapted for cutting, grinding and working glass and this article describes one application of Diamond Impregnated Products Limited, GF3 milling machine.

Chromatography troughs and boats of various diameters can be made, using two Magnetic " Vee " blocks and a round iron bar, 12 inches long, for holding the work. The blocks are set on the miller bed in line, end on to each other about four inches apart. The 1¼ inch iron rod is put inside a 12 inch length of 35 millimetre glass tube and both are placed in the " Vee " blocks. The combined weight and pull of the bar to the blocks will hold the tube quite adequately for the sawing operation which follows. The saw blade used is resin bonded Silicon Carbide, 6 inches diameter and $\frac{3}{32}$ inches thick (120 Grit). The work is fed into the wheel from underneath.



By means of the longitudinal traversing mechanism, a light cut is made starting 1 inch from one end and ending 1 inch from the other, the uncut ends ensure that the glass does not shatter when the second slot is being cut. A series of cuts is now made, the depth of cut can be controlled to .002in. by the vertical feed handwheel. When the wheel is " through," the bed is lowered clear of the wheel and the tube rotated 180°, the bed raised and the second slot is now made following the same procedure as the first.

The end product is a tube with two slots in opposition along most of its length. A knife cut and hot spot will split them in two halves for finishing in the bench lamp. If many tubes are cut, they are best stored by leaving as cut from the machine.

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(Further workshop notes and technical articles held over.—EDITOR)