SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

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Contents

Introduction	- safety lectures	Page 1.
	- future of SSSERC	1.
	- ASE Scottish Region Annual Meeting	1.
Opinion	- SSSERC's law?	2.
Biology Notes	- oxygen meters	3.
Integrated Science Notes	- 'exploding match' experiment: a safer alternative method	7.
Physics Notes	- freezing by evaporation: an o.h.p. demonstration	8.
Trade News	- ASE Annual Meeting Exhibition report	10.
Address List		12.

Introduction

Our diary is filling up with bookings for lecture demonstrations on aspects of laboratory safety. However we would still be pleased to hear from science advisers, local science teachers' associations, or other parties interested in having SSSERC staff contribute to their safety training programmes. By the time this bulletin reaches the schools, we will have already given one lecture demonstration, on 'Safety in Microbiology', at the Robertson Centre, Paisley. Other venues and subjects for the early part of the year include:

Markinch Centre, Fife, 21st February, 'General Laboratory Safety';

Newton St. Boswells, Borders Region, 28th February, 'Safety in Chemistry Laboratories';

Markinch Centre, Fife, 1st March, 'Safety in Microbiology'.

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We would like to thank all those science teachers and others who wrote to us as a result of the 'Introduction' in Bulletin 100 and expressed their appreciation of SSSERC and its services. We would also like to record our thanks to all those whom we know have written or spoken to their science adviser or education officers giving their support for the continuance of the centre. We felt that a standard, duplicated letter of thanks would be inappropriate and, ironically, we are so busy with routine work for other teachers that we could not reply personally to everyone who has written in giving their support.

There is still some uncertainty about the long term future of SSSERC. However, we can now report that the Education Committee of the Convention of Scottish Local Authorities has set up a working group to look at the provision of resource services to education authorities. The terms of reference agreed for the working party are as follows:

"To assess generally the complementary nature of local authority and national activity in the field of educational technology and resources; to consider how local authority services might derive most benefit from national services (and vice versa) with particular reference to those offered by SCET and SSSERC; to assess the level of services which these bodies should aim to provide for authorities and particularly for those parts of the country where few or no services presently exist; and to make recommendations."

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The Annual Meeting of the Scottish Region of the Association for Science Education will take place from 30th March to 1st April, 1978 in Aberdeen College of Education. We will be staging an exhibition of SSSERC apparatus for the duration of the meeting.

Opinion

With the publication of the Munn and Dunning reports, new curricular developments in science appear inevitable. Indeed a pilot scheme on 'Modular Science', already under way prior to publication of these reports, is being developed and expanded. Fortunately, because all involved in these matters are very conscious that many teachers are tired of major curricular upheaval, these developments look like being more evolutionary than revolutionary in nature. One of the new considerata is 'constraint on curriculum development'. Acceptability to teachers of the degree of change is seen as a major 'constraint'.

If the development is to be evolutionary in nature, then this has several advantages. It allows material to be properly trialled and evaluated, practical work to be validated and many of the snags ironed out. Hopefully it will also give those involved more time to reflect on their aims and to decide on the best ways of achieving them. This assumes that Parkinson's First Law - "Work expands to fill the time available" - does not operate. One of the things they might profitably turn their minds to, is the question of equipment costs. Many aspects of course structure, content, suggested teaching strategies and classroom organisation have far reaching effects on costs. We at SSSERC are acutely conscious of these effects and of how costs have escalated. Since May, 1974, during a period of virtual standstill in educational spending, we have seen our cost index jump from its base of 100 to 175.6 at the latest computation.

We have had a growing number of enquiries from principal teachers about the cheapest sources of particular items, and from science advisers and education officers equipping new schools or laboratories. Increasingly we are finding that authorities just cannot afford the levels of expenditure needed to equip to the extent described in our equipment lists. These lists are based very closely on the published syllabuses which, with their 'Suggested Practical' headings, set narrow limits as to the type and quantity of apparatus required. Within these limits we have always sought to recommend the most cost-effective apparatus available, subject to it being able to perform what the syllabus requires. We are aware that one does not need to teach all of the syllabus to the same degree, but we think it is not part of our function to decide what should be omitted or played down. For as long as we can remember parts of the syllabuses have been omitted because of lack of time. Syllabuses have always been overcrowded and 'question spotting' is a traditional pastime with many teachers. However, we can at least hope that what is omitted is sometimes decided on 'educational' grounds. If financial considerations become the main ones, then some of the most important practical work may not be done because the equipment cannot be made available, not because it is time consuming or esoteric.

In his book "The Law and the Profits", C. Northcote-Parkinson states 'Parkinson's Second Law' - "Expenditure rises to meet income". In the past this could be adapted for application to the provision of science equipment for schools and could be restated in this form: "Expenditure rises to meet the income generated by each new curricular development". This can no longer be the case. As Parkinson suggested, the proper way to decide financial priorities, and exercise fiscal control, is to start at the other end. Three of the stated aims of any new science course should perhaps be:

1. The course should employ the minimum of expensive capital and consumable equipment needed to achieve the stated aims and objectives.

2. The course should be so structured and organised that the unnecessary duplication of items of equipment can be avoided.

3. The course should be so structured and organised that the apparatus required is mainly of a type that is general or multi-purpose and is likely to receive maximal usage.

One of the central ideas underlying the thinking of ASEP staff when they were developing their materials was that a great deal of science can be taught without employing unnecessary amounts of expensive apparatus. The ASEP scheme has served as a model for much of the current development in Scottish science education. Perhaps ASEP still has things left to teach us.

Biology Notes

Oxygen electrodes, used routinely in industry and research for some time, have recently been made sufficiently robust and inexpensive for school use. They allow continuous, direct monitoring and have few of the disadvantages of wet chemical methods or tedious manometric procedures. Although comparatively inexpensive electrodes are available, a complete oxygen meter represents a large slice of any science requisition. It is a pity that such as useful tool should become available just when schools are least likely to be able to afford it. Fortunately electrodes can be bought separately and used with home-made circuitry, some of which will be described in a future bulletin.

Attempts have been made to design specific reversible oxygen electrodes and to determine their electrode potential with respect to an oxygen solution. If this potential were measured at high impedance, so that there were negligible current and oxygen consumption, then oxygen concentration could be measured as easily as pH. Unfortunately, in practice reversible electrodes have proved very difficult to construct and are too easily poisoned. Instead two main types of irreversible electrode are used, the galvanic and polarographic oxygen electrodes.

Galvanic oxygen electrodes are used in the Philip Harris and S.E.A. dissolved oxygen meters and in the oxygen meter of the Unilab Environmental Kit. An inexpensive electrode of this type is available from Uniprobe who also supply circuit details and applicational notes. The essential features of this type of probe are shown in Fig. 1.

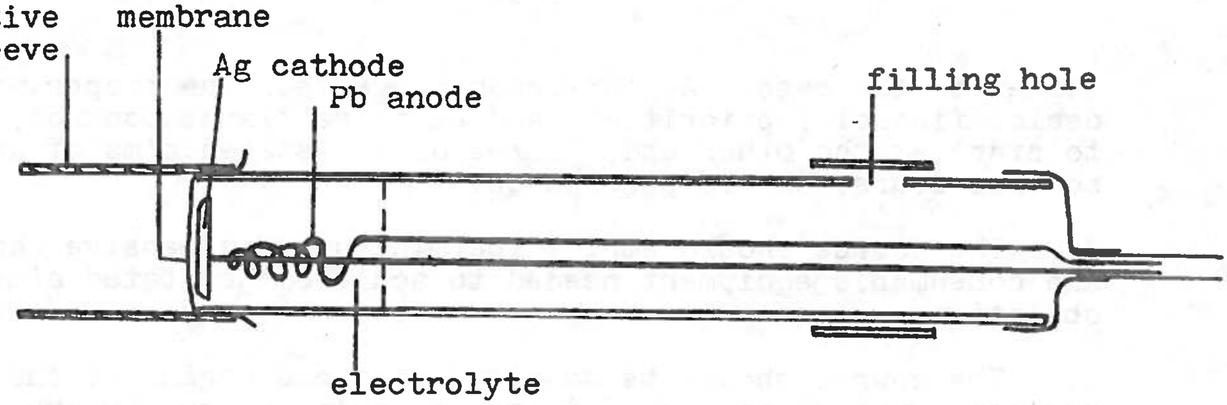


Fig. 1. Galvanic Oxygen Electrode. Note that the normal operating position is vertical.

The operation of this type of electrode does not require the application of a voltage. There is already a potential difference between the silver cathode and the lead anode. The action of the cell is essentially as follows:

Ag <u>Cathode</u> $\frac{1}{2}O_2 + 2H_2O + 2e \rightarrow 2OH^-$

Pb <u>Anode</u> $Pb \rightarrow Pb^{++} + 2e$

$Pb^{++} + 2OH^- \rightarrow Pb(OH)_2$

<u>Overall</u> $\frac{1}{2}O_2 + Pb + H_2O \rightarrow Pb(OH)_2$

The rate of this overall reaction and therefore the electrode current is determined by the rate of transfer of oxygen to the cathode. This in turn depends upon the diffusion gradient across the membrane.

Polarographic electrodes, based on the 'Clarke' electrode originally developed for blood gas analysis, are used in the <u>Griffin and George</u>, <u>Rank Brothers</u> and <u>W.P.A</u>. oxygen meters. The construction of these electrodes is very similar to the galvanic tyoes but their mechanism is different.

In polarographic electrodes a voltage is applied so that a platinum 'cathode' is held at a negative potential to the solution. The other electrode in the cell is a non polarising, anodal electrode of chlorided silver wire. The applied voltage is too low for electrolysis to take place. Instead the platinum cathode becomes polarised, hydrogen being formed on it. Oxygen diffuses through the membrane and combines with the hydrogen to form water or hydrogen peroxide. This 'depolarisation' alters the current flowing in the electrode. The amount of alteration will depend, as with the galvanic probe, on the rate of transfer of oxygen across the membrane. This will in turn depend on the concentration gradient. Provided the concentration of oxygen inside the probe is kept low, the change in electrode current is proportional to the external oxygen concentration.

Absolute polarographic measurements of oxygen concentrations would be feasible if it were not for the difficulty of determining and controlling all the factors which affect the rate of transfer of oxygen to the cathode. The measurement or calculation of this rate is affected by a large number of variables such as thickness of membrane, temperature, rate of stirring etc. Those

Manufacturer/ Supplier	Description Cat. No.	Price	Electrode Type	Notes
Griffin and George	The Griffin Oxygen Meter DOS-210-K.	£75.00	Polarographic. Electrolyte saturated KCl. Polythene membrane. Electrode available separately: DOS-230-030K, £25.30.	Simple probe/meter case format. Measures both gaseous and dissolved oxygen. Battery operated (1 PP3).
Philip Harris	The Harris Dissolved Oxygen Meter B18700/4.	£72.00	Galvanic. Electrolyte 1 M KOH. PTFE membrane.	Format as above, case has storage space for probe. Meant for dissolved oxygen only. Battery operated (2 PP3s).
Rank Brothers	Rank oxygen electrode system. Oxygen electrode Polarising circuit and readout Magnetic stirrer	 £27.50 £55.00 £29.70	Polarographic, built into chamber with water jacket. Electrolyte saturated KCl. PTFE membrane. Available separately - see price column.	Specialised system for physiological work. Modular in format. Measures dissolved oxygen only. Very sensitive. Battery operated (HP2s). Stirrer is mains.
S.E.A.	OM11 Portable oxygen meter.	£75.00	Galvanic. Electrode available separately as OE 10, £18.00.	Simple probe/meter format. Measures dissolved oxygen 0-100% saturation or 0-15 ppm. Battery operated (2 PP3s).

Unilab	Oxygen module of Environmental Kit 423.001.	£43.25	Galvanic (Uniprobe DO 100). Electrolyte based on $KHCO_3$ solution. Available separately as 424-009, £19.20.	Format modular, using separate oxygen and meter/power units. Measures gaseous and dissolved oxygen. Battery operated (1 PP3)
Uniprobe Instruments	DO 100 oxygen electrode (electrode only).	£16.50	Galvanic, see above.	Electrode supplied with full operating instructions and details of three simple do-it-yourself measuring circuits.
W.P.A.	Oxygen meter 02.	£75.00	Polarographic. Electrolyte saturated KCl. Polythene membrane. Available separately, 021, £25.30.	Simple probe/meter format. Gaseous and dissolved oxygen. Battery operated (1 PP3)
W.P.A.	Environmental Multiprobe E1 main unit E1/O oxygen module and electrode	 £53.00 £38.00	Polarographic. See above.	Part of modular environmental kit. Battery operated (2 PP9s) or battery eliminator P529E may be fitted, £15.40.

With the exception of the S.E.A. oxygen meter, all the apparatus listed has been fully tested at this Centre and intending purchasers requiring fuller information may if they wish consult SSSERC staff. CLEAPSE have produced a very informative report on environmental equipment (2) which includes detailed information on all the equipment in the table, except the Rank Brothers system and the S.E.A. OM 11 meter. Copies of this report may be borrowed for up to one month by writing to the Director of SSSERC at the address given on page 12.

References:

(1) Kay, R.H., 1966, "Experimental Biology- Measurement and Analysis", Chapman and Hall Ltd.

(2) CLEAPSE, 1977, Report L142, "Environmental Equipment for Schools".

who are interested in the more technical aspects of oxygen electrodes will find an excellent introduction to the subject in (1). Largely because of this difficulty in predicting the rate of transfer in any particular situation, polarographic, and galvanic, electrodes are usually calibrated empirically in the experimental arrangement in which they are to be used.

Also, with both types of electrode a compromise is made between having accuracy and a reasonably quick response. A very accurate electrode requires a strictly diffusion limited transfer of oxygen, but this results in a slow response. Diffusion limited currents are small, little oxygen is consumed and depletion in the area of the probe is avoided. However in order to increase the size of signal when measuring dissolved oxygen, controlled stirring is often used. Here continuous mass transfer of oxygen to the electrode occurs. All the electrodes available from schools' suppliers attempt to exploit the advantages of both diffusion limited transfer and controlled stirring. This is achieved by having a localised area in which oxygen exchange with the cathode is diffusion limited, separated by a membrane from the sample being tested, so that mass transfer of oxygen to the vicinity of the electrode can occur.

The effective use of oxygen electrodes requires a knowledge of their mechanism and limitations and the development of certain techniques. Some of these limitations and techniques will be described in a future bulletin. The table gives some information on the electrodes and oxygen meters currently on the school market.

Integrated Science Notes

It has been brought to our attention that the second experiment in Section 3 Core Sheet 2 of the new S1 and S2 Mixed Ability Worksheets can sometimes result in a burning match and its fragments being propelled several metres. This has already resulted in one accident, a pupil being hit on the back of the neck by a burning match. In order to ensure that everyone is out of the firing line this experiment, as shown in the worksheet, should be carried out only as a demonstration. We were at first appalled, and then fascinated, by the size of the explosion, the distance travelled by the match and the force behind it.

One modification we have made, in order to reduce the hazards and enable it to be retained as a pupil/stations experiment, consists essentially of fixing the match in 'Blutak' or plasticene. Thus only the aluminium cap is propelled and unlike the match it cools rapidly and is unlikely to throw off bits of burning material. Its flight can be blocked by placing not more than 10 cm in front of it, the open end of a horizontally held, wide mouthed tin. If they can be afforded these days, 1½ lb instant coffee tins are suitable. Similar sized tins of diameter greater than 15 cm could easily be obtained from the school dining hall.

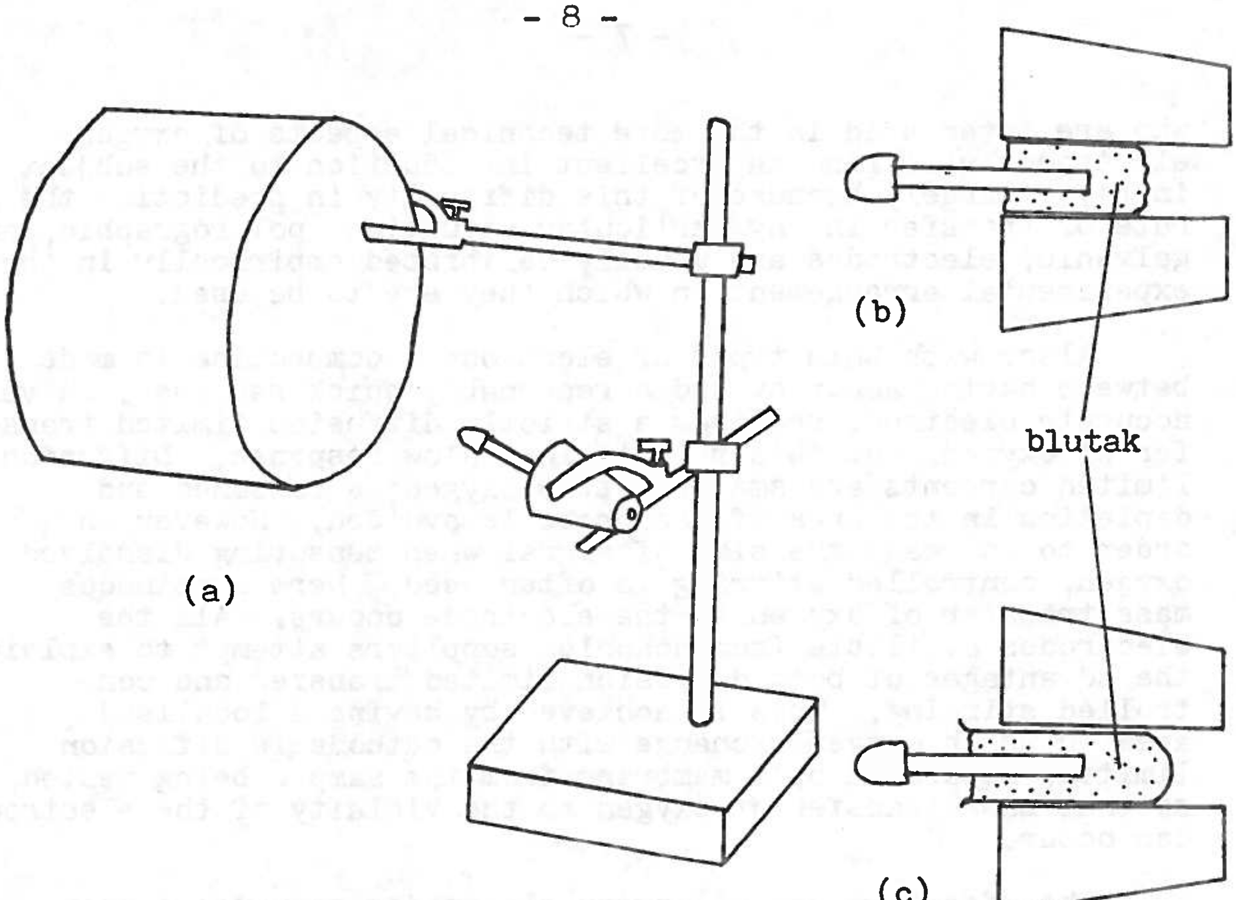


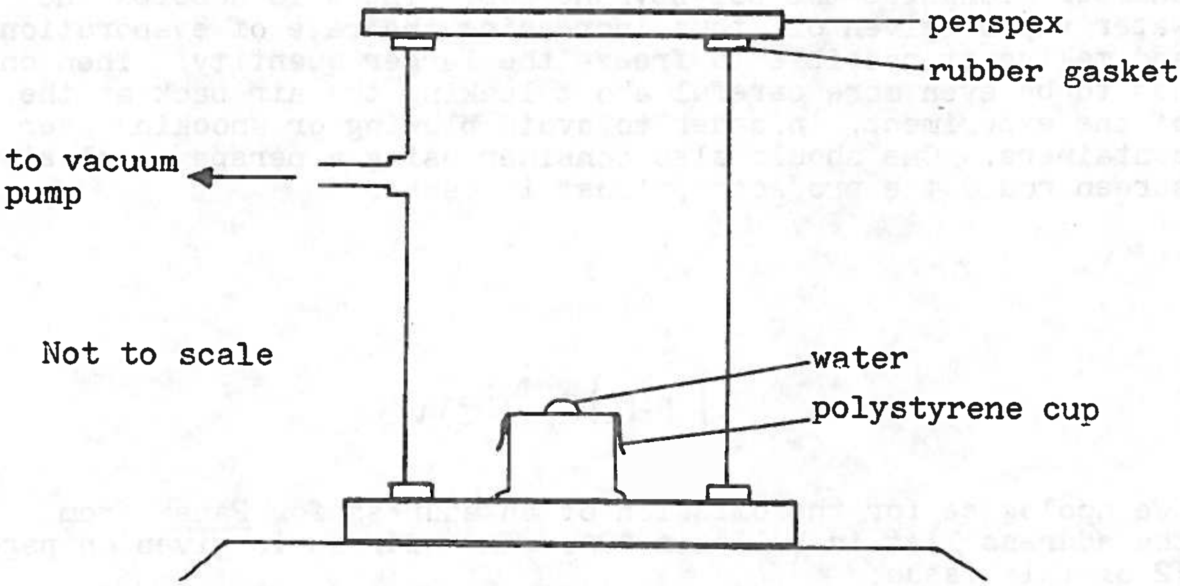
Fig. 1.

The match can be mounted in Blutak in a one holed bung held in a retort stand so that it points towards the mouth of the tin, Figs. 1(a) and 1(b). An improvement suggested by Hawick High School is that of placing the Blutak in a small sealed tube which keeps the bung clean and also provides a means of storage, Fig. 1(c).

This method results in a satisfyingly resounding clang when the kinetic energy of the flying cap is dissipated in striking the tin. Those who may feel that the pupils cannot see an object moving rapidly over this short distance can use a large loosely hung polythene curtain, placed at a much greater distance from the match. This will stop fast moving projectiles without any ricochet. A long taper is more satisfactory than a bunsen for lighting the 'charge'. The need for the safety measures described above should be pointed out to pupils and perhaps a warning issued not to carry out the experiment at home.

Physics Notes

This experiment was described in the September, 1977 issue of The Physics Teacher, an American journal, and all we have done, apart from confirming that the experiment works, is to translate proprietary brand names into their U.K. counterparts, and to give an account of the experiment as we performed it. Evaporation of the water is done by evacuating the space surrounding it using a rotary pump. The amount which can be frozen is very small, of the order of a few drops, so that the overhead projector is used to show the process happening.



It is important to isolate the water thermally as much as possible. Hence it is placed in the middle of a taut sheet of Klingfilm, the plastic food-wrapping material which is supported between two rings cut from two small polystyrene cups in the same way as a piece of cloth is stretched in an embroidery hoop. The sources of the cups is unknown: they are 35 mm high, 40 mm top and 30 mm bottom diameter and look very like the jam pots used for aircraft meals. The important considerations are that they should be of plastic or other heat insulator and preferably should not be wider than the 40 mm dimension.

The container to be evacuated is a brass cylinder 80 mm dia. and 100 mm tall. This was cut from a piece of scrap brass tube, and any metal tube or pipe of similar size would be suitable. Near one end a brass nozzle is soldered over a hole drilled in the side: this is for the vacuum pump connection. Two rubber rings of the correct diameter to cover the tube ends were cut from motor lorry inner tube. Over these are placed squares of 7 mm thick perspex.

The whole is assembled on the projector table as shown in the diagram. Three drops of water from a 2 ml syringe are placed in the centre of the Klingfilm. If the upper perspex sheet is pressed down when the pump is turned on, the suction (?) is enough to seal both ends of the brass tube against the rubber gaskets. Those watching the projected image will see that after 2 - 3 minutes the drop suddenly goes opaque: ice has formed. The vacuum is cut off and the pump stopped: then the air is leaked back slowly into the chamber via the pump control valve. If this is done too quickly the polystyrene cup will be blown over and the ice may melt before it can be recovered, but if it is done carefully the ice, still on the Klingfilm can be examined and identified by pupils.

The original article recommends the use of polaroid squares above and below the chamber so that colours caused by the ice crystals may be observed, but we found this the least satisfactory part of the experiemnt, besides being irrelevant and unnecessary when one can identify the ice directly.

If one is prepared to take the risk, the amount of water frozen can be increased to 0.5 ml. This involves placing a small crucible containing 2 - 3 ml concentrated sulphuric acid in the chamber alongside the polystyrene cup. The acid adsorbs the water vapour given off thus increasing the rate of evaporation and making it possible to freeze the larger quantity. Then one has to be even more careful about leaking the air back at the end of the experiment, in order to avoid blowing or knocking over the containers. One should also consider using a perspex explosion screen round the projector, 'just in case'.

Trade News

We apologise for the omission of an address for Panax from the address list in Bulletin 101. The address is given on page 12 of this issue.

At the Association for Science Education Annual Meeting in Liverpool in early January, a number of manufacturers and suppliers were showing new products. Lack of space precludes a comprehensive treatment, but here are a few items that caught our eye.

E.J. Arnold were showing a new range of secondary science equipment including the Arnold 'Simkits' designed by Dr. Simpson of Hong Kong University. These kits, ranging in price from £3.99 to £6.50, deal with different aspects of the physics of light. A new Arnold 1978 Secondary Science Catalogue is available from the address given on page 12.

Bausch and Lomb Optical had a new microscope, the HSM Student, on show. The same basic body form is available with a range of optical and other accessories.

Control System Services were offering to service and repair a whole range of electrical and electronic equipment - more on this in a future bulletin. Even more interesting was a solid state spot galvonometer they have developed which has no suspension system, mirror etc. and is therefore very robust. They hope that this will sell at about £85.00.

Amongst the usual very comprehensive displays on the Griffin and George stands were up-dated balances from Mettler and three Prior microscopes somewhat more lightweight than the usual Prior models. Also available is the 1978 Griffin price list which includes some lower prices for consumable essentials. All prices in the new list will be held firm for orders received up to 30th April, 1978. A new Chemicals Catalogue is to be published shortly and will be mailed direct to schools during February.

A fair number of new items were on show on the Philip Harris stand. These included an 'Environmental Light Comparator' and a pH Meter at £43.50 each (Cat. Nos. B18580/9 and B18860/4 respectively): a Student Microtome B35800/5, £90.00; a Scaler/Timer, P67342/6, £107.63: Ratemeter, P67302/5, £80.75; Digital Joulemeter, P26590/7, £84.00: and a dual trace attachment for single beam CROs or chart recorders. P63890/6, £55.00.

Ideas for Education were showing, among other things, the Life Wharton Counter Timer LF534, a lightweight, battery operated, digital counter/timer/electronic stopclock, at £71.50, and a prototype double beam colorimeter using l.e.d.s as light sources.

Irwin Desman Ltd. had new or improved versions of a number of items of equipment. These ranged from a new version of their EA331 pH and mV meter (battery model £48.50, mains version £51.00) to a new electronic thermometer EA567 at £48.00 with probe. An optional extra for this was a multiprobe input module allowing the use of several probes - EA1002 at £7.60. An interesting safety aid, suitable for purchase on a regional or science centre basis, was their new insulation and earth fault tester - EA799 at £80.00.

New British made microscopes - the OM Series - were featured on the stand of Offord Scientific Equipment Ltd. These range from £85.60 for the simplest model (OM 100) to £124.98 for an instrument to an 'H' grade specification.

Pyser Ltd. have three new models of microscope, all aimed at the budget conscious customer. Two of these are modifications of previous models - the Swift M20E stereomicroscope and the Tecnar. The third is a fixed x15 'Stereomagnifier' at £33.00. Pyser's Scottish agents are MacFarlane Robson.

A prototype of a new chart recorder capable of accepting signals from the modules of their Environmental Kit was amongst the wide range of equipment shown by Unilab Ltd. This recorder, which may be marketed in about six months time, was designed to run from a 12 V accumulator as well as mains and will be capable of operating in the field.

Another prototype, this time a new 6" Demonstration Meter, probable selling price £36.40, was exhibited by Weir Electrical. That other demonstration instrument manufacturer White Electrical were showing their new multi-range demonstration meter, the 'Polymetron'.

A number of innovations were in evidence on the W.P.A. stand. These included: a colorimeter attachment (E1/Col) for their Environmental Multiprobe at £39.00: a new attachment for the CO 65 Colorimeter to allow it to take smaller sample tubes and an exciting, modular format timer/frequency meter/ voltmeter/scaler with the same digital read-out unit being fed from a number of different function units.

No doubt many of these new items will be on show at the Scottish Region Annual Meeting (see Introduction).

S.S.S.E.R.C., 103 Broughton Street, Edinburgh, EH1 3RZ.
Tel. 031 556 2184.

E.J. Arnold and Son, Butterley Street, Leeds, 10.

Bausch and Lomb Optical Co., Lenten House, Lenten Street, Alton, Hampshire, GU34 1JD.

Control System Services, 4 Manningham Lane, Bradford, BD1 3DE.

Griffin and George Ltd., Braeview Place, Nerston, East Kilbride, Glasgow, G74 3XJ.

Philip Harris Ltd., 30 Carron Place, Kelvin Industrial Estate, East Kilbride, Glasgow, G75 OTL.

Ideas for Education, 87a Trowbridge Road, Bradford-on-Avon, Wiltshire, BA15 1EE.

Irwin-Desman Ltd., 294 Purley Way, Croydon, CR9 4OL.

MacFarlane Robson Ltd., Burnfield Avenue, Thornliebank, Glasgow, G46 7TP.

Offord Scientific Equipment Ltd., 113 Lavender Hill, Tonbridge, Kent, TN9 2AY.

Panax Equipment Ltd., Willow Lane, Mitcham, Surrey, CR4 4UX.

W.R. Prior and Co., London Road, Bishop's Stortford, Herts.

Pyser Ltd., Fircroft Way, Edenbridge, Kent, TN8 6HE.

Rank Brothers, High Street, Bottisham, Cambridge, CB5 9DA.

S.E.A. Ltd., Vale Road, Windsor, SL4 5JL.

Unilab Ltd., Clarendon Road, Blackburn, Lancs., BB1 9TA.

Uniprobe Instruments Ltd., Clive Road, Cardiff, South Glamorgan.

(W.P.A.) Walden Precision Apparatus Ltd., Shire Hill, Saffron Walden, Essex.

Weir Electrical Instrument Co., Bradford-on-Avon, Wilts.

White Electrical Instrument Co., Spring Lane North, Malvern Link, Worcs., WR14 1BL.