SCOTTISH SCHOOLS SCIENCE EQUIPMENT RESEARCH CENTRE

Bulletin No. 26. November, 1968.

Contents

Introduction

We gave notice some time ago that we had arranged to reprint back numbers of our Bulletins, in response to many requests for out-of-print issues. This has now been completed, and details of how application for these should be made are on the leaflet enclosed with this Bulletin. We have printed approximately 300 of each issue, which we hope will be adequate to meet the demand, but we should state that orders within the U.K. will be dealt with in rotation as received.

It will be known to many of our readers that on occasions when a report summary is included in a Bulletin, we print two versions; then those Bulletins which go furth of Scotland carry a blank page in place of the summary. We have not made special reprints to cover this situation; what we shall do in these cases is to remove the final page altogether, which means that not only the report summary, but also the address list for that particular Bulletin will be missing. We hope that this will be a minor inconvenience to non-Scottish readers.

Orders from organisations or individuals within the U.K. can be paid either cash with order, or by invoicing the local authority or other responsible body. Orders from abroad must be sent cash with order, and it is suggested that the simplest method of payment here is by postal order. Postal orders in the payer's own currency will be accepted.

Opinion

Primary school science is the subject which, if I read my crystal ball aright, is to be the trend-setter of the seventies. Just as, in the early sixties, we had "Physics for All", followed at the present time by the Integrated Science Course, which started life as the Non-Certificate Course, so in the future I predict that we shall push the nub of our activities further down the age range into the primary school. The signs and portents are already here; the Nuffield Junior Science Project has made a mammoth trial and produced several books on the subject. We have in the Centre a "syllabus" of suggested experiments issued to primary teachers in one Scottish local authority; another such has committed itself to spending £X,000 on apparatus for primary school science this session.

At this stage we would hesitate to advise any authority on what equipment one should provide for the subject, since one must first of all determine what one expects to achieve. Who, in the face of the following quotation from the Nuffield Project (Teacher's Guide 1, p.15) would attempt to prescribe in advance what the equipment should be? "We believe that the way to fulfil the different needs of individual children is to offer them the opportunities for as wide a range of experience as possible (by taking children out and by bringing materials/

materials into the classroom) and then to encourage them to explore freely and savour what they will;" or again (p.17) "we should look carefully at the individual child as he is, and not as we would like him to be, or as we think he should be at a certain age." Primary school science, as the Nuffield Project sees it, is child-centred. In fact the "science" means much more a process of learning by discovery than a formal, logical progression of physics or chemistry. It contains as much of mathematics and mensuration, of geography and art as it does of the formal disciplines of science as we know them.

But if one is faced with a need to spend the apportioned money by a given date, or lose it altogether, as is the way with local authorities, if one has a teaching staff who were brought up, if they studied science at all, on the traditional syllabus, is it not necessary even if not so desirable, to fall back on a syllabus which is subject-, rather than child-centred; something, in fact, like this?

Heating and Cooling.

Fill a small medicine bottle with water. Insert a cork with tube through it and press down so that the water rises a little in the tube.

(a) Now put into a basin of hot water. Observe. (Expansion).

(b) Now put into a basin of cold water. Observe. (Contraction).

(c) Explain the working of a thermometer.

(d) Weigh a bottle of cold water on scales - counter-balance with weights and sand. Now fill the same bottle with hot water and compare.

(e) Pour cold coloured water carefully down the inside of a jar half filled with warm water. Observe.

(f) Place a potassium permanganate crystal on the bottom of a jar of water and near the side. Apply heat near the crystal and watch movement of the dye.

(g) The hot water system in house or school.

Physics Notes

Some teachers may have noticed, and been intrigued by the experiments with a large capacitor described in the School Science Review No. 166, p.831. The capacitance was 70,000µF, 15V, and the experiments consisted in verifying that charge stored was proportional to voltage V, and that energy stored was proportional to V^2. The appearance on the market of similar capacitors at a lower price, from Keytronics, prompted us to repeat the experiments and add one or two others. The capacitors, all of which cost 7s.6d. each with postage, which were selected were 25,000µF, 15V, and 6,300µF, 75V working. One of the former is used in the first/

first of the experiments described in the School Science Review to be carried out, to verify that charge stored is proportional to V. After charging, the capacitor is discharged through a 0.02M solution of potassium iodide containing starch, in a voltameter with platinum electrodes. Instead of titrating the iodine liberated, we used 5ml of the solution in the colorimeter described in Bulletin 25, to estimate the amount of iodine.

To verify that the P.D. achieved is directly proportional to the charge fed on to the capacitance can be done more directly, using the relation it = VC. Six of the 6,300μF capacitors were connected in parallel to an H.T. power supply with milliammeter in the charging lead. Using a stopclock, at t = o the voltage control on the power supply is turned up and adjusted manually to give a charging current of between 10 and 20mA which is then maintained constant by slowly raising the charging voltage as the capacitor charges up. The voltage across the capacitor is measured with a high resistance voltmeter, i.e. one drawing 100μA or less F.S.D., so that one can assume without appreciable error that the current registered is all flowing into the capacitor. A plot of capacitor P.D. against time gives a straight line through the origin, from which the capacitance can be calculated. In our own case the capacitor needed 165s to charge to 50V at 15mA, which gives a value for C of 49,000μF in place of the 40,000μF which one might expect from the quoted value. As leakage current through the capacitor would slow down the charging rate and give a spuriously high value for C, we measured the leakage current at 50V and found the surprisingly low figure of 300μA. It is possible that we were lucky with our 6 capacitors since with such high value electrolytics one would expect greater leakage than this.

That the larger capacitance is due to the tolerance of 20% on the quoted value was verified in the next experiment, which consists in charging the capacitor exponentially. The power unit is set to deliver a nominal 100V on open circuit. A 10 - 15kΩ charging resistor is put in series with the capacitor, and the P.D. across is recorded against time. During the charging process it is necessary at some point to measure the actual voltage V_o being delivered by the power supply. To get a straight line graph on semi-logarithmic paper, from which the time constant can be calculated, it is necessary to graph $(V_o - V)$ against time. Knowing the value of R, the capacitance can be calculated; this confirmed our previous value. As an example of the kind of result to be expected, with a charging resistor of 15Ω the system takes 10 minutes to reach 50V.

Both these experiments can be performed equally well on discharge. The second, the exponential discharge, is straightforward, and from a graph of the discharge time between 60 and 20V on semi-log paper one can get the time constant and capacitance. To achieve a linear discharge we used a 10kΩ wirewound potentiometer. The capacitor was charged to 62 - 65V, which gives time for the resistance to be manipulated to set a discharge current of 8 - 9mA before reaching 60V, at which point the stopclock is started. The experiment requires three people; one to manipulate the resistance to keep a constant current, one to read the voltmeter, and one to read and record time. Using a large sized/

sized knob on the potentiometer it is possible to keep the current constant within a few % of the desired value down to 20V, which is sufficient for a plot.

The experiment to verify that the energy stored is proportional to the square of the voltage was verified in essentially the same way as described in the School Science Review, although we have the advantage that although our capacitance was only half the size, it could be charged up to over four times the P.D., giving a maximum energy greater by a factor of 8 - 10 times.

An immersion heater was made up from 50cm length of 36 SWG nichrome wire - resistance 18.5Ω - hard soldered to copper leads. The heater was immersed in approximately 5ml of methylated spirit in a test-tube which in turn was sunk into a hole drilled in a polystyrene block. One junction of a copper-constantan thermo-couple was also in the test-tube, the other end being immersed in a 2 litre vacuum flask of cold water. The thermo-couple was connected direct to a mirror galvanometer, in our case the W.P.A. K104. No attempt was made to calibrate this in deg. C, as it can be assumed that the galvanometer deflection will be proportional to temperature over the small range being used, provided the instrument maintains a constant resistance, i.e. if the range is not switched during the experiment. If the capacitor voltage is kept within a 3:1 range, say between 20V and 60V, the ratio of largest to smallest deflection to be observed will be 9:1 which can be accomplished within a single range of the galvanometer without either having the least deflection too small to be accurate or the greatest going off scale. The only remaining problem is then the zeroing of the spot after each shot. We found the cooling of the test-tube and contents tedious and time-consuming, and used the simpler alternative of mixing in hot water in the vacuum flask. This will not allow an accurate zero to be set, but is sufficient to place the spot near one end of the scale so that the subsequent throw will be within the scale's compass.

A milliammeter in the charging circuit is useful since by manipulating the power supply control to return the charging current to zero one can set the capacitor charge at any given voltage, and maintain it at this potential irrespective of leakage while the thermo-couple side of the experiment is being checked. A change-over switch is then used to discharge the capacitor directly into the immersion heater. "Stirring" of the calorimeter contents is necessary, which we achieved by shaking up and down. The graph of V^2 against galvanometer throw should then show the direct proportionality property.

Display Laboratory

The following items have been added to the display laboratory since publication of Bulletin 24.

Item	Manufacturer
Ether Engine	SSSERC
Hot Air Engine	SSSERC
Steam Turbine	SSSERC
Tetrahedral Atom Jig	SSSERC
Synchronised Ripple Tank	SSSERC
M.K.S. Electricity Apparatus	Philip Harris
Interferometer	Philip Harris
Grating Spectrometer	Philip Harris
Colorimeter	Philip Harris
Gyroscope and Stool	Philip Harris
Hall Effect Probe	Unilab
Hall Effect Probe	Avo
Student Microscope	Griffin and George
Hair Hygrometer	Griffin and George
Prism Spectrometer	W.B. Nicolson
Electronics Kit	A.M. Lock
Swift M244 Microscope	A.H. Baird
Quadrant Electrometer	W.P.A.
Olympus HSC Microscope	Gallenkamp

Trade News

The Scottish representative of Morris Laboratory Instruments, Mr. E.J. Brown, has moved to a new address at 11 Quarry Road, Law, Lanarkshire, telephone No. Carluke 3755. Having larger premises he is now able to store equipment which he will lend to interested teachers either on a "trial use" basis, or as a replacement while the teacher's own apparatus is undergoing repair or servicing. While orders for apparatus should still be sent to head office, enquiries for after sales service, replacement or trial use should be sent direct to Mr. Brown.

A new series 240 microscope by Swift is being marketed in Scotland by Andrew H. Baird. The basic features of the series are inclined stand, built-in condenser, substage disc diaphragm and plano-concave 40mm mirror. The M245 has single x10 objective and zoom eyepiece from x10 to x20, cost £22. The M244 has triple turret nosepiece with x4, x10, and x20 objectives, x10 eyepiece, cost £23. The M240 is similar to M244 but with wide field x10 eyepiece with pointer, cost £24.10s. Two extras to the series are MA201 sub-stage illuminator for mains voltage, £4, and MA207 x40 objective in place of the x20, £2.12s.

The firm of Teltron have changed address to the new one given in the address list to this Bulletin.

A new microscope from Griffin and George costing £31.10s., has inclined stand, built-in condenser, sub-stage disc diaphragm with dark ground illumination, coarse and fine focus, plane mirror, triple nosepiece with x4, x10 and x20 objectives, and x10 eyepiece with pointer. The sub-stage illuminator, available as an extra, is fitted for polarisation work.

Labgear equipment supplied by Telecare, who are the Scottish agents, is available to schools at 10 - 12% discount on list prices.

A catalogue recently received from Lind Air (Optronics) lists a wide variety of optical equipment from individual lenses to telescopes, microscopes, binoculars etc.

Weir Electrical Instruments are manufacturing a current amplifier to operate into their 10mA demonstration equipment, but which will accommodate any similar moving coil meter of the same sensitivity. The ranges obtainable with the meter amplifier are 5mA, 1mA, 500μA and 50μA. The price of the meter amplifier is £15.15s.

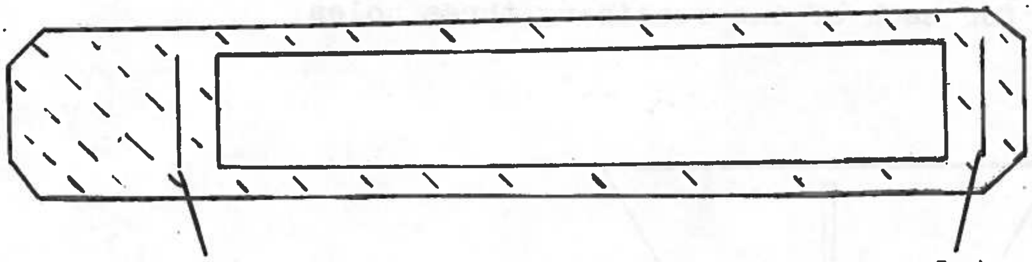
Gillett and Sibert have introduced a scheme whereby schools may lease microscopes rather than purchase them outright. This ensures that microscopes are only retained for as long as they remain up-to-date, being replaced by a more modern instrument before they become obsolete.

A quadrant electrometer has been produced by Walden Precision Apparatus, also known for their K100 series galvanometer. The styling of the instrument is similar to the K series, but two scales, for ideostatic and heterostatic use, are provided. On ideostatic use the sensitivity is about 80V F.S.D. An input resistance of $10^{17}\Omega$ or greater is claimed. The electrometer will sell for £34. 15s.

Many teachers will have seen the wooden circuit boxes, type MK3890, which we mentioned first in Bulletin 7, being used for mounting various small components in our exhibitions. Regrettably we have learned that of the two suppliers quoted in Bulletin 7, one has gone into liquidation and the other has ceased to manufacture this particular type. At the moment we are actively seeking an alternative supplier for this useful item.

In The Workshop

Paper chromatography apparatus ranges from the very simple to the elaborate and expensive. With simple equipment one of the problems to be overcome is the evaporation of the solvent, so that a technique which solves this problem may have some merit. Provided one can find a means of supporting the paper, the boiling tube provides a satisfactory answer. Our support is cut from the side of a plastic detergent bottle. Filter paper strip, measuring 120 x 10mm is inserted through the top and bottom slots which keep it in position. The system fits the 150 x 25mm size of perspex boiling tube.



Scale: Full size

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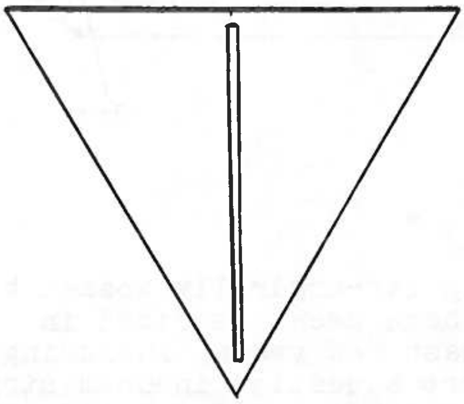
A number of jigs for marking tetrahedrally spaced holes in expanded polystyrene spheres have been described in scientific literature over the past few years, including a very advanced system in the latest Education in Chemistry journal, (Vol. 5, No. 5, p.186) which is sufficiently versatile to allow construction of any ball-and-spoke model. The jig which we describe below is to some extent a development of that which appeared in the School Science Review, No. 168, p.481. As described, it will accommodate all except the smallest size of Elford sphere, i.e. from 20 to 75mm diameter, but could be made larger if desired for larger spheres. Unlike the model described in the School Science Review, it will take spheres of any size within the prescribed range.

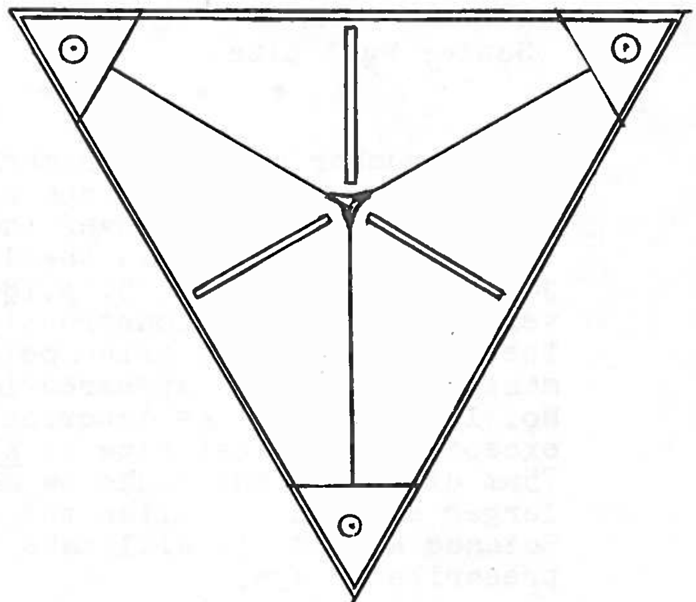
The basic arrangement is the same as that referred to above, i.e. a hollow tetrahedron into which the ball is put, but with the difference that slots in preference to holes are used for marking. We used perspex 3mm thick in constructing the jig but this was largely because the principle can then be readily seen; for a laboratory technician using the jig hardboard would be equally suitable. Three equilateral triangles of 20cm side are first cut out; a 2mm wide slot is then cut along one of the medians, stopping 1cm from each end (see Fig. 1). Although we used a milling machine to cut these out, it may equally well be done by drilling a hole at each end of the slot and cutting out the intervening section with a fret saw. The triangle edges on either side of the median then require to be bevelled down to allow adjacent triangles to be cemented together as in Fig. 2. For hardboard, Evostik adhesive may be used; for perspex we make up a cement by dissolving perspex chippings in chloroform.

When the cement has set, each of the top corners of the model is reinforced by cementing on each a small triangle of the same material of 4cm side, to which a 4 BA bolt has been fixed in the centroid position. The top of the jig is a 20cm triangle of 16 SWG aluminium sheet with fixing holes in each apex which allow the sheet to drop down on the bolts and form a 'lid' to the tetrahedron. Riveted to the centroid of the sheet is an aluminium rod 10mm in diameter which has had one end turned down on the lathe to provide a riveting collar. This has an axial hole large enough to take a knitting needle, which passes down into the jig and spikes the sphere being marked to hold it in position, and also to give one of the desired holes. A pen or pencil is then drawn down each of the slots in turn; where the ball contacts the slot this will give a short line on the surface of the ball. The mid point/

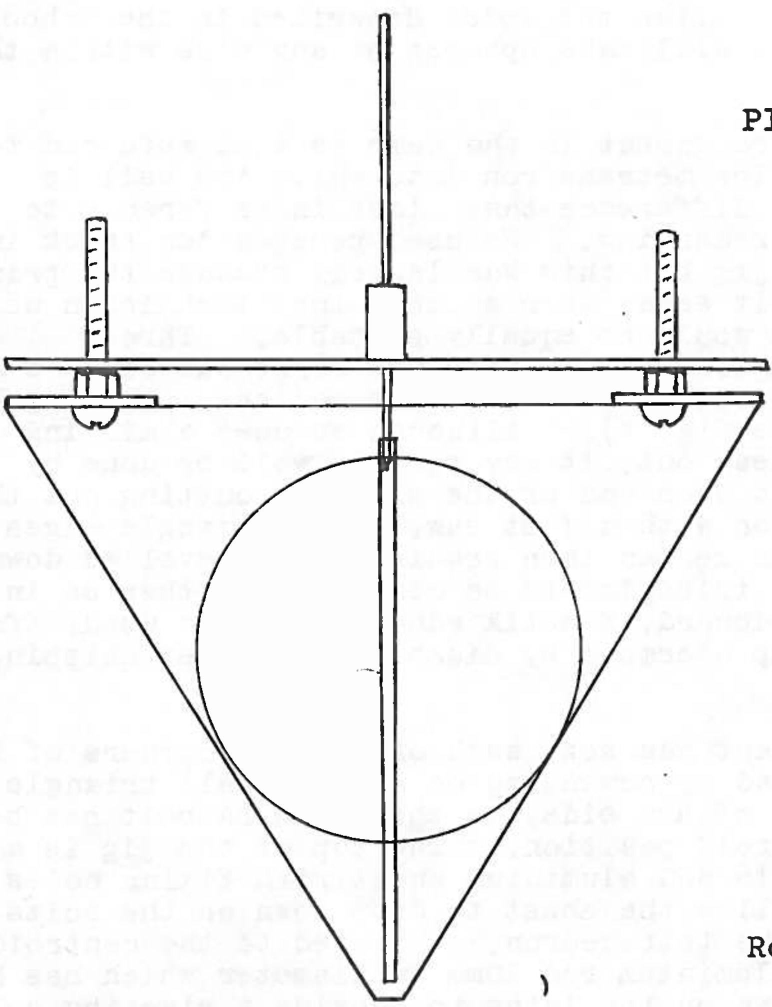
point of each of these lines is then the marking position for each of the remaining three holes.



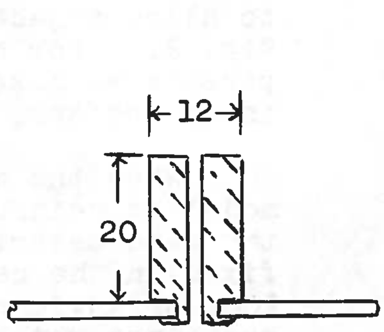
Tetrahedron face



Plan



Elevation



Rod support detail

Dimensions in mm

Bulletin Supplement

Below is a summary of the tests carried out on a further selection of low voltage power supplies. Summaries of other models will be found in Bulletins 21 and 22. Individual reports on these models can be borrowed for up to one month by writing to the Director. The classifications used are: A - most suitable for school use; B - satisfactory for school use; C - unsatisfactory.

Model No.		P7997/06*	K95/1300	Lab 59R	N59R
Supplier		Philip Harris	W.B. Nicolson	Radford Electronics	Radford Electronics
Price		£28.10s.	£29	£22.10s.	£18
Voltage Control		Variable Transformer	Variable Transformer	Switched 0.2V steps	Switched 0.2V steps
Maximum outputs at zero current	AC	26.4V	29.0V	24.0V ∓	24.4V
	DC	27.0V	33.0V	22.0V	22.0V
Maximum Current	AC	10A**	8.5A	8.0A ∓	8.0A
	DC	8A	8.5A	8.0A	8.0A
Outputs at maximum current	AC	24.0V	27.0V	21.5V ∓	22.0V
	DC	24.2V	22.1V	17.0V	16.0V
Overload protection		Secondary fuse, 10A	Primary fuse, 2A	Magnetic cut-out	Magnetic cut-out
Behaviour on continuous load		Satisfactory	Satisfactory	Transformer overheats on full load	Rectifier over-rated on full load
Smoothing		None	None	None	None
Stacking Ability		Good	Bad	Good	Good
Assessment		A	B	B	B

Notes: * This unit incorporates an output voltmeter, with AC and DC ranges.

** Subject also to 200VA AC or 160W DC maximum power.

∓ These values relate to the variable low voltage output; the unit is designed to provide also fixed outputs of 12V, 8A and 6.3V, 3A AC and 300V, 100mA DC.

S.S.S.E.R.C., 103 Broughton Street, Edinburgh, 1. Tel 031-556 2184.

Avo International, Avocet House, Dorset, Kent.

Andrew H. Baird Ltd., 33-39 Lothian Street, Edinburgh, 1.

Elford Plastics Ltd., Brookfield Works, Wood Street, Elland, Yorks.

A. Gallenkamp and Co. Ltd., Portrack Lane, Stockton-on-Tees.

Gillett and Sibert Ltd., 417 Battersea Park Road, London, S.W.11.

Griffin and George Ltd., Braeview Place, Nerston, East Kilbride.

Philip Harris Ltd., St. Colme Drive, Dalgety Bay, Fife.

Keytronics, 52 Earls Court Road, London, W.8.

Labgear Ltd., Cromwell Road, Cambridge.

Lindair (Optronics) Ltd., 25 Tottenham Court Road, London, W.1.

A.M. Lock and Co. Ltd., Prudential Buildings, Oldham, Lancs.

Morris Laboratory Instruments Ltd., 96-98 High Street, Putney, London, S.W.15.

W.B. Nicolson Ltd., Thornliebank Industrial Estate, Glasgow.

Radford Electronics Ltd., Ashton Vale Estate, Bristol, 3.

Telecare Ltd., 66 Osborne Street, Glasgow, C.1.

Teltron Ltd., 32/36 Telford Way, London, W.3.

Unilab Science Teaching Equipment, Clarendon Road, Blackburn, Lancs.

Walden Precision Apparatus Ltd., Shire Hill, Saffron Walden, Essex.

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