SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 35. December, 1969.

Contents

Introduction

We have recently posted to all addresses on our mailing list an equipment and chemicals list for the Certificate of Sixth Year Studies in Chemistry, and a chemicals list for the syllabus in Chemistry, Ordinary and Higher Grades (revised Circular 512), and a statement of what these lists do and do not purport to be may not be out of place here, a statement which also applies to all our equipment lists. We have examined the relevant syllabus and listed those items of equipment which we consider necessary to teach the syllabus adequately. We have also attempted to prescribe the scale on which such apparatus should be supplied, although this provision does not apply to the S.Y.S. syllabus, where numbers of pupils vary widely from school to school. For apparatus for pupil use, the scale is one per two or three pupils. For demonstration experiments, and for pupil use in "stations" experiments, i.e. where pupils circulate from one experiment to the next, the scale is one per class. This leaves the principal teacher free to determine the quantity of a particular piece of apparatus he requires to equip his department overall, a decision which will be influenced by such factors as time-tabling, location of laboratories and the adequacy or otherwise of technical assistance. Experience tends to show that equipment is used more frequently - so that lesser quantities are needed for initial stocking up - but is more frequently broken if it be kept in a central store rather than in individual labs. This underlines the need for adequate technical help, both to distribute the apparatus and to keep it in good repair in schools with central storage facilities.

Where possible, we have listed two suppliers of each item of apparatus, and given what is hopefully a current price for the article. Teachers reading a list will soon realise that we tend to jump about from one supplier to the next, when undoubtedly the major suppliers could provide almost every item on a list. This may give teachers a mistaken impression that items listed have been tested and approved by us. In a minority of cases this may be true, but in most cases we have not even seen the items in question. We have accepted a catalogue description of the article as being a bona fide statement of what it will do, and have matched this against the requirements of the syllabus. When we jump from firm to firm it is because we try to give a representative selection of the range of items which each firm supplies, although we soon realise the impossibility of achieving this when the complaints start flowing in. In some instances we believe that one supplier has an article better than any of the others; in some instances we have deliberately omitted to mention a supplier whose article we believe is inferior to the others. These are to some extent subjective judgments, although based on our own and on teachers' experiences, and we would not state these except informally to a teacher. But in most cases where we have listed only one supplier of an article, the reason is that we could not find a second source for a comparable item.

Prices are as up to date as we can make them, but cannot be looked upon as fixed. They are intended as a guide only to the amount that one may expect to spend on a given article. We are sometimes asked what will be the total cost of equipping a laboratory to teach a given syllabus. This is almost an impossible question to answer since it depends so much on the school situation. With favourable time-tabling, close proximity of laboratories and a central store, it may be possible to make two class sets of apparatus serve the needs of three or even four laboratories. Some schools may need demonstration equipment on/

on a scale of one per laboratory, some only on a scale of one per department. This depends on siting as much as on time-tabling. Architects are still designing science annexes with entrance steps rather than ramps so that trolley loads of equipment cannot be wheeled from one part of the building to another, and so orders must be duplicated. Even when we have nailed ourselves down to a particular figure, it is highly probable that some political act, like the imposition of S.E.T. or the nickel miners' strike in Canada, would upset our calculations as soon as they were made.

Opinion

The march of progress is often hesitant and ill-defined, perhaps nowhere more so than in the commercial field. In an age when costs keep rising almost daily, either directly by means of a penny added on here and there, or more obliquely by reducing the quantity of e.g. soap flakes in the packet, the consumer might be forgiven for thinking that he is the last to be considered. But though the depth to which his pocket may be plumbed varies almost as the manufacturer's whim, in other respects he is still right. In fact, he is so right that the commercial world have invested him with a world of prejudices which may be wholly imaginary since few of them have been tested.

Thus he is resistant to the introduction of the metric system, to decimal coinage, and to centigrade temperatures if the radio broadcasts are to be believed. On the first, manufacturers have been dragging their feet for months. We are apparently still not clear whether we want our primary school children to use 20, 25 or 30cm long rulers, but inevitably the scales seem to be coming down in favour of 30cm because it most resembles the old foot rule. This is the progress of a man who walks backwards to his goal. With a fine but unconscious irony, a firm making cm adhesive tape to stick over the inch scales on existing foot rulers, offers them in $\frac{3}{4}$ and $\frac{1}{2}$in widths, and in 72 yard lengths!

Coming nearer home, we recently thought it advisable and progressive to use the recommended nomenclature for chemicals in preparing our chemistry lists. Some of these names were given in the A.S.E. Bulletin, Education in Science, No. 32, April 1969; they in turn were taken from I.U.P.A.C. rules, formulated in 1957. Thus, ferric chloride becomes iron (III) chloride and so on. In the interests of accuracy, we sent a draft copy to a supplier with the request that prices should be brought up to date, and while they could cope with iron (II) and iron (III) compounds, items like lead (IV) oxide, ammonium trioxovanadate (V), butane were marked as insufficiently described for identification. Which says something for the I.U.P.A.C. rules, or the manufacturers and perhaps for the teachers themselves when they examine their own reactions after reading this. Who is out of step besides Oor Jock?

Biology Notes

Microprojectors have not featured in our equipment lists because we believe that the photomicrograph used with a slide or strip projector offers certain advantages. The illumination intensity/

intensity is much higher, the picture area much greater, as is the field of view. There may be occasions however, if for example the teacher wishes to project live material, when the slide projector is not suitable, and the following technique may be a suitable alternative. The idea was presented to us by Galashiels Academy.

Remove the eyepiece lens from a microscope (Olympus MIC, MBR1E etc.) and clamp a plane mirror above the eyepiece tube so that it throws the image on a suitable wall or screen. Mount the slide as for the ordinary microscope and direct artificial illumination e.g. from a slide projector into the sub-stage mirror. It will pay to experiment with varied arrangements as the results depend very much on the type of microscope and illuminant used. We have found that in general only the low power objective can be used as the loss of light is too great for easy viewing on higher magnifications. Also although only a small portion of a slide may be projected, it is possible to sweep through the entire slide by tilting the substage mirror, or sometimes by merely moving the microscope towards or away from the illuminant.

* * * * * *

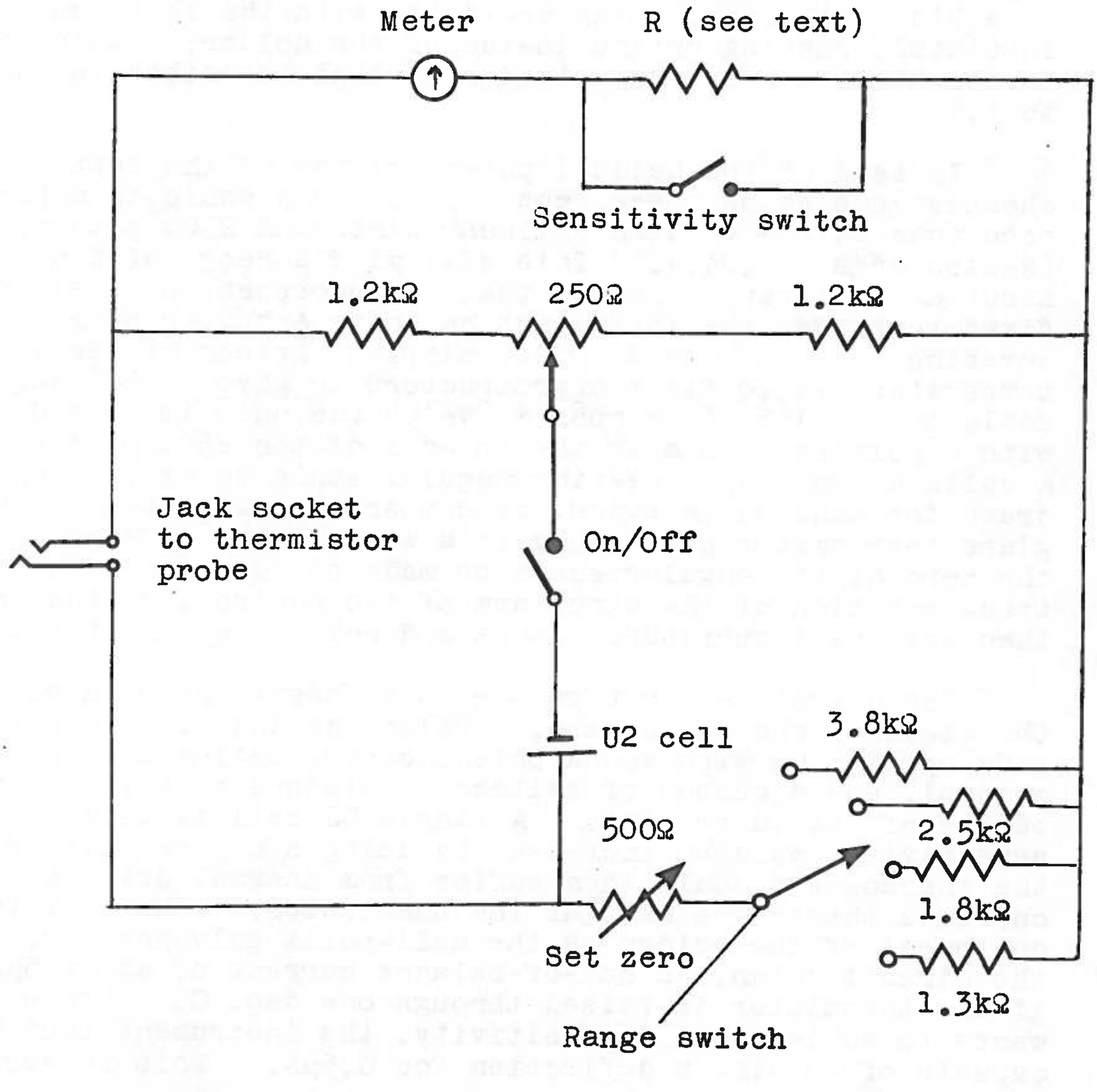
These notes are given for the guidance of teachers who may wish to construct the thermistor thermometer described in Nuffield Biology Teachers' Guide III, p.47. We have modified the circuit to make use of more readily available components. A <u>Radiospares</u> bead thermistor, type TH-B12, currently priced at 15s. was used. This is in the form of a cylindrical glass bead 10mm long and 2.5mm dia. with two wire ends. It can be cemented into the end of a Bic pen-holder, using Araldite, with the leads suitably insulated, running up the inside of the holder; this part of the construction is very similar to that described in the Nuffield text.

Instead of the helical potentiometer of the text - the cheapest one we have seen costs 35s. and a scale to match costs more than this - we used a linear wirewound 250Ω potentiometer (Radiospares, 6s.9d.). This will give a range of ±5 deg. C about an arbitrary zero, so that by incorporating a series of fixed resistors the instrument can have a number of ranges, each covering 10 deg. C band. The simplest method of reading temperature is to fix two protractors to give a 360° angular scale on the lid of the box in which the unit is housed, together with a pointer knob over the spindle of the 250Ω potentiometer. A calibration graph relating angular scale to deg. C can then be drawn for each scale range, by comparison against a mercury-in-glass thermometer preferably in a water bath. We recommend that the zero of the angular scale be made to coincide with the mid-track position of the wiper arm of the control, so that one can then measure temperatures above and below the selected zero.

The circuit - see page 4 - is a Wheatstone bridge, with the thermistor probe in one arm. Balancing this is a resistive arm made up of 500Ω wire-wound potentiometer acting as a set zero control, and a number of switched resistors to give the various ranges of the instrument. A single U2 cell is used; the sensitivity could be increased by using a higher voltage but the thermometer would then suffer from thermal drift as the currents themselves heat up the thermistor. The most important component of the bridge is the null-point galvanometer. With the circuit shown, an out-of-balance current of about 5μA flows if the thermistor is raised through one deg. C. Hence if one wants to achieve 0.1°C sensitivity, the instrument must be capable of showing a deflection for 0.5μA. This is very readily achieved/

achieved with a mirror galvanometer such as the Pye Evro or Scalamp types, or the Walden K104, but doing this sacrifices the portability and restricts the thermometer to laboratory use. To keep it portable so that one can use it out of doors, the unit needs a moving coil microammeter, as sensitive as possible. The best we can find in regular supply are from G.W. Smith, 50-0-50μA at £1.17s.6d. 1μA deflection should be visible on this, giving a sensitivity to the thermometer of 0.2°C. A resistance in parallel with a switch is used to limit the meter current when the bridge is far off balance; its value is not given in the circuit as it requires to be selected so that when it is put into circuit the meter current is reduced by a factor of about 5.

We have chosen to limit the range to 0 - 40°C as being the one of most interest to biologists, so that four switched ranges, marked 5, 15, 25 and 35°C, each denoting the mid-point of the range are used. The fixed resistor values given in the circuit diagram have been chosen to obtain these mid-points with the 500Ω set zero control about the middle of its track. Obviously it would be possible to have other mid-range temperatures by adjusting the zero control. This control is necessary if different thermistor probes are used with the same circuit, and also to allow for drift due to ageing of the resistors etc. The nearest rotary type switch which can be used for range selection is the Radiospares 2-pole, 5-way make-before-break type, ignoring one pole completely. With a 5-way switch, five ranges are possible, and a little experimentation would determine the suitable resistance value (about 1kΩ) which would give a mid-range zero of 45°C and extend the upper limit to 50°C.

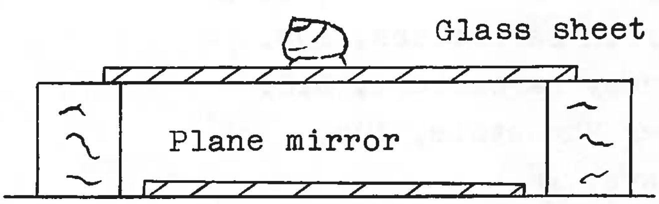


Calibration is carried out as follows. Select the range to be calibrated on the range switch, set the meter sensitivity to "Low" (resistance in circuit), set the dial pointer to zero and with the thermistor probe immersed in a water bath at the correct temperature adjust the set zero control to obtain balance on the meter, switching from "Low" to "High" sensitivity when near balance to get the most accurate balance possible. Raise the water bath temperature by 1°C and set the dial pointer for balance, noting the reading on the angular scale. Continue in 1° steps to 5°C above the arbitrary zero which will take the dial potentiometer almost to the end of its track. Then by adding colder water, reduce the water bath temperature in 1° steps through the zero to 5°C below the zero. A graph can then be drawn for this range showing angular degrees for -5° - 0 - +5°C. This is then repeated for the other ranges.

To use the thermometer it is necessary to know what temperature range one is likely to have to measure, select the mid-temperature of that range and set the zero with a water bath at that temperature. The instrument can then be used over a range of 5° above or below the zero using the calibration graph which most closely corresponds with the actual temperatures used.

* * * * * * *

Although the suggestion below came from the Science Education Center, University of the Philippines, we see no reason why it should not be equally effective here. Its purpose is to show animal movement, and the diagram is largely self-explanatory. The end spacers can be books or wooden blocks, and the sizes suggested for the glass and mirror are 25 x 20cm and 20 x 15cm respectively.



* * * * * * *

Since writing in Bulletin 33 on the preservation of drosophila by freezing we have had a note from Aberdeen College of Education saying that the wings of the flies tend to get damaged unless they are isolated from the silica gel by a polystyrene foam plug, and preferably a similar plug should be used at the top of the specimen tube.

Physics Notes

In Bulletin 34 we mentioned that the International Nickel Co. will no longer supply free bimetallic strip, and that we were examining the possibilities of a bulk purchase for distribution to schools. This we have now done, and the following strip is available at a cost of 6d. each; postage may be charged extra on large quantities. The strips are between 6 and 8in. long, between $\frac{1}{4}$ and $\frac{1}{2}$in. wide and 0.01 - 0.02in. thick. The alloy selected is such that a strip 8 x 0.01in, heated to 80°C in a water bath with one end free, shows a deflection at the free end of about 8cm. Thicker strip deflects less in proportion, e.g. 0.02in. thick will deflect about 4cm, but it has the advantage that the thrust applied by the deflecting end is greater. This may be significant if the strip is required to operate a micro-switch or similar device. By microscopic examination of the edge of a strip it is possible to see that two metals are employed.

Since the strip we supply consists of offcuts from larger sections we cannot guarantee to supply a specific size and thickness, but only that the dimensions will be within the limits given above. As is the case with all our sales, this may be paid for either directly through petty cash, or invoiced to the local authority.

* * * * * * *

The following items of surplus equipment detailed in Bulletins 31 and 32 are still available, and from Item 26 onwards we give details of new lines not previously listed.

Item 1. Large Scale Ammeters, 10s.

Item 2. Aneroid Barometers, 10s.

Item 3. Mercury Barometers, £10.

Item 14. Power Rheostats, 10s.

Item 15. Relays, 1s.

Item 16. Switches, 6d.

Item 17. Potentiometers (no helipots), 6d.

Item 18. Block Paper Capacitors, 6d.

Item 21. Drawing Instruments, £2.

Item 22. Wirewound Resistors, 5s.

Item 23. Fahrenheit Thermometers (both types), 5s.

Item 24. Transformers and Chokes, 1s.

Item 25. Electronic Valves, 6d.

26. Half Wave Rectifier type H112 17 1AW by S.T.C. Maximum input 300V R.M.S.; maximum output 10A on resistive or 8A on capacitative load. Price 5s.

27. Nickel Cadmium Battery, 2.5V, 10AH. The terminals are suitable for connection to crocodile clips only. Supplied filled and charged. Although it is unlikely that these will spill in transit, personal collection is advised because of the weight involved. Price 5s.

28./

28. Communications Receiver, type CR300, by Marconi. Tuning from 15kHz to 25MHz in 8 wavebands; loudspeaker output. The receiver requires the following power supplies: 24V at 1A for valve heaters, and 250V DC at 60mA. There is space to build this supply inside the receiver. Price £6.

29. E.H.T. Power Unit by Labgear, giving 0-1, 0-2 or 0-4kV, positive or negative polarity. Price £1.

30. Universal Impedance Bridge by B.P.L. inductance to 10mH, capacitance to 10μF, resistance to 100kΩ, in five ranges. The capacity can be extended to 50μF or 50H by using an oscilloscope as the null point indicator. Price £2.

31. Oscillator and Power Amplifier by Elliott. This generates a single frequency about 1kHz, and requires 115V, 50Hz input. Price 5s.

32. Pressure Recorder by Foxboro' Labs. Range 0-15 lbf in^{-2}, recording on a 10in diameter disc chart. Chart motor speed is 1 rev/min. Price 10s.

33. Decade Counter type 704 by Airmec. This will count a regular or random series of pulses or sine waves from 1 - 25V peak amplitude. Capacity 999,999 counts, and maximum count rate 50kHz. Input impedance 50kΩ. Price £2. Also one model with maximum count rate 100kHz, £2.10s.

34. Pre-Scaler type 501 by Isotope Developments. Maximum count 99, with pulse output every 100th count. Input 5V square wave or greater, 50Hz - 5kHz. Price 10s.

35. Scaling Unit type 1221C by Ericsson Telephones. A five decatron register with output pulse thereafter, and provision for counting either polarity. This will count square waves or pulses of 5V amplitude or greater, 250Hz - 2.5kHz. Price £1.

36. Decade Counter type TF922 by Marconi. 6 decade neon register. Not in working order, price 10s.

37. Millivoltmeter type 784 by Airmec. Ranges 0-10, 0-100 and 0-1000mV; input impedance 1MΩ in parallel with 15pf. Frequency range 30Hz to 10MHz. This also functions as an amplifier with maximum output 1V R.M.S. Price £5.

38. Calculating Machine (electric) by Madas. This has four 20-digit and two 9-digit registers. Although we can add, subtract, multiply and divide on this machine, its capabilities have not been fully explored. Personal collection by the user is essential here, so that he may be instructed in the use of the machine. Price £2.

39. Magnetic Amplifier type MA112 by Elliott. Function unknown but supplied with circuit diagram. Price 10s.

40. Variable Toroidal Transformers, 30V, 10A maximum. These will give an adjustable output alternating voltage from a fixed low voltage transformer. Price 10s.

41. Pressure Operated Switches. A change-over switch rated at 5A, 250V AC, which is tripped at a pressure of 3000 Nm^{-2} (1 ft of water to the uninitiated). Price 10s.

42. Maximum/

42. Maximum/minimum thermometers. Range 0-120 x $2^{o}F$. Magnetic indicators. Price 5s.

43. Power Rheostats. These are similar in operation to Item 14, value 0.25Ω, current rating unknown but probably 10A or more. Price 5s.

44. Power Rheostats, 46Ω, 6.5A. Price 5s.

45. Slide Rules, Unique II, without cursors. Price 2s.

46. Water Baths. These were originally used for keeping beverages hot on aircraft flights, and require a power supply at 115V or 28V, 120W. The heating element is controlled by a fixed thermostat. The interior measures 12.5 x 25 x 26cm deep. Price £1.

47. Power Amplifier. Input sensitivity 5mV, transformer output intended to supply a 6Ω loudspeaker. The amplifier requires a power supply of 300V, 60mA and 6.3V, 1.5A. Price 5s.

* * * * * * *

Chemistry Notes

Sections L5 of the S.C.E.E.B. syllabus in Chemistry suggests the examination, if not the determination of the ignition temperature of the various fractions obtained in the distillation of crude oil. We suggest that the following qualitative method may be all that is required. When the fractions have been collected (Johnstone and Morrison, Chemistry Takes Shape, Book 4, p.30, Heinemann) two drops of each fraction are put at intervals along a length of asbestos tape or on an asbestos square. At the end are put two drops of the residue after distillation. A lighted wood splint or taper is moved quickly over each fraction in turn; No. 1 and possibly No. 2 will ignite. The taper is then held on each of the remaining samples when the next one or two fractions may ignite. This is followed by holding a 2cm high Bunsen flame on the remainders, and finally by a larger, hotter Bunsen flame.

Trade News

New products from Griffin and George include an audio signal generator at £35. This has a frequency range from 1Hz to 100kHz, power output of 1W, voltage output of 2.8V R.M.S. on sine wave and 4V peak on square wave, and provision for using the amplifier section separately from the oscillator, giving a voltage gain of 20. For use with the generator the firm have also produced a mechanical vibrator, price £12.12s.

Hard plastic discs, 25mm dia. with radial slots cut in them form the basis of a molecular model set. Two such discs keyed together form a carbon atom; bonding is achieved by flexible plastic tubing. The set comprises 114 discs in various colours, representing 12 different elements, with adequate connecting tubes. The cost is approximately £1.5s., from the European Book Centre, although the manufacturers state that the set, called the Kenney Disc Molecular Model Set, may be ordered through booksellers.

The/

The firm of Eureka Scientific have gone into liquidation, and references to their products should be deleted from our equipment lists for Physics and Integrated Science Course.

A new electronic multi-range meter from Avo, the EA113, costs £47.10s. nett. Voltage ranges are from 10mV to 1kV AC and DC; currents from 1μA DC and 10μA AC to 3A; resistance from 1 to $10^8\Omega$. Input impedance is 1MΩ/V on DC, 10MΩ on AC. All Avo products are obtainable in Scotland from Elesco-Fraser.

There has been a considerable increase in the cost of the tiny micro-lamps from H.F. Collison which we have used and recommended for energy conversion experiments (Physics list B16; I.S.C. list, 38). This has occurred because of devaluation of the £, and revaluation of the German mark, since the lamps are imported from West Germany. We are awaiting a revised price list, but meanwhile teachers are advised that some types of lamp in the range have been discontinued, and that the price of others may have risen by up to 100%.

A set of 10 stackable test-tube racks, each of which will accommodate 20 16mm dia. tubes is available from Luckham for £4.10s. Made in anodised aluminium, the racks have a Z-shaped profile, which means that when empty the set of 10 will stack into a space 230 x 130 x 73mm. Besides having greater capacity and storing into smaller space, it would seem that these racks would be easier cleaned than the upright wooden variety.

The Opax model ABF microscope has had several small changes made to make it more pupil-proof. Philips head screws are being used, the eyepiece is secured to the draw tube with an Allen screw, and the stage clips screw in to prevent them being lifted or falling off. The microscope, which can be seen in our display laboratory, still costs £29.18s. for x10 eyepiece and x5, 10 and 40 objectives.

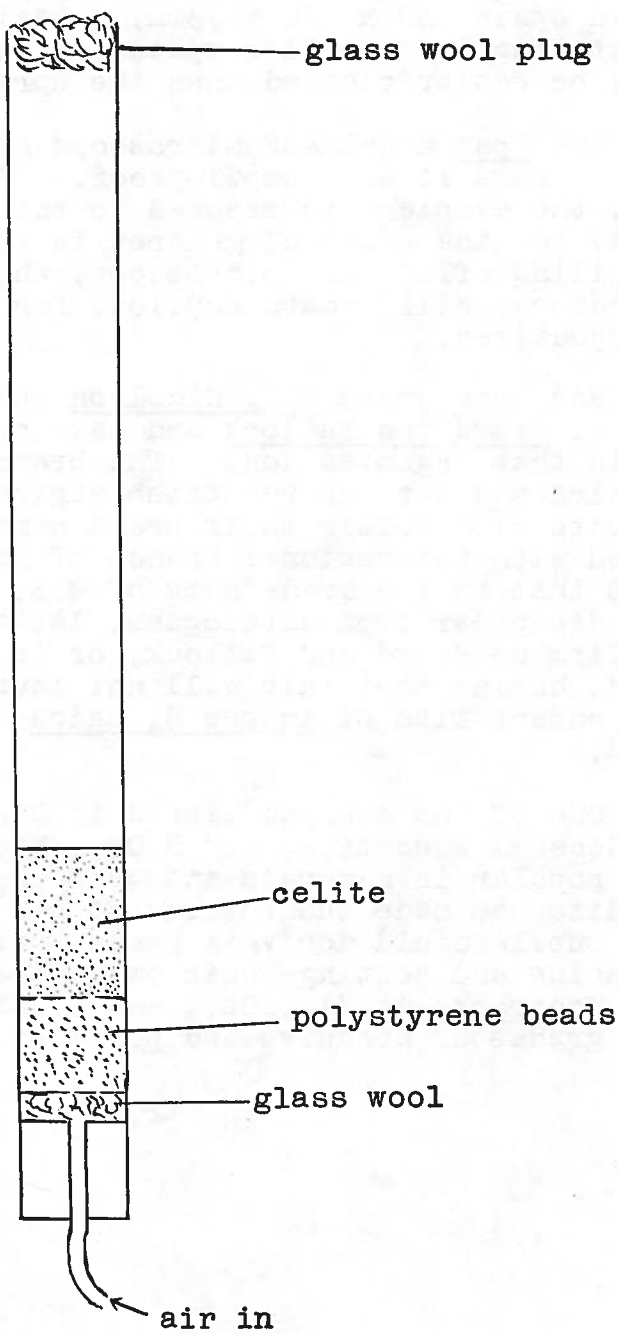
For some years W.B. Nicolson have been associated with the firm of Baird and Tatlock and have now been totally integrated within that organisation. The branch in Glasgow is now known as Baird and Tatlock (Scottish Region) and while W.B. Nicolson products will retain their brand name, orders for them should be placed with the regional branch of Baird and Tatlock. The change means that as the trade name of W.B. Nicolson has disappeared or will disappear from catalogues, letterheads etc. we shall refer to the firm as Baird and Tatlock, or (on equipment lists) simply as Baird, hoping that this will not cause confusion with the independent firm of Andrew H. Baird, also trading in the same field.

One of the courses listed in Curriculum Paper 7: Science for General Education, H.M.S.O., which we believe may become very popular is minerals and gemstones. The development of Araldite has made the setting of gemstones such a simple matter that pupils could derive a great deal of satisfaction from polishing and setting their own stones. A basic kit is available from Scotrocks at £12.10s., and consists of a tumbler machine, four grades of abrasive and polisher, and 5 lb of rough stones.

In The Workshop

The model described demonstrates thermal expansion, evaporation and boiling; the suggestion originated as far as we know in the Chemistry Department of Hull University. It operates on the principle of fluidisation of celite which we have found to be the most satisfactory medium of those tried. A glass combustion tube, 20 x 300mm is fitted with single-holed stopper and glass tube and clamped vertically. Above the stopper is packed 5mm thickness of glass wool, followed by 10mm depth of polystyrene beads and then 500mm depth of celite, 30-80 mesh size. A plug of glass wool is fitted at the top.

Air is blown in from a bellows, gently at first when the celite will "expand", then more forcefully when the material will "boil" and generate molecules of vapour in the upper section of the tube. Exhaled breath will work the apparatus very well, but must be dried by passing through a desiccant such as silica gel to prevent coagulation.



Bulletin Supplement

Below is a summary of the tests carried out on a selection of top pan balances. Individual reports on these balances 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	P161	P160N	TP30	PL800
Manufacturer	Mettler	Mettler	Oertling	Torsion Balance Co.
Agent	Gallenkamp	Gallenkamp	Oertling	"
Price	£145	£196.17.6d.	£145	£162
Capacity	160g	160g	120g	800g
Optical Scale Range	10g	10g	120g	100g
Sensitivity 1 division =	10mg	10mg	10mg	10mg
Readability: division separation =	3mm	3mm	2mm	***
Reliability: standard deviation =	0.7mg	***	***	***
Third place obtained by	micrometer	micrometer	estimation	not applicable
Number of standard masses used	4	4	None	4
Scale pan dia.	10cm	10cm	9.8cm	***
Clamping screw turns *	27	25	11	not applicable
Tare range	None	None	None	40g +
Suspended weighing	Yes	Yes	Yes	No
Out-of-level correction	No	Yes	Yes	No
Operating time**	8s	6s	3s	2s
Overall dimensions: height, width and depth front to rear, mm.	290 200 330	290 200 330	290 210 360	220 350 430
Classification	A	B	A	A

<u>Notes</u>:

* This gives the number of turns required to completely immobilise the balance for transport.

** Time for the beam to come to rest when loaded to the optical scale capacity.

*** Not measured.

\+ The tare range can be increased by addition of external weights to 100g.

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

Airmec Instruments Ltd., High Wycombe, Bucks.

Avo Ltd., Avocet House, Dover, Kent.

Andrew H. Baird Ltd., 33-39 Lothian Street, Edinburgh, EH1 1HE.

Baird and Tatlock Ltd., Thornliebank Industrial Estate, Glasgow.

British Physical Laboratories, Radlett, Herts.

H.F. Collison (Goodwell) Ltd., High Street, Coleshill, Birmingham.

Elesco-Fraser Ltd., 36 St. Vincent Crescent, Glasgow, C.3.

Elliott Brothers Ltd., Century Works, Lewisham, London, S.E.13.

Ericsson Telephones Ltd., Beeston, Nottingham.

Eureka Scientific Co. Ltd., 192/198 Ilford Lane, Ilford, Essex.

European Book Co., P.O. Box 124, Weesp, Holland.

Forboro-Yoxall Ltd., Redhill, Surrey.

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

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

International Nickel Co. Ltd., Thames House, Millbank, London, S.W.1.

Isotope Developments Ltd., Bath Road, Beenham, Reading, Berks.

Labgear Ltd., Cromwell Road, Cambridge.

Luckham Ltd., Labro Works, Victoria Gardens, Burgess Hill, Sussex.

Marconi Instruments Ltd., Longacres, St. Albans, Herts.

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

L. Oertling Ltd., Cray Valley Works, St. Mary Cray, Orpington, Kent.

Opax Ltd., 6 Frant Road, Tunbridge Wells, Kent.

W.G. Pye and Co. Ltd., York Street, Cambridge.

Radiospares Ltd., P.O. Box 427, 13-17 Epworth Street, London, W.12.

Scotrocks Ltd., 48 Park Road, Glasgow, C.4.

G.W. Smith and Co. Ltd., 3-34 Lisle Street, London, W.C.2.

Standard Telephones and Cables Ltd., Edinburgh Way, Harlow, Essex.

Torsion Balance Co. Ltd., 694 Stirling Road, Trading Estate, Slough, Bucks.

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