SCOTTISH SCHOOLS SCIENCE EQUIPMENT RESEARCH CENTRE

Bulletin No. 71. May, 1974.

Contents

Introduction

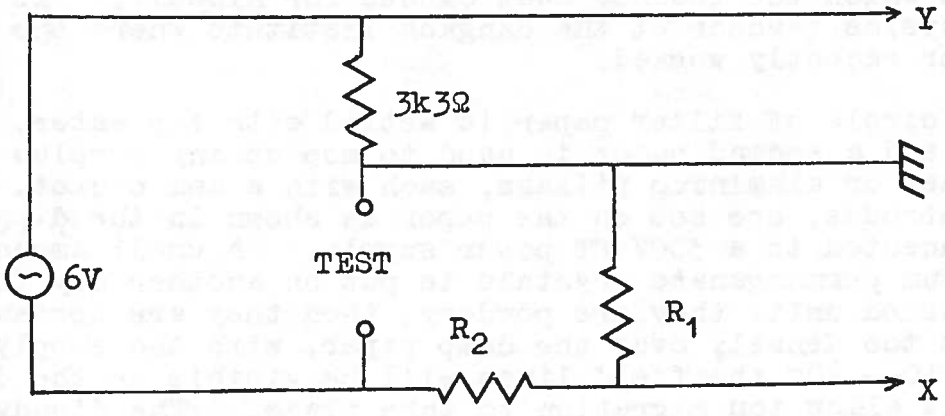
With the ending of the energy emergency, we are back to Saturday opening, which means that the Centre is open 9 a.m. - 1 p.m. every Saturday, although with only one member of staff in charge.

Less pleasant news will be the fact that we are now in a controlled parking zone. During our hours of business, no parking is permitted in Broughton Street, and this regulation is firmly enforced. The nearest permitted parking is by ticket machine in Broughton Place, which intersects Broughton Street just south of our premises. The ticket machine is hard to find, though we doubt if that excuse will be accepted; it is round the corner in Hart Street, outside the Shelborne Hotel.

For those who have equipment to collect, or who intend to spend considerable time with us, there is very limited parking space (1 or 2 cars) in our own back yard. Access to this is along Broughton Place, turn left into Broughton Place Lane and continue to the very end, which will be through a gate and down a sloping ramp into our yard.

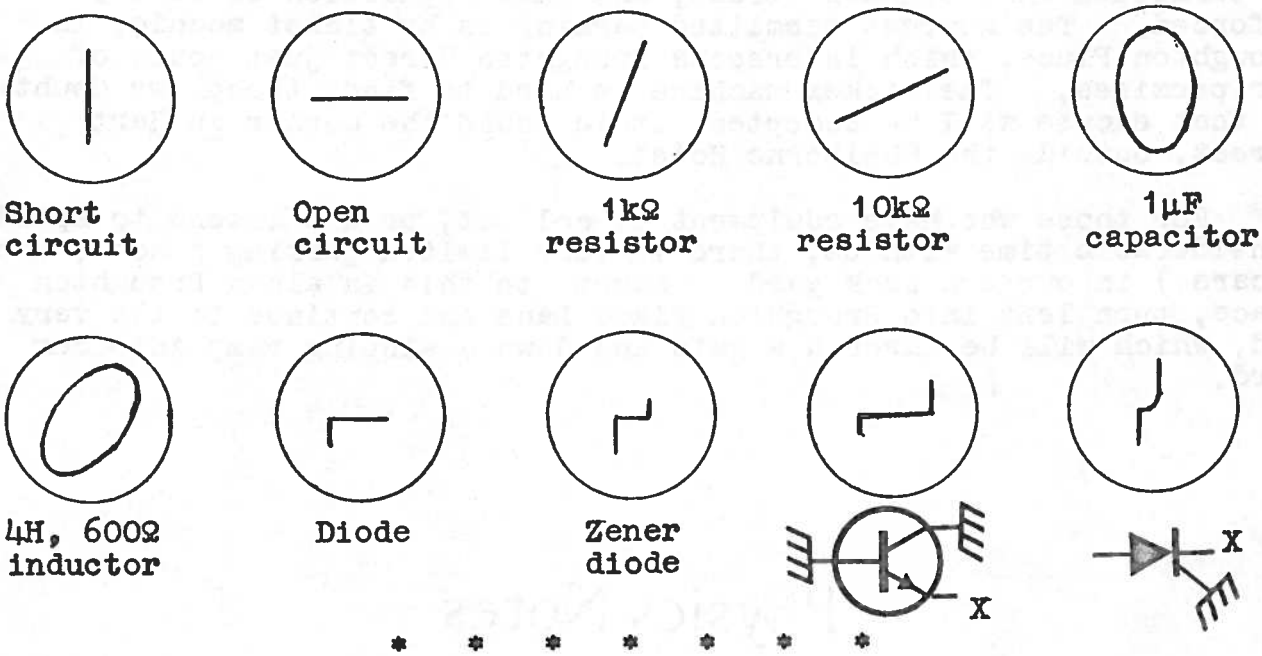
Physics Notes

The component tester to be described allows one to make a quick check on the value of any impedance, linear or non-linear. It can be used to identify a component in those irritating situations when all markings have been rubbed off, or where its position in a circuit makes them impossible to read; it will check whether transistors and diodes have shorted connections, and will give rough quantitative estimates of reactance values.



The circuit is as shown, with connections to X, Y, and ground or earth terminal of an oscilloscope. The values of R_1 and R_2 should be adjusted so that with a 3k3Ω resistor in the test position

the X and Y gain controls can be set to give a line sloping at 45°, i.e. the diagonal of a square. It is usually the case that the X gain cannot be reduced sufficiently to achieve this, hence we have put the potentiometer $R_1 R_2$ in the X-lead to the oscilloscope. $R_1 + R_2$ should be something of order 100kΩ, so that it does not shunt the test component. Below we give some examples of what patterns to expect from various components.



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In connection with the article on the measurement of air track velocities in Bulletin 70, we must apologise for having printed the chart record on page 3 upside down.

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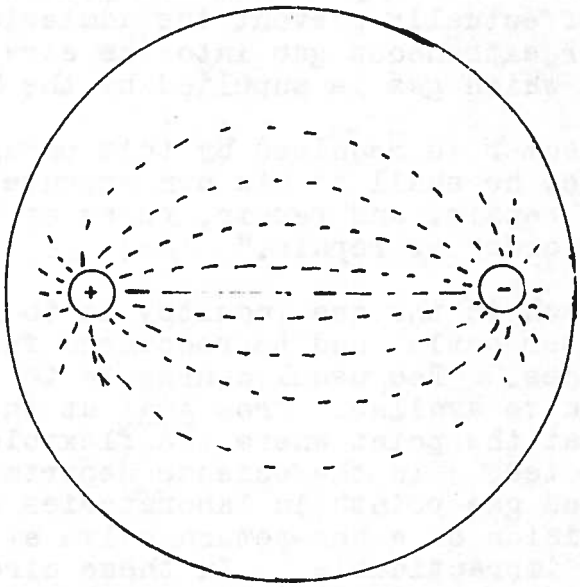
Electro-static fields are usually illustrated in a messy concoction of tetrachloromethane, oil, and grass seeds, with a van de Graaff generator. This alternative has advantages and disadvantages between which the teacher must choose for himself. It was devised by a physics teacher at the Bangkok Institute where the SSSERC Director recently worked.

A circle of filter paper is wetted with tap water, placed on the bench, and a second paper is used to mop up any surplus moisture. Two brass or aluminium pillars, each with a 4mm socket, and which act as electrodes, are set on the paper as shown in the diagram below, and connected to a 300V HT power supply. A small amount of potassium permanganate crystals is put on another dry filter paper and crushed until they are powdery, then they are sprinkled evenly, and not too densely over the damp paper, with the supply switched on. Within 10 - 20s the field lines will be visible as the dissolving crystals allow ion migration to take place. The disadvantages of the method are that using a 300V supply makes it a demonstration experiment, and at the same time it cannot be overhead projected.



Chemistry Notes

We have had discussions with Scottish Gas on blowpipes suitable for natural gas. The type we looked for was one which would be of general use in the science department and suitable for simple glass blowing, brazing, and heating of crucibles etc. Since high pressure air compressors are not usually available in the science department our choice was limited to blowpipes which would work satisfactorily from a vacuum cleaner or foot bellows. When conversion from town to natural gas is carried out by Scottish Gas suitable replacement or modification of town gas models is carried out.

A very important point regarding safety requires to be emphasised for the operation of blowpipes and torches which use compressed air. If the air supplied to the blowpipe is at a higher pressure than the gas, whether it be town or natural gas, there is the possibility that air could enter the gas pipe and form an explosive mixture. The normal pressures of town and natural gas are about 0.2 - 0.3 lb/in^2 (Scottish Gas are still using imperial dimensions) so that even compressed air at a pressure of $\frac{1}{2}$ - 1 lb/in^2 derived from a vacuum cleaner could pass into the gas pipe line. There is therefore legislation requiring the fitting of a non-return valve to prevent the mixing of gas and air in the pipelines or meter. The statute in the Gas Act to cover such a situation is as follows:

> "Where a consumer of gas supplied by the Corporation uses for or in connection with the consumption of the gas so supplied any air at high pressure (in this paragraph referred to as "compressed air") or any gas not supplied by the Corporation (in this paragraph referred to as "extraneous gas"), he shall, if so required by the Corporation by notice in writing, fix in

a suitable position and keep in use an appliance provided by him which will effectually prevent the admission of the compressed air or extraneous gas into the service pipe or into any main through which gas is supplied by the Corporation.

Where a consumer is required by this paragraph to keep in use any appliance, he shall at his own expense keep it in proper order and repair, and repair, renew or replace it if it is not in proper order or repair."

The general approach in the gas industry is to insist on a non-return valve at the meter outlet and to recommend further valves at the individual appliances. The usual course is to fit in line an Amal-Otan non-return valve available from Amal at the outlet from the meter and another at the point where the flexible tube of blow-pipe or torch is connected. In the science department blowpipes might be used at various gas points in laboratories and technician's workshop and thus provision of a non-return valve at a large number of gas points would be impracticable. In these circumstances it is suggested by Scottish Gas that an Amal-Otan valve could be installed in the gas line as far downstream as possible and before the branches to the different supply points for the blowpipe. This would ensure that the volume of pipeline involved in any reverse flow would be comparatively small. It is further suggested that a simple ball type non-return valve be fitted at the blowpipe itself, a suitable one, the Saffire Hose Check valve being available from British Oxygen Co.

Blowpipes which we have tested and consider suitable for use in the science department can operate on town or natural gas and compressed air at $\frac{1}{2}$ - 2 lb/in^2, and are listed below. For general use we prefer ones which are obtainable with a stand capable of tilting; this applies to the Griffin and George and Philip Harris models.

Supplier	Model	Cost	Construction	Flame stability	Flame intensity
Griffin and George*	S15-968 (Bench torch)	£18.00	Steel with heavy cast iron base.	Good	Medium
Philip Harris	C392 (Bench torch)	£12.10	Steel with heavy cast iron base.	Good	Medium
Flamefast	200S	£11.61	Aluminium body and head.	Good	Strong
Adaptagas	3 4	£ 9.15 £12.76	Brass body and head. Common control for air and gas.	Fair	Medium

* This has three inlet tubes for air, oxygen, and fuel gas.

Model	Length of burner tube from valves	Number of jets	Tube dia.	Consumption of natural gas	Air pressure required	Flame length without air*
Griffin	80mm	3	13mm	50 ft^3/h	$\frac{1}{2}$-1$\frac{1}{2}$ lb/in^2	50mm
Harris	170mm	1	20mm	45 ft^3/h	$\frac{1}{2}$-1$\frac{1}{2}$ lb/in^2	65mm
Flamefast	140mm	2	13mm	72 ft^3/h	$\frac{1}{2}$-1$\frac{1}{2}$ lb/in^2	70mm
Adaptagas model 3	280mm	1	13mm	32 ft^3/h	$\frac{1}{2}$-1$\frac{1}{2}$ lb/in^2	45mm
Adaptagas model 4	360mm	1	13mm	72 ft^3/h	$\frac{1}{2}$-1$\frac{1}{2}$ lb/in^2	50mm

* Flame lengths without air being admitted are the same for town and natural gas.

The prices for Amal-Otan non-return valves, type 506, are: $\frac{1}{2}$", £8.64; 1", £9.23; 2", £15.09; 3", £32.73; and 4", £44.95. The Saffire Hose Check valve, ref. No. 153662, for fuel gas, hose 8mm, costs £1.02.

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Arising from a letter from a teacher on heat of neutralisation, the Central Committee on Chemistry asked us to carry out an investigation on this using school type apparatus. The teacher's letter quoted results obtained by his pupils for the heat of neutralisation of sodium hydroxide by hydrochloric, nitric, and ethanoic acids which did not show a distinct difference in value between ethanoic and the strong acids. Allowance had not been made for the possibility of different specific heats of the solutions. We carried out the experiment using the method given on pp 25 - 26 in Chemistry Takes Shape, Book 5, and also tried modifications such as measuring volume by burette instead of measuring jar, using 50cm^3 of 1M solutions instead of 25cm^3 etc. The solutions used were standards from Griffin and George with an accuracy of ± 0.002M. 25cm^3 of acid and alkali are mixed and the temperature taken with a thermometer reading in 0.1° divisions. Errors can occur therefore due to innaccurate concentration of solutions, volume measurement, and temperature readings. To this must be added the fact that no allowance has been made for possible differences in specific heats of 0.5M sodium chloride, 0.5M sodium nitrate, and 0.5M sodium acetate solutions.

We did obtain results for ΔH = 57kJ/mol for hydrochloric and nitric acids, and ΔH = 55kJ/mol for ethanoic acid by using 1M solution, measuring volume accurately and reading temperature to 0.05°, but these results did not allow for differences in specific heats. Accurate measurement of specific heat is rather difficult. We did, however, try and obtained average figures over three readings of 0.971 for 0.5M sodium acetate, and 0.959 for 0.5M sodium chloride. When corrected for these differences we get ΔH = 54.7kJ/mol for hydrochloric, and ΔH = 53.4kJ/mol for ethanoic acid. These results show that considerable accuracy is required to show any difference in the values for heat of neutralisation, and therefore any results obtained with the usual school apparatus would not be valid.

Experiments were carried out in the Chemistry department of The New University of Ulster, Coleraine, using a micro-calorimeter which is designed for making precise thermodynamic measurements and it was found that the heat of dissociation of ethanoic acid is of the order of only 3% of the heat of neutralisation at room temperature. It is also the case that above 30°C, the enthalpy change of dissociation is exothermic, and the resulting difference in temperature rise compared with that for the neutralisation of a strong acid is less than the experimental error inherent in simple calorimetry, and is comparable with the effects arising from the different specific heats of the solutions.

Recognising the difficulty in obtaining significant differences in heat of neutralisation of ethanoic and the strong acids, we were asked to investigate the possibility of using an alternative weak acid or even weak alkali. Methanoic, propanoic, tri-methyl ethanoic (pivalic acid) and ammonium hydroxide were tried. The first two gave results quite near that for ethanoic; the tri-methyl ethanoic saturated solution was only 0.27M which eliminated it at once, and 1M ammonium hydroxide on exposure decreased in concentration so quickly due to loss of ammonia that it was necessary to back titrate after mixing with acid in order to determine the actual molarity at time of mixing.

We informed the S.C.E.E.B. of our findings and they are sending out information to schools stating that this experiment involving ethanoic acid will be omitted from the examinations. In fact, section Q1 asks for simple experiments on heat of neutralisation only and heat of neutralisation of weak acids is not specifically mentioned.

Biology Notes

Although 'Clinistix' have proved extremely useful in school biology courses there may be some teachers who do not like using them because of the possibility of carcinogenic effects. We will describe the history and background to this problem below; teachers and others must then make up their own minds.

The active end of a Clinistix strip contains a 'very small amount' (how much we do not know since that is considered a commercial secret by the makers) of 4,4'-diamino-3,3'-dimethyl diphenyl, which is o-tolidine to most of us. O-tolidine is in the list of controlled substances in the Carcinogenic Substances Regulations, 1967. A Department of Health and Social Security memorandum (HM(69)57) published in July, 1969 advises on the use of this substance amongst others. The use of benzidine, o-tolidine or any of the other amines as liquid reagents was ruled out. The use of diagnostic reagent strips and tablets was allowed because of the very small amounts of carcinogen contained in them. However, this was qualified as follows:

> "Provided that the recommendations of the manufacturers are correctly followed and reasonable precautions are taken in handling (i.e. use of rubber gloves and forceps so that at no stage the tablets or the sensitive ends of the reagent strips are touched with the fingers) it is perfectly safe to use them".

After further negotiations with the manufacturers and others the D.H.S.S. amended this memorandum in a corrigendum (HM(69)74) in August 1969.

> "The sub-committee of the Central Pathology Committee considered that all available diagnostic reagent strips should be regarded as entirely safe and not needing to be handled with gloves or forceps".

Our advice would be not to touch the ends of the Clinistix strips. Provided one is sensible and follows the instructions there should be no danger. Staff in hospitals and G.P.s use the strips continually and the D.H.S.S. says they are in no danger. One's pupils would use the strips at most three or four times in their school career. We also need to have a sense of proportion; tobacco smoke and tars are amongst the strongest carcinogens known and we have all been exposed to these - some more than others. It is a question of deciding where to draw the line and in this case where the risk appears minimal or even non-existent, perhaps it is best left to the individual teacher to decide. Moreover, a new range of products soon to be on the market will fulfil the same functions as the 'stix strips and this 'Quantan' range does not contain any controlled substances. We have obtained samples and hope to report on them in the near future.

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Ash content determinations of plant material (Higher syllabus section 3d) are often time-consuming and tedious, involving heating to constant weight in a crucible. If carried out carefully the procedure can give good comparative results. However, if things are taken a little further and a quantitative elemental analysis is attempted then problems arise. The elements which form gaseous oxides are often present in the ash in only very small amounts. This poses problems in any subsequent analysis, as well as causing errors in the original ash content determination, since most of the tests used for the elements require a certain minimum level for solubility products to be exceeded, complexes to form etc. There are other methods available and biology teachers may have met with Lassaigne's sodium fusion method or Middleton's soda ash/zinc powder fusion technique. Both these methods have very real inherent dangers associated with the initial fusion, and are not suitable for school use.

There has been some interest lately in modified forms of the Schöniger method of quantitative elemental analysis (Boulton, Education in Chemistry, Vol.10, No.6, and Schmidt, School Science Review, Vol.55, No.191). The method known as the 'oxygen-flask method' can be simplified so that even a relatively inexperienced student can produce accurate qualitative analyses. The method is usually used for the analysis of pure organic compounds but with further modification it gives good results with much more complex

samples, e.g. plant material and foodstuffs.

The primary use for the method in the existing H-grade syllabus would appear to be in teacher demonstration or pupil experiments with plant material. The material should be dried before burning as otherwise the combustion will be incomplete. Where %age dry matter determinations are not required, we suggest hay or straw as convenient materials since they burn without any pre-treatment. It can also be used as part of a quick demonstration of the chemical composition of proteins and other important biochemical compounds. It may well prove a useful technique for sixth year projects and for work in the C.S.Y.S. biology course.

Essentially the technique consists of three stages: the complete burning of the organic sample in an atmosphere of oxygen; the absorption of the fumes by a small volume of liquid absorbent and the detection of inorganic ions in the absorbent by standard analytical procedures. A complete description of the simple apparatus and techniques used will be found in Boulton's account (ibid.) and in the interests of brevity we will not repeat that information here. Biologists will find that many of their chemistry colleagues will have a copy of the journal, or it will be available through the local science centre or library. The only apparatus required is a $500cm^3$ Buchner flask, a cork to fit, a length of nichrome or stainless steel wire and a cylinder of oxygen.

We have modified and extended the technique to make it more suitable for biological use. Boulton suggests the use of household tissue or toilet paper to hold the sample and act as a wick. This means that a separate analysis is required to check the paper as a source of contaminants. Good quality filter paper, e.g. 'Whatman' ashless type is better since it is nearly all cellulose and has a minimal ash content. It is also suggested that $5cm^3$ of absorbent be used for work on pure organic compounds. We have found that this gives too low a concentration of some elements when more complex mixtures are burnt. The recommended procedures of washing flask and coil with about $20cm^3$ of distilled water may make things worse. Accordingly we tended to use a smaller volume of absorbent and abandon the washing procedure. This meant that the 1M sodium hydroxide used as absorbent was not diluted and one had to bear in mind that the resulting solutions were strongly alkaline. Volumes of sample are small and tests are carried out on very small aliquots. Pupils need to be warned about the caustic nature of the solution. We concentrated on the elements of most interest to the biologist and found the following procedures worked well.

Sulphur. Many organic compounds contain little sulphur and with some samples concentration will be low. If the prescribed technique fails, even when the test solution is viewed against a dark background with a 'control' of barium chloride alongside, then either or both the following should be tried:

(1). Reduce the absorbent to $2cm^3$ and use the whole volume for the sulphate test.

(2). Carry out multiple burnings over the same absorbent to increase the concentration.

Reduction of volume by evaporation is to be avoided since it can lead to formation of sodium carbonate from the hydroxide and this will give a white precipitate of barium carbonate with barium chloride. It is therefore an unnecessary complication and a source of confusion as well as error.

Phosphorus. It is usually suggested that a different absorbent be used for phosphorus and 20% nitric acid is quoted. However the use of a separate absorbent can be a nuisance and we have found that sodium hydroxide is a satisfactory absorbent if the following method is used. 5cm^3 of sodium hydroxide absorbent can be used with most samples but if 'false' negative results are suspected try multiple burning or a smaller volume of absorbent - say 2cm^3. After burning the sample, 2-3cm^3 of the resultant solution is added to an equal volume of 20% nitric acid. This mixture is then heated until it boils - this requires care - to ensure that any sodium/phosphorus compounds are oxidised and hydrolysed. Heat 2-3cm^3 of ammonium molybdate solution and add the acidified sample to this dropwise. On cooling a canary yellow precipitate of ammonium phosphomolybdate is formed.

Sample \ Element	S	N	P	K
Hay. 5cm^3 NaOH as absorbent.	-	+	+	+
Double burning over 2cm^3 NaOH.	+			
D.N.A. (from Calf-thymus), 5cm^3 NaOH.	-	+	+	-
2cm^3 NaOH.	-			
Dry cheese, 5cm^3 NaOH.	-	+	+	+
Double burning, 2cm^3 NaOH.	+			
Human hair, Double burning, 2cm^3 NaOH.	+			

Some results of analyses of organic compounds.

Potassium. This is an additional test and is not described in the published accounts referred to above. A small sample of the absorbent is acidified with hydrochloric acid. A nichrome wire is dipped into the solution and potassium, if present, gives the characteristic lilac colour in a bunsen flame. View through a blue filter. The sodium hydroxide used as an absorbent may well contain traces of potassium and the sample under test should be compared with a blank of sodium hydroxide only, acidified in the same way. If the blank is heavily contaminated it would be better to burn a sample over sodium hydroxide and test this for nitrogen and sulphur. Another sample could then be burnt over 20% nitric acid and tests carried out for phosphorus and potassium.

Nitrogen. Boulton's prescribed method, using nitrosation of resorcinol works extremely well and all samples tested gave good results.

Other elements can also be detected by straightforward tests - e.g. the halogens, iron. For the halogens, see Boulton. For iron acidify with dilute nitric and add a little potassium ferrocyanide solution. A blue coloration or precipitate indicates iron. Confirm with potassium thiocyanate solution which turns blood-red.

Excellent results were obtained for phosphorus in D.N.A. and for sulphur in human hair. This ties in very nicely with the known chemical structures. The bases in D.N.A. are joined by phosphate groups to form the polynucleotide chain. The protein keratin, in human hair, contains a lot of cystine and it is believed that sulphur-sulphur bonds formed between adjacent molecular fibres account for the high tensile strength and other mechanical properties of hair.

Trade News

R.S. Components have asked us to point out that in cases where the customer is advised that some items are out of stock, the order is automatically cancelled and must be re-ordered. This can be done simply by telephoning the firm and quoting the original order number.

We have received the following reports from CLEAPSE, which may be borrowed on the same conditions as our own, i.e. for a period of one month.

L92 - Ratemeters, scalers and scaler-timers.

L13a - Large scale energy conversion - tilt hammer.

L109 - Small scale glassware kits for organic chemistry.

L56 - Small mammal cages for school use.

L3c - Eye Models (revised).

L85 - Electronics Kits.

A firm which specialises in recording accessories is Sensitised Coatings and schools owning a chart recorder are recommended to seek quotations for their chart paper, as there is sometimes a considerable saving compared with buying from the manufacturer of the recorder. The firm also sells Anaplot, a version of conducting paper, at £3 for a 60ft. roll, 29" wide, or £3.30 for 200 sheets, 10" square, and silver conducting paint at £2.50 per 1oz. bottle, or £8 for 4oz.

Elesco Fraser have been appointed sole Scottish agents for A.M. Lock and Co.

A storage cabinet for flammable liquids designed jointly by the Glasgow Science Centre and Strathclyde University is being marketed by Preston Components at a cost of about £60. We have the following description from the firm. Steel storage cabinet 45" high x 36" wide x 18" deep fitted with 2 shelves with expanded metal face and spillage tank of 110 pint capacity, louvred vents, 5" wide, each side of cabinet. Pair of doors at front of cabinet with rubber sealing

on face of cabinet. 2 point locking gear actuated by locking handle complete with 2 keys for each cabinet. Front of each cabinet bearing legend "DANGER FLAMMABLE LIQUID" in red letters. The spillage tray in the base is closed at the top by a panel of 1" x 1" x 13G Weldmesh to prevent the tray being used for storage purposes. The front of this tray has the following stencilled in red letters "SPILLAGE TRAY MUST NOT BE USED FOR STORAGE PURPOSES". If the imperial units annoy, perhaps they are an indication of what we are up against in attempting to go metric.

The Macmillan molecular models which we have shown at several exhibitions are now obtainable from Cochranes of Oxford and Philip Harris. A Basic Structures set, ref. 8.06, contains 520 atom centres and costs £5.50. The organic and inorganic chemistry set, ref. 8.07, contains 540 atom centres and costs £6.50. Other class sets are lattices, ref. 8.08, containing 380 atom centres, cost £6.50, and biochemistry, ref. 8.09, 400 atom centres. £5.50.

Griffin and George are now marketing a "Griffin Basic Microbiology Kit" at £14.90. This kit includes disposable petri dishes, sterile broths and media, inoculating loops etc., together with all stains and cultures necessary to perform experiments described in the booklet supplied. The experiments in the booklet are basic types, not tied to any particular course but of general application. The kit also contains autoclavable bags for disposal of contaminated plastics ware and specimen containers etc. Plastic petri dishes should in any event be incinerated and not just dumped in the bin - autoclaved or not.

Griffin Biological Laboratories are now supplying a range of "Genetics Seeds Kits". There is a "simple" kit - four experiments, and an "Intermediate" kit - three more complex experiments, viz. Mendel's second law, tight linkage, monohybrid segregation all in tomato. The "Advanced" kit contains three even more involved experiments - complementary genes, complete and incomplete dominance, and loose linkage - again all in tomato. Each kit costs £6.25 and contains packets of 10 - 15 seeds of the relevant P_1, P_2 and F_1 genotypes and at least 100 seeds of the F_2 and backcross progenies. Full experimental instructions are provided. There is also a "Rural Studies" kit with four simple experiments of particular application to rural studies.

A.M.L. Distributors who market Hitachi calculators give a 5-year parts and service guarantee with the machine. Moreover they guarantee to replace a defective calculator by a loan machine within 24 hours.

Sauter balances are no longer supplied by Shandon Scientific. The new agency is with European Instruments or the Balance Consultancy.

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

Adaptagas Ltd., Meadows Mills, Water Street, Stockport,
Cheshire SK1 2BY.

A.M.L. Distributors Ltd., 8 Wemyss Place, Edinburgh, 3.

Amal Ltd., Holdford Road, Birmingham B6 7ES.

Balance Consultancy, Avon Court, Castle Street, Trowbridge, Wilts.

British Oxygen Co. Ltd.. 491 Aikenhead Road, Polmadie, Glasgow C.2.

CLEAPSE Development Group, Brunel University, Kingston Lane,
Uxbridge, Middlesex.

Cochranes of Oxford Ltd., Leafield Oxford OX8 5NT.

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

European Instruments Ltd., 5 Wycombe Road, Holmer Green,
High Wycombe, Bucks.

Flamefast Engineering Ltd., Pendlebury Industrial Estate,
Manchester, M27 1FJ.

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

Griffin Biological Laboratories Ltd., 113 Lavender Hill,
Tonbridge, Kent.

Philip Harris, 30 Carron Place, Kelvin Industrial Estate,
East Kilbride.

A.M. Lock and Co. Ltd., Neville Street, Oldham, Lancs.

Preston Components Ltd., Boswell Square, Hillington, Glasgow, S.W.2.

R.S. Components Ltd., P.O. Box 427, 13-17 Epworth Street,
London EC2P 2HA.

Sensitised Coatings Ltd., A3 Redlands, Marlpit Lane, Coulsdon,
Surrey.

Shandon Scientific Ltd., Frimley Road, Camberley, Surrey.