SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 95. March, 1977.

Contents

Introduction

The annual meeting of the Scottish Branch of the Association for Science Education will be held in Jordanhill College of Education, Glasgow from 5th - 7th April. On the closing afternoon we will give a demonstration lecture on the theme of "Beat the Budget" which we hope will outline a number of ways in which teachers can increase the cost-effectiveness of their apparatus. We will also have the usual exhibition of SSSERC designed and/or built apparatus for the duration of the meeting.

On the morning of Saturday, 19th March we will give a demonstration lecture in the Physics Dept., St. Andrews University on the topic of digital integrated circuits, starting at 10.30 a.m. Over the past few bulletin issues we have published a number of applications for digital integrated circuits, and the lecture will give teachers in and around St. Andrews an opportunity of seeing these and other designs and assessing their significance in the science curriculum. We can see applications for digital integrated circuits in SYS physics: one project shown at a Science Fair last summer used five signal generators in various combinations of beats to link a keyboard scale based on A440 to the 50 Hz mains frequency. The same could have been done more accurately and economically using the circuit for the concert pitch generator of Bulletin 92. Amongst the applications which we hope to demonstrate - bulletin numbers in brackets where the designs have already been published - will be timer/frequency meter (86, 87), traffic lights control (72), concert pitch generator (92), keyboard and programmable frequency generators, digital clock, Nim machine, random sequence note generator (94), mathematical Mastermind, genetics models (93).

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The following sources of material for SYS chemistry projects may not be well known to teachers. The <u>Schools Information Centre on the Chemical Industry</u> publishes annually three bulletins at 30p each, covering a range of topics such as colour, metals, synthetic fibres etc. A complete set of 14 back numbers of these can be obtained for £4.

The <u>Department of Fibre Science</u> at the University of Strathclyde has published a useful booklet, available free to teachers, entitled "School projects in Fibre Science and Technology".

The <u>School Liaison Officer</u> of the Department of Polymer and Fibre Science, University of Manchester Institute of Science and Technology is willing to help sixth year students with their projects and will also provide samples and suggest experiments.

In these and indeed in any project material teachers should be thoroughly familiar with the possible hazards of any chemicals suggested before exposing their pupils, and as we pointed out in our last bulletin we are always available for consultation on this aspect.

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Following the introduction by the S.C.E.E.B. of the geology syllabus, we are examining the practical implications of the course. It is too early to say that we will publish an equipment list for geology, although this is being considered. Two aspects of geological fieldwork which have particularly concerned us are the needs for conservation and safety. On the former, we can report that the Geologists Association will supply free copies of their pamphlet 'A Code for Geological Field Work', but they do require a refund on postage and suggest 40p per 100 copies.

Some advice we have on conservation goes further than the code. Where it advises to keep collecting to a minimum, local organisations suggest that no pupils be issued with hammers, and that in nearly every case the young geologist is better advised to use a hand lens.

On safety, one interpretation of the Health and Safety at Work Act is that children on fieldwork excursions should wear hard hats of the type used by building site workers, and for shore excursions, life jackets.

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After the departure of our junior technician, Mrs. Anne Robinson, we have decided not to fill the vacancy meantime. While this may disappoint some of our audiences at our demonstrations and exhibitions, hopefully it will mean that there will be more expertise available to answer questions, as now there will be two directors in attendance where previously there was one director and a technician.

Biology Notes

Like everything else, microscopes wear out, but the process can be delayed by regular maintenance. It is a task which after adequate training can be given the technician for the summer vacation. Generally, microscopes suffer more deterioration from poor environmental conditions and bad storage than from proper handling in use. They should not be stored near heaters where the lubricants will dry out: near blackboards or other dusty locations; in or near chemical stores where fumes may encourage corrosion: or in a moist, warm atmosphere when fungi may grow on the lenses. They should also be kept covered whenever they are not in use.

The routine attention given to microscopes should include the removal of superficial dust from the stand using a soft cloth, after closing the dovetails with a piece of cloth or tissue, and periodic inspection of lenses for dirt deposits, grease smears and dust. Servicing operations which can be carried out by a school technician include the cleaning and regreasing of dovetails and nosepiece movements, the adjustment of some types of coarse focussing mechanism, and the cleaning of optics. Work which should not be attempted includes anything requiring the dismantling of objectives, adjustments to fine focussing mechanisms or the removal of pinions.

Before starting operations spread out a large, clean sheet of white paper on the bench and lay out the tools and materials: Allen keys imperial and metric, a set of watchmaker's screwdrivers, a range of larger screwdrivers both ordinary and 'Phillips' types, (the plain screwdrivers should have wide but fine blades), a rubber hand bellows of the type used by photographers, camel hair brushes, a good quality 50 mm focal length hand lens, lens tissues, Selvyt cloths and dogwood pegs (obtainable from H.S. Walsh), clean, lint-free rags, xylol (xylene), petrol, distilled water, grease pencil, lubricants. The thin grease Kilopoise 0001 G is used for dovetail slides and the thicker 0868 G grade for pinion bearings (spindles). Both are available from Farnell Electronic Components.

When working on an instrument, give yourself plenty of room and work well away from the edges of the bench so that screws do not find their way to the floor. A few small dishes or boxes are useful as receptacles for components which are removed. A well shaded adjustable lamp is an asset, especially for inspection of lens surfaces. It is also advisable to finish work on and reassemble one instrument before starting work on the next, to rule out the possibility of screws or small parts getting mixed up.

A. Cleaning and regreasing the movements.

Remove the eyepiece(s), objectives, condenser, mirror and gimbal. Whenever screws are removed take great care to use the correct size of screwdriver. If the blade is not an exact fit place a piece of paper towel or cloth over the screw slot. Rack off the body tube with the nosepiece attached. Any stops at the top of the movement should be removed before running the movement apart and this should be done very carefully. Dismantle the substage condenser scroll focussing assembly by loosening the mounting screws or rack off if of the rack-and-pinion type. The dovetail slides and other parts of a fine focussing movement are hardly ever exposed in use and usually do not require attention. Where the mechanism is a straightforward screw and lever or other simple type it could be partly dismantled, the condition of the grease inspected and if necessary the dovetails cleaned and regreased as described below. With more complicated movements it is wise to seek professional aid.

Clean the slides on the body tube and limb using a sharpened dogwood peg and a cloth moistened with petrol to remove old grease. Take care not to allow any petrol into the fine focussing mechanism or on to the pinion, where it may run along the shaft and affect the grease in the bearings. This is courting disaster and may result in a seized pinion bearing. The removal and reassembly of pinion bearings is best left to an engineer. Fortunately, it is rarely necessary. Carefully brush out the rack and pinion and clean out the teeth of the rack with a sharpened dogwood peg. Repeat this treatment to any substage rackwork which may be fitted. All the larger dovetails and any scroll or helical movements can then be regreased with Kilopoise 0001 G or other thin grease as recommended by the manufacturer. For smaller dovetails use Duckhams LB10, obtainable from garages, or a similar grease. Some authors recommend the use of oil and some talk of the 'finest clock oil'. However the majority of experts agree that oil should not be used on slides, or most other moving parts of a microscope. Oil picks up dust and dries out to form an efficient abrasive. It can also affect the grease packed in the pinion bearings by the manufacturer and may cause them to seize up.

Remove the nosepiece by undoing the central holding screw with a wide but fine bladed screwdriver. Clean the spindle and regrease with the thin grease. The touching surfaces of the rims should also be lightly greased. Replace and tighten until the movement is firm without being harsh. Replace the body tube in the slide, sliding the mating member down and very gently feeding the rack into the pinion. Do not bump them together or serious damage may be done to the teeth. Rack the body tube up and down a few times and then remove any excess grease.

The condenser mount can now be refitted. The majority of authors recommend that iris diaphragm movements should run dry. However some workers use thin oil on the outer lever movement and some even use a touch of oil on the blades themselves. Move the condenser mount assembly up and down a few times and remove excess grease as before.

Rack-and-pinion movements are meant to run dry and should never have an lubricant on the teeth. Clean and regrease the mirror gimbal peg with Kilopoise 0868 G and replace it.

On many instrument it is a relatively simple matter to adjust the coarse focussing mechanism at this point. Usually there is some provision for increasing the tension or pressure on the pinion spindle at the bearing point. It may be a pressure pad, friction washers or cones or some other device. On some models the adjustment is affected by simple contra-rotation of the coarse focus knobs. On others it is necessary to undo a locking nut or plate on one knob before contra-rotation, or one knob is held while the other is tightened, until the correct tension is obtained. Any locking devices present are then retightened and the movement tested for 'feel'. A smooth, but slightly stiff, action is aimed for. A properly adjusted movement should need as much effort to lower the body or stage as to raise it and should be free from jerks even when operated very slowly. On some instruments screws on the limb may have to be tightened alternately or a more complicated procedure may be necessary. If contra-rotation is not possible and it is not obvious how adjustment is affected, consult the supplier. If a complex instrument has noticeable body slip or backlash it is best to call in an engineer. What must be resisted is the temptation to effect a cure by making the teeth of rack and pinion engage more deeply be fitting packing pieces or by bending the rack. This will only make matters worse.

B. Cleaning the optics.

There are two distinct schools of thought on this subject. Some claim that frequent cleaning can only do harm, because dust, repeatedly rubbed across polished surfaces is bound to scratch them. Others claim that dust and grease must be removed regularly if instruments are to give of their best. Certainly great harm can be done by heavy-handed cleaning and clearly little is achieved by removing dust if a greasy fingerprint is left in its place. Cleaning optical glass needs a light touch, and a certain amount of care, if the best results are to be achieved and damage is to be avoided. A compromise must be made between too frequent cleaning and complete neglect.

Take each objective in turn. With a brush, Selvyt cloth or several thicknesses of lens tissue, very gently remove dirt and dust from the front lens. Xylol can be used to remove greasy deposits but use only enough to moisten the cloth or tissue. Xylol is a solvent for the cement used to hold lenses in place and only a minimal amount should be used. Another good reason for using small amounts is its toxicity. It should only be used in a well ventilated place for short periods of time and should be kept off the skin. Alcohol is a solvent for the cement used to hold the lens components together and its use for cleaning is best avoided. Never immerse objectives in these solvents: they are likely to fall apart!

For contamination by 'aqueous' materials e.g. sugar solution, blood, glycerine, copper sulphate etc. use distilled water either in the form of condensation from the breath or a dampened lens tissue. Heavy contamination is best removed by repeated gentle rubbing, changing the tissue frequently. Never use a tool of any kind, and avoid the use of tap water which may leave a deposit of salts after evaporation. Immersion oil may be removed, using xylol, instead of water, in the manner just described. If the old type of oil has been used and has dried to a caked deposit, xylol may not remove it. In this case fresh immersion oil may be an efficient solvent and remove most of the deposit. The remainder can then be cleaned off with xylol. Use a hand bellows to blow off any loose fibres left behind by cloth or tissues. Then hold the objective front lens uppermost and puff air in strongly to remove any dust from inside. Hold it up to the light and examine the back lens with the magnifier to ensure that no dust remains. In persistent cases a camel hair brush may be used to clean gently the back lens. Some workers use a brush which has been degreased (in 1,1,1, trichloroethane), with a rubber bung slipped over it to fit a test tube in which it is stored. This brush is electrostatically charged by rubbing it over a lighted lamp bulb. It may then be used to 'pick up' dust from a lens surface. Under no circumstances take objectives apart. If components are displaced the objectives will have to be returned to the maker for realignment on a collimator.

Eyepieces are cleaned in the same way as objectives. To prevent dust settling on cleaned surfaces the eye lens is unscrewed first and cleaned, then replaced before the bottom (field) lens is tackled. If there is likely to be any confusion about the way in which a lens should face, mark an edge with a grease pencil. When reassembling take care not to cross the very finely pitched threads. Dirt on the condenser and mirror is relatively unimportant though it may sometimes cause glare or loss of intensity. Cleaning is as for lenses but there should be no need to use any solvent. Replace the condenser and objectives and set the microscope up for testing.

Physics Notes

The experiments to be described show how to investigate the relation it = VC, how to establish that capacitors in series carry the same charge, and that this is equal to the total charge in the system, and how to verify the relation

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$ for capacitors in series.

The techniques are therefore an alternative to those described on p 9 - 10 of our experimental guide to Memorandum no. 18, Electrostatics for C.S.Y.S., which required the use of a charge measuring amplifier. As the experiments described use only a stopclock, milliammeter and rheostats, they have the advantage of low cost, although the capacitors being millifarad electrolytics, will cost more. We still think the apparatus cheap enough to allow students to carry out the experiments themselves, and in fact the capacitors used by us were taken from surplus equipment panels, and we have sold such panels very cheaply in the past.

To discharge a capacitor at constant current is not as difficult as many teachers may suppose. Modern electrolytic capacitors have surprisingly low leakage current so that if a discharge current of 1 mA or greater is used the effect of leakage can be neglected. The results can be graphed to establish that $Q \propto V$, and hence to calculate a value for the capacitance. The teacher (or pupil, if this is done in sixth year) can then carry out a constant load, i.e. exponential discharge and from it get a check on the capacitance value.

Our experiments were carried out with three 12 mF capacitors in parallel. Commercial alternatives would be 25 mF, 40 V at £1.25, or 47 mF, 40 V at £2, from Kinnie Components. The capacitors were used in the circuit of Fig. 1.

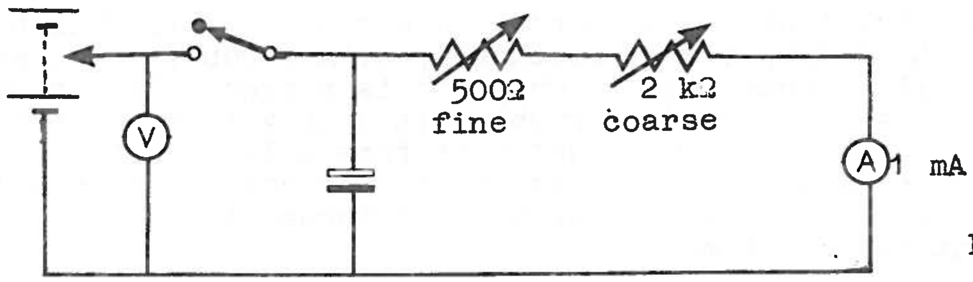

Fig. 1.

With the nife battery on its lowest tapping, the rheostats are set to maximum. The switch is closed and the 2 kΩ reduced until the current is 1 mA. Then the switch is opened, and a stopclock started simultaneously. As the capacitor discharges, the coarse control is reduced continuously to keep the discharge current at 1 mA. This can be tricky, and it is easier to allow the current to drop to, say, half a scale division below 1 mA and then to overcompensate by setting the pointer to half a division above 1 mA. As the coarse control nears zero resistance, the rate at which the meter pointer moves increases, and the fine control is brought into use. When both resistors are at zero, the clock is stopped.

The experiment is repeated in steps, increasing the battery voltage each time, and changing the coarse control to 5, 10 and finally 20 kΩ to keep the current down to 1 mA. Both the rheostats were linear, wirewound types, with pointer type knobs to make manipulation easier. Since the capacitance is high, the discharge time is quite long and an error of a second or two in determining the end point is not significant.

Initial voltage (V)	2.6	5.2	8.0	10.6	13.4
Discharge time t (s)	102	201	304	410	509

The values when graphed give a straight line through the origin, showing the proportionality of Q and V. From the slope of the graph the capacitance can be calculated:

$$C = \frac{it}{V} = \frac{10^{-3} \times 500}{13} = 38.5 \times 10^{-3}\,F.$$

The exponential discharge is done in a very similar fashion. Only the coarse control rheostat is used; the circuit is adjusted for i_o = 1 mA and then during discharge the rheostat is not touched but the times of occurrence of i = 0.9, 0.8, 0.7 ... 0.3 mA are noted. Either by graphing logi against t, or i against t on semi-logarithmic paper, one gets a straight line from which it is possible to obtain the half-life, i.e. the time for the current to drop by half. The time constant of the discharge = CR = 1.44 x $t_{\frac{1}{2}}$ (1.44 = 1/ln 2). Without touching the setting of the rheostat R is measured as accurately as possible and hence C can be calculated. If a decade resistance box is available then this could be used in place of the rheostat, eliminating the need to measure R. Since the ammeter resistance has been neglected, the result is more accurate if a high R and consequently high V are used. Using this method we obtained a capacitance value of 40.4 mF.

The same technique may be used to show that when capacitors are connected in series, each capacitor has the same charge. A little more care is needed, to minimise the effects of leakage.

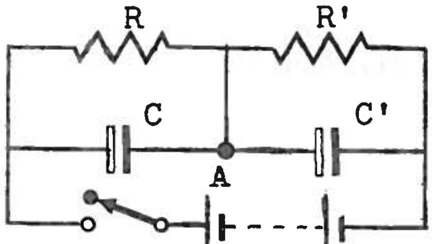

Fig. 2. Effect of leakage.

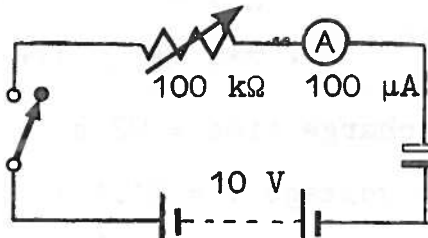

Fig. 3. Measurement of leakage.

Referring to Fig. 2, which shows the two capacitors each with its own leakage resistance, when the switch is closed the immediate potential at A is determined by the condition that each capacitor has the same charge. If the switch is kept closed, however, the potential at A will be determined by Ohm's Law applied to the resistors R and R', and this may be different from the immediate condition which is what we want to determine. Hence when measuring the charge on either C or C', we require to close the charging switch only momentarily, and to start the discharge immediately thereafter.

The leakage current of a capacitor at any given voltage may be measured using the circuit of Fig. 3. The rheostat is set to maximum, the switch closed, and the circuit left for several minutes. By then the capacitor will be nearly fully charged and the rheostat may be slowly reduced to zero, taking care not to overload the meter. The steady current shown on the meter with the rheostat at zero is the leakage: any capacitor showing more than 100 μA leakage should be rejected, and obviously the lower the leakage current the better. To measure leakage at higher voltages the rheostat value should be increased in proportion. The capacitors we used in the series circuit of Figs. 4 and 5 were

C_1 = 6.3 mF, 60 V: leakage at 10 V = 2 μA

C_2 = 12 mF, 50 V: leakage at 10 V = 20 μA.

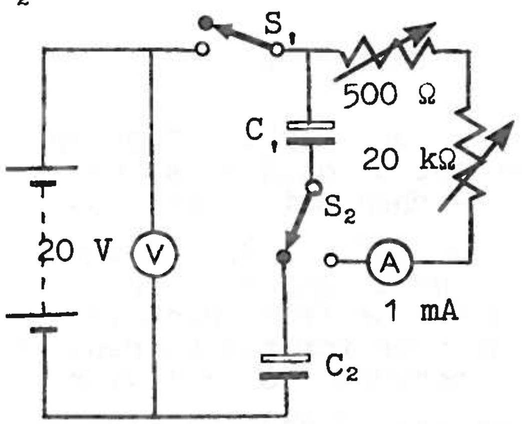

Fig. 4. Discharge circuit for C_1; S_1 is closed momentarily then S_2 is switched.

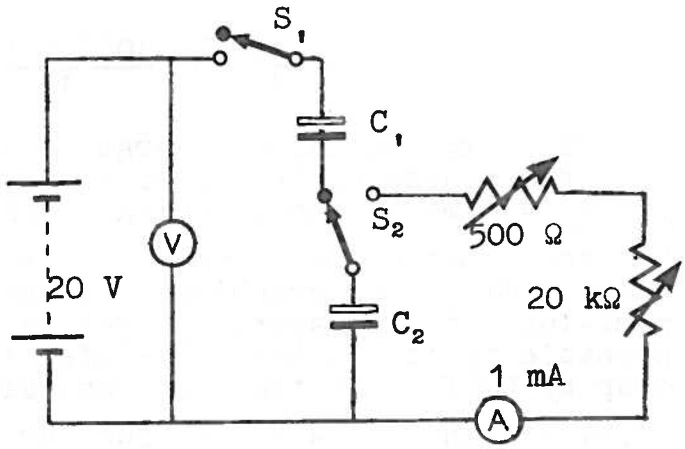

Fig. 5. Discharge circuit for C_2.

The discharge of C, the effective capacitance of C_1 and C_2 in series, was carried out using the circuit of Fig. 1. The discharge current was kept constant at 1 mA.

Result:

	C	C_1	C_2
Discharge time (s)	92, 94, 94	94, 95, 88	94, 86, 92

Mean discharge time = 92 s

Measured voltage V = 21.1 V

$$C = \frac{it}{V} = \frac{10^{-3} \times 92}{21.1} = 4.34 \text{ mF.}$$

Discharging C exponentially as already described we found C = 4.64 mF. When the separate capacitors were discharged using the method of Fig. 1 they gave C_1 = 7.1 mF and C_2 = 12.6 mF. These would give a calculated value for C = 4.53 mF.

During experiments on the series circuit, we kept handy a 10 Ω resistor, to be connected and held for 10 - 15 s across the capacitors, to ensure that there could be no inadvertent residual charge which would give an 'Ohm's Law' situation. This was done on each capacitor is turn, before starting the experiment. If anyone attempts these experiments using a low voltage power unit in place of a battery, it should be kept in mind that many units give bridge rectified a.c., and a voltmeter connected to this will give the average value of the p.d., whereas when a capacitor is charged from it it charges to the peak value. Hence any voltages to be measured should be taken with the capacitor in circuit.

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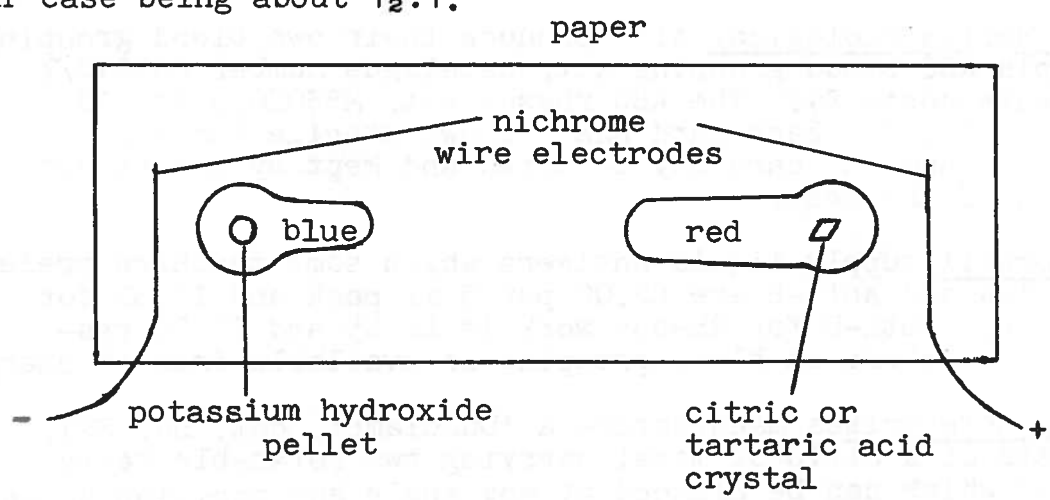
We have to point out a printing error in Fig. 2 of the article on the random sequence note generator in Bulletin 94. The output transistor driving the loudspeaker should be type 2N3053.

Chemistry Notes

A school has reported that the experiment to demonstrate the relative mobilities of H^+ and OH^- ions in chapter 10 of Chemistry Takes Shape has suddenly started giving very indifferent results, possibly due to a difference in a new sample of gelatine. Using a variety of different combinations of the variables i.e. p.d. applied, concentration of gelatine and of potassium nitrate, and the pH of the gelatine the experiment was repeated at the Centre on two different samples of gelatine. Again the results have been indifferent and more samples of gelatine will be investigated. We would be glad to hear both from teachers who find this experiment unsatisfactory and from those who are satisfied with the results.

An alternative method is to use filter paper dipped in a solution of universal indicator in place of the gelatine and to place small amounts of solid acids and alkalis at opposite ends. Universal indicator solution is made up by dissolving 2 g potassium nitrate in 50 ml water, adding 20 ml propan-1,2,3 triol and 10 ml of universal indicator. The solution is then adjusted to approx. pH 8 by adding drops of either M/10 sodium hydroxide or M/10 hydrochloric acid.

Electrical connection to the paper is made by laying on two lengths of nichrome wire, holding them in place by heavy weights, e.g. 50 ml beakers containing lead shot or similar material. Pupils should be warned not to handle the hydroxide pellet with fingers, and indeed it is safer if the teacher places it in position and pupils are warned against touching it at all. With the apparatus sketched below the expected results can be obtained in 15 minutes with a p.d. of 20 volts across the electrodes. With the p.d. reduced to 12 volts, the time will be about 40 min, but the results may not be so convincing, the ratio of mobilities in our case being about 1½:1.



Trade News

Following our note on asbestos substitutes in this section of our last bulletin we have had a note from Philip Harris objecting that in the case of stainless steel gauze (Harris 50p each, Griffin £2.85 for 5) we were not comparing like with like. This we accept, although at this point we would not like to say whether we were comparing good with better, or bad with worse. Harris gauze is 10 mesh, 24 s.w.g., while Griffin and George is 20 mesh, 26 s.w.g. For more information on asbestos replacements, see below. Philip Harris also pointed out that our statement of their policy on supplying gauzes with centres was the opposite of the truth, that, in fact they will not supply asbestos centred gauze unless forced to do so by a firm demand that it must be asbestos and not ceramic. We apologise for this mistake.

We have received the following reports from CLEAPSE, any of which may be borrowed by writing to the Director at the Centre.

L133 - Replacements for asbestos products

L135 - Eye protection

L136 - Fume cupboards - the present position.

Christison (S.E.) have informed us that they are agents for the Gravitron electronic balance. There are two models, the DSK2, 2900 x 0.1 g with subtractive tare of 900 g, at £439, and the DSG200, 290 x 0.01 g with tare of 90 g, at £438. The Gravitron has no controls other than on/off switch and a push button tare control. Christison's have arranged with a Scottish firm, Burke Electronics for the installation and servicing of these balances.

Nordisk of Denmark, makers of Eldoncards, have a distributor in Britain - Nordisk Diagnostics. A new product catalogue and price list which gives details of Eldoncards as well as liquid anti-sera for the ABO, Rho(D) system and for the M and N system, is now available. A leaflet dealing with blood components, historical attitudes, inheritance and Rhesus groups at a fairly basic level is also available. This four page pamphlet is designed to supplement the student's own notes, and can be bought in sets of 40 at 43p per set.

Philip Harris Biological also produce their own blood grouping kit. A simple ABO blood grouping kit, catalogue number M83010/7 for 25 students costs £4. The ABO rhesus kit, M83020/9 for 10 students costs £2.50. Each card has its own sterile lancet, used only once, and the card may be dried and kept by the student on completion of the test.

A.R. Horwell supply liquid Antisera which some teachers prefer to use. Anti-A and Anti-B are £2.00 per 5 ml pack and £3.50 for the 10 ml size. Anti-D for Rhesus work is £4.45 and £6.00 respectively. A brochure on blood grouping is available free of charge.

Spiring Enterprises manufacture a 'Duoclamp', cat. no. SC1, which consists of a strip of metal carrying two rotatable terry clips, one of which can be clamped at any angle and position along half the length of the strip. It may seem expensive at £1.20 but in distillation experiments for example it replaces the second retort stand, two clamps and one bosshead and eliminates the risk of breakage resulting from independent movement of one or other of the stands. The terry clips are of the size for holding B14 joints and the arrangement can be rapidly altered for a new operation.

Philip Harris are now supplying soil profiles which are resin impregnated and are therefore durable enough to withstand handling by pupils. There are six profiles, these being brown earth, calcareous, clay, organic, podsol and regasol, at £7.65 each. A display stand for all six profiles costs £9.

Some of Corning's disposable glassware may prove to be a good buy depending on how careful your pupils are. For example at 2½p each, pupils would have to break sixteen 1 ml graduated disposable pipettes to make up the price of one similar non-disposable pipette made of heavier glass. Their borosilicate light weight tubes, size 10 x 75 mm, described as disposable glass culture tubes could be used as test tubes. We have satisfactorily reduced lead oxides with carbon in these tubes using either town or natural gas. For biology their range of microscope slides is very competitive with cut edge 75 x 26 mm slides at £6.05 per 1000, and ground edge at £11 per 1000. There is a minimum order restriction of £50, and smaller amounts have to be ordered through their distributors, who include Mackay and Lynn, Glass Appliances, R. and J. Wood, Philip Harris, Townson and Mercer.

Corning also have a number of items of interest in non-disposable glassware. E-mil Univol volumetric flasks made of borosilicate glass which should last longer are available in A grade form at a price which is competitive with soda glass B grade from other manufacturers. Burettes and separating funnels with 'Rotaflo' taps cost little more than those with glass taps but the PTFE valves on Rotaflo are not prone to seizing or breakage. E.g. 250 ml separating funnel £4.90 (other brands in glass £3.20 - £5.22); 50 ml burette £2.75 (other brands £2.00 - £4.30) with in the case of the burettes a minimum order of 12.

For those who prefer the traditional stopcock G. Springham and Co. offer their Interflow borosilicate glass burette with interchangeable keys at £2.85 each, minimum quantity 10.

The E.S.I. Nuclear type 202 xenon stroboscope has three ranges from 1 - 250 Hz, and a maximum energy per flash in the lowest range (1 - 10 Hz) of 0.8 J. A pair of external trigger sockets in association with a switch can be used either to drive external equipment in synchronism with the stroboscope, or to drive the stroboscope in synchronism with externally applied 4 V negative pulses. The 202 costs £64.

The Haig wave machine which illustrates travelling longitudinal and transverse waves is obtainable from Irwin-Desman, cat. no. ER630C in kit form at £14.50 or assembled at £24.30. The same apparatus can be bought from I for E as a kit (IE121) at £16, or assembled (IE120) at £22.

Also in the Irwin-Desman catalogue at No. ER617.2 is a crystal microphone cartridge which will feed directly to the oscilloscope (Integrated Science Worksheet 6, Section 1) without the need for amplification of the signal, at 45p.

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

Burke Electronics Ltd., 22 Royal Crescent, Sauchiehall Street, Glasgow.

A. Christison (S.E.) Ltd., Albany Road, East Gateshead Industrial Estate, Gateshead, NE8 3AT.

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

Corning Ltd., Laboratory Division, Stone, Staffs, ST15 OBG.

Department of Fibre Science, University of Strathclyde, George Street, Glasgow, G1 1XW.

E.S.I. Nuclear Ltd., Klempfern House, Holmesdale Road, Reigate, RH2 OBG.

Farnell Electronic Components Ltd., Canal Road, Leeds, LS12 2TU.

Glass Appliances Ltd., 488 Holburn Street, Aberdeen, AB1 7LY.

Geologists Association, c/o Dept. of Geology, University College, Gower Street, London, WC1E 6BT.

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.

Philip Harris Biological, Oldmixon, Weston-super-Mare, Avon.

A.R.Horwell Ltd., 2 Grangeway, Kilburn High Road, London, NW6 2BP.

I for E Ltd., 87a Trowbridge Road, Bradford on Avon, Wilts, BA15 1EE.

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

Kinnie Components Ltd., 10 Nelmes Way, Hornchurch, Essex, RM11 2OZ.

Mackay and Lynn Ltd., 30 Marchmont Crescent, Edinburgh, EH9 1HG.

Nordisk Diagnostics Ltd., 17 Halkingcroft, Langley, Berks, SL3 7BB.

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