SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 25. September, 1968.

Contents

Introduction

We have been taken to task by a teacher for referring in Bulletin 23 to a Common Core Science Course, a title which was unfamiliar to him and probably to many other teachers. Since the Working Party for Secondary School Science was set up in 1965 the project on which they have been engaged has undergone several changes of name. As the political winds veered or backed, it has been the Non-Certificate Science Course, the Secondary Science Course, the Common Core Science Course and the Integrated Science Course. In March of this year the Working Party decided to nail their colours firmly to the mast, and in a minute of that date they decreed that henceforth it shall be known as the Integrated Science Course. It is under this title that the syllabus has been recently issued to schools. As the title implies, the course integrates fully with the examination syllabuses in Biology, Chemistry and Physics, the last two of which have been revised. These revisions were issued in draft form in March of this year.

Concurrent with these changes we are bringing our apparatus lists up to date by giving one list for Integrated and examination syllabuses for the first two years of secondary education. At this stage it is not yet clear whether the lists will be suitable for publishing in a future Bulletin, and information on this point will be given at a future date.

Opinion

Sales managers of commercial undertakings are very familiar with the fact that a brand name product may sell very well in one part of the country and can be a complete flop in another, and that by changing the name though not the product the sales to a recalcitrant public may be boosted to the level of the original if not beyond. In the jargon of the trade the product image has to fit the area in which one is selling. It is a mild deception which does no great harm, since the requirements for washing the Aberdonian or Devonian face are not vastly different.

In similar vein the tartan and thistle motif is used to sell products which have little or no Scottish connection to tourists tramping the broad thoroughfares of Princes and Sauchiehall Street who are content to accept this as the image of Scotland. They scorn to dig into the souks of Auchenshoogle or Ullapool in search of the authentic Gael or Kelt who anyway is more probably to be found in Fife programming a computer for the churning out of micro-circuit chips.

Heretofore the teacher, and particularly the science teacher, was considered to be proof against the wiles of the ad. man. Indeed most manufacturers in science education were glad and thankful to believe so, thinking the cost and effort of producing just one catalogue of the thousands of lines/

lines they are obliged to carry more than enough without diversifying into districts. In the general commercial field, selling to tourists under the tartan banner can be looked upon as fair game, but to try the same thing with the indigenous Scot is very dicey indeed; alright for some things like sweets and shortbread since the public then assumes they are home produced, but not good for hardware and durable goods unless they very definitely are home produced and have export potential, which of course is inverted tourism. Selling goods of identifiably foreign manufacture to a Scottish public under a Scottish motif was just a non-starter, selling them to Scottish teachers was unthinkable.

Unthinkable, that is, until Gerrard produced their Scottish Biology Catalogue. This has a cover emblazoned with the national emblem of Scotland; in charity I must assume they were ignorant of the national motto. By itself this lapse from grace could be ignored as only one of many from similar English-based firms who have swallowed whole the tourist bait. Regrettably, however, the Scottish Biology Catalogue is not what it purports to be. Once inside the cover, the contents are those of the Nuffield Biology 'O' Level Course Catalogue from the same firm. In preparing the equipment list of Bulletin 23 we have used the latter catalogue, and items bearing the prefix NM will be found in this or the thistle catalogue of Gerrard. Other Gerrard items not so prefixed, are in neither catalogue and must be sought in their subject catalogues.

I have discussed this with a representative of the firm, who as is to be expected has a different opinion from that expressed here of the impact the thistle catalogue will have in Scotland, and he has agreed to supplement the catalogue with a price list based on the list of Bulletin 23 of items not included in the Nuffield Biology Catalogue.

Centrifuges

Four models of centrifuge have been tested in the Centre, viz. Eureka Scientific two and four-station models, Griffin and George Simplex II, and the M.S.E. Minette. Reports on the latter two are summarised in the Supplement to this Bulletin and the other two will be given later.

All four models used a biassed switch to control the motor, meaning that the switch has to be held in position while centrifuging. Only one, the Simplex II, has anti-interference suppression components. The centrifuge speed both with the lid open and closed was measured by using two small magnets in opposing tubes. These were selected to have a moment of inertia approximately the same as that of a test-tube full of water. The Unilab high inductance was set up outside the bowl of the centrifuge as a pick-up coil and the pulses induced in it by the rotating magnets were displayed on a C.R.O. and frequently balanced against a signal generator using the Lissajou technique. Rather than trust the frequency calibration of the generator at the low end of its range, its output was also fed to a digital timer, and a count taken over a 1 minute period. It was not always possible to count the induced/

induced pulses directly, which would have been a simpler technique, because of amplitude variations. From the speed, the maximum acceleration at the base of a test-tube was calculated.

Although not a proper method of use, pupils will sooner or later centrifuge single test-tubes, causing an imbalance about the central axis, and setting up forces which might literally shake the centrifuge to pieces. We therefore examined the effects of opposing one, or in the case of four-station heads two full test-tubes against empty ones.

Spillage is another hazard more likely to affect pupil centrifuges than the sophisticated versions in use in industry or university. If spilled solutions can penetrate to the motor parts they cannot be cleaned short of a complete dismantling of the motor which we have not attempted. An unnoticed or ignored spill may therefore cause corrosion of the motor, and we emptied 10ml water into the bowl, centrifuged for 1 minute and then allowed the equipment to stand for some time before examining the effects.

Safety in use is an important feature of a centrifuge, and such factors as the possibility of test-tubes becoming dislodged during centrifuging, the proximity of the rotating tubes to the rim of the bowl, the ease with which the motor can be stopped, have been considered and included in the individual reports.

Chemistry Notes

A colorimeter which is adequate for determining the concentrations of solutions by comparisons against a standard can be constructed using a cadmium sulphide photo-cell. The basic arrangement is that the cell forms the base of a long light-proof tube down which the light shines from above. The sample tube containing the solution is lowered into this so that its base rests on the cell. Since the light path is through the depth of solution, some care must be taken to use equal volumes of the various solutions, so that the light path through the solution is the same in every case. If greater selectivity is required a filter may be simply rested on top of the sample tube. A desk lamp or any similar bulb is a suitable light source.

Since the effect of illuminating a cadmium sulphide cell is to reduce its resistance, this change is observed by measuring the current through the cell produced by a constant voltage source. The rheostat of Fig. 1 then acts as a set zero control.

To use the colorimeter, a standard volume of distilled water is placed in the sample tube which is then lowered into the colorimeter. The position of the light source - with filter if necessary - and the rheostat setting are then adjusted to give a full scale reading on the meter. Equal volumes of standard solutions are used in the same sample tube in turn, and the current readings taken. These readings give fraction of light transmitted, and if graphed directly against molarity on semi-logarithmic paper will give a straight line calibration graph.

With/

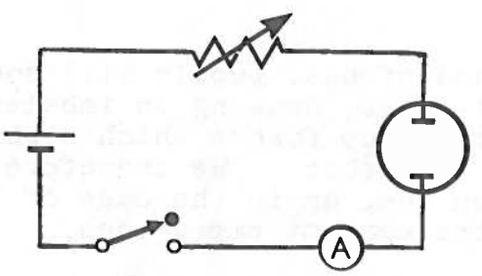

Fig. 1. Circuit

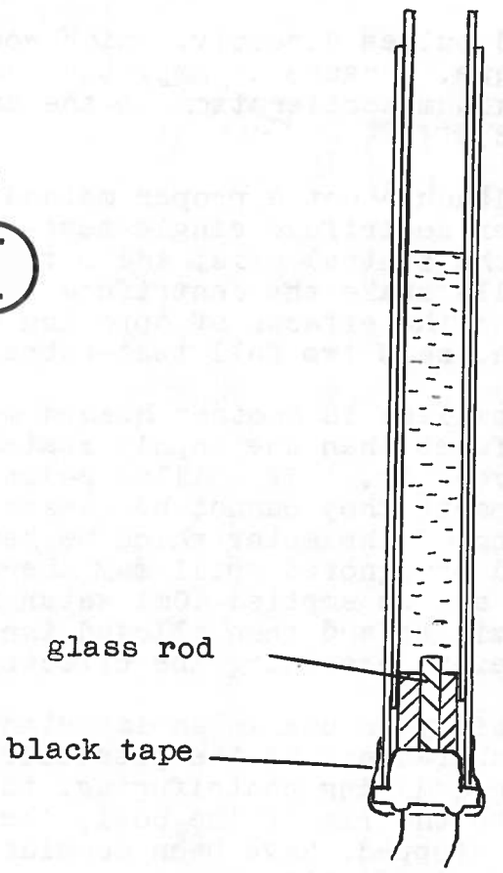

Fig. 2. Colorimeter tube

With simple equipment such as this, several precautions have to be taken to ensure reliable results. The photo-cell must have all stray light excluded and hence the base and sides of the cell must be taped over with black plastic adhesive tape, which can also be used to secure the cell to the protective tube. For the latter we used a 15cm length of metal electric conduit tube, 12mm inside diameter, although this had to be turned out slightly on the lathe to allow the photo-cell to fit inside it.

Test-tubes are useless as specimen tubes because of the rounded base, and other flat base tubes which we examined all seemed to have uneven thickness of glass around the junction of wall and bottom. In any case one does not need to transmit light through more than a small portion of the base, since the circuit is sufficiently sensitive to deal with quite low levels of illumination. Thus we used a length of soda glass tube, selected to be as good a fit as possible inside the metal tube, stoppering the base with a one-holed No. 11 rubber stopper. The hole is plugged with a short length of glass rod, fitting flush with the stopper on the outside end. Glass rod does not always break cleanly, sometimes forming a bevel or a burr on one side. One can then either accept the fact that the specimen tube is directionally "polarised", and make allowance for this by ensuring that it is always inserted in the metal tube the same way round, e.g. by a coincidence mark on both tubes, or one can grind flat the ends of the rod. The existence of directional properties in a tube can be checked by rotating the tube in the colorimeter while watching the meter reading. If a number of sample tubes are to be used in the/

the same experiment, they must have the same length of glass rod plug, since this forms part of the light path. With care and by making a few extra bits and pieces, it should not be too difficult to obtain 3 or 4 sample tubes free from directional properties and sufficiently alike in their transmission characteristics.

The assembly of the circuit is left for the teacher to decide. Some may wish to have the photo-cell terminals connected to flying leads, and to wire up other components as needed on the bench, clamping the colorimeter tube in a retort stand. In a more permanent arrangement such as we have made up, meter, switch and rheostat are on the lid of a box, which holds the U2 cell and colorimeter tube. The tube is fixed by two Terry clips to one side of the box and projects upwards through a hole in the lid. The components we specify are those we have used, although none are in any way critical except the photo-electric cell. A prototype of the colorimeter tube by Philip Harris is at present being tested in the Centre.

Components

MKY101-C photo cell	Proops Brothers	10s. 6d.
0-1mA MR65 meter	G.W. Smith	£1.12s. 6d.
Single pole on/off switch	Radiospares	3s. 0d.
1,000Ω potentiometer wirewound	Radiospares	5s. 6d.
U2 cell	Woolworths	10d.

Biology Notes

Following a complaint from a keen and competent ecologist that fertilisation using pomatoceros was a technique so difficult to accomplish that it made the method a very unsatisfactory one for classroom work, we decided to investigate the method. It is worth while pointing out that the method appears in section 6 of the Integrated Science Course, i.e. it must be done, if at all, with first year secondary classes. To be able to show to such pupils the fusion of egg and sperm must rank as a tremendous achievement and we feel that the experiment must have as much prominence as, say the Brownian motion experiment has in physics and chemistry. The experiment, however must be reliable; each pupil, or group of pupils, depending on the number of microscopes available, must mix the two suspensions and certainly each pupil should see the fusion process for himself.

This raises important questions of time, questions which we cannot answer until we have had much greater experience of the technique. For example, how long will the gametes remain viable; can they be kept for an hour, a morning, overnight or longer, so that a preparation can be planned? Our own single experience of the method suggests that all may not be plain sailing.

Small/

Small rocks carrying numerous tubeworms were selected, taking only obviously living specimens. These can be identified with the naked eye by a really pearly white orifice, compared with the rest of the tube. The empty tubes of dead pomatoceros are uniformly dirty yellow in colour. It is necessary to obtain plenty specimens, probably at least 100.

The tube was broken 25-30mm from the orifice, and the worm gently poked out using a seeker on to a cavity slide or spotting tile cavity along with some sea water. Immediately the gametes are set free, tiny pink eggs, and in other cases a grey green cloud of sperm cells. Of approximately fifty animals, only four produced sperm, the remainder eggs. If any reliance can be put on this sex ratio, this suggests that this part of the preparation, which in the Centre took three hours by one individual, could well be carried out by pupils themselves. Certainly both eggs and sperm are visible without magnification, and even with the ratio given above, a class of 20 pupils or over should produce a few males, given two or three animals per pupil.

This however is not the end of the story. We suspect that the gametes we obtained were not all quite ripe, as in only one of the four mixings was fertilisation actually seen, and this within five minutes of mixing. On the question of time, the Nuffield Biology Project is even less optimistic. They state (Teacher's Guide I, p.55), "Fertilisation takes place almost immediately, and therefore only small groups of about six pupils at a time can view the process under a single microscope." We would go further and say that the single act of fusion can be seen by only one pupil at a time looking into a single microscope, and if six pupils - and we hope that this is an exceptionally large number by Scottish standards - have to use one microscope, they must view the process sequentially. We therefore still need to know what Nuffield means by "immediate fertilisation." What is the half-life time of the unfertilised egg once mixed with sperm? Is it so short that a first year pupil, having had relatively little experience of handling a microscope, will find nothing but fertilised eggs in his field of view, once he has accustomed his eye to viewing? Is it long enough to allow selection of unfertilised eggs in a single mix by several pupils using the same microscope sequentially?

These are questions we cannot answer until we have had more experience of the technique. Similarly, until we know the probabilities of obtaining ripe gametes from a batch of animals, we cannot pronounce on the reliability of the experiment. Finally we give a quote from the introduction to the Integrated Science Course syllabus, which indicates clearly that the biologists who have read this should be viewing this experiment as a matter of some urgency, since they may very soon have to teach the technique to their non-biology colleagues, before they in turn teach their classes. "It is realised that some difficulties may arise if this syllabus is taught in its integrated form by one teacher. The benefits to be derived from such a unified treatment, however, so outweigh the problems created that the Working Party has felt justified in preparing it and in recommending its use to teachers."

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Among the experiments recommended for the new Biology syllabus, and also for the integrated science course, is the quantitative measurement of Vitamin C using 2:6 Dichlorophenol indophenol (DCPIP). The indicator is standardised by decolorising a known concentration of vitamin C made up from tablets. It is important to note that both of these reagents are unstable, and it was found on average that a solution of vitamin C became ineffective after four days, while the DCPIP solution lasted about two weeks. For satisfactory results we recommend that these solutions be used only within two days of preparation.

In The Workshop

The use of a meter to determine light intensity is required in the ecology section of the new Biology syllabus. While the absolute measurement of the intensity of solar radiation, taking in both light and heat rays, is a difficult problem as it involves the spectral response of the measuring device, this is not what is required. It is sufficient to provide an instrument which will give comparative values for light and shade etc., and this can be carried out with exposure meters originally made for photographic work. These, however, are liable to have scales in units peculiar to the pupil, and it is an advantage to have a meter which readily converts the reading into units of rate of energy per unit area, i.e. watts per square metre. If this should read strangely to a biologist accustomed to dealing in calories, he should reflect on the advantages to the pupil of using only one unit for energy measurement, on the fact that Britain is soon to go metric, and that as part of the change the Examination Board has decided to use only S.I. units, wherein the calorie does not appear, in future examinations.

The light meter shown consists only of a photo-emissive cell connected to a milliammeter. In sunlight in spring and autumn this records a current of 8-10 mA. If the meter resistance is measured - an exercise for the physics department - then the power generated by the circuit can be determined. For the meter we specify this resistance is about 5Ω, although there can be considerable variation in different samples of meter. With a current of 10mA, this gives the power as

$$RI^2 = 5 \times (10 \times 10^{-3})^2 = 5 \times 10^{-4} \text{ watts}$$

The cell which we specify has a receptive surface of dimensions 25 x 35mm, so that the power per unit area is

$$\frac{5 \times 10^{-4}}{25 \times 35 \times 10^{-6}} = \frac{4}{7} \text{ watt per square metre}$$

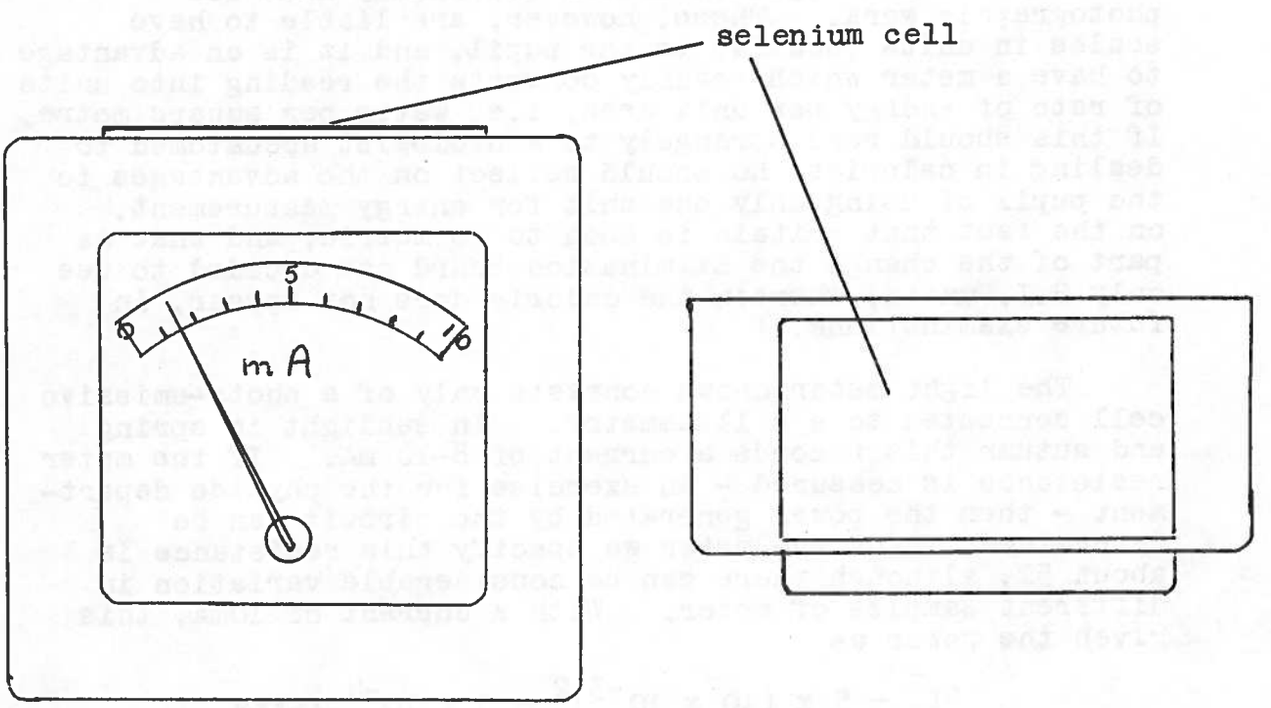
This calculation has been carried out to show the order of magnitude of the result; in practice a calibration curve of meter reading against power per unit area would be constructed/

structed and used to avoid separate calculations each time.

The diagrams showing the construction are largely self-explanatory. The wooden box top has a hole 38mm diameter cut in it to accommodate the meter; four small holes to take the meter fixing bolts will also be needed. In most cases we find it unnecessary to attach the nuts to these bolts, the meter being simply a push fit in the hole. The photo-electric cell is cemented to one side of the box with Evostik, although two strips of Selotape over the face of the cell are equally effective. The tape does not reduce the light intensity very much, and it has the advantage of protecting the face of the cell from being scratched, which is a possibility with outdoor work. The correct polarity must be observed when connecting cell to meter.

Materials

0-1mA meter, MR38P	G.W. Smith	£1. 5s. 0d.
Photogenerative cell, Type 1	Proops	5s. 0d.
Wooden box, MK3890	Wootton and Co., per dozen	7s. 6d.



Bulletin Supplement

Below is a summary of the results of tests carried out on two of the four centrifuges mentioned on page 2. Individual reports on these models can be borrowed by writing to the Director. The classifications used are: A - most suitable for school use; B - satisfactory for school use; C - unsatisfactory.

Model No.	W10-800	Minette
Supplier	Griffin and George	M.S.E.
Price	£22.10s. -d.	£13. -s. -d.
Head	4-station swing-out	4-station swing-out or angled
Test-tube size	98x17mm	98x17mm
Speed		
lid open	2,100	1,300*
lid closed	2,500	2,200
Maximum Acceleration	910g	900g*
Classification	A	B

* In the swing-out position; with angled head, speeds are about 10% greater.

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<u>High Voltage Power Supplies</u>

Model No.	D4160	P7996
Supplier	Labgear	Philip Harris
Price	£30. -s. -d.	£36. -s. -d.
High Voltage Control	electronic	variable transformer
Maximum outputs at zero current	300 and 24.5V D.C; 6.4V A.C.	400 and 44.5V D.C.; 38 and 6.7V A.C.
Maximum currents	60mA D.C.; 1.5A A.C.	200mA D.C.; 200mA and 2A A.C.
Outputs at maximum current	282 and 24.2V D.C.; 6.2V A.C.	350 and 37.4V D.C. 36.2 and 6.2V A.C.
Output Meter	None	None
Meter Error	-	-
R.M.S. ripple at full load	29mV	87mV
Assessment	A	B

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

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

T. Gerrard and Co. Ltd., Gerrard House, Worthing Road, East Preston, Near Littlehampton, Sussex.

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

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

Labgear Ltd., Cromwell Road, Cambridge.

(M.S.E.) Measuring and Scientific Equipment Ltd., 25-28 Buckingham Gate, London, S.W.1.

Proops Brothers Ltd., 52 Tottenham Court Road, London, W.1.

Radiospares Ltd., P.O. Box 268, 4-8 Maple Street, London, W.1.

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

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

Wootton and Co. Ltd., Alma Works, Ponders End, Middlesex.