SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 60. January, 1973.

Contents

Introduction

As a profession, science teachers are becoming more and more aware of the need to apply rigorous standards of safety within their laboratories. This is not due to a venal recognition of the fact that the costs of litigation and the awards of damages are spiralling ever upward, but to an increased awareness of our moral responsibility to ensure that no child in our charge shall be placed at risk of disfigurement, disability or death. Teachers in some local authorities, particularly those which have a science adviser on their staff, are routinely supplied with information concerning safety. But every teacher has the responsibility of informing himself as well as he can on matters affecting safety, and principal teachers have the responsibility of seeing that all such information reaches their staffs.

The School Science Review carries from time to time letters from teachers dealing with specific cases of laboratory accidents, most of which are followed up by a discussion of the hazards involved, and perhaps advice on how the experiment may be conducted with greater safety. We ourselves have asked in Bulletin 40 that we be given details of any accident in which the writer was personally involved, so that we might give publicity to such accidents with a view to reducing the risk of their recurrence. The results of this query were published in Bulletin 43, and we would repeat here that we are still prepared in the interests of safety to publicise any future communications we may receive of the same nature.

Another important aspect of safety is applying proper procedures and taking necessary precautions to prevent accidents. Advice in this respect is obtainable from the Scottish Education Department which has over the years issued a number of circulars on safety, and these should be compulsory reading for all teachers. Unfortunately, there may be teachers who do not see these, either because their Principal teacher omits to bring them to the notice of new members of staff, or because the originals have been mislaid, or removed by an over-zealous head moving to a new post. One purpose of this note therefore is to remind all teachers that these circulars should be available for their examination. If the originals have been lost, then principal teachers can and should purchase fresh copies from H.M.S.O. The circulars referred to are:

Circular 689 (29/9/68) Ionising Radiations in Schools, Colleges of Education and Further Education Establishments, price 11p.
Circular 759 (25/6/70) The Use of Carcinogenic Substances in Education Establishments, price 5p.
Circular 766 (8/10/70) Use of Lasers in Schools, Colleges of Education and Further Education Establishments, price 4p.
In addition there is a Scottish Education Department memorandum No. 6/1968, called The Asbestos Regulations, available without charge from the Schools Branch.

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The Deposit of Poisonous Waste Act, 1972, which came into force this year, makes it an offence to deposit on land (which includes land covered by water) any poisonous, noxious or polluting waste in circumstances in which it can give rise to an environmental hazard. Categories of waste which are exempted from the Act are described in Statutory Instruments 1972, No. 1017, The Deposit of Poisonous Waste (Notification of Removal or Deposit) Regulations, 1972, available from H.M.S.O. A person proposing to deposit waste not exempted from the Act is required to give three clear days notice of his intention to the local authorities, and the river purification boards controlling the areas from which the waste is to be removed, and in which it is to be deposited. This notice must specify the nature and chemical composition of the waste, the quantity, and the number, size and description of any containers used to convey the waste. Failure to comply with the requirements of the Act can result in a fine of up to £400. It therefore becomes an offence for a teacher to dispose of sodium or potassium residues by throwing them into the sea, or to burn off inflammable liquids on waste ground, to give only two examples.

While the requirements of the Act may seem unduly complicated to any teacher wishing to dispose of waste chemicals, they do make it necessary that there shall be in each local authority area an official, probably a sanitary inspector, who is responsible for handling notifications of intention to remove or deposit waste in that area. It can be assumed that this official knows the interpretation of the Act, and he can and should be called on to give advice to any teacher wishing to dispose of hazardous chemicals.

On the related problem of the circumstances under which it is permissible to pour chemicals down the sink, the same official can give advice. In many areas a local bye law restricts such disposal to the condition that the pH shall be within a given range, e.g. 8-11, and lays down maximum permissible concentrations for toxic solutions. A hazard which the teacher should be aware of is the build up of vapour from volatile liquids to explosive concentrations inside the sewers. In all cases where there is a question of the disposal of chemicals or other waste which might constitute an environmental hazard, the teacher should consult this official whom the local authority is obliged to appoint to have responsibility for the administration of the Act.

Opinion

By the end of this academic year the last vestige of the 'traditional' science syllabuses - in the shape of Higher Grade Biology - will have disappeared from Scottish Schools. This is therefore an appropriate time at which to set out our views on what we see as the very differing roles of equipment in the two types of course.

Most readers will have shared the writer's experience of being taught the traditional deductive syllabuses, where theory tended to be handed down from on high, and formal practical sessions were apparently designed mainly to reinforce what had already been stated. Indeed, if we are honest we will admit that in many cases practical work was done simply because we had to take a practical examination at the end of the course. In these circumstances the work tended to become a series of set-piece exercises ("Using a - to show that...") with specified pieces of equipment - Kundt's Dust Tube; Hoffman's Voltameter; the Thoday Potometer, etc. Frequently one was simply provided with cookery-book type instructions, and inevitably one gained a warped view of such equipment, as part of the folk-lore of the subject. Such an approach, of course, as well as giving a totally false impression of the role of equipment in scientific research, also greatly inhibited the development of more suitable designs for school use.

The new courses differ in many ways from the old, but from our point of view the most important difference is that, in line with 'scientific method' practical work is integral with the theory. Frequently, therefore, equipment is used to make observations which are crucial to a successful build-up of the desired concepts. While this approach can be overdone - and there are those who would say that in some of the new courses it has been overdone - most of us would probably agree that it is on the whole an improvement on the old didactic approach.

As a result of this new approach, some of our ideas on suitable specifications for major items have had to be changed. For example, in the typical traditional biology course microscopes tended to be used relatively infrequently, and then mainly for 'set-piece' exercises in more senior classes, with prepared material. On the other hand, in the new courses they are used throughout the secondary school - and frequently to examine fresh preparations made by the pupils. Clearly, then, there is a greater need to provide versatile, robust instruments with good optical performance and suitable optical specifications, than was formerly the case.

Even more important, with the emphasis on pupil involvement, simple pupil-scale apparatus is much more prominent in the new courses, and it becomes particularly important that such equipment is not only cheap and simple to make, but that it is also relatively easy for pupils to handle, and produces reliable results. To this end there is need for a continuing flow of ideas, aimed at simplifying and making more reliable the practical work involved in obtaining the essential preliminary observations on which later concepts are based.

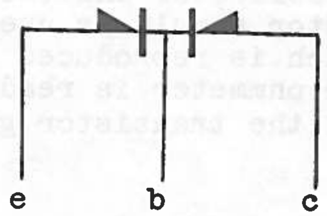
It is clear then that equipment plays a more vital role in the successful teaching of the new courses than it did in the old. These same courses are, as a consequence, more likely to provide a correct perspective of equipment as a means to an end, rather than as an end it itself. Nevertheless, there are in our opinion some unfortunate trends which if allowed to continue could result in a new equipment mythology replacing the old. The most obvious and potentially harmful of these trends is that of treating 'Nuffield' items as being imbued with some special properties not possessed by other equipment, such that they must be persisted with even though they clearly fail, on some occasions, to meet such criteria as simplicity and reliability. It is interesting to speculate, for example, on the number of fruitless, frustrating hours biologists have spent trying to obtain worthwhile results from the differential air thermometer pioneered by the Nuffield Biology Project - culminating in the suggestion in some publications that mice be placed in it, to demonstrate heat production by living organisms! When an ordinary mercury-in-glass thermometer will register a visible temperature rise if placed against the animal, one begins to appreciate how such equipment has become virtually an end in itself.

I hasten to add that such tendencies have not been overtly encouraged by the Nuffield Project teams. Nevertheless, there is little doubt that they are given further impetus by the habit - popularised if not pioneered by the Nuffield 'O' level Physics Project - of 'naming' articles. Thus we now have items entitled 'Malvern', 'Malvern Link', 'Whitley Bay', 'Worcester', 'Musselburgh' and (let's be fair) 'SSSERC'. Such titles inevitably invest these items with a status out of all proportion to their importance. While the habit might be justified on the grounds that it at least identifies equipment, there is little doubt that it also inhibits further development.

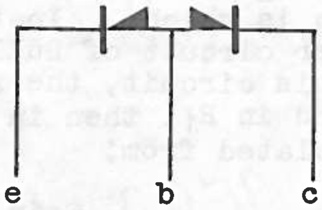
Another unfortunate trend in our view is that of manufacturers who distort much simple, pupil-scale apparatus by turning it into well-finished, 'named' production models which are so expensive as to preclude the very pupil-scale use for which they were originally designed. We are the first to admit that the school suppliers have played a vital and most praiseworthy part in the development of equipment for the new curriculum. Nevertheless, in the case of such simple, pupil-scale apparatus, we feel that there is much to be said for producing, in place of - or as well as - expensive finished articles, kits of parts from which class sets can be easily made up. Some moves have already been made in this direction and such kits, in our view, would provide an important service to science education in four ways: 1. Costs would be lowered. 2. In consequence, pupil-scale work would be encouraged. 3. There would be less tendency for equipment to assume a pseudo-importance out of all porportion to its real function as a means of achieving educational objectives. 4. Perhaps most important of all, continued improvements in design would be encouraged, for it is easier to make modifications while constructing equipment than to a finished article, while it should also be easier for suppliers to modify such kits to take account of improvements.

Physics Notes

Transistors in school science departments arrive by various means; bought new, bought cheaply through trade sources as manufacturers' seconds, cannibalised off obsolete or scrap equipment, by the shovelful as manufacturers' rejects in some fortunate schools. The teacher or technician faced with an unmarked transistor may learn a great deal about it by the intelligent use of an ohmmeter, such as the multi-range meter on a resistance range. In using a single range voltmeter, the investigator must first determine the polarity of the voltage which appears across the ends of the testprobes of his multi-range meter when it is switched to ohms. It is usual, but not necessarily always the case, that the positive (red) terminal on the meter has negative polarity.



p-n-p



n-p-n

Since the basic configuration of a transistor is that of two diodes placed back to back, if the base is forward biassed it will show a low resistance towards emitter or collector, and if the base is reverse biassed these resistances will be high. Thus to find which of the three transistor connections is base, it is necessary to find the one which shows a low resistance to the other two terminals with one pole of the meter connected to it, and a high resistance to the other two when the opposite pole is connected to it. When the meter polarity is known, this test also establishes whether the transistor is p-n-p or n-p-n. Referring to the diagrams, if the base shows a low resistance to the other two terminals when it is negative with respect to them it is a p-n-p; if the low resistance appears with the base positive it is n-p-n.

The terms high and low resistance are somewhat relative and the actual values will depend on whether the transistor is a germanium or silicon type, and whether it is a small signal or power type. The table below gives the resistances we measured using an Avometer on the appropriate ohms range for various types of transistor. For all columns, the first named connection was negative with respect to the other.

			Type	c-e	e-c	b-c	c-b	b-e	e-b
Ge	PNP	Small Signal	OC71	12K	1M4	300	3M5	300	5M
			OC81	7K	300K	300	5M	300	7M
		Power	OC29	150	8K5	125	150K	125	100K
			OC35	500	14K	175	1M7	175	900K
	NPN	Small Signal	OC140	2M	1M5	∞	400	∞	400
			AC127	450K	20K	10M	300	10M	350
		Power	AD161	300K	1K2	2M	200	3M	200
Si	PNP	Small Signal	BFX13	∞	150K	1K5	∞	1K5	140K
			BFX29	∞	150K	1K5	∞	1K6	140K
	NPN	Small Signal	2N696	400K	∞	∞	1K3	320K	1K4
			2N697	250K	∞	∞	1K4	200K	1K5
		Power	BD123	400K	∞	∞	1K	350K	1K
			BD124	250K	∞	∞	1K2	200K	1K2

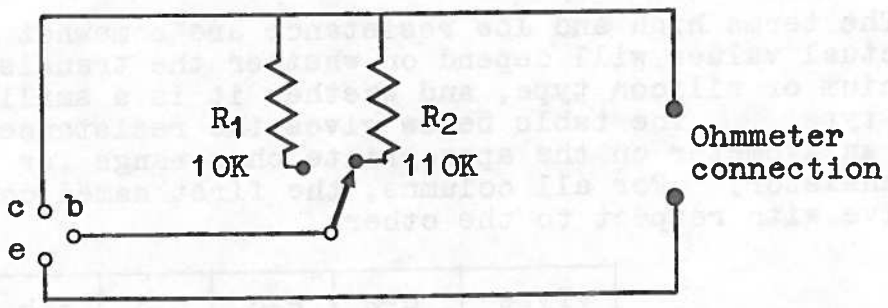
Typical resistances measured between pairs of transistor terminals, the first named of each pair being negative.

Having identified the base, the next step is to determine the identity of collector and emitter. An examination of the first two columns will show that there is no simple method of deciding from the resistances between collector and emitter, which is which. Instead, the transistor should be used in the tester circuit of Bulletin 54, and which is reproduced below. In this circuit, the resistance on the ohmmeter is read with the switch in R_1, then in R_2 position, and the transistor gain is calculated from:

$$\text{Gain} = \frac{100,000}{\text{Difference between ohmmeter readings}}$$

If collector and emitter are correctly connected in this circuit, the resistance values obtained will be lower, and the calculated gain higher, than if collector and emitter are reversed.

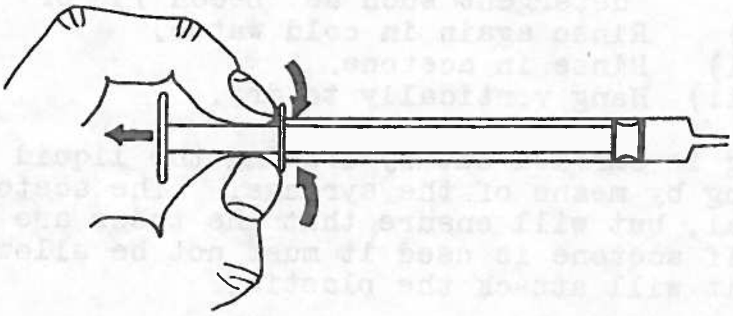
While the above will help the teacher or technician to identify the connections on a transistor there is no way of determining the maximum operating conditions, except by trying the transistor in an actual circuit. Also, while the above system works for good transistors, a 'dud' makes things more difficult. The usual form of failure is for one of the junctions to cease functioning as a rectifier, becoming purely resistive. The resistances measured across this junction will then be approximately equal, instead of being much higher when the base is reverse biassed.



Biology Notes

Gas Analysis. In Bulletin 50 we published a suggested simplification of the technique for gas analysis, using a straight length of capillary tubing connected to a 1 cm^3 syringe in place of the widely known J-capillary tube with brass bolt. There seems to be three main difficulties associated with this technique - though it should be said that two of these are equally associated with the J-tube. These are, firstly, the problem of manipulating the syringe plunger; secondly, making up and storing the pyrogallol; and thirdly, cleaning the capillary tubing after use. We have investigated these problems and present our suggested solutions below.

1. Manipulation of syringe. Many people - particularly young pupils - find it difficult to move the syringe plunger sufficiently delicately to prevent the gas bubble either from disappearing into the syringe barrel or from being ejected from the open end of the tubing. To overcome this problem the grip shown in the diagram is recommended.



If the finger and thumb are squeezed inwards, in the direction indicated by the curved arrows, the plunger is pulled gently outwards and is under complete control. For movement in the opposite direction the plunger is pushed in, using the finger and thumb as stops against the top of the barrel. In both cases, extended movement in one direction will require adjustment of the position of the finger and thumb on the plunger from time to time.

2. Preparing pyrogallol solution. The standard method of preparing this solution is to make it up in concentrated potassium hydroxide, and then to store it under oil. This can be a tricky and time-consuming operation; moreover, care has then to be taken to prevent oil from entering the analysis capillary tubing thus sealing the pyrogallol from the gas bubble. A further problem can arise in cleaning the capillary of oil - though the cleaning routine described below should obviate this.

With these problems in mind, we have found the following simple technique to be successful. It is based on ideas derived from an article in the Biology Notes in School Science Review, No. 180, page 584, from the broadsheet NUFFBISS, and from the West of Scotland Association of Biology Teachers Newsletter, No. 2.

Weigh out approximately 3g of pyrogallol, and place this in a small screw-top bottle - a McCartney bottle is ideal for this purpose. Add about 25cm^3 of water and stir to dissolve. Prepare a similar volume of concentrated sodium or potassium hydroxide solution, again storing it in a screw-top bottle. The analysis procedure is then carried out by first drawing the hydroxide into the analysis tube as usual, to absorb any carbon dioxide. After this, push the gas bubble gently towards the end of the capillary tube until about 2 or 3cm of hydroxide solution remains in the tube. Dip the tube into a small beaker of water and draw in about 1cm of water. This is simply to prevent immediate reaction between the hydroxide and the pyrogallol, which would then be liable to exhaust its absorptive properties on the air. Transfer the tube to the bottle of pyrogallol and draw in several centimetres of this. If the bubble is then gently moved back and forth in the tube the hydroxide and the pyrogallol will meet, and the resulting alkaline pyrogallol will absorb the oxygen in the sample.

3. Cleaning capillary tubing. We have found the following procedure to be effective in removing both alkali and oil.

(i) Rinse tube in cold water.
(ii) Rinse tube in dilute sulphuric acid.
(iii) Rinse again in cold water.
(iv) Rinse in hot water containing a detergent such as 'Decon 75' or 'Byprox'.
(v) Rinse again in cold water.
(vi) Rinse in acetone.
(vii) Hang vertically to dry.

Rinsing is carried out by drawing the liquid into and out of the tubing by means of the syringe. The acetone rinse is not essential, but will ensure that the tubes are dry for prolonged storage. If acetone is used it must not be allowed to enter the syringe as it will attack the plastic.

* * * * *

We have a small stock of seeds of Pharbitis nil kindly donated by Dundee College of Education, and can therefore supply schools with 12 seeds each. The plant is mentioned in Biology by Inquiry, Book 3, as being particularly suitable for demonstrating the effect of day length on flowering, and we are assured by the College, although we have not done so ourselves, that it can be cultivated and will produce fertile seeds under normal greenhouse conditions. Please send 5p in stamps to cover cost of postage and packing.

Chemistry Notes

Following the offer of vanadium (v) oxide in our last bulletin we have had a steady stream of orders for the catalyst, but there are still adequate stocks for teachers who may still wish to order. We have been asked by the Chemistry Department to point out that sulphur trioxide is a very dangerous material, particularly in contact with water or people.

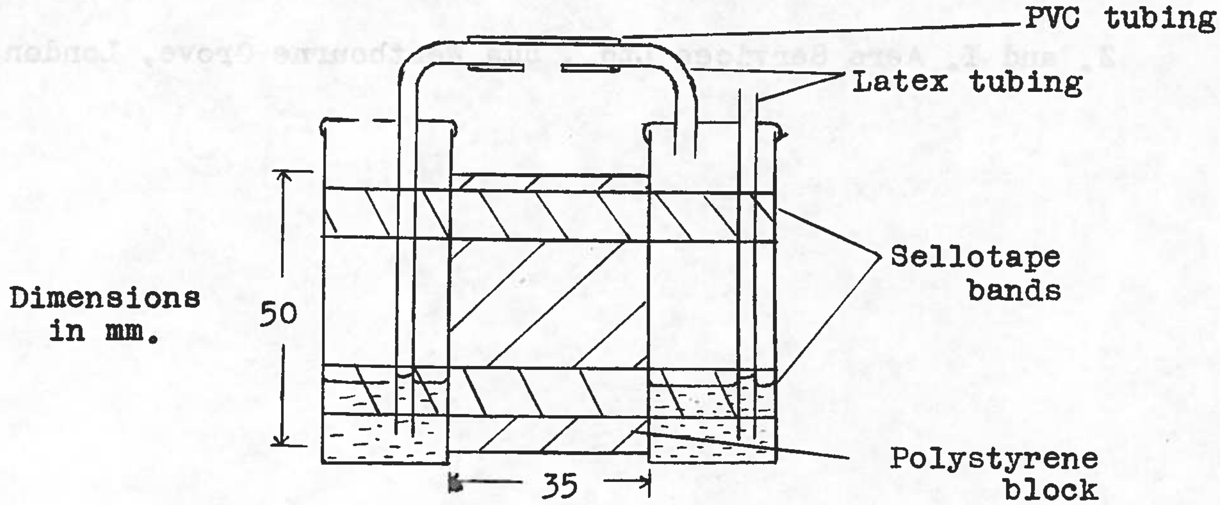
Trade News

We have a note from Griffin and George pointing out that contrary to what we said in bulletin 59, there is an alphabetical index at the end of their catalogue for Nuffield Secondary Science, and that although no prices are given in the catalogue, they issue a separate price list (which we must have lost) with each catalogue.

The Russian pen recorder H320-1, and all other goods obtainable from Z and I Aero Services, can now be supplied by Morris Laboratory Instruments. While the price will not be changed, there may be advantage in obtaining these through a recognised educational supplier who will give credit facilities.

In The Workshop

Respiration Module In bulletin 53 we published details of a module which can be used to detect carbon dioxide production by a wide range of organisms, from soil microbes to humans. Shortly after this, we were sent a modified design by Auchenharvie Academy, Ayrshire, which we believe has some advantages over our original design. The construction is shown in the diagram. In this case the syringe nozzle fits into a hole carefully cut in the middle of the PVC tubing. This gives a less rigid connection than in the original version, but we feel that this slight disadvantage is outweighed by its advantages.



It will be appreciated that this version is both cheaper and easier to make than the original, and is also free standing. Further, it eliminates one notable disadvantage from which our design suffered; the use of solid rubber bungs concealed part of the module, and many people were convinced as a result that there must be valves hidden somewhere! In fact, this was an example of a piece of equipment interfering in the clear attainment of objectives by sidetracking pupils into considerations of how it worked.

Materials.

Expanded polystyrene block 20 x 35 x 50mm;
PVC tubing, 5mm internal, 6.5mm external diameter, 35mm;
2 specimen tubes, 72 x 17mm, with plastic stoppers;
Latex tubing, 3mm inside, 4mm outside diameter, 20cm;
2 strips of sellotape.

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

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

H.M.S.O., 13A Castle Street, Edinburgh, EH2 3AR.

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

Schools Branch, Scottish Education Department, St. Andrews House, Edinburgh, 1.

Z. and I. Aero Services Ltd., 44a Westbourne Grove, London, W.2.

Bulletin Index Nos. 50 – 59.