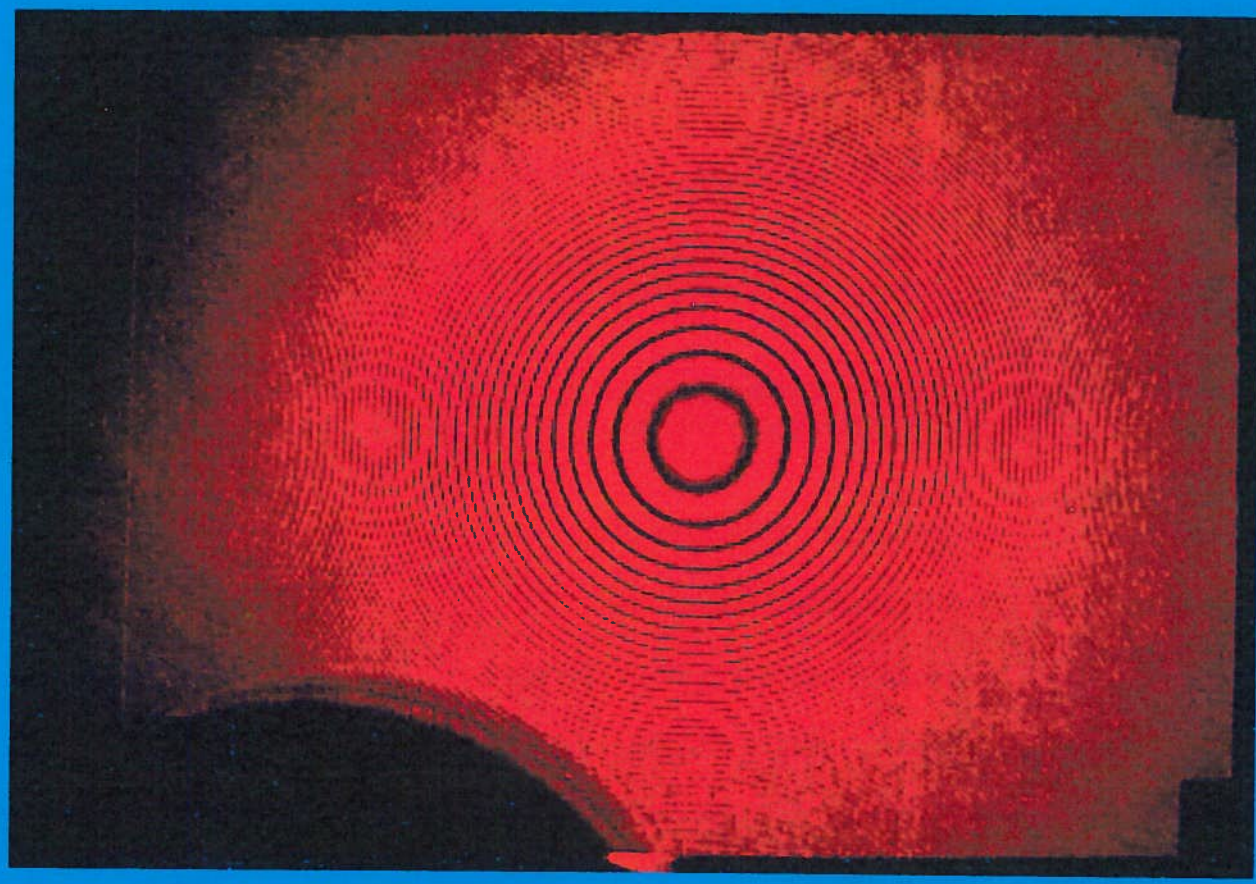
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE



Science & Technology Bulletin

For: Teachers and Technicians in Technical Subjects and the Sciences

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EDITORIAL

Made it - just!

It's only a month or so since the election. For over eighteen years, some of the staff in here have had their noses to the wheels, their shoulders to the grindstones, of the last administration. I trust that I can write it now, with a degree of impunity, rather than merely encrypt it :

SSERC is, and always was, an organisation with a philosophy of service rooted in the ideals of a cohesive and collective Scottish educational system. Here, we never did hold with all that "education is a market with parents as the customers", and "there is no such thing as society" guff - not that we don't believe in efficiency, effectiveness and quality. It's also not that we don't wish always to give the best possible value for public money. We do not however like pretence verging dangerously on delusion, nor enjoy operating in a false market. Adam Smith, that famous son of Fife of whom Baroness T was such an infamous fan, must have been - betimes in these last weary eighteen years - a mere blur, spinning so fast in his grave. It's a wonder he didn't disinter himself and go looking for her with a sawn-off spoon.

How can one have a true market where the real clients and customers - the weans - don't hold, and do not decide on how to spend, the money? Parents certainly aren't always best placed to represent their offspring as the real clients of the system. Sometimes there are powerful reasons for that same system to protect children from their parents. That is something else which *Market Forces* haven't effectively controlled over the last decade or two. And that is why Scottish education seems always to be at its best when operating on a cohesive and collegiate basis. Consensus and combined effort, not conflict, are what best lead - not drive - us all forward.

Revenge, however is a powerful philosophical and political motive - it's probably the strongest such there is. I have the scars about my own posterior thoracic lumbar region to prove it. An amnesty should possibly be declared - for a wee while - to allow a breathing space for reflection, just enough time perhaps for the erstwhile fellow travellers out there to repent, recant and confess the error of their ways.

Swinging - doors and pendula

"As one door closes" - as we have learned to say in the teaching and advisory game - "another one shuts".

The old jokes were aye the best. There are signs that such long standing cynicism is becoming less justified. Certainly we've had a lot of recent letters and 'phone calls from folk who've simply had enough and were getting out whilst they could. We've also heard from others who were leaving the profession early for a variety of more complex reasons. It is always invidious, in these circumstances, to single out individuals for mentioning in despatches as it were.

There are some specific characters, whom not a few us will particularly miss. One such, without whom the Scottish Science Advisory Group will never feel quite the same, is the oft far-sighted and nearly always funny (and I do mean "humorous") Wilson Flood. Another is Stewart King, latterly a Health and Safety co-ordinator in the education department of City of Glasgow but earlier much better known as one of the chief architects of what was possibly the best organised and managed educational technical support services yet seen. Awra best!

Whereas previously there seemed little or no prospect of sufficient young blood coming in to replace such folk and so renew the profession, such a possibility now seems just a tad less remote. Some of the mechanisms and routes, at least in the short term, may just be different. For example we have been much impressed with the recent efforts of some University outreach teams such as that of Glasgow's GUSTO. A number of innovative, and partly extra-curricular, projects to refresh the science and technology parts which schools find difficult to reach are either underway or are planned.

It seems therefore that we older fogies may yet have grounds for optimism. The pendulum may have swung too far in the direction of dullness and ennui for the taste of many of us. It is, it seems, swinging back, but - for now at any rate - on an apparently elliptical path.

Open House - *STS Helpline*

One of the problems associated with a shrinking science and technology teaching profession is a smaller pool of regular enquirers to SSERC. We have become a little concerned of late to realise that now too many teachers and technicians don't know that they can access the service directly by telephone, letter or fax. Nothing, if relevant to a practical science and technology matter, is too small for us to bother with. We really do not mind. One call to us could save you many. The corollary of course is that once (if!) we find the answer it then becomes available for the next person. If we know that it is likely to be of wider interest or concern then we can publish it. That is how many of the items make their way into these Bulletin pages. Unless otherwise indicated, enquiries or reports on safety matters, accidents or near misses are always held in confidence between ourselves and the person making the enquiry or report. Even when such matters are eventually reported upon in general terms the school, college or other source remains anonymous.

So, don't be shy! The service was set up chiefly to offer information and advice on anything to do with the sourcing, purchase, use (including health and safety), maintenance and repair of educational equipment and materials. So long as your local authority, school or college is in current membership, you are entitled to access our enquiry service.

cont./over

Open house (cont.)

You may write, 'phone or fax (and, soon, E-mail) us without necessarily going through any local or other intermediary. See the list on the inside rear cover for our address details. Core hours are 09.00 to 17.00 but usually there will be someone available to take calls from about 08.30 h. If you happen to be coming to Edinburgh (even if only on your annual criticism pilgrimage from the West) then by all means drop in. You'll find a location map on page 3 of Bulletin 190. Should you have a particular specialist area in mind it does help to telephone first to ensure that the relevant person will be available.

Despite the Capital's reputation for a degree of douce inhospitality, you will be made very welcome here and, our tea and coffee are free (the first six cups anyway).

Endpiece

Amongst the recent fareweel letters was one from Jim Boyd, until of late of the chemistry department at Crookston Castle Secondary in Glasgow. Typical of Jim he was tidying his desk and decided that as "Some items remain unfinished" he might as well send us a wee reminder about an earlier enquiry and start a new hare running on the meaning of "a homogenous catalyst" (Higher Chemistry Paper II, 1996). In closing, he was kind enough to pay us one of the nicest compliments I think we've ever had : *"Lastly, thanks to SSERC for being an island of reliability, in a sea of dodgy science, over the years"*.

It reminded me of that ancient Glaswegian joke, *"A yer dancin? . ."*

NEWS AND COMMENT

Welcome back!

We have a near complete collection of Aberdeen College of Education, come ***Northern College, Biology Newsletters***. We were very sad when publication lapsed at the turn of 1993. It gives SSERC great pleasure to announce that both it and its Editor, the redoubtable Paul Mills, have bounced back to health. Paul has been retained on a part-time basis by Northern College Science and Technology Department. One of his tasks is to again edit the Biology Newsletter. Earlier this year the Newsletter recommenced publication. We can thus add issue number 61, April 1997, to our valued collection.

Paul tells us that the circulation via the authorities should be more or less as before. If your school had received copies in the past it should do so again. We know however, through our own experience with the SSERC Bulletins and 5-14 Newsletter, that what should happen and what takes place on the ground are sometimes seriously mismatched. It's the carrier-snail system - as one of our own bulletin readers christened it. If you used to get the Biology Newsletter and have yet to see a copy of issue number 61, then before contacting Northern College, first ask around within the school and then enquire of your Council's education department to check whether or not they received it and passed it on to schools.

Northern College hope that through sponsorship and other means the first copy of any issue shall remain free to Scottish schools. Additional copies cost £5 each and can be ordered from the Secretary of the college's Science & Technology Department. See the inside, rear cover for the address details. Should you wish to submit articles to the Editor for consideration for publication, then Paul Mills can be contacted via that same route.

Meeting reports

It would seem that all of the Scottish educational meetings of the various learned societies - announced in the last bulletin issue - went swimmingly. Especially pleasing was the good attendance at the Royal Society of Chemistry inaugural event at St. Andrews. The other two meetings, those of the IoB and IoP also went very well. We had intended carrying fuller reports of all of those events and had gone so far as to obtain pieces from some of the semi-official scribes. However our printing deadline approacheth and space disappeareth both more rapidly than may be contemplated further. We do know that the next edition of the ASE Scotland serial publication, ***Scottish Science Issues***, should carry such reports which is more its kind of fare in any case. So, if you want the latest on Higher Still etc - you know where to go.

TIMS Survey

Steady the Buffs - not even we dare repeat, in print, any of the obvious jokes! We would however flag up our concern that the results of the Third International Mathematics and Science Survey, in the short term, may promote ill founded, inappropriate responses. After all, TIMS made it into TESS. If it's in the 'papers it must be:

a) True b) important and

c) something will have to be done about it.

Having heard firsthand from someone who was personally involved in carrying out the Scottish end of TIMS, we know that the questions selected and the methodology adopted were at least as important as the answers given (or not) by the weans and Scotland's supposed resultant rank in the international order of things. As the ambassador reportedly said to the political attaché at the outbreak of a coup - "Don't just do something - for now, stand there!"

School prosecuted

After an accident in which two thirteen old pupils suffered burns the Health and Safety Executive has successfully prosecuted a school.

The case in question was brought under Section 3 of the Health and Safety at Work Act. It was heard in an English Magistrates' Court, which found against the school - a grant-maintained, comprehensive. The school was fined £7,000 and ordered also to pay the costs of the case which were just over £1,000. It was the Governing Body, as the employer, which the HSE had accused of a breach of its statutory duty. As far as we are aware, this is the first occasion on which a school - as a body corporate - rather than an individual teacher or an employing EA, has been involved in such a science related case. Although the case was brought in the Spring of this year the incident occurred last Autumn. This was during an open evening for parents and pupils, both current and prospective. Several practical activities had been set up in a chemistry laboratory, one of which was the DIY manufacture of 'sparklers'. This was identical to an activity carried out the previous year with the knowledge of both the Head Teacher and the Head of Science.

The sparklers were made by coating the end of a wooden spill with glue and then dipping this in a mixture of magnesium powder and potassium chlorate held in an open tray on the bench. The coated spills were then ignited in a Bunsen flame in a fume cupboard. The activity was under the supervision of a sixth form student who had been shown by the teacher how to prepare the DIY sparklers. The sixth year pupil handed out safety goggles to pupils or visitors who wished to try the activity. In absence of any further instruction or supervision, and on his own initiative, he also topped up the tray with supplies of the mixture. He noticed that spent spills placed in a bin for eventual disposal occasionally re-ignited. He added some water to the bin.

During the course of the open evening, two pupils were trying the activity. They were apparently sensible boys and there was no suggestion of any misbehaviour nor other contributory negligence on their part. They successfully made sparklers and burned them in the fume cupboard. As they returned to the tray of chemicals with fresh spills, there was an explosion. This burned both boys and severely damaged the safety goggles each had been wearing.

The origin of the ignition of the mixture could not be determined - neither at the time nor afterwards by the HSE's own investigations. Both pupils suffered some facial burns and serious damage to their hands. They will have to wear pressure gloves and undergo specialised burns treatment for a period of at least two years with a possible need for further surgery if impaired mobility of their hands should persist.

In their prosecution case, the HSE cited the requirement, in Section 3 of the Health and Safety at Work Act, that an employer so conduct his undertaking as to ensure, as far as is reasonably practicable, that persons not in his employment - in this case pupils and other visitors to the open evening - be not exposed to risks to their health and safety. In bringing this case, the HSE personnel involved took the view that extensive guidance was available generally - as well as for science in particular - and that there was no reasonable excuse for the school not knowing the standards required. In place at the time were both a whole school and a science department safety policy. Some guidance on risk assessments had also been given. The HSE however argued that the school management had failed to monitor the proper, practical implementation of either policy and that there were no systems for monitoring and checking that health and safety issues were in fact being addressed. None of the Science staff had had any formal training in making risk assessments. The departmental policy simply stated that staff should inform themselves of the contents of the safety file. This contained a range of information including material safety data sheets, EA guidance, DfEE documents and some HSE publications.

The defence had argued strongly for limiting the size of any fine saying that in the long run it was only the pupils who would suffer from the financial consequences to the school. According to an HSE statement they "are well aware of the implications of a financial penalty on an educational establishment, but would wish to emphasise that the Governing Body have the same legal duty to their employees and other persons as any other employer . . . and that the failure adequately to control risks . . . must be treated seriously." In a separate written statement, an HSE spokesperson has indicated that they are indeed conscious of *the need to strike a balance between on the one hand allowing pupils to do experiments so gaining practical experience and on the other the need to also ensure their health and safety* (our emphasis). Whilst the provision of information and guidance were important parts of health and safety provisions, staff *must read, note and act* upon such advice if it is to have any practical effect (again, our emphasis).

The HSE had considered prosecuting the individual chemistry teacher, but decided that the root cause of the breach of duty lay largely with the management. In the HSE's view it was the responsibility of the educational managers to ensure that the health and safety policy, systems of work, training of staff and the monitoring of health and safety performance all dealt effectively with the relevant issues.

Sportswear in practical areas

In this section of Bulletins 169 and 170, the risks from wearing the then highly fashionable shellsuits were discussed at some length. We concluded that they were an unsuitable form of clothing for laboratories, workshops and other similar practical subject areas. Recently we have had yet more enquiries from schools about the latest fashions in lightweight sportswear and whether or not these are acceptably safe garments for laboratories and workshops. To put things in a nutshell, if you will forgive the pun: The manufacturers we contacted, all stated that their sportswear simply was not suitable for use in workshops or laboratories; indeed many of these garments they have clearly marked as being flammable.

Explaining the legalities always takes longer than conveying that simple message. The general principle is that the employer (an education authority or governing body) has a general duty to his employees [eg teachers and technicians] - *to ensure an absence of risk* (Section 2.1 of the Health and Safety at Work Act) and *also to ensure, so far as is reasonably practicable, that persons not in his employment* [e.g. pupils] *who may be affected thereby are not exposed to risks to their health or safety* (Section 3.1). These general duties are more specifically dealt with in the Management of Health and Safety at Work Regulations, whereby the employer is required to identify hazards; to use protective and preventive measures to eliminate or minimise the resultant risks, and to exercise supervision and control by monitoring his health and safety arrangements.

Forbidding the use of unsuitable garments in practical work may thus be seen as a specific and reasonable example of an action intended to meet the more general, statutory, duty of care assigned to the employer. A second relevant principle is that employees also have a legal duty to take reasonable care for the health and safety of themselves and of other persons who may be affected by their acts or omissions at work; to co-operate with the employer (Section 7 Health and Safety at Work Act) and to inform their employer of any work situation which might be considered to represent a serious and immediate danger to health and safety (Regulation 12 of the Management Regulations). It is thus perfectly proper for a teacher to bring such matters to the attention of the management team as senior officers of the employer.

A final point concerns labelling. If a garment manufacturer or supplier labels his wares as being flammable and gives the advice that they should not be worn in workshops and laboratories, he may to some degree protect himself against possible claims for damages in the event of an accident. This is so even though it is possible that the basic materials in many shirts and blouses, not so labelled, could be equally flammable. (Apart from the chemical composition of the fibres, the thickness or type of weave and the cut of the garment can all greatly affect the flammability - see our earlier articles on shellsuits). However, if an employer overrides or ignores the advice and recommendations of the manufacturer, then the onus may well shift - wholly or in part - from the manufacturer or supplier to that employer.

Mouse allergies

No, not a case of getting the cat or the mouse-trap into hunting mode. There have been reports of office workers using computers suffering allergic contact dermatitis on the palm of the hand. Tests showed them to have been sensitised to dimethyl benzene-1,2-dicarboxylate (dimethyl phthalate), a plasticiser used in the casing of the mouse.

The recommended cure, apart from giving up a pet mouse, is to put a cover on it!

SAFETY NOTES

Accident with copper/sulphur mix

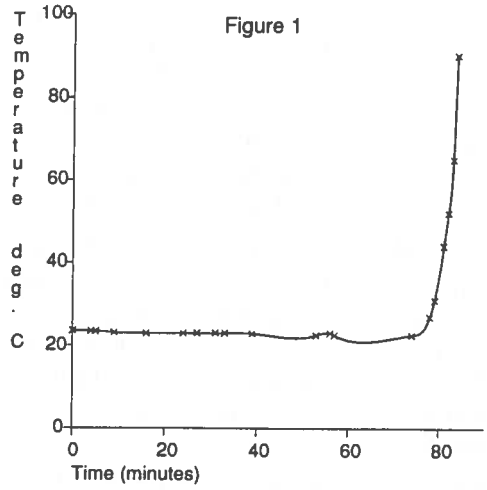
We have had a report from a school of an accident concerning the reaction of copper and sulphur. This particular practical activity had been carried out with many classes in the school for several years without mishap.

In the method used, two equal scoops each of copper and sulphur powders are mixed and placed in a test tube (this gives approximately the correct stoichiometric amounts and the total volume is about 7 cm^3). The tube is put in a horizontal position and tapped to produce a slope rather than a packed tube. Before the tube is heated to initiate the reaction, a balloon is fitted over the mouth of the tube to trap and contain any fumes and also to allow the operation of the law of conservation of mass to be seen. (We were impressed by this simple and apparently effective control measure which allows the activity to be carried out in an open laboratory rather than in a fume cupboard).

It is thought that the pupil had reached this balloon fitting stage when the reaction began suddenly and vigorously, ejecting burning sulphur onto his hand.

In later discussion it transpired that there was some uncertainty about exactly what the pupil had done. It was thought he may have heated the tube strongly and possibly with the mixture in a plug rather than a wedge with an air space above it. In the interim we had been considering and investigating the possibility of some form of "self-heating" as the cause. We came up with interesting results which may or may not have been the cause of the accident in the school. These are shown graphically in Figure 1. below.

Figure 1



The same mixture as that used in the school experiment was placed in a test tube, set vertically in a beaker full of expanded polystyrene insulation (Figure 2). Using at first our own copper and sulphur powder stocks and later a batch of the school's chemicals, the mixture was placed in a tube as earlier described. Without any external heat source the temperature of the mix was recorded against time.

Several runs showed no rise above ambient. However when a small amount of water was deliberately added to the unheated mixture the temperature rose rapidly, the exotherm indicating that a reaction was starting. In the run with the results shown in Figure 1, 0.5 cm^3 portions of water were added at the 77^{th} and again at the 78^{th} minute, the mixture being stirred after addition of the water. The amount of water is small and insufficient to make the powder mixture even appear damp. As can be seen, the temperature began immediately and quickly to rise - a nice example of positive feed-back and a run away exotherm. The residue was black, indicating the formation of copper sulphide. In one trial an alcohol filled thermometer was actually ejected out of the tube and had to be caught by the investigator.

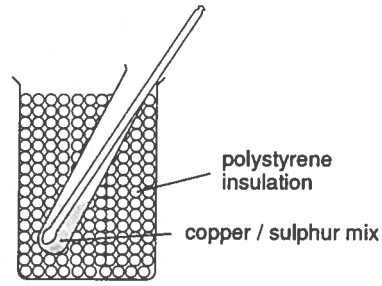


Figure 2

The precise cause of this accident is not known, but the general importance of using good technique when heating solids is emphasised; i.e. the powder is arranged in a slope, the tube not pointing at any person, gentle heating is applied initially at the base - just enough to start the reaction and of course eye protection is to be worn. Another way of controlling the reaction rate is to use coarser powders, e.g. ground up roll sulphur rather than flowers of sulphur and copper filings or turnings rather than copper powder. Our own investigations now suggest that with this particular reaction there is an additional danger which arises from using damp powders.

There may well be scope here for a CSYS project on this reaction and those of other solid mixtures. The reaction of solids is quite complex and maybe that's why they seem largely to be ignored at school level.

Summary of control measures

1. Do not use fine powders. Coarser forms and fine turnings are preferred. Do not mix by grinding.
2. Ensure that glassware used for this activity is dry and that as far as is practicable the powders to be mixed likewise are free of any dampness.
3. Utilise the elements of general good practice for heating solids as described in the body of this article that is : the powder is at a slope; the mouth of the tube points away from any person; the heating is started gently and appropriate eye protection is worn.

TECHNICAL ARTICLE

Phosphatase enzymes in plants

A reliable and relatively simple practical procedure is described which should prove useful for investigative work in both biology and chemistry courses in the new Scottish "*Higher Still*" Arrangements.

The core procedures to be described were first seen by SSERC staff at the turn of the year during a practical workshop session at the ASE UK Annual Meeting in Birmingham. Allen Cochrane, one of our chemistry specialists, attended that session run by Dr Barry Meatyard of Warwick University Institute of Education - a part of the SAPS (Science and Plants for Schools) Project Network. Since then both SSERC and SAPS project staff at the Edinburgh Royal Botanic Garden have been trialling the method with a view to its potential use for Scottish Biology and Chemistry courses. Much of the material which follows was first published in the SAPS Newsletter *Osmosis*. We are reprinting it here because not every biology teacher yet receives *Osmosis* and chemistry teachers almost certainly won't. But chiefly we are further publicising the method because of its simplicity and potential usefulness for projects etc.

Your attention is drawn to the acknowledgements and copyright conditions appended to this article.

Background

Curricular One of the suggested sets of practical activities for chemistry at the new Higher Level is to investigate enzyme activity. There are a number of similar suggestions at various levels for biology. Phosphatases recommend themselves for such activities since they are ubiquitous in seeds, are readily extracted and the results of the relevant reaction can be simply detected using an indicator system (phenolphthalein) already familiar to many students.

Theoretical The key points are as follows :

- Phosphatase enzymes are widespread in nature and may easily be extracted from germinating seeds such as those of the mung bean.
- They serve to remove phosphate groups from a wide range of organic phosphates thus making available a metabolic pool of phosphate ions.
- The formation of adenosine triphosphate (ATP), the regeneration of ribulose bis-phosphate and the phosphorylation of glucose at the start of the glycolytic pathway are all important biochemical processes requiring phosphate.
- Some phosphatases are specific for a particular substrate (e.g. glucose-6-phosphatase). Others show broader specificity and can cleave a phosphate group from a wide range of organic substrates.
- The basic reaction is as follows -

$$XPO_4 \xrightarrow[phosphatase]{} X + PO_4^{3-}$$

- Accurate estimation of phosphate is a complex process so instead this protocol relies on phenolphthalein phosphate (PPP) which yields a product readily estimated by colorimetric methods. Indeed for simple investigative work conclusions may be drawn on a semi-quantitative basis after direct observation.
- The method relies on the fact that PPP is colourless in alkaline solution, whereas free phenolphthalein is pink. The amount of enzyme activity can thus be estimated from the intensity of colour in a standard reaction mixture on the addition of a convenient base such as sodium carbonate.
- The phosphatase enzyme from mung beans has an optimum pH of around 5, unless pH is one of the variables under investigation, keep it below pH 9 or so. Standard buffer systems may be used including those made up with buffer tablets. The apparatus needed is basic except perhaps for a colorimeter which in some cases biologists may have to borrow from chemists or possibly even vice-versa.
- Once the sodium carbonate is added to produce the pink colour, the reaction stops - because the pH is excessively high. This is useful since it means that tubes can be stored in a refrigerator for several days before the colour intensity has to be assessed. It also means that results may be tested for reproducibility. If replicates are set up for each variable under investigation (which is but good practice) the colorimeter readings for each set of replicates should be the same.

Materials : Phenolphthalein phosphate (PPP) is available from Sigma (Cat. No. P9875). This is a good, clean source containing little or no free phenolphthalein. It is used as a 1% (w:v) aqueous solution a sample of which should then be tested with sodium carbonate to ensure that there is no pink colour and thus no contamination by free phenolphthalein.

Mung beans are available both from Health Food shops and some of the mainstream biological suppliers. They should be grown in the dark in a seed tray with about a 1cm depth of vermiculite.

Method : A description for student use, in diagrammatic form, of the basic procedure follows (opposite and page 8). These background notes continue on page 9.

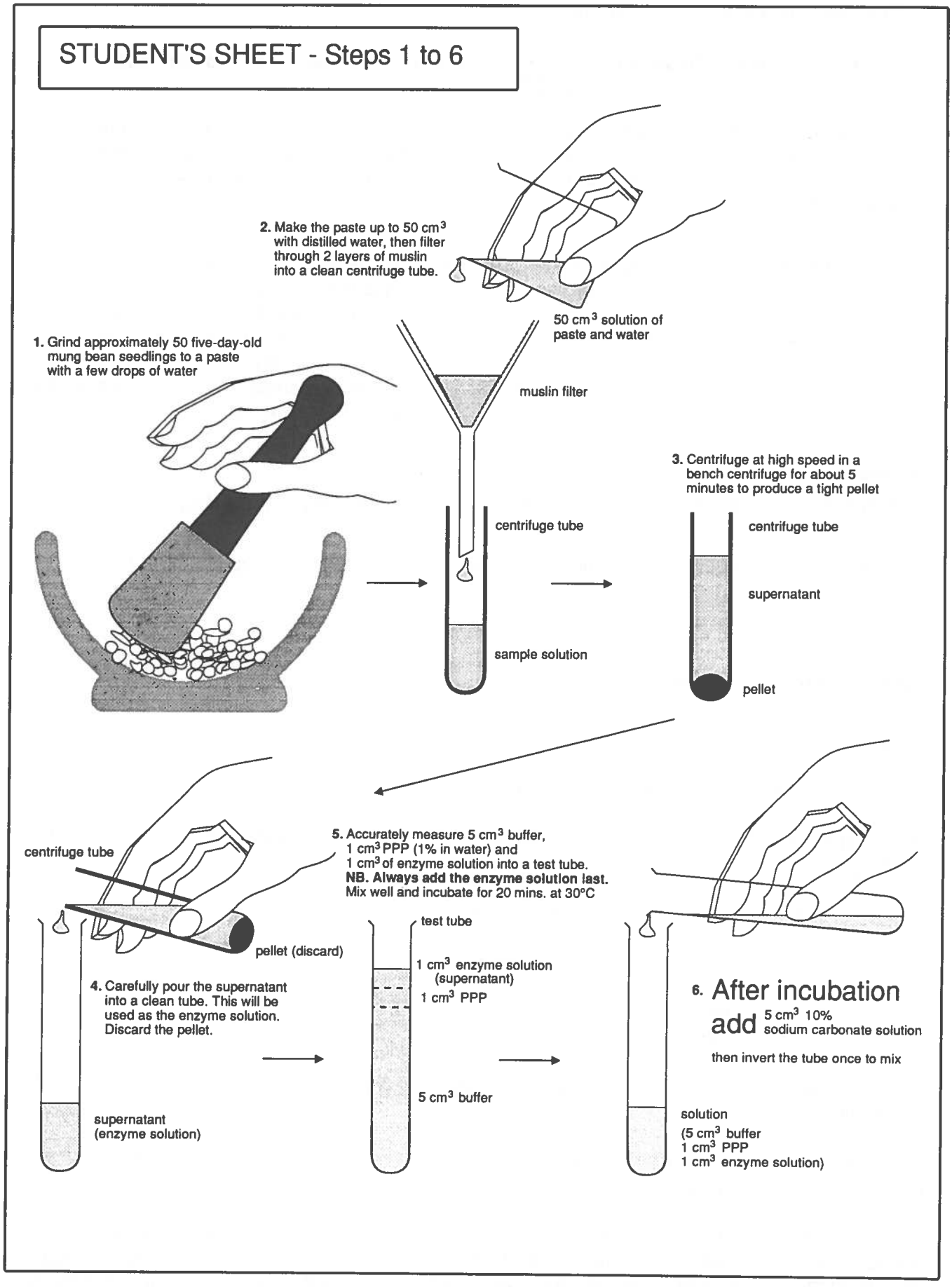


Figure 1 Diagrammatic representation of the various stages in the core procedure for investigations using phosphatase from mung beans. This and the following page may be copied for use as students' workcards (subject to copyright restrictions on page 9).

7. The following reaction occurs at Step 5 :

phenolphthalein phosphate $\xrightarrow[\text{enzyme}]{\text{phosphatase}}$ **'free' phenolphthalein + phosphate ions**

8. The addition of sodium carbonate solution, increases the pH and stops the reaction. If free phenolphthalein is present in such alkaline conditions it will produce a pink colour. The greater the rate of the enzyme mediated breakdown, the more phenolphthalein produced in a unit time and the deeper the pink colour.

9. For simple, qualitative investigations you can merely arrange the experimental tubes in rank order of the amount of pink tint they develop. For more quantitative work measure the depth of colour in units of absorbance or % transmission in a colorimeter against a blank of 1 cm^3 of water. If a suitable colorimeter is not available, compare your samples visually with a series of dilutions of phenolphthalein in sodium carbonate solution. This should provide estimates of the amount of phenolphthalein released by the enzyme. A further possibility is to use a suitable pink standard paint chart against which you can compare the depth of pink tint.

Questions

1. Why is the enzyme solution (supernatant) always added last (Step 5 in the diagrams)?

2. How might the method be made more accurate (i.e. more precise and reproducible)?

3. What substances might inhibit this reaction?

Ideas for further investigation

What is the effect of pH on the activity of the enzyme?

Where in a plant is the enzyme most likely to be found?

How long does it take for the enzyme to convert all of the available substrate (e.g. try 0, 5, 10, 15, 20 minutes)?

Can we express this as a rate and if so what units can you suggest?

What is the effect on the rate of reaction of varying :

- *enzyme concentration?*
- *substrate concentration?*

What is the effect of prolonged exposure of the enzyme to high temperatures (e.g. 65° C at 0, 5, 10, 15, 20 minutes)?

Does the activity of the enzyme change at varying intervals of time after its actual extraction? If so, what might be the significance of this?

Do other seeds contain this enzyme? If so, is it evenly distributed or do some parts contain more than do others? Is it evenly distributed in seedling roots or shoots? Does its concentration change as cotyledons age or as samples are taken away from rootips in 'older' parts of the root? Is it found in older plants - if so where?

(continued from page 6)

Sample results

The effects of some of the variables suggested for investigation were often clear cut and tubes could be put in a rank order judging by eye alone. Some more quantitative work was done using colorimetry and the results of one such trial of the core procedures is illustrated in Figure 2 opposite (WPA CO75 digital readout colorimeter, which takes test tubes). Similar results were obtained with an analogue readout instrument (Griffin Student Colorimeter - uses cuvettes).

Summary

SAPS has published a core procedure which is reliable so that the focus falls where it belongs - in identifying relevant variables and studying them. The protocol could be a powerful tool for investigative work and projects in Scottish biology and chemistry courses. Liaison and co-operation may be needed to avoid duplication where the same students are studying both subjects.

Copyright

Other acknowledgements

This article has been adapted from one first published in the SAPS Newsletter *OSMOSIS* (No. 12 , Spring 1997). The work was in turn based on an undergraduate practical publicised by Dr Barry Meatyard of the SAPS Centre, Warwick.

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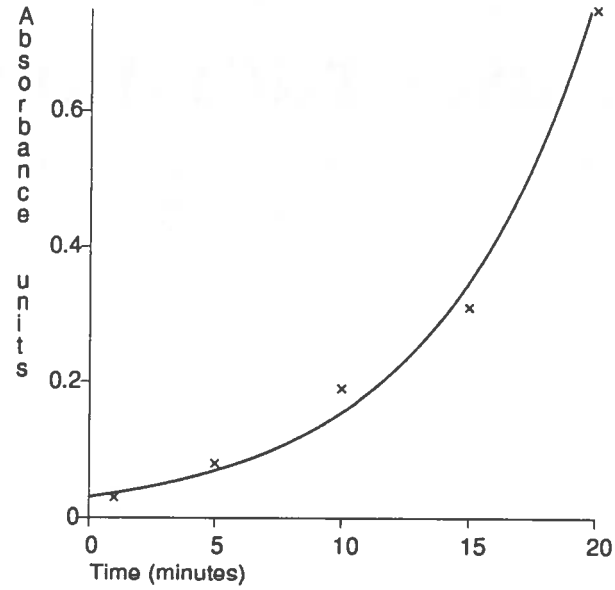


Figure 2 Results obtained with a WPA colorimeter and 520 nm filter. Absorbance (proportional to concentration of phenolphthalein) against time. (Drawn using Insight 2 and 'best fit' function).

Despite his best efforts, Dr Meatyard has been unable to trace the original source of these ideas and thus neither SAPS nor we are able to acknowledge same. The graphics for the student's sheet were redrawn in the SSERC house style - a computer drafted format - by Ian Birrell of SSERC from original artwork by Linda Gray of SAPS Head Office. The SSERC trials were undertaken firstly by Allen Cochrane who attended the Birmingham workshop, then by Marjorie Hamilton in co-operation with Rodger McAndrew of SAPS Edinburgh. We are most grateful to Richard Price, Director of the SAPS Project for permission to use this work. Any errors here however, are the sole responsibility of SSERC.

TECHNICAL ARTICLE

Laser radiation interference

The article describes how to set up a large scale demonstration of Newton's rings, measure the wavelength of light with a ruler and estimate the diameters of microscopic cells or particles.

Unlike earlier articles in this series [1] [2] this one panders to the widespread enthusiasm for producing interference fringes with laser radiation. However the three experiments chosen may be new to many readers.

The intention of this series of articles is to bring about a greater use of the laser in schools. This follows the relaxation of restrictions and revised health and safety arrangements issued recently by the Scottish Office [3]. Any practical work with lasers must comply with these arrangements.

There are two standard methods for demonstrating interference fringes. One uses laser radiation; the other, sodium light. In both of these methods light is diffracted by double or multiple slits. The arrangement with laser radiation gives a rectilinear array of dots which is sufficiently large and bright to be shown as a class demonstration. It is highly satisfactory, being simple to set up and effective in showing what interference fringes may look like. However unless reinforced by showing other interference patterns, pupils may not sufficiently appreciate the effect they have seen.

If sodium light is used, the fringe pattern is normally viewed by microscope or telescope. This has the disadvantage that you can never be sure as what each pupil has actually seen. When I first crossed the Equator, the Second Officer, who was master of ceremonies at this not wholly enjoyable experience, held a telescope to my face and asked if I could see the Line. No, I don't think I did, but then my face and eyes were slaistered in engine oil off the telescope eyepiece and fish scales off an earlier encounter with a flying fish. I used to recall that experience ruefully when supervising interference experiments with sodium light. As each pupil peered into the telescope I would ask, "Do you see the fringes?", saying it as a foreigner would speak, because the Second Officer was a Dane. The Line! The fringes! It matters not! They are all figments of our imagination!

The purpose of these demonstrations of Newton's rings - two methods are given - is to produce interference patterns for easy viewing that do not comprise of the standard array of dots. Both methods are relatively simple to set up, but it is recommended that you practise first on your own before attempting either of them in front of a class.

Newton's rings

If laser radiation is directed at a lens, interference takes place between light reflected from the two lens surfaces, front and back [4]. Whilst almost any lens may be used, the effect is seen at its best with a good quality, thin, positive meniscus type of large focal length (e.g. Edmund Scientific, A94646, 41 mm dia., 440 mm focal length - at about £15 from Coherent-Ealing). I also found that the experiment is easier to set up when using this lens type.

Because of spherical symmetry, the fringe pattern is a set of concentric rings. It is sufficiently bright to view in subdued daylight, but is better under blackout. Eight dark fringes are produced with the arrangement shown below (Fig. 1). The diameter of the eighth fringe is 6 cm (see rear outside cover).

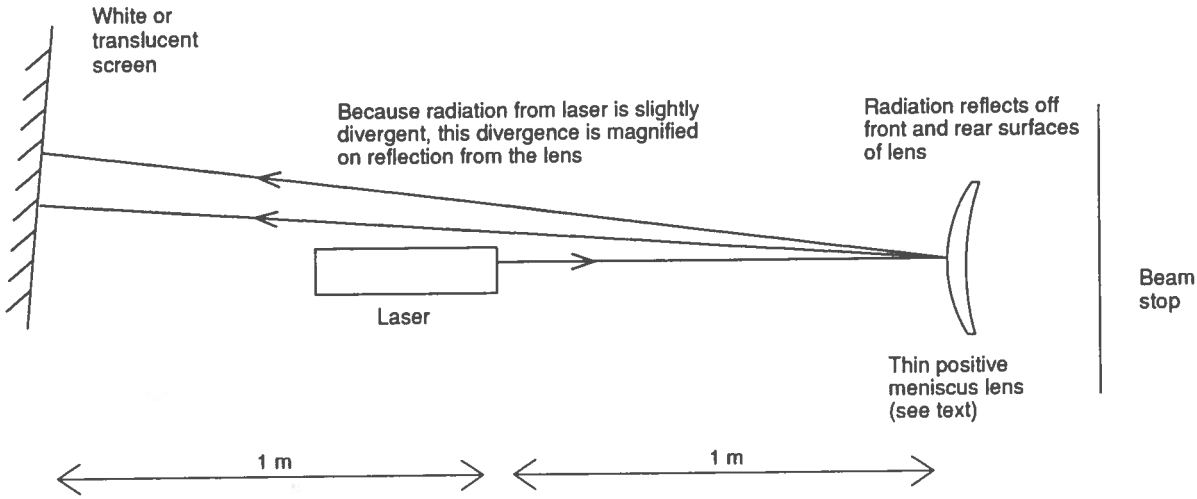


Figure 1. Simple arrangement for demonstrating Newton's rings. Produces a small number of bright fringes.

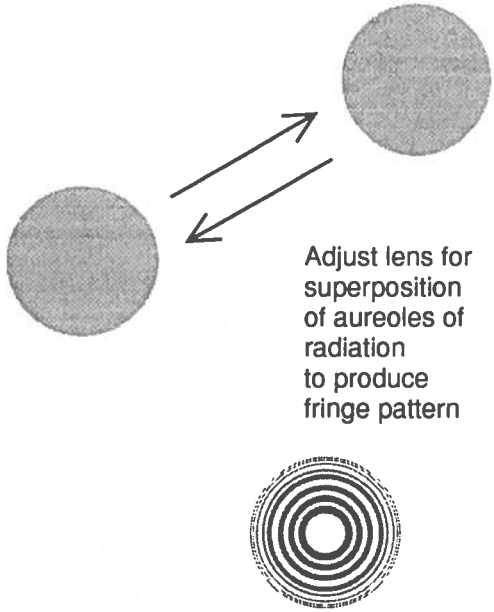


Figure 2. Production of interference fringes.

A white screen should be used when setting up so that the experimenter can see what he or she is doing. This may then be replaced by a translucent screen, which gives better viewing of the fringes.

The demonstration relies on the radiation from the laser being slightly divergent rather than perfectly collimated. If the laser is about one metre from the lens, then its beam should have spread out to cover a sufficiently large area. Because of the curvature of the glass surfaces, the reflected beams diverge further to cast two aureoles, about 6 cm in diameter each, on a screen 2 m from the lens (Fig. 2). One of these aureoles is radiation cast off the lens's front surface, the other off its back surface. The trick which the experimenter now needs to practise is to manipulate the lens so that both of these aureoles overlap to give circular fringes. This takes some fine adjustment of both the lens height and its lateral position. By starting with the laser radiation incident on the centre of the lens, and directing the reflected radiation on to the screen, the fine adjustments are quite easy.

It is interesting to note that there are no interference fringes on the screen when the two aureoles are apart. Fringes only occur when the aureoles overlap. Thus by sleight of hand, the experimenter can turn on, or turn off, the interference effect. It may be worth demonstrating that this is so. Indeed it adds to the interest. But you would need some practice to get that sleight of hand!

Larger display with many more rings

To produce a display with many more rings covering a greater area of screen, an optical element should be placed in the radiation to cause the laser beam to diverge before reaching the positive meniscus lens (Fig. 3). A biconvex lens of 50 mm focal length produces a sufficient amount of divergence. However a typical school lens of this sort has too many imperfections to be worth using. It creates blotches or shadows on the aureoles and makes the fringes fuzzy.

Instead we recommend using a good quality, high power lens of small diameter such as Edmund, A43911, at about £9 (dia. = 6 mm, focal length = 20 mm).

In our case (Fig. 3) we used a ball lens with a diameter of 10 mm (Edmund, A32748, at about £25), which is more expensive than the one we are recommending. This was mounted on a stackable 4 mm plug (Fig. 4) as described in Bulletin 188 [5].

In this interference display, about thirty rings are apparent (see front cover). The overall diameter is about 20 cm. The bright fringes are dimmer than in the first setup because the radiation has spread out more. Thus blackout is needed. As with the other method the fringes are more clearly seen when viewed through a translucent screen than from a white one.

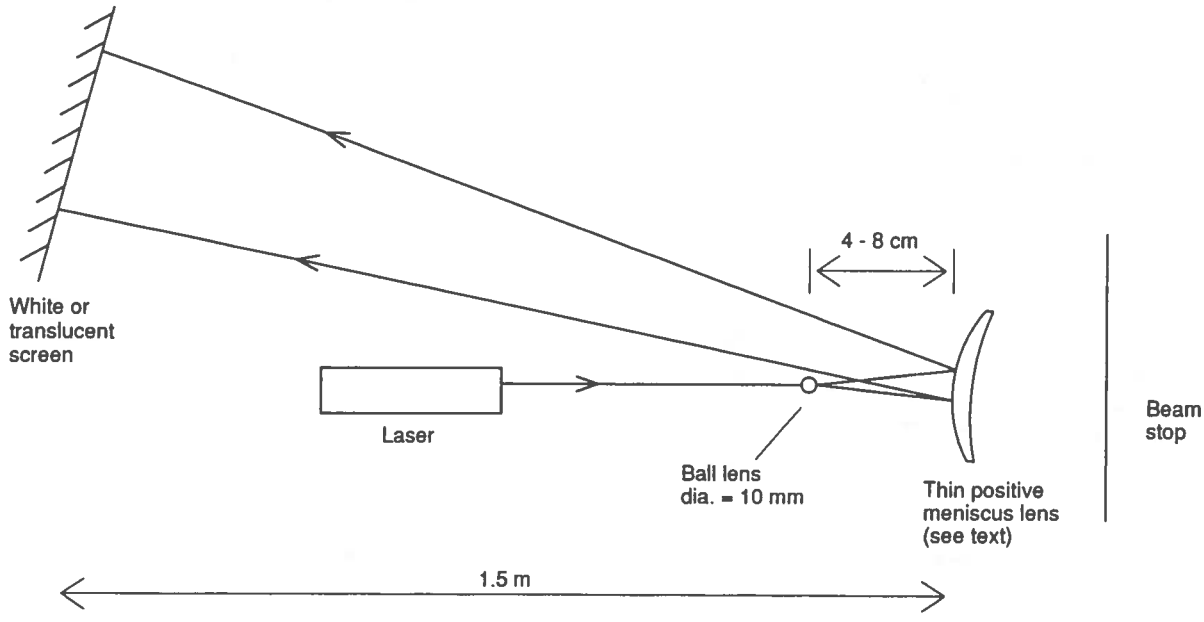


Figure 3. Arrangement to produce a large number of interference rings.

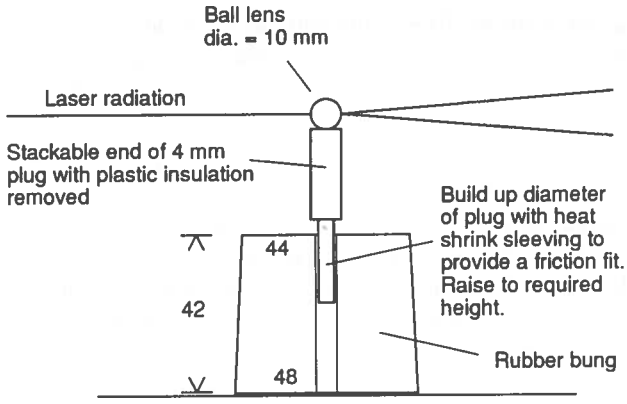


Figure 4. Ball lens mount.

Wavelength measurement with a ruler grating

We are familiar with good diffraction spectra when light reflects off grooved surfaces on compact discs or credit cards. By a similar process, a diffraction pattern of many orders can be produced when laser radiation is diffracted at grazing incidence by the rulings on a steel scale.

In 1965 A. L. Schawlow [6] described a lecture demonstration experiment on this effect (Fig. 5). The wavelength of light is obtained by measuring the fringe spacings and the distance from the ruler to the screen. The experiment is of historical interest because Schawlow was one of the co-authors of the first paper on lasers [7] back in 1958.

A value for the wavelength of light λ is obtained from the formula :

$$\lambda = (d / 2n) (y_n^2 - y_0^2) / x^2 \qquad \mathbf{1}$$

where d is the spacing between the rulings, n is an integer (the diffraction order), x is the distance between the ruler and the screen, and y_n and y_0 are measured from 0 along the projection screen. The intersection of the plane of the grating with the screen (0) lies halfway between the spots of the direct beam ($- y_0$) and the zero order diffracted beam which is specularly reflected (y_0).

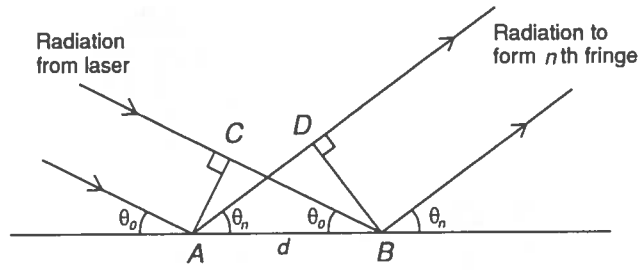


Figure 6. Reflection forming n th fringe.

To derive Equation **1** please refer to the geometrical drawing (Fig. 6).

Path difference = CB - AD

$$\therefore \quad n\lambda = d(\cos\theta_0 - \cos\theta_n) \qquad \mathbf{2}$$

Equation **1** is derived from this by expanding cos θ for small angle θ and omitting terms which are smaller than the second order of θ :

$$\cos\theta = 1 - 1/(2\,\theta^2)$$

If we then replace θ with y/x (Fig. 5), which again is justified because θ is small, cos θ becomes :

$$\cos\theta = 1 - y^2 / (2\,x^2)$$

and may be substituted in **2** to obtain **1**.

If measurements of fringes are made from origin 0' such that $Y_0 = 2\,y_0$, $Y_n = y_n + y_0$, etc., **1** becomes

$$\lambda = (d/2n)\, Y_n (Y_n - Y_0) / x^2 \qquad \mathbf{3}$$

This avoids the need to find position 0 and simplifies the measurements.

If values of $Y_n (Y_n - Y_0)$ are plotted against values of n, the gradient is $(2\lambda x^2) / d$ from which λ can be obtained.

The main source of uncertainty is the value of x because the term is squared in the calculation and its value depends on judging where radiation reflects off the ruler.

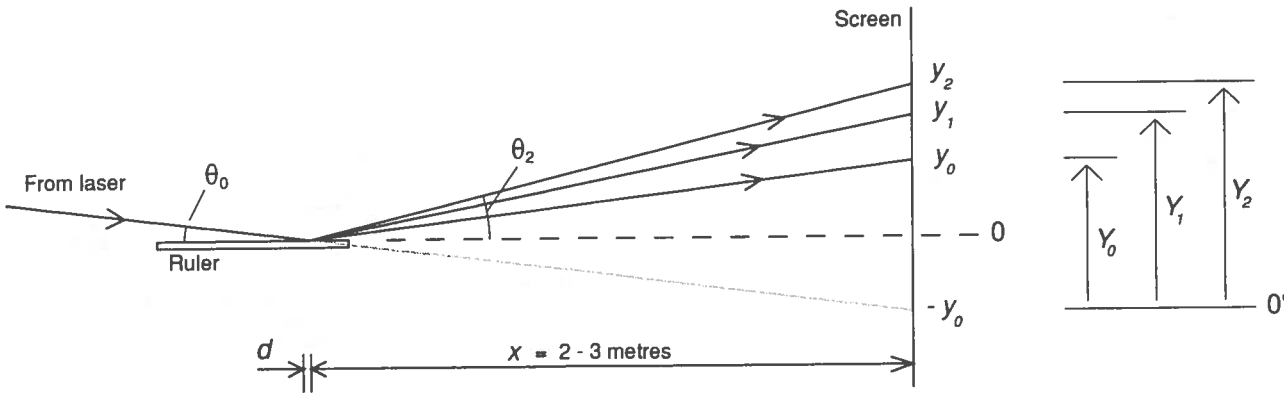


Figure 5. Schawlow's experiment with a ruler.

Measurement of particle size in lycopodium powder

If laser radiation is directed at a microscope slide which has a dusting of lycopodium powder, the diffraction caused by the random array of roughly similar sized particles creates an interference pattern consisting of a series of concentric rings. The mean particle size can then be computed from measurements of the ring diameters.

This effect is similar to solar or lunar coronae. In the atmospheric phenomenon, coloured interference rings are produced when the Sun or Moon shines directly through a cloud of water droplets of relatively uniform size. By measuring the angular diameters of these fringes, a value for the mean droplet diameter can be found.

The notes here are based on the method of measuring red blood cell diameters described by Bowlt [8]. While blood may be used under careful controls in schools and colleges, lycopodium powder is a safer substitute.

If light is diffracted at an opaque disc of diameter d the condition for a dark fringe is $n\lambda/d = \sin\theta$ where n is a non-integer. The values of n are 1.22, 2.23, 3.24, 4.24, 5.24 . . .). The effect of multiple diffraction sources as from a blood smear or a dusting of lycopodium powder is to enhance the intensity of the diffraction pattern you would get from a single diffracting object.

Because the angular deviation is small

$$\sin\theta \approx \theta \approx S_n / L$$

where S_n is the radius of the nth dark fringe and L is the distance between the diffracting particles and the screen.

$$\therefore \quad d = n\lambda L/S_n \qquad (n = 1.22, 2.23, \text{etc.})$$

The experiment was conducted in a darkroom. The distance between the screen and diffracting particles was about 35 cm. Graph paper with millimetre rulings was used as the screen.

Quite a lot of time was spent initially in producing the interference pattern (Fig. 7). It was found that a heavy dusting of powder on a microscope slide was required. Even then the slide had to be moved by minute steps in the laser radiation to search for a position where the particle density was sufficient to give a display of fringes. Subsequent examination with a microscope showed that the effective part of the slide had a surface coverage of perhaps 30% to 60% of particles. We were at best able to discern three dark fringes and measure their radii.

Several independent measurements of fringe radii were obtained. Values of n versus S_n were plotted and found to give a straight line through the origin graph. Since the gradient is equal to $d/(\lambda L)$ a value for particle size was calculated. It was 30 µm approximately.

The mean particle size was then found by an independent method, microprojection (Fig. 8). The slide with lycopodium powder was placed on the stage of a microscope and an Aldis projector used for illumination. Images of particles were produced on a translucent screen mounted 250 mm above the eyepiece. With a x10 objective lens, the image magnification is x100; with a x40 objective, the magnification is x400. Since most of the images were oval in shape, both minor and major axes were measured. The mean particle size by this method was found to be 30 µm approximately, in agreement with the diffraction method.

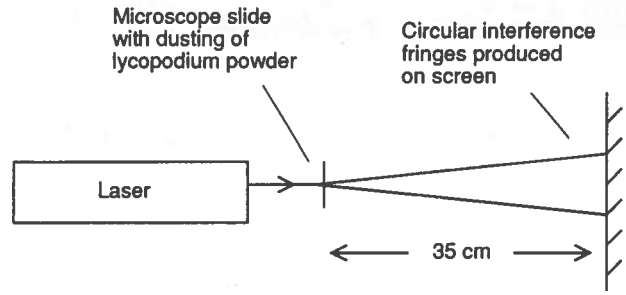


Figure 7. Measurement of particle size by diffraction.

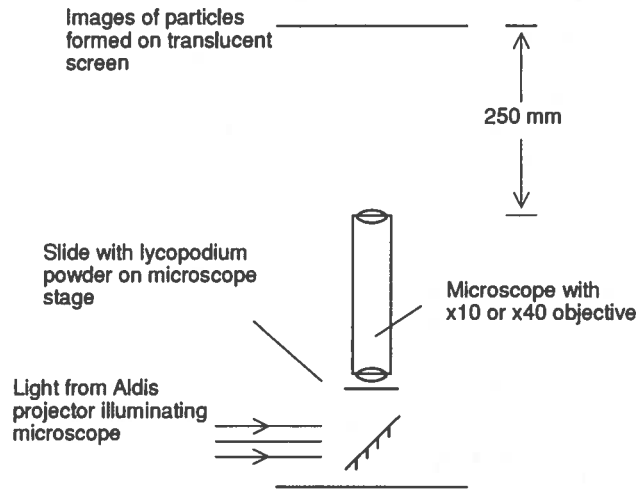


Figure 8. Measurement of particle size by microprojection.

References

1. *Optics with lasers* Bulletin 188 SSERC 1996
2. *Laser radiation* Bulletin 190 SSERC 1997
3. Circular No: 7/95 *Guidance on the use of lasers in laboratory work in schools and colleges of education, and in non-advanced work in further education establishments* SOEID 1995
4. Moloney M J *Newton's rings demonstration* American Journal of Physics 1974 42 411
5. *Optics with lasers* Bulletin 188 SSERC 1996 14
6. Schawlow A L *Measuring the wavelength of light with a ruler* American Journal of Physics 1965 33 922
7. Schawlow A L and Townes C H *Infrared and optical masers* The Physical Review 1958 112 6
8. Bowlt C *Measurement of red blood cell diameters using a laser* Physics Education 1971 6

UK Technicians' Conference

The inaugural UK conference for technician members of the Association for Science Education was staged at Solihull College on the 27th and 28th of June, running parallel with a Midlands Section INSET meeting. Only a handful of Scots (apart from the Exiles living in England that is) attended. This at least saved yours truly any excessive embarrassment since I appeared by some mysterious means billed as "An OFSTED registered Inspector" - it's a long story.

South of the Border, ASE's technician membership is on a definite roll and the conference was heavily over subscribed with over 350 attending the formal sessions and about 75 enrolled for the Esso sponsored Health and Safety Course. The organising team had done their best in very difficult and rapidly changing circumstances. In more normal summer weather conditions rather than the extremes of this June, the decision to use a marquee might have proved a stroke of genius, as it turned out . . ! No doubt the Technicians' Task Group have learned some valuable lessons from this event and next year the fates and the weather both may prove somewhat kinder.

S/NVQ occupational standards

A progress report and discussion on these featured prominently in the conference programme. A fairly full update was presented which was based upon a report in *Education in Science* [1]. Groups of Units have been put together from a variety of sources including The Chemical, Pharmaceutical and Allied Industries Board of the Chemical Industries Association (CIA) for some aspects of laboratory based operational competence, the Management Charter Initiative NVQ, the Training and Development Lead Body for relevant units and the Association for Science Education for some specific educational technical support functions. The groups of units are now nearing completion for awards at Levels 1, 2 and 3 with Level 4 apparently still under discussion and further development. What follows is a description of intent and should not be taken as definitive since both NCVQ and the SQA have still finally to approve these proposals.

The unit titles at the various levels are listed in the text boxes opposite. At Level 1 all seven units are to be mandatory but at successive Levels more optional units appear. At Level 2 there are eight core units with one optional unit to be chosen from a bank of three. Level 3 awards also require eight core units with two optional units chosen from a bank of five. A fuller description of these unit groupings may be found in the article already cited or by contacting Colette Baird at the ASE (see inside rear cover).

All of the listed units were either selected or specially developed to match functions which in, the usual occupational standards development methodology, all flow from a "key purpose statement". The ASE development group have defined the key purpose of educational science technicians as :

> *"To support the safe, healthy and effective learning of science in schools and colleges".*

Most units have been taken from those developed by the CIA as the "Laboratory Operations Awards". A few have been taken from the Management Charter Initiative NVQ or the Training and Development Lead Body and are denoted in the lists as [MCI] and [TDLB] respectively and units especially written by the ASE group are denoted [ASE].

Level 1 Units

1. Communicating information.
2. Working in a team.
3. Performing safely in the laboratory.
4. Using laboratory information and supply systems.
5. Taking laboratory measurements.
6. Carrying out basic laboratory operations.
7. Using simple laboratory processing equipment.

All Units at Level 1 are mandatory.

Level 2 Mandatory Units

1. Communicating information.
2. Performing safely in the laboratory.
3. Carrying out basic laboratory operations.
4. Preparing samples for laboratory use.
5. Preparing standardised materials for laboratory use.
6. Maintaining and calibrating laboratory equipment.
7. Controlling stocks of laboratory materials and equipment.
8. Process requests to support learning [ASE].

Level 2 Optional Units

A choice of <u>one</u> from the following three :

1. Contribute to the support of student performance [ASE].
2. Generate results by chemical and physical testing.
3. Generate results by biological testing.

Level 3 Mandatory Units

1. Modifying laboratory procedures.
2. Servicing laboratory equipment.
3. Manage self to optimise performance [MCI].
4. Maintain effective working relationships [MCI].
5. Provide information for action [MCI].
6. Contribute to the development and revision of safe working practice [ASE].
7. Contribute to the support of student performance [ASE].
8. Contribute to (the) planning of teaching and learning [ASE].

Level 3 Optional Units

A choice of two from the following five :

1. Developing new laboratory methods.
2. Control the use of financial resources [MCI].
3. Contribute to the training and development of teams and individuals [TDLB].
4. Diagnosing and repairing equipment.
5. Facilitate learning through instruction.

Awarding body

Negotiations are ongoing to establish a tripartite awarding consortium involving the relevant board of the CIA, the ASE and the Institute of Science Technology (IST). What currency a qualification awarded by such a body might have in Scotland remains to be seen.

There are also a number of other outstanding issues which may have to be resolved, possibly through the good offices of the recently established Scottish Qualifications Authority (SQA). One such issue is the obvious mis-match between parts of the ASE developed functional framework and some of the ways in which many educational technicians north of the border actually work. In those areas where the service is organised more or less on a whole school basis, some of the narrower - science laboratory based - units may be partly inappropriate. They may need to be supplemented or differently interpreted so as to better reflect the wider range of work that many Scottish technicians actually do.

Any comments from Scottish technicians on these SVQ arrangements would be welcome either here or at ASE.

Reference

1. *Defining competence. Development of an SINVQ occupational standard for technicians in education.* Education in Science, April, 1997, Number 172. ASE. (An update article giving further news of progress is scheduled for the September EiS).

ASE Technician membership

One way to better influence ASE developments - such as that of the SVQ - is to get involved in the Association as a member. The technician membership category of ASE remains open. At only £11 per year and tax deductible it offers great value. In addition to receiving some of the ASE's serial publications such as Education in Science you will get news of some of the one-off publications being written or compiled for technicians. Two are due out in the coming year and a technicians' task group is looking to develop others.

Further details are available from the Membership Department at ASE Headquarters or from the Secretary, ASE Scotland (see address list rear inside cover).

Bon-mots

Apart from the nine hours to get there and the eight spent coming back next day, those few of us from Scotland who braved the unseasonal weather in Solihull, thoroughly enjoyed the company of the technician delegates. One pleasant activity was the swapping of suitable slogans etc. for pinning up on prep- or staff room noticeboards.

One of my favourites was Pauline Anderson's[1] offering on time, and stress, management :

"What is it, precisely, that you
don't understand about "No!"?"

My own I had lifted, from a piece by Gregor Steele[2] in the Times Educational Supplement, Scotland :

"Blessed is the science department where there is mutual respect between teachers and technicians, for they shall retain a sense of proportion."

Footnotes

1. Of Earlston High School and the ASE Technicians' Task Group.

2. Gregor Steele's piece on technicians - "Songspotting with Sheila" is well worth reading in its entirety. You shall find it in the TESS of Friday 30th May 1997 (it may be still around in the staff room midden - if it didn't get pinched for the job adverts).

Esso sponsored courses

Esso has agreed to again sponsor some ASE Health and Safety Courses for technicians. Two were run in Scotland last year and at least two will be held this. The first will be held in the North East of Scotland in the Autumn. This will meet demand from a number of technicians who were disappointed not to get a place on the Aberdeen course earlier this year. The second will form part of the programme of the ASE Scotland Annual Meeting in Erskine on Saturday the 7th of March 1998. The course also may be offered in other areas if demand warrants it - watch this space.

TECHNICAL TIPS and TRADE NEWS

O-rings on burettes

Some schools have for several years used the burettes with PTFE taps (see below) and speak very highly of them. The only problem with these burettes which we have heard of is that the O-ring, which acts as a tap retaining device tends to perish after about six years. This neoprene ring does not normally come into contact with reagents, but, since the burettes in question had been stored near a window there is the possibility that the degradation had been accelerated by light. They had bought this type of PTFE tap burette from one of the main suppliers who were unhelpful and had refused to supply spares or even indicate where they might be obtained. We are grateful to the school for bringing this problem to our attention. They recommended substituting *Viton* O-rings from RS (Cat. No. 129-022 BS 010) as suitable alternatives. These have an inside diameter of $^1/_4$ inch and outside diameter of $^3/_8$ inch and cost £3.40 for 50. A less expensive alternative is a nitrile ring of the same dimensions. These should do the job even though they are not as resistant to chemicals and oxidation as is *Viton*.

Cowie, the manufacturers of the tap unit, have not come on such problems to date, but are happy to supply replacement rings free of charge to anyone who has purchased from them directly. Their address is listed on the inside rear cover.

Bargains for titrators

The next two items are examples of how savings can be made by buying directly from the manufacturer.

Pipette fillers:

Volac fillers of the *Pi* type are available at approximately half the price of that asked for by some other suppliers. The three sizes, 0-2 cm^3 (R622), 0-10 cm^3 (R623) and 0-25 cm^3 (R624) from the manufacturer sell at £5.75 with no minimum charge and no carriage charge if you purchase directly from the manufacturers, John Poulten Ltd. Liquids can be drawn into pipettes either by using these fillers single handed with the knurled wheel or by pulling up the plunger using a two-handed approach.

Burettes: You can buy burettes with interchangeable PTFE stopcocks directly from Cowie Technology for £8.90. This is a saving of 33 to 50% on the prices of other suppliers. Cowie Technology specialises in all manner of PTFE products - stirrers, vessels, stoppers, connecting joints for Quickfit apparatus, etc. They sell the separate stopcocks for £5.00 (Cat. no 016.9202 with polypropylene jet and 016.9203 with a glass jet) and a Class B 50 x 0.1 cm^3 burette tube for £3.90 (Cat. No. 016.350.1). Discounts are also given, 10% for 25 burettes increasing to 30% for 100. There is no carriage charge and no minimum order.

Being less expensive to buy and maintain, these burettes must provide the best way of managing burette stock. The tap is unbreakable and rarely if ever jams. If necessary the burette tube can be replaced separately. Spare jets are available in glass or polypropylene for only 32 p each. Unlike glass taps, PTFE ones do not need the bother of lubrication - too little grease on glass taps and they leak, a shade too much and the jet blocks just when you are a few cm^3 from the end point!

For those requiring the greater accuracy of a Class A burette, you can have one for £10.45 (£5.45 for the tube plus the price of the tap.) An extra 55 p gets you a Schellbach Class A tube. Some suppliers sell Class A burettes for at least twice this price.

Microscope lamps - spares

We have had some fun, and a little success, recently chasing sources of spare bulbs for older models of sub-stage, microscope illuminators. As well as becoming as rare as hens' teeth some of these bulbs are getting costly. Eight pounds or more is not an unusual asking price and often there is also a minimum order. Compared to the cost of a new microscope however these are prices well worth paying. Lately, on behalf of various schools we have found spares for older Opax models and for Russian Zenith Biolams. If you wish such assistance for other types of lamps then contact Marjorie Hamilton, SSERC Technical Officer.

Manganese(IV) oxide granules

Dunfermline High School alerted us to the fact that without telling anyone some suppliers took this useful form of the oxide out of their catalogues. Granules are more useful than powder in catalyst studies with hydrogen peroxide solutions because they are much more easily separated from the spent peroxide solution.

The granular form can still be obtained from Hoggs. The catalogue number for the entry in their catalogue is C4060 (£8.60 for 1kg of granules of dimension 0.35 - 0.85 mm). They tell us this has recently been changed to C4061, the only difference being the reduced pack size of 500 g for £4.50.

Two in one

Hanna Instrument's inexpensive, pocket-sized meters for measuring several parameters - pH, conductivity, oxidation potential, etc, have become accepted as something of a breakthrough in instrumentation. These separate meters are now complemented by a new range with several combined instruments. For example, the *Watercheck* measures pH over the range 0.0 to 14.0 and conductivity over 0 to 1990 µS. It also has built-in, automatic temperature compensation and costs £84. The replacement combined probe costs £48. Available from several suppliers as well as directly from Hanna.

X - Y plot

Many teachers and students will now be familiar with datalogged information plotted against time. Usually they can predict the shapes of graphs as per the text-book. Bring back a bit of wonderment to your science teaching. Plot one parameter against another and forget about the time! We show also one solution to that Holy Grail of Chemistry teachers - volume on the X-axis in a titration plot.

Introduction

Ask the average Chemistry teacher or student to sketch the shape of a conductivity vs. time plot during the neutralisation of a strong base by a strong acid or the distinctive temperature curve in the same reaction (Fig. 1) and they should have little difficulty.

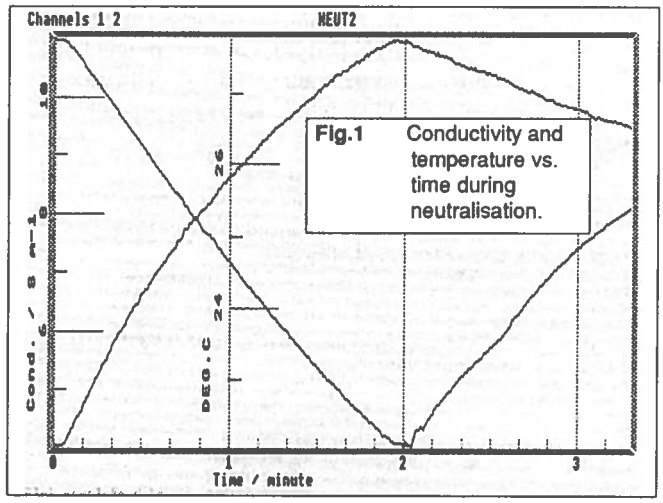


Fig.1 Conductivity and temperature vs. time during neutralisation.

Ask them to draw the curve for temperature against conductivity for the same reaction. The responses will range from bewilderment to "but it's not in the syllabus" to "why?" to an embarrassed "let me think about it". Try it yourself - just as a paper and pencil exercise!

OK, too difficult? Here it is in easy steps! How many say a horizontal line is the answer?

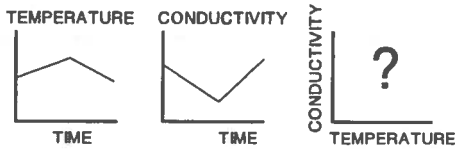


Fig.2 What's the answer? Read on and see Figure 3.

It would be nice to think that not all school science is cut and dried - that there is still some scientific thinking and discovery to be done by the teacher as well as the student, and not just as part of a Sixth Year Studies project.

Much datalogging software available nowadays allows us the freedom to investigate variations on familiar themes. These exercises should lead ultimately to a better understanding of the science involved. Here we look in particular at examples where the software allows us to plot one channel of data against one or more others i.e. X-Y plots.

X-Y plots - After the event and as it happens

There are two ways of producing X-Y plots of one channel against another thereby removing time as a variable:

After the event - The data is logged vs. time on two or more channels (Fig. 1) then replotted by software (Fig. 3). Most current software is capable of doing this. The examples here use *Datadisc PP (Plus & Plot)* from Philip Harris. We have supplied practical instructions at the end of this article on how to use this software to produce graphs like this.

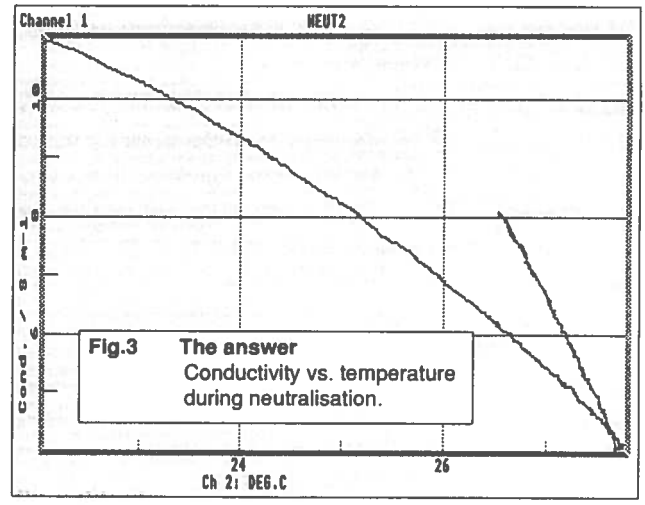


Fig.3 **The answer**
Conductivity vs. temperature during neutralisation.

Was your sketch a good likeness of Fig.3? The resultant graph is certainly thought provoking even when you know the answer. Producing the X-Y plot *after the event* allows a progression from the understanding of what is happening on the separate channels to the more complex relationship between the channels. It never fails to please watching the plot as it meanders across the screen and then perhaps goes in the reverse direction.

As it happens - This is otherwise known as **real time** or 'Jimmy Saville' mode. We are all used to seeing rough plots of the levels on separate channels as time passes and the graphs move from left to right.

Datadisc PP (Fig. 4) and most datalogging software allows you to log one channel against another and display the X-Y plot on the screen there and then. This requires some quick thinking to interpret graphs where time has been removed as a variable. For this reason it is best not to introduce this method to students until they have a good understanding of what is happening on the separate channels.

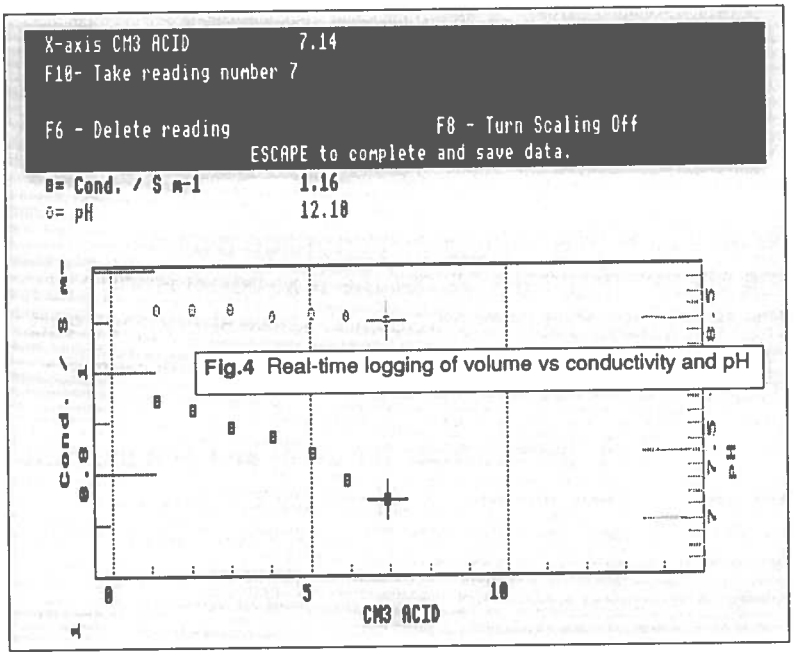


Fig.4 Real-time logging of volume vs conductivity and pH

The more observant of you out there will have noticed that Fig. 4 features the variable *volume* in the titration. How do we do that?

Volume vs. pH & conductivity

When we run interfacing courses for chemistry teachers the first questions asked are typically :-

a) Can I plot the graphs with *cm³ of acid* on the X-axis?

b) I don't want the computer to do all the work for the students. Is there a half-way-house where the student still has control during the experiment?

These can be answered by using software to do a real time plot of e.g. pH and conductivity against volume.

Fig.5 shows archetypal graphs for pH and conductivity logged against time. This is fair enough as long as it is just the general shapes of the graphs in which we are interested. Even so, it is important to make sure that acid is added at a constant rate i.e. time is directly proportional to the amount of acid added so that the X-axis also is linear with respect to the volume of acid.

The volume on one channel comes from the calibrated output of a voltage divider circuit (Fig.6). A 10 turn, 10K precision pot. is used with a 1.5 V cell to *dial - a - volume*. Our design has a fixed perspex dial marked with 10 divisions. Another dial with a pointer is free to rotate with the pot. knob. The full voltage divider output can be represented by 10 x 10 divisions = say 100 cm^3.

The other channels are calibrated to read pH and conductivity and in the example (Fig.4) *Datadisc PP* software is used to plot these against volume *as it happens*.

In a traditional titration we run in a given volume of acid e.g. 1 cm^3 and note down the volume from the burette and the pH and conductivity from the respective meters. We repeat this until a table is completed then plot a graph.

For this semi-automated method we run in acid as before but use the divider circuit to dial up the same volume. One reading is taken at a time with the actual volume of acid added being exactly mirrored by the dialled volume. You can also add (and dial up) smaller volumes as you approach the end point thereby achieving a better resolved graph where it matters (Fig.7). Once all points have been recorded the data is redisplayed full screen. Compare the shape to Fig.5 where we logged continuously vs. time.

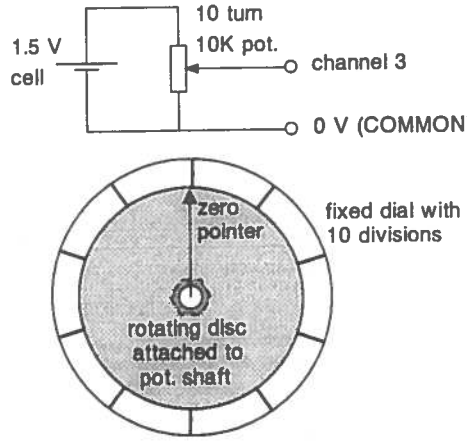


Fig.6 Voltage divider circuit and plan view of dial on pot. counter

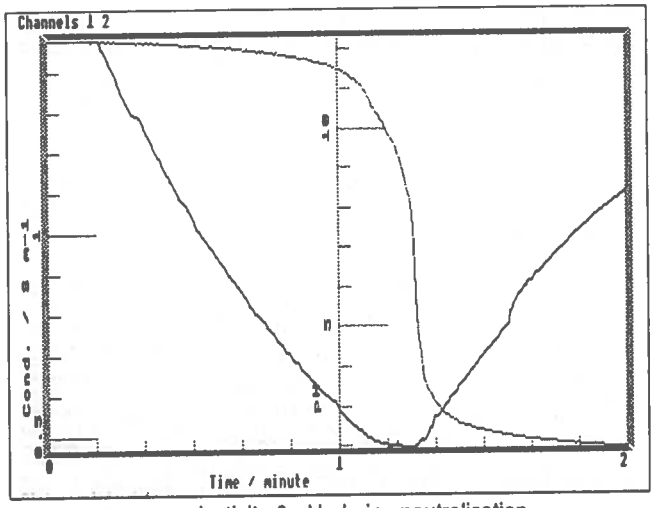


Fig.5 Time vs. conductivity & pH during neutralisation

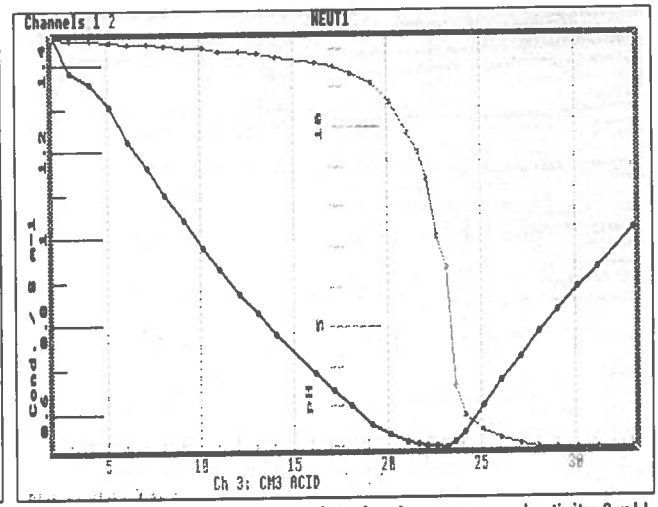


Fig.7 Redisplayed full screen plot of volume vs conductivity & pH

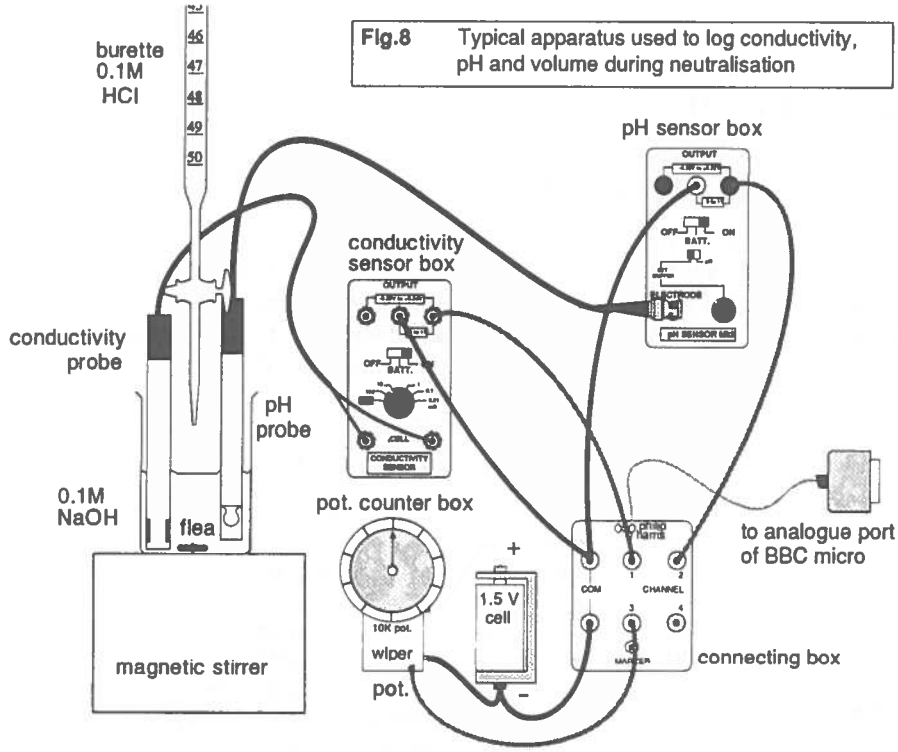


Fig.8 Typical apparatus used to log conductivity, pH and volume during neutralisation

Volume vs. pH & conductivity

Using Datadisc PP with 4 channel analogue port box

Connect the apparatus as above - if you can make sense of the spaghetti! The connections should be as follows :-

Channel 1 to RED on conductivity sensor box,

Channel 2 to RED on sensor pH box.

Channel 3 to wiper of the precision pot.

COMMON to BLACK on the conductivity & pH sensor boxes and the NEGATIVE side of the cell.

Conductivity or pH meters with suitable outputs may be used in place of the sensor boxes if available.

Calibration of channels (short instructions for Philip Harris software Datadisc PP as one example)

Ch.1 (conductivity) - From the *Main Menu* :-

Press *C, RETURN, P, C, D,* (move sensor switch to BATT.) press *SPACEBAR,* (move sensor switch to ON) press *SPACEBAR,* type in *CELL CONSTANT No.* then *RETURN* (if unknown just type *RETURN*). Note that if 0.1M sodium hydroxide is used, the conductivity knob should be set to *0 - 10 mS.*

Ch.2 (pH) - From the *Main Menu* :-

Press *C, 2, P, P, B,* (move sensor switch to BATT.) press *SPACEBAR,* (move sensor switch to ON), press *SPACEBAR,* (place probe in buffer pH4, set wee switch to pH and adjust SET BUFFER knob to read *4* on the bar), press *SPACEBAR.*

Ch.3 (cm^3 acid) - From the *Main Menu* :-

Press *C, 3, G,* type *cm^3 of acid, RETURN,* (wind pot. anti-clockwise to zero position), type *0, RETURN,* (wind pot. fully clockwise 10 revolutions), type *100, RETURN.*

X-Y real-time logging of Ch.3 vs. Ch.1 & Ch.2

From the *Main Menu* :-

Press *R, 3, 1, 2, RETURN.* A display similar to Fig.4 appears. Press *f10* (function key 10 on the keyboard) to take a reading of conductivity and pH with no acid added. Switch the stirrer on, run in 1 cm^3 of acid from the burette and dial up position 1 on the pot. counter box.

The reading at the top of the screen should read approx. *1.* Press *f10* to take another reading of conductivity and pH with 1 cm^3 of acid added.

Repeat this process 1 cm^3 at a time (or less than this as the end-point approaches - just remember to *dial-up* the same volume of acid).

When all the required points have been logged press *ESCAPE* to complete and redisplay the data on the full screen (Fig.7).

X-Y plot of conductivity vs. pH

This is where we came in. This procedure can be carried out when the *Display Menu, Display Utilities Menu* or the plotted data (vs. cm^3 or time) is displayed.

Press *X* for X-Y plot and *1* to put conductivity on the X-axis. When prompted choose the number of the channel for the Y-axis i.e. *2* then press *RETURN* (Fig.6). To convert the display to a line plot enter *J* with the X-Y point plot on screen. We recommend that this type of data is saved and/ or dumped to a printer for comparison with other experimental data.

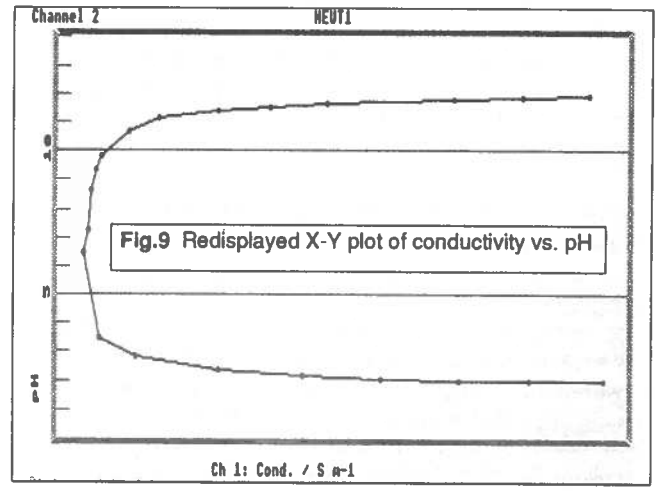


Fig.9 Redisplayed X-Y plot of conductivity vs. pH

You should be able to see from Fig.9 the neutral point (pH7) corresponds to a minimum conductivity and a rapid change in the pH.

INTERFACING NOTES

Dataloggers - three compared

The features and benefits of three dataloggers are summarised.

These notes were prepared as a quick comparative survey for those currently in the educational market for datalogging equipment. We were told that they were very useful for that purpose and so reprint them here. Before any supplier complains however, we must stress that the summaries are just that and that they were never meant to be either complete as a whole nor each as comprehensive in itself. Some opinions on desirable features or disadvantages are always likely to be coloured by personal or corporate preferences. There are no absolutes here. When staff time and bulletin space allow, we intend publishing a fuller technical evaluation and market survey.

DL plus - Harris

Pluses: Well made, robust sensors and datalogger with a wide range of sensor types which usually have a number of user-selectable ranges.
Automatic sensor recognition and sensors are compatible with the Universal Interface (like a DL plus without memory)
LCD display and simple automatic logging straight-forward to initiate.
Recorded data or graph can be viewed on the LCD screen without the need for a computer.
Can be used with Insight 2 software.
'Own-brand' Datadisc software is of high quality.
'PC Mode' can be used to transfer files to PC, Mac or Acorn computers running Terminal programs - or spread-sheets such as Microsoft Excel, Lotus 123 or Clarisworks.
Real-time update of readings on sensor box and datalogger
Sensors and probes can be used stand-alone - datalogger can be configured to accept and pre-calibrate data from Blue-Box sensor types.
Good workcard examples available to support use.
Large number of data files (20 or 100 on DL plus 128) can be stored in the datalogger before transferral to computer.

Minuses: Expensive in comparison with other systems
Bulky compared to other systems - possibly less portable
Only standard alkaline power source may be used on DL plus 32 i.e. 8 off AA type. 128 model has mains socket.
No integral digital logging facilities (timing package avail.)
'System' software cannot be updated easily by user.
Can be hard on cells used to communicate with sensors.
Menu system and file saving on datalogger laborious.
No facilities at present to link with palmtop computers e.g. Psion Series III & Acorn Pocket Book II.

*

Sense & Control EasyLog - Data Harvest

Pluses: Well made and robust.
Wide range of sensor types with automatic sensor recognition.
Intermediate in portability between DL plus and DataMeter.
Lower start-up costs than DL plus or DataMeter 1000.
Powered from integral rechargeable battery or power pack.
Simple automatic logging is straightforward to initiate.
Best used with Insight 2 software or Palmtop computer.
Excellent Palmtop software suite available on a plug-in ROM.
Integral digital logging facilities (requires external software).
Good workcard examples available to support use.
Can be used with other equipment for 'control'.

DataMeter 1000 - Griffin

A development & upgrade of *LogIT. LogIT SL* still available.
Pluses: Well made and robust with a wide range of sensor types with automatic sensor recognition.
Lower start-up costs than DLplus.
LCD display (LogIT SL available with CheckIT LCD display)
Sensors can be used with LogIT SL datalogger and LIVE interface (like a LogIT without the memory).
Simple automatic logging is straightforward to initiate.
'System' software can be easily updated from disc.
Palmtop software has to be loaded from disc (also a minus!)
'Own-brand' Multilink software is of high quality or logger may be used with Insight 2 software.
Powered from integral rechargeable battery or power pack
Integral digital logging facilities (palmtop timing software also)
Real-time update of readings on datalogger.
Facilities to link with palmtop computers e.g. Psion series III and Acorn Pocket Book II.
Good menu structure for selecting different recording types.
Automatic saving of data files without giving filenames
Can be used with other equipment (*SwitchIT*) for 'control'.

Minuses: No real-time update of readings on sensor box (datalogger only) and sensors cannot be used stand-alone
'System' software has to be reloaded from disc if rechargeable batteries are completely discharged.
Capable of retaining only 4 data files at a time.
Palmtop software has to be loaded from disc (also a plus!)
Recorded data or graph cannot be viewed on the LCD screen - a desktop or palmtop computer being required to view the data.

*

Minuses: No real-time update of readings on sensors or the datalogger, no LCD display and sensors cannot be used stand-alone. Additional ADC interface required to use proprietary e.g. Blue-Box sensors.
Datalogger and ADC interface with proprietary sensors cannot be used if not connected to computer.
'Own-brand' Practical Science software is not of the highest quality and is only available for BBC B/Master 128 and IBM PCs or compatibles.
Capable of retaining only 1 data file at a time.

*

Further reading

1. SSERC's *Interfacing for . . .* series : biology, chemistry and physics (see *Bulletin 189*, Autumn 1996).
2. Northern College *Biology Newsletter* No.61 April 1997.
3. SSERC *Bulletin 183*, Winter 1994.

Hazardous chemicals manual for science

Sample pages of the forthcoming second edition of the *SSERC Hazardous Chemicals Manual* are provided on the following two page spread.

Background

At the time of writing the final proofs of the new manual are being printed out. We apologise to those teachers, technicians and advisers who expressed an interest in this publication possibly two, even three, years ago. Compiling this edition, with more than 250 entries has been difficult enough. It has been a doubly frustrating experience for Centre staff to have the work continually disrupted by Local Government Re-organisation, our consequent funding crises and having to move premises to save money. This was especially so since the manual is intended as a major contribution to easing teacher and technician workload as well as again increasing the quantity and quality of practical work.

The final, camera ready copy will be going to the printer shortly. A further announcement will be made in these pages once stocks for direct sale are to hand.

Layout

The second edition of the manual, like the first, contains a general introduction giving wide ranging advice on storing, handling, using and disposing of hazardous chemicals in schools and colleges. Specially annotated sample layouts follow which provide detailed explanation as to the meaning and purpose of each section of an entry for a substance, The body of the manual is taken up with entries for over 250 substances or groups of substances. Most of these chemical entries occupy a double page spread like the one shown overleaf for aluminium powder. Some, like ammonia, take up three or more pages. (It is probable that the final versions will be reduced to give a handier A5 format). In most entries the left hand page provides basic data on the substance and describes its hazards, toxicology etc, advises on how and where to store it and how to deal with any spillage or disposal problems. The facing page usually describes educational applications of the chemical.

These descriptions should take a lot of the slog out of making risk assessments to meet the requirements of the ***Control of Substances Hazardous to Health Regulations*** (COSHH).

Risk assessments

Under the heading *Uses and Control Measures* the manual describes many educational applications of hazardous substances in such a way as to provide a significant bank of model risk assessment results. Also, in showing how risks may be controlled it provides teachers with encouragement to carry out potentially hazardous practical activities with acceptable safety. Where the planned activity is not significantly different in scale, method etc. from that described, these generic risk assessments may be adopted as they stand. Where there are only slight differences between the activity planned and that described, the risk assessments may be adapted to that somewhat different use. Finally where a project or investigation is significantly different from any of the uses described then a 'novel' risk assessment will be required. The entry for each of the various chemicals needed then becomes a source of information on which to base such a risk assessment from first principles. The Introduction and Guide to the manual provide advice on how to use the data contained in the entries on exposure levels and likely exposure routes, data on physical properties - such as indicators of volatility - to make assessments of risk and where necessary deciding on preventive and protective measures (controls) to remove risks or reduce them to acceptable levels.

Emergencies and environment

A text box is set aside to suggest remedial measures should anyone be accidently exposed to the chemical by a variety of described routes. Actions to take in the event of a spillage are also suggested. These aspects of the manual contribute to meeting some of the requirements of the ***Management of Health and Safety at Work Regulations*** and other secondary legislation.

To assist educational employers and their staff to stay on the right side of environmental law, information and advice are also given on acceptable disposal methods, routes and quantities. This section is intended to assist educational employers and employees to comply with the ***Environmental Protection Act*** and related legal requirements.

Aluminium powder

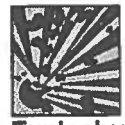
$Al_{(s)}$

Numbers	Data	
CAS 7429-90-5	*mp*	660
	bp	1800
CHIP 013-001-00-6	*vp*	
	fl.p	
EEC 231-072-3	*ait*	
	LD_{50}	
	OES	-
total respirable dust (8hr)	5 mgm^{-3}	

Risk & Safety Codes

F; R15-17
S(2-)-7/8-43

Highly Flammable



Explosive

Grey metallic powder

Hazards

Though inert the dust is harmful if inhaled in quantity. Possibility of dust **explosion** when exposed to flame. Hydrogen is evolved with acids, alkalis and even from water. Damp powder will self-heat and may ignite.

Incompatibility

With strong oxidising agents there is a possibility of explosions e.g. a mixture with oxidising agents including chlorates(V), metal oxides, sulphur, halogens, ammonium nitrate, silver nitrate. It can react violently with halogenated hydrocarbons with formation of carbonyl chloride, carbon dioxide, alcohols (often after a long induction period). With mercury and mercury salts the oxide layer will be removed and self ignition of powder may occur.

Handling

Wear eye protection and pvc gloves. Powder must be handled carefully to avoid dust rising. Remove samples out of bottle away from bunsen and replace lid. For many reactions use coarse powder, granules or foil. ***FF*** - DP, S. **NOT** halon or CO_2.

Storage

In general store with reducing agents. Keep dry and away from mercury and mercury salts. Containers may develop pressure. Recommended shelf life of 3 years maximum.

Disposal

Wear eye protection and pvc gloves. Extinguish sources of ignition. Mix with 10-20 volumes of dry sand, carefully sweep up, seal in plastic bag and place in waste bin.

Spillage

Wear eye protection and pvc gloves. Remove all sources of ignition and treat as in *Disposal.*

Remedial Measures

Eyes

Irrigate with water for at least 10 minutes. Treat as for non-toxic foreign body in the eye. Obtain medical attention.

Mouth

Wash out mouth thoroughly with water. Don't induce vomiting. Drink water in small sips. If unconscious do not give anything to drink.

Lungs

Remove patient from exposure to fresh air. Obtain medical attention.

Skin

Wash well with soap and water. Remove and wash contaminated clothing.

Uses and Control Measures

1. Reaction of aluminium with oxygen (S2) - Wear eye protection. Use only a small spatulaful of the powder on the deflagrating spoon in a gas jar of oxygen. The Arculus method could be very dangerous if aluminium powder and potassium manganate(VII) (OXIDISING & IRRITANT) are accidentally mixed; this should be demonstrated by the teacher, with a plug of glass wool (IRRITATING) used to ensure separation of the reactants.

2. Reaction of aluminium with steam (S4) - Wear eye protection. Use only a small spatulaful of powder and carry out reaction behind safety screens.

3. Thermit reaction (Teacher or S6 with supervision)

Any mixing of powdered metals with oxidising agents should be done as above and behind a safety screen.

Do not use the oxides of copper, lead, cobalt, nickel, manganese or chromium(VI). This is a vigorous reaction. White hot sparks can be ejected up to 2 metres. Perform outdoors or behind tall safety screens. All present should wear eye protection and sit 2 metres back from the screen. The teacher should wear heavy chrome leather gloves or equivalent and faceshield. See also *Thermit mixture*.

Thermit mix - Sometimes referred to as the thermite reaction. Set up a safety screen and wear eye protection Dry the iron(III) oxide and aluminium powder **separately** by gentle heating and stirring or use of an oven. When cool make up the thermit mix with 12 and 4 g respectively (mix gently on paper) and set at the bottom of a crucible. Do not use a metal spatula - use a plastic or wooden one. Set the crucible in sand in a metal bucket. Carry out between two safety screens.

As an alternative use a depression made in the sand with a dibble. If this procedure is followed it is important that the sand in the bucket is dry. Push a pencil 1 cm into the thermit mix to leave a cavity for the igniting mixture.

Into this cavity sprinkle alternate thin layers of magnesium powder (HIGHLY FLAMMABLE) and barium peroxide (CORROSIVE & HARMFUL) - this avoids the need to mix them. Take about 15 cm of magnesium ribbon and push it into the igniting mix at a slight angle from the vertical.

Play a bunsen flame onto the top of the ribbon to ignite it and step back immediately. After vigorous initial reaction has subsided red hot molten metal is left in the crucible - leave to cool.

4. Reaction of aluminium with air (T) - Wear eye protection. Clamp sheet or pipe and abrade part of surface. With a small piece of cotton wool held in tongs, moisten it with a little 0.1M mercury(II) chloride solution (TOXIC) and rub on the abraded surface. This will become extremely hot. Collect oxide whiskers on a tray and dispose with solid waste. Cover the oxidised metal with sand and place on heat resistant mat to cool off or leave immersed in water.

5. Reaction of aluminium with iodine (T) - Wear eye protection. Carry out in a fume cupboard and add a drop of water to the mixture to start the reaction. It is sometimes necessary to gently stir to wet the mixture through and start the reaction. Alternatively a little detergent helps. Leave the cupboard running for some time afterwards.

EQUIPMENT NOTES

Laboratory power supplies

In our third article on laboratory power supplies we review products from Harris, Shaw and Weir. Changes to the Griffin range are also announced.

Versions of the Harris Autotrip were tested by SSERC in the late 80s when the product was developed. In researching this article we obtained a new sample for evaluation. The Autotrip has a unique protection system. It senses for an overcurrent on the supply drawn from the isolating transformer's secondary winding. A signal is sent through an optoisolated link to control circuitry on the primary supply which operates an electronic cut-out. Unusual though it may be, it would seem to be effective, reliable and safe. Weaknesses of the unit are its rotary switch, internal wire arrangement, temperature rise and output voltage values.

The Shaw power supplies are larger and heftier than the Harris Autotrip, which is remarkably lightweight. Built like tanks! However the enclosure panels on the Shaws do not fit together snugly. There are gaps into which objects might be poked.

Both Shaw power supplies have electronic cut-outs. These are sited conventionally on the load side of the transformer. However unlike that on the Harris Autotrip, the Shaw protection system senses for an overcurrent on only one half-cycle of the supply. By failing to notice overcurrents on other half-cycles, its protection is incomplete.

The Weir Power Supply Unit LV269 was designed a long time ago, but has been refitted into a new style of enclosure. The original two-part enclosure had unacceptably large gaps between its two parts. This new enclosure has no gaps and is very satisfactory. The front panel slopes inwards so that the lid and side panels form a cowl. By being partially recessed, fitments on the front panel are protected from impacts during carriage.

The Weir supply output is continuously variable. Its market rivals are Griffin's new VariVolt Power Supply, the EJ0032 from Irwin at £86.24 and the Ranger Supply from Unilab at £126.24.

Test findings

Reports on individual power supplies are given in pages 26 to 29. The ABC key used in the summary (Table 2) is explained below. In general it stands for :

A Good B Fair C Poor

Electrical safety :

A Complies fully with IEC 1010-1 as far as our tests are able to indicate, except for some very minor infringements; has no appreciable risk for use in schools.

B Complies in general with IEC 1010-1, but has one or more features where there is a very small risk of harm.

C One or more features present an unacceptable risk of harm.

Electrical design :

A Sound design using good quality components of sufficient strength. Adequate mechanisms to protect against some single fault conditions. Able to meet specified voltage and current outputs.

Next page/

Product code	Product name	AC voltage	DC voltage	Maximum current	Voltage selection	Voltage locking	Price
		(V)	(V)	(A)			(£)
Harris power supply							
Y42500/2	Autotrip PS	2, 3, 4, 5, 6, 8, 10, 12 a.c. and d.c.		5	Rotary switch	None	98.70
Shaw power supplies							
L40235	Lockable PS	2, 4, 6, 8, 10, 12 a.c. and d.c.		5	Rotary switch	Mechanical	105.45
L40240	1-20 V AC/DC PS	1-20 (1 V steps) a.c. and d.c.		5	Multi-terminals	None	142.00
Weir power supply							
LV269	Power Supply Unit	0-13 continuous	0-17 continuous	8	Rotary, continuous	Mechanical	143.00

Table 1. Power supplies from Harris, Shaw and Weir reviewed in this article : specifications and prices.

Product code	Product name	Electrical safety	Electrical design	Mechanical design	Operational design	Perform-ance	Protection mechanisms	Assess-ment
Harris power supply								
Y42500/2	Autotrip PS	A	B	A	A	B	A	A
Shaw power supplies								
L40235	Lockable PS	B	C	B	A	B	B	B
L40240	1-20 V AC/DC PS	B	C	B	A	B	B	B
Weir power supply								
LV269	Power Supply Unit	(A)	A	A	A	A	A	(A)

Table 2. Power supply performance and assessment.

B Minor weaknesses in design. May not deliver current and voltage to specification.

C Major weaknesses in design. One or several of the following may occur: liable to malfunction; components liable to get destroyed; gross underachievement of performance.

Mechanical design :

A Robust enclosure and parts. Secure fitment of parts. No significant mechanical weakness.

B Minor significant weaknesses identified.

C Major weaknesses identified.

Operational design :

A Controls and outlets clearly and adequately marked. Operation is simple, clear and obvious.

B Minor weaknesses identified.

C Awkward to work with, or misleading to operate.

Performance :

A Electrical outputs perform to specification. Voltage does not fall away steeply with current. Temperature rise is not excessive.

B Significant minor underachievement found.

C Significant underachievement, or excessive temperature rise.

Protection mechanisms :

A Overcurrent and short circuit protection operates reliably and to specification. Adequate protection of primary circuit.

B Minor weaknesses.

C Significant weaknesses. Because of inadequate protection, fault conditions may lead to destruction of parts. Electrical safety may then be compromised.

Assessment :

A Most suitable for use in Scottish schools and non-advanced FE

B Satisfactory for use in above.

C Unsatisfactory.

Griffin power supply changes

Details of changes are shown in Table 3. Most of the items we reported on in Bulletin 187 are still in production.

The LoVolt Power Supply has been superseded by the Lockavolt, the significant difference being the replacement of the rotary switch with one controlled by a key to set and lock its voltage output.

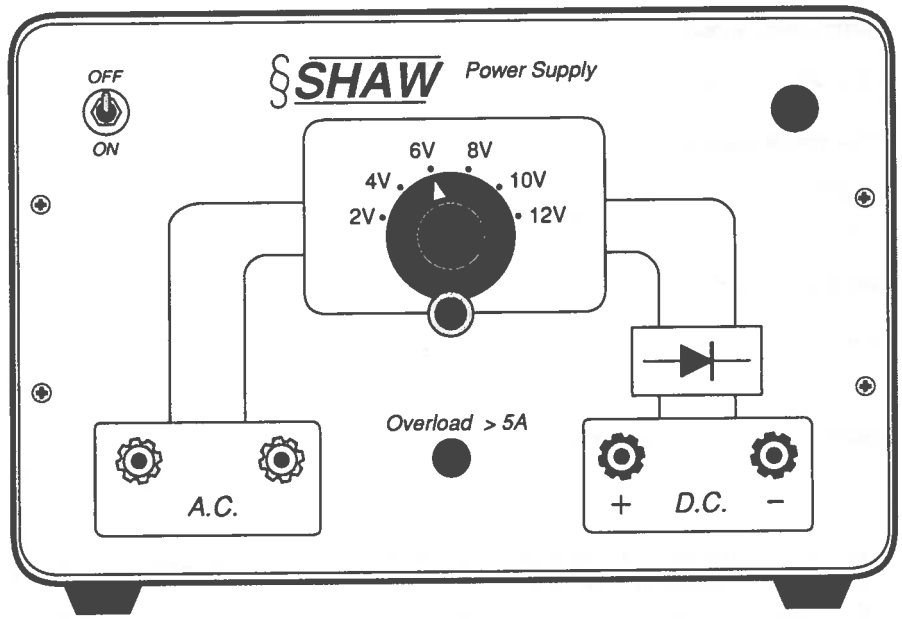
The Voltline Supply with voltage level controlled by an infrared link is discontinued. It has been replaced by the VariVolt, which is specified to supply a continuously variable 0-12 V a.c. and full wave rectified d.c. at 8 A maximum current.

The High Tension supply has been redesigned with calibrated scales instead of a bar meter.

Product code	Product name	Comment
Griffin power supplies reviewed in Bulletin 187		
EKR-451-010W	Battery Replacement	No change
XKB-370-011V	Low Voltage Supply	No change
EKP-141-010E	Multitap Transformer	No change
EKR-410-010K	LoVolt Power Supply	Superseded by LockaVolt
EKR-681-010Y	Voltline Supply	Discontinued
EKR-286-010K	Single Rail Regulated	No change
EKR-260-010X	Dual Rail Regulated	No change
New items		
EKR-420-010D	LockaVolt	As LoVolt but with key switch to lock set position
EKR-683-010T	VariVolt	Continuously variable 0-12 V AC/DC, 8 A max.
EKR-553-010C	High Tension	New scale

Table 3. Current Griffin power supplies

Shaw Lockable Power Supply L40235 — *£105.45*



Function : Power supply for general laboratory use.

Specification : Outlets at 2, 4, 6, 8, 10 and 12 V AC and DC. Maximum current 5 A continuous. Outputs not referenced to earth.

Circuit : Low voltage is drawn from a step-down isolating transformer with several taps to the secondary winding. The outlet voltage is selected by a rotary switch that has a specified maximum non-switching current of 5 A. However because this switch may be rotated while carrying a current of 5 A, we are concerned that it is not up to the demands that would be placed upon it.

The primary winding is protected by a fuse. The outlets have electronic overcurrent protection. This protection circuit senses for an overcurrent on one half-cycle of the supply. Thus by being insensitive to an overcurrent on alternate half-cycles, the protection is not wholly adequate. A further criticism is that it shuts down the DC supply at considerably less than 5 A. We believe that the electronic protection should be improved, or backed up by other means.

Construction : Strong 4-piece metal enclosure. Class 1 electrical safety standard of construction. Complies with IEC 1010-1 on electrical safety. However a 1 mm gap has opened up between the rear and base panels through which objects could be inserted. A test pin inserted into this gap does not touch any interior hazardous live conductor.

We are concerned that insulated conductors from the supply to the neon indicator are routed alongside insulated LT conductors behind the rotary switch. In a fault condition wherein the LT conductors were excessively overloaded, insulation might melt resulting in a hazardous live supply conductor shorting to a supposedly LT outlet.

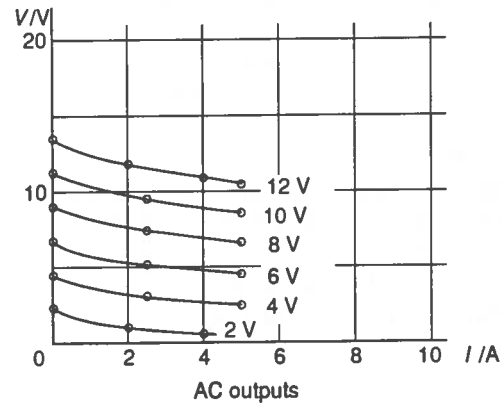
Performance : AC output voltages agree with settings. DC output voltages register low. Higher than average voltage drop-off with current. Maximum DC current is nearer to 4 A than 5 A.

Maximum temperature rise on enclosure is 19°C, which is very acceptable.

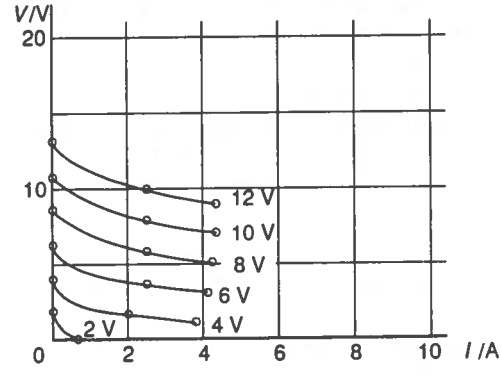
Verdict :

B (Satisfactory, but with weaknesses.)

Enclosure : Strongly constructed. Red and cream stove-enamelled steel. Black markings.
Dimensions : Width 234 mm, depth 198 mm, height 158 mm.
Weight 3.2 kg. No carrying handle or aid. Stackable.
Detachable mains cord with IEC connector.
External mains fuse on rear panel.
Overcurrent protection : fuse on primary; electronic cut-out on the LT outlet which senses an overcurrent on one half-cycle of AC from the secondary winding.
Outlets : Shrouded 4 mm terminals, accepts 4 mm plugs or unterminated wire.

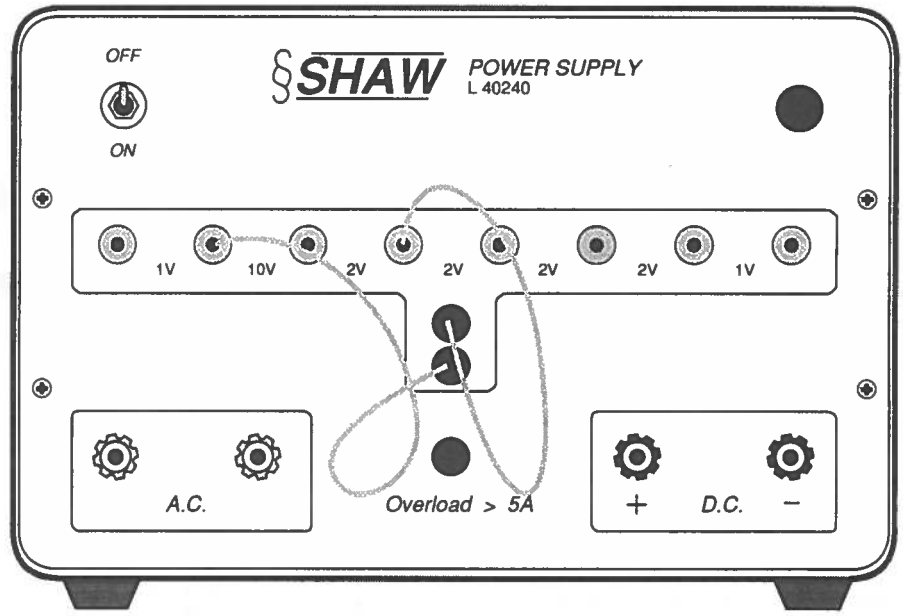


AC outputs



DC outputs

Shaw Power Supply 1-20 V AC/DC L40240 — *£142.00*



Function : Power supply for general laboratory use.

Specification : Outlets at 1 V to 20 V AC and DC by 1 V steps. DC outlet is smoothed. Maximum current 5 A continuous. Outputs not referenced to earth.

Circuit : Low voltage is drawn from a step-down isolating transformer. The outlet voltage is selected by connecting a pair of flying leads to a bank of socket outlets which connect to different taps off the secondary winding.

The primary winding is protected by a fuse. The outlets have electronic overcurrent protection. This protection circuit senses for an overcurrent on one half-cycle of the supply. Thus by being insensitive to an overcurrent on alternate half-cycles, the protection is not wholly adequate. A further criticism is that it shuts down the DC supply at considerably less than 5 A. We believe that the electronic protection should be improved, or backed up by other means.

The voltage selector outlets are unprotected. If two of these were to be shorted or otherwise overloaded, the transformer might be damaged.

Construction : Strong 4-piece metal enclosure. Class 1 electrical safety standard of construction. Complies with IEC 1010-1 on electrical safety. However a 2.5 mm gap has opened up between the front and base panels through which objects could be inserted. A test pin inserted into this gap does not touch any interior hazardous live conductor.

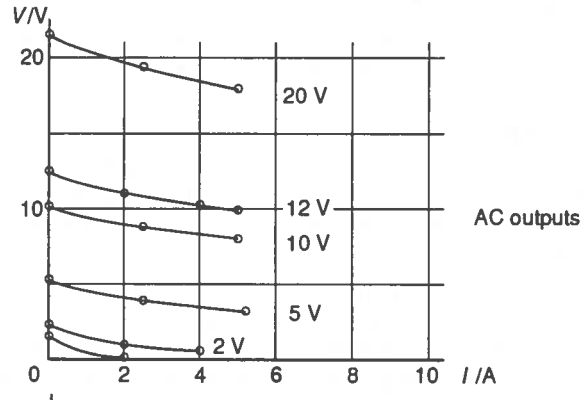
Performance : AC output voltages are generally about 10% lower than the settings indicate. DC output voltages register very low for currents greater than 1 A. Higher than average voltage drop-off with current. Maximum DC current is nearer to 4 A than 5 A.

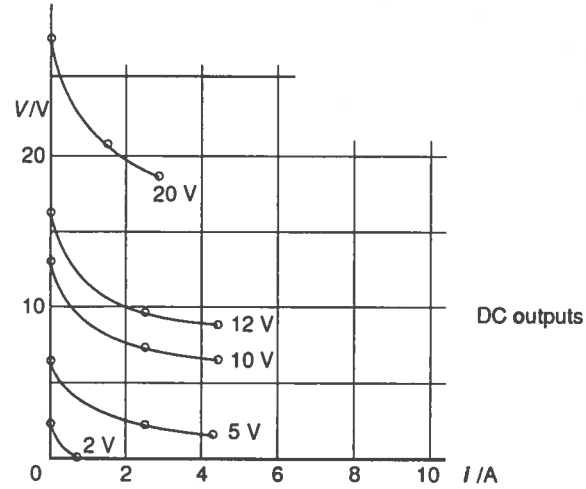
Maximum temperature rise on enclosure is 17°C, which is very acceptable.

Verdict :

B (Satisfactory, but overexpensive and has weaknesses.)

Enclosure : Strongly constructed. Red and cream stove-enamelled steel. Black markings.
Dimensions : Width 234 mm, depth 198 mm, height 158 mm.
Weight 3.3 kg. No carrying handle or aid. Stackable.
Detachable mains cord with IEC connector.
External mains fuse on rear panel.
Overcurrent protection : fuse on primary; electronic cut-out on the LT outlet which senses an overcurrent on one half-cycle of AC from the secondary winding.
Outlets : Shrouded 4 mm terminals, accepts 4 mm plugs or unterminated wire.





Harris S Range Autotrip Power Supply Y42500/2 *£98.70*

Function : Power supply for general laboratory use.

Specification : Outlets at 2, 3, 4, 5, 6, 8, 10 and 12 V AC and DC unsmoothed. Maximum current 5 A continuous. Outputs not referenced to earth.

Circuit : Low voltage is drawn from a step-down isolating transformer with several taps to the secondary winding.

The primary winding is protected by a fuse. The outlets have electronic overcurrent protection. This protection circuit senses for an overcurrent on both half-cycles of the supply drawn from the secondary winding. A signal is transmitted via optoisolators to a bistable in the primary supply circuit which activates a triac to switch off the supply. From our own experience of the system and feedback from schools, along with information from the manufacturer, this protection system seems to be effective, reliable and safe.

The outlet voltage is selected by a rotary switch. There is an instruction on the front panel warning that this should not be changed while under load. However this restriction is unlikely to be followed. The switch's specification shows that the switch is rated at 5 A continuous, but only 500 mA during changeover. Thus it is under par.

Construction : Strong 4-piece composite enclosure. Hybrid Class 1 and Class 2 electrical safety standard of construction. Complies with IEC 1010-1 on electrical safety. Printed circuit board with mixed HT and LT circuits complies with standard.

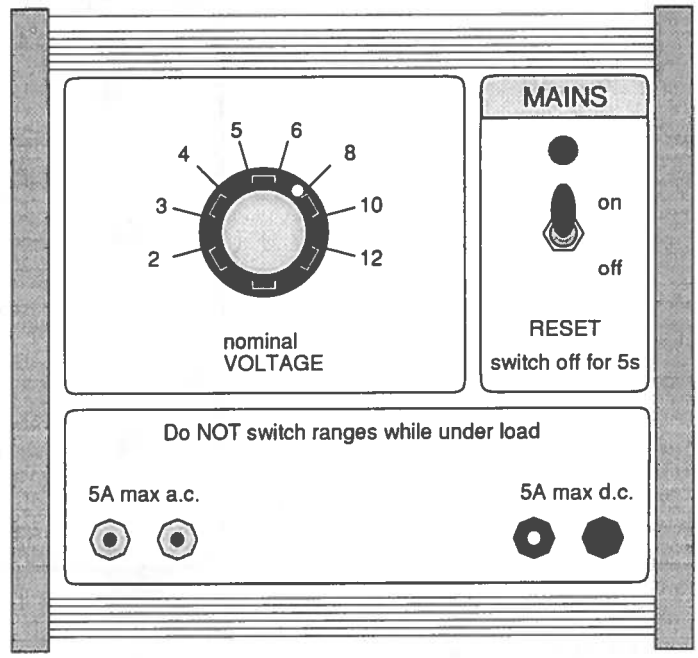
We are concerned that insulated conductors from the transformer are routed, rat's nest fashion, within the enclosure. A fault condition has occurred caused by insulation on an LT conductor being burnt touching the overcurrent sensing resistor, which occasionally gets hot. We understand that Harris will reappraise the cable arrangement.

Performance : AC output voltages are about 25% above settings. DC output voltage values are satisfactory. The voltage drop-off with loading is normal for this type of power supply. Maximum continuous current values are higher (or better) than specified.

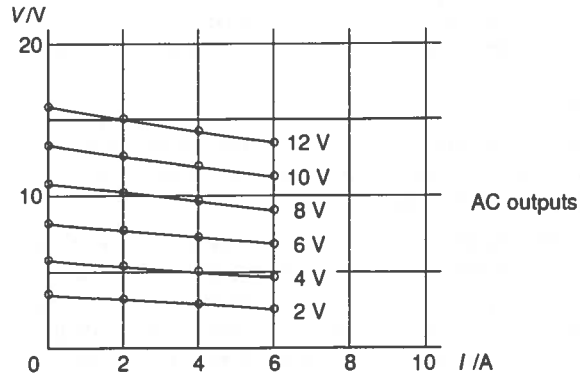
The maximum temperature rise on a small part of the enclosure to which the rectifier is fastened is 50°C. However the risk of someone being burnt is slight because the hot spot is unlikely to be gripped since a large carrying lip is provided.

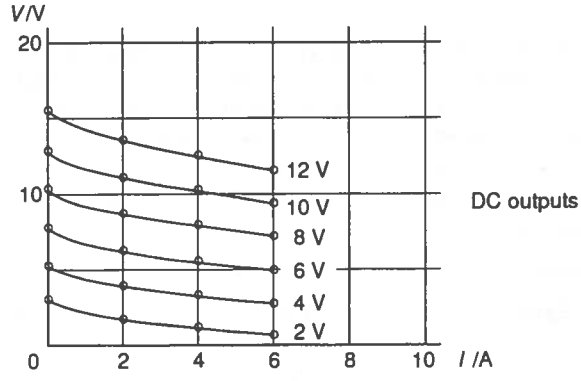
Verdict :

A (Very satisfactory in most respects.)

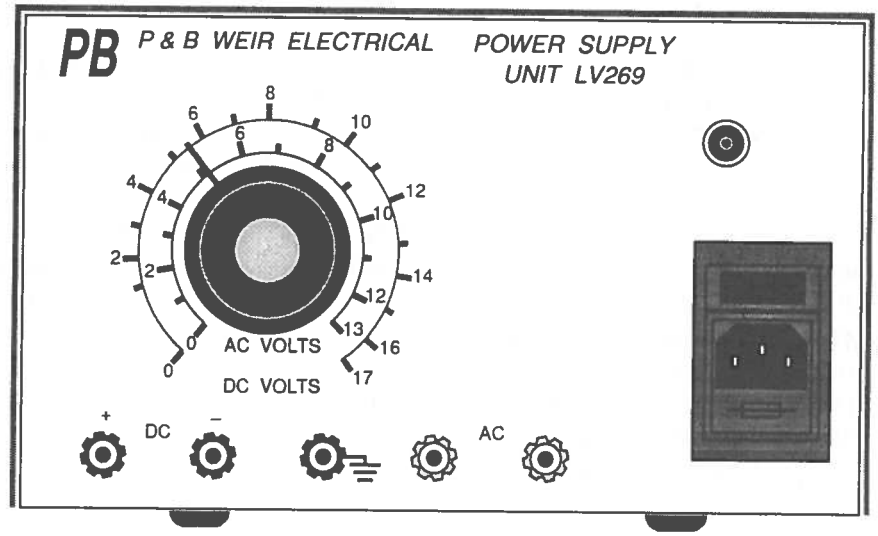


Enclosure : Extruded aluminium front panel with top lip for carrying; folded steel panel covering top, rear and base, deep blue, plastic coated with blue ABS plastic end panels.
Dimensions : Width 177 mm, depth 152 mm, height 163 mm.
Weight 2.2 kg. Stacking not recommended.
Detachable mains cord with IEC connector.
Internal mains fuse on printed circuit board.
Overcurrent protection : fuse on primary; electronic cut-out on the HT supply operated by an overcurrent on the outlets.
Outlets : 4 mm insulated sockets accepting 4 mm plugs.





Weir Power Supply Unit LV269 — *£143*



Function : Power supply for general laboratory use.

Specification : Continuously variable outlets up to 13 V a.c. and 17 V d.c. smoothed. Maximum current 8 A a.c. continuous, 8 A d.c. for 1 hour, or 6 A d.c. continuous. Outputs not referenced to earth. Functional earth socket provided.

Circuit : The supply is taken to a variable transformer (output = 0 - 230 V), from where it goes to an isolating transformer. The maximum voltage which this can deliver is 13 V a.c. The control knob on the front panel operates the variable transformer's output. The maximum voltage can be set by the position of a brass collar behind the control knob. This can only be reset by means of an Allen key.

The isolating transformer is protected by a fuse and electromagnetic cut-out.

The DC supply is full-wave rectified with capacitive smoothing.

Construction : Robust two-piece folded steel enclosure secured by anti-tamper screws. Built to Class 1 electrical safety standard. Complies with IEC 1010-1 on electrical safety, except that, on the unit we inspected, the spindle on the variable transformer had not been earth bonded.

Performance : AC voltage values hold up well with current when load is increased, but DC values fall considerably with load. The AC drop-off is better than average. The DC performance is a little worse.

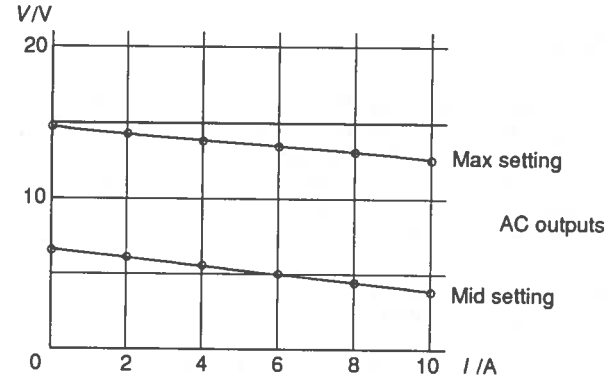
Maximum continuous current values are higher than specified. For instance the unit can deliver 14 A a.c. for 35 min, or 12 A d.c. for 3 min, before cutting out. Being able to deliver currents greater than 10 A is useful for some applications, such as certain experiments in electromagnetism, but could on occasions cause difficulties due to misuse by children.

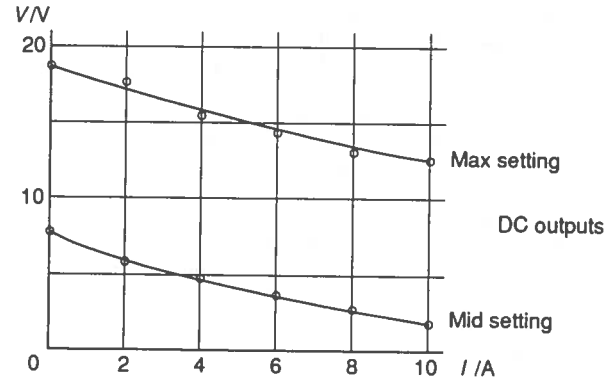
Both the overcurrent and overtemperature protection works satisfactorily and seem adequate. The maximum temperature rise was 36°C.

Verdict :

A (Very satisfactory, but expensive) (Conditional on assurances from Weir on variable transformer fitment)

Enclosure : 2-part folded steel enclosure. Stove enamelled in shades of mid and pale grey.
Dimensions : Width 228 mm, depth 165 mm, height 135 mm.
Weight 4.2 kg. No carrying handle, but cowl on lid is an aid to lifting. May be stacked in storage.
Detachable mains cord with IEC connector.
External mains fuse on IEC chassis plug on front panel.
Overcurrent protection : fuse and electromagnetic cut-out on primary supply.
Outlets : 4 mm insulated terminals accepting 4 mm plugs, or unterminated wire. Functional earth terminal.





Equipment Offers

Items are arranged by similarity of application, or for other reasons, and not by stock number sequence. Often the item number serves only for stock identification by us in making up orders. Newer stock items are underlined, so as to be more easily seen.

Since the publication of Bulletin 190 and the 5-14 Newsletter No. 11 the following changes to the listings have become necessary :

Withdrawals from stock : Regrettably several of our listed items are subject to uncertainty of supply. A number of items have to be dropped when stock runs out etc. The relevant items this time are :

629 : dual tone buzzer and 814 : ring magnet.

Other changes : Screened Kynar film (items 501 and 502) is no longer made in pieces 18 x 100 mm (item 501) the nearest equivalent now being only 12 x 30 mm which is a screened version of our item 503. The base cost of the new sensor is still £20 but 4 mm plug terminations are no longer included. By the time we add these the total cost is likely to be of order of £22. The new screened assembly has yet to be bench tested for its suitability in the various curricular applications and thus item 501 has been withdrawn meantime.

The unscreened version (Item 503) is still available but the manufacturer has significantly increased the price and we have had to follow suit.

Item 640 - disk thermistor - also is now no longer available at the 15 kilohm value at the size previously supplied. It has proved possible to stock a smaller version with the same characteristics and a superior tolerance. Its reduced power rating will have no appreciable effect in low voltage circuits.

VAT and postage : The prices quoted do not include VAT. However it is added to every customer's order. Local authority establishments will be able to reclaim this input VAT.

Postage and, where necessary, packing, will be charged for. It is therefore best not to send cash with an order, but wait for us to bill you. Official orders may be used. Please try and ask for at least £10 worth of goods because the administrative costs of handling orders are significant.

Don't send cash with orders

We repeat, please do not send payment with your order. Wait until you receive our advice note upon which payment may be made. This saves unnecessary complications e.g. when items are out of stock, failure to make provision for VAT, or if a delivery charge needs to be made. Items of equivalent value may be deducted from your order to balance any shortfall.

Motors

778 Stepper motor, Philips MB11, been stored in damp conditions but unused and retested. 4 phase, 12 V d.c., 100 mA per coil, 120 Ω coil per phase, step angle 7.5°, with 7 mm x 2 mm dia. output shaft. Dimensions 21 mm x 46 mm dia. on oval mounting plate with 2 fixing holes, diam. 3 mm, pitch 42 mm, at 56 mm centres. Circuit diagram supplied. £2.50

755 Pulley wheel kit comprising:
- plastic pulley wheel, 30 mm dia., with deep V-notch to fit 4 mm dia. shaft,
- two M4 grub screws to secure pulley wheel,
- Allen key for grub screws, and
- 3 mm to 4 mm axle adaptor.

The whole making up a kit devised for SSERC tacho-generators with 3 mm shafts.
Specially supplied to SSERC by Unilab. £1.25

614 Miniature motor, 3 V to 6 V d.c., no load current 220 mA at 9600 r.p.m. and 3 V, stall torque 110 mN m, dims. 30 mm x 24 mm dia., shaft 10 mm x 2 mm dia. 45p

593 Miniature motor, 1.5 V to 3 V d.c., no load current 350 mA at 14800 r.p.m. and 3 V, stall torque 50 mN m, dims. 25 mm x 21 mm dia., shaft 8 mm x 2 mm dia. 30p

739 Miniature motor, 1.5 V d.c., dimensions 23 mm x 15 mm dia., shaft 8 mm x 1.7 mm dia. 25p

621 Miniature motor, 1.5 V to 3 V d.c., open construction, ideal for demonstration, dimensions 19 x 9 x 18 mm, eight tooth pinion on output shaft. 25p

732 Motor with gear box, high torque, 1.5 V to 12 V d.c., 125 r.p.m. at 12 V, dimensions 40 x 40 x 28 mm, shaft 10 mm x 3 mm dia. with key. Suitable for driving buggies, conveyor belt, or any other mechanism requiring a slow drive £6.00

773 Tachometer (ex equipment) £2.25

811 Worm and gear for use with miniature motors, 34 : 1 reduction ratio plastic worm and gear wheel. 35p

378 Encoder disk, 15 slots, stainless steel, 30 mm dia. with 4 mm dia. fixing hole. 80p

642 Encoder disk, 30 slots, stainless steel, 30 mm dia. with 4 mm dia. fixing hole. 80p

772 Encoder disk, 4-bit Gray code, stainless steel, 81.28 mm dia., 3 mm fixing hole, slots sized to register with components mounted on 0.1" stripboard. Applications: shaft position sensing, wind direction indicator.
For related electronic circuitry see Bulletin 146. £3.00

Precision motor stock

785 Precision motor with optical shaft encoder, 0.25 to 24 V d.c., no load current and speed 9 mA and 6,600 r.p.m. at 24 V, stall torque 23 mNm, 9 segments. Overall body length including shaft encoder 59 mm, dia. 23 mm with output shaft 20 x 3 mm dia. Back EMF constant 3.6 V/1000 r.p.m. Suggested application - tachogenerator. Data on shaft encoder section available on application. £15

787 Precision motor with attached gearbox, 0.15 to 12 V d.c. With a supply of 3 V, the no load current is 25 mA and the output shaft turns at ca. 20 r.p.m. Gearbox ratio 1 : 365. Overall body length including gearbox 43.5 mm and diameter 16 mm. Output shaft 6 x 3 mm dia. with flat side to maximum depth of 0.3 mm along outer 5 mm length of shaft. Application - any system where a very slow angular velocity is required. £15

836 Motor mounts, plastic push-fit with self adhesive base pad, suitable for SSERC motors 593 & 614, pk of 10 £1.95

Miscellaneous items

801 Propeller, 3 blade, to fit 2 mm shaft, 62 long. 35p
(Replaces Item 791at lower cost).

792 Propeller kit with 10 hubs and 20 blades for making 2 or 3 bladed propellers. 130 mm diameter. Accepts either 2 mm or 3 mm shafts. £3.40

790 Buzzer, 3 V. 55p

827 Buzzer, 6 V. 55p

629 Dual tone buzzer with flashing light. WITHDRAWN

710 Sonic switch and motor assembly. First sound starts the motor, a second reverses the direction of rotation, a third sound stops the motor. Driven by 4 AA cells (not supplied). 85p

715 Pressure gauge, ca. 40 mm o.d. case, 25 mm deep and 33 mm dia. dial reading 0 to 4 bar (i.e. above atmospheric). With rear fitting for $^1/_8$" BSP. Suitable for use as indicator for pneumatic circuits in Technological Studies. 75p

165 Bimetallic strip, length 10 cm;
high expansivity metal: Ni/Cr/Fe - 22/3/75
low expansivity metal: Ni/Fe - 36/64 (invar) 15p

166 Ditto, but 30 cm length. 40p

385 Pressure switch, operable by water or air pressure. Rated 15 A, 250 V (low voltage operation therefore possible). Dimensions 2" x 3" dia. 65p

758 Loudspeaker, 8 Ω, 0.5 W, 66 mm dia. 50p

771 Neodymium magnet, 13.5 mm dia. x 3.5 mm thick. £1.30

814 Ring magnet, 24 mm o.d., 6 mm i.d. WITHDRAWN

837 Ring magnet, 40 mm o.d., 22 mm i.d. 35p

815 Ceramic block magnets, random polarisation, 19 x 19 x 5 mm. 15p

823 Ceramic block magnets, poles at ends, 10 x 6 x 22 mm. 12p

824 Ceramic block magnets, poles on faces, 25 x 19 x 6 mm. 35p

825 Forehead temperature measuring strips 50p

745 Sub-miniature microphone insert (ex James Bond?), dia. 9 mm, overall depth 5 mm, solder pad connections. 40p

723 Microswitch, miniature, SPDT, lever operated. 40p

354 Reed switch, SPST, 46 mm long overall, fits RS reed operating coil Type 3. 10p

738 Relay, 6 V coil, DPDT, contacts rated 3 A, 24 V d.c. or 110 V a.c. 75p

774 Solenoid, 12 V, stroke length 30 mm, spring not provided. £2.25

742 Key switch, 8 pole changeover. 40p

382 Wafer switch, rotary, 6 pole, 8 way. 70p

688 Croc clip, miniature, insulated, red. 5p

759 Ditto, black. 5p

788 Crocodile clip leads, assorted colours, insulated croc. clip at each end, 360 mm long. £1.35

809 Wire ended lamp, 3 V 10p

741 LES lamp, 6 V. 15p
770 ditto, but 12 V. 15p
789 MES lamp, 3.5 V, 0.3 A 9p
690 MES lamp, 6 V, 150 mA. 9p
691 MES battenholder. 20p

692 Battery holder, C-type cell, holds 4 cells, PP3 outlet. 20p

730 Battery holder, AA-type cell, holds 4 cells, PP3 outlet. 20p

835 Battery holder, AA-type cell, holds 2 cells, PP3 outlet. 15p

729 Battery connector, PP3 type, snap-on press-stud, also suitable for items 692 and 730. 5p

724 Dual in line (DIL) sockets, 8 way. 5p

760 DIL sockets, 14 way. 7p

826 DIL sockets, 16 way. 8p

808 Electrodes for making lemon or other fruit cells etc. 1 pair, comprising 1 of copper, 1 of zinc, each approx. 60 mm square, per pair 50p

716 3-core cable with heat resisting silicone rubber insulation, 0.75 mm² conductors, can be used to re-wire soldering irons as per Safety Notes, Bulletin 166. Per metre. £1.35

756 Silicone coated, braided glass sleeving, yellow, 2.5 mm dia., gives both heat and electrical insulation to conductors (e.g. for autoclave rewiring). Price per metre. 55p

714 Sign "Radioactive substance" to BS spec., 145 x 105 mm, semi-rigid plastic material. Suitable for labelling a radioactive materials store. With pictogram and legend. £2.70

763 Sign "DANGER, Electric shock risk" to BS spec., rigid plastic, 200 x 150 mm. £2.70

764 Sign "DANGER, Laser hazard" to BS spec., rigid plastic, 200 x 150 mm. £2.70

727 Hose clamp, clamping diameter from 8 mm to 90 mm, 101 uses - securing hose to metal pipe, tree to stake, joining wooden battens for blueing, etc. 30p

731 Re-usable cable ties, length 90 mm, width 2 mm, 50 per pack. 12p

752 Shandon chromatography solvent trough. £1.00

805 Condenser lens, bi-convex, 200 mm focal length, 75 mm dia. Crown glass. £12.50

806 Condenser lens, plano-convex, 150 mm focal length, 75 mm dia. Crown glass. £12.50

Components - resistors

420 resistors, 5% tolerance, ¼ W :
1R5, 4R7, 5R6, 6R8, 8R2, 10R, 15R, 22R, 33R, 47R, 56R, 68R, 82R, 100R, 120R, 150R, 180R, 220R, 270R, 330R, 390R, 470R, 560R, 680R, 820R, 1K0, 1K2, 1K5, 1K8, 2K2, 2K7, 3K3, 3K9, 4K7, 5K6, 6K8, 8K2, 10K, 12K, 15K, 18K, 22K, 27K, 33K, 39K, 47K, 56K, 68K, 82K, 100K, 150K, 220K, 330K, 390K, 470K, 680K, 1M0, 1M5, 2M2, 4M7, 10M. Per 10. 6p

421 DIL resistor networks, following values available: 62R. 1K0, 6K8, 10K, 20K, 150K. Per 10. 30p

BP100 Precision Helipots, Beckman, mainly 10 turn. 10p-50p

Components - capacitors

813 Capacitors, polystyrene: 4p
180 pF, 220 pF, 330 pF, 560 pF, 1000 pF, 2400 pF, 3000 pF, 3300 pF, 3900 pF & 4700 pF

695 Capacitors, tantalum,
15 µF 10 V, 47 µF 6.3 V. 1p

696 Capacitors, polycarbonate,
10 nF, 220 nF, 1 µF, 2.2 µF. 2p

697 Capacitor, polyester, 15 nF 63 V. 1p

698 Capacitors, electrolytic,
1 µF 25 V, 2.2 µF 63 V, 10 µF 35 V. 1p

358 Capacitor, electrolytic, 28 µF, 400 V. £1.00

Components - semiconductors

807 Schools' Chip Set, designed by Edinburgh University, comprises the 4 chips and prototype board. £4.00

Edinburgh University support material :
Volume 1 : Teaching Support Material (+£2 p&p). £4.50
Volume 2 : Laboratory Work (+£2 p&p). £5.00

322 Germanium diodes 8p

701 Transistor, BC184, NPN Si, low power. 4p

702 Transistor, BC214, PNP Si, low power. 4p

717 Triac, Z0105DT, 0.8 A, low power. 5p

725 MC74HC139N dual 2 to 4 line decoders/multiplexers 5p

699 MC14015BCP dual 4-stage shift register. 5p

711 Voltage regulator, 6.2 V, 100 mA, pre-cut leads. 10p

Sensors

615 Thermocouple wire, Type K, 0.5 mm dia., 1 m of each type supplied: Chromel (Ni Cr) and Alumel (Ni Al); for making thermocouples, see Bulletins 158 and 165. £2.20

640 Disk thermistor, (substitute type) resistance of 15 kΩ at 25°C, β = 4200 K. Means of accurate usage described in Bulletin 162. 30p

641 Precision R-T curve matched thermistor, resistance of 3000 Ω at 25°C, tolerance ±0.2°C, R-T characteristics supplied. Means of accurate usage described in Bulletin 162. £3.00

718 Pyroelectric infrared sensor, single element, Philips RPY101, spectral response 6.5 µm to >14 µm, recommended blanking frequency range of 0.1 Hz to 20 Hz. The sensor is sealed in a low profile TO39 can with a window optically coated to filter out wavelengths below 6.5 µm. Data sheet supplied. For application see SG Physics Technical Guide, Vol.2, pp 34-5. 50p

503 Kynar film, unscreened, 28 µm thick, surface area 12 x 30 mm, no connecting leads. £1.00p

504 Copper foil with conductive adhesive backing, makes pads for unscreened Kynar film to which connecting leads may be soldered. Priced per inch. 15p

506 Resistor, 1 gigohm, ¼ W. £1.40

Opto-electronic devices

507 Optical fibre, plastic, single strand, 1 mm dia. Applications described in Bulletin 140 and SG Physics Technical Guide Vol.1. Priced per metre. 50p
508 LEDs, 3 mm, red. Price per 10. 50p
761 Ditto, yellow. Per 10. 60p
762 Ditto, green. Per 10. 60p

Items not for posting

All of the following items are only available to callers because of our difficulties in packing and posting glassware and chemicals. We will of course hold items for a reasonable period of time to enable you to arrange an uplift.

Glassware, chemicals etc.

664 Flat bottom round flask, 500 ml. 50p

768 Sodium lamp, low pressure, 35 W. Notes on method of control available on application. 85p

810 Watch glasses, assorted sizes 20p

712 Smoke pellets. For testing local exhaust ventilation (LEV) - fume cupboards and extractor fans, etc. large, 50p, small 35p

SSERC, St Mary's Building, 23 Holyrood Road, Edinburgh, EH8 8AE;
Tel. 0131 558 8180, Fax. 0131 558 8191.

ASE, College Lane, Hatfield, Herts., AL10 9AA; Tel. 01707 267411, Fax. 01707 266532.

ASE Scotland, Secretary : Susan Burr, Newbarns, 18 Mainholm Holdings, Ayr KA6 5HE

Cowie Technology Group, Ridgeway, Coulby Newham, Middlesbrough, TS8 0TQ. Tel. 01642 59910, Fax. 01642 59810.

Data Harvest (Educational Electronics), Woburn Lodge, Waterloo Road, Linslade, Leighton Buzzard, Bedfordshire, LU7 7NR; Tel. 01525 373666, Fax. 0525 851638.

Edmund Scientific order via UK Agents : Coherent-Ealing Europe, Greycaine Road , Watford, WD2 4PW; Tel. 01923 242261, Fax. 01923 234220.

Griffin & George Limited, Bishop Meadow Road, Loughborough, Leicestershire LE11 0RG;
Tel. 01509 233344, Fax. 01509 231893.

Hanna Instruments Limited, Eden Way, Pages Industrial Park, Leighton Buzzard, Bedfordshire LU7 8TZ;
Tel (01525) 850855, Fax. (01525) 853668.

Philip Harris Education : 2 North Avenue, Clydebank Business Park, Clydebank, Glasgow G81 2DR;
Tel. 0141 952 9538, Fax. 0141 951 1033 and at
Lynn Lane, Shenstone, Lichfield, Staffordshire, WS14 0EE; Tel. 01543 480077, Fax. 01543 483056.

Hogg Laboratory Supplies Limited, Sloane Street, Birmingham, B1 3BW; Tel. (0121-233) 1972.

Science & Technology Department, Northern College, Aberdeen Campus, Hilton Place, Aberdeen AB9 1FA;
Tel. 01224 283500 Fax 01224 487046.

John Poulten Ltd, 77 - 93 Tanner Street, Barking, Essex, IG11 8QD;
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Tel. 01536 201201, Fax. 0536 201501.

SAPS (Science & Plants for Schools), Homerton College, Cambridge, CB2 2PH; Tel. 01223 411141 Ext 233, Fax. 01223 215004. SAPS Scottish Office : The Royal Botanic Garden, Edinburgh EH3 5LR;
Tel. 0131 552 7171 Ext. 465, Fax. 0131 552 0382.

Shaw Scientific Ltd, Agents - NES Arnold Ltd, Ludlow Hill Road, West Bridgford, Nottingham, NG2 6HD;
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P & B Weir Electrical, Unit 10, Leafield Way, Leafield Industrial Estate, Corsham, Wilts, SN13 9SW;
Tel. 01225 811449, Fax. 01225 810909.

Interference fringes produced when laser radiation is reflected off front and rear surfaces of a thin positive meniscus lens.