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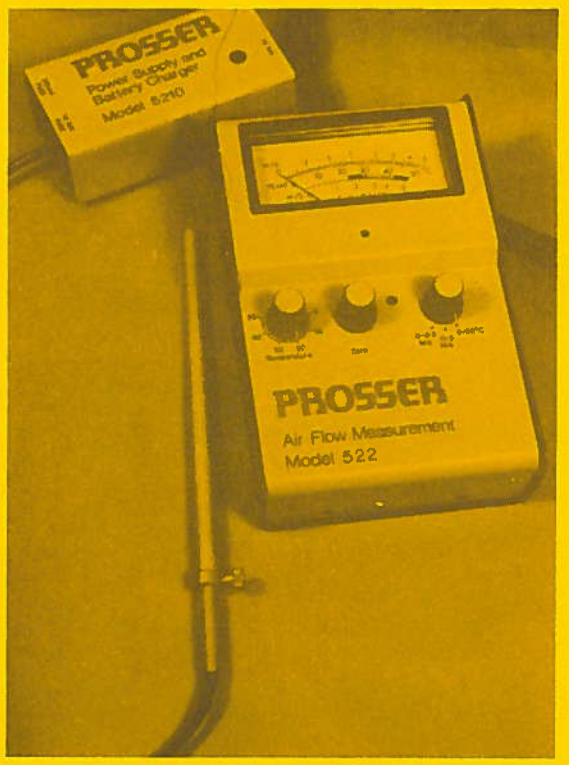
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE



For: Teachers and Technicians in Technical subjects and in the Sciences

Science & Technology Bulletin

Number 165

March 1990

Anemometers

SSERC, 24 Bernard Terrace, Edinburgh EH8 9NX; Tel. 031-668 4421.

Airflow Developments Ltd., Lancaster Road, Cressex Industrial Estate, High Wycombe, Buckinghamshire HP12 3QP; Tel. (0494) 25252/443281

ASE (Scottish Region) Annual Meeting, c/o Brian Carroll, Dryburgh Education Centre, Napier Drive, Dundee DD2 2TF; Tel. (0382) 612086.

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Unit 7, Altens Trade Centre, Hareness Circle, Aberdeen AB1 4LY; Tel. (0224 897022);
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British Thornton, PO Box 3, Wythenshawe, Manchester M22 4SS; Tel. 061-998 1311.
(Ian Douglas, Area Manager, Home Tel. (0592) 750587)

Brocks Explosives Ltd., Sanquhar, Dumfriesshire DG4 6JP; Tel. (0659) 50531.

Clandon Scientific Ltd., Lysons Avenue, Ashvale, Aldershot, Hampshire GU12 5QF; Tel. (0252) 51411.

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Damon/IEC (UK) Ltd., Unit 7, Lawrence Way, Brewers Hill Road, Dunstable, Bedfordshire LU6 1BD;
Tel. (0582) 604669.

DES Publications Despatch Centre, Government Buildings, Honeypot Lane, Stanmore, Middlesex HA7 1AZ.

Educational Electronics, 28 Lake Street, Leighton Buzzard, Bedfordshire; Tel. (0525) 373666.

J.W.Fairbairn Ltd., 120 Woodneuk Road, Darnley Estate, Glasgow G53 7QS; Tel. 041-880 7455.

(continued on inside back cover)

The Centre is an independent national advisory service, solely controlled and largely financed by Scottish Regional and Islands Councils as Education Authorities. It currently incorporates the Science Equipment Research Centre and the Scottish TVEI Joint Support Activity Project :

STERAC (Science and Technology Equipment Research and Advisory Centre).

Prosser 5225 and Lownes LEDA 1000 L anemometers.

OPINION

DTP Addiction

Desk Top Publishing is a wonderful facility. We all love it. It enables the maladroit to produce professional-looking worksheets.

Remember the days of hand-written worksheets, reproduced on an old spirit duplicator? They varied from useful to illegible, from elegant to awful. The useful took some time to compose. Elegance and legibility may have come easily to some teachers, painfully to others. For some of us they were impossibilities. Typewriters and photocopiers changed all that. Everyone could produce legible sheets, although for the stubborn who wouldn't learn to touch type (most) and didn't have a nimble fingered slave, there was a substantial cost in time. It would be churlish to suggest that some of that time may have been recovered by a cut-back in care over content and composition.

Word-processors were a great leap forward. Gone were the agonizing decisions whether to start a sheet again or put up with that eleventh typographical error. Now we could put an extra paragraph between the second and third, after we were half way through typing. We could adapt large chunks of old worksheets, a wee bit out of date or written for a different kind of class. Time was saved.

DTP has nothing to do with saving time. After we've finished typing in the material, and editing the content, we start worrying about a completely new exercise: presentation. The word-processed worksheet is perfectly clear, but the DTP product is beautiful. Back to agonizing decisions. Should I put this paragraph at the top of the next page, or close everything up a little? Would this look better in bold, or italics? Should I put text opposite that table, or would it be better to use this graphic (that I spent an hour getting just right)? Let's just try this other layout and see what it looks like.

Who can spare the time to think whether the beautiful worksheets are any use in the classroom? Whether the facts are accurate, or the principles well elucidated? Just to twist the knife a little, much of the beauty is in the eye of the creator. Frequently there is precious little in the eye of the beholder. DTP may give us the tools for good presentation, but how many of us have the necessary skills? There is value in good presentation, of course - but unless we are publishing for a large readership it is not worth the expenditure of large amounts of time. DTP is a profligate consumer of time.

INTRODUCTION

Easter Closure

Centre staff will all be on holiday from the close of business at 5 p.m. on Thursday the 12th of April until 9 a.m. on Tuesday the 17th of April 1990.

Saturday mornings

Saturday morning opening is to continue until at least the end of the current school session. We will be open therefore on the first two Saturdays of each month, from 9 a.m. until 1 p.m. Note that because of the Easter break (see above) there will be only one Saturday opening in April - the 7th.

The last such opening this session will be on the 9th of June. We will remain open on weekdays right through the Summer holiday period but will suspend Saturday morning openings until September.

Scottish A.S.E. Annual Meeting

The 1990 meeting will be held in Dundee University from 10th-12th April inclusive. Programme details and booking forms were sent out as inserts with the Scottish circulation of the January issue of "Education in Science", the official journal of the Association for Science Education.

Non-members interested in attending should contact one of the nominated members of the local organising committee (see Address List on the inside front cover of this Bulletin).

Technology - open courses

The Dundee courses on technology in schools are again to be run on an open basis. These courses, run at the Northern College's Dundee Campus, started life as official National Courses for the nominees of Scottish EAs. Their success ensured their continuation and so a series of courses is again on offer. The courses will be held during the fortnight - 18th to the 29th of June 1990.

SSERC staff will once more be tutoring, having been invited back to organise and run a practical workshop session for the course on Higher Grade Technological Studies.

Initial details of all of these courses have already been circulated by the in-service section of Northern College to Scottish schools and other relevant establishments. Other interested parties who have not received the provisional course outline should contact Dr.F.Partington at the College (see Address List)

Bulletin blockages

We are sorry to drone on again about the non-distribution of "Bulletin" copies. We are currently trying to streamline those parts of the system over which we have some influence, the bits between here and the schools and colleges. There are however, some parts which only you - our clients - can reach. What evidence we have points to major breakdowns in circulation somewhere in the schools themselves.

We are thus faced, at least in part, with a classical "Catch 22". If you don't get your copy then you obviously cannot be reading this. If you do and you are: (no, not "you must be crazy!") please do investigate on behalf of colleagues where all the Bulletin copies which enter your school or college actually go. A number of folk have complained to us that copies do not reach those who could make best use of them, or that copies are filed away by PTs, etc. without being circulated.

Bulletin production

The best spur to circulation is of course to make a publication so useful that folk actively seek it out. To that end, in our next issue, we will be making some changes to Bulletin layout and format. Despite what we have said elsewhere about the snares and delusions attendant on desk-top publishing we judge it proper that we use it in an attempt to improve the quality of the Bulletin.

Which brings us straightway to a grovel. We apologise for the poor quality of some of the diagrams in Bulletin 164. This was through experimental origination methods, which caused production problems.

Technical Resource Support for Standard Grade Chemistry

Most chemistry readers will be aware that SSERC has been preparing "Practical Guides" in support of Standard Grade Chemistry. The first of these, Volume 1, was distributed some time ago. As this Bulletin goes to press Volume 2, covering Topics 6, 8/9 and 10-13, has been sent to SCCC for distribution.

Again each secondary school in Scotland will receive one copy free, with further copies available at £5 each (incl. post and packing).

Surveys of consumer opinion

This Bulletin contains two short questionnaires the completion and return of which should give us valuable information on two sorts of science and technology education equipment - electronics teaching kits and eye protectors.

Both groups of products suffer from wear and tear as well as possible abuse. We did consider field trials with samples placed in schools. We felt however that these could well be an unwieldy, slow way to obtain the sorts of information which we seek. We have thus plumped for a historical approach which will at least tell us something of the good and bad features of products already in use in Scottish schools.

We hope that readers will not be annoyed by this request to them for the filling in of yet more forms. We are conscious that it was as recently as Bulletin 163 that the last such request was made. These questionnaires are different in purpose to the Bulletin insert in issue 163. That form-filling, for the external evaluation of SSERC, was possibly open to the usual cynical question associated with educational research - "Are they doing this for me, or I am doing it for them?".

Be assured, on this occasion the short time required of relevant staff to complete the forms should be time well spent. We will use the data to both advise purchasers in the future and in persuading suppliers to improve their products.

Interactivity

It has been said that interactive exhibits are the ones that you should touch, but are really too frightened to do so!

Perhaps that is being perversely cynical and adult. I think so! Being present at the opening of Scotland's first interactive science and technology centre in Aberdeen there was no sign of fear amongst the children swarming around, under, over and within the exhibits.

The value of such exhibitions in encouraging children to learn about, and adults to take an interest in, science and technology has long been recognised. It is splendid news that two interactive exhibition centres open this year in Scotland.

February saw the opening in Aberdeen of Satrosphere, a permanent exhibition, centrally sited just off the west end of Union Street. It is the brainchild of Dr Lesley Glasser, Director of SATRO North Scotland, the science and technology regional organisation.

This April should see the opening of The Glasgow Dome of Discovery. It uses the Rotunda, on the south bank of the River in what was Nardini's ice cream parlour at the Garden Festival. The prime organiser here is the Hunterian Museum of Glasgow University. There is initial funding for one year. It is hoped that this will be extended so that the exhibition can become permanently established.

Both exhibitions cater for parties of school-children. Teachers wishing to book can find addresses and telephone numbers on the inside cover.

STANDARD GRADE TECHNOLOGICAL STUDIES

Editorial Foreword

That which follows completes a trilogy of articles on how coursework for the new Standard Grade might be organised, managed and taught. In Bulletin 163 we explained some of our reasons for going beyond our previously established remit in order to deal with such issues. With the last article in this particular series we may be in danger of doing some serious toe-treading since it is largely discussive and deals with appropriate forms of assessment.

We are sure however, that this issue must be raised before turning our attention to more detailed technical aspects of the course. In prescribing Technological Studies as a largely process-based course, with only broadly specified content areas, the folk responsible undoubtedly took calculated risks. We think they were right so to do. Their critics may however include a number of teachers who remain unconvinced of the practical, detailed implementation of such an approach in day to day classroom activities.

There is therefore a need to develop and support sound working practices which underpin the broad philosophy and aims behind the course. Without tactics even the soundest of strategies may founder in the field. It is as well, then, to remember that no matter how laudable are the aims and intentions of any course, all may be lost if individual teachers cannot see how the work might be managed and taught.

Active learning, educating for capability, learning through solving practical problems, picking up and using ideas in natural, rather than forced, contexts - these and other aims, such as learning to work in teams, are all worthy of the most careful fostering. Some teaching and learning styles, possibly many, are clearly incompatible with such aims. Above all, insensitively chosen or applied means of assessment could destroy all that which had been striven for.

We think it only proper that the last of these general articles by a classroom practitioner should be on the assessment of project-based work. The author is only a recent seeker of asylum (take that how you will) in the SSERC ivory tower. Before that he taught in a school which trialled Standard Grade Technological Studies. We feel sure that his practical experience will prove useful to others - even if only in stimulating their own thinking on how to implement the SEB Conditions and Arrangements document.

Assessment and Profiling

Introduction

Earlier articles in this series attempted to explore ways in which a project based and pupil centred course might be organised so as to comply with SEB guidelines. Specifically an attempt was made to show how careful top-down analysis and choice of context for projects could limit the risks of the need-to-know and problem solving approaches recommended for the course.

It remains difficult however for some teachers to be persuaded of the practicality of such teaching and learning styles. Their own education (and mine) was founded on a knowledge base gained largely in the abstract but one built in hopes of eventual application. In consequence, many find it hard to see how pupils might solve practical problems without having first acquired appropriate theoretical knowledge.

Hence the temptation to be didactic, to feed knowledge to pupils in bite-sized chunks and to use small, well controlled, projects to test whether or no the knowledge has been taken in. That is not the philosophy of Standard Grade as set out either in original Joint Working Party Reports or elsewhere since in SCCC or SEB papers. In 20th century Western society there is no shortage of informational material - possibly the contrary. Memorising such material no longer equates with being educated or knowledgeable. Just as important now, if not more so, are knowledge and experience of the means and skills through which such information is sourced, sorted, judged and used.

But, whilst we might argue over the means by which pupils are to acquire knowledge and skills, we cannot deny that a scheme entirely without mechanisms for testing whether they had actually acquired such would be unsound and thoroughly unprofessional. One escape from such a dilemma is through the integration of assessment into the management of the course. Indeed, techniques of continuous assessment may serve several purposes. The prime aim of this article is to explore two such major applications within Technological Studies, namely, how continuous assessment may:

- be an effective analytical tool assisting curricular refinement and
- provide data on the performance of individual pupils and inform the compiling of profiles.

In the first role assessment is largely diagnostic, being concerned with the effectiveness of the course itself - for example, its structure, style, suggested activities and resources. In the second category the assessment may be both diagnostic and formative. It may pinpoint specific areas of difficulty being met by pupils and thus inform remediation.

A systems approach

It is all too easy to pontificate on assessment. Much harder is the turning of ideas into effective classroom tools.

In illustrating some of the ways in which such assessment may be implemented, a systems analysis approach (as outlined in Bulletins 163 and 164) will again be used.

Figure 1 is repeated from Bulletin 163 and deals with the broadest category of diagnostic assessment - that of the whole course and all aspects of its delivery and assessment. Note that, as shown, this overall system can exert little or no immediate control at classroom or school level. Moderation happens before pupils are exposed to the work. Although it may thereby improve a course at the outset, moderation does not assist pupils once that course has begun.

Evaluation, on the other hand, tends in practice to be done at the end of a course. For Technological Studies this means summative assessments, by teachers for the problem solving aspects, by SEB for the knowledge and understanding bits. Such assessment comes too late in the day for that set of pupils to correct any weaknesses in their performance or for the SEB to modify the assessment instruments.

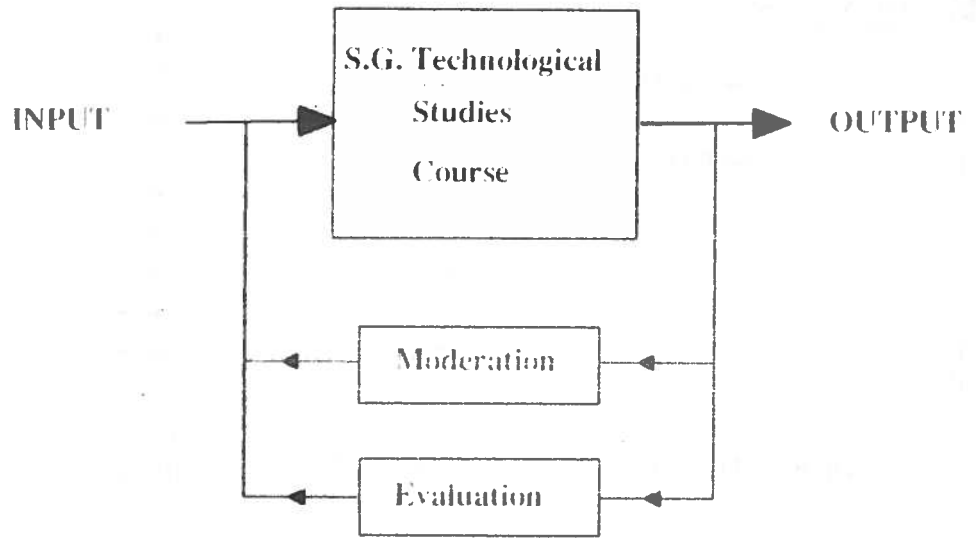


Fig.1

It seems that although moderation and evaluation may provide valuable feedback over the longer term, they can provide little or no control at the time to assist any paricular cohort of students. Continuous assessment may be able to improve matters. To see how, we need to look deeper into the system.

Open-loop - immediate perfection?

Again readers may recall, but this time from Bulletin 164, the diagram shown here as Figure 2. It illustrates one project based scheme used to flesh out the course outline and intended to cover required learning outcomes.

As shown, it is effectively an open-loop system. The only control is exercised at the end in ascertaining whether or not pupils can satisfy the appropriate performance criteria. It is a system which can only work on the assumption of a perfect course suitable for all pupils of all abilities and interests.

This is an unlikely prospect. Even were it to be met with, the absence of assessment at earlier stages means opportunities lost for the gathering of data of likely value in the detailed management of learning.

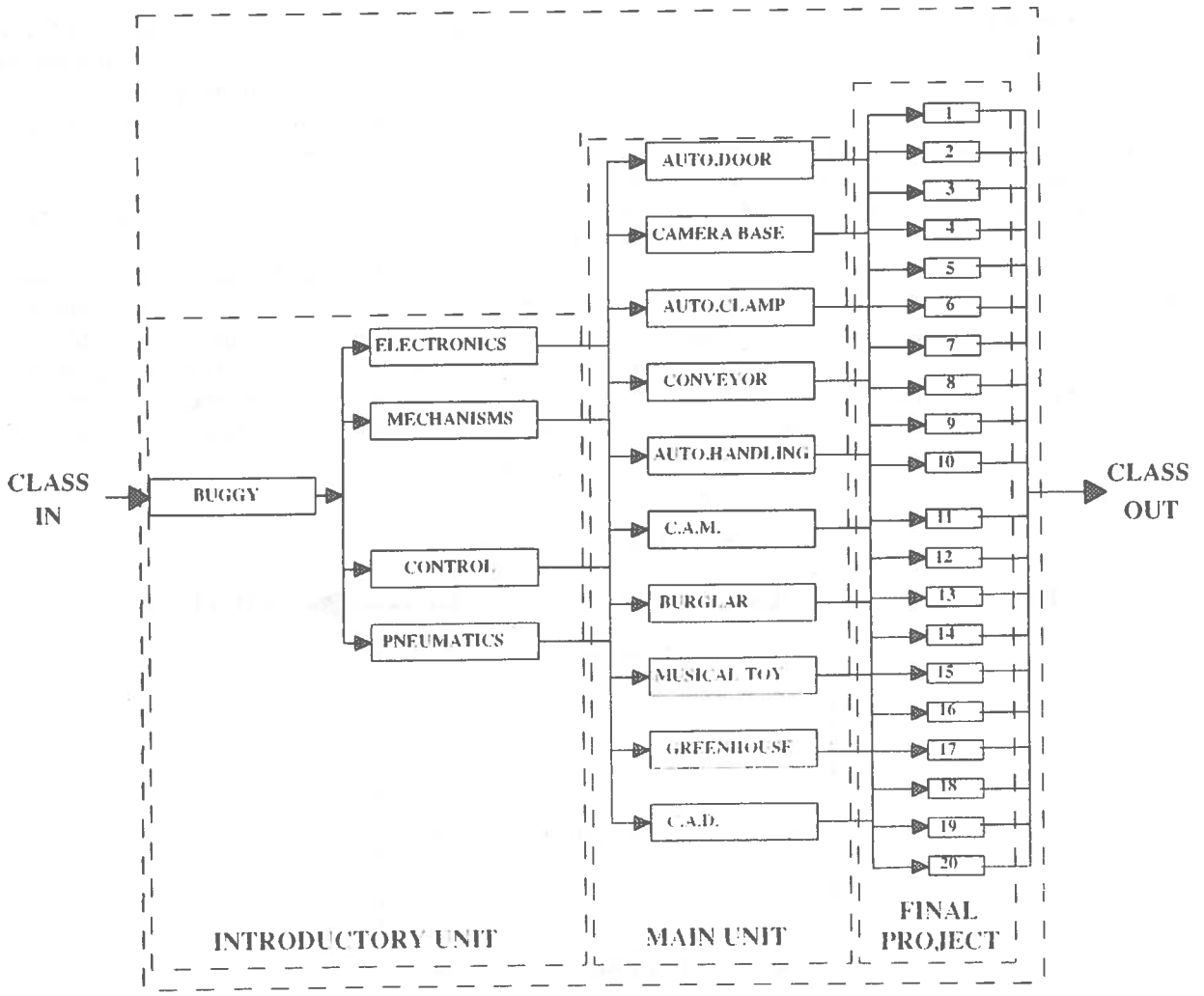


Fig. 2

Pragmatic solutions

If assessment cannot be left too late, where then might it be used?

Consider the Introductory Unit with its four discrete elements: Mechanisms, Electronics, Pneumatics and Computer Control with some integration and overlap occurring naturally. Consider also a scheme of work where this introductory unit is tackled on a stations basis. There are four stations and a matching number of separate pupil groups. Each is allocated one of the four areas of activity. In four, ten hour, cycles each group will eventually rotate round all the activities in 40 hours, spread over a number of weeks.

In Figure 3 the system is illustrated for just one of the four activities - Electronics. Here alone five points are indicated where simple assessment may be done. Apply the same idea to the other three activities and it can be seen that there is no lack of opportunity for the continuous assessment of pupil progress.

Looking in more detail at this scheme for Electronics reveals four project activities. Each has assigned to it a set of clearly stated learning outcomes. The assessment elements at the top of the figure, in what is labelled the "forward path", are best made informal:

- teacher led discussion with an individual pupil wherein the pupil is required to justify a particular choice of solution to a specific problem,

- pupil reports of progress either orally or in writing (e.g. in a diary of work),

- teacher's observations of work in progress and of completed worksheets or similar resources.

Such informal assessment should be diagnostic since it can reveal strengths and weaknesses in pupil performance, in the scheme of work, and in support materials. It may also be formative, allowing the teacher a clearer insight into the progress of individual pupils. It can provide feedback so that project activities may be improved for the next group.

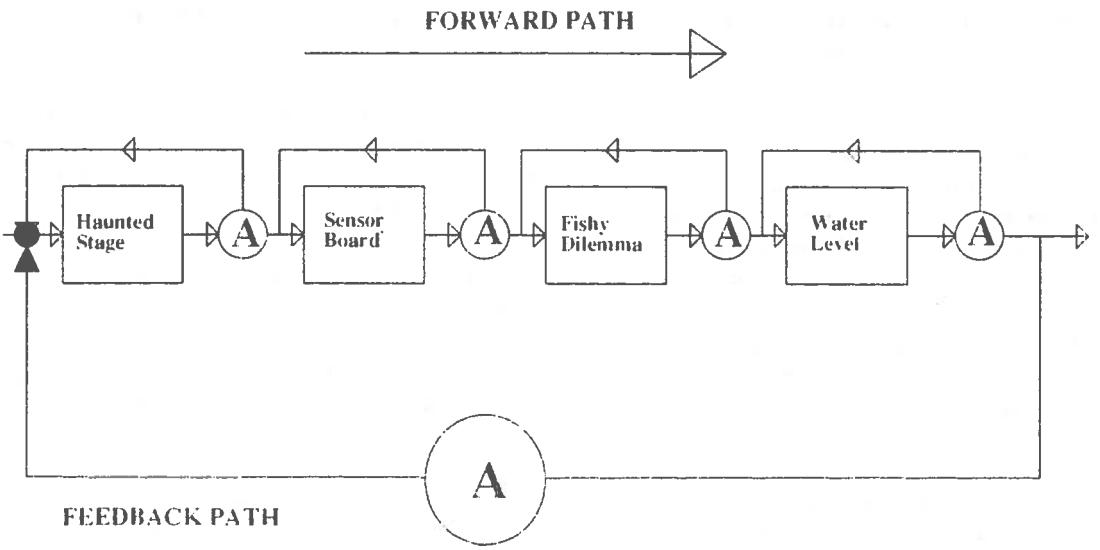


Fig. 3

It may also provide 'feedforward' in that it can influence the way in which the next project activity in the sequence is presented or supported for any particular pupil or group of pupils.

The single assessment step shown at the bottom of the figure ("feedback path") may be slightly more formal. One relatively simple method is through the use of perhaps ten multiple choice questions based on the learning outcomes for the electronics element. The administrative burden may be eased with the introduction of an element of self assessment using a microcomputer. The results from any one area of study can be pooled with those from the informal assessments for the other four project activities.

Taken together the resulting data should be more than adequate for the dual purposes of further refining teaching and learning and of building up pupils' performance profiles. For the former improvements can, where necessary, be effected almost immediately. Should a difficulty or weakness in an activity be identified for one group of pupils, there is the opportunity to correct matters for the next.

Main Unit Projects

Similar tactics can be adopted for the Main Unit but here it is suggested that pupils are paired. At the outset each pupil pair is allocated a case-study or 'project context' from a menu of ten or so. Each such will require about 8 to 10 hours for the work to develop. This allows a reasonable chance that the appropriate learning outcomes will be covered before that pair moves on to look at another problem set in a different context.

Assessment is carried out after the pupils have tackled a problem. The results may then help the teacher to decide the level at which the next problem might be set. The problem itself may be modified or the provision of assistance or information may be increased, or reduced, for any particular pupil pair. Assessment results from the Introductory Unit activities have obviously to inform decisions related to pupils' entry to their first Main Unit activity.

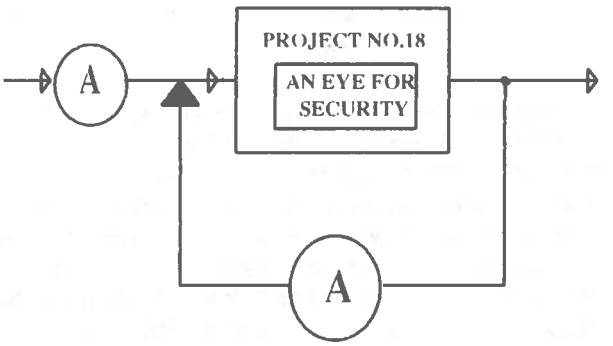


Fig. 4.

Such an assessment system may then again provide feedforward in that information from work in the Introductory Unit may influence approaches to individual Main Unit project activities. It also provides negative feedback - as iterative loops both within and at the end of any one project. As for the Introductory Unit activities the results may be used:

-during a project to modify it for the pupil pair currently engaged in it, or

-at the end of a project to modify it for the next pair coming along.

Available assessment techniques include all those informal and semi-formal elements already indicated for the Introductory Unit activities but supplemented with:

-written project reports of the SEB recommended format [1],

-more formal, organised, oral, reporting back of progress (to the teacher and, or, fellow pupils) or,

-a short, end of project, written test based on the stated learning outcomes for that project.

SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE

ELECTRONIC SYSTEMS BOARDS: FRIEND OR FOE ?

Electronic systems boards are now used extensively in the technical and science departments of Scottish secondary schools. Indeed some departments may have been using them for over four years. In the light of that experience we would like to consider their worth. Have they stood up to constant classroom use? And, perhaps more importantly, have they promoted the development of understanding of electronics in both teachers and pupils? A task they were designed to achieve.

This questionnaire is an attempt to address these issues.

Please circle the appropriate number, or tick 'Yes' or 'No' and return the completed form to:

SSERC 24 Bernard Terrace, Edinburgh, EH8 9NX

If you have any additional general or specific comments on this subject please continue on a separate sheet of paper. If you are willing to be contacted directly in any follow up please give also your name and that of your school.

Section A : Pupil usage

1. How long have you been using systems boards?

   1 One year
   2 Two years
   3 Three years
   4 Four years

2. Which type of board have you been using?

   1 E and L
   2 Unilab
   3 Other

   If other please specify:

3. How reliable do you consider these systems boards to be?

   1 Very
   2 Fairly
   3 Unreliable

4. Are there any particular boards you find unreliable? Yes / No

   If 'Yes' please specify which ones:

5. Do you regard electronic system boards as safe to use? Yes / No

6. Do you find pupils can easily construct electronic systems? Yes / No

Section B: Classroom management

7. If you answered 'Yes' to Q6 do you consider the speed at which pupils work to be of advantage or disadvantage in classroom management?
   1. Advantage
   2. Disadvantage

8. How would you describe the use ofsystems boards in integrated, Main Unit, projects? (SG Technological Studies).
   1. Straightforward
   2. Fairly easy
   3. Difficult
   4. Very Difficult

9. Do you consider there to be enough backup material to describe the function and operation of system boards? Yes / No

Section C: Electronic concepts

After completing a course that includes the use of system boards as a teaching aid do you consider that pupils understand:

9. The difference between analogue and digital signals. Yes / No

10. The concept of logic levels. Yes / No

11. How a voltage divider works. Yes / No

12. That electronic systems are generally small scale. Yes / No

Section D General Comments

SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE

EYE PROTECTION SURVEY

Concern has been expressed to SSERC over the costs of replacing damaged parts or worn lenses in safety spectacles and goggles. We are considering appropriate specifications or guidelines for future purchases of eye protection for use in Scottish school science laboratories. A pre-requisite is the gathering of information on those types of eye protection in use in schools. We would be most grateful if you would spare the time to complete and return this short questionnaire.

1. **PATTERNS OF PROVISION** - what type(s) of protector do you use?

a). Spectacles (to BS2092) _____? b). Goggles to BS2092C (or 2092 1C or 2092 2C) _____? c). Faceshields _____?

Many schools have settled on mixed provision with different kinds of protectors in use for different tasks. Briefly describe the pattern of any such provision in your school:

2. **PROBLEMS**

What would you say were the major problem areas connected with eye protection in your science departments?

Are they connected with:

A. **Poor fit** _____? If so please briefly describe specific problems or models.

B. **Breakages** _____? More specifically: a). Broken frames ____?

b). Lens fixings ____? c). Loose or missing screws ____?

d). Other ____ specify:

cont./

Please detail any specific types or models which have proved especially unreliable or, more positively, any which seem particularly robust mechanically:

C. Scratched lenses ____? If so were the protectors -

a). Spectacles ____? b). Goggles ____? c). Other ____?

Lens material (if known) : acetate ____? polycarbonate ____?

Supplier, model & cat. ref. where known:

Are replacement lenses available ___?

Have you any ____? If yes did you buy them with the protectors ____? or later ____?

Have you ever attempted to re-polish lenses ____? If yes, did you use:

metal polish ____? perspex polish ____? other ____?(specify)

Any comments on their relative effectiveness?

D. Storage ____? If so, briefly specify type of problem -

If this is not a serious problem do you use special or protective storage arrangements ____?

[Constructional details for any such arrangements gratefully received].

3. **GENERAL COMMENTS** (if need be continue on a separate piece of paper). If you are willing to be contacted directly in any follow up please give also your name and that of your school.

THANK YOU FOR YOUR TIME

SSERC, 24 Bernard Terrace, Edinburgh EH8 9NX Tel.031 668 4421

Handling the data

The rotational nature of such a scheme allows for the continual development of resources and ways of working to the benefit of all the pupils actually following the course. Integration of assessment as a continuous process throughout the course allows also for the possibility of building up comprehensive records of positive, pupil achievement. That depends however on mechanisms for the methodical recording and analysis of a lot of assessment data. Such record keeping and analysis could prove burdensome. Indeed it is looked upon by a lot of teachers of many a Standard Grade subject as the most wearisome of many a tiresome task.

One way to lighten the load is the use of database software to record and then process the assessment results. There are a number of such database programs, running on hardware commonly held in schools. Some are up to the task of assisting the building up of pupil performance profiles. One such program which has been applied to assessment management for Technological Studies is "KEY" from ITV.

Within the database records are set aside for each pupil and, within each record, fields are assigned for elements of pupil performance in each project activity. For example the following fields have proved useful:

Knowledge and Understanding
Problem Solving
Technological Communication
Ability to Work with Others
Attitudes
Adaptability
Progress

Numerical values may be assigned to fields to reflect levels of pupil achievement. This allows for the display of assessment data as graphs so that both pupil and teacher may observe progress. Pupils are thus given free and direct access to the database. There is merit in actively so encouraging them to use it. Such use may not only provide motivation but can also assist with the development of their own information gathering and data handling skills.

Summary

Technological Studies is but part of what should be a sea-change in Scottish secondary education. It is, in practice, still evolving. It is also, we believe, likely to emerge from that evolutionary process able to make a significant contribution to the development of technological awareness and capability of all pupils, only if the chosen assessment methods underpin, rather than counteract, the aims of the course. Indeed, close linkage between assessment and curriculum is fundamental to the philosophy behind the whole of Standard Grade.

References

1. "Starter Materials : Pack 3 - Project Briefs", 1988, Scottish Consultative Council on the Curriculum.

* * * *

Further notes on thermocouples

Introduction

The design of an electronic thermometer using a Type K thermocouple and a specialised thermocouple amplifier with cold junction compensation is described. This should interest anyone wanting to build a cheap thermometer with a working range of -200°C to +1250°C.

The article should be seen as a refinement of that which we published on thermocouples in Bulletin 158.

Thermocouples

Thermal emf's are generated along lengths of conductors which are subjected to temperature gradients and not, as is sometimes mistakenly thought, at junctions between conductors. The design of a thermocouple thermometer needs to take account of this fact. A thermocouple voltage is the difference in the thermal emf's produced in two dissimilar conducting wires in the same temperature gradient.

It follows that differences such as impurities, or physical or thermal stress, affecting the thermocouple wires in regions of temperature gradient are significant. It also follows that differences in isothermal regions are not significant.

Our design uses wires of Type K thermocouple metals. This is by far the most widely used industrial thermocouple combination. The two dissimilar materials are chromel and alumel wire, both of 0.5 mm diameter. These are stocked by SSERC for sale to schools at £2/metre pair (order code 615).

Thermocouple emf's are always tabulated with respect to the ice-point of water. The Type K response is roughly linear between 0°C and +1200°C, having a sensitivity of about 40 uV/°C.

Comment on earlier designs

Our earlier, simple design (Fig.1) in Bulletin 158 had a main, or probe, junction comprising four twists of chromel and alumel wire. The other ends of the thermocouple wires were both soldered to 4 mm sockets across which the voltmeter was connected. The secondary junction was therefore at whatever temperature was ambient at the 4 mm sockets.

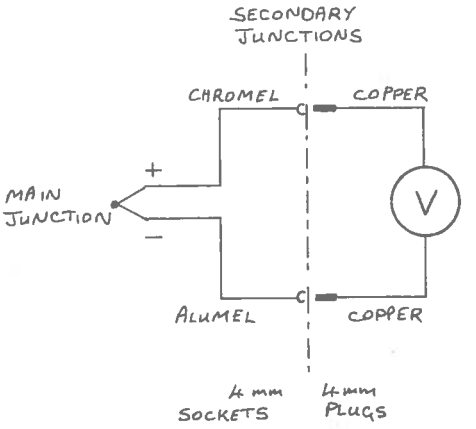


Fig.1 – Very simple thermocouple thermometer

The version with the x25 amplifier (Bulletin 158 and S.G.Chemistry Practical Guide) is physically similar. The secondary junction again is at the temperature of the connections on the amplifier board.

These circuits had been designed primarily for high temperature measurements, such as Bunsen flame profiles. Unquestionably they provide fairly good estimates.

These estimates can be corrected for what is assuaged to be the temperature of the secondary point. For instance if the secondary point temperature is judged to be +30°C then the tabulated emf for +30°C should be added to the measured thermocouple emf as shown below.

measured thermocouple emf	=	44.66 mV
thermocouple emf at 30°C	=	1.20 mV
corrected thermocouple emf	=	45.86 mV
temperature of main junction read from table	=	1120°C

Water-ice point thermocouple

If making a thermocouple referenced to the water-ice point, care has to be taken that the voltmeter is sited in a part of the conductors that is not, and would not be in the absence of the voltmeter, subject to a temperature gradient. This may scarcely be practicable.

One way is to take the thermocouple wires from the main junction, X, to two secondary junctions, Y and Z, which are held at the same temperature, usually 0°C (Fig.2). A voltmeter is connected by copper conductors to junctions Y and Z.

Another way is to use two thermocouple junctions, P and Q, and break open one of the thermoelectric conductors, so inserting the voltmeter.

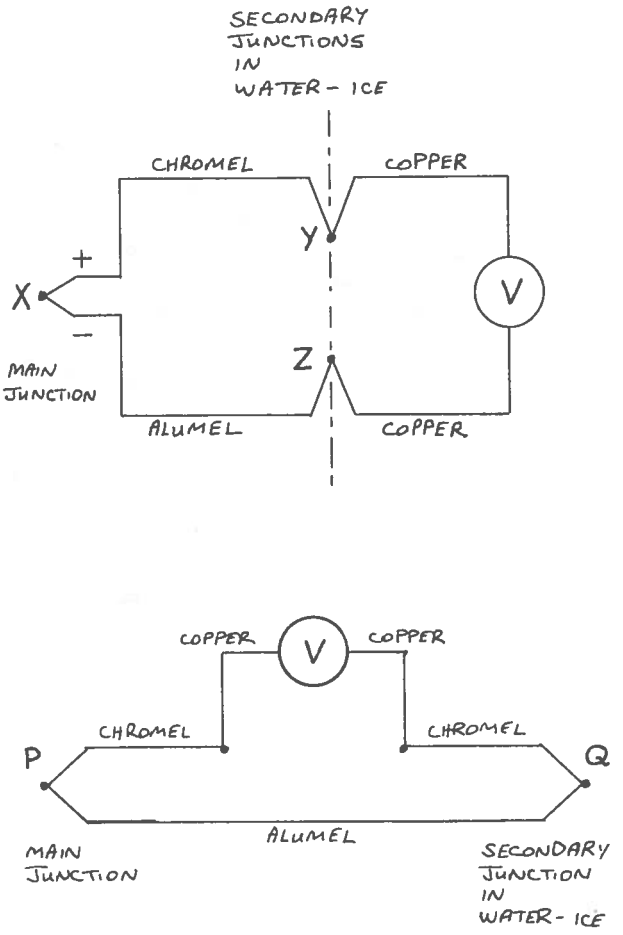


Fig.2 - Simple water-ice point thermocouples

It should be clear that any advantage conferred by the use of a water-ice junction in removing the need for applying corrections has to be offset by the errors which may be introduced by not siting the voltmeter in an isothermal part of the thermocouple, and by not maintaining the secondary junction at exactly 0°C.

A further disadvantage is the complexity and messiness of working with secondary junctions at the water-ice point.

Refined design

We now get to the point of the article.

The refined design uses an instrumentation amplifier and thermocouple cold junction compensator on a monolithic chip. This specialized integrated circuit is product number AD595 from Analog Devices.

The main junction, as in the earlier designs, should comprise four twists of 0.5 mm diameter chromel and alumel wire. Both lengths should be similar at about 300 mm each, or longer, depending on the application. The other ends of the thermocouple wires should be soldered symetrically to 0.1" stripboard adjacent to pins 1 and 14 (Fig.3), which are the inputs to the instrumentation amplifier found within the AD595.

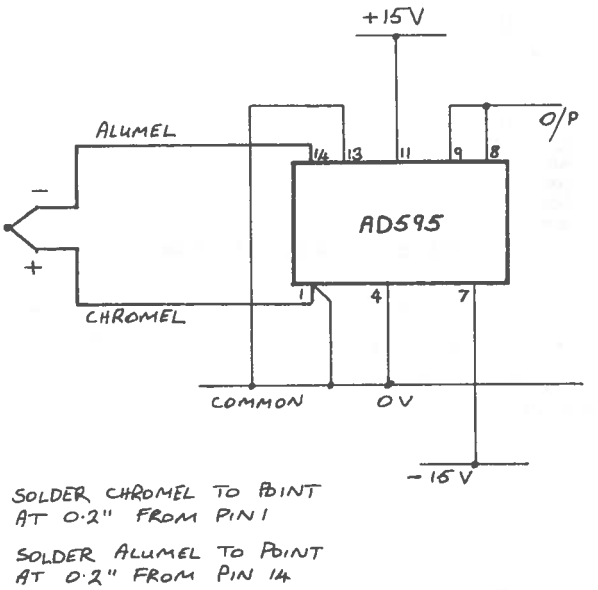


Fig.3 - Refined design: thermocouple thermometer

The cold junction compensator includes a temperature sensor within the AD595. The voltage generated by the compensator is referenced to 0°C and scaled to the Type K thermocouple sensitivity. This reference voltage is added to the output of the instrumentation amplifier. The signal from the summing point is amplified and then taken to pin 9 to provide outputs.

The circuit should be powered by a +/- 15 V dual rail regulated supply. The output range cannot swing to within less than 2.5 V of the positive rail. The highest possible output of ±12.5 V corresponds to a temperature of about 1250°C.

The AD595 output voltage is shown in Table 1 against the thermocouple temperature and thermocouple voltage.

Thermocouple temperature (°C)	Type K voltage (mV)	AD595 output (mV)
-200	-5.891	-1454
-100	-3.553	-876
0	0	3
100	4.095	1015
200	8.137	2015
300	12.207	3022
400	16.395	4057
500	20.640	5017
600	24.902	6161
700	28.128	7206
800	33.277	8232
900	37.325	9233
1000	41.269	10209
1100	45.108	11158
1200	48.828	12078

Table 1 - AD595 performance

The version of the AD595 available from the suppliers below is subject to an uncertainty over the calibration of the reference point of ±3°C maximum.

Strain relief

The physical support between the thermocouple wire and AD595 circuitry should not depend on the electrical connections. Stresses within the solder joints, or the copper stripboard tracks, may affect accuracy.

We suggest mounting the AD595 on stripboard such that pins 1 and 14 are about 30 mm from the stripboard edge. The thermocouple wire should be taken from the connections adjacent to these pins and run slackly along the top surface to the edge of the board, where it should be tied down by insulated copper wire. These tie points would then take the strain.

Concluding remarks

Our refined design describes how to use an AD595 to build a wide ranging thermometer.

The AD595 can be used in other ways. Further refinements can be made by adding compensation circuitry, operating off single rail supplies, or recalibrating for other thermoelectric materials. They can be applied to controllers as well as, as in this article, thermometry. If you are interested in following up any of these, the technical data sheet from Analog Devices should be consulted. This is obtainable from Farnell Electronic Components.

Both RS and Farnell stock the AD595. Order codes and prices are:

Farnell	AD595AQ	£6.14
RS	301-779	£8.96

* * * * *

Standard Grade Biology

Topic 7 - Biotechnology

Introduction

Recently we have been running one or two practical training workshops in biotechnology. In the course of these we have come across some snags in two of the practical activities in the Topic 7 National Exemplar materials.

In the main, these minor difficulties arise out a lack of detail in the Teacher/Technician Guide for the topic. These short notes aim to plug such gaps.

Staining yoghurt bacteria

The use of nigrosin stain as a simple counter-stain for yoghurt [1] bacteria can prove tricky. Nigrosin is potentially a simple stain to use and is good at showing up spores and bacterial capsules. The preparation of the stain solution, however, must be carefully carried out. This is undoubtedly the critical part of the procedure.

The concentration of the stain (10% w:v) is important. Even when using a water soluble grade, such as from BDH, getting the stain to dissolve can take quite some time. It is crucial to success that all the powder is dissolved, otherwise undissolved stain particles will interfere with the microscopic examination of the slide. Ensuring this full dissolution requires the use of a magnetic stirrer preferably of the stirrer/hot-plate type.

We tried the following three brands of yoghurt, none of which contained additives and all of which gave good results:

- Cairngorm Natural Goats' Milk Yoghurt

- Greek Yoghurt

- Rachel's Dairy Natural Yoghurt

It is possible to observe the bacteria under x200 magnification. But with a higher magnification of x400, the bacteria are more easily observed against the dark background.

Pectinase - extraction of fruit juice

Pectin is a complex polysaccharide usually found as calcium pectate between plant cells, where it is a component of the middle lamella. Pectin poses a problem for the food industry as it increases the viscosity of juice extracted from fruits. It thus creates problems during the process of concentrating such juices.

Commercial pectinase, produced mainly from **Aspergillus niger**, is a mixture of enzymes which attack the pectin molecule. Treating waste fruit pulp with pectinase increases the yield and decreases the turbidity of the extracted juice. It does so by degrading the pectin between the cells, breaking up cell masses. It therefore allows more juice, containing less gross cell debris, to be extracted.

Recently we have received several inquiries concerning the practical activity described for Standard Grade Biology which involves this application of pectinase [2]. We examined the suggested protocol (see Figure 1) using different concentrations of enzyme (Figure 2) and different sources of apple pulp (Figure 3). The pectinase enzyme was obtained from NCSB at a cost of £5 for 50 cm^3. The NCSB version is supplied as a concentrate in a resealable plastic container and is accompanied by a detailed information sheet and safety leaflet.

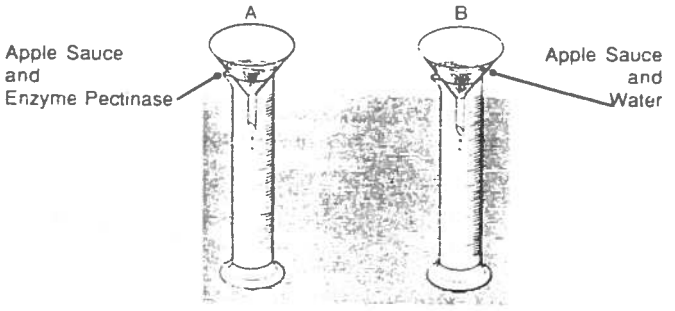


Fig.1

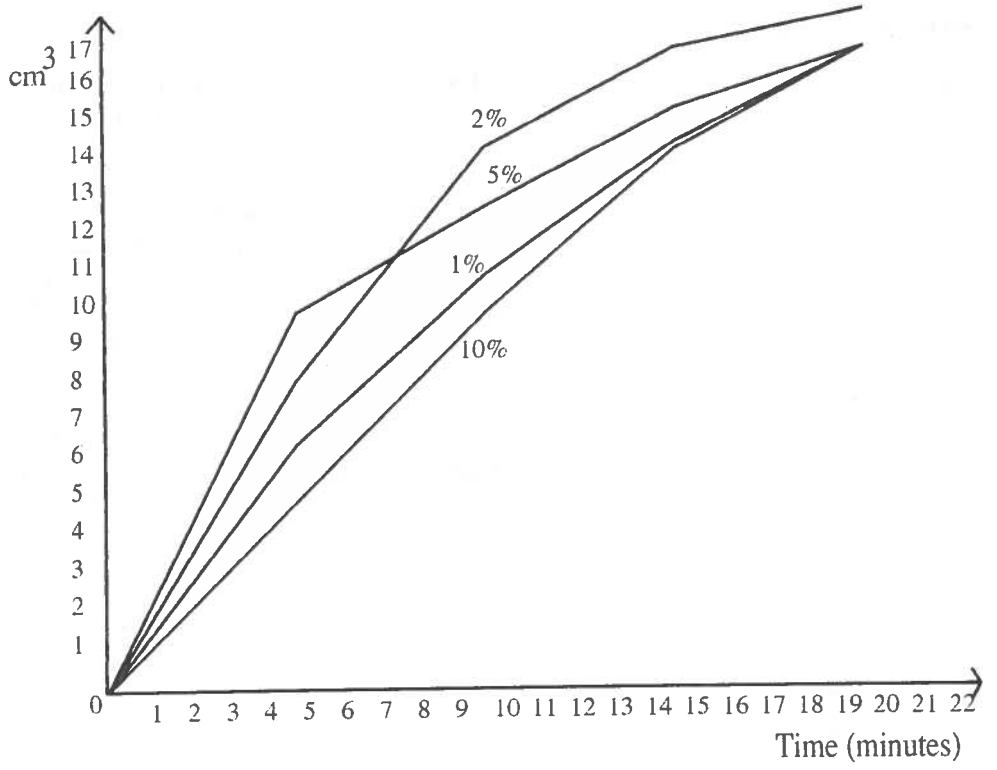

cm3
2%
5%
1%
10%
Time (minutes)

Fig.2

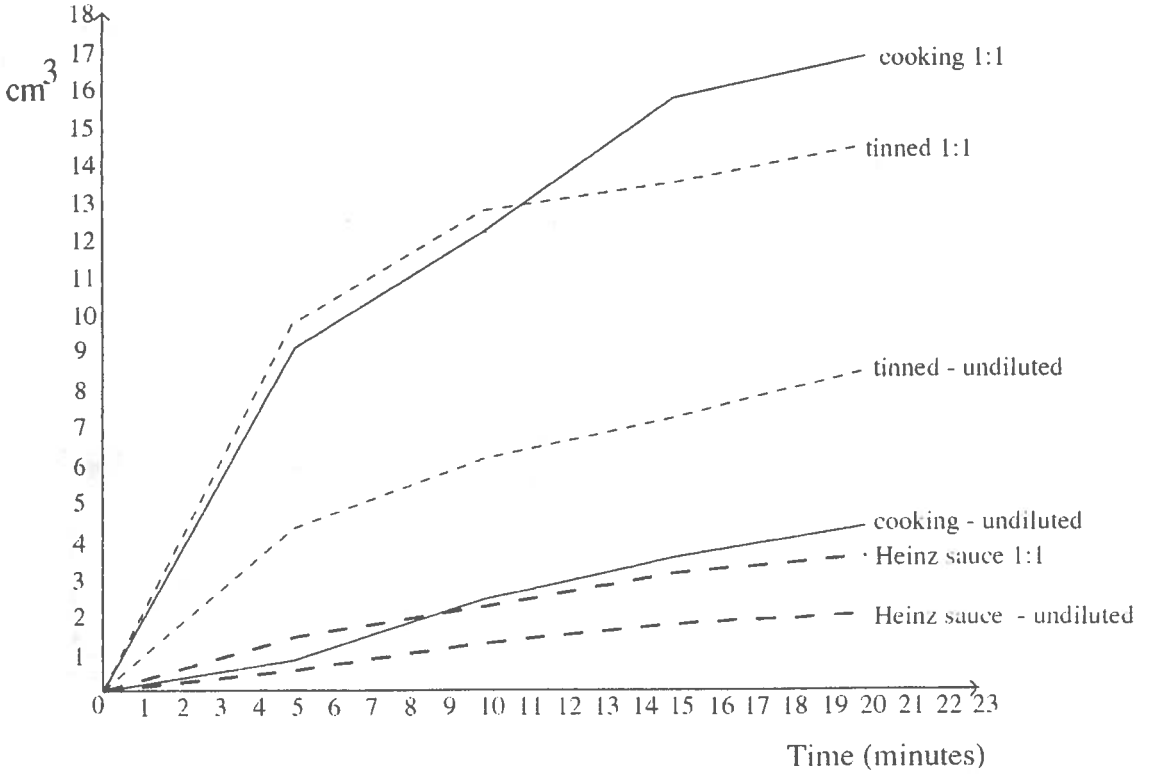

cm3
cooking 1:1
tinned 1:1
tinned - undiluted
cooking - undiluted
Heinz sauce 1:1
Heinz sauce - undiluted
Time (minutes)

Fig.3

As Figure 2 illustrates, 1% v:v is the minimum of those concentrations trialled which is adequate for this experiment. However when you take into account the concentration used and volume required, a 50 cm^3 stock bottle will last for longer than its recommended storage time (one year at 5-10°C). It would thus seem more sensible to use a 2% v:v concentration thereby ensuring a faster consumption rate resulting in new stock (with a known stated activity) being purchased for the start of each new session.

The best source of apple pulp and cheapest of those we trialled, was liquidised cooking apple (see Figure 3). When diluted 1:1 with water the volume of juice extracted is significantly increased. This increase in volume makes it easier for pupils to measure the yield. It is interesting to note that the yield from 'Heinz Apple Sauce' is significantly lower than from those from other sources*. It may be that the apple sauce source has already been processed using pectinase. Most of the juice would have been thereby extracted before canning took place.

(* Okay, okay - you find some way to avoid the pun!).

References

1. "National Examplar Material for Standard Grade Biology : Topic 7 Biotechnology. Sub-topic C - Reprogramming Microbes - Pupil Workcard G1". 1989, SCCC.

2. Ibid. but "Sub-topic D - Problems and Profit with Waste - Pupil Workcard G6".

* * * * *

EQUIPMENT NOTES

Anemometers for fume cupboard monitoring

Abstract

This article discusses fume cupboard monitoring and looks at several of the more reasonably priced anemometers that can be used to measure the face velocities of fume cupboards.

Introduction

COSHH requires that all engineering devices which have been installed to control contamination to adequate levels be checked every 14 months. The only local exhaust ventilation (LEV) likely to be fitted in laboratories is a fume cupboard. The inspection period can be interpreted as being every year with two months' grace.

An additional simple test worth using at the time of installation, or after any modification, is a smoke test. This can detect any leaks or eddy currents which cause fumes to be ejected, even though the velocity of the air flow as measured with an anemometer is adequate. Sources of suitable smoke pellets are listed at the end of the article.

Methods of measuring face velocity

The sash of the cupboard should be moved to its maximum working opening and the aperture divided into nine equal rectangles (Fig.1).

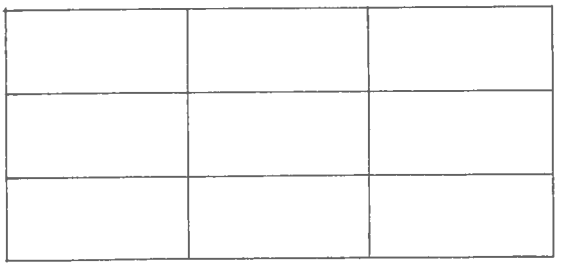


Fig.1 – Sub-divide aperture

With the room doors and windows closed and any other fans switched on, measure the average air speed in each rectangle over a ten second period. The operator should avoid obstructing the airflow with his or her body. The time averaged value should not be less than 0.3 m/s for any one area nor differ from the mean by more than 30%. Higher velocities, in excess of 0.6 m/s, are undesirable. The resulting airflow can blow out Bunsens and generate eddies.

Management of monitoring

It makes sense for the capital cost and the running expenses of calibration to be shared between several schools. For instance monitoring could be carried out by school technicians using anemometers loaned for a short period. Or instead, a centrally based technician could travel round the schools.

The main argument against sharing and loaning out is the probable increase in breakdowns of delicately balanced rotor bearings, or of a thermistor sensing head.

We estimate that the face velocity of one fume cupboard can be monitored in 10 or 15 minutes. An hour to an hour and a half should be adequate for a whole school.

SSERC has an anemometer which we loan to schools on a collection and return basis. Whilst this service will still be available in the future a charge will be made to cover calibration costs.

The instruments tested

Most of the anemometers currently on the market within a price limit around £350 have been examined in the Centre. They have been tried out on our own fume cupboard. Our findings described below mainly reflect the physical construction, ease of use, and our general impressions. The main features are listed in Tables 1 and 2, and in the footnotes. Since SSERC does not possess a calibrated test rig the one factor not tested is the accuracy.

The anemometers we tested were of two types: rotating vane and hot wire.

Rotating vane type

This is in essence a small windmill with a precision bearing on the vane's axle. One example of the type, the LCA6000, is shown in Figure 2.

Fig.2 - Rotating vane type

Speed of rotation is measured by some form of tachometer with a non-mechanical connection. Modern types usually sample velocity over a given time period before showing the time averaged result on a digital display. Because there is no such thing as a frictionless bearing, simple vane meters will read low at slow air speeds. Some manufacturers supply calibration tables and others compensate for this electronically.

This type normally has a short handle and tends to be bulkier than the hot wire meters. The bulk, both of the instrument and, if he is not a contortionist, of the operator will partly block the area of the face and thereby slightly increase, by about 5%, the air flow in the unobstructed part.

Hot wire type

The cooling effect of air currents is measured and converted to read directly in units of speed. This is normally done by measuring the electric current needed to maintain a thermistor bead at a fixed high temperature. The usual method of compensating for differences in temperature of the ambient air is by building into the same bridge circuit a second thermistor which is shielded from the flow of air.

Fig.3 - Hot wire type

The term 'hot wire' is, strictly speaking, a misnomer. Early instruments indeed used heated wire, but this has been superseded in modern designs by an NTC thermistor. This is because the

latter gives a bigger output for the same change in air velocity and requires much less current to run it. However the name has stuck. The principle being the same, thermistor instruments are always referred to as 'hot wire' anemometers.

The thermistor beads are small and usually fitted on the end of a wand, sometimes telescopic (Fig.3). Thus there is virtually no blockage of the air flow.

These instruments have an analogue display and rely on some electrical damping to help read the scale. It was noted that they do not integrate the reading over a period of time. The operator therefore has to take several, separate readings over a 10 s period, or longer, and estimate the time weighted mean.

In general we think there is an advantage in using a meter with signal averaging. Vane types score over hot wire types in this respect. However were a fume cupboard to suffer from a fluctuating airflow, this might only show up on a hot wire meter. But a smoke test ought also to be able to show this.

Manufacturer	Model/ Price	Power supply	Range (m/s)	Length of 0.3–0.4 division	Sampling period (s)	Correction for low speed	Ease of use	Wand
Rotating vane type, digital display, resolution of 0.01 m/s								
Airflow Developments	LCA6000 £163-20	PP3	0.2-30	-	3	none	***	-
Airflow Developments	LCA6000VT £229-80	PP3	0.25-30	-	3, and variable for 3 to 120	yes, electron-ically	****	-
Lownes	LEDA1000L £355	4xMP675H mercury cells	0.2-8	-	15, 30 & 60	yes, chart supplied	*****	-
Hot wire type, analogue display								
Airflow Developments	TA 2-2 £306-30	4xAA (1.5 V)	0-2	6 mm	none	n.a.	***	telescopic to 2 m
Prosser Scientific	AVM521S £298	recharge -able, charger supplied	0-3 0-30	4 mm	none	n.a.	**	23 cm long
Prosser Scientific	AVM522S £330	recharge -able, charger supplied	0-0.5 0-5	8 mm	none	n.a.	****	23 cm long
Testoterm	Testovent 4100 £395	IEC 6F 22	0-2 0-20	4 mm	none	n.a.	****	telescopic to 0.8 m

Table 1 - Summary of anemometers tested

General Comments

1. Apart from the Testovent 4100 the price includes carrying cases. The case for the Testovent is £23 extra.

2. The ease of use is a subjective estimate based on several factors. It takes into account the position of switches, the order and way in which they have to be pressed, and the ease of reading the meter.

3. Clearly the vane instruments, which average the velocity over a sampling period, are easier to read than the fluctuating needle on the analogue scale of a hot wire meter. The Testovent 4100 has a variable damping control, which does help.

4. Only two anemometers, LEDA1000L and TA 2-2, have the instructions printed on the instrument.

Comments on individual meters

Rotating vane anemometers

Lownes LEDA 1000L

The bearing on this instrument is delicately balanced and the vanes are of light mica sheets. Consequently the meter responds rapidly to changes in air speed. The controls are simple.

Each instrument is supplied with its own calibration chart giving corrections for a range of displayed speeds.

This is a precision instrument which is very easy to use. We recommend it for use by one or two individuals alone since the fine bearings and vanes might not survive too long if used in a pool of instruments stored centrally and loaned widely.

Airflow Development LCA6000 & LCA6000VT

The aluminium vanes of these two models are infinitely sturdier than those of the Lownes model, but at the expense of performance. Having greater inertia in their rotors these two instruments take a bit longer to wind up to equilibrium speed. Also the handle being stouter and shorter compels the operator to be closer to the fume cupboard opening and thereby affect the reading (see notes above).

A particularly poor feature of their design is that when held at a fume cupboard face with the air flowing in the direction indicated by the arrow on the head the display faces away from the operator.

There are a few differences in the modes of operation of these two instruments. These are summarized on Table 1. Of the two, we consider the VT model to be far more directly useful because it can sample over the 10 s period specified in Design Note 29.

Both Airflow anemometers are good sturdy instruments at reasonable prices and should be accurate enough for the annual check of fume cupboards. It is unfortunate that the digital displays read the wrong way up while air flow is being measured. This considerably slows down the monitoring across a grid because each time the meter is turned round to be read the rotor loses its angular momentum.

Hot wire anemometers

These models have a lot in common and are discussed together.

1. The instruments examined were generally less easy to read than the vane types both because of their more rapid response to fluctuations in the velocity of air flowing into the cupboard and because of the lack of a built-in sampling time with averaging facility.

2. Size of scale divisions affect the ease of reading. The division between 0.3 and 0.4 m/s is listed in column 5 of Table 1. The Prosser 522S seems to be best in this respect with an 8 mm span further divided into five subdivisions of 0.02 m/s.

3. The heads of th probes containing the sensors differ in shape. The Testoterm sensor is fitted in an open cage. This operates at all angles to the wind direction. Provided the other heads are angled to within about 40° of airflow direction they too read true.

4. With the exception of the 522S all have automatic temperature compensation. However the 522S has a built-in thermometer and it is a simple matter to manually set the temperature compensation control.

5. The wand or handle on all the instruments is long enough to avoid the operator obstructing the air flow.

6. The TA 2-2 and the Testovent 4100 are easily held in the palm of the hand, but the latter also has a folding leg which will prop up the meter at an angle if placed on a horizontal surface. Although the 521 and 522 are heavier and a little larger, the carrying case provided can act as a cradle supporting the meter horizontally at waist level.

Calibration

To meet the requirements of COSHH valid measurements of the face velocity of the fume cupboard are necessary. Generally manufacturers prefer to calibrate only their own meters. Table 2 gives a list of the manufacturers, their local suppliers and the cost of calibration. A calibration traceable to a Standard is more expensive than one with a lesser pedigree. With some manufacturers you can pay a smaller sum for calibration on the limited part of the range that needs to be calibrated. Several will negotiate a discount for the calibration of several meters of the same type.

The calibration charges given below are those made by the manufacturers. Of the local agents, Cuthbertson & Laird charge £39 for calibrating any of the three Airflow anemometers. J.W.Fairbairn do not offer a calibration service.

Recommendations

The only meter we do not recommend is the AVM521S from Prosser. Any of the others will suffice for monitoring fume cupboards to COSHH requirements.

Depending on the strategies adopted by the EA's in managing this monitoring, the following is our advice on purchasing:

- if each school is to be supplied with its own anemometer we advise that they purchase one of the cheaper, but more robust, vane types, i.e. the LCA6000VT preferably, or, failing that, the LCA6000;

- if the monitoring is to be done by a technician who visits each school in turn, or if an authority requires a good quality back-up meter, we advise buying the Lownes LEDA1000L vane type, or one of the hot wire instruments such as either the Prosser 522S, with its good readability, or, if you can afford it, the Testovent 4100, with its variable damping facility.

Manufacturer	UK agents	Local agents	Model	Cost of calibration
Lownes	-	-	LEDA 1000L	£40
Airflow Developments	-	Cuthbertson & Laird	LCA6000 LCA6000VT TA2-2	£38.40 with no certificate £64.10 with certificate £67.75
Prosser	-	-	AVM521S AVM522S	£44 £60
Testoterm	Testoterm (UK)	J.W.Fairbairn	4100	£30 for 0-1 m/s range.

Table 2 - Suppliers and calibration charges

Sources of smoke generators

Brocks Explosives Ltd. sell small and large smoke pellets at 29p and 36p respectively, but a minimum of 200 must be purchased. Another product of theirs are 2 minute smoke generators at £32 for a pack of 10.

P.H. Smoke Products Ltd. offer a tube of 6 small pellets for £2.45, or £3.50 for 2 large pellets. The minimum order is 10 small tubes, or 5 large ones.

Another useful source are the cheap toy smoke bombs which can be purchased in 'joke' shops.

Other agents

Those likely to be used by schools are:

Philip Harris	for Prosser (AVM521 only)
Solex	for Airflow Developments
Safelab	for Airflow (LCA6000 only)

References

1. Design Note 29, Fume cupboards in Schools, DES - free from address given on inside cover.

2. Fume cupboards, SSERC, 1986.

* * *

Pulse monitors - Addendum

Introduction

Bulletin 164 carried a summary based on recent SSERC test reports for a number of pulse monitors. We aplogise to Educational Electronics Ltd. for not having included in that summary the results of our tests on their monitor and software. The omission was due to a simple oversight on our part. We trust that the test summary shown below (Table 1) will make amends.

Both the equipment and the accompanying software performed well in our tests. At £79 this device is certainly worthy of serious consideration for application at Standard Grade. A fuller test report is available on application to the Director of SSERC.

Model	Supplier/price & cat.no.	Type	Sensor	Display, size & accuracy	Other functions	Comments
MEU Pulse Unit	Educational Electronics £79-00 9000	Bench instrument, interface. batt. 9V (alkaline)	Optical finger/ earlobe	40T 5¼" disc BBC B & Master Accuracy in pulse triggered mode is doubtful	Pulse rate, rate versus time; fitness index and pulse triggered heart simulation	Good documentation & versatile software. Probably a good buy

Table 1

Centrifuges

Introduction

In our equipment lists for Standard Grade Biology we only mentioned less expensive models of centrifuge intended for general school laboratory applications. We did annotate the list to the effect that we would be updating our test programme on more sophisticated models suitable for use right through to CSYS level.

Models tested

An initial survey of the market identified two competively priced models of appropriate specification. They are Clandon Laboratories' MLWT51 and Damon IEC's Spinette. These we have now tested. The results of our tests are summarised in Table 1 opposite.

Copies of the full test reports are available, to Scottish member institutions, on application to the Director of SSERC.

Notes

* - 3 rotor types available and the machine has several speed settings. The speed shown is our measured figure for the 8 place swing-out head. The figures in brackets are the maxima claimed for the 8 place angled head.

** - Figures as measured in our tests with manufacturer's claimed maxima in brackets.

Switch on/off - the times in seconds to reach the maximum speed from rest, and vice-versa. The figure in square brackets is with the T51's electronic brake in operation.

Classification - (A) is very satisfactory and (B) is satisfactory for use in Scottish courses.

Model tested	MLWT51 Cat.no. INC-51	Spinette Cat.no. 2357
Supplier	Clandon	Damon IEC/UK
Price	£358 not incl. rotors	£330
Head type	4 & 8 place swing out, 8 place angled*	4 place swing out
Tube sizes	97x13 mm min. 118x17 mm max.	100x7 mm min. 133x16 mm max.
Max. speed (r.p.m.)	4800 (7000)*	2,820 (2760)**
Max. accel. (g)	3220 (5400)*	977 (916)**
Switch on/off	10/50 [23]	25/80
Isolate chloroplasts? (for the Hill reaction)	Yes	Yes
Classification	Recommended (A)	Recommended (B)

Table 1 – Centrifuges tested

Printing and Drawing: Printers and Plotters

Introduction

Both from the "Opinion" section and the announcement on Bulletin production in the "Introduction" for this issue it is obvious that we have been looking at ways of improving the presentation of our printed materials. In so doing we have had on loan for evaluation a number of printers and plotters.

Visitors to the Centre have noticed staff testing out such devices. In a small country the word soon gets round. We are now getting enquiries for purchasing advice for printers and plotters. In general, this is not our field though we probably do have a remit to advise technology teachers on output devices for computer aided drawing.

Clearly many teachers and technicians, in science as well as technical departments, are spending time and effort in learning the hard way how to use these new facilities. Like most Centre staff, many of you will have had little or no professional experience or training in this field. We presume therefore that it would be useful if we share our own hard-won experience as well as the knowledge and expertise of our own information technology equipment specialists.

In this article we discuss the appropriateness of dot-matrix, ink jet and laser printers as well as plotters in producing good quality print and graphics (drawings to we and you). Several specific models of some types of device are mentioned. Some have been trialled, but not evaluated in depth. Others we just know of. The article is therefore only in part a technical review along with a restricted market survey.

Laser-less quality print

A laser printer is, apparently, de-rigeur for the educational information technology buff. Any worksheet sweat-shop, it would seem, would be bare without one. Given suitable software however it is not too difficult to produce good quality print from devices costing a good deal less than a laser printer.

For example, Acorn's new Archimedes DTP package has a number of high resolution typestyles which output at the printer port at 360 dots per inch (dpi). Several such fonts are available in that package. It is a relatively simple matter to transfer these fonts for use with a drafting package such as "Draw". This is a utility which forms part of Acorn's applications support for its reduced instruction set computer operating system (RISCOS).

The problem lies in finding relatively inexpensive devices - compared to a laser printer that is - which can produce a printout of similar resolution.

Dot Matrix Printers

We assume that most readers will realise that, as their name suggests, such printers build up characters and graphics as patterns of small dots. Early, and cheaper current, printers use a print head with only 9 pins. Later models use 24 pins to produce better quality print (near letter quality - NLQ). Both sorts are capable of emboldening and other effects by using pins more than once, multiple passes etc. We will not bore you with any further, technical detail than that.

Laser printers cost at least £900. Or £2,500 or more for a fancy one. They can produce output with a resolution of 300 dots per inch (dpi). Many dot matrix printers at much lower prices are capable of 360 dpi - so why use a laser printer?

The fact is that dot matrix printers can't really resolve 360 dpi. Each dot position may be only 1/360" from the next, but the dots are considerably larger than 1/360". This means that smooth edges can be achieved, rather than the normal dot matrix pixelly effect; but fine detail cannot be produced. Normal size text looks considerably better in the high resolution (DTP) format than in standard word processor output, but small text is poor or illegible (Figure 1).

Fig. 1

In DTP use, most dot matrix printers have another problem. Although the print head movement can be controlled accurately within each pass to 1/360", successive passes may be slightly out of register with each other. In normal use this isn't noticeable because the slip occurs between one line and the next. DTP output may have lines of text split across two or more print head passes. The slip may then show as a little step in the edges of every letter on the line. Similarly, small errors in the vertical movement of the paper can cause squashed lines of text, or thin white lines through the characters (Figure 2).

Misregistration errors
(exaggerated)

Fig. 2

Ink Jet Printers

As with the dot-matrix printer the name, ink-jet, describes the basic mechanism of such printers. Unlikely though it may sound, ink-jet printers spray the patterns of characters or graphics onto the paper. Control of the pattern is usually achieved by means of an electrically generated field. Some early models proved unreliable because of problems with air-locks blocking the flow of ink in the jets. Later models use a variety of techniques to get around such snags. For example the model reviewed below employs a heated print head and wax based ink so as to minimise blockages.

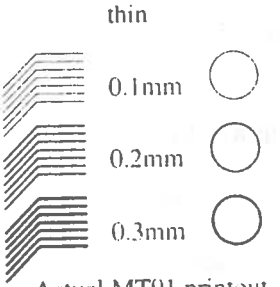
Ink jet printers can easily achieve dot sizes of 1/360". With good mechanics to avoid the registration problem, they can produce output as good as that from some laser printers.

The innards of cheap laser printers are just like cheap photo-copiers and they may suffer from the same diseases. The laser printer which produces beautiful sharp black and white output when new may well soon produce blotchy grey output.

The MT91 ink-jet

We have been using a Mannesmann Tally MT91 ink-jet printer for the last few weeks, with very pleasing results. Its output is scarcely inferior to laser printers at their best: very small text, or very thin lines, can be a little less dense on the MT91 unless good quality paper is used; and misregistration steps are occasionally just noticeable (though much less so than with a dot matrix). The resolution is actually a little better than a laser printer's.

Apart from the price (£550 with education discount), the MT91 has another major advantage: it can handle any paper size up to A3 with a built in cut sheet feeder, or up to A2 hand fed. For plain text, from a word processor say, it's quicker than most dot matrix printers; it's as slow as a laser printer for graphics or DTP. Since it can produce easily distinguishable line widths of 0.7, 0.4, and 0.2 mm or less, this also puts it squarely in competition with plotters for computer aided drafting applications (Figure 3).



Actual MT91 printout

Fig. 3

It is very slow compared with even a slow plotter, except for very complex drawings, which take it no longer to produce than simple ones.

The quality of the output is distinctly better than a plotter can achieve, unless expensive good quality plotter pens and paper are used.

With A2 paper, it is a possible means of obtaining large plots - plotters larger than A3 are too expensive for a school to contemplate buying.

Compatibility

The MT91 has a parallel interface (Centronics 8-bit) as standard. A serial RS232C interface is available for it. It normally emulates an IBM Proprinter XL. For the 360 dpi graphic output, you need the optional NEC P7 emulation. Any software you use must have a driver for an NEC P7. NEC P6 is one of the standard drivers provided with Acorn A3000 or Archimedes computers. NEC P6 is the same as NEC P7 except for the paper size; a simple adjustment to the P6 driver is necessary to use paper sizes greater than A4.

Plotters

With the imminence of Graphical Communications (Standard Grade Technical Drawing!) many schools will need to consider buying computers, plotters, and software for computer aided drafting [1]. In the past, this meant a BBC model B or Master, with a Linear Graphics Plotmate Plotter. The situation is now much less clear.

The advantage that the original Plotmate had was that it understood the internal graphics language of the BBC Microcomputer. This made the writing of simple CAD software very easy. However, all recent CAD software is able to control other plotters, using standard graphics languages such as HP-GL (Hewlett Packard Graphics Language).

If you don't already have the computers and software, our clear recommendation for this application is Acorn A3000, using Autosketch. Several manufacturers now offer A3 plotters of high quality, at prices around the £550 mark. Almost any of them work without any trouble with any software, on any computer.

Certainly any of the plotters listed in Table 1 work with an Acorn A3000 running Autosketch, or an Apple Macintosh running ClarisCad. All of them handle A3 paper, and have both serial and parallel interfaces to connect to most computers.

All except the Hitachi are flat-bed plotters; that is, the paper stays put on a flat surface, while the pen moves in both X and Y directions. The Hitachi is a pinch-wheel plotter; the pen moves in the X direction, but the paper moves in the Y direction. This is a fundamentally inferior technique, but in practice is remarkably successful. On large, complex drawings there is some cumulative error in the Y direction, resulting in slight misregistration between lines drawn early in the process, and those drawn later. The effect is very slight as long as care is taken to allow a free path for the movement of the paper.

Plotter	Source	Target price (£)	Writing speed (mm/s)	No. of pens	Self capping?
Graphtec MP4100	Morrison McLean	550	500	8	yes
Plotmate A3M	Linear Graphics	480	160	1	no
Plotmate A3M + multipen	Linear Graphics	580	160	10	no
Sekonic SPL-450	Morrison McLean	550	400	8	yes
Hitachi 672-XD	Testbed or Commotion	620	200	4	no

Table 1

The Plotmate A3M without the multipen attachment is included for completeness - and to make the point that multiple pens are essential, either for colour work, or for variations in line width. Changing pens manually every time the plotter bleeps at you is not a practicable proposition, and recent advanced software doesn't even make provision for it. Plotmate plotters without the M suffix can only be used with BBC model Bs or Masters.

The writing speed is important when you have a whole class waiting to plot their drawings on a single plotter! Plotting is very quick compared to hand drafting - watching a plotter is mesmeric - but complex drawings still take quite a long time to plot. It is also quite important that the pens should be capped automatically (self cap) when they are not in use, otherwise they dry up rather quickly, and they are not cheap.

Of the plotters we know, the Sekonix or the Graphtec seem the best buys. The Graphtec has a slightly inferior way of holding the paper on the table [2], but against that it can be angled at 60° to the horizontal, which may be very convenient if desk space is limited.

It must be said that there are other plotters on the market, and that we haven't carried out a thorough test programme. We may provide more advice in the future.

Just one last thought: if you have a good enough printer, do you need a plotter? Some printers can draw lines of controlled width very well indeed. If you want multicolour, then you need a plotter, because colour printers good enough to produce technical drawings are expensive. Similarly, if speed is important then good quality printers are too slow when printing graphics. But if slow, black and white, printout is good enough for your needs, or you need plots larger than A3, then read or re-read the section on Printers . . . .

Footnotes

1. CAD is usually interpreted as Computer Aided Design. What is actually practised, especially in schools, is usually Computer Aided Draughting. The software assists in the process of drawing, but the responsibility for the design lies entirely with the human. A computer aided design program would also be able to perform calculations and checks relating to the product being designed.

2. Don't put floppy discs down on a plotter drawing table - it's a big sheet of magnetic rubber! Changing paper involves fiddling around the pen arm, or moving it out of the way using the control panel. The metal strips that hold the paper down are often rather flimsy and easily kinked.

* * * * *

NOTICE

Science And Plants for Schools (SAPS)

The SAPS programme has been set up to promote and support exciting plant science teaching in schools. Launched at the UK ASE Annual Meeting in January, it has already generated a great deal of interest among biology teachers.

One area of the programme which we believe will become an essential resource for the Standard Grade Biology 'World of Plants' topic, is the SAPS work with rapid cycling Brassicas. These 'fast plants' go from seed to flowering in two weeks and from seed to seed in five. They are particularly amenable to classroom exercises because of their rapid development, their small size, and the ease with which they can be grown and pollinated. Many variants of the wild type population have been bred, opening the way to genetic studies.

SAPS have produced a commercial kit containing the seeds, vermiculite, pots, etc. The kit will cost around £15 and should be available at the end of March 1990. A school wishing to use these plants will need a lamp frame with a bank of six, 4 foot, cool-white fluorescent tubes (40 watts each). It will be necessary also to maintain optimal growing temperatures of 21-27°C. Temperatures below 21°C delay growth and those below 15°C may inhibit germination.

SAPS are in a position to assist a limited number of schools with funding the necessary apparatus. Selection of schools for sponsorship will not be open to all. Preference will be given to those schools willing to actively assist with research and development of teaching applications of the plant material. Those schools who do not wish to be sponsored can become an associates, allowing them to receive the SAPS Newsletter, which will be published every term. For more information contact SAPS - see the address list on the inside cover.

It is serendipitous that someone who has been closely associated with SAPS should shortly be taking up an important new post in Scotland. Dr David Ingram, at the time of writing a member of the academic staff at Cambridge University, will in April 1990 become the Curator of the Scottish Royal Botanic Gardens.

TRADE NEWS

Ian Douglas

Ian A.Douglas Esq., representative and gentleman is well kent in Scottish school and college science and technology departments. Ian has asked us to announce that he is no longer with Griffin and George Ltd. His request arises out of his wish to avoid some of the confusion and slight embarassment which may arise as he continues to call on such establishments and is assailed with enquiries on Griffin items or services.

Ian is now Area Manager for British Thornton, the Manchester based technology education equipment supply company. He can be contacted in that new capacity at the address and telephone numbers shown on the inside cover of this issue.

Microscope servicing

There is a recent entrant into the market for contract servicing of educational microscopes. We announced previously in these pages the decision of the Japanese company Olympus to set up its own direct trading organisation - Olympus Optical Co. (U.K.) Limited. This firm began direct selling of instruments some time ago although major educational suppliers still carry Olympus microscopes in their catalogues.

This UK company has more recently been actively marketing contract servicing schemes for customers in education. These may interest several Scottish EAs whose schools bought Olympus models, on SSERC's recommendation, when they were relatively less expensive and schools had a bit more money.

Contract terms for routine servicing of the HSC, STN and MIC - three models likely to be held in schools - are £18.75 per instrument for 1 to 4 units. Larger numbers gathered at one site attract a 20% discount for 5 to 19 units and 32% for 20 or more units. The figures quoted are based on annual service visits and do not include the costs of any repairs or parts which may be required. The engineer to whom we spoke stated that for schools it should be possible to negotiate contracts based on biennial visits.

Farnell Electronic Components Ltd., Canal Road, Leeds LS12 2TU; Tel. (0532) 636311.

Glasgow Dome of Discovery, South Rotunda, 100 Govan Road, Glasgow; Tel. 041-427 1792.

Philip Harris Education:
2 North Avenue, Clydebank Business Park, Glasgow G81 2DR; Tel. 041-952 9538
Lynn Lane, Shenstone, Lichfield, Staffordshire WS14 0EE; Tel. (0543) 480077

Linear Graphics Ltd., Mochdre Industrial Estate, Newtown, Powys SY16 4LE; Tel. (0686) 29292.

Lowne Instruments Ltd., Boone Street, London SE13 5SA; Tel. 01-852 0143.

Mannesmann Tally Ltd., 7 Grampian Court, Almondvale, Livingston, West Lothian EH54 6QF;
Tel. (0506) 415943

Morrison & McLean Associates, 172 Market Street, Aberdeen AB1 2PP; Tel. (0224) 575011.

National Centre for School Biotechnology (NCSB), Department of Microbiology, University of Reading,
London Road, Reading RG1 5AQ; Tel. (0734) 873743.

Northern College of Education, Dundee Campus, Gardyne Road, Broughty Ferry, Dundee DD5 1NY;
Tel. (0382) 453433.

Olympus Optical Co. (UK) Ltd., 2-8 Honduras Street, London EC1Y OTX; Tel. 01-253 2772.
(Scottish Product Support Engineer, Mr. Webster; Tel. (0236) 825045).

P.H.Smoke Products Ltd., Glenview Road, Eldwick, Bingley, West Yorks, BD16 2EF; Tel. (0274) 567931.

Prosser Scientific Instruments Ltd., Lady Lane Industrial Estate, Hadleigh, Ipswich IP7 6BQ;
Tel. (0473) 823005.

RS Components, PO Box 99, Corby, Northants NN17 9RS; Tel. (0536) 201201.

RTS Technology Ltd. (Mannesmann Tally MT91 Agents)
St. Pancras Commercial Centre, Pratt Street, London NW1 0BY; Tel. 01-267 7541.

Safelab Systems Ltd., 62 Prince Street, Bristol BS1 4QD; Tel. (0272) 393413.

Satrosphere, 19 Justice Mill Lane, Aberdeen AB1 2EQ; Tel. (0224) 213232.

SCCC, Gardyne Road, Broughty Ferry, Dundee DD5 1NY; Tel. (0382) 455053.

Science and Plants for Schools (SAPS), Homerton College, Hills Road, Cambridge CB2 2PH;
Tel. (0223) 41141.

Solex International, Cottage Lane Industrial Estate, Broughton Astley, Leicestershire LE9 6PD;
Tel. (0455) 283486.

Testbed Technology Ltd., The Science Park, Hutton Street, Blackburn, Lancashire BB1 3BT;
Tel. (0254) 681222.

Testoterm Ltd., Old Flour Mill, Queen Street, Emsworth, Hampshire PO10 7BT; Tel. (0243) 377222.

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